2nd MEETING OF THE PZJA TORRES STRAIT
HAND COLLECTABLES RESOURCE ASSESSMENT GROUP (HCRAG)

27-28 September 2022

Torres Strait Regional Authority Board Room, Level 1 Torres Strait Haus, 46 Victoria Parade, Thursday Island

AGENDA

The meeting will open at 8:30 am on Tuesday 27 September 2022.

AGENDA ITEM 1 PRELIMINARIES

1.1 Acknowledgement of Traditional Owners, welcome and apologies

The Chair will welcome HCRAG members and observers to the 2nd meeting of the Torres Strait Hand Collectables Resource Assessment Group (HCRAG).

1.2 Adoption of agenda

The HCRAG is invited to consider and adopt the draft agenda.

1.3 Declarations of interest

HCRAG members and observers are invited to declare any real or potential conflicts of interests and determine whether a member may or may not be present during discussion of or decisions made on the matter which is the subject of the conflict.

1.4 Action items from previous meetings

The HCRAG is invited to note the status of action items arising from previous HCWG meetings.

1.5 Out of session correspondence

The HCRAG is invited to note any out of session correspondence to the HCRAG since the last meeting.

AGENDA ITEM 2 HCRAG UPDATES

2.1 Industry members

Industry members are invited to introduce themselves and provide an update on matters concerning the Torres Strait Hand Collectable fisheries, in particular, providing comment on fishing patterns, behaviours, prices, and market trends.

2.2 Scientific members

Scientific members are invited to provide an update on relevant research matters relevant to Torres Strait Hand Collectable fisheries.

2.3 Government Agencies

The HCRAG is invited to note updates from AFMA, TSRA and Fisheries Queensland on matters relevant to Torres Strait Hand Collectable fisheries.

2.4 Native Title

The HCRAG will note a verbal update from the Malu Lamar (Torres Strait Islander) Corporation RNTBC representative if available to attend.

2.5 PNG National Fisheries Authority

The HCRAG will note an update from the PNG National Fisheries Authority if available to attend.

AGENDA ITEM 3 BLACK TEATFISH TRIAL OPENING 9 – 12 MAY 2022 AND FUTURE OPENINGS

Considering the outcomes of the 2022 black teatfish trial reopening, including the outcomes of the size frequency sampling undertaken during the opening, and in accordance with conditions 5, 6 and 7 of the Re-opening Decision Rule in the BDM Harvest Strategy, the HCRAG is invited to:

- review whether data collection during the second trial opening was conducted satisfactorily;
- consider the analysis of the data collected and its suitability to inform a future TAC and potential to stay open; and
- provide advice to the Hand Collectables Working Group and the PZJA:
    - on the potential for future fishery openings including an appropriate TAC, interval between openings and reporting and data collection requirements and any other conditions that should apply.
    - identify additional data that should be collected during future openings (e.g. length sampling).

Industry observers will be invited to participate during this discussion to inform the RAG's consideration.

AGENDA ITEM 4 TOTAL ALLOWABLE CATCHES FOR THE 2023 FISHING SEASON

The HCRAG is invited to review the current TACs for sea cucumber species under the guidance of the BDM Harvest Strategy, taking into account catches for the 2021 fishing season and any other relevant information available.

If required, the HCRAG is invited to recommend to the HCWG and the PZJA new TACs for the 2023 fishing season in line with the BDM Harvest Strategy.

AGENDA ITEM 5 UPDATE ON CLIMATE CHANGE IMPACTS ON TORRES STRAIT FISHERIES

The HCRAG is invited to note:

- the outcomes of the project *Scoping a future project to address impacts from climate variability and change on key Torres Strait Fisheries*.
- a presentation on the work that AFMA is doing to build climate change information into decision making processes.

AGENDA ITEM 6 RESEARCH PRIORITIES

The HCRAG is invited to consider the annual and five-year research plans for Hand Collectable Fisheries and recommend research priorities to the HCWG and the Torres Strait Scientific Advisory Committee research priorities for funding in 2023-24 and beyond.

AGENDA ITEM 7 NEW APPLICATION TO UNDERTAKE AQUARIUM FISHING IN THE TORRES STRAIT

AFMA has received an application to undertake aquarium fishing in the Torres Strait and is seeking the HCRAG's advice on the minimum reporting and data collection requirements that should be applied subject to approval of the activity under Part 13 of the EPBC Act.

AGENDA ITEM 8 RAG PRIORITIES AND DATE FOR NEXT MEETING

The HCRAG is invited to discuss a suitable date for the next meeting.

AGENDA ITEM 9 OTHER BUSINESS

The HCRAG is invited to nominate any other business for discussion.

- Balancing the Dimensions of Sustainable BDM Fisheries Management (TSRA to present)

The Chair must approve the attendance of all observers at the meeting. Individuals wishing to attend the meeting as an observer must contact AFMA (fisheriesTI@afma.gov.au).

The meeting will be voice recorded for the purpose of developing the meeting minutes and will be deleted once the meeting outcomes have been finalised.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No. 2** **27-28 September 2022**
PRELIMINARIES **Welcome and apologies**	**Agenda Item 1.1** **For NOTING**

RECOMMENDATIONS

1. That the Resource Assessment Group **NOTE**:
    a. an acknowledgement of Traditional Owners;
    b. the Chair's welcome address;
    c. apologies received from members unable to attend.
2. A formal apology has been received from Scientific Member, Assoc. Prof. Steve Purcell.
3. The QDAF Member Ms. Samantha Miller has advised that she will be participating via video conference.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No.2** **27-28 September 2022**
PRELIMINARIES **Adoption of agenda**	**Agenda Item 1.2** **For DECISION**

RECOMMENDATION

1. That the Resource Assessment Group consider and **ADOPT** the draft agenda.

BACKGROUND

2. A first draft annotated agenda was circulated to members and observers on 12 September 2022.
3. The draft agenda was revised to include minor comments from members and an additonal Agenda item on a proposed new fishing activity and recirculated on 21 September.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	Meeting No. 2 27-28 September 2022
PRELIMINARIES **Declarations of interest**	**Agenda Item 1.3** **For DECISION**

RECOMMENDATIONS

1. That the Resource Assessment Group members:
    a. **DECLARE** all real or potential conflicts of interest in Torres Strait hand collectable fisheries at the commencement of the meeting (**Table 1**).
    b. **DETERMINE** whether the member may or may not be present during discussion of or decisions made on the matter which is the subject of the conflict;
    c. **ABIDE** by decisions of the Resource Assessment Group regarding the management of conflicts of interest.
    d. **NOTE** that the record of the meeting must record the fact of any disclosure, and the determination of the Resource Assessment Group as to whether the member may or may not be present during discussion of or decisions made on the matter which is the subject of the conflict.

BACKGROUND

2. Consistent with the *Protected Zone Joint Authority (PZJA) Fisheries Management Paper No. 1* (FMP1), which guides the operation and administration of PZJA consultative forums, members are asked to declare any real or potential conflicts of interest.
3. Resource Assessment Group members are asked to declare all real or potential conflicts of interest or update the standing list of declared interests (**Table 1**) if required.
4. FMP1 recognises that members are appointed to provide input based on their knowledge and expertise and as a consequence, may face potential or direct conflicts of interest. Where a member has a material personal interest in a matter being considered, including a direct or indirect financial or economic interest; the interest could conflict with the proper performance of the member's duties. Of greater concern is the specific conflict created where a member is in a position to derive direct benefit from a recommendation if it is implemented.
5. When a member recognises that a real or potential conflict of interest exists, the conflict must be disclosed as soon as possible. Where this relates to an issue on the agenda of a meeting this can normally wait until that meeting, but where the conflict relates to decisions already made, members must be informed immediately. Conflicts of interest should be dealt with at the start of each meeting. If members become aware of a potential conflict of interest during the meeting, they must immediately disclose the conflict of interest.
6. Where it is determined that a direct conflict of interest exists, the forum may allow the member to continue to participate in the discussions relating to the matter but not in any decision making process. They may also determine that, having made their contribution to the discussions, the member should retire from the meeting for the remainder of discussions on that issue. Declarations

of interest, and subsequent decisions by the forum, must be recorded accurately in the meeting minutes.

Table 1. HCRAG member and observer Declarations of Interest to be updated at the meeting.

Name	Position	Declaration of interest
Members		
Sian Breen	Chair	Employed by Department of Agriculture and Fisheries. No pecuniary interest in Torres Strait Fisheries but from time to time other staff members may work on fishery research projects in the Torres Strait (not occurring now).
Tim Skewes	Scientific Member	Independent Consultant. Previously employed by CSIRO. Scientific Member on the Hand Collectables Working Group. Previous principal scientist and co-investigator for Torres Strait Scientific Advisory Committee (TSSAC) and TSRA funded projects focused on the sea cucumber, tropical rock lobster, finfish and traditional fisheries in Torres Strait.
Steve Purcell	Scientific Member	Scientific Member on the Hand Collectables Working Group. Has interest in invertebrate fishery research has previously worked in the assessment of sea cucumber fisheries in the Pacific and New Caledonia, and on restocking/sea-ranching research. Specialist in sea cucumber ecology and fisheries. Will be involved in a sea cucumber population survey in New Caledonia to inform the CITES Appendix II listing of black and white teatfish.
Eva Plaganyi-Lloyd	Scientific Member	Employed by the CSIRO and from time to time receives funds to undertake research relating to Torres Strait Fisheries but not currently funded for BDM Fishery projects. Scientific member on the Tropical Rock Lobster Resource Assessment Group. Lead scientist for PZJA funded TRL research projects conducted by CSIRO.
Graham Hirakawa	Traditional Inhabitant Member Kaiwalagal	To be declared.
Nicholas Pearson	Traditional Inhabitant Member Kulkalgal	To be declared.
Pabai Pabai	Traditional Inhabitant Member Gudumalulgal	To be declared.
Toshi Kris	Traditional Inhabitant Member Maluiligal	To be declared
Emma Freeman	AFMA member	Employed by AFMA, no pecuniary interests or otherwise

Name	Position	Declaration of interest
Damian Miley	TSRA member	To be declared
Executive officer		
Danait Ghebrezgabhier	Executive Officer AFMA	Employed by AFMA, no pecuniary interests or otherwise
Permanent Observers		
TBC	Malu Lamar	TIB licence holder; Chairperson of Malu Lamar, Director of MDW Fisheries Association on Mer; Traditional Inhabitant Member on TSSAC and the HCWG.
Observers and invited industry participants		
Yen Loban	TSRA Fisheries Portfolio Member	TIB licence holder. TSRA Board Member for Ngurupai and Muralug and Fisheries Portfolio Member.
Michael Passi	Invited industry participant	To be declared
Simon Naawi	Invited industry participant	To be declared
Harry Ghee	Invited industry participant	To be declared
Patterson Mosby	Invited industry participant	To be declared
Quinten Hirakawa	TSRA officer	Employed by TSRA and TIB licence holder with a BDM fishery entry.
Ian Butler	Australian Bureau of Agriculture and Resource Economics (ABARES)	Employed by the Australian Bureau of Agricultural and Resource Economics and Science (ABARES), Department of Agriculture, Forestry and Fisheries (DAFF). No pecuniary interests or otherwise.
Nicholas Richards	TSRA	To be declared

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No. 2** **27-28 September 2022**
PRELIMINARIES **Action items from previous meetings**	**Agenda Item 1.4** **FOR NOTING**

RECOMMENDATIONS

1. That the Resource Assessment Group **NOTE:**
    a. the progress against actions arising from the first Hand Collectable Resource Assessment Group meeting (**Attachment 1.4a**); and
    b. the meeting record of the HCRAG01 meeting held on 6-7 October 2021 (**Attachment 1.4b**) also available on the PZJA website.

BACKGROUND

Actions arising

2. Updates are provided on the status of actions arising from the HCRAG01.

Meeting Record

3. The draft meeting record for HCRAG01 was circulated out-of-session to members on 22 October 2021 for comment. The record was finalised out of session, emailed to HCRAG members and posted on the PZJA website on 30 November 2021.

Status of actions arising from the HCRAG01 meeting held on 6-7 October 2021

#	Meeting	Action item	Responsibility	Status
1	HCRAG01	AFMA to circulate the QLD east coast black teatfish stock assessment to members.	AFMA	**Completed**. The stock assessment for black teatfish in the Queensland Sea Cucumber Fishery can be accessed here **–** https://era.daf.qld.gov.au/id/eprint/8265/1/Black%20teatfish%20stock%20assessment%202021.pdf
2	HCRAG01	AFMA to work with relevant fishers and fish receivers to confirm or otherwise the validity of the catch reported to have been caught in the Warrior reef reporting zone to ascertain whether the absence of data for the other days was because no one fished there or the area fished wasn't recorded.	AFMA	**Completed**. AFMA followed up with the relevant fishers which advised that the black teatfish that was reported to have been caught in Area 11 (Warrior) was actually caught in Area 17 (Cumberland). The fisher advised that they fished in south east Cumberland for the first few days and final day of the 2021 black teatfish opening.
3	HCRAG01	AFMA to invite Queensland Fisheries to provide information on access requirements to sea cucumber fishing grounds in the Queensland east coast sea cucumber fishery and at Ashmore reef.	AFMA	**In progress.** AFMA has advised Queensland Fisheries of this action item and invited the Queensland Fisheries member on the HCRAG to provide this information at the HCRAG02 meeting on 27-28 September 2022. Queensland Fisheries have also provided a fact sheet (**Attachment 1.4c**) on the changes to commercial fishing rules in Queensland that came into effect on 1 September 2021. Additional information on the Indigenous fishing permit policy and application form can be accessed here Fishing permits | Business Queensland and Aboriginal and Torres Strait Islander commercial fishing development policy - Aboriginal and Torres Strait Islander commercial fishing development policy - Publications | Queensland Government
4	HCRAG01	The Executive Officer to circulate the white teatfish stock assessment for the Queensland Sea Cucumber Fishery to RAG members.	AFMA	**Completed**. The stock assessment for white teatfish in the Queensland Sea Cucumber Fishery can be accessed here - https://era.daf.qld.gov.au/id/eprint/8264/1/White%20teatfish%20stock%20assessment%202021.pdf
5	HCRAG01	RAG recommended that AFMA write to Iama island PBC, GBK, TOs and fishers seeking their feedback on the priority for assessing the	AFMA	**Completed**. AFMA wrote to Iama PBC Chair Ned David, Iama Traditional Owner Mark David, and Iama fisher Charles David on 20 September 2022. AFMA will provide an update at the HCRAG2 meeting on a response.

#	Meeting	Action item	Responsibility	Status
		status of the sandfish stock and inviting representatives to the RAG's next meeting.		
6	HCRAG01	RAG to review recent information for the Queensland Crab Fishery as a precursor to better understanding the status of the crab stock in the Torres Strait.	AFMA	**In progress.** AFMA will continue to liaise with Queensland Fisheries on any new information that becomes available to inform a better understanding of the crab stock(s) in the Torres Strait. In the interim, information on the crab fisheries managed by Queensland can be accessed at the links below: **Crab harvest strategies** Blue Swimmer Crab Harvest Strategy 2021-2026 - Queensland fisheries harvest strategies - Publications | Queensland Government Mud Crab Fishery Harvest Strategy 2021-2026 - Queensland fisheries harvest strategies - Publications | Queensland Government Spanner Crab Harvest Strategy 2020-2025 - Queensland fisheries harvest strategies - Publications | Queensland Government **Stock assessments** Stock assessment program | Department of Agriculture and Fisheries, Queensland (daf.qld.gov.au) Mud crab fishery: commercial fishing rules in Queensland (daf.qld.gov.au)

Australian Government
Australian Fisheries Management Authority

Torres Strait Hand Collectables Resource Assessment Group

Meeting No. 1

6-7 October 2021

Final record

Note all meeting papers and minutes are available on the PZJA webpage: www.pzja.gov.au

Contents

1 Preliminaries

1.1 Acknowledgment of traditional owners, welcome and apologies

1. The meeting was opening in prayer by Sereako Stephen around 8:45am.

2. The Chair welcomed members and observers to inaugural meeting of the Torres Strait Hand Collectables Resource Assessment Group (the RAG). The Chair acknowledge the traditional owners of the lands in which members were participating in the meeting from and paid respect to Elders past, present and emerging.

3. The Chair provided an overview of the role of the RAG and obligations on members, including conduct and the treatment of confidential information as outlined in the PZJA *Fisheries management Paper No.1*. The Chair noted that whilst the RAG seeks to make consensus recommendations to the PZJA and Hand Collectable Working Group, from time to time members may have dissenting views. When consensus cannot be reached the views of each member will be recorded.

4. The Chair noted the following apologies:

    - Milton Savage, Kulkalgal Traditional Inhabitant Industry member (note Mr Savage joined the meeting on day two)
    - George Morseau, PZJA HCRAG Traditional Inhabitant industry member from Maluialgal
    - Nicole Murphy, observer, CSIRO Principal Investigator for the Eastern Torres Strait Beche-de-mer stock survey.
    - Mark Anderson, TSRA member
    - Samantha Miller, QDAF member

5. The Chair and all scientific members and observers participated in the meeting via video conference whilst all other members and industry observers participated from the James Cook University conference room on Thursday Island.

1.2 Adoption of agenda

6. The RAG adopted the draft agenda with one change to defer consideration of *Agenda Item 7 – Climate Change Impacts on Torres Strait Fisheries* to the RAG's next meeting.

1.3 Declarations of interest

7. The Chair advised members and observers, that as provided in the PZJA Fisheries Management Paper No. 1 (FMP1), all members must declare all real and potential conflicts of interest in the Torres Strait Beche-de-mer Fishery at the commencement of the meeting.

8. Where it is determined that a direct conflict of interest exists, the RAG may allow the member(s) to continue to participate in the discussions relating to the matter but may also determine that, having made their contribution to the discussions, the member should retire from the meeting for the remainder of the discussions on that issue.

9. Declared interests are detailed in **Table 1** below. Each group of members and observers with similar interests where asked to leave the meeting to enable the remaining members to:

    a. Freely comment on the declared interests;

    b. Discuss if the interests preclude the members from participating in any discussions; and

    c. Agree on any actions to manage declared conflicts of interest.

10. The scientific members removed themselves from the meeting (left their seats and camera view) while the remaining members discussed whether they should participate in the research priorities (Agenda item 8) discussion and recommendation process or just the discussion given they may be the potential recipients of research funding. The Chair and members recognised that although the scientific members may have a real or perceived conflict of interest, they have research expertise and knowledge relevant to the fishery that is valuable to the development of the RAG's advice. They agreed that the scientific members should participate in the research discussions but not in the recommendation making process.

11. The industry members that hold a fishing licence, including the TSRA observer left the meeting room and the remaining members discussed whether they should be present for the discussion and recommendation of items where they may have real or perceived conflicts of interest. The Chair and remaining members agreed that it is important for industry members to be part of the discussion and the recommendation making process as their expertise is valuable to the development of the RAG advice that impacts the industry as a whole. They agreed to review this approach if matters arise that are likely to directly benefit only some industry members.

12. The Chair reiterated the obligation of all members to act in the best interest of the Fishery as specified in the terms of reference for the RAG.

13. The RAG agreed to address any additional conflicts of interest should they arise throughout the discussion of agenda items.

Table 1. Declared interests from each attendee

Name	Position	Declaration of interest
Members		
Sian Breen	Chair	Employed by Department of Agriculture and Fisheries. No pecuniary interest in Torres Strait Fisheries but from time to time other staff members may work on fishery research projects in the Torres Strait (not occurring now).
Tim Skewes	Scientific Member	Independent Consultant. Previously employed by CSIRO. Scientific Member on the Hand Collectables Working Group. Previous principal scientist and co-investigator for Torres Strait Scientific Advisory Committee (TSSAC) and TSRA funded projects focused on the sea cucumber, tropical rock lobster, finfish and traditional fisheries in Torres Strait.
Steve Purcell	Scientific Member	Scientific Member on the Hand Collectables Working Group. Has interest in invertebrate fishery research has previously worked in the assessment of sea cucumber fisheries in the Pacific and New Caledonia, and on restocking/sea-ranching research. Specialist in sea cucumber ecology and fisheries.

Name	Position	Declaration of interest
		Will be involved in a sea cucumber population survey in New Caledonia to inform the CITES Appendix II listing of black and white teatfish.
Eva Plaganyi-Lloyd	Scientific Member	Employed by the CSIRO and from time to time receives funds to undertake research relating to Torres Strait Fisheries but not currently funded for BDM Fishery projects. Scientific member on the Tropical Rock Lobster Resource Assessment Group. Lead scientist for PZJA funded TRL research projects conducted by CSIRO.
Michael Passi	Traditional Inhabitant Member Kemer Kemer Meriam	Traditional inhabitant boat (TIB) licence holder and full time BDM operator. Hand Collectables Working Group Member.
Milton Savage	Traditional Inhabitant Member Kaiwalagal	Currently does not hold a TIB licence but has held one in the past.
Mark Pearson	Traditional Inhabitant Member Kulkalgal	Traditional inhabitant boat (TIB) licence holder.
Thomas Mooka	Traditional Inhabitant Member Gudumalulgal	Traditional inhabitant boat (TIB) licence holder.
Selina Stoute	AFMA Member	Employed by AFMA, no pecuniary interests or otherwise
Executive officer		
Danait Ghebrezgabhier	Executive Officer AFMA	Employed by AFMA, no pecuniary interests or otherwise
Permanent Observers		
Maluwap Nona	Malu Lamar	TIB licence holder; Chairperson of Malu Lamar, Director of MDW Fisheries Association on Mer; Traditional Inhabitant Member on TSSAC and the HCWG.
Observers and invited industry participants		
Quinten Hirakawa	TSRA officer	Employed by TSRA and TIB licence holder with a BDM endorsement.
Monty Naawi	Invited industry participant (Moa Island, St Paul's)	holds a TIB licence
Joseph Billy	Invited industry participant (Poruma Island)	holds a TIB licence
Dennis Passi	Invited industry participant (Mer Island)	holds a TIB licence and own a private fishing business. Traditional Owner on Mer Island.
Sereako Stephen	PBC Chair Ugar Island	PBC Chair Ugar Island and currently does not hold a TIB licence but intending to re-engage full time in the industry. Has family members that old TIB licences
Simon Naawi	Invited industry participant (Masig Island)	holds a TIB licence

Name	Position	Declaration of interest
Sam Mye	Invited industry participant (Erub Island)	holds a TIB licence with BDM and reef line entries
Isaac Ghee	Invited industry participant (Erub Island)	holds a TIB licence with BDM, CRAY and reef line entries and President of the Erub Fisheries Management Association
Lala Gutchen	Invited industry participant (Erub Island)	fishes under father's TIB licence and assists uncle with fish receiver operations.
Leo Dutra	CSIRO Staff	Employed by the CSIRO and from time to time receives funds to undertake research relating to Torres Strait Fisheries.

1.4 Terms of reference (TOR) of the RAG

14. The RAG discussed and noted the role of a PZJA RAG and the terms of reference for the group as outlines in the PZJA Fisheries management Paper No.1 and detailed in the agenda paper.

1.5 Out of session correspondence

15. The RAG noted the correspondence circulated by AFMA to members out of session. Members noted this information is provided for members records and to ensure members have not missed any out-of-session business or notifications. The RAG noted that paper would be updated to clarify that agenda papers for the meeting were email on 16 September 2021.

2 HCRAG Updates

2.1 Industry members

16. The RAG noted the following updates from Industry members and observers:

    a. The weather has not been great this year for fishing and therefore fishers have not fished as much as usual. The reduced fishing effort however has given the reefs a chance to recover and there does seem to be more sea cucumber available on the reefs as a result.

    b. In relation to the black teatfish opening, it was good that AFMA closed the fishery before the TAC was exceeded. Fishers were concerned that the TAC would be overcaught.

    c. As a private owner of a fishing business, one observer was of the view that the communal approach to managing sea cucumber stocks is not working and local private fishing businesses need to be better engaged in consultative bodies such as the RAG. He has worked to establish his business over the last 5 years. Private business also helps the community.

    d. Being in the fishing industry isn't a one-day thing and it doesn't come easy. It takes interest and commitment over years. In their experience they have worked for seven years to develop processing techniques and have trained youth coming into the industry. They have gone from firewood, gas to now having a drier and are able to maximise returns from buyers. Prices for processed/value added, product is better than for wet. In general buyers are demanding more product and having multiple buyers is an advantage.

e. The big picture for the fishery is that the TIB licencing process is long overdue for review. An economic evaluation of the system needs to be undertaken so that licencing arrangements benefits the industry. As a 100 percent owned fishery, we have the right to take control. When you are in the industry you have responsibility. Policy changes are required to ensure that the relatively small resource remains sustainable and fishers can be properly educated for the betterment of the community and the people that share those resources. If advice is taken from people that do not understand the industry, it can have consequences for those that heavily rely on it down the track.

f. The economic potential is not maximised by individual operators and communities when so many of the BDM TACs are under caught. White teatfish is consistently under caught. This issue needs to be a priority for the Working Group.

g. The Erub freezer has been out of operation so it has been hard for fishers. Focus has mostly been on finfish.

h. During the black teatfish opening Erub fishers did not fish beyond 5 miles due to bad weather. Whilst fishing they noticed a lot of pollution on the reef (for example ghost nets) which is of concern. There has not been much fishing for Aber (sea cucumber) at Erub water restrictions on the island has impacted the fish receiver’s operation and they have not been buying.

i. In terms of Covid 19 impacts, industry advised of mixed impacts. In one case, where the fisher supplies a Tasmanian abalone company prices have dropped. Pre-Covid 19 the buyer directly supplied buyers visiting from China. Once the Chinese buyers could no longer travel to Tasmania the prices dropped. In response the Tasmanian company has opted to stock-pile product until conditions improve. In contrast prices from a buyer on the Sunshine Coast have not changed as the domestic demand for BDM seems to be increasing. The Torres Strait BDM Fishery was not impacted by freight disruptions as the fishery relies on the Seaswift barge service to move product out of the region.

j. Many fishers have a preference to be able to dry the product in the Torres Strait and export it directly. Doing so would also reduce freight costs and the return is higher. A good drier however costs approximately 40k. TSRA should look to support private businesses to make these investments. Buyer’s currently reluctant to buy processed product as they do not want to lose money.

k. There is a lot of pressure on currently open high value species whilst there are plenty of species not being fished. Pricing drives targeting. Processing is largely the same across species. If TSRA could assist with funding, individual operators could get driers to value add to other species. Prices paid to fishers for dried curryfish is $100kg.

l. There is plenty of curryfish, stonefish and other species on reefs between St Paul’s and the east. It is up to the divers to catch it.

m. Currently medium to high value species are being fished. That is the current trend of the market from personal experience and from outside advice.

n. Now that the crayfish season has finished so some of the fishers on Warraber have switched to fishing for curryfish.

2.2 Scientific members

17. The RAG noted the following updates from the Scientific member, Dr Eva Plaganyi:

    a. CSIRO has recently published articles on the development of the conversion ratios and the harvest strategy for the Torres Strait Beche de mer Fishery (articles were provided with the agenda papers).
    b. CSIRO convened a science capacity building workshop in May at CSIRO labs in Brisbane that several new HCRAG traditional inhabitant industry members attended. The workshop was considered a success and received good feedback. The workshop was funded by AFMA and also involved visiting CSIRO's Bribie island aquaculture facility.
    c. As part of an FRDC funded project, CSIRO is continuing to seek opportunities to support traditional inhabitants' attendance and participation in fisheries conferences. Frank Loban recently co-presented the BDM Harvest Strategy with CSIRO at the World Fisheries Conference (WFC) held virtually. For the first time the WFC convened a specific indigenous fishing session which was very well received. If other members are interested to take up similar opportunities, please let CSIRO know. CSIRO has one placement available in the current funding year.

18. The RAG noted the following updates from the Scientific member, Dr Purcell:

    a. There are new proposals lodged with CITES to consider listing for *Thelenota* species (prickly redfish, amberfish, Candycanefish [*T. rubralineata*]) but there is not much data available to support the listing evaluation;
    b. Advice from the Sea Cucumber Assessment Group of New Caledonia reported that fishers have moved north to new grounds and are targeting leopard fish. Fishers in the north of the territory have been particularly active as stock in the southern grounds have been depleted;
    c. The species name for Surf redfish (*Actinopyga mauritiana*) is set to be changed to *A. varians*; and
    d. A private venture running a white teatfish stock enhancement project, in French Polynesia has had recent success, with successful spawning and survival of white teatfish for the first time. Generally, these types of projects are risky, in terms of being economically viable. White teatfish is long lived with slow growth rates and can take 5-10 years to reach the required size. Further risks to be carefully monitored and mitigated are environmental effects. This include the risk of spreading disease. It is the case however that animals can be screened in the laboratory for a range of diseases and the species (white teatfish) is generally not considered invasive.

19. The RAG noted the following updates from the Scientific member Tim Skewes:

   a. The Western Australia sea cucumber fishery has recently received Marine Stewardship Council (MSC) certification. The QLD east coast fishing industry is in the process of pursuing MSC certification.
   b. A three-year study to monitor sea cucumbers in the Great Barrier Reef Marine Park has been funded. The study will use aerial and underwater drones to survey areas.
   c. He is assisting the Seychelles Government with a white teatfish and prickly redfish stock assessments. Stocks in the Seychelles are mostly now found in deeper water as the shallow reefs have been fished out.

2.3 Government Agencies

20. The RAG noted the update provided by AFMA as detailed in the agenda paper. The RAG further noted the Communique from the Queensland Sea Cucumber Fishery Working Group's meeting on 23 August 2021. In addition to the Communique the Chair advised that the QLD east coast black and white teatfish stock assessments had recently been published (~ 30 September) to meet their WTO export approval conditions.

21. The RAG noted the following TSRA update provided by the TSRA Observer:

   a. The TSRA's Fisheries Programme continues to focus on supporting traditional inhabitant members and fishers with questions; and
   b. Although a separate fishery, some fishers in the TRL fishery had not fished due to ambiguity with China and having less buyers.

2.4 Native Title

22. The RAG noted an update on native title matters from the Chair of Malu Lamar (Torres Strait Islanders) Corporation RNTBC (Malu Lamar). The Chair provided an overview of role of Malu Lamar as outlined in the *Native Title Act 1993*. The Chair advised that relevant to the RAG, Malu Lamar seeks TRSA's assistance together with legal advice on how the Intellectual Property of Traditional Owners (TO) in research such as the BDM survey can be protected. Following discussions with TSRA, the Chair advised that Malu Lamar would then advise AFMA of the outcomes. The Chair confirmed his support for such research however noted that TOs only receive a 'thank you' for allowing researchers to come into their lands and waters. The Chair advised that TOs hold property rights over the marine environment. The TSRA observer undertook to notify relevant officers within TSRA of Malu Lamar's request.

2.5 PNG National Fisheries Authority

23. The RAG noted that although invited to the meeting, officials from the Papua New Guinea National Fisheries Authority were not in attendance to provide a further update to the background information on the PNG BDM fishery provided by AFMA in the agenda paper.

3 Final Results of the Beche de mer stock survey (CSIRO)

24. The RAG considered the final results of the CSIRO research project: '*Stock survey of Torres Strait Beche-de-mer species'* as presented by Scientific member, Tim Skewes (**Attachment A**). The RAG noted that the survey results had been considered by most members and observers at previous

meetings such as meetings of the HCWG, the Mer industry workshop held on 8-10 February and the CSIRO capacity building workshop held on 24-28 May for RAG members.

25. The RAG thanked the Project Team for delivering a high-quality survey and corresponding report and noted the outcomes would inform the RAGs advice on future black teatfish openings (agenda item 4) and application of the harvest strategy (agenda item 5).

26. Members and observers raised several broader matters including:

    a) *Spawning and larval transport*: Did the survey provide any further insight into when and where BDM species of the Torres Strait spawn and patterns of larval movement? The Scientific member advised that no further information was gained but it is generally understood that BDM species spawn in summer with black teatfish however spawning in the winter months. An Industry observer advised that he had observed curry fish spawning twice in Oct/Nov.

       In terms of larval transport, the Scientific member advise that it is likely that BDM larvae do not travel far from the spawning location as they have a relative short larval phase (in the order of 2 weeks). This means it is unlikely that there is significant net transport of larval between areas. The Scientific Member advised that this was the finding from a water circulation model developed some years ago focused on sandfish at Warrior Reef.

       The Scientific member did not consider having finer scale, region specific information on spawning as a critical knowledge gap currently. Instead the higher priority was to monitor the status of the stock and develop reliable fisheries dependent data. Another scientific member advised that management measures to protect spawning is generally only required if fishing puts at risk the spawning behaviour (aggregating) or the species is more vulnerable to overfishing.

    b) *East coast stock assessment:* The Chair advised that the recent QLD east coast sea cucumber stock assessment found that stocks were in good condition. The exploitable biomass of east coast black teatfish stock was found to be at 40-48% of virgin biomass. Fishing for black teatfish only resumed on the east coast a few years ago (2019) following a 20-year closure.

    c) *Crown of thorns (COTS):* Members sought advice on whether there were any regular COTS surveys in the Torres Strait similar to those conducted on the east coast. Scientific members were not aware of any regular COTS surveys (some COTS counting done during the TRL survey) but noted that fishers were often the first to observe any outbreaks.

27. In designing a future survey, the RAG **RECOMMENDED** that consideration be given to adding more sites in northern Great Barrier Reef (GBR) (from the Green Zone north to Mer Island) noting advice from a traditional inhabitant industry member that historical catches of black teatfish from this area were significant.

    - The member reported that between 1994-1999 three large vessels worked the area from the northern most green zone of the Great Barrier Reef Marine Park to Mer averaged 5-10 tonnes per trip. The vessels worked to Sue Frazer’s Factory at Rose Hill on Thursday Island.

ACTION - AFMA to circulate the QLD east coast black teatfish stock assessment to members.

4 Black teatfish trial opening 30 April - 3 May 2021 and future openings

28. RAG members noted and discussed:
    a. the AFMA update on the outcomes of the black teatfish trial opening that took place on 30 April – 3 May including catch and effort reporting by licenced fish receivers;
    b. a presentation by the Scientific member Dr Eva Plaganyi of the CSIRO analysis of data from the opening; and
    c. information from industry members and observers that participated at the opening.

Recommendation summary

29. Having regard for all available information and conditions 5-8 of the BDM Fishery Harvest strategy (HS) relating to reopening decision rule that need to be addressed, following a trial opening the RAG **RECOMMENDED** a black teatfish opening in 2022 with a 20t TAC on the basis that:
    a. the 2021 trial reopening TAC of 20t was not overcaught (condition 5 of the HS);
    b. data was collected satisfactorily during the opening (condition 6 of the HS);
    c. updated modelling analysis, inclusive of 2021 catch data, confirmed that a 20t TAC is sustainable (conservative estimate of MSY being 21t) and would not lead to a decrease in black teatfish biomass after the first year of fishing (condition 7 of the HS). In contrast, the modelling found that annual catches of 30t could lead to a gradual depletion of the stock.
    d. prior to a future black teatfish opening AFMA focus on communication and education on improving voluntary reporting of area and effort data by fishers and fish receivers, including preparing fact/information sheets and organising a teleconference with all fish receivers as a cost effective way to discuss ways of improving voluntary reporting.
    e. opportunities to undertake a sub-sampling program to collect size and weight frequency data during black teatfish openings at key landing locations be explored. Noting that the sampling program would need to be scientifically designed.

30. The RAG **RECOMMENDED** that the HCWG, noting the ongoing concern of the economic viability of so many licences being able to access the relatively small black teatfish TAC in a short period of time, consider the performance of licencing arrangements for the fishery in line with the *Torres Strait Fisheries* Act *1984*.

CONDITION 5 - If the Trial TAC is exceeded by more than 5%, then the fishery is automatically paused (i.e. no fishing allowed) for the following year

31. The RAG noted that the total reported catch of black teatfish during the 2021 trial opening was 17.6t which did not exceed the 20t TAC. Accordingly, the harvest strategy recommendation that the fishery be automatically paused for the following year if the TAC is exceeded by more than 5 per cent does not apply.

CONDITION 6 - Was data collection during the trial conducted satisfactorily?

Catch reporting during the opening

32. The RAG noted AFMA's advice that it believes reported catches accurately reflect the total amount of black teatfish that was caught and landed during the opening due to the high level of industry compliance with the daily catch landing and reporting requirements that applied. AFMA however

sought industry members and observers' advice on whether they considered the catch landing data to be accurate. Industry members and observers unanimously agreed that the catch data was accurate.

33. AFMA advised that it deployed a significant compliance presence throughout the region during the opening, including land-based officers on some of the key islands which were able to support and assist industry to meet the licencing and reporting requirements. The AFMA member thanked the Queensland and Federal enforcement agencies that assisted the AFMA Thursday Island Compliance team during the operation.

34. Industry members and observers that fished during the opening reported that it was beneficial to have Compliance fisheries officers on ground on Mer Island. As well as enforcing the regulatory arrangements for the opening, the compliance officers also supported fishers and fish receivers with the reporting and licencing requirements to be able to participate in the opening.

CSIRO Analysis of catch and effort data

35. The Scientific member Dr Eva Plaganyi presented the results of the CSIRO analysis of data reported during the opening, starting with a brief overview of the (**Attachment B**):
    a. harvest strategy framework that guided the reopening of black teatfish (conditions 1 – 4 of the reopening decision rule)
    b. scientific surveys results that helped establish that the black teatfish stock was above the limit refence point to enable its opening in 2021; and
    c. preliminary modelling considered by the HCWG which provided validation that the black teatfish stock had recovered and demonstrated that a 20t TAC, although higher than the default HS starting TAC of 15t, was still demonstrably conservative.

36. A summary of total catch per area and per day showed that most of the black teatfish was reported as being caught in the Cumberland, Darnley and Don Cay reporting areas. However, a significant amount of the catch did not include corresponding location data which limits its usefulness to support additional trend analyses in the future relating to the sustainability and productivity of the stock. CSIRO advised that the temporal pattern in the catch data shows that:
    a. there was no evidence of stockpiling before the opening
    b. there was no evidence of declining catch after a few days which would indicate depletion (low catch on the third day of the opening was due to significantly reduced fishing in observance of the Sabath). The highest daily catch and fishing effort was recorded for the fourth day of the opening (also the last day).
    c. cumulative catches were tracked and adhered to the 20t TAC.
    d. the number of fishers participating was controlled due to good organisation and centralised catch landing points.

37. Based on the analysis CSIRO recommended:
    a. Improved location catch data is required to increase the usefulness of the data. Communication of the importance of location information may lead to higher levels of location reporting. To demonstrate the importance of increased location reporting (which could be used in communication material to industry) Dr Plaganyi presented a plot of standardised daily catch rates for each reporting area based on a subset of the catch data. Over time, and given the

patchy distribution of sea cucumber species, this type of trend analyses can be used to monitor depletion and help support the fishery demonstrate its ongoing sustainability.

b. More information be requested on the catch reported as being from the Warrior Reef reporting area to help scientific understanding of the information content of the data because it was unclear why fishing was only reported there for one of the days, and hence whether the absence of data for the other days was because no one fished there or the area fished wasn't recorded.

38. Industry participants confirmed that most of the fishing took place in the reporting areas Cumberland (17), Darnley (16) and Don Cay (19) consistent with the catch reporting and where high densities of black teatfish are found. With regards to the catch that is missing location information, they advised that most of it, would have been caught in Cumberland (17) which includes Mer Island where most of the catch was landed. They further commented that catches from Don Cay (19) may be underrepresented as an artefact of the boundaries of the CDR reporting areas. Industry queried the validity of the catch that was reported as being caught at Warrior (11) as they are not aware of any fishing occurring in that area during the opening.

ACTION - AFMA to work with relevant fishers and fish receivers to confirm or otherwise the validity of the catch reported to have been caught in the Warrior reef reporting zone to ascertain whether the absence of data for the other days was because no one fished there or the area fished wasn't recorded.

CONDITION 7 - Noting the TAC was not exceeded and reliable data were collected, the data needs to be analysed to review the TAC and potential for the fishery to stay open in the future, or be re-opened periodically after a pre-specified interval

39. The RAG noted a presentation from Dr Plaganyi explaining the black teatfish modelling used to support the 20 tonne TAC for the trial opening and updated modelling results inclusive of catch data from the 2021 black teatfish opening (**Attachment A**).

40. The RAG noted that the model is based on a time series of biomass estimates from scientific surveys (which provide an index of abundance), available catch data and key life history parameters for black teatfish. The model estimates the trajectory of the black teatfish biomass in response to catches since 1995 as well as a forward projection of the biomass to 2024 using annual TAC scenarios between 15t and 30t. The results of the recent survey were used to estimate a biomass recovery rate – this approach was validated by comparing with management strategy evaluation modelling done for the east coast black teatfish stock and published literature. The model indicated that a 15t – 20t annual TAC would be sustainable (MSY being 21t) while a 30t TAC might lead to a consistent decline in black teatfish biomass over the next few fishing years. The model was updated to include the 17.6t catch from the 2021 trial opening which confirmed that a 20t TAC continued to be sustainable.

41. The RAG discussed the need to balance the current uncertainty due to insufficient fishery data with a precautionary approach whilst also taking into account the importance of the resource to support Torres Strait Islander livelihoods. Setting a TAC higher than 20t to meet the high level of interest in the fishery in the short term risks depletion of the resource, resulting in the loss of the benefits to the industry in the long term and to future generations. Additional data, especially fishery data,

would go a long way towards addressing some of the existing uncertainties and supporting a potential increase to the TAC in the future.

42. The RAG **RECOMMENDED** reopening black teatfish with a 20t TAC on the basis that updated modelling analysis, inclusive of 2021 catch data, confirmed that a 20t TAC is sustainable (conservative estimate of MSY being 21t) and would not lead to a consistent decline in black teatfish biomass after the first year of fishing. In contrast, the modelling found that catches of 30t could lead to a gradual depletion of the stock.

43. In making its recommendation, the RAG noted that the fishery is going to need increasingly better area (location) and effort data reporting. This will inform the scientific assessment of the fishery.

44. The RAG noted advice from industry members and observers that in their view the black teatfish opening should be held on Monday 9 May next year. This timing coincides with favourable tides and is unlikely to overlap with Sunday (the sabbath).

CONDITION 8 - Additional data to be collected during future openings

Effort and catch location information

45. The RAG was particularly concerned by the level of black teatfish catch that was not attributed to a reporting area (as specified in the catch disposal record book) during the 2021 trial opening and agreed that this needs to improve substantially for future openings. Industry participants suggested that better voluntary reporting of area and effort data should be a priority focus of future industry consultation prior to a future black teatfish opening, especially for the so called ‘weekend warriors’ that may not be familiar with the current reporting requirements.

46. Given the importance of building a sufficient time series of key fishery dependent data (including catch, location and effort data) for management, industry participants called for compulsory location and effort reporting. The RAG noted the AFMA member’s advice that there is a process underway to progress the legislative amendments required to mandate reporting for the TIB sector and stated their strong support for this to continue/be expedited.

47. AFMA advised that it would continue to work with RAG and Working Group industry members to find more cost-effective ways to better understand and resolve industry impediments to voluntary location and effort reporting. As a cost-effective option, the Malu Lamar Chairperson recommended AFMA convene a teleconference discussion with all the fish receivers from the black teatfish opening as a starting point.

48. The RAG noted that over time the fishery may be able to also consider a range of other potential options for collecting representative fishery information including, divers wearing data loggers to get detailed information of fishing behaviour, location and catch rates.

49. The RAG **RECOMMENDED** that prior to a future black teatfish opening AFMA focus on communication and education on better voluntary reporting of area and effort data by fishers and fish receivers, including preparing fact/information sheets and organising a teleconference with all fish receivers as a cost effective way to discuss ways of improving voluntary reporting.

Catch size and weight

50. The RAG **RECOMMENDED** that opportunities to undertake a sub-sampling program to collect size and weight frequency data during black teatfish openings at key landing locations be explored. Noting that the sampling program would need to be scientifically designed.

51. The RAG noted that such a program could be initially led by scientists and AFMA officers (or potentially Rangers) but ultimately transition to industry and fishing communities.

52. The RAG noted a suggestion from an industry member for the TSRA to consider training the TSRA Rangers to undertake sea cucumber sampling at key locations. The TSRA observer undertook to follow up with a suggestion with the Land and Sea Management Unit Team.

Socio-economic data

53. The RAG noted that there are some large socioeconomic knowledge gaps that could be addressed through semi-structured interview-based surveys of fishers and fishery workers. AFMA advised that the CDR data can provide an overview of the nature and extent of participation in the fishery by fishers across the region which could inform the design of such a survey.

Future research considerations

54. Industry members and observers advised that the 20t TAC will continue to come from a limited area close to communities while there are areas south of Mer Island that contain black teatfish that are not fished, partly due to the boat size restriction in the fishery.

55. The Scientific member Tim Skewes advised that black teatfish populations found in the small reef areas of the South east zone are not included in the biomass estimate as they have not been surveyed recently but surveying these is unlikely to offer more information than that which could be collected through additional fishery logbook data:
    a. South east zone part of the Torres Strait region near Dugong Island – makes up less than 10% of the reef area in eastern Torres Strait (last surveyed in 1995/96).
    b. Ashmore Reef

56. Industry members requested the TSRA consider funding additional scientific surveys of areas previously not included as a matter of priority to help provide additional information that may support increasing the black teatfish TAC. The TSRA observer undertook to notify relevant officers within TSRA of industry’s request.

Economic viability and efficiency

57. The RAG noted some industry’s suggestion for future reviews of the BDM HS to consider including carry over provisions for re-opening arrangements. This may address industry’s current concerns regarding foregone catch and therefore income from high value species. The RAG noted that the HS did not currently provide for carry over arrangements for reopening species noting the need for a precautionary approach to rebuilding stocks that have been closed due to overfishing.

58. The Malu Lamar Chairperson advised that the black teatfish TAC and future openings need to be economically viable and contribute to economic growth and to the improvement of the livelihoods and quality of life of Torres Strait Islander peoples in line with the closing the gap campaign. He

commented that the current licencing arrangements encourage a race to fish and opportunistic fishing for black teatfish which does not benefit those operators that are investing in the industry. He called for licences or effort to be limited so that the full economic benefits of the openings can be realised.

59. The RAG **RECOMMENDED** that the HCWG, noting the ongoing concern of the economic viability of so many licences being able to access the relatively small black teatfish TAC in a short period of time, consider the performance of licencing arrangements for the fishery in line with the *Torres Strait Fisheries* Act *1984*.

Access to sea cucumber fishing grounds outside of the Torres Strait Protected Zone

60. Industry questioned the possibility of Torres Strait fishers being able to access sea cucumber fishing grounds south of the Torres Strait BDM Fishery (i.e. outside but near zone down to Cape York) and at Ashmore Reef and asked that AFMA seek more information from Queensland Fisheries on access requirements.

ACTION – AFMA to invite Queensland Fisheries to provide information on access requirements to sea cucumber fishing grounds in the Queensland east coast sea cucumber fishery and at Ashmore reef.

5 Harvest strategy implications of scientific survey results and catch data

61. The RAG considered total allowable catches (TAC) for the 2022 fishing season commencing on 1 January in line with the BDM HS tiers and decision rules and taking into account new data and information available for the fishery since the HS was implemented.

62. Given the large number of species, the RAG agreed to prioritise the assessment of species where survey results have indicated a need for review, with the rest of the species to be reviewed at the RAG's next meeting. The species that were assessed included:

- White teatfish (target species)
- Prickly redfish (target species)
- Deepwater redfish (target species)
- Hairy blackfish (target species)
- Curryfish Herrmanni (common) and Curryfish vastus (curryfish basket species)
- Elephant's trunkfish (basket species)
- Lollyfish (basket species)
- Deepwater blackfish (basket species)
- Pinkfish (basket species)

63. The RAG noted that all species assessed remain in the low tier of the harvest strategy. This is because a transition to the middle tier requires at least two primary indicators and is not applicable during the initial years of HS implementation as insufficient detailed historical fishery data are available. For the high tier to apply a time series of high-quality species-specific surveys together with a reasonable level of catch is required.

64. The RAG agreed to discuss sandfish upon industry's request, noting that it remains closed until there is reliable information to establish that the stock is above a limit reference point level. A stock survey was planned for 2019/20 but did not proceed.

Recommendation summary

65. Having considered the latest information available and the BDM Harvest Strategy the RAG **RECOMMENDED**:
    a. no changes to the current TACs for the 2022 BDM fishing season.
    b. that the basket trigger limit for curryfish vastus be increased to 30t in light of the additional information available for the species and the survey results indicating a more even relative abundance.
    c. that the HCWG continue to consider the review of the current hookah ban in relation to white teatfish and undertake further community consultation on management arrangements that would support sustainable harvesting of white teatfish using hookah.

66. The RAG **RECOMMENDED** the following short-medium term data, research and analysis needs:

    a. stock assessment modelling to assess the potential (and extent) for an increase to the white teatfish TAC.
    b. consistent with the BDM harvest strategy and where there is sufficient information available, determine the current status of sea cucumber stocks in relation to the harvest strategy reference points.
    c. ongoing data collection to better understand fishing practices for lollyfish on Poruma as there may be some evidence of home reef depletion.

67. Guided by the species assessment sheets provided as part of the meeting papers (also provided as **Attachment C**), the RAG provided the following advice for each species considered.

White teatfish

68. The RAG noted that the recent survey results, which include the deep water population for the first time, indicate that the stock is above the default BDM HS limit reference point of B40 (compared to the Commonwealth Harvest Strategy Policy default of B20). The RAG further noted advice from the scientific members that the results show there is potential to increase the TAC.

69. The TAC has not been achieved for a number of years, industry advised that this is due to the inaccessibility of deep water stock without hookah. While the 15t TAC is considered appropriate for the current fishery management arrangements an increase may be considered if there's any additional fishery dependent data to support this process. The RAG also noted the advice from scientific member Tim Skewes that there may be areas that were not included in the survey but are known to have white teatfish (namely south east Torres Strait and deep-water reefs), further supporting a defensible TAC increase.

70. Industry members and observers advised that, economically, this is a priority species for them in terms of considering a TAC increase and being able to use hookah to access deep water stocks similar to the arrangements that are currently in place for the Queensland Sea Cucumber fishery.

71. The RAG noted advice from scientific member that because Torres Strait reefs are about 1/10th of the GBR reef area, it is unlikely to support a similar white teatfish TAC. However, the 15t starting TAC is set at or less than 10% of the 2009 survey biomass estimate which did not account for the substantial deep water population. While a proportional increase to the starting TAC may be calculated given the new survey results it would need to be precautionary due to insufficient fishery dependent data and lack of comprehensive biological understanding of the species. The RAG **RECOMMENDED** stock assessment modelling to assess the potential (and extent) for an increase to the white teatfish TAC.

72. The Chair suggested that the white teatfish stock assessment for the Queensland sea cucumber fishery be circulated to RAG members to provide more information on the assessment that underpins catch limits for the fishery.

73. In terms of other considerations for the species, the Scientific member Steven Purcell advised that the species is listed as vulnerable on the International Union for Conservation of Nature (IUCN) Red list due to a decreasing population trend globally. There is less biological information known about them than black teatfish and a lot more data uncertainty. They may be vulnerable due to their life history traits (slower growing to a larger size and takes longer to reach sexual maturity).

74. The RAG **RECOMMENDED** that the HCWG continue to consider the review of the current hookah ban in relation to white teatfish and undertake further community consultation on management arrangements that would support sustainable harvesting of white teatfish using hookah.

ACTION – The Executive Officer to circulate the white teatfish stock assessment for the Queensland Sea Cucumber Fishery to RAG members.

Prickly redfish

75. Based on the results of the recent survey the RAG supported advice from the Scientific members that the stock is above the default BDM HS limit reference point of B40. A slight decline in trend was observed in the survey results but it is not considered indicative of the stock being at risk and the RAG agreed to monitor annual catches of this species closely.

76. The RAG noted that the 2020 TAC was overcaught by 4.36%. Whist level of overcatch does not trigger the harvest strategy decision rule, repeated over catches should be avoided. Industry members advised that:
    a. catches have been slow this year due to inclement weather but may pick up towards the end of the year as the conditions improve but they are not anticipating exceeding the TAC this year (AFMA confirmed that 10t had been caught in the 2021 season to date).
    b. Don Cay is a good fishing area for prickly redfish and white teatfish due to suitable habitat as well as the being a breeding area for white teatfish.
    c. they currently adopt a rotational harvesting approach that was initially used by Mer fishers and has now been taken up more widely.

77. In terms of other considerations for the species, the scientific member Steven Purcell advised that the species is on the list for possible CITES listing consideration in the future and listed as endangered on the IUCN red list.

Deepwater redfish

78. The RAG noted that the survey trend indicates a slight increase in density and supported advice from the scientific members that there is no evidence to support an assessment that the species is below the limit reference point. However, the biomass estimate excludes areas known to have deepwater redfish as they were not surveyed (e.g. Warrior Reef) and is somewhat imprecise due to the patchy distribution of the species. The Scientific member, Tim Skewes advised that deepwater redfish is known to occur on Warrior reef.

79. There were no catches of this species in 2020 and are very low so far for 2021. It was taken out of the basket and assigned an individual TAC (based on its basket trigger limit) when the BDM HS was developed because it was historically caught in large volumes in the 1990s and likely misidentified as surf redfish. Industry advised that there is plenty of the species around, but it is not targeted much due to low beach price ($3/kg).

80. The RAG noted that deepwater redfish is listed as vulnerable on the IUCN red list.

Hairy blackfish

81. The RAG noted that the survey found patchy distribution of this species possibly due to other known habitats not being surveyed (e.g. Warrior reef) and natural stock variability driven by other factors (e.g. climate change). The landed weight was low, high density patches of deepwater redfish and hairy blackfish observed in previous surveys were not encountered in the recent survey. The species' burrowing behaviour may have also made it difficult to spot. There is insufficient information to assess the status of the stock in relation to the limit reference point.

82. Industry members and observers advised that the species is normally caught in the afternoon on the incoming tide, mostly dry picked and can fetch about 80-100 dollars a kilo when dried. They are not currently targeting the species due to low beach price ($3/kg).

Curryfish Basket

83. The RAG noted that the recent survey trend indicates a decline in the density of curryfish common (*Stichopus herrmanni*) but an increase in that of curryfish vastus (*S. vastus*). The decline in *S. Herrmanni* is concerning but can be plausibly explained by the recent commencement of fishing for the species, however data collection and close ongoing monitoring by the RAG is needed if the decline continues. Fishing for this species only commenced a few years ago so an initial decline or depletion can be expected. The Scientific members advised that both species are considered to be above the default limit reference point of B40.

84. The survey found an even split in the density of the two species, whereas historically *S. Vastus* made up 20% of the total curryfish biomass. Both species where taken out of the general basket due to increased fishing interest driven by market demand and a trigger limit put in place for *S. Vastus,* being the lesser known species as a precaution. The increased catches of curryfish in 2018 were accompanied by high levels of discard which industry advise have since reduced due to more appropriate processing methods for the species.

85. In terms of the catch data, the RAG noted that most of the reported curryfish catch is not differentiated by species which can make it challenging to monitor trigger limits. Industry members and observers advised that it is easy to distinguish the two species apart and it is a matter of ongoing education with industry to promote catch recording by species.

86. Industry members and observers advised that, consistent with the survey findings, the two species are generally evenly split but there are some regional variations (e.g. Masig fishers more commonly encounter *S. Vastus* and Mer fishers *S. Herrmanni*). They have also observed the increasing trend of *S. Vastus* and the decreasing trend of *S. Herrmanni* and members discussed whether this might be in response to changing environmental conditions that are impacting each species differently.

87. The RAG noted that curryfish common is listed as vulnerable on the IUCN red list, however curryfish *S. Vastus* is not listed as yet most likely due to lack of information.

88. The RAG agreed that it is a priority to improve the species identification in curryfish catch reporting to allow better monitoring of trigger limits in the future and, based on the survey results indicating a more even relative abundance. The RAG **RECOMMENDED** that the trigger limit for *S. Vastus* be increased from 15t to 30t. The RAG will consider the need for a trigger limit for curryfish common in the future.

89. The RAG agreed it would be beneficial to get an update on density/biomass trends of similar sea cucumber species in the Queensland sea cucumber fishery.

Status of stocks in relation to the BDM harvest strategy reference points

90. Consistent with the BDM harvest strategy and where there is sufficient information available, the RAG **RECOMMENDED** a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points.

Basket species - general

Elephant's trunkfish

91. The RAG noted that the survey results show a declining trend in abundance in surveyed sites but it is not considered to be fishing induced given low to no catches recently.

92. Industry members and observers advised that they have seen the species roll with the tide and have seen plenty of them in Mer and Erub areas, co-occurring with curryfish in lagoons or off the reef edge. They further advised that there isn't a high market demand for the species and the beach price is low ($2/kg).

Lollyfish

93. The RAG noted that the survey results show an overall linear trend for the species with a slight downward slope. CSIRO advised that there is no degree of concern that the stock is below the limit reference point (noted a standing stock biomass of 5,668t). The species has high fluctuations in density.

94. With regards to the relatively low catches, industry advised that it is most likely due to the depletion of the species from Poruma's home reef where it is mostly caught by dry picking. The

species is known to stay on top of the reef and can be easily collected leading up to Christmas for income when the TRL fishery is closed. It has a beach price of $2-5$/kilo.

95. The RAG **RECOMMENDED** that AFMA work with Poruma fishers to ongoing data collection to better understand fishing practices for lollyfish on Poruma as there may be some evidence of home reef depletion.

Deepwater blackfish

96. The RAG noted that the survey trend is not a concern however estimates are uncertain. The recent survey provides the first biomass estimate for the species, however it was assessed as being of limited adequacy and it may benefit from a dedicated survey in the future. The RAG may want to continuously monitor this species noting that it has a very conservative catch trigger limit.

97. The RAG discussed whether species identification between the blackfish species is an issue and industry commented that they can be differentiated by the thickness of their skin and water content. Industry confirmed that the species' distribution across the reefs is extremely patchy and highly variable, but it is not clear if this is due to habitat or climate related factors.

Pinkfish

98. The RAG noted that this is a very common species however the survey trend indicates a decline most likely as a function of the survey or due to natural variability as it is hardly fished. The population density can also be highly variable. Industry members and observers advised that it is a very low value species with low market demand, noting that it is increasingly becoming a key commercial species in New Caledonia.

6 Ecological Risk Assessment (CSIRO)

99. The RAG reviewed the draft results of the CSIRO Ecological Risk Assessment for the Effects of Fishing (ERA) on the Torres Strait BDM Fishery (ERA) as presented by Dr Leo Dutra and Miriana Sporcic of CSIRO (**Attachment D**).

100. The RAG noted that the draft ERA assessed all direct and indirect impacts to and of the BDM Fishery as having either minor or negligible scores and the overall risk for the ecological impacts for the effects of fishing and external activities is low. The assessment outcome was based on the scale and nature of the fishery as well as available survey data. Fishing for sea cucumbers is very selective as done by hand collection. There is no by-catch or byproduct. It followed also in the assessment that the direct ecological impact on the benthos from harvesting the species is low.

101. The RAG provided the following comments to the project team to consider when finalising the ERA noting the assessment outcomes are not expected to change as a result of addressing the RAGs comments:
    a. review finding in the ERA that catch rates of prickly redfish have declined over the assessment period given the catch per unit effort trends in the survey report indicate an increase.
    b. 'dry picking' or 'walking the reef' occurs occasionally in the fishery with most of the catch being taken whilst diving. Prickly redfish, curry fish and white teatfish can only be taken by diving. The only species that may be taken by dry picking, include species that are infrequently targeted such as stone fish, black fish, deepwater redfish, lolly fish, leopard fish and green fish.

7 Climate change impacts on Torres Strait Fisheries (CSIRO)

102. The RAG agreed to defer consideration of this item until its next meeting.

8 Research priorities

103. The RAG considered the information provided on the status of identified research priorities and needs for the BDM Fishery, and on the TSSAC research funding process, including funding available for the 2022/23 financial year. The RAG also considered the additional analysis and sampling needs identified during the meeting to address some of the key data gaps that exist in the fishery. The RAG reviewed all identified research needs and prioritised as outlined in Table 1.

104. With regards to a future sandfish survey, the RAG considers it to be an important research requirement for the BDM fishery to be able to assess the status of the sandfish stock at Warrior reef and enable consideration of a future opening to benefit Torres Strait Islanders. The RAG agreed that AFMA would write to the Iama and Tudu island PBC and relevant stakeholders to gauge their level of interest in a survey being undertaken. The Scientific member Tim Skewes suggested that efforts be made to engage PNG in the research also given it is a shared stock.

105. The RAG revisited its earlier discussion under Agenda Item 4 on the large socioeconomic knowledge gaps in the fishery. The RAG discussed the data that can be obtained from socioeconomic surveys on fishing effort, fishing activities, motivations of fishers, economic importance and dependence, fishing costs, supply chain and value chain issues and opportunities, trade issues, cultural issues, perceptions of fishers (e.g. about stocks and management), changes in fishing strategies, and fishing gear use. It was discussed that the data from many of these metrics can strongly inform the management of the fishery and members were supportive of undertaking such surveys and study. The RAG requested an update of the current wording of the socioeconomic research need identified for the fishery to reflect the RAG's discussion and agreed that the development of an appropriate research scope could benefit from further consideration by the RAG and social science expertise..

ACTION – RAG recommended that AFMA write to Iama island PBC, GBK, TOs and fishers seeking their feedback on the priority for assessing the status of the sandfish stock and inviting representatives to the RAG's next meeting.

ACTION – RAG to review recent information for the Queensland Crab Fishery as a precursor to better understanding the status of the crab stock in the Torres Strait.

9 Other business

106. There was no other business nominated for discussion.

10 HCRAG priorities and date for next meeting

107. The RAG agreed to defer the discussion on HCRAG priorities to its next meeting. The RAG agreed to tentatively schedule its next meeting for June-July 2021.

108. The Chair thanked all members and observers for their contribution to a productive meeting. Mr Simon Naawi closed the meeting at 1805 in Prayer.

Table colour key	Completed	Scoped and/or costed	Not scoped/not costed

Table 1. Overview and status update of research needs identified or discussed for Hand Collectable Fisheries at previous HCWG meetings and the rolling five-year research plan including HCRAG's recommendations and assigned priorities from its meeting on 6-7 October 2021.

	Research activity	Detail	Status	Comments/questions	HCRAG priority and comments
1	Status of BDM stocks in relation to harvest strategy reference points	Consistent with the BDM harvest strategy and where there is sufficient information available, a tactical research project is needed to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points.	Not scoped/not costed		**High priority**
2	White teatfish modelling	Additional analysis on white teatfish to develop a rationale on the status of the stock in relation to harvest strategy reference points and modelling analysis on a sustainable TAC increase.	Not scoped/not costed		**High priority**
3	Black teatfish sampling	Representative sampling to collect size and weight frequencies during the black teatfish openings.	Not scoped/not costed		**High priority**
4	Development of curryfish conversion ratios	Project to develop conversion ratios for curryfish with industry undertaking the sampling process.	Scoped and costed $12,000	Full proposal developed and allocated funding in 2019/20 but did not proceed due to COVID-19.	**High priority**
5	Sandfish stock survey	Outstanding stock survey of Sandfish at Warrior Reef to better understand its status	Not scoped/not costed	Identified as a research need for the fishery by HCWG17 at its meeting 12 October 2020. Was part of the 2019-20 stock survey but did not proceed.	**High priority** subject to confirmation of support from Iama and Tudu Island PBC, GBK, Traditional Owners and fishers.

	Research activity	Detail	Status	Comments/questions	HCRAG priority and comments
6	Black and white teatfish follow up surveys	Follow up black and white teatfish surveys focusing on specific areas and potentially including areas not surveyed previously such as south east TSPZ, barrier and deep-water strata.	Not scoped/not costed	The RAG will initially need to determine what is required, other than an independent survey, to meet the WTO requirement to provide a revised population estimate.	**Medium term priority**
7	Socio-economic	Collection and analysis of socioeconomic data from interview-based questionnaire surveys.	Not scoped/not costed	Identified as a research need for the fishery by HCWG members. Research scope and survey design and development to be: • Informed by AFMA's review of CDR participation data to date • further considered by the HCRAG and social science expertise to ensure it is appropriate	**Medium term priority as there is preceding work** and update the current wording to reflect RAG discussion.
8	Management Strategy Evaluation (MSE) of the Beche-de-mer Harvest Strategy	1. Collate all data and biological information; 2. Update and extend the spatial multispecies TS BDM operating model developed earlier (or construct a new model); 3. Use MSE to evaluate how well the HS achieves the pre-specified objectives; 4. In consultation with stakeholders, use the MSE framework to investigate ways to improve the current HS.	Not scoped Est cost – $130k	Identified as an essential research priority by HCWG in the rolling five-year research plan for Hand Collectable Fisheries. Requires 3-5 years of BDM HS implementation.	**Medium priority** and to be held off until the harvest strategy has been in place for a few years.

	Research activity	Detail	Status	Comments/questions	HCRAG priority and comments
9	Supply chain	Better understanding of the supply chains as per other fisheries to better understand vulnerabilities and help develop an industry that is resilient to fluctuating export market conditions.	Not scoped/not costed		**Not prioritised**
10	Exploring sea ranching/re-seeding opportunities		Not scoped/not costed	Identified as a key research need for the fishery by HCWG Traditional Inhabitant members. Industry initiated pilot project currently underway on Ugar.	**To be removed from the research plan** - Aquaculture falls outside the remit of the PZJA. PZJA can provide support through provision of information and permitting collection of broodstock. With regarding to Sandfish aquaculture, the PZJA will initially want to establish the status of the sandfish stock on Warrior reef.
11	Ecological Risk Assessment (ERA) – Torres Strait Pearl Shell Fishery	Conduct an ERA for the Torres Strait Pearl Shell (TSPF) Fishery	Not scoped Est cost - $20,400	Identified as an essential research priority by HCWG in the rolling five-year research plan for Hand Collectable Fisheries	**To be remove from the research plan** as there is no fishing activity and therefore no immediate ecological risk.
12	Understanding biological parameters of BDM species, including growth, mortality, size and breeding seasonality	Identifying gaps in knowledge of biological parameters of BDM species and investigating options for collaborative research	Not scoped/not costed	Identified as an essential research priority by HCWG in the rolling five-year research plan for Hand Collectable Fisheries Requires further scientific advice.	Low priority and proposed that it be addressed as the need arises.
13	Stock Status Survey	To undertake a stock survey of all Torres Strait beche-de-mer species with a focus on deeper water species	Completed in 2019 - 2020	Final report identified research needs that the HCRAG may want to consider further	N/A

	Research activity	Detail	Status	Comments/questions	HCRAG priority and comments
14	Ecological Risk Assessment (ERA)	Conduct an ERA for the TSBDM Fishery	Draft completed on 30 June 2021.	Needs to be completed by January 2022 to meet WTO condition 5 for the fishery.	N/A
15	Climate Change impacts and vulnerability	Scoping study across all Torres Strait	Completed	Final report made recommendations for further research	N/A
16	Data analysis	Further analysis of catch data collected during the 2021 trial reopening of black teatfish to inform future openings and follow up work from the stock survey.	Completed	HCWG identified this as the highest research need for the BDM Fishery. CSIRO completed the black teatfish catch data analysis from the 2021 opening and updated the modelling to inform future opening and TAC.	Completed

Summary of actions arising from HCRAG 1

Action Item	Responsibility
AFMA to circulate the QLD east coast black teatfish stock assessment to members.	AFMA
AFMA to work with relevant fishers and fish receivers to confirm or otherwise the validity of the catch reported to have been caught in the Warrior reef reporting zone to ascertain whether the absence of data for the other days was because no one fished there or the area fished wasn't recorded.	AFMA
AFMA to invite Queensland Fisheries to provide information on access requirements to sea cucumber fishing grounds in the Queensland east coast sea cucumber fishery and at Ashmore reef.	AFMA
The Executive Officer to circulate the white teatfish stock assessment for the Queensland Sea Cucumber Fishery to RAG members.	AFMA
RAG recommended that AFMA write to Iama island PBC, GBK, TOs and fishers seeking their feedback on the priority for assessing the status of the sandfish stock and inviting representatives to the RAG's next meeting.	AFMA
RAG to review recent information for the Queensland Crab Fishery as a precursor to better understanding the status of the crab stock in the Torres Strait.	AFMA

Summary of HCRAG 1 recommendations

Agenda Item #	Recommendations
3	In designing a future survey, the RAG **RECOMMENDED** that consideration be given to adding more sites in northern Great Barrier Reef (GBR) (from the Green Zone north to Mer Island) noting advice from a traditional inhabitant industry member that historical catches of black teatfish from this area were significant.
4	Having regard for all available information and conditions 5-8 of the BDM Fishery Harvest strategy (HS) relating to reopening decision rule that need to be addressed, following a trial opening the RAG **RECOMMENDED** a black teatfish opening in 2022 with a 20t TAC on the basis that: a. the 2021 trial reopening TAC of 20t was not overcaught (condition 5 of the HS); b. data was collected satisfactorily during the opening (condition 6 of the HS); c. updated modelling analysis, inclusive of 2021 catch data, confirmed that a 20t TAC is sustainable (conservative estimate of MSY being 21t) and would not lead to a decrease in black teatfish biomass after the first year of fishing (condition 7 of the HS). In contrast, the modelling found that annual catches of 30t could lead to a gradual depletion of the stock. d. prior to a future black teatfish opening AFMA focus on communication and education on improving voluntary reporting of area and effort data by fishers and fish receivers, including preparing fact/information sheets and

Agenda Item #	Recommendations
	organising a teleconference with all fish receivers as a cost effective way to discuss ways of improving voluntary reporting. e. opportunities to undertake a sub-sampling program to collect size and weight frequency data during black teatfish openings at key landing locations be explored. Noting that the sampling program would need to be scientifically designed.
4	The RAG **RECOMMENDED** that the HCWG, noting the ongoing concern of the economic viability of so many licences being able to access the relatively small black teatfish TAC in a short period of time, consider the performance of licencing arrangements for the fishery in line with the *Torres Strait Fisheries* Act *1984*.
5	Having considered the latest information available and the BDM Harvest Strategy the RAG **RECOMMENDED**: a. no changes to the current TACs for the 2022 BDM fishing season. b. that the basket trigger limit for curryfish vastus be increased to 30t in light of the additional information available for the species and the survey results indicating a more even relative abundance. c. that the HCWG continue to consider the review of the current hookah ban in relation to white teatfish and undertake further community consultation on management arrangements that would support sustainable harvesting of white teatfish using hookah
5	The RAG **RECOMMENDED** the following short-medium term data, research and analysis needs: a. stock assessment modelling to assess the potential (and extent) for an increase to the white teatfish TAC. b. consistent with the BDM harvest strategy and where there is sufficient information available, a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible. c. ongoing data collection to better understand fishing practices for lollyfish on Poruma as there may be some evidence of home reef depletion.

List of attachments

Attachment A – Presentation on the outcomes of the CSIRO research project: ‘Stock survey of Torres Strait Beche-de-mer species’

Attachment B – Presentation on the results of the CSIRO analysis of data reported during the opening

Attachment C – Presentation on the draft results of the CSIRO Ecological Risk Assessment for the Torres Strait Beche-de-mer Fishery

Attachment D – Species Assessment Sheets

Attachment E – Meeting Agenda

Sea cucumber fishery

Commercial fishing rules in Queensland

From **1 September 2021**, the sea cucumber fishery will be managed under the *Queensland sea cucumber fishery harvest strategy*.

General

- The commercial sea cucumber (beche-de-mer) fishery area consists of all tidal waters east of longitude 142°31'49"E between latitude 10°41'S and latitude 26°S (parallel to the southern limit of Tin Can Bay). However, in practice, waters south of the Great Barrier Reef are rarely fished.
- The fishery is managed under a rotational harvest arrangement. Reefs within the Great Barrier Reef Marine Park and the Coral Sea in the fishery area are divided into 158 zones.
- The fishery operates under the B1 symbol.
- The major commercially harvested sea cucumber species include:
    - black teatfish (*Holothuria whitmaei*)
    - white teatfish (*Holothuria fuscogilva*)
    - burrowing blackfish (*Actinopyga spinea*)
    - various other sea cucumber species.
- The fishery has been quota-managed since 1991 with a total allowable commercial catch (TACC). The TACC is allocated amongst individual transferable quota (ITQ) units for black teatfish, white teatfsh and other sea cucumber.
- The TACC is adjusted according to the decision rules in the harvest strategy each year. The current TACC can be found in the Fisheries Quota Declaration 2019.
- Refer to the harvest strategy for information on fishery targets, biomass indicators, reference points, and decision rules that will be implemented if biomass limits are reached – visit **fisheries.qld.gov.au**.
- Australian Government requirements include displaying unique identifying numbers, safety management plans, safety equipment and licensing – for more information, visit **amsa.gov.au**.

Equipment

- Sea cucumber operations are dive-based (hookah) using hand collection techniques. Sea cucumbers are harvested mainly by divers breathing surface-supplied air from hookah equipment and, to a lesser extent, by free-diving from dinghies or by hand collection along reefs at low tide.
- Only 1 primary boat plus up to 4 tender boats can operate under a licence at any one time.
- Under Queensland fisheries legislation, an assistant fisher is not required to be within 800 m of a commercial fisher. However, Australian Maritime Safety Authority safety rules apply – for more information, visit **amsa.gov.au**.

☎ **13 25 23**

fisheriesmanagers@daf.qld.gov.au

fisheries.qld.gov.au

Queensland Government

Fishing operation

- Up to 6 people can operate under the licence at any one time.
- An approved vessel tracking unit must be:
    - installed as per the department's *Vessel tracking installation and maintenance standard*
    - installed on vessel/s and confirmed working prior to commencement of a fishing trip.
- The licence holder must have a contract with an approved supplier for collection of vessel tracking positional data
- There is also no longer a distance requirement for primary and tender vessels operating in this fishery. However, Australian Maritime Safety Authority safety rules apply – for more information, visit **amsa.gov.au**.
- Fishers must comply with marine park and go-slow zoning – for more information, visit **gbrmpa.qld.gov.au** and/or **des.qld.gov.au**.

Licensing

- To operate in the fishery, a fisher must have:
    - a primary commercial fishing licence
    - at least one B1 symbol
    - unused entitlements of quota units for the hand-harvest individual transferable quota year for the relevant species.
- The person in charge of an operation must hold a commercial fisher licence, in order to operate under a primary commercial fishing licence.
- A range of transactions can be completed online using FishNet Secure (e.g. quota temporary transfers, registering vessel tracking units to primary commercial fishing licences, accessing quota activity statements and registering change of personal contact details).
- Fees for licences and quota are invoiced in advance (i.e. before the fishing season starts or before the licence can be used).
- The licence holder is responsible for keeping contact details up to date on FishNet Secure.
- You may require accreditation with Safe Food in order to legally sell or supply your product in Queensland – for more information, visit **safefood.qld.gov.au**.

Reporting requirements

In summary, fishers must:

- report trip/catch notices for all catch to which a TACC applies via approved means (e.g. Automated Integrated Voice Response system)
- complete catch and effort logbooks and the threatened, endangered and protected animal logbook
- complete catch disposal records for the disposal of all catch to which a TACC applies
- keep sale dockets for all wholesale sales for 5 years, including to businesses involved in the processing and storage of fisheries resources.

For more information on reporting requirements, visit **fisheries.qld.gov.au**.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No. 2** **27-28 September 2022**
PRELIMINARIES **Out of session correspondence**	**Agenda Item 1.5** **For NOTING**

RECOMMENDATIONS

1. That the Resource Assessment Group **NOTE** the correspondence circulated out of session.

BACKGROUND

2. The following correspondence was circulated out of session since the first HCRAG meeting on 6-7 October 2021. Copies of this correspondence can be requested at any time from the HCRAG Executive Officer.
3. A correspondence summary is provided at each meeting to ensure members have not missed any out-of-session business or notifications.

Date	**Item**
12 September 2022	AFMA emailed a draft agenda for HCRAG02 to all HCRAG members and observers for comment.
2 September 2022	AFMA emailed RAG and WG members seeking advice on TSSAC research funding for 2023-24 financial year
7 July 2022	AFMA emailed all HCRAG members to confirm the dates for HCRAG 02 being 27-28 September 2022.
1 June 2022	AFMA sought availabilities of all HCRAG members for a potential RAG meeting in July or August 2022.
3 March 2022	AFMA emailed all HCRAG and HCWG members seeking comment on an additional TSSAC research application relating to climate change.
9 February 2022	AFMA emailed all HCRAG and WG members seeking comments on TSSAC research applications received from the 2022-23 financial year call for research. Comments were required back by 7 March.
11 January 2022	AFMA emailed all HCRAG members to advise on a proposed approach t handling the 2022 black teatfish opening given COVID-19 challenges at the time.
21 December 2021	AFMA circulated the final report for the Ecological Risk Assessment for the BDM Fishery which was also made publicly available on the PZJA website.
16 December 2021	AFMA emailed all HCRAG and WG members advising that a public call for research applications had been made to address research priorities identified for potential funding in the 2022-23 financial year as supported

	by the TSSAC. Proposals for the project scopes were due by 4 February 2022.
23 November 2021	AFMA circulated a link to a pre-recorded video presentation made by Dr Leo Dutra (CSIRO) on the outcomes of the climate change scoping study which was available online to view until 7 December 2021.
3 November 2021	AFMA circulated a series of draft research project scopes for comment that had been developed by HCRAG members at their first meeting on 6-7 October 2011. Comments on the draft scopes were due by 8 November 2021.
22 October 2021	AFMA circulated the draft meeting record from HCRAG01 for comments, with comments due by 5 November 2021.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No.2** **27-28 September 2022**
PZJA TRADITIONAL INHABITANT MEMBER UPDATES	**Agenda Item 2.1** **For NOTING & DISCUSSION**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG):
    a. **NOTE** any verbal updates provided by PZJA Traditional Inhabitant members;
    b. **DISCUSS** any strategic issues, including economic trends, relevant to the development of the Torres Strait Hand Collectable Fisheries.

BACKGROUND

2. Verbal reports are sought from PZJA Traditional Inhabitant members under this item.
3. It is important that the RAG develops a common understanding of any strategic issues, including economic, fishing and research trends relevant to the management of Torres Strait Hand Collectable Fisheries, including within adjacent jurisdictions. This ensures that where relevant, the RAG is able to have regard for these strategic issues and trends.
4. RAG industry members are asked to provide any updates on trends and opportunities in markets, processing and value adding. Industry is also asked to contribute advice on economic and market trends where possible.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No.2** **27-28 September 2022**
RESOURCE ASSESSMENT GROUP SCIENTIFIC MEMBER UPDATES	**Agenda Item 2.2** **For NOTING & DISCUSSION**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG):
    a. **NOTE** any verbal updates provided by scientific members; and
    b. **DISCUSS** any strategic research projects or issues that may be relevant or of interest to Torres Strait Fisheries.

BACKGROUND

2. Verbal reports are sought from scientific members under this item.
3. It is important that the RAG develops a common understanding of any strategic issues, including economic, fishing and research trends relevant to the management of Torres Strait Hand Collectable Fisheries, including within adjacent jurisdictions. This ensures that where relevant, the RAG is able to have regard for these strategic issues and trends.
4. Scientific members are asked to contribute advice on any broader strategic research projects or issues that may be relevant or of interest to Torres Strait Fisheries.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	Meeting No.2 27-28 September 2022
GOVERNMENT AGENCY UPDATES	**Agenda Item 2.3** **For NOTING & DISCUSSION**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG):
   a. **NOTE** the update provided by the Australian Fisheries Management Authority (AFMA) below;
   b. **DISCUSS** the progress to date against the Wildlife Trade Operation (WTO) conditions for the BDM fishery as summarised in **Table 1**;
   c. **NOTE** verbal updates provided by the Torres Strait Regional Authority (TSRA) and the Queensland Department of Agriculture and Fisheries (QDAF).

KEY ISSUES

Developmental Fishery updates – Transferable Vessel Holder (TVH) fishing licences without fishery entries

2. At its meeting on 16 March 2022, the PZJA:
   a. **NOTED** AFMA has received an application for the permanent transfer of an inactive transferrable vessel holder (TVH) licence. This class of licence authorises the holder to commercially fish for Torres Strait species which are not covered by a fisheries management instrument. In the current case, the applicant has indicated an intention to fish for a number of ornamental aquarium species which fall in this category.

   b. **NOTED** the TVH licence in question is one of 10 licences (9 fishing and 1 carrier class A) that had their fishery entries removed as part of a PZJA latent effort review process undertaken in 2004 in the Tropical Rock Lobster (TRL) and Finfish fisheries. All ten licences have continued to be renewed annually.
   c. **NOTED** that the applicant is not an identified traditional inhabitant. As such, the proposed activity does not align with the current PZJA policy to reserve further expansion of effort for traditional inhabitants and the aspiration for a sustainable fishery that is 100 per cent owned by Torres Strait Islander and Aboriginal traditional owners.
   d. **NOTED** that AFMA does not have the power to extinguish the entitlement to commercially fish conferred to the holders of the 9 TVH licences while they are in force without significant legal risk.
   e. **NOTE** that AFMA, as the licensing delegate of the PZJA, intends to:
      i. Approve the transfer of the licence and authorise the applicant to commercially fish subject to specific licence conditions to regulate the proposed activities.
      ii. Seek advice from the Hand Collectables Working Group (HCWG) and Hand Collectables Resource Assessment Group (HCRAG) on the policy parameters and additional conditions under which any continuing activity should occur.

   f. **NOTED** AFMA separately intends to review the basis for the 10 licences to be issued in future noting the availability of development permits under Section 12 of the *Torres Strait Fisheries Act 1984* (TSFA) and the current policy setting of the PZJA and provide advice to PZJA on a recommended course of action.

   g. Members also noted the importance of communicating with all licence holders about the likely future of the permits. Members noted that the application will raise a range of sensitivities and concerns, particularly for traditional inhabitant fishers, and highlighted the importance of a rigorous consideration process using PZJA's existing advisory mechanisms.

3. On 25 March 2022, in line with the intent outlined to the PZJA, AFMA approved the transfer of the licence as requested by the applicant, Aus Fish Coral Pty Ltd (Aus Fish Coral). In correspondence to Aus Fish Coral, AFMA noted that the proposed fishing activities are not covered by established arrangements to manage and regulate the sustainable harvest of ornamental and aquarium species. Therefore, licence conditions and management arrangements that are consistent with the objectives of the TSFA and the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) must be developed before fishing activities can commence. The correspondence noted that this may involve AFMA taking a number of steps including:

   a. submission of an application to the Department of Agriculture, Water and the Environment seeking Part 13 and Part13A EPBC Act approval.

   b. seeking Hand Collectables Resource Assessment and Working Group advice on the requirements that need to be met to ensure the sustainability of the proposed activity, including management, monitoring and reporting arrangements.

   c. undertaking Native Title Notification of the proposed conditions.

4. Concurrently, AFMA wrote to all licence holders and advised:

   a. The PZJA has reaffirmed its policy position on reserving expansion of effort in the Torres Strait, where there is scope, for traditional inhabitants.

   b. It is AFMA's preliminary view that any commercial fishing activity undertaken with the use of these fishing licences is akin to expansion of effort and therefore, inconsistent with the PZJA's current policy settings.

   c. AFMA intends to seek a PZJA decision on the ongoing role of these licences and whether they align with the policies of the PZJA and the objectives of the TSFA.

5. Licence holders were invited to provide input on this matter prior to any recommendation being put to the PZJA. Nil feedback was received.

6. As per the commitment made at the PZJA meeting in March, AFMA has completed a review of the basis of the 10 licences and the current PZJA policy setting and prepared advice for the PZJA's consideration at a meeting scheduled for 4 October 2022. AFMA has determined that the licences are inconsistent with the PZJA's policy of reserving expansion in the Torres Strait, where there is scope, to traditional inhabitants. Therefore, AFMA recommends that the licences should not be renewed.

7. While the PZJA's decision is pending, AFMA has acted in good faith with Aus Fish Coral and commenced preliminary work to consider the licence conditions, management and monitoring arrangements required to meet the objectives of the TSFA and the requirements of the EPBC Act.

8. The HCRAG's views on the proposed fishing activities are an important consideration in the development of the management and monitoring arrangements and therefore, Aus Fish Coral has been invited to present to the HCRAG at **Agenda Item 7 - New application to undertake aquarium fishing in the Torres Strait**.

Wildlife Trade Operation (WTO) Approval under the EPBC Act 1999

9. The *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) requires the Australian Government to assess the environmental performance of all commercial fisheries, including those in the Torres Strait, and promote ecologically sustainable fisheries management. Approval under the EPBC Act is necessary for fisheries to be able to legally export commercially wild caught seafood from Australia. Such approvals may be subject to conditions applicable to the responsible management authority and fishers.
10. The Torres Strait BDM Fishery was first accredited as an approved Wildlife Trade Operation (WTO) in June 2005 for a period of three years and was subsequently reassessed and re-approved in 2008, 2011, 2014 and 2017.
11. The fishery was last assessed in 2020 and, as of 23 December 2020, was declared by the Delegate for the Minister of the Environment, as an approved WTO under the EPBC Act until 30 November 2023 subject to several conditions being addressed during the period of the approval. The advice from the Delegate to AFMA on the WTO approval and the conditions imposed on the Torres Strait BDM Fishery is provided as **Attachment 2.3a**.
12. AFMA invites both the RAG and Hand Collectable Working Group (WG) to monitor progress against each condition and provide advice on addressing conditions. To assist the RAG and WG, **Table 1** provides a summary of relevant actions taken or proposed to address each condition.

Table 1. progress to date against the Wildlife Trade Operation (WTO) conditions for the TSBDM fishery. A copy of the advice to AFMA on the WTO approval is also provided as Attachment A.

WTO Conditions for the BDM Fishery	Progress as of September 2022
Condition 1 The Torres Strait Protected Zone Joint Authority must ensure that operation of the Torres Strait Bêche-de-mer is carried out in accordance with management arrangements defined in the *Torres Strait Fisheries Act 1984*, Torres Strait Fisheries Regulations 1985, Torres Strait Fisheries Management Instrument No.15 (Torres Strait Sea Cucumber Fishery), licence conditions and the Torres Strait Bêche-de-mer Fishery Harvest Strategy.	**On track:** The Torres Strait Bêche-de-mer Fishery continues to be managed in accordance with management arrangements in force under the *Torres Strait Fisheries Act 1984.*
Condition 2 The Torres Strait Protected Zone Joint Authority must inform the Department of Agriculture, Water and the Environment of any intended material changes to the Torres Strait Bêche-de-mer Fishery management arrangements that may affect the assessment against which *Environment Protection and Biodiversity Conservation Act 1999* decisions are made.	**On track:** There have been no material changes to management arrangements for the Fishery. As a result AFMA, on behalf of the PZJA, has not been required to inform the Department.

WTO Conditions for the BDM Fishery	Progress as of September 2022
Condition 3 The Torres Strait Protected Zone Joint Authority must inform the Department of Agriculture, Water and the Environment of any intended changes to fisheries legislation that may affect the legislative instruments relevant to this approval.	**On track:** AFMA, on behalf of the PZJA, provided the Department an update on proposed legislative amendments on 26 October 2021.
Condition 4 The Torres Strait Protected Zone Joint Authority must provide reports to the Department of Agriculture, Water and the Environment annually as per Appendix B of the *Guidelines for the Ecologically Sustainable Management of Fisheries - 2nd Edition.*	**On track:** AFMA, on behalf of the PZJA, submitted the 2021 annual report on 29 November and will provide the second annual report by 30 November 2022.
Condition 5 The Protected Zone Joint Authority must complete an ecological risk assessment of the Torres Strait Bêche-de-mer Fishery by 1 January 2022 and develop an associated risk management strategy to address any risks identified in this assessment.	**Completed:** The CSIRO undertook the ecological risk assessment for the fishery, the draft of which was considered by the HCRAG at its meeting on 6-7 October 2021. The final report was circulated to the HCRAG on 21 December 2021 and is also available on the PZJA website. The Department was also updated on the draft outcomes of the ERA as part of the 2021 annual report with a final update to be included in the 2022 annual report.
Condition 6 The Torres Strait Protected Zone Joint Authority must ensure that there is a sufficient level of compliance measures in place to ensure the sustainable management of the Torres Strait Bêche-de-mer Fishery, in accordance with the management arrangements in place for the fishery.	**On track:** To ensure AFMA's compliance efforts are targeted in the right areas an intelligence driven risk based approach, using Compliance Risk Management Teams (CRMTs) will be applied under the 2020-21 National Compliance and Enforcement Program. The 2020-21 Program will focus on four key areas, one of which is compliance within Torres Strait Fisheries, focusing on quota evasion and reporting of threatened, endangered and protected (TEP) species. This document explains AFMA's compliance program priorities and objectives for the 2020-21 financial year (FY) and performance in the 2019-20 FY.
Condition 7 By 1 November 2023 the Protected Zone Joint Authority must provide the department with a revised population estimate for Black Teatfish (*Holothuria whitmaei*) and White Teatfish (*Holothuria fuscogilva*) in the Torres Strait that is based on new information for the fishery, including catch data and fishery-independent data	**On track:** AFMA, on behalf of the PZJA, is on track to meet this condition by the due date. During this meeting, HCRAG is invited to discuss and provide advice on the approach to providing a revised population estimate and an assessment of the impact of harvest on the stocks for both species.

WTO Conditions for the BDM Fishery	Progress as of September 2022
or scientific expert advice and an assessment of the impact of harvest on the stocks.	
Condition 8 The Torres Strait Protected Zone Joint Authority must limit the seasonal take of the following species listed under the Convention on the International Trade of Endangered Species (CITES), from the Torres Strait Bêche-de-mer Fishery to no more than: 1) 15 tonnes of White Teatfish (*Holothuria fuscogilva*); and 2) 20 tonnes of Black Teatfish (*Holothuria whitmaei*). The Torres Strait Protected Zone Joint Authority must report the amount of White Teatfish and Black Teatfish harvested by weight and where available, include the number of individuals, their lengths and locations of harvest, as part of the annual reporting referred to in Condition 4	**In progress:** The current TACs for white and black teatfish are 15t and 20t respectively. Black teatfish catches during the 2021 and 2022 trial openings did not exceed the 20t TAC and catches of white teatfish to date are significantly below the TAC of 15t. AFMA will report black and white teatfish catches for 2022 and their location of harvest as part of the annual report to the department. Information on the number of and length of individual black and white teatfish collected will be provided to the department if and when available.
Condition 9 The Protected Zone Joint Authority must address any over harvest of the Total Allowable Catch (TAC) for either Black Teatfish (*Holothuria whitmaei*) or White Teatfish (*Holothuria fuscogilva*) in one season and ensure that any over harvest of the species is properly accounted for in subsequent fishing seasons in line with the provisions in the Torres Strait Bêche-de-mer Fishery's Harvest Strategy.	**On track:** AFMA, on behalf of the PZJA, will address any overcatch of black or white teatfish in accordance with the provisions in the fishery's harvest strategy.

Appendix II CITES listing of sea cucumber species:

Black and white teatfish in August 2020

13. The new WTO approval includes additional requirements that need to be met by the PZJA to manage the harvest of black and white teatfish which were listed under Appendix II of the Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES) on 28 August 2020.

14. CITES is a binding international agreement aimed at preventing international trade from driving unsustainable population decline in species listed under the Convention. Species listed under Appendix II of CITES are not necessarily threatened with extinction, and may still be traded internationally provided the trade, or a specified level of trade, has been determined to be non-detrimental to the survival of the species in the wild.

15. The then Department of Agriculture, Water and the Environment (DAWE) is Australia's CITES Scientific Authority and has made a positive non-detriment finding of the Torres Strait Beche-de-mer Fishery subject to the conditions of the Fishery's wildlife trade operation (WTO) approval. One of these conditions places a seasonal TAC limit of 20t and 15t for black and white teatfish respectively.

Proposed listing of species in the genus Thelenota (including Thelenota ananas prickly redfish)

16. AFMA is aware that, in November 2022, the 19th meeting of the Conference of the Parties to CITES (CoP19) will be considering a proposal to include all species in the genus *Thelenota* under Appendix II of CITES.

17. The Wildlife Trade Office at the Department of Climate Change, Energy, the Environment and Water (DCCEEW) is leading the engagement with the various jurisdictions to better understand the potential business and regulatory impacts of the proposed listing. This information will inform Australia's negotiating position at CoP19 and the required Regulatory Impact Analysis and National Impact Analysis, to be considered by the Australian Parliament, should they be adopted. This information will also inform the necessary regulatory arrangements to allow international trade to continue.

Compliance outcomes for the 2021-22 season

1. AFMA has been delivering domestic compliance functions in the Torres Strait in accordance with the National Compliance and Enforcement Program. There were four compliance officers based in the Thursday Island office delivering both domestic and foreign compliance outcomes.

2. In May 2022, the Black Teatfish fishery opened for a second successful year with high compliance, this trial opening was supported by a strong interagency team.

3. AFMA recommenced operational field activities and continues to conduct these activities in accordance with best practise, mandatory social distancing, and hygiene and in accordance with guidelines developed for field activities. In April 2022 Australia reopened its international borders after 2 years due to COVID-19. PNG Treaty village visits are being planned for the coming year.

4. AFMA fisheries officers have delivered the following outcomes between July 2021 – June 2022:
    a. 34 ports/freight hubs visits;
    b. 70 fish receiver inspections;
    c. 33 vessel inspections;
    d. With the loosening of restrictions the FMB team were able to recommence community visits, the compliance team was able to attend one of these meetings at Masig Island in June. AFMA officers delivered a number of trainings to other joint agencies.
    e. AFMA has one matter currently before the court, with one recent matter under investigation. One matter dating back to 2018 was also decided in favour of AFMA by the court this reporting year with fines and a conviction recorded.
    f. AFMA conducted 17 at sea patrols of the TSPZ supported by Queensland Police and Australian Border Force.

5. To target priority risks in Torres Strait fisheries, AFMA have established a specialised multi-disciplinary Compliance Risk Management Team (CRMT). Priority risks specific to the Torres Strait include unlicensed fishing, unlicensed fish receiving and non-compliance with catch/landing reporting to AFMA. Failing to report catch or landings is considered quota evasion and results in the undermining of the ongoing sustainable management of the Torres Strait Fisheries.

6. Further details are contained in AFMA's National Compliance and Enforcement Program document accessible on the AFMA website at: https://www.afma.gov.au/domestic-compliance. This document explains AFMA's compliance program priorities and objectives for the 2021-2022 financial year.

7. All stakeholders are encouraged to report any suspicious or illegal fishing activity involving your fisheries to AFMA, either directly to our Torres Strait office or CRIMFISH (1800 274 634)

ABARES Fishery Status Reports

8. Each year, the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) compiles fishery status reports which provide an independent assessment of the biological status of fish stocks and the economic status of fisheries managed, or jointly managed, by the Australian Government (Commonwealth fisheries). The most recent ABARES Fishery Status Report was released in 2021 and summarises the performance of these fisheries in 2019 and 2020 and over time, against the requirements of fisheries legislation and policy.

9. In the 2021 report, all BDM species are classified as not being subject to overfishing, with Sandfish being the only species in the Torres Strait that continues to be classified as overfished. The status of the Torres Strait Beche-de-mer and Trochus Fisheries is summarised in the table below.

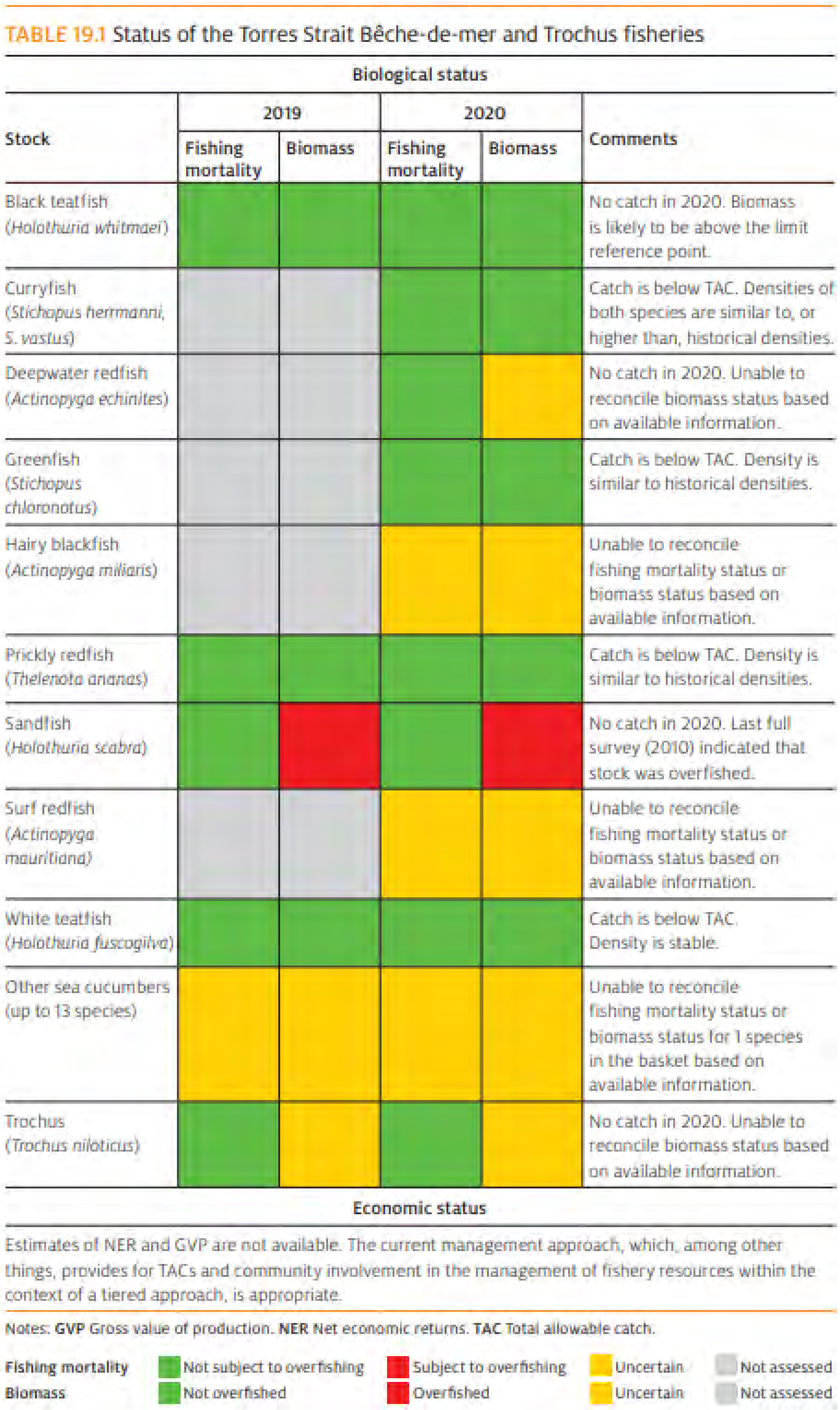

TABLE 19.1 Status of the Torres Strait Bêche-de-mer and Trochus fisheries

Biological status					
Stock	2019		2020		Comments
	Fishing mortality	Biomass	Fishing mortality	Biomass	
Black teatfish (*Holothuria whitmaei*)	🟩	🟩	🟩	🟩	No catch in 2020. Biomass is likely to be above the limit reference point.
Curryfish (*Stichopus herrmanni*, *S. vastus*)	⬜	⬜	🟩	🟩	Catch is below TAC. Densities of both species are similar to, or higher than, historical densities.
Deepwater redfish (*Actinopyga echinites*)	⬜	⬜	🟩	🟨	No catch in 2020. Unable to reconcile biomass status based on available information.
Greenfish (*Stichopus chloronotus*)	⬜	⬜	🟩	🟩	Catch is below TAC. Density is similar to historical densities.
Hairy blackfish (*Actinopyga miliaris*)	⬜	⬜	🟨	🟨	Unable to reconcile fishing mortality status or biomass status based on available information.
Prickly redfish (*Thelenota ananas*)	🟩	🟩	🟩	🟩	Catch is below TAC. Density is similar to historical densities.
Sandfish (*Holothuria scabra*)	🟩	🟥	🟩	🟥	No catch in 2020. Last full survey (2010) indicated that stock was overfished.
Surf redfish (*Actinopyga mauritiana*)	⬜	⬜	🟨	🟨	Unable to reconcile fishing mortality status or biomass status based on available information.
White teatfish (*Holothuria fuscogilva*)	🟩	🟩	🟩	🟩	Catch is below TAC. Density is stable.
Other sea cucumbers (up to 13 species)	🟨	🟨	🟨	🟨	Unable to reconcile fishing mortality status or biomass status for 1 species in the basket based on available information.
Trochus (*Trochus niloticus*)	🟩	🟨	🟩	🟨	No catch in 2020. Unable to reconcile biomass status based on available information.

Economic status

Estimates of NER and GVP are not available. The current management approach, which, among other things, provides for TACs and community involvement in the management of fishery resources within the context of a tiered approach, is appropriate.

Notes: **GVP** Gross value of production. **NER** Net economic returns. **TAC** Total allowable catch.

Fishing mortality	🟩 Not subject to overfishing	🟥 Subject to overfishing	🟨 Uncertain	⬜ Not assessed
Biomass	🟩 Not overfished	🟥 Overfished	🟨 Uncertain	⬜ Not assessed

10. ABARES fishery status reports can be accessed on the ABARES website at: https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1032581/0

Torres Strait Trochus Fishery update

Management arrangements

11. Many of the management arrangements applicable to the fishery are set out in *Fisheries Management Notice (FMN) No 76* and include:
    a. The taking of trochus is restricted to hand collection or by hand-held non-mechanical implements.
    b. The use of underwater breathing apparatus is not permitted.
    c. A minimum size limit of 80 millimetres and maximum size limit of 125 millimetres applies to all fishing (except traditional).
12. The total allowable catch for the Torres Strait Protected Zone (TSPZ) is 150 tonnes.

Strategic assessment

13. On 12 April 2017, AFMA submitted an application on behalf of the Torres Strait Protected Zone Joint Authority (PZJA), for assessment of the Torres Strait Trochus Fishery under the EPBC Act as a WTO.
14. The then Department of the Environment and Energy (DOEE) assessed this application against the Australian Government 'Guidelines for the Ecologically Sustainable Management of Fisheries – 2nd Edition'. Public consultation on the application was undertaken between 26 April to 31 May 2017. No comments were received.
15. The Torres Strait Trochus Fishery targets a single trochus species, *Tectus niloticus*, using hand-collection and diving in the TSPZ. Historically this fishery has been declared as a WTO. However, there has been no commercial fishing activity in this fishery since 2010. While there is no effort in the fishery, it does not pose any ecological risks.
16. The DOEE recommended that the fishery be exempt from the export requirements of the EPBC Act and product derived from the fishery be included on the List of Exempt Native Specimens until 9 October 2026. Should fishing effort increase in the Torres Strait Trochus Fishery, the fishery will be reassessed.

Commercial catch and number of licences

17. AFMA understands the fishery to have little to no fishing activity in recent years, with no commercial catches reported since 2018 (41kg). As at 1 September 2020, 2021 and 2022, the following number of TIB licences had trochus (TR) fishery entries:

Year	Number of TIB licences with Trochus fishery entries	Number of TVH licences
2020	71	0
2021	92	0
2022	61	0

Torres Strait Pearl Shell Fishery update

Management arrangements

18. The gold-lipped pearl shell (*Pinctada maxima*) and to a lesser extent the black-lipped pearl shell (*Pinctada margaritifera*) are the main species targeted in the Torres Strait, although five other species occur.

19. Pearl farms purchase product from fishers for use in seeding for the production of pearls and also for use in making other shell products such as jewellery.

20. There are a range of input controls that apply to the Pearl Shell fishery, including:
    a. Minimum shell size limits which are aimed at ensuring the most suitable shells are taken for farming and affording some protection to young shells and spawning stocks; and
        i. *Pinctada maxima* must be >130mm and <230mm;
        ii. *Pinctada margaritifera* must be > 90mm
    b. Gear restrictions; shell can only be harvested by diving or collected by hand.
    c. Boat length restrictions; boats must not exceed 6m in length.

21. The fishery is regulated through Torres Strait *Fisheries Management Instrument No. 7 (Torres Strait Pearl Shell Fishery).*

Minimum size limit trial with developmental permits

22. Following a recommendation from the HCWG in 2013, the PZJA agreed to issue developmental permits to existing licence holders for the taking of undersized pearl shell (*Pinctada maxima*). The objective of the permits was to support revitalisation of the Torres Strait pearl farming industry by developing a commercial trial to investigate whether using smaller shell for seeding and culture could increase the overall productivity of pearl farming. At the time, industry considered that smaller shell enabled them to maximise their seeding cycle potential due to more cycles, with the later seeding cycles producing larger and more valuable products.

23. Eight existing licence holders were subsequently issued developmental permits in 2015 with a competitive total allowable catch set of no more than 2,000 undersize pearl shell size between 100-130 mm to be taken within the allocated period of one year. Mandatory catch reporting of harvested pearl shell was a condition of the permit. Only two of the eight permits issued were active during the trial.

24. In 2017, AFMA undertook a review of the developmental permit trial in an effort to understand the low uptake of developmental permits that were issued.

25. Through interviews with permit holders and buyers, AFMA understood that:
    b. Approximately 800 pearl shell was reported to have been harvested during the permit period, with roughly 15-20% comprised of shell between 100-130 mm.
    c. The pearl shells harvested were used for seeding in aquaculture but due to the low level of undersize pearl shell harvested, any benefits to the aquaculture sector in relation to any improvement in profitability could not be determined.
    d. The primary reason as to why there is little interest in fishing the TSPSF by both TIB and TVH fishers is due to more lucrative opportunities in other Torres Strait fisheries (e.g. Tropical Rock Lobster).

Commercial catch and number of licences

26. AFMA understands the fishery to have little to no fishing activity in recent years, with no commercial catches reported since 1 December 2017. As at 1 September 2020, 2021 and 2022, the following number of TIB licences had pearl shell (PL) fishery entries:

Year	Number of TIB licences with Pearl shell fishery entries	Number of TVH licences
2020	67	4 primary/tender packages 3 individual licences 6 held in trust by the TSRA
2021	75	4 primary/tender packages 3 individual licences 6 held in trust by the TSRA
2022	61	4 primary/tender packages 3 individual licences 6 held in trust by the TSRA

Australian Government

**Department of Agriculture,
Water and the Environment**

Ref: 002068366

Mr Wez Norris
Chief Executive Officer
Australian Fisheries Management Authority
GPO Box 7051
CANBERRA ACT 2610

Dear Mr Norris

I am writing to you as Delegate of the Minister for the Environment in relation to the assessment of the Torres Strait Bêche-de-mer Fishery (the fishery) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In October 2020 the Australian Fisheries Management Authority applied for export approval for the fishery under the EPBC Act.

The application has been assessed and I have declared the fishery an approved wildlife trade operation (WTO) under Part 13A of the EPBC Act until 30 November 2023. The list of exempt native specimens has also been amended to allow export of product from the fishery while the specimens are covered by the declaration as an approved wildlife trade operation.

The Part 13A declaration includes conditions that were agreed by officials from both departments as areas requiring ongoing attention. These are set out at Attachment 1. Conditions are to be implemented in the period of the wildlife trade operation approval, unless a date is otherwise specified. Further, in assessing the management arrangements in place for this fishery, the Department has identified a number of inconsistencies in the published material relevant to the management of this fishery. In order to ensure that there is no ambiguity to fishers and for the purpose of compliance and enforcement, we urge AFMA to rectify this matter.

Two species harvested in this fishery, White Teatfish (*Holothuria fuscogilva*) and Black Teatfish (*Holothuria whitmaei*), are now listed under Appendix II of the Convention on the International Trade of Endangered Species (CITES). As such, Australia's CITES Scientific Authority must make a non-detriment finding in relation to the harvest of these species in the fishery to ensure that continued trade in these species from Australian fisheries is not detrimental to the survival of the species in the wild. Measures should be in place to limit such export in order to maintain such species throughout their range at a level consistent with their role in the ecosystems and well above the level at which they would qualify for Appendix I lising. Further information on CITES non-detriment findings can be found at Attachment 2.

Australia's CITES Scientific Authority is located in the Wildlife Trade Office of the Department of Agriculture, Water and the Environment. As required under Part 13A of the EPBC Act, Australia's CITES Scientific Authority included its assessment for the purpose of a Non-detriment finding in the Part 13A assessment for this fishery. A positive non-detriment finding has been made for this fishery and conditions have been placed in the relevant WTO to ensure that Australian CITES requirements are met.

Please note that any person whose interests are affected by this decision may make an application to the Department for the reasons for the decision and may apply to the Administrative Appeals Tribunal to have this decision reviewed. I have enclosed further information on these processes at Attachment 3.

Yours sincerely

Laura Ti

Laura Timmins
Delegate of the Minister for the Environment

23 December 2020

Attachment 1

Part 13A conditions to the Torres Strait Protected Zone Joint Authority on the approved wildlife trade operation declaration for the Torres Strait Bêche-de-mer Fishery – December 2020

Condition 1:
The Torres Strait Protected Zone Joint Authority must ensure that operation of the Torres Strait Bêche-de-mer is carried out in accordance with management arrangements defined in the *Torres Strait Fisheries Act 1984*, Torres Strait Fisheries Regulations 1985, Torres Strait Fisheries Management Instrument No.15 (Torres Strait Sea Cucumber Fishery), licence conditions and the Torres Strait Bêche-de-mer Fishery Harvest Strategy.

Condition 2:
The Torres Strait Protected Zone Joint Authority must inform the Department of Agriculture, Water and the Environment of any intended material changes to the Torres Strait Bêche-de-mer Fishery management arrangements that may affect the assessment against which *Environment Protection and Biodiversity Conservation Act 1999* decisions are made.

Condition 3:
The Torres Strait Protected Zone Joint Authority must inform the Department of Agriculture, Water and the Environment of any intended changes to fisheries legislation that may affect the legislative instruments relevant to this approval.

Condition 4:
The Torres Strait Protected Zone Joint Authority must provide reports to the Department of Agriculture, Water and the Environment annually as per Appendix B of the *Guidelines for the Ecologically Sustainable Management of Fisheries - 2nd Edition.*

Condition 5:
The Protected Zone Joint Authority must complete an ecological risk assessment of the Torres Strait Bêche-de-mer Fishery by 1 January 2022 and develop an associated risk management strategy to address any risks identified in this assessment.

Condition 6:
The Torres Strait Protected Zone Joint Authority must ensure that there is a sufficient level of compliance measures in place to ensure the sustainable management of the Torres Strait Bêche-de-mer Fishery, in accordance with the management arrangements in place for the fishery.

Condition 7:
By 1 November 2023 the Protected Zone Joint Authority must provide the department with a revised population estimate for Black Teatfish (*Holothuria whitmaei*) and White Teatfish (*Holothuria fuscogilva*) in the Torres Strait that is based on new information for the fishery, including catch data and fishery-independent data or scientific expert advice and an assessment of the impact of harvest on the stocks.

Condition 8:
The Torres Strait Protected Zone Joint Authority must limit the seasonal take of the following species listed under the Convention on the International Trade of Endangered Species (CITES), from the Torres Strait Bêche-de-mer Fishery to no more than:

1) 15 tonnes of White Teatfish (*Holothuria fuscogilva*); and
2) 20 tonnes of Black Teatfish (*Holothuria whitmaei*).

The Torres Strait Protected Zone Joint Authority must report the amount of White Teatfish and Black Teatfish harvested by weight and where available, include the number of individuals, their lengths and locations of harvest, as part of the annual reporting referred to in Condition 4.

Condition 9:

The Protected Zone Joint Authority must address any over harvest of the Total Allowable Catch (TAC) for either Black Teatfish (*Holothuria whitmaei*) or White Teatfish (*Holothuria fuscogilva*) in one season and ensure that any over harvest of the species is properly accounted for in subsequent fishing seasons in line with the provisions in the Torres Strait Bêche-de-mer Fishery's Harvest Strategy.

CITES Non-Detriment Findings in commercial fisheries

The Convention on International Trade in Endangered Species (CITES) is a binding international agreement, which was ratified by Australia in 1976. The purpose of CITES is to prevent international trade from driving unsustainable population decline in species listed on the Convention's three appendices.

There are three levels of CITES listing:

- Appendix I - for species threatened with extinction. CITES prohibits international trade of Appendix I species except for strictly controlled non-commercial purposes, such as scientific research.
- Appendix II - for species not currently threatened with extinction, but which may become so if harvest is not carefully controlled. CITES allows some limited international trade of these species under very tight rules and controls. CITES permits are required for all exports of Appendix II species.
- Appendix III - for species that may be threatened locally within certain countries. International trade in these species is only allowed with presentation of appropriate 'country of origin' certification. This assists countries with locally threatened populations to better manage trade of these species.

CITES requires the exporting Party's Scientific Authority to make a positive non-detriment finding (NDF) prior to export of CITES specimens listed in Appendix I and II. Australia's CITES Scientific Authority is in the Wildlife Trade Office.

A positive NDF is made when *"the sum of all harvests is sustainable in that it does not result in unplanned range reduction, or long term population decline, or otherwise change the population in a way that might be expected to lead to the species being eligible for inclusion in Appendix I".*

To ensure that fisheries declared as approved Wildlife Trade Operations (WTO) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) continue to be able to trade internationally in CITES-listed marine species, NDFs need to be based on a level of information that meets international standards, consistent with guidance agreed by resolution by CITES Parties (https://cites.org/sites/default/files/document/E-Res-16-07-R17_0.pdf).

Consistent with Resolution Conf. 16.7 Rev CoP 17, Australia's CITES Scientific Authority has taken a risk-based approach to the information requirements for making NDFs. Under this approach, the level of information required to inform an NDF will vary depending on the biological vulnerability of the species, its global and national status, the risks posed to the species, and the degree of certainty associated with these factors. The standard information fields for NDFs include:

- species biology;
- species life history characteristics;
- species range – historic and current;
- population structure, status and trends (nationally and in the harvest area);
- threats;
- species specific (or in some instances genus specific[1]) levels of harvest/ mortality from the fishery (historic and current);
- estimates of species specific (or in some instances genus specific1) levels of harvest/mortality from *all sources* combined;
- results of population modelling;

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[1] Genus-level reporting is acceptable for some coral species.

- management measures currently in place and proposed, including consideration of rates of compliance;
- a *scientific* assessment of the level of harvest that is considered sustainable under the management regime taking into account all sources of mortality;
- The ability of management measures to constrain harvest to the level assessed to be sustainable; and
- trade information relating to the species.

Where significant risks of species decline are identified (or credible scientific information about the species is limited), highly precautionary fishery management arrangements are likely to be required before non-detriment findings can be issued. A common requirement in this circumstance is for management arrangements to include prescriptive annual trigger limits on the harvest of each CITES listed species.

It is common practice for other countries receiving exports from Australia to monitor and review Australia's non-detriment findings. If an importing country is not satisfied with the quality or level of precaution applied in Australia's non-detriment finding, it can choose to reject an import on that basis and suspend future imports of that species from Australia.

Australian Government

Department of Agriculture, Water and the Environment

Attachment 3

Notification of Reviewable Decisions and Rights of Review[2]

There is a right of review to the Administrative Appeals Tribunal (AAT) in relation to certain decisions/declarations made by the Minister, the Minister's delegate or the Secretary under Part 13A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Section 303GJ(1) of the EPBC Act provides that applications may be made to the AAT for the review of the following decisions:

(a) to issue or refuse a permit; or
(b) to specify, vary or revoke a condition of a permit; or
(c) to impose a further condition of a permit; or
(d) to transfer or refuse to transfer a permit; or
(e) to suspend or cancel a permit; or
(f) to issue or refuse a certificate under subsection 303CC(5); or
(g) of the Secretary under a determination in force under section 303EU; or
(h) to make or refuse a declaration under section 303FN, 303FO or 303FP; or
(i) to vary or revoke a declaration under section 303FN, 303FO or 303FP.

If you are dissatisfied with a decision of a type listed above you may:

- by notice, provided in writing, request that the Minister or the Minister's delegate give you a statement in writing setting out the reasons for the decision as per section 28 of the *Administrative Appeals Tribunal Act 1975*. The Minister, or Minister's delegate may refuse to give you a statement of reasons if your application is made more than 28 days after the day on which you received this notice.
- apply to the AAT for independent merits review of the decision. The AAT undertakes *de novo* merits review. This means they take a fresh look at the facts, law and policy relating to the decision and arrive at their own decision. They decide if the decision should stay the same or be changed. They are independent of the Department.

Application for review of a decision must be made to the AAT within **28 days** after the day on which you have received the reviewable decision. However an extension of time for lodging an application may be granted by the AAT under certain circumstances. Please visit the AAT's website at http://www.aat.gov.au/ or telephone 1800 228 333 for further information. The role of the AAT is to provide a review mechanism that is fair, just, economical, informal and quick.

Applications & Costs

Applications to the AAT are made by lodging an Application Form (Form 1). This can be found on the AAT's website at http://www.aat.gov.au/.

There are no strict timelines in which the AAT must review the decision, however the first conference between the parties will usually be held within 6 to 10 weeks of the application

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[2] In accordance with the *Administrative Appeals Tribunal Act 1975* Code of Practice for Notification of Reviewable Decisions and Rights of Review

being lodged. The time frame for review of certain decisions can be expedited in some circumstances.

The cost of lodging an application for review is $952 (as of 1 July 2020) (GST inclusive). You may be eligible to pay a reduced fee of $100.00 if

- you are receiving legal aid for your application;
- you hold a health care card, a Commonwealth seniors health card or any other card issued by the Department of Social Services or the Department of Veteran's Affairs that entitles the holder to Commonwealth health concessions;
- you are in prison or lawfully detained in a public institution;
- you are under 18 years of age; or
- you are receiving youth allowance, Austudy or ABSTUDY.

You may also be eligible for a reduced fee if you can demonstrate to the AAT that paying the full fee would cause you financial hardship. Further information can be found on the AAT's website. Additionally, you can access information about legal assistance at https://www.ag.gov.au/LegalSystem/Legalaidprogrammes/Commonwealthlegalfinancialassistance/Documents/LegalFinancialAssistanceInformationSheet.pdf.

If you pay a standard application fee, most of it will be refunded if the case is resolved in your favour. The refund amount is the difference between the fee you paid and $100. So, if you paid $920, you get back $820 and if you pay $952, you get back $852. There is no refund if you paid the lower application fee for certain taxation decisions or the reduced fee of $100.

Contact Details

Further information or enquiries relating to the decision should be directed to:

The Director
Wildlife Trade Assessments Section
Department of Agriculture, Water and the Environment
GPO Box 858
Canberra ACT 2601
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TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	Meeting No.2 27-28 September 2022
NATIVE TITLE UPDATE	**Agenda Item 2.4** **For NOTING & DISCUSSION**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG) **NOTE** any updates on Native Title matters from members, including the representative from Malu Lamar (Torres Strait Islanders) Corporation RNTBC (Malu Lamar).

BACKGROUND

2. On 7 August 2013 the High Court of Australia confirmed coexisting Native Title rights, including commercial fishing, in the claimed area (covering most of the Torres Strait Protected Zone). This decision gives judicial authority for Traditional Owners to access and take the resources of the sea for all purposes. Native Title rights in relation to commercial fishing must be exercisable in accordance with the *Torres Strait Fisheries Act 1984*.
3. Traditional Owners and Native Title representative bodies have an important role in the management of Torres Strait fisheries. It is important therefore that the RAG keep informed on any relevant Native Title issues arising.
4. AFMA has extended an invitation to Malu Lamar to attend this meeting as an observer and is investigating longer term arrangements for representation in consultation with PZJA agencies.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	Meeting No.2 27-28 September 2022
PAPUA NEW GUINEA NATIONAL FISHERIES AUTHORITY UPDATES	**Agenda Item 2.5** **For NOTING**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG):
    a. **NOTE** the fishery update to be provided by representatives from the Papua New Guinea National Fisheries Authority if in attendance (via video conference).
    b. **NOTE** the Australia and Papua New Guinea (PNG) bilateral meetings series was held in Cairns recently, including the Fisheries Committee Meeting which was held on 30 August. The outcomes of the discussions will be circulated to the RAG once finalised and available.

KEY ISSUES

2. AFMA has a standing invite for officials from the PNG National Fisheries Authority (NFA) to attend all PZJA consultative forums. If in attendance, NFA officials will provide an update on the PNG hand collectable fisheries at the meeting, including an update on the beche-de-mer fishery.
3. In 2010 PNG placed a moratorium on fishing for BDM. On 1 July 2017 the moratorium was lifted and the PNG beche-de-mer fishery has been opened three times since (2018, 2019 and 2020). AFMA understands that although the season open date usually falls on 1 July, it can vary from year to year depending on the progress of the stock biomass assessment surveys and analysis that is used to set the total allowable catches for each province. A notice issued by NFA in 2017 is provided at **Attachment 2.5a** for further background.

BACKGROUND

4. The *Treaty between Australia and the Independent State of Papua New Guinea concerning Sovereignty and Maritime Boundaries in the area between the two Countries, including the area known as Torres Strait, and Related Matters* (the Treaty) was signed by both Parties at Sydney on 18 December 1978 and ratified by Australia on 15 February 1985. The Treaty defines the border between Australia and PNG and provides a management framework of the common border area. This area is defined by the Treaty and is known as the TSPZ.
5. Australia and PNG established the TSPZ with the principal purpose of acknowledging and protecting the traditional way of life and livelihood of the traditional inhabitants of both Parties, including their traditional fishing and free movement (Article 10(3)). A further purpose is to protect and preserve the marine environment and indigenous fauna and flora in, and in the vicinity of, the TSPZ (Article 10(4)). A range of subsidiary obligations and rights exist under the Treaty. Relevantly, Australia and PNG commit under the Treaty to co-operate in the conservation management and optimum utilisation of Protected Zone commercial fisheries (Article 21) insofar that the achievement of the purposes for the establishment of the TSPZ are not prejudiced in regard to traditional fishing (Article 20(1)).

6. The Treaty recognises the rights of both countries to Protected Zone commercial fisheries. This recognition is implemented through cooperative management and catch sharing provisions of Part 5 of the Treaty. Since the Treaty was ratified, Australia and PNG have entered into formal arrangements under Article 22 to cooperatively manage six fisheries, referred to as ‘Article 22 fisheries’. These are the commercial fisheries for prawns, tropical rock lobster, Spanish mackerel, pearl shell, and traditional fisheries for turtles and dugong.
7. The BDM Fishery is not an Article 22 fishery and is, therefore, not managed under formal catch sharing arrangements with PNG. However, Australia and PNG recognise the importance of complimentary management arrangements, shared science and strong communication between both Parties given some sea cucumber stocks are shared (e.g. Sandfish) and beche-de-mer stocks are vulnerable to overfishing.
8. Updates on the status of the respective fisheries and agreements between PNG and Australia on catch sharing arrangements and related matters usually take place at annual fishery bilateral meetings and meetings of the Torres Strait Joint Advisory Council (JAC) established under Article 19 of the Treaty, but may occur intersessionally as required by the two Parties.

ATTACHMENT 2a – PNG NFA 2017 update on the lifting of the Beche-de-mer moratorium

PNG BECHE-DE-MER FISHERY - GOLD OF THE SEA

Coastal and Island Fishermen throughout the country are reaping the benefits of the 7-year closure of the beche-de-mer fishery. An estimated 13 million kina has been paid already directly to the coastal and island communities throughout PNG for the 6-week period that the fishery has been open in 2017. By the time all provincial Total Allowable Catch (TAC) have been reached and the open season ends this year, we estimate that a total of 18 to 36 million kina would have been earned by the coastal and island fishermen and fisherwomen. Whole families especially women have been the main beneficiaries. Disadvantaged and isolated island communities in the coastal provinces are earning a very high income from this fishery. The value quoted in above does not include the benefits accrued to the people who are indirectly engaged in this fishery especially those who are employed by licensed exporters.

The beche-de-mer fishery is projected to generate 40 to 53 million kina in foreign revenue in the 2017 fishing season because all the beche-de-mer are being exported to overseas markets, mainly to Hong Kong and China. This is a fishery where the coastal and island communities are directly involved to generate foreign revenue for PNG. About half a million people, from the coastal and island communities benefit from the fishery.

The fishery was closed for 7 years since 2010 because there was extensive overfishing and populations of sea cucumber were severely depleted. NFA has been monitoring the recovery of the sea cucumber populations through provincial sea cucumber annual stock assessments when the fishery has been closed. NFA also consulted extensively and revised the beche-de-mer fishery management plan. Results of the annual sea cucumber surveys indicated that full recovery of the sea cucumber populations has not been achieved yet. NFA wanted to give something back to the coastal and island fishermen for the 7-year investment of no fishing and test the revised plan. The NFA Board approved the plan in 2016 and the fishery was opened on the first of April in 2017. Copies of the Beche-de-mer Fisheries Management plan can be obtained from NFA.

GOVERNANCE AND MANAGEMENT

The approved Beche-de-mer Fisheries Management Plan allows for the joint management by the National Fisheries Authority (NFA), Provincial Government, Local Level Government (NFA) and communities. Roles for NFA, provinces, LLG and communities are defined in the plan. This means the management of beche-de-mer is decentralized with the communities responsible for the day to day management of the fishery. To enable joint management, the plan establishes a National Management Advisory Committee (NMAC), Provincial Management Committees (PMAC) and Local Management Advisory Committees (LLGMAC) which is optional. Communities can also establish committees to manage the fishery at the community level. NMAC and PMAC are functional meaning that they have regular meetings and make decisions. PMACs have been involved in the decision making process to screen and approve export and buyers licenses for the 2017 open season.

Since the opening of the fishery some communities have formulated bylaws to help them manage the day to day management of the fishery under the jurisdiction of the community. Some example of community bylaws include controlling the days to harvest, the species to harvest and the areas where no fishing is allowed in order to protect undersizes or the spawning population. NFA is encouraging other communities to create community bylaws to help manage the fishery at the community level. During the course of the year and leading to the 2018 open season, NFA will work with the provinces, LLGs and communities to formulate provincial and community beche-de-mer fishery management plans especially for those communities who wish to apply such bylaws.

SEASONAL OPENING AND CLOSURE

Under the new Beche-de-mer Fishery Management Plan the fishery is scheduled to open every year for six months from the 1st April to the 31st September 2017. However if the TAC for the province is reached early the fishery for the province must close. The fishery is closed from the 1st October to the 31st March for a compulsory 6 month closure. The 6 month closure is necessary to help protect the spawning population and help the sea cucumber population grow into adults before the fishery is opened.

The fishery in a specific province is closed early if the TAC for the province is reached. Three provinces, New Ireland (TAC=43 tonnes), West New Britain (TAC=15 tonnes) and AROB (TAC= 28 tonnes) have already reached their TAC after 6 weeks of harvest. Fishing for sea cucumbers in these provinces is now closed on Wednesday 17th May 2017. Selling and buying for the three provinces will cease on Monday 24nd May 2017. Fishermen in these three provinces are allowed to sell their dried products for 7 days between Wednesday 17th May and Wednesday 24nd May. This is to ensure that the dried products for the fishermen in isolated and distant coastal and island locations are sold.

Other provinces are also approaching their TAC. Milne Bay province has the highest TAC of 118 tonnes and has already reached 53% of its TAC. The current rate of production for Milne Bay is 10 tonnes per week and is projected to close in mid-June 2017. MOMASE provinces have low TAC and are expected to reach their TAC soon. The current rate of harvest for the provinces vary from province to province but indicate that the fishery will be closed for most of the provinces by July 2017.

TOTAL ALLOWABLE CATCH

The beche-de-mer fishery is managed using a number of strategies including a minimum size limit to protect the immature individuals and allocation of Total Allowable Catch (TAC) for each maritime province to control how much sea cucumber can be harvested from each province. The TAC for each province are calculated for each year based on the harvestable sizes present on the waters and reefs of each province (see table). In order for the beche-de-mer fishery to be open every year so the coastal and island communities continue to earn an annual income, 30% of the estimated harvestable biomass (weight) is allowed to be harvested and forms the TAC for the province. Seventy percent of the biomass must remain on the reefs to repopulate and grow.

TAC for the Provinces

PROVINCE	**2017 TAC (tonnes)**
Milne Bay	118
Central	58
Manus	53
New Ireland	43
AROB	28
West New Britain	15
Northern	15
Morobe	9

Western	7
East New Britain	7
Madang	5
East Sepik	2
Sandaun	2

NFA is appealing to the fishermen and fisherwomen not to harvest all the sea cucumbers on the reef especially on the reef flats and shallow areas. At the end of the open fishing season a lot of sea cucumbers must still be seen on the reef.

It has taken only 6 weeks for some provinces such as New Ireland, West New Britain and Bougainville to reach their TAC. The big rush to harvest sea cucumbers from the reefs was expected because most of the sea cucumbers live in shallow waters. Fishermen and fisherwomen only have to walk on the reefs to harvest the sea cucumbers.

To ensure that the TAC is not exceeded, NFA trained and placed Compliance Monitors in all the provinces to help monitor the TAC. NFA has established an information system to monitor the TAC in all the provinces. The information system is designed to monitor the TAC in near real time and involves collection of data from the buyers and exporters on a weekly basis, data is entered and data is analyzed and summarized immediately.

SIZE LIMITS

Size limits have been set for 30 species of sea cucumbers to protect immature sea cucumbers and a portion of the recently mature young sea cucumbers. This is also the portion of the population that is harvested the following year as they grow into harvestable sizes. It is important that fishermen and fisherwomen don’t take undersizes if they want to continue to earn an income from the fishery every year.

Because the largest portion of undersizes of sea cucumbers are located on the reef flat which is the shallow areas (see graph) they are easily targeted by the fishermen and fisherwomen. Harvesting of undersizes has been a major issue that was expected by NFA when the fishery opened. It was a major issue in the past leading up to the closure of the fishery in late 2009 when a large portion of the products was exported including as much as 100% undersizes for some species. NFA is appealing to the fishermen and fisherwomen not to harvest the undersizes as they are worth more if they are left for harvesting the following years.

Penalties apply to the Buyers and Exporters if they buy or export undersize beche-de-mer. The penalties include loss of the Buyers and Export licences. NFA is appealing to the Buyers and Exporters to comply with the size limits.

LICENSING

A licence is required in order to participate in the buying, storage and export of Beche-de-mer. This is necessary in order to control the trade of beche-de-mer in the country. There are three main types of licences required, Buyers, Storage Facility and Export. A Buyers licence is issued to individuals, normally those working for a Beche-de-mer exporter company. The Buyers licence allows the individuals to buy sea cucumbers from the fishermen and fisherwomen. A Buyers licence is like a drivers licence. It cannot be transferred and the licensed Buyer must always have in his or her possession the licence. He or she must also be present at all times in the buying of the beche-de-mer products. A Beche-de-mer export company is allowed to have a maximum of 5 buyers licence.

A Storage Facility licence is issued to the company for the use of a Storage Facility to store and process beche-de-mer. Before the Storage Facility licence is issued it must be inspected by NFA staff to ensure that it meets requirements for the storage of beche-de-mer which is a perishable food product.

An Export licence is issued to the company to allow it to export beche-de-mer to overseas markets. Companies must meet export requirements as specified in the beche-de-mer fisheries management plan before the company is allowed to export.

REVIEW OF THE BECHE-DE-MER FISHERY MANAGEMENT PLAN

NFA is committed to ensuring the Beche-de-mer Fishery benefits the coastal and island Communities, Buyers and Exporters as key stakeholders in the long term. This will be achieved through the effective implementation of the beche-de-mer fishery management plan. The plan must maintain the sustainable of the sea cucumber populations through effective control measures of the fishery. At the moment there are no examples of a tropical beche-de-mer fishery that is effectively managed around the world. NFA is challenged but is fully committed to be effective in the management of the PNG Beche-de-mer fishery and is therefore initiating the review of the current plan.

As part of the management plan review process NFA is identifying key issues affecting the implementation of the management plan including elements of the plan that are working and those that are not are not working. NFA will consult stakeholders initially in the provinces that have reached their TAC and are closing the fishery, to identify areas of the plan that can be improved. An intensive consultation workshop to review the plan will be conducted in October 2017. NFA is confident that revision of the beche-de-mer fishery management plan will significantly improve implementation in the 2018 open season.

For further information, please contact Mr Leban Gisawa, Executive Manager, Fisheries Management Unit on Phone: 3090444 or Email: lgisawa@fisheries.gov.pg

Authorized by:
Mr. John Kasu
Managing Director

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	Meeting No.2 27-28 September 2022
BLACK TEATFISH TRIAL OPENING 9 – 12 MAY 2022 AND FUTURE OPENINGS	Agenda Item 3 FOR DISCUSSION & ADVICE

RECOMMENDATIONS

That the Resource Assessment Group (RAG):

1. **NOTE** the update on the outcomes of the black teatfish trial opening on 9 – 12 May 2022, including an overview of catch and effort reporting by licenced fish receivers (**Attachment 3a**) and information from fishers that participated in the opening who will be in attendance at the meeting.

2. **NOTE** that length and weight sampling was undertaken during the opening on Erub and Mer Islands and, to a limited extent, Bourke Islet.

3. In accordance with Condition 5, 6 and 7 of the Re-opening Decision Rule in the Torres Strait Beche-de-mer Fishery Harvest Strategy (Section 2.11.4, page 34-35):

    a. **NOTE** that the trial opening Total Allowable Catch (TAC) was not exceeded, meaning the harvest strategy recommendation that the fishery be automatically paused for the following year if the TAC is exceeded by more than 5 percent does not apply (Condition 5)

    b. **REVIEW** and **DISCUSS** the data collected for the opening and advise whether the level of data collection during the trial opening was conducted satisfactorily (condition 6).

    c. **REVIEW** the CSIRO analysis of data from the opening (**Attachment 3b**) to review the TAC and potential for the fishery to stay open in the future, or be re-opened periodically after a pre-specified interval (Condition 7). CSIRO will present the analysis and the updated stock assessment results at the meeting.

4. Having considered the above, **DISCUSS** and **PROVIDE ADVICE** on the potential for the fishery to stay open on an ongoing basis (Condition 7) and under what conditions including:

    a. an appropriate, ongoing, TAC; and

    b. any additional data that should continue to be collected during future openings, noting an ongoing condition of the fishery remaining open is that reliable data collection continues, and preferably includes additional data such as CPUE, spatial footprint and size composition (Condition 8).

    c. Any ongoing assessment of the impact of harvest on the stock to ensure it continues to be at sustainable levels.

KEY ISSUES

5. The re-opening decision rule in the BDM Harvest Strategy (Section 2.11.4) sets out the conditions that need to be met when considering the potential for a previously closed fishery to stay open in future, following a successful trial opening. These are outlined below to guide the RAG's discussion:

i. ***STEP 1 - Was data collection during the trial conducted satisfactorily (condition 6)***

- AFMA believes that reported catches accurately reflect the total amount of black teatfish that was caught and landed during the season due to the high level of industry compliance with the daily catch landing and reporting requirements that applied. AFMA had a significant compliance presence throughout the region during the opening, including land-based officers on some of the key islands which were able to support and assist industry meet the licencing and reporting requirements.

- AFMA also had four (4) scientific fisheries observers that where undertaking size frequency sampling during the entire period of the opening as part of the CSIRO-led research project. Those observers were also able to support and assist industry with the catch reporting requirements for the opening.

ii. ***STEP 2 - Noting the TAC was not exceeded and reliable data were collected (RAG to comment on this assessment), the data need to be analysed to review the TAC and potential for the fishery to stay open in the future, or be re-opened periodically after a pre-specified interval (Condition 7)***

- CSIRO have undertaken an analysis of the size frequency sampling, catch and effort data from the opening including an analysis of catch rates to the extent that the available reported effort information allows (**Attachment 3b**).

- CSIRO will present the analysis and the updated stock assessment results at the meeting..

iii. ***STEP 3 - Future TAC***

- The rationale for the 20 tonne opening TAC is outlined in the Background section below.

- The RAG is now asked to provide advice on a TAC for a future black teatfish opening that is set at a demonstrably conservative level taking into account the outcomes of the trial opening outlined in Steps 1 and 2.

iv. ***STEP 4 - Additional data to be collected during future openings***

- Prior to the 2021 black teatfish trial opening AFMA broached the possibility of doing logbook reporting and some length sampling with industry during consultation with industry and communities on the timing of the opening. Initial feedback from industry was positive however they had concerns that it may not be feasible given the realities of sea cucumber fishing operations. AFMA did not pursue these initiatives further with industry in 2022, recognising the need to first focus on some of the more fundamental aspects of the opening such as daily reporting and empowering industry to agreeing on an appropriate timing for the opening.

- An ongoing condition of the fishery remaining open is that reliable data collection continues, and preferably includes additional data such as CPUE, spatial footprint and size composition. AFMA considers that industry is broadly interested in pursuing logbook reporting and, as is the case for the Spanish Mackerel Fishery, would be willing to assist with sampling.

- At its first meeting, the HCRAG recommended that opportunities to undertake a scientific sub-sampling program to collect size and weight frequency data during black teatfish openings at key landing locations be explored. A research project was subsequently funded through the TSSAC process which saw the collection of sea cucumber length and weight data during the opening by four scientific observers on Erub and Mer Islands. Some limited sampling was also undertaken by Compliance Officers on Bourke Islet.

- Continuous guidance and feedback is needed from industry and scientific members on how best to structure future sampling and data collection programs ensuring sufficient support and meaningful sampling. For example, training for fishers to take length measurements, complete logbooks and having data collection officers at key landing areas to support industry sampling as per the 2022 sampling program.

BACKGROUND

6. The 2022 black teatfish opening commenced on 9 May 2022. In line with decisions of the PZJA, the TAC was set at 20 tonnes and it was mandatory for fishers to report catches to a fish receiver daily and for fish receivers to report landings to AFMA daily. Aside from data provided by fish receivers, and the size frequency sampling undertaken by observers no other data was collected, for example detailed effort information (for example reef location or hours fished).

7. The fishery went for four (3.5) days resulting in 17.06 t of the 20 t TAC being caught. The daily black teatfish catches are summarised in Table 1 below.

Table 1. Summary of daily black teatfish catches during the opening 9-12 May 2022

Fishing Day	Daily catch (kg)	Cumulative catch (kg)
9-May	4,193.85	4193.85
10-May	5,826.99	10,020.83
11-May	5,979.52	16,000.36
12-May (1/2 day of fishing)	1,055.41	17,055.76

8. The total catch across all sea cucumber species caught during the black teatfish opening was 19.09t, 89.3% of which was black teatfish (17.06t). A summary of the data collected during the black teatfish opening is provided in **Attachment 3a**.

Industry experience of the black teatfish opening

9. AFMA has invited a number of fishers and fish receivers that participated during the opening to attend the HCRAG's meeting to discuss their experiences fishing for black teatfish. In the absence of logbook reporting in the sector, it will be especially valuable to get:
    a. an insight into fishing operations to better understand and interpret the catch and effort data reported,
    b. ground truth the results of the data analysis with industry members' experiences and observations during fishing operations,
    c. data collection and sampling strategies for future openings that are most likely to be successful,
    d. general industry feedback on the opening.

10. Starting the industry engagement and consultation process now will ensure that management, monitoring and reporting measures for future openings are well considered, should the PZJA agree to allow fishing for black teatfish in 2023 and beyond.

TAC rationale – 2022 black teatfish trial opening

HCRAG01 Recommendation

11. The HCRAG had its inaugural meeting on 6-7 October 2022 and considered the outcomes of the 2021 black teatfish trial opening with a view to providing advice on the potential for the fishery to stay open in the future. Having regard for all available information and conditions 5-8 of the BDM Fishery Harvest Strategy, relating to the reopening decision rule that needed to be addressed, following a trial opening the **RAG RECOMMENDED** a black teatfish opening in 2022 with a 20t TAC on the basis that:
    a. the 2021 trial reopening TAC of 20t was not overcaught (condition 5 of the HS);
    b. data was collected satisfactorily during the opening (condition 6 of the HS);
    c. updated modelling analysis, inclusive of 2021 catch data, confirmed that a 20t TAC is sustainable (conservative estimate of MSY being 21t) and would not lead to a decrease in black teatfish biomass after the first year of fishing (condition 7 of the HS). In contrast, the modelling found that annual catches of 30t could lead to a gradual depletion of the stock.
    d. prior to a future black teatfish opening AFMA focuses on communication and education on improving voluntary reporting of area and effort data by fishers and fish receivers, including preparing fact/information sheets and organising a teleconference with all fish receivers as a cost effective way to discuss ways of improving voluntary reporting.
    e. opportunities to undertake a sub-sampling program to collect size and weight frequency data during black teatfish openings at key landing locations be explored. Noting that the sampling program would need to be scientifically designed.

12. The HCRAG01 meeting record is provided as **Attachment 1.4b under Agenda Item 1.4**.

HCWG18 Recommendation

13. At its meeting on 28-29 October 2021, the HCWG18 considered HCRAG01's advice and recommendation on future black teatfish openings and the outcome of the 2021 black teatfish trial opening (**Attachment 3c**). The HCWG supported HCRAG's advice and **recommended** a black teatfish opening in 2022 with a 20t TAC, considering:
    a. the outcomes of the updated CSIRO population modelling which confirmed that a 20t TAC is sustainable and would not lead to a consistent decline in black teatfish biomass after the first year of fishing. In contrast the modelling found that catches of 30t could lead to a gradual depletion of the stock.
    b. industry member advice to ensure that all catch data continues to be captured during future openings.

TAC rationale – 2021 black teatfish trial opening

14. At its meeting on 21 February 2020, the Hand collectable Working Group (HCWG) considered very preliminary outcomes of the fishery independent sea cucumber dive survey conducted in November 2019 and January 2020 and recommended a trial reopening of the fishery for black teatfish, subject to a 15 tonnes TAC and daily reporting to AFMA (meeting record is available on the PZJA website). The PZJA's consideration in April 2020 of the HCWG's recommendation was delayed on TSRA's request to allow for a more complete CSIRO report on the stock status of black teatfish, and provide time for TSRA to consider options for filling the vacant position on the HCWG for a traditional inhabitant member for Maluialgal (inner western cluster).

15. Members of the HCWG met again on 7 August 2020. Due to unexpected changes in the availability of some traditional inhabitant members, the quorum requirements for the meeting[1] were not met.

16. To support members advice on possible arrangements for a black teatfish opening the following was presented:

    e. Preliminary[2] outcomes of the fishery independent dive survey which included: i) recorded densities across locations and within habitats; ii) standing stock population estimates; iii) length distributions; and iv) a comparison of results with previous surveys; and

    f. Preliminary population modelling together with estimates of standing stock biomass above the legal-size limit (generally known as the available biomass).

17. All members reaffirmed previous HCWG advice that based on all available information, the black teatfish stock is likely to be well above the biomass limit reference (a pre-requisite under the harvest strategy for reopening a species closed to fishing). Advice from members is detailed in the meeting record available on the PZJA website with advice on a recommended reopening TAC summarised below.

    g. The two traditional inhabitant members, AFMA and one scientific member (also a co-investigator on the current stock survey project), recommended a re-opening TAC of 20 tonnes. This recommendation was also supported by the TSRA Fisheries Portfolio Board member who is a Permanent Observer on the HCWG;

    h. The TSRA member recommended a reopening TAC of 21 tonnes; and

    i. A Scientific Member and the QDAF member recommended a reopening TAC of 15 tonnes.

18. Having consider the advice of the HCWG, the PZJA agreed to an opening TAC of 20 tonnes on the basis that the preliminary modelling work undertaken by CSIRO, although preliminary, found that across all model versions and sensitivity tests, 20 tonnes was shown to be sustainable. Although 20 tonnes (or 20.8t) is the estimated Maximum Sustainable Yield (MSY) for the preferred model, the MSY estimate was considered conservative due to the inputs used in the preliminary model.

19. The default reopening TAC for black teatfish prescribed in the harvest strategy is 15 tonnes. AFMA considered there was sufficient basis to depart from this default setting. The new modelling, albeit preliminary, gave insight into the productivity of the stock and importantly how it might respond to different levels of fishing exploitation. The preliminary modelling used the newly collected survey data and reported catch data. For these reasons, AFMA considered 20 tonnes to be consistent with the Harvest Strategy requirement for the starting TAC to be demonstrably conservative.

20. In the absence of other data or analysis the application of generally assumed conservative harvest rates of standing stock biomass estimates for sea cucumbers has been used. The standing stock biomass estimate derived from the recent survey was 818 tonnes. If applied, the rule of thumb harvest control rule of harvesting 5% of the total biomass estimate (818t) would have resulted in a TAC recommendation of 41 tonnes. The preliminary modelling indicated that catches above 30 tonnes would not be sustainable and would lead to a decline in the biomass after the first year of fishing.

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[1] PZJA Fisheries Management Paper No. 1. Management Advisory Committees, Scientific Advisory Committees, Working Groups and Resource Assessment Group.

[2] The results were considered preliminary at the time as the final report for the project was not due until December 2020 with further work on interpreting the results across the range of species surveyed to be undertaken.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No.2** **27-28 September 2022**

Summary of Black teatfish opening catch data 9 – 12 May 2022

1. The black teatfish trial opening lasted for three and half days, resulting in a total catch of 19.09t of sea cucumber, 89.3% of which was black teatfish (17.06t). A summary of all sea cucumber catches during the black teatf ish opening is provided in Table 1.

Table 1. Summary provides a summary of all sea cucumber catches during the opening 9-12 May 2022

Species	9 May (Day 1)	10 May (Day 2)	11 May (Day 3)	12 May (Day 4)	Total catch by species (kg)
Black Teatfish	4,193.85	5,826.99	5,979.52	1,055.41	17,055.76
Blackfish	47.18	66.06	30.28	12.55	156.07
Curryfish - mixed	15.62	62.12	68.41		146.15
Prickly redfish	215.22	489.08	632.83	94.91	1,432.04
White Teatfish	56.57	107.36	106.33	29.82	300.08
Total catch by day (kg)	**4,528.44**	**6,551.60**	**6,817.38**	**1,192.68**	**19,090.10**

2. Apart from the last day, catches increased during the opening. Catches for 12 May were significantly low as fishing was only allowed until noon to manage the level of fishing effort and mitigate the risk of overcatch of the TAC.

3. A total of 11 fish receivers reported black teatfish during the opening from five different locations (Mer, Erub, Ugar Islands and Bourke and Memey Islets). Bourke and Memey Islets are uninhabited islands from which some fish receivers where permitted to operate during the black teatfish opening to help facilitate the daily catch landing and reporting requirements.

4. Of the 17.06 t of black teatfish caught, 39.6% (6.76t) was landed at Mer Island, 31.6% (5.4t) at Bourke Islet, 21.4% (3.64t) at Erub Island, 2.7% (0.47t) at Ugar Island and 4.6% (0.79t) at Memey Islet.

5. 62.6% (10.68t) of the landed black teatfish catch was reported as being salted, 18.9% (3.22t) as whole weight and 18.5% (3.16t) as wet gutted weight. For catch monitoring purposes, all reported catch was converted to wet gutted weight using the conversion ratios available for these processing methods.

6. The majority of the total catch (92.3%) was landed to eight (8) fish receivers, with over half of the catch (56.9%) landed to four (4) fish receivers.

Effort information (number of fishers and area)

7. Fishers reported as having fished for black teatfish in various areas as summarised in Table 2 below. A map of the reporting areas used in the catch disposal record is provided in Figure 1.

Table 2. Black teatfish catches by area during the 2022 opening 9-12 May

Area Fishery	Catch per area (t)
Great North East Channel (14)	0.33
Darnley (16)	3.77
Cumberland (17)	8.14
Seven Reefs (18)	0.59
Don Cay (19)	2.87
Barrier (20)	0.19
Not assigned	1.17
Total	**17.06**

8. A total of 37 fishing licences participated in the opening and landed black teatfish catch during the opening. It should be noted that individual licences or boats with high catch levels against them are for multiple boats that the fishers/fish receivers did not specify in the CDR page.

9. Based on the reporting and discussions with industry before and during the opening, AFMA believes that fishers mainly originated from the eastern and central region of the Torres Strait with some fishers travelling over from Waiben (Thursday Island).

Price and GVP information

2022 trial opening

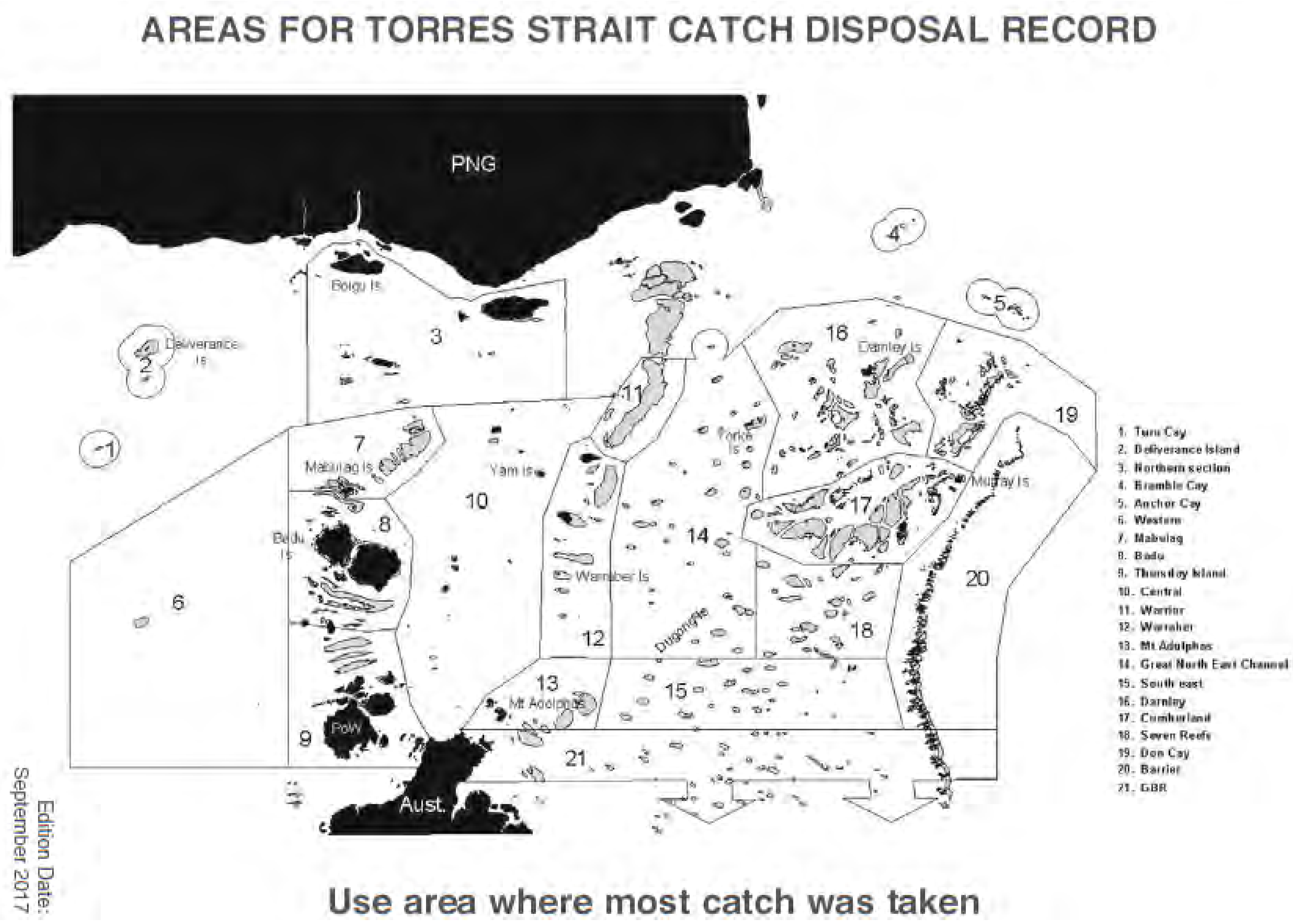
10. One of the fishers/fish receivers/buyers that AFMA has had the opportunity to talk to advised paying a slightly higher price of approximately AUD36 for black teatfish during the 2022 trial opening compared to 2021.

11. AFMA has been liaising with the Natural Resource Economics Team at the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) regarding the calculation and publication of gross value of production (GVP) for the BDM Fishery. Although yet to be published, ABARES have preliminarily estimated the GVP for the BDM Fishery for 2020-21 to be AUD642,000. AFMA will circulate the final GVP figures to the HCRAG once they are published.

2021 trial opening

12. Some of the fishers/fish receivers and some of the buyers that AFMA had the opportunity to talk to last year advised that black teatfish prices during the 2021 opening ranged from approximately AUD26 to approximately AUD 30 or potentially even AUD 40 depending on the quality and the level of processing. More accurate price information would assist the PZJA in getting a better understanding of the value of the fishery.

Figure 1. Map of areas for Torres Strait Catch Disposal Reporting (TDB02)



Black teatfish trial fishery openings – 2021 & 2022

Nicole Murphy, Éva Plagányi and Tim Skewes

The data in this summary were gathered by AFMA logbooks and observers during the Black teatfish fishery openings in 2021 (April 30 to May 3) and 2022 (May 9 to May 12).

Thank you and appreciation to TSI fishers for providing their fishery data and AFMA Thursday Island and Observers Tamre Sarhan, Ben Lidell, David Schubert, Henry Oak and Stephen Hall.

This document provides a brief summary of some of the data in order to inform ongoing management.

Length frequency

A total of 1886 Black teatfish were sampled for size frequency measurements of length and width during the 2022 fishery season, with 1701 weights also recorded. Measurements of length, width and weight were also recorded for other sea cucumber species (Table 1).

Table 1. Number of sea cucumber species measured during Black teatfish opening in 2022.

Common name	Whole Length (mm)	Number
Black teatfish	*Holothuria whitmaei*	1886
White teatfish	*Holothuria fuscogilva*	29
Curryfish common	*Stichopus herrmanni*	44
Curryfish vastus	*Stichopus vastus*	33
Prickly redfish	*Thelenota ananas*	24
Burrowing blackfish	*Actinopyga spinea*	2

Length frequency measurements (whole) from previous sea cucumber surveys (Figure 1) and observer data (Figure 2) are shown below. Unfortunately, the pre-2020 population survey data aren't sufficiently comparable to the 2022 Observer data (as the latter are based on commercial catches and a Minimum Legal Size (MLS) restriction), but data from future fishery openings will allow more detailed comparisons such as of the median size of animals caught, and trends in growth.

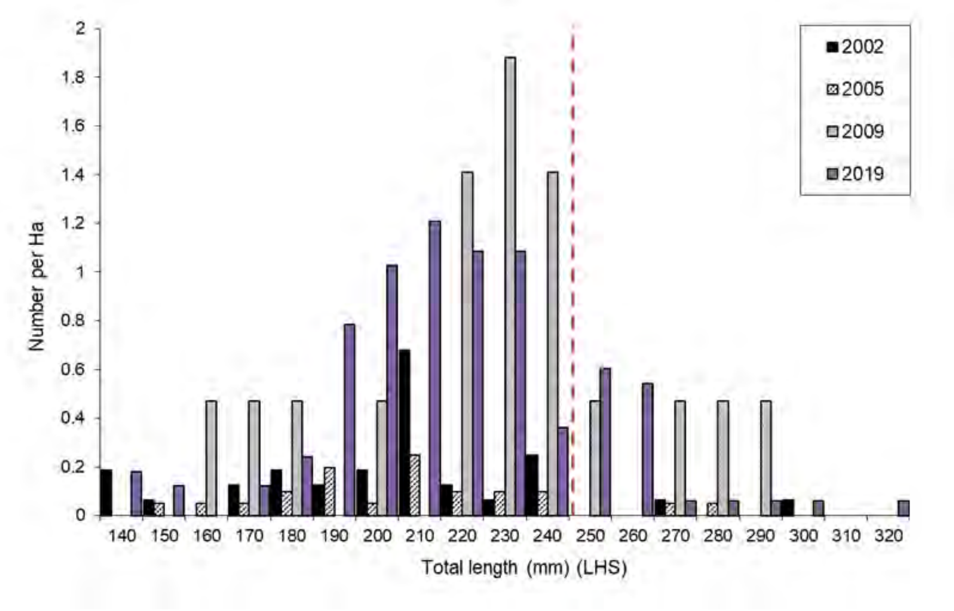


Figure 1. Length frequency for Black teatfish collected during population surveys in East Torres Strait in 2002, 2005, 2009 and 2019/2020. Minimum Legal Size (MLS) of 250 mm indicated; LHS = minimum size of bin range (Murphy et al. 2021).

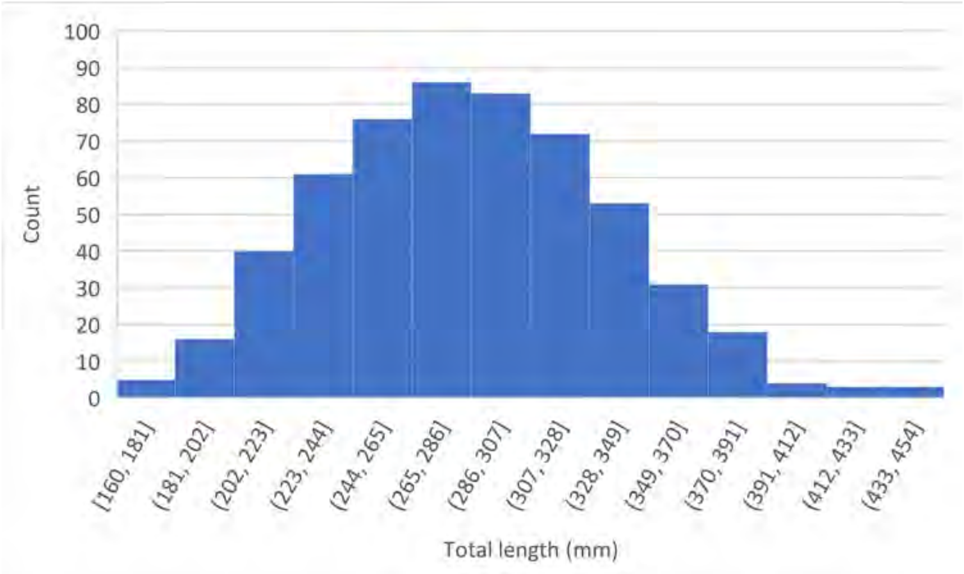


Figure 2. Length frequency measurements (whole) for Black teatfish for the 2022 fishery opening.

Black teatfish catch

Data analyses for 2021 and 2022 fishery openings

A summary of the total catch per area and per day, for 2021 and 2022 is shown in Table 2. Recorded weights have all been converted to standard units (wet-gutted weight) using the agreed conversion factors. The total Black teatfish catch for 2021 was 17.4 tonnes and for 2022 was 17.05 tonnes and hence below the TAC (Total Allowable Catch) limit of 20 tonnes, confirming that the trial openings for both years were successfully managed.

Whereas the total catch amounts were reliably reported in 2021, the majority (55%) of the catch did not include details such as the area caught. This limits the usefulness of the data to support additional analyses related to the sustainability and productivity of the stock. In 2022, catch amounts were again reliably reported and there was an improvement in reporting the area caught (logbook zone), with 68% of total records recording the corresponding area caught (Table 2).

*Catch error – 2021: A slight dating error exists that has implication for the total catch for Black teatfish to date – a catch entry was entered for the 2nd of April due to a dating error on the CDR. This resulted in the record not being captured in the data extract for the opening period (30th April – 3rd May 2021). The record amount was 181.95 kg and brings the total catch of Black teatfish to *17,615.47* kg.

Table 2. Sum of converted (gutted) weight (kg) for catch taken for logbook zones for each fishing day in years 2021 and 2022.

	Day	Warrior	GNE Channel	Darnley	Cumberland	Don Cay	Seven Reefs	Barrier	Unknown$^{\%}$	Grand total
2021	30-Apr	-	119.78	41.24	468.95	311.13	-	-	3075.51	**4016.62**
2021	1-May	-	141.19	551.31	1392.45	-	-	-	2820.29	**4905.24**
2021	2-May	-	67.14	276.20	1030.81	-	-	-	166.42	**1540.57**
2021	3-May	50.95	-	1010.19	2210.87	145.56	-	-	3553.51	**6971.08**
Total		**50.95**	**328.12**	**1878.94**	**5103.08**	**456.69**	-	**-**	**9797.69**	**17615.47**
	Day	**Warrior**	**GNE Channel**	**Darnley**	**Cumberland**	**Don Cay**	**Seven Reefs**	**Barrier**	**Unknown$^{\%}$**	**Grand total**
2022	9-May	-	-	985.82	1768.25	1229.02	-	-	210.75	**4193.85**
2022	10-May	-	331.00	1379.75	1948.39	631.25	324.11	-	873.56	**5488.07**
2022	11-May	-	-	1065.44	4024.48	641.80	270.01	185.23	-	**6186.96**
2022	12-May	-	-	335.02	397.09	371.24	--	-	83.54	**1186.90**
Total		**-**	**331.00**	**3766.03**	**8138.22**	**594.13**	**2873.30**	**185.23**	**1167.85**	**17055.76**

%Unknown: Fished area left blank in reporting.

Catch per day

In 2021, the largest catch was taken on day 4 and the least on day 3. For 2022, the largest catch was taken on day 3 and the least on day 4 (Figure 3).

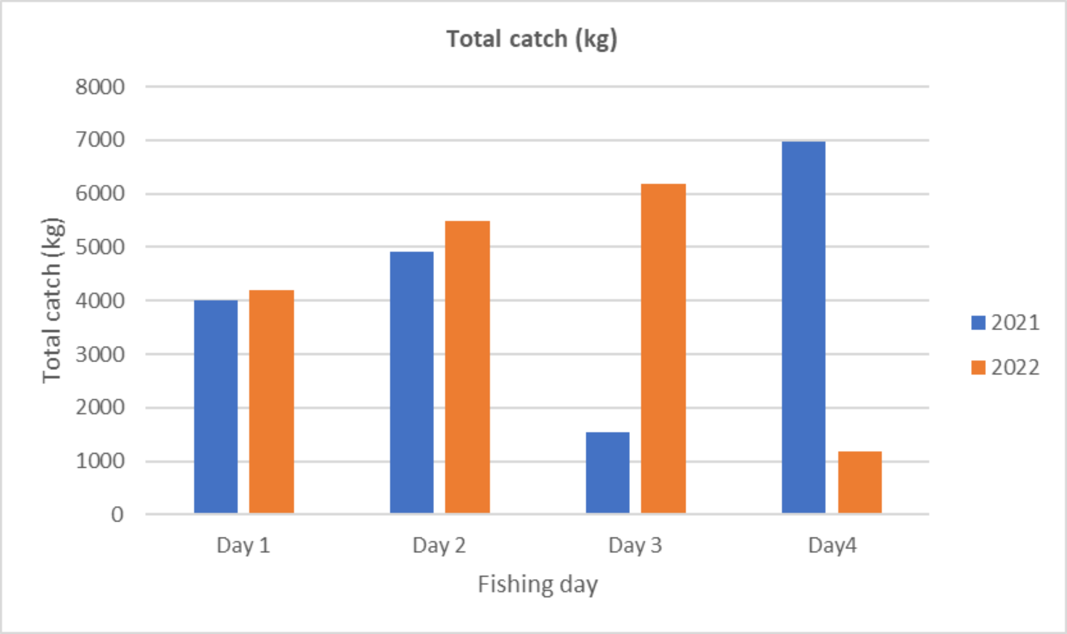


Figure 3. Total catch per day (gutted weight - kg).

The temporal pattern in catches as shown in Table 2 and Figure 3 suggest the following:

- No evidence of stockpiling as day 1 catches were not relatively large
- No evidence of declining catch after a few days, which would indicate depletion
- Low catch on day 3 - 2021 due to falling on the Sabbath
- Low catch on day 4 - 2022 due to fishery opening for a half day and some fishers choosing not to fish
- Cumulative catches were tracked and adhered to the management TAC
- The number of fishers participating in the fishery was only a fraction of the available fishing effort (i.e. potential TIB effort in Torres Strait) indicating possibly that fishing effort was controlled by local traditional “Island custom” management

Area fished

In 2021, the largest catch was taken from ‘Unknown’ area recorded in the catch data (Table 3; Figure 4). Following this opening, meetings stressed that it is important to improve communication for future fishing around the need to record location, as this limits the usefulness of the data.

In 2022, there was an improvement in recording location for catch (Table 3; Figure 4). The areas of Darnley, Cumberland and Don Cay received more effort, suggesting these areas may have contributed to the Unknown data in 2021. The areas of Seven Reefs and Barrier were additionally fished—they were not in 2021. Further information as to why these areas were accessed would help scientific understanding of the information content of the data and inform on fisher behaviour.

Table 3. Total sum of converted weight (kg) for catch taken for logbook zones for each fishing day between years.

2021	Day	Warrior	GNE Channel	Darnley	Cumberland	Don Cay	Seven Reefs	Barrier	Unknown
	1	-	119.78	41.24	468.95	311.13	-	-	3075.51
	2	-	141.19	551.31	1392.45	-	-	-	2820.29
	3	-	67.14	276.20	1030.81	-	-	-	166.42
	4	50.95	-	1010.19	2210.87	145.56	-	-	3553.51
2022	**Day**	**Warrior**	**GNE Channel**	**Darnley**	**Cumberland**	**Don Cay**	**Seven Reefs**	**Barrier**	**Unknown**
	1	-	-	985.82	1768.25	1229.02	-	-	210.75
	2	-	331.000	1379.75	1948.39	631.25	324.11	-	873.56
	3	-	-	1065.44	4024.48	641.80	270.01	185.23	-
	4	-	-	335.02	397.09	371.24	-	-	83.54

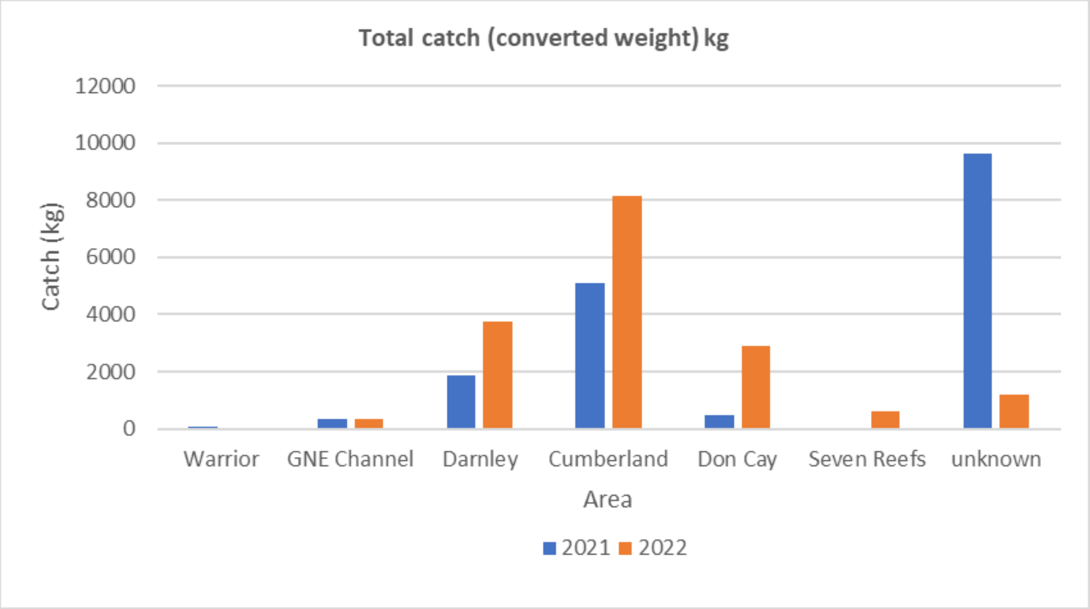


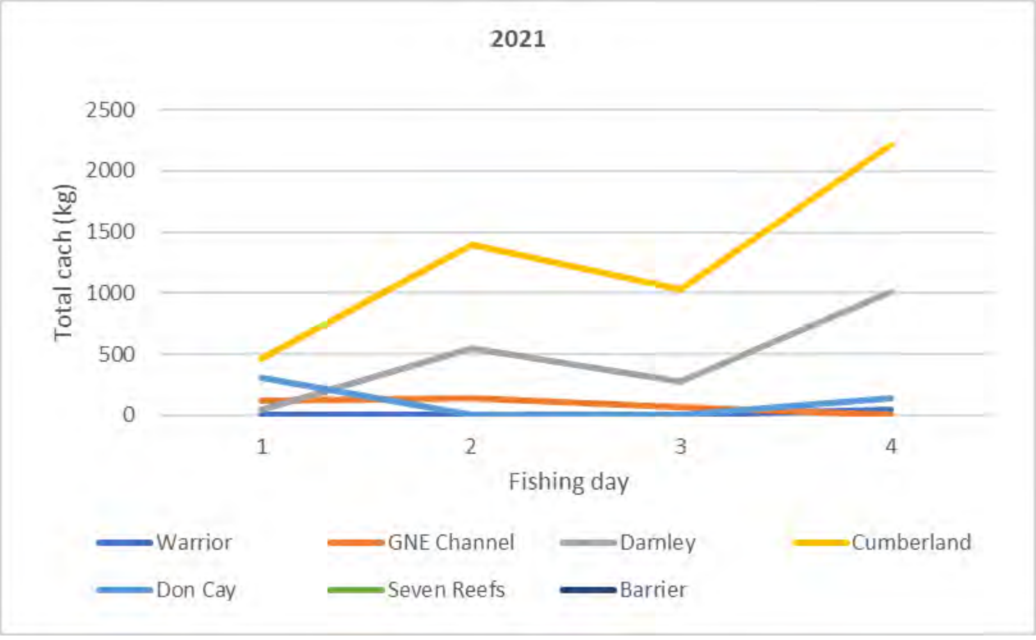
Figure 4. Total catch (converted weight - kg) for logbook zones between years.

Area fished across days

In 2021, most of the fishing effort was in the areas of Darnley and Cumberland, with similar effort across days (Figure 5).

For 2022, the majority of effort occurred at Cumberland, increasing across days. Effort was also seen at Darnley and Don Cay (Figure 5).

Travelling and processor location likely played a role in areas fished.



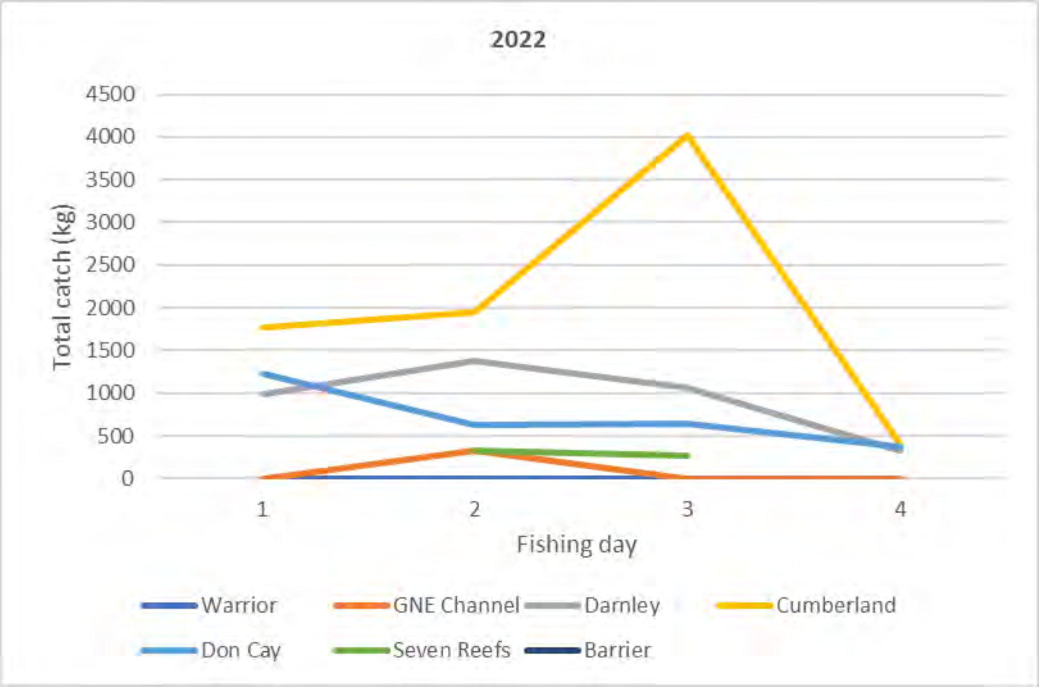


Figure 5. Total catch (converted weight - kg) for logbook zones for each fishing day for 2021 (top) and 2022 (bottom).

Sea cucumber stock survey 2019/2020

The 2019/2020 sea cucumber survey found that areas with highest average densities were in Barrier and Don Cay, which is consistent with earlier surveys, and is consistent with surveys in other regions (e.g. Great Barrier Reef has highest population density in outer shelf and barrier reef (Benzie and Uthicke, 2003; Knuckey and Koopman, 2016).

The density in Cumberland in 2019/2020 was lower than in 2009 but still higher than historical surveys, and Seven Reefs had the highest density since surveys have been undertaken.

Darnley had the lowest density ever observed (though never a high-density zone in any year) and no Black teatfish were observed at the Great North East Channel zone (Figure 6; Murphy et al., 2021).

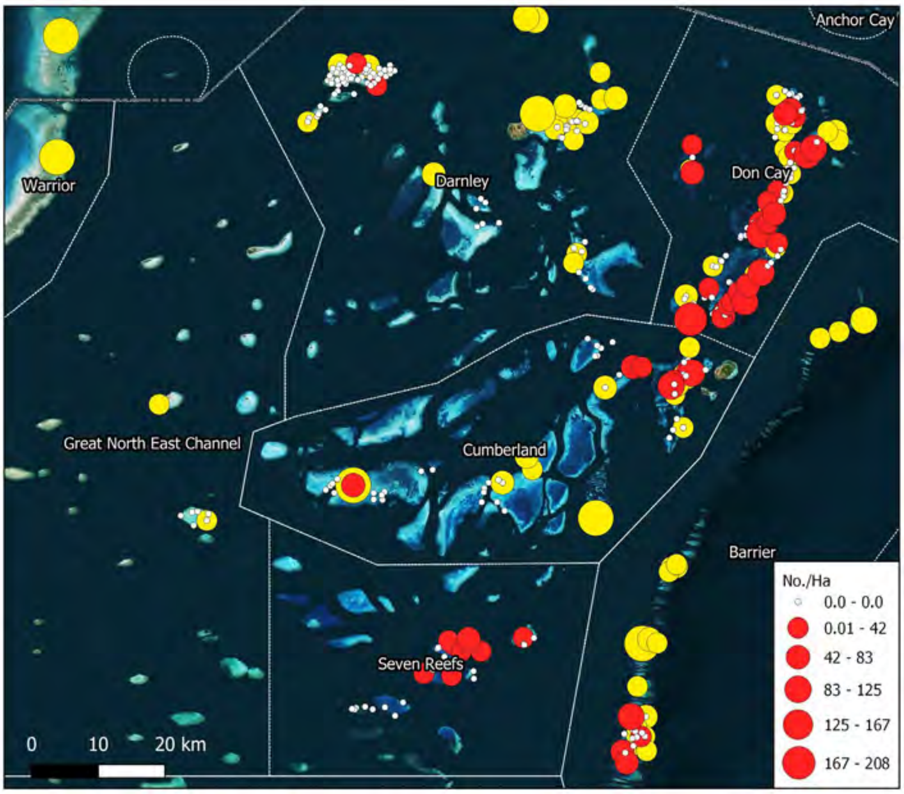
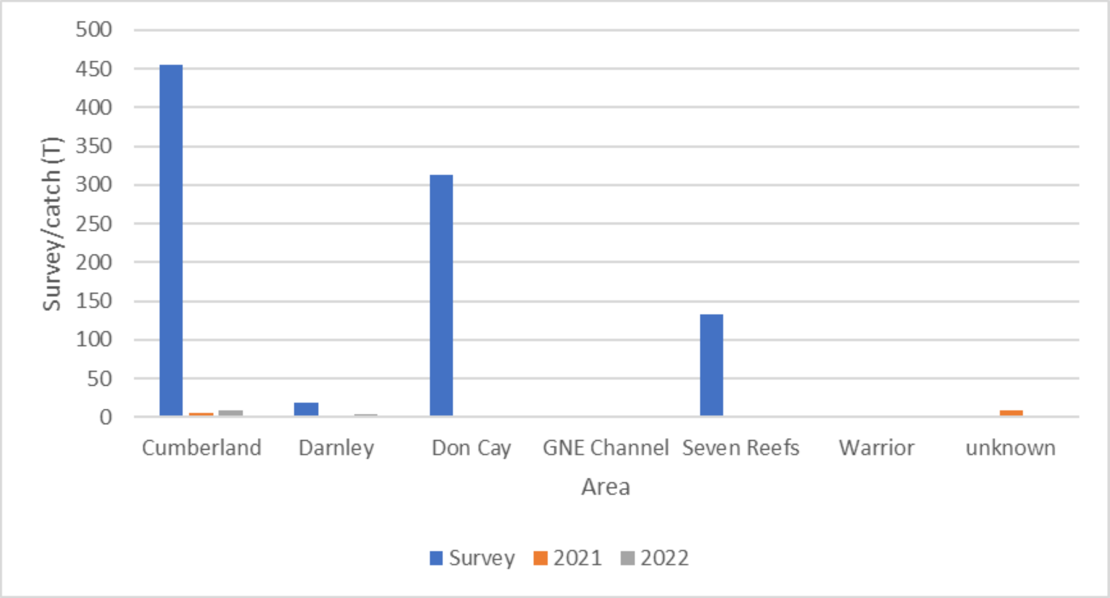


Figure 6. Density of Black teatfish (*H. whitmaei*) at individual survey sites during surveys in East Torres Strait from 1995 to 2009 (yellow) and 2019 (red).

Survey versus catch data

The 2022 catch is modest in comparison to the 2019/2020 survey biomass estimate, even if all the Unknown catch was taken from any of the fished zones (Figure 7).



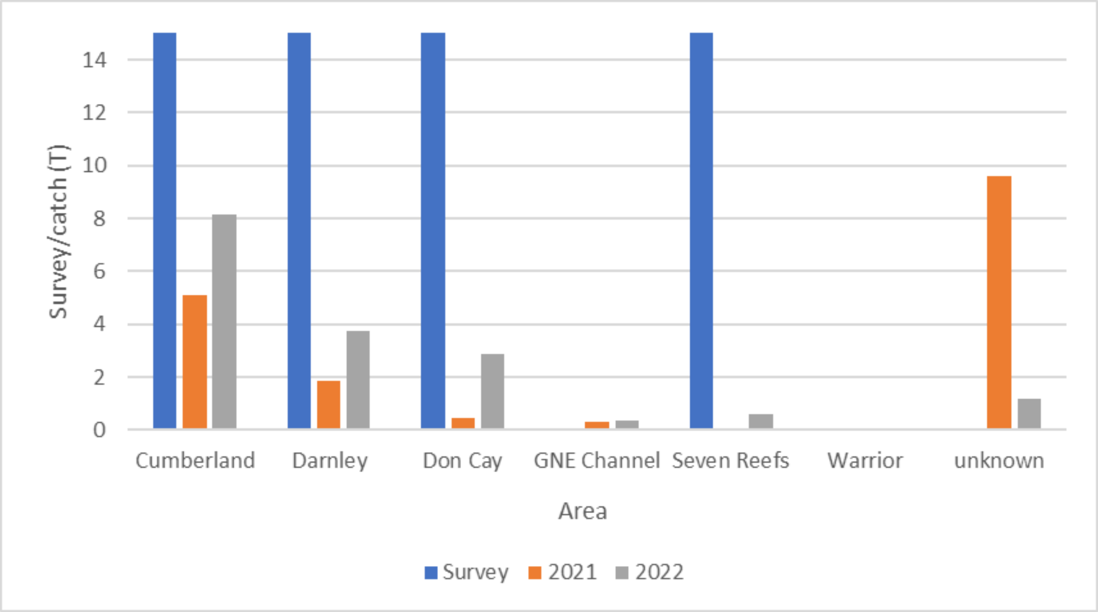


Figure 7. Survey estimates (gutted weight - t) and catch (gutted weight - t) for logbook zones (bottom graph is the same at the top with a reduced (Y) scale).

Total daily catch

In 2021, the area noted ‘Unknown’ in catch records showed consistent catch effort over days fished. Cumberland was also fished consistently and it is likely that Unknown was taken from this logbook zone (Figure 8).

For 2022, consistent catch effort was seen for Cumberland and Darnley, with Don Cay fished more intensely on the first day, with less (but similar) effort for the remaining days (Figure 8).

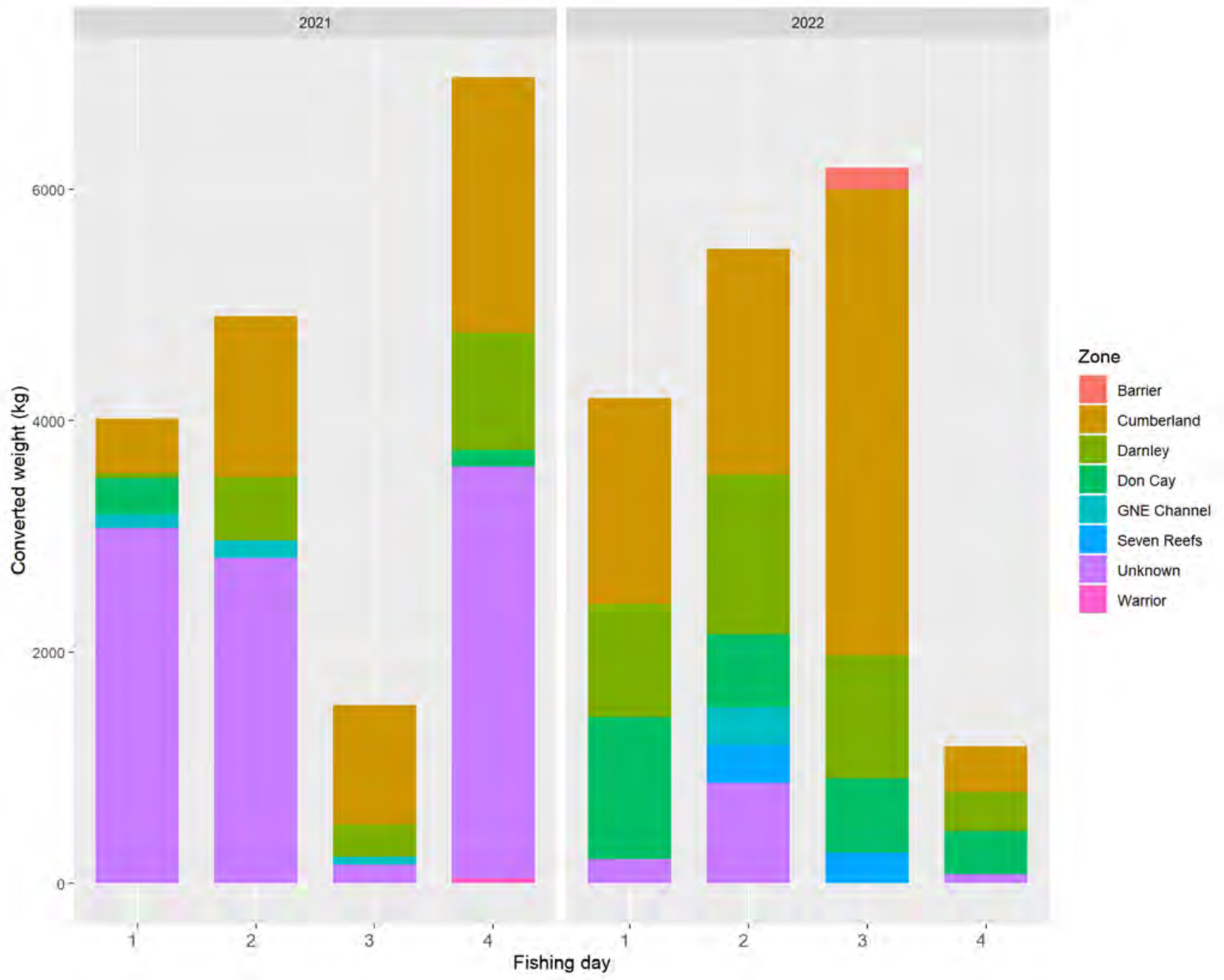
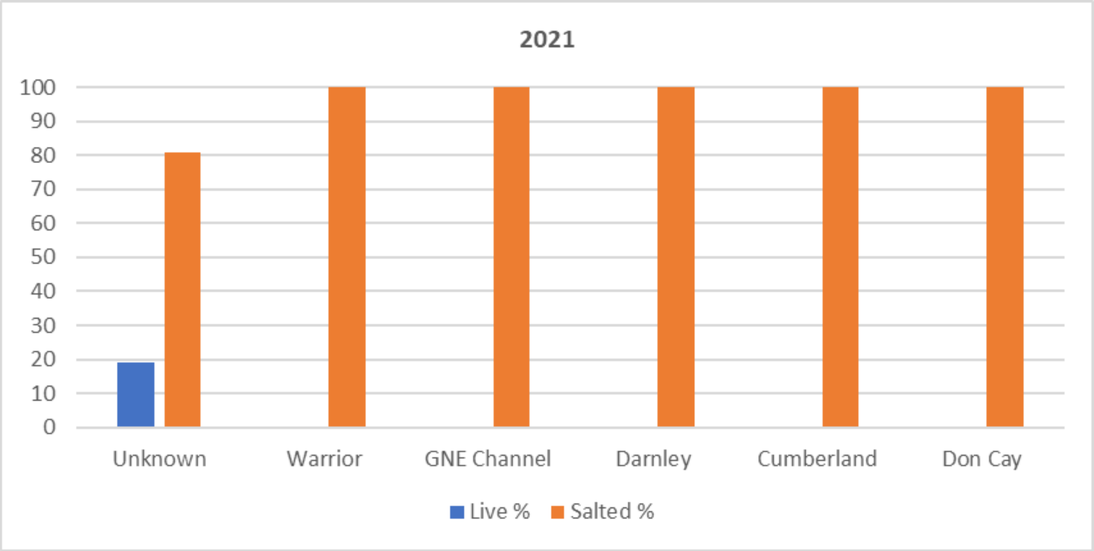


Figure 8. Total daily catch (converted weight – kg) across logbook zones for days fished, between years.

Processing state

In 2021, the majority of product landed at fish receivers was salted, with ~20% live landed for one zone (Unknown) only (Figure 9).

For 2022, a greater variety of product types were landed. Gutted catch was recorded solely for the area of the Great North East Channel, as well as Unknown, Darnley and Cumberland. There was also live product landed for Unknown, Cumberland and Don Cay, which wasn’t the case in 2021 (Figure 9).



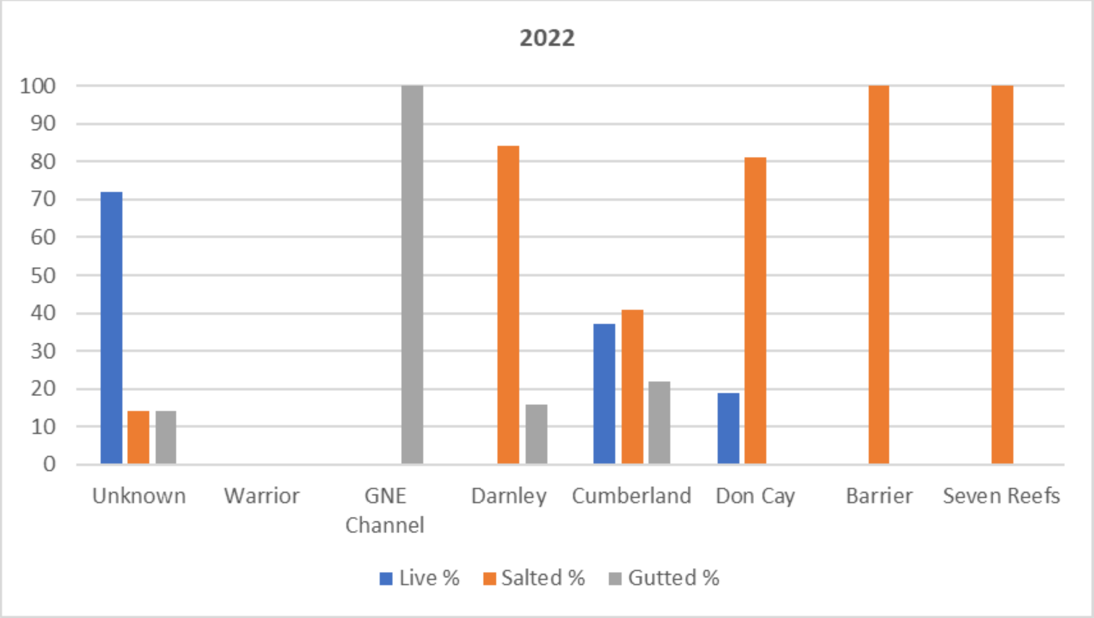


Figure 9. Percent product form of catch landed at fish receivers, also showing logbook zones for 2021 (top) and 2022 (bottom).

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Australian Government
Australian Fisheries Management Authority

Torres Strait Hand Collectables Working Group

Meeting 18

28-29 October 2021

Final record

Note all meeting papers and minutes are available on the PZJA webpage: www.pzja.gov.au

Contents

1 Preliminaries

1.1 Acknowledgment of traditional owners, welcome and apologies

1. The meeting was opening in prayer by Sereako Stephen around 8.45am.

2. The Chair welcomed members and observers to the 18th meeting of the Torres Strait Hand Collectables Working Group (the WG), in particular Nicholas Pearson and Gerald Bowie to their first meeting as newly appointed members for Kulkalgal and Maluialgal. The Chair acknowledged the traditional owners of the lands on which members were participating both in the meeting and those members on video conference and paid respect to Elders past, present and emerging.

3. The Chair noted that no apologies had been received.

4. The meeting was conducted as a face-to-face in Cairns and a video conference. All scientific members, the QDAF member and observers participated in the meeting via video conference whilst all other members and the Malu Lamar (Torres Strait Islander) Corporation RNTBC (Malu Lamar) observer participated from the Novotel Hotel conference room in Cairns.

1.2 Adoption of agenda

5. The WG adopted the draft agenda without any changes. Members and observers did not object to the meeting being voice recorded for the purposes of developing the meeting record. The recording is deleted once the meeting record is finalised and ratified by the WG.

1.3 Declarations of interest

6. The Chair advised members and observers, that as provided in the PZJA Fisheries Management Paper No. 1 (FMP1), all members must declare all real and potential conflicts of interest in the Torres Strait Beche-de-mer Fishery at the commencement of the meeting.

7. Where it is determined that a direct conflict of interest exists, the WG may allow the member(s) to continue to participate in the discussions relating to the matter but may also determine that, having made their contribution to the discussions, the member should retire from the meeting for the remainder of the discussions on that issue.

8. Declared interests are detailed in **Table 1** below. Each group of members and observers with similar interests were usually asked to leave the meeting to enable the remaining members to:

    a. Freely comment on the declared interests;

    b. Discuss if the interests preclude the members from participating in any discussions; and

    c. Agree on any actions to manage declared conflicts of interest.

   but in this meeting the WG agreed to address any additional conflicts of interest should they arise throughout the discussion of agenda items.

Table 1. Declared interests from each attendee

Name	Position	Declaration of interest
Members		
Anne Clarke	Chair	Previously contracted with Regional Development Australia Far North Queensland and Torres Strait. No pecuniary interests or otherwise.
Tim Skewes	Scientific Member	Independent Consultant. Previously employed by CSIRO. Scientific Member on the Hand Collectables Resource Assessment Group. Has been involved in Torres Strait research for about 30 years as a principal scientist and co-investigator for Torres Strait Scientific Advisory Committee (TSSAC) and TSRA funded projects focused on the sea cucumber, tropical rock lobster, finfish and traditional fisheries in Torres Strait. More recently involved in the 2019-20 sea cucumber survey and assisted with the report on developing options to measure non-commercial fishing in the Torres Strait. No current pecuniary interest in the fishery.
Steve Purcell	Scientific Member	Scientific Member on the Hand Collectables Resource Assessment Group. Lecturer at the Southern Cross University. Has interest in invertebrate fishery research has previously worked in the assessment of sea cucumber fisheries in the Pacific and New Caledonia, and on restocking/sea-ranching research. Specialist in sea cucumber ecology and fisheries. Will be involved in a sea cucumber population survey in New Caledonia to inform the CITES Appendix II listing of black and white teatfish. No other pecuniary interests or otherwise in the TS BDM Fishery.
Michael Passi	Traditional Inhabitant Member Kemer Kemer Meriam	Traditional inhabitant boat (TIB) licence holder and full time BDM operator. Hand Collectables Working Group Member.
Anthony Salam	Traditional Inhabitant Member Kaiwalagal	Traditional inhabitant boat (TIB) licence holder.
Nicholas Pearson	Traditional Inhabitant Member Kulkalgal	Traditional inhabitant boat (TIB) licence holder. TSRA Board Member. Owner of a fishing company that operates in the BDM and TRL Fisheries.
Maluwap Nona	Traditional Inhabitant Member Gudumalulgal	TIB licence holder and full time BDM operator. Chairperson of Malu Lamar; Director of MDW Fisheries Association on Mer; Traditional Inhabitant Member on TSSAC. Applicant on the Torres Strait Sea Claim Part B with other representatives.

Name	Position	Declaration of interest
		Employed as a Case Manager in the Northern Peninsula Area.
Gerald Bowie	Traditional Inhabitant Member Maluialgal	Traditional inhabitant boat (TIB) licence holder.
Selina Stoute	AFMA Member	Employed by AFMA, no pecuniary interests or otherwise
Mark Anderson	Torres Strait Regional Authority (TSRA) Member	Employed by TSRA in the Fisheries and Infrastructure programs, no pecuniary interests as an individual, TSRA holds fishing licences on behalf of traditional inhabitants.
Samantha Miller	QDAF Member	Employed by Queensland Government and working in the Management and Reform Section, managing the East Coast Sea Cucumber and other harvest fisheries in Queensland. No pecuniary interests or otherwise.
Executive officer		
Danait Ghebrezgabhier	Executive Officer AFMA	Employed by AFMA, no pecuniary interests or otherwise
Permanent Observers		
Sereako Stephen	Malu Lamar (Torres Strait Islander) Corporation RNTBC	Malu Lamar Director, TSRA Board Member for TRAWQ, Director on Gur A Baradharaw Kod Torres Strait Sea and Land Council (GBK), Chair of the Ugar Prescribed Body Corporate, Ugar Traditional Owner has previously held TIB fishing licence
Observers and invited industry participants		
Yen Loban	TSRA	TSRA Board Member and Fisheries Portfolio Member
Quinten Hirakawa	TSRA	Employed by TSRA and TIB licence holder with a BDM endorsement.
Keith Brightman	TSRA	Employed by TSRA working on PZJA related matters no pecuniary interests as an individual, TSRA holds fishing licences on behalf of traditional inhabitants.
Ian Butler	Australian Bureau of Agriculture and Resource Economics (ABARES)	Employed by the Australian Bureau of Agricultural and Resource Economics and Science (ABARES), Department of Agriculture, Water and the Environment (DAWE). No pecuniary interests or otherwise.

1.4 Action items from previous meetings

9. The WG noted the progress update provided against action item arising at previous HCWG meetings and that the meeting records for the HCWG Member's meeting on 7 August and the HCWG17 meeting on 12 October 2020 have been finalised and published on the PZJA website.

10. The HCWG noted further updates in relation to the specific action items outlined below:

    a. Item 4 (HCWG16) - *Malu Lamar to take the lead in convening a stakeholder workshop to further discuss and agree on cultural lore and industry agreements with respect to fishing for black teatfish and report outcomes to the HCWG*:

    - HCWG TI members, including new ones, will continue to be involved in this process.
    - The TSRA's Fisheries Advisory Committee is currently seeking advice from GBK on how to proceed given this process needs to be led by Traditional Inhabitants.

2 Working group updates

2.1 Industry members

11. The WG noted the following updates from Industry members.

12. Fishers on Thursday Island and surrounding islands are seeking an update on the process for the review of the current hookah prohibition in the TS BDM Fishery in relation to fishing for white teatfish. Fishers had mixed feelings about the black teatfish opening, they were happy it opened but upset that they couldn’t participate as it was during the TRL hookah season although they understood that there would have been too much effort if the opening had occurred during a TRL hookah closure.
13. Fishers at Mer Island have mainly focussed on prickly redfish and white teatfish and fishers on Erub and Ugar and the Central cluster on curryfish during this fishing season. There have been ups and downs due to the weather but it has been a good season overall. Reporting has been good throughout the year especially the reporting and other management arrangements that were in place during the black teatfish opening earlier this year which worked out really well. Fishers from the eastern cluster landed their catches back at their respective islands while fishers from the central cluster were based on Bourke Island.

14. Fisher members generally approved that AFMA closed the fishery before the 20t TAC was exceeded thus allowing the fishery to potentially remain open. Fishers were concerned that the TAC would be overcaught. Industry members that fished during the opening reported that it was beneficial to have Compliance fisheries officers on ground on Mer Island. As well as enforcing the regulatory arrangements for the opening, the compliance officers also supported fishers and fish receivers with the reporting and licencing requirements to be able to participate in the opening.

15. The Gudamaluylgal Nation was privileged to participate in the black teatfish opening and exercise their cultural protocols. Dories from Saibai and Dauan arrived on Mer Island and met with the Traditional Owners. Fishers were able to make returns for their families in Gudamaluylgal Nation. Gudamaluylgal Nation also supports the concept of lifting the hookah ban to fish for white teatfish as a much needed fishery for everyone. Gudamaluylgal Nation is the only nation that does not have any accessible fisheries at the moment and it is working with the TSRA Fisheries Portfolio Member and others at the moment to have the Western Line closure lifted north of Buru (Turnagain Island). Gudamaluylgal fishers will continue to seek the permission and guidance from relevant Traditional Owners as per protocols as they continue to participate at future black teatfish openings even though the TIB licence does not restrict fishing grounds they can access.

16. Stakeholders in the Maluialgal Nation were not happy about the directness with which fisheries officers on Mer and other islands were boarding and searching some boats and disregarding their privacy. However, on the other hand they were happy about the TAC not being exceeded and fishers complying with maritime safety requirements although some fishers were not fully compliant. There have been complaints about there not being enough buyers during the black teatfish opening and those that where available being mostly based on Mer and Masig Islands.

17. It was discussed that fisheries officers need to be able to visually inspect boats in the course of undertaking their role such as checking for compliance with catch limits and fishing gear/equipment requirements. AFMA has received feedback from some operators from Mer Island

that they found this process confronting and is looking for feedback from Industry members on how fisheries officers might approach fishers when undertaking inspections. Industry members suggested that AFMA consider engaging a liaison officer that is across the cultural protocol during future black teatfish opening compliance operations.

18. Fish receivers based in the central region during the black teatfish opening worked with fishers from Poruma and Masig Islands as well as some that were based on Memey. The weather was a bit rough and therefore not ideal, but they managed to catch a few tonnes. An Industry member commented that some fishers weighed their catch with salt thus overestimating its weight and suggested that AFMA clarify the weighing requirements with industry leading up to the next black teatfish opening.
19. Fishers from Poruma and Iama are not able to fish for curryfish at Dungeness and Warrior at the moment.

20. An Industry member proposed that consideration be given to allowing the use of hookah equipment to fish for curryfish found in deep waters (e.g. at Cumberland) as well as white teatfish.

2.2 Scientific members

21. The WG noted the following updates from the Scientific member, Tim Skewes:

    - The Western Australia sea cucumber fishery has recently received Marine Stewardship Council (MSC) certification for access to the European and North American markets. The Northern Territory and QLD east coast fishing industry is in the process of pursuing MSC certification. The TS BDM Fishery is in a good position to pursue this accreditation once the stock status of key species in relation to the limit reference point has been addressed.
    - He is assisting the Seychelles Government with a white teatfish and prickly redfish stock assessments. Stocks in the Seychelles are mostly now found in deeper water as the shallow reefs have been fished out.

22. The WG noted the following updates from the Scientific member, Steve Purcell:

    - There are new proposals lodged with CITES to consider listing for Thelenota species (prickly redfish, amberfish, lemonfish, candycane fish (*T. rubralineata*)) but there is not much data available to support the listing evaluation.
    - Currently involved in fisheries assessment in New Caledonia which include undertaking underwater surveys to determine stock size. Advice from the Sea Cucumber Assessment Group that fishers have moved north to new grounds and are targeting leopard fish (medium value species). Fishers in the north of the territory have been particularly active as stock in the southern grounds have been depleted. This is an interesting study as New Caledonia is one of the few fisheries that seems to have a sustainable sea cucumber fishery in the region and has some parallels with the BDM fishery and the east coast sea cucumber fishery.
    - Started a project with the World Food Organisation that includes undertaking a market study in China to provide information on the price of all sea cucumber species harvested in the Torres Strait which may be useful information for the fishery. Someone from Honk Kong will be commissioned to collect the price information.

2.3 Government Agencies

23. The WG noted the Communique from the Queensland Sea Cucumber Fishery Working Group's meeting on 23 August 2021 and the verbal update provided by the QDAF Member, Samantha Miller:
    - Harvest Strategy updates for a number of fisheries are now available on the Fisheries Queensland website.
    - The Queensland Sea cucumber and Coral sea fisheries are currently undergoing a challenging Wildlife Trade Operation approval process in relation to some of the requirements being proposed and the tight timeframes for meeting the requirements which include:
        - determining appropriate minimum size limits and conversion ratios
        - establishing supply chain of evidence documentation
        - interpretation of stock assessments
    - economic data is available for Queensland fisheries but it has been challenging to publish data for small fisheries due to confidentiality considerations.
    - Queensland fisheries is seeking to employ an Indigenous fisheries manager and requested that AFMA and TSRA distribute the job advert to appropriate organisations within their network.

24. The WG noted the following TSRA update provided by the TSRA Member:
    - Zenadth Kes Fisheries was established as of Dec 2020 comprising 25 members, which is made up of 5 members from each Cluster Nation and 5 Board Members. The Chair of the Board is Mr Yen Loban (currently also the TSRA Board Fisheries Portfolio Member). Zenadth Kes Fisheries will be looking to monetise and increase the value of the fishery across the next 5-10 years.
    - The TSRA Chair has formed a Fisheries Advisory Committee made up of seven committee members that are also TSRA Borad members. Mr Yen Loban and Mr Nicholas Pearson are Chair and Vice Chair of the committee, respectively, and the rest of the membership consists of a TSRA Board member representative from each Cluster Nation. The committee's role is to provide advice from their communities to the TSRA.
    - At the PZJA level, TSRA is developing a 5-year action plan in partnership with the TSRA Fishery Advisory Committee working towards a long held aspiration of Torres Strait Islanders of 100% ownership of all Torres Strait fisheries and developing actions towards 100% utilisation of the fisheries.
    - The Wapil Project (employment and training project) was paused over the last 12 months due to travel restrictions and inability to do certain things but it is planned to resume and negotiations are underway with Prescribed Body Corporates (PBC) on locations to extend the program to Gudamaluylgal Nation which may tie in with opening the top western line closure.
    - There is some interest in Badu with an established factory which is already operating.
    - Commenced detailed conversations with the Ugar PBC regarding aquaculture, BDM being one of their species of interest – with some communities in the Central cluster also showing interest
    - TSRA has approached Scientific Members on the Torres Strait Scientific Advisory Committee for their advice on how to pursue aquaculture opportunities across all Torres Strait Fisheries which has yielded some promising contacts.

25. The WG noted the written update provided by AFMA, including:
    - Progress to date against the nine WTO conditions for the BDM Fishery that will be provided to DAWE in November 2021 as part of the annual reporting requirement. The WTO conditions for the BDM Fishery include additional requirements that need to be met by the PZJA in managing the harvest of black and white teatfish, species listed under Appendix II of CITES.
    - An update on the status of proposed amendments to the *Torres Strait Fisheries Act 1984* and the *Torres Strait Fisheries Regulations 1985*, which includes an amendment to provide for catch

reporting across all licence holders to allow for the implementation of mandatory logbook reporting by the TIB sector.

- The launch of electronic catch disposal records (eCDRs) as part of the mandatory fish receiver system which provides fishers with a fast and easy way to electronically report received catch information to AFMA.

2.4 Native Title

26. The WG noted an update on the progress of Malu Lamar's request to become a member on the PZJA and advisory groups, the TSRA member advised that progress is underway to consider options on achieving this and working through the implications and significance of individual Director/Board members agreeing to recommendations that would require broader notification.

27. In response to a question about how information from Malu Lamar meetings is disseminated, the Malu Lamar Chairperson explained that this is supposed to occur through the PBC Chair of each Island and the GBK representatives. The TSRA also facilitates industry engagement and communications of outcomes through cluster visits with PZJA Traditional Inhabitant members.

28. Malu Lamar is under resourced and not able to engage with individual fishers on meetings outcomes but there is a process underway to secure funding to facilitate better engagement.

2.5 PNG National Fisheries Authority

29. The WG noted that although invited to the meeting, officials from the Papua New Guinea National Fisheries Authority were not in attendance to provide a further update to the background information on the PNG BDM fishery provided by AFMA in the agenda paper.
30. The WG further noted the reports from the Torres Strait Treaty Traditional Inhabitant Meeting held on 9 September 2021 and the Torres Strait Treaty Joint Advisory Council Meeting held on 10 September 2021.

3 Black teatfish trial opening 30 April – 3 May 2021 and future opening

31. The WG noted the update on the outcomes of the black teatfish trial opening on 30 April – 3 May 2021 and considered the HCRAG's draft recommendation on future black teatfish openings as outlined in the agenda paper. The WG also considered Dr Eva Plaganyi's presentation of the CSIRO analysis of the data collected during the black teatfish opening and the outcomes of the updated population modelling to include black teatfish catch data from the opening.

CONDITION 5 - If the Trial TAC is exceeded by more than 5%, then the fishery is automatically paused (i.e. no fishing allowed) for the following year

32. The WG noted that as the 20t TAC was not exceeded (total catch was 17.62t), the harvest strategy recommendation that the fishery automatically pause for the following year if the TAC is exceeded by 5 per cent does not apply.

CONDITION 6 - Was data collection during the trial conducted satisfactorily?

33. The WG agreed that data collection during the trial was conducted satisfactorily based on the HCRAG's advice on the reliability of the total catch reported and the results of the CSIRO analysis of the data. However, the voluntary reporting of area and effort information needs to improve

significantly. This is particularly relevant in light of the large amount of black teatfish catch that did not include corresponding location information.

34. The WG noted industry member comments that this catch is most likely from the Cumberland and Warrior areas and it should be followed up with the relevant fishers and fish receivers.

35. The WG noted that it is highly unlikely that there is damaged product that was discarded but not captured in the catch report due to the hardy nature of black teatfish as well as the daily catch landing and reporting requirements that applied during the opening. However, there is a provision in the CDRs to capture data on unmarketable catch due to damage.

CONDITION 7 - Noting the TAC was not exceeded and reliable data were collected, the data needs to be analysed to review the TAC and potential for the fishery to stay open in the future, or be re-opened periodically after a pre-specified interval

36. The WG supported HCRAG's advice and **recommended** a black teatfish opening in 2022 with a 20t TAC. In making this recommendation, the WG considered the outcomes of the updated CSIRO population modelling which confirmed that a 20t TAC is sustainable and would not lead to a consistent decline in black teatfish biomass after the first year of fishing. In contrast the modelling found that catches of 30t could lead to a gradual depletion of the stock.

37. The WG also took into account industry member advice to ensure that all catch data continues to be captured during future openings.

38. Industry members discussed that closing the trial opening with a 2.4t residual TAC, whilst not ideal economically in the short term, was important to support the sustainability of the fishery to ensure that the competitive TAC was not overcaught given fishing effort can increase substantially.

39. The current BDM harvest strategy does not provide for the carryover of a rebuilding species, such provisions would need to be formulated and tested carefully before they can be considered for future openings.

40. The Queensland Member emphasized to the WG the need to be precautionary in setting a TAC for black teatfish. The east coast sea cucumber fishery is struggling to demonstrate to the Department of Environment why its black teatfish catch limit of 30t is acceptable and currently does not have a positive non-detriment finding, and hence a WTO approval, for the species.

Economic viability of current licencing arrangements

41. The WG discussed the HCRAG's recommendation for it to consider the performance of the current licencing arrangements in the fishery given industry's concern about the economic viability of the fishery. Amongst other things, this may entail separating the licencing system for commercial and traditional fishing (noting traditional fishing does not require a licence). The WG commented that industry guidance is required to progress this issue and supported for the discussion to commence at an industry workshop ahead of the next black teatfish opening. Industry members supported this approach, including running the meeting with AFMA's support and with a standing invite for Malu Lamar.

CONDITION 8 - Additional data to be collected during future openings

42. The WG discussed ways in which voluntary area and effort reporting in catch disposal records (CDRs) by fishers can be improved while AFMA progressed the legislative amendments required to facilitate logbook reporting for the TIB sector. These include:
    - ongoing education and engagement of individual fishers and fish receivers through workshops to reinforce the reporting system.
    - develop and engagement strategy for non-full time fishers that are either unfamiliar with the reporting requirements or may not understand the importance of providing the voluntary information.

43. The TSRA member sought the WG's endorsement to undertake a sea cucumber scientific stock survey in 2022/23.

4 Applying the harvest strategy to review total allowable catches (TACs)

44. The WG considered TACs for the 2022 fishing season commencing on 1 January 2022, in line with the BDM harvest strategy tiers and decision rules and taking into account new data and information available for the fishery since the harvest strategy was implemented and the HCRAG's recommendations that:
    - changes are not required to the current TACs for the 2022 fishing season.
    - that the basket trigger for curryfish vastus be increased to 30t in light of the additional information available for the species and the survey results indicating a more even relative abundance with curryfish herrmanni.

45. The WG further noted the HCRAG's advice that all species remain in the low tier of the harvest strategy as a transition to middle tier requires at least two primary indicators and is not applicable during the initial years of harvest strategy implementation as insufficient detailed historical fishery data are available. For the high tier to apply a time series of high-quality species-specific surveys together with a reasonable level of catch is required.

46. Given the large number of species, the working group agreed to focus on the select species below, which were also assessed by the HCRAG, with the rest of the species to be considered at the next meeting:
    - White teatfish (target species)
    - Prickly redfish (target species)
    - Deepwater redfish (target species)
    - Hairy blackfish (target species)
    - Curryfish herrmanni (common) and Curryfish vastus (curryfish basket species)
    - Lollyfish (basket species)

White teatfish

47. The WG noted the HCRAG's assessment outlined in the species assessment sheet (SAS) and:
    - did not recommend any changes to the white teatfish TAC in 2022

- noted the HCRAG's recommendation that it continue to consider the review of the current hookah prohibition in relation to white teatfish and undertake further community consultation on management arrangements that would support sustainable harvesting of white teatfish.

Prickly redfish

48. The WG noted that the prickly redfish TAC for 2020 was slightly overcaught although not enough to trigger the application of the overcatch rule in the harvest strategy. The WG further noted the HCRAG's assessment of the species in the SAS, including advice to review the TAC if the species continues to be overcaught. The WG did not recommended any change to the prickly redfish TAC in 2022.

49. The stock is not considered to be at risk however Industry members commented that allowing hookah use to target deepwater sea cucumber species may help alleviate the pressure from frequently targeted species such as prickly redfish and optimise the value of the fishery. Targeting the same areas due to weather considerations may also have an impact on specific size classes and the industry more broadly may consider rotating their harvest of the species as practiced by Mer Island fishers. In addition to this, the industry might also need to do more work in finding markets for basket species.

50. The WG did not recommend any changes to the prickly redfish TAC in 2022.

Curryfish basket

Curryfish common (S. herrmanni)

51. The WG noted Scientific Member Tim Skewes' advice that recent survey trend indicates a decline in the density of curryfish common compared to previous years, however the biomass estimate is somewhat conservative as it does not include the central zone which wasn't surveyed but where there are known to be a significant biomass of curryfish. The surveyed areas predominantly consisted of large individuals, consistent with previous surveys and experience in the Pacific as it is rare to find juveniles. Part of it can be explained because small curryfish are cryptic and hide to avoid predation. They might also have a big interval between recruitments to the fishery.

52. Industry members advised that they mainly find curryfish at the top of the shallows at Dungeness and Warrior reef.

Curryfish vastus (S. vastus)

53. With regards to the HCRAG's recommendation to double the curryfish vastus trigger limit, the WG sought clarification from the HCRAG on the basis for the increase. The WG **recommended** that the HCRAG revisit its advice given the modest standing stock biomass from the survey, relative to the 60t TAC for the curryfish basket. The WG sought further detail from the RAG to justify its recommendation to increase the trigger limit. The WG also noted that the approach to managing curryfish with a basket TAC may need to be reviewed.

54. Industry members advised that they do not encounter much curryfish vastus near Dungeness (~400kg per fishing event) and tend to process curryfish differently depending on the area they are from due to size differences.

55. The WG did not recommend any changes to the curryfish basket TAC or the curryfish vastus trigger limit in 2022. The WG agreed that species differentiation of reported curryfish catches needs to improve.

Lollyfish

56. The WG noted the decline in reported lollyfish catches over the last few fishing seasons and the HCRAG's recommendation to AFMA to work with Poruma fishers to better understand fishing practices for the species. Industry members commented that fishing for this species had traditionally started as a source of income for women and children on the Island. Catches increased significantly as a buyer(s) offered attractive prices. Prices at landing have since dropped.

57. The WG did not recommend any changes to the lollyfish trigger limit in 2022.

Deepwater redfish

58. The WG noted the ABARES observer's comments that deepwater redfish was assessed individually as part of the annual ABARES Fishery Status Reports and the TAC for this species seems high relative to the standing stock biomass from the survey. The priority level for the ABARES assessment increased following its removal from the basket when the BDM harvest strategy was implemented in January 2020.

59. The WG did not recommend any changes to the deepwater redfish TAC in 2022 and **recommended** that the HCRAG review the TAC in light of the biomass results from the survey.

Hairy blackfish

60. The WG noted the ABARES observer's comments that hairy blackfish was assessed individually as part of the annual ABARES Fishery Status Reports and the TAC for this species seems high relative to the standing stock biomass from the survey. The priority level for the ABARES assessment increased following its removal from the basket when the BDM harvest strategy was implemented in January 2020.

61. The Scientific member Tim Skewes commented that the scientific survey was not able to find many hairy blackfish due to their patchy distribution. They are a highly aggregating and cryptic species but can be found on Warrior Reef. Warrior Reef was not included in the 2019-20 survey.

62. The WG did not suggest any changes to the hairy blackfish TAC in 2022 and **recommended** that the HCRAG review the TAC in light of the biomass results from the survey.

5 Management

5.1 Management options for the utilisation of white teatfish

63. The WG considered the AFMA agenda paper seeking its advice on the:
    a. relative priority of directing management resources to develop advice to the PZJA on management options to support the utilisation of the white teatfish TAC.
    b. key considerations for assessing management options to help guide discussions with broader stakeholders; and

   c. draft workplan proposed by AFMA to develop these management options.

64. In discussing this item, the WG noted the ongoing industry request to review the hookah prohibition to be able to fish in deeper water and further developments since it had last considered this matter, which include:
    i. the recent stock survey of sea cucumbers in east Torres Strait undertaken by CSIRO has confirmed previous understanding that white teatfish are a deeper water sea cucumber species. The survey found that over 75% of the stock is found in the deep water strata (>20 m deep), though none were found beyond 36m.
    ii. white teatfish was listed on appendix II of CITES meaning the harvest and export of the species is subject to additional requirements including a seasonal TAC limit of 15t and any increase would need to be demonstrated not to be detrimental to its survival in the wild.
    iii. the HCRAG recommended that:
        1. stock assessment modelling be undertaken for white teatfish in light of the recent scientific information to inform current management arrangements for the species such as the TAC.
        2. The WG continue to consider the review of the current hookah ban in relation to the species and undertake further community consultation on management arrangements that would support sustainable harvesting of white teatfish using hookah.

a) Relative priority of directing management resources to develop advice to the PZJA on management options to support the utilisation of the white teatfish TAC.

65. The WG **recommended** that the assessment and development of management options for the utilisation of white teatfish is a high short-medium term priority for the fishery requesting AFMA consider directing resources towards this management activity.

b) Key considerations for assessing management options to help guide discussions with broader stakeholders.

66. The WG noted that industry's preferred options for utilising the white teatfish TAC require the use of hookah equipment to access deeper waters and the advice put forward by industry and communities during consultations on how these options might be implemented include:
    - Allowing the use of hookah to fish for white teatfish only.
    - Allowing the use of hookah to fish for white teatfish only and in certain areas.
    - Having a designated white teatfish hookah fishing season which may potentially involve closing fishing to all other BDM species.
    - Trialling fishing for white teatfish using hookah with one fisher per community.

67. The WG further considered the AFMA Member's advice that the development and implementation of these options (and any other options that may be identified) is likely to be complex due to:
    - divided views among stakeholders on the use of hookah equipment in the BDM Fishery generally.
    - the potential impact of options on the performance of broader management objectives. The BDM Fishery is open access to traditional inhabitants. TACs are fished competitively by licence

holders and input controls are in place to constrain fishing efficiency. In doing so, the catch per unit of effort by a fisher is constrained allowing the TAC to be shared by relatively more fishers. These same arrangements however place a regulatory barrier to fishers being able to fully take the TAC of the white teatfish; and
- the feasibility (inclusive of cost) of implementing, monitoring, and enforcing different options (for example allowing the use of hookah equipment in certain areas, by certain fishers and for certain species only).

68. The WG discussed that any option to use hookah equipment to fish for white teatfish would require more real time monitoring arrangements (boat level monitoring such as VMS, electronic monitoring, compliance officers) to ensure compliance with rules and avoid any unintended impacts on sea cucumber stocks. The components of each management option and the nature of those components (e.g. spatial, temporal or boat level effort controls) will determine the complexity and combination of the associated monitoring and compliance tools, with more elaborate management options (e.g. fishing in certain areas by certain fishers and for certain species only) requiring more complex monitoring and compliance arrangements. Any management option will therefore need to be assessed in light of the key monitoring and enforcement considerations associated with each option.

69. The WG discussed that the management options developed by industry will still need to be consistent with the objectives of the *Torres Strait Fisheries Act 1984* and the objectives adopted by the PZJA for the Torres Strait BDM Fishery, as outlined in the agenda paper. However, it is important for industry to be aware of the trade-offs as different management options will perform differently against the objectives in light of the management arrangements that are in place for the BDM Fishery.

c) draft workplan proposed by AFMA to develop these management options.

70. The WG noted the draft workplan and indicative timeline proposed to develop and implement the management options to support the use of hookah to fish for white teatfish. This included the administrative and consultative processes required to seek PZJA approval on the preferred management option and review the management instrument for the fishery to allow the use of hookah equipment, which is currently prohibited.

71. The WG **recommended** an industry workshop be held to enable industry to develop its preferred management options while acknowledging the need for AFMA's assessment of the administrative feasibility of the preferred management option(s). The WG discussed the benefit of Traditional Inhabitant members on the WG and HCRAG meeting in early 2022 initially to develop potential management options and associated monitoring and compliance considerations to provide to the workshop. The WG was of the view that this would be of limited benefit to progress this issue given discussions held to date and could potentially delay the industry workshop due to other management commitments scheduled for Torres Fisheries. The WG also saw the benefit in having broader industry stakeholder input in the development of the management options.

72. The WG took the advice of WG TI members to assist AFMA with the workshop by taking carriage of nominating participants and facilitation similar to the black teatfish industry workshop held in February 2021.

73. The WG noted a recommendation from an industry member to invite TVH operators from the TRL Fishery to advise industry participants on the workplace safety considerations of using hookah equipment.

5.2 Torres Strait Fisheries (Beche-de-mer) Management Instrument

74. The WG considered the draft new legislative instrument proposed by AFMA to replace the current legislative instrument, the *Torres Strait Fisheries Management Instrument No. 15*, made under section 16 of the Torres Strait Fisheries Act 1984 (the Act). The new management instrument is being proposed to reflect updated management arrangements in the BDM fishery, to meet current legislative drafting styles and to ensure consistency with provisions in other Torres Strait Fisheries, including:
    a. Implementation of new size limits prescribed in the BDM harvest strategy.
    b. Strengthening current hookah gear/equipment restrictions to improve enforceability and maintain the integrity of the existing requirements by clarifying any ambiguity that may arise in relation to whether sea cucumber was caught with the use of prohibited equipment. This is especially relevant during limited fishery openings of previously closed species such as black teatfish.
    c. Additional exemption to allow for persons without a boat to fish in the BDM Fishery provided they are appropriately licenced under subsection 19(4A) of the Act. The WG noted that AFMA will need to consult with stakeholders on the design of the actual licencing arrangements that would apply to ensure they are fit for purpose. This includes ensuring that any licencing arrangements are consistent with the objectives of the Act to promote economic development in the Torres Strait area and employment opportunities for traditional inhabitants. The WG **agreed** to discuss this issue at the BDM industry workshop.
    d. Removing provisions in subclauses 8.1(a)(b) and (c) of the current instrument as the original purpose is unclear (no record of a PZJA decision and not discussed in the Explanatory Statement for the current Instrument) but appears inconsistent with the current understanding in the fishery that a licence is required to commercially fish and that licenced commercial fishers are not restricted to the number of sea cucumber they can have in their possession. The exemption basically states that anyone can take sea cucumbers with or without the use of a boat provided they stick to the limits specified in the instrument.
    e. Remove provisions for activities that are outside of the PZJA's remit (e.g. traditional fishing) and/or create administrative burden (e.g. instrument cessation date as the PZJA can review legislative instruments at any time if required).

75. The WG **recommended** that AFMA seek Malu Lamar's comments on the proposed new instruments as the Native Title representative body that holds native title rights, including commercial fishing rights, covering most of the waters of the Torres Strait Protected Zone. The WG **recommended** that AFMA provide Malu Lamar a one month consideration period.

    ACTION – AFMA to seek Malu Lamar comments on the proposed new instrument.

76. The WG did not have any further comments on the rest of the proposed changes to be implemented via the new Instrument, Torres Strait Fisheries (Beche-de-mer) Management Instrument 2021.

5.3 Ecological Risk Assessment for the BDM Fishery

77. The WG noted the draft results of the CSIRO Ecological Risk Assessment for the Effects of Fishing (ERA) on the Torres Strait BDM Fishery (ERA) as outlined in the draft report. The draft ERA assessed all direct and indirect impacts to and of the BDM Fishery as having either minor or negligible scores and the overall risk for the ecological impacts for the effects of fishing and external activities is low. The assessment outcome was based on the scale and nature of the fishery as well as available survey data. Fishing for sea cucumbers is very selective as done by hand collection. There is no by-catch or by-product. The assessment concluded that the direct ecological impact on the benthos from harvesting the species is low.

78. The WG noted that the HCRAG provided some comments for the ERA project team to consider when finalising the ERA and understood that in doing so the assessment outcomes are not expected to change. The WG noted the draft ERA did not identify any moderate-high risks, that all ecological components were eliminated at Level 1 and no specific ecological risk management strategy is required.

79. The WG noted the clarification that golden sandfish is classified as a secondary commercial species in the ERA as it comprises less than 20% of the annual average catches for the fishery for the assessment period (2016-2020) (and not based on value). The WG briefly discussed golden sandfish as a species of interest given the endangered status of stocks globally and the lack of a biomass estimate from the recent BDM stock survey as the species is known to be rare in the area of east Torres Strait that was surveyed. The species is known to occur in the western region of the Torres Strait in high aggregations due to its distinct habitat preferences so there may be some data for the species from Tropical Rock Lobster surveys, but its status remains relatively unknown. The direct impacts of fishing on the species in the context of the ERA assessment are likely low as there have been no reported catches of the species in the 2020 and 2021 fishing seasons and previous reported catches have remained well below the conservative 0.5t basket trigger limit for the species.

80. The WG **recommended** that the HCRAG assess golden sandfish in line with the BDM Harvest Strategy at a future meeting.

6 Research priorities

81. The WG considered the information provided on the status of identified research priorities and needs for the BDM Fishery, and on the TSSAC research funding process, including funding available for the 2022/23 financial year. The WG also considered the additional analysis and sampling needs identified by the HCRAG to address some of the key data gaps that exist in the fishery. The WG reviewed all identified research needs and priorities as outlined in Table 1, taking into account HCRAG's advice on priorities.

82. With regards to the collection of socioeconomic data, the WG **recommended** that

a. this research need is a high priority noting Industry members' strong support for this work to address the large socioeconomic knowledge gap in the fishery.
b. As per HCRAG's recommendation, the scope development of a socio economic analysis of the fishery needs to be informed by AFMA's review of CDR participation data to date, by social science expertise and HCRAG and WG advice before it is finalised.

83. The WG acknowledged Scientific member Steven Purcell's extensive experience conducting socioeconomic studies in Pacific Island fisheries that has informed the management of those fisheries. The WG invited Dr Purcell to present at future meetings of the WG and the HCRAG on his work.

ACTION – Scientific member Steven Purcell to present at future meetings of the WG and HCRAG his work on socioeconomic studies and how they have informed fisheries management.

7 Other business

84. There was no other business nominated for discussion.

8 Future priorities and date for the next meeting

85. The WG noted that the agenda paper on future priorities captures items previously identified and endorsed by the WG, as well as a progress update against each item. The WG also noted that the next WG meeting is tentatively scheduled for June-July 2022.

86. The Chair thanked all members and observers for their contribution to a productive meeting. The Chair and members acknowledged and thanked the outgoing AFMA member and Senior Manager of Torres Strait Fisheries, Selina Stoute for all her work in and contributions to Torres Strait Fisheries.

87. Mr Sereako Stephen closed the meeting at 12:10pm in Prayer.

Table colour key	Completed	Scoped and/or costed	Not scoped/not costed

Table 1. Overview and status update of research needs identified or discussed for Hand Collectable Fisheries at previous HCWG meetings and the rolling five-year research plan including HCRAG's recommendations and assigned priorities from its meeting on 6-7 October 2021.

	Research activity	**Detail**	**Status**	**Comments/questions**	**HCRAG priority**	**HCWG priority and comments**
1	Status of BDM stocks in relation to harvest strategy reference points	Consistent with the BDM harvest strategy and where there is sufficient information available, a tactical research project is needed to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible.	Not scoped/not costed		**High priority**	Scope of the project requires further consideration by the HCRAG.
2	White teatfish modelling	Additional analysis on white teatfish to develop a rationale on the status of the stock in relation to harvest strategy reference points and modelling analysis on a sustainable TAC increase.	Not scoped/not costed		**High priority**	**High priority.** Estimate cost 60,000 (as per cost of similar projects for other species e.g. Spanish mackerel)
3	Black teatfish sampling	Representative sampling to collect size and weight frequencies during the black teatfish openings.	Not scoped/not costed		**High priority**	**High priority.** Estimated cost 40,000 – 80,000 depending on the level of work required (as per cost of similar projects for

	Research activity	Detail	Status	Comments/questions	HCRAG priority	HCWG priority and comments
						other species e.g. Spanish mackerel)
4	Development of curryfish conversion ratios	Project to develop conversion ratios for curryfish with industry undertaking the sampling process.	Scoped and costed $12,000	Full proposal developed and allocated funding in 2019/20 but did not proceed due to COVID-19.	**High priority**	**High priority.**
5	Sandfish stock survey	Outstanding stock survey of Sandfish at Warrior Reef to better understand its status	Not scoped/not costed	Identified as a research need for the fishery by HCWG17 at its meeting 12 October 2020. Was part of the 2019-20 stock survey but did not proceed.	**High priority** subject to confirmation of support from Iama and Tudu Island PBC, GBK, Traditional Owners and fishers.	**High priority.** Contingent on support from Iama and Tudu Traditional Owners which have already indicated through TSRA that they support a sandfish survey and this advice being provided to the HCRAG. Estimated cost 150,000.
6	Black and white teatfish follow up surveys	Follow up black and white teatfish surveys focusing on specific areas and potentially including areas not surveyed previously such as south east TSPZ, barrier and deep-water strata.	Not scoped/not costed	The RAG will initially need to determine what is required, other than an independent survey, to meet the WTO requirement to provide a revised population estimate.	**Medium term priority**	**Supported** post another black teatfish opening. Estimate cost 290,000 (based on last survey).
7	Socio-economic	Collecting data on socioeconomic indicators for	Not scoped/not costed	Identified as a research need for the fishery by HCWG17 members.	**Medium term priority** and update the current wording to reflect RAG advice.	**High priority.** Subject to:

	Research activity	Detail	Status	Comments/questions	HCRAG priority	HCWG priority and comments
		the fishery through recall surveys.			Research scope and survey design and development to be: • Informed by AFMA's review of CDR participation data to date and by social science expertise • further considered by the HCRAG	• further HCRAG advice on the scope and additional work to be done to support it. • more clarity on questions being asked, data required and indicative cost. Project may fall within the remit of ACR.
8	Management Strategy Evaluation (MSE) of the Beche-de-mer Harvest Strategy	1. Collate all data and biological information; 2. Update and extend the spatial multispecies TS BDM operating model developed earlier (or construct a new model); 3. Use MSE to evaluate how well the HS achieves the pre-specified objectives; 4. In consultation with stakeholders, use the MSE framework to investigate ways to improve the current HS.	Not scoped Est cost – $130k	Identified as an essential research priority by HCWG in the rolling five-year research plan for Hand Collectable Fisheries. Requires 3-5 years of BDM HS implementation.	**Medium priority** and to be held off until the harvest strategy has been in place for a few years.	Interacts with no.1
9	Supply chain	Better understanding of the supply chains as per other fisheries to better understand	Not scoped/not costed		**Not prioritised**	

	Research activity	Detail	Status	Comments/questions	HCRAG priority	HCWG priority and comments
		vulnerabilities and help develop an industry that is resilient to fluctuating export market conditions.				
10	Exploring sea ranching/re-seeding opportunities		Not scoped/not costed	Identified as a key research need for the fishery by HCWG Traditional Inhabitant members. Industry initiated pilot project currently underway on Ugar.	**To be removed from the research plan** - Aquaculture falls outside the remit of the PZJA. PZJA can provide support through provision of information and permitting collection of broodstock. With regarding to Sandfish aquaculture, the PZJA will initially want to establish the status of the sandfish stock on Warrior reef.	Noted
11	Ecological Risk Assessment (ERA) – Torres Strait Pearl Shell Fishery	Conduct an ERA for the Torres Strait Pearl Shell (TSPF) Fishery	Not scoped Est cost - $20,400	Identified as an essential research priority by HCWG in the rolling five-year research plan for Hand Collectable Fisheries	**To be remove from the research plan** as there is no fishing activity and therefore no immediate ecological risk.	**To be retained in research plan** and activated when fishing for pearl oysters commences. There is some information on Pearl shell stock estimates from Tropical Rock Lobster surveys**.**
12	Understanding biological parameters of BDM species,	Identifying gaps in knowledge of biological parameters of BDM species and	Not scoped/not costed	Identified as an essential research priority by HCWG in the rolling five-year research plan for Hand Collectable	Low priority and proposed that it be addressed as the need arises.	There are conservative proxies that are best addressed through

	Research activity	Detail	Status	Comments/questions	HCRAG priority	HCWG priority and comments
	including growth, mortality, size and breeding seasonality	investigating options for collaborative research		Fisheries Requires further scientific advice.		other avenues such as University students.
13	Stock Status Survey	To undertake a stock survey of all Torres Strait beche-de-mer species with a focus on deeper water species	Completed in 2019 - 2020	Final report identified research needs that the HCRAG may want to consider further	N/A	
14	Ecological Risk Assessment (ERA)	Conduct an ERA for the TSBDM Fishery	Draft completed on 30 June 2021.	Needs to be completed by January 2022 to meet WTO condition 5 for the fishery.	N/A	
15	Climate Change impacts and vulnerability	Scoping study across all Torres Strait	Completed	Final report made recommendations for further research	N/A	
16	Data analysis	Further analysis of catch data collected during the 2021 trial reopening of black teatfish to inform future openings and follow up work from the stock survey.	Completed	HCWG identified this as the highest research need for the BDM Fishery. CSIRO completed the black teatfish catch data analysis from the 2021 opening and updated the modelling to inform future opening and TAC.	Completed	

Summary of actions arising from HCWG18

Action item	Responsibility
AFMA to seek Malu Lamar comments on the proposed new instrument proposed by AFMA to replace the current legislative instrument, the *Torres Strait Fisheries Management Instrument No. 15*, made under section 16 of the Torres Strait Fisheries Act 1984 (the Act).	AFMA
Scientific member Steven Purcell to present at future meetings of the WG and HCRAG his work on socioeconomic studies and how they have informed fisheries management.	Steve Purcell

Summary of HCWG18 recommendations

Agenda item #	Recommendation
3	The WG supported HCRAG's advice and **recommended** a black teatfish opening in 2022 with a 20t TAC, considering: • the outcomes of the updated CSIRO population modelling which confirmed that a 20t TAC is sustainable and would not lead to a consistent decline in black teatfish biomass after the first year of fishing. In contrast the modelling found that catches of 30t could lead to a gradual depletion of the stock. • industry member advice to ensure that all catch data continues to be captured during future openings.
4	The WG **recommended** that the HCRAG revisit its advice given the modest standing stock biomass from the survey, relative to the 60t TAC for the curryfish basket. The WG sought further detail from the RAG to justify its recommendation to increase the trigger limit.
4	The WG did not recommend any changes to the deepwater redfish TAC in 2022 and **recommended** that the HCRAG review the TAC in light of the biomass results from the survey.
4	The WG did not suggest any changes to the hairy blackfish TAC in 2022 and **recommended** that the HCRAG review the TAC in light of the biomass results from the survey.
5.1	The WG **recommended** that the assessment and development of management options for the utilisation of white teatfish is a high short-medium term priority for the fishery requesting AFMA consider directing resources towards this management activity.
5.1	The WG **recommended** an industry workshop be held to enable industry to develop its preferred management options for the utilisation of white teatfish, while acknowledging the need for AFMA's assessment of the administrative feasibility of the preferred management option(s).
5.2	The WG **recommended** that AFMA seek Malu Lamar's comments on the proposed new instruments as the Native Title representative body that holds native title rights, including commercial fishing rights, covering most of the waters of the Torres Strait Protected Zone. The WG **recommended** that AFMA provide Malu Lamar a one month consideration period.
5.3	The WG **recommended** that the HCRAG assess golden sandfish in line with the BDM Harvest Strategy at a future meeting.

Agenda item #	Recommendation
6	With regards to the collection of socioeconomic data, the WG **recommended** that: a. this research need is a high priority noting Industry members' strong support for this work to address the large socioeconomic knowledge gap in the fishery. b. As per HCRAG's recommendation, the scope development of a socio economic analysis of the fishery needs to be informed by AFMA's review of CDR participation data to date, by social science expertise and HCRAG and WG advice before it is finalised.

List of attachments

Attachment A – Presentation on the results of the CSIRO analysis of data reported during the opening

Attachment B – Meeting Agenda

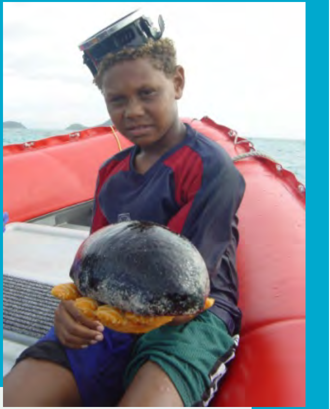
Torres Strait bêche de mer fishery: black teatfish trial re-opening

Éva Plagányi, Nicole Murphy and Timothy Skewes

HCRAG| October 2021

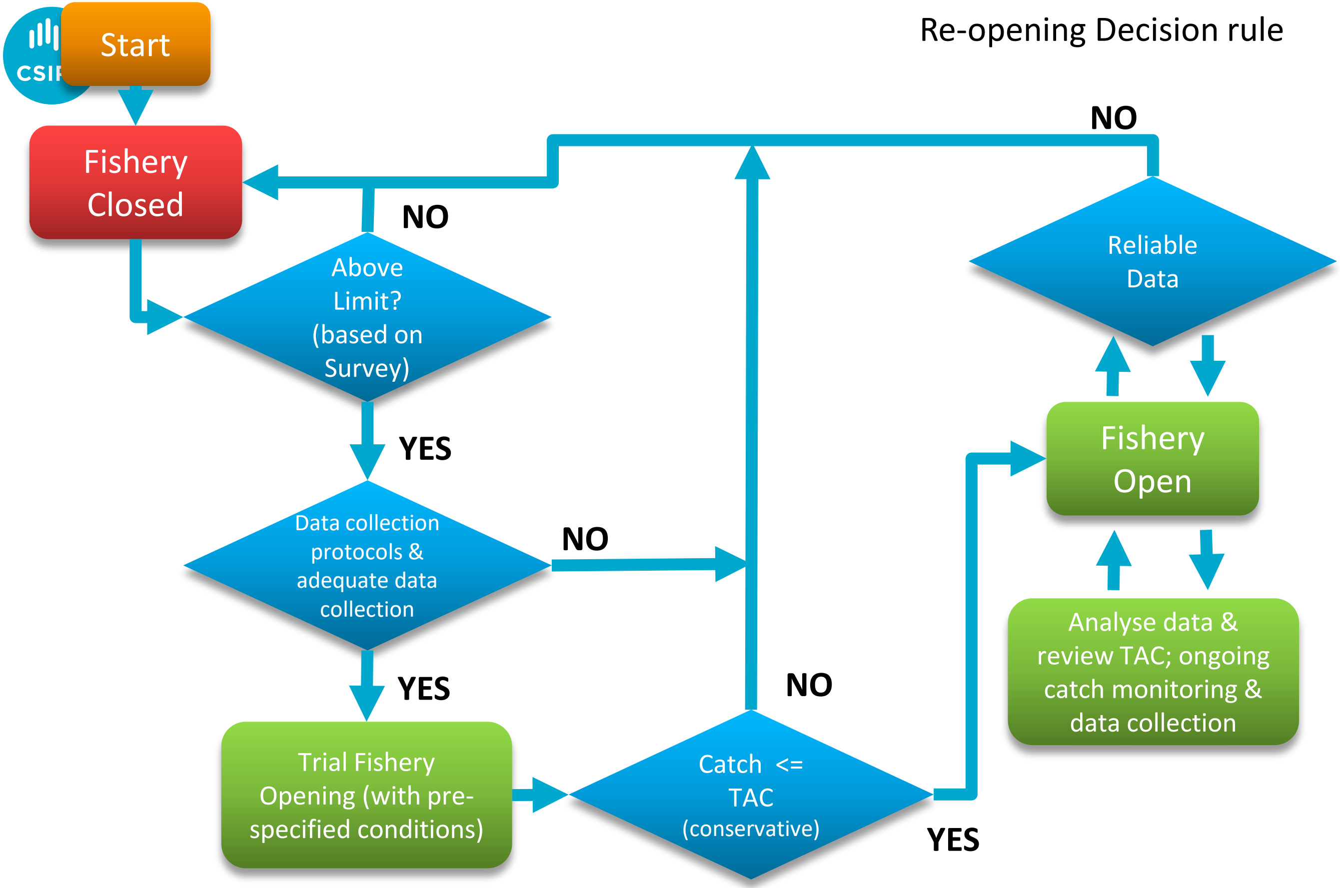
Australia's National Science Agency

Black teatfish 'Pauraber or Goleh-Golher Pauraber'



CSIRO acknowledges the Traditional Owners of the land, sea and waters, of the area that we live and work on across Australia. We acknowledge their continuing connection to their culture and we pay our respects to their Elders past and present

Re-opening Decision rule



Start

Fishery Closed

Above Limit? (based on Survey)

NO

YES

Data collection protocols & adequate data collection

NO

YES

Trial Fishery Opening (with pre-specified conditions)

Catch <= TAC (conservative)

NO

YES

Fishery Open

Reliable Data

NO

Analyse data & review TAC; ongoing catch monitoring & data collection

Re-opening

- New catch reporting measures in place

➢ CDR catch reporting - compulsory since 2017

- Torres Strait Beche-de-mer Harvest Strategy

Re-opening Decision Rule applies for species that have been:

➢ *Closed to fishing due to concerns of overfishing or stock depletion, significantly exceeding catches beyond the TAC, or in the absence of reported catches*

- Stock above B_{LIM} from use of high quality survey data

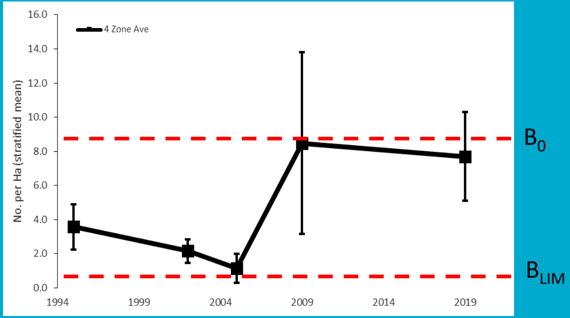
➢ Meets parameters of the Decision Rule - species to be opened with *Trial 15 t*

- Additional population modelling - 21 t can be removed

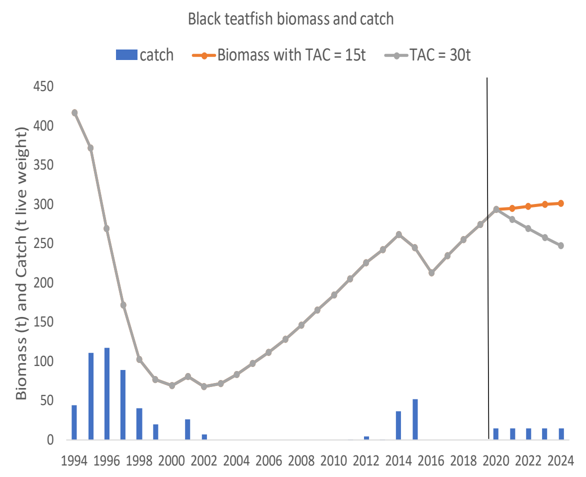
➢ Allows for higher opening TAC (tier 3)

- Quota allowance: 20 t

SURVEY



POPULATION MODELLING



Re-opening

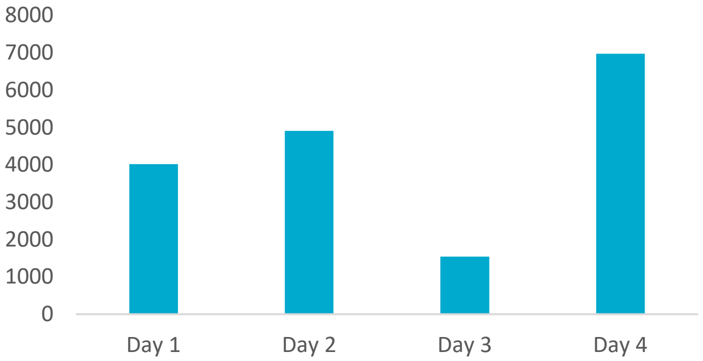
- Trial opening: 30th April 2021 for 20 t
  - Closed 3rd May 2021
  - 17.26 t caught as at 15:00 on 5th May 2021

(https://www.pzja.gov.au/2021-black-teatfish-trial-opening)

- Notes
  - Fishers organised among themselves, previous times described as ‘free for all’
  - Went further out and worked in across days
  - Came in early on fourth day in anticipation that nearing quota
  - Happy with how the fishing went

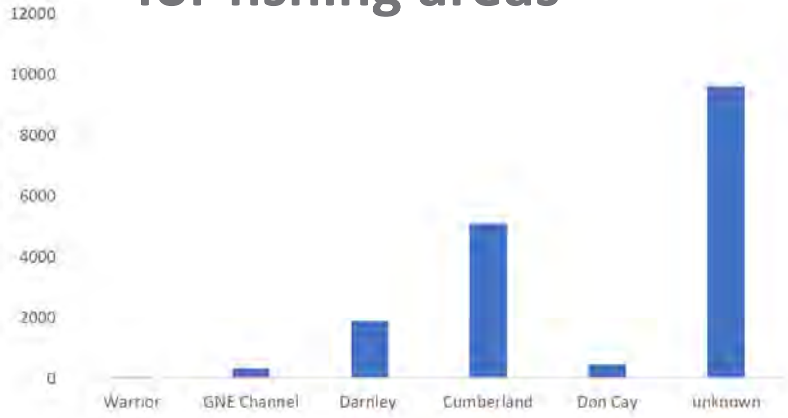
Traditional Owner & fisher, Mr Tristen Passi – Mer Island

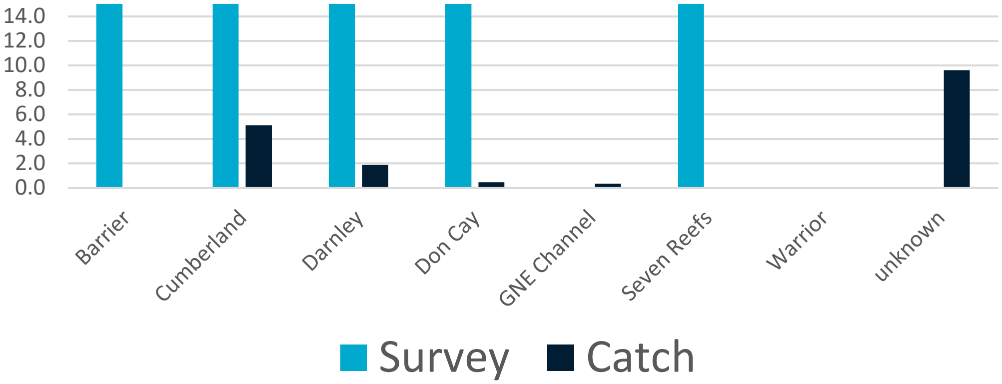
Sum of converted weight (kg) for catch taken for areas fished for each fishing day



Weight (kg)	Warrior	GNE Channel	Darnley	Cumberland	Don Cay	Blank*	Grand total
April total	-	119.78	41.24	468.95	311.13	3257.46	4198.57
30-Apr	-	119.78	41.24	468.95	311.13	3075.51	4016.62
May total	50.95	208.33	1837.69	4634.13	145.56	6358.28	13234.94
1-May	-	141.19	551.31	1392.45	-	2820.29	4905.24
2-May	-	67.15	276.20	1030.81	-	166.42	1540.57
3-May	50.95	-	1010.19	2210.87	145.56	3553.51	6971.08
Grand total	50.95	328.12	1878.94	5103.08	456.69	9615.74	17433.51

Total catch (converted weight - kg) for fishing areas





Missing Data to Inform assessments

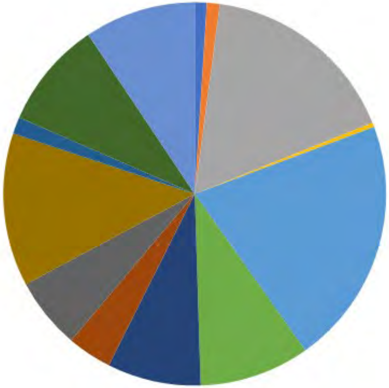
Day	Warrior	GNE Channel	Darnley	Cumberland	Don Cay	Unknown area
1	-	119.8	41.2	468.9	311.1	3075.5
2	-	141.2	551.3	1392.5	-	2820.3
3	-	67.1	276.2	1030.8	-	166.4
4	50.9	-	1010.2	2210.9	145.6	3553.5

Largest catch taken from ‘unknown’ area recorded in catch data

It is important to improve communication for future fishing around the need to record location, as this limits the usefulness of the data.

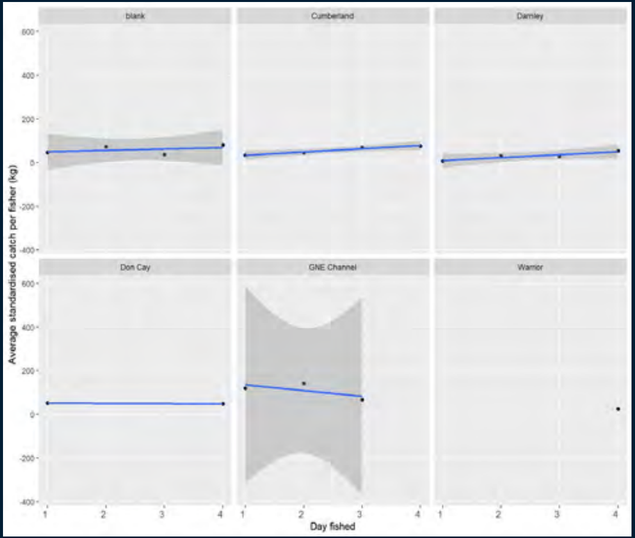
Information as to why Warrior Reef was only fished on day 4 – or whether this is the only day for which area was recorded – would also help scientific understanding of the information content of the data.

Catch landed at fish receivers

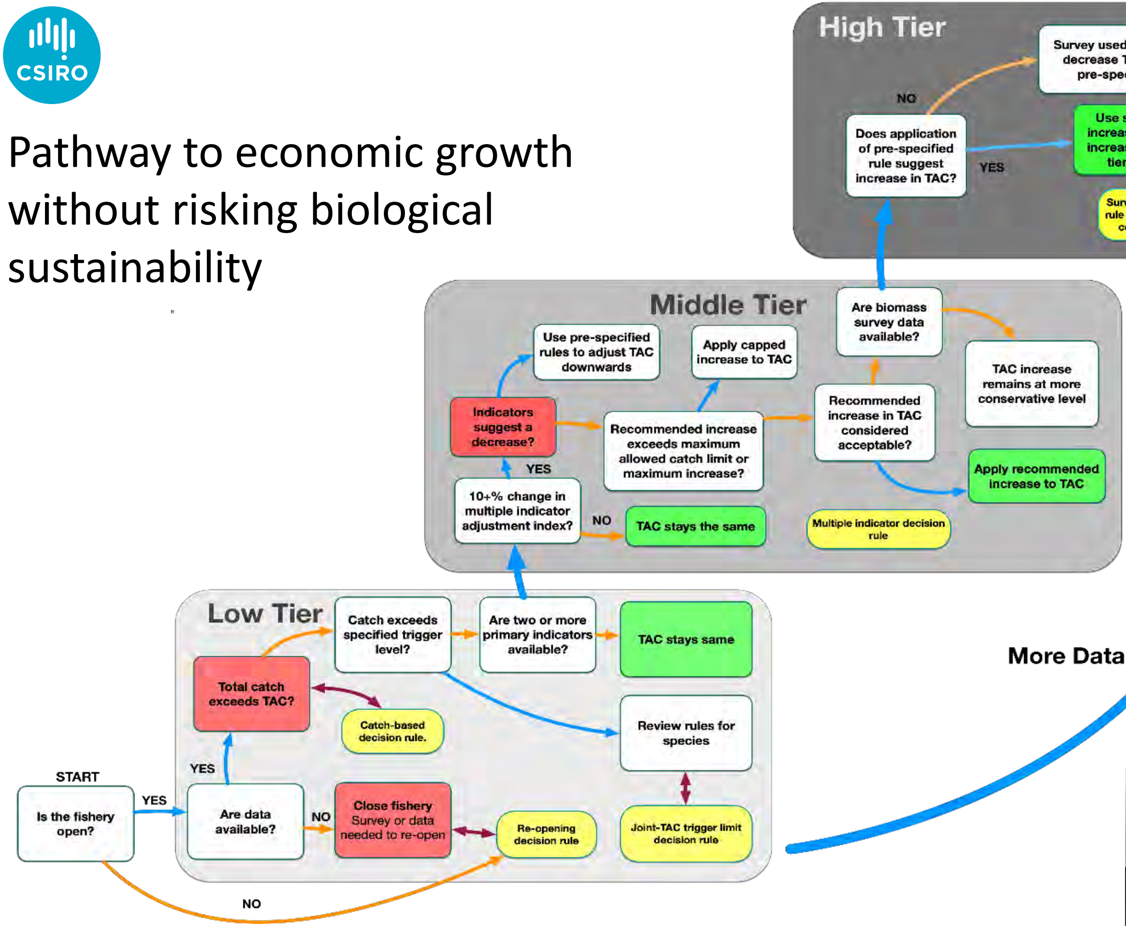


- Fairly good spread of the catch amongst fish receivers,
- 3 fish receivers landed ~half catch

- No trends or local depletion was seen for catch and areas fished. The high variance for the Great North East Channel results from the area not being fished on day 4



Pathway to economic growth without risking biological sustainability



High Tier

Does application of pre-specified rule suggest increase in TAC?

NO

Survey used to maintain or decrease TAC based on pre-specified rules

YES

Use survey rule to increase TAC (bigger increase than middle tier permitted)

Survey-based decision rule (allows setting less conservative TAC)

Middle Tier

10+% change in multiple indicator adjustment index?

NO

TAC stays the same

YES

Indicators suggest a decrease?

Use pre-specified rules to adjust TAC downwards

Recommended increase exceeds maximum allowed catch limit or maximum increase?

Apply capped increase to TAC

Recommended increase in TAC considered acceptable?

Apply recommended increase to TAC

Are biomass survey data available?

TAC increase remains at more conservative level

Multiple indicator decision rule

Low Tier

START

Is the fishery open?

YES

Are data available?

NO

Close fishery Survey or data needed to re-open

Re-opening decision rule

NO

YES

Total catch exceeds TAC?

Catch-based decision rule.

Catch exceeds specified trigger level?

Are two or more primary indicators available?

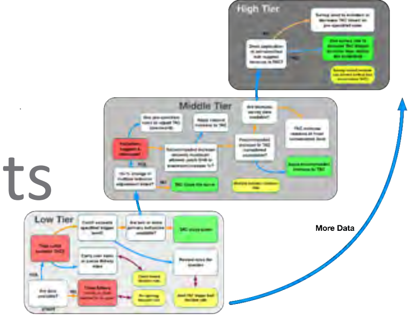
TAC stays same

Review rules for species

Joint-TAC trigger limit decision rule

More Data

Summary Framework Components



- **Management controls – static**
  - Size limits
  - Close areas or seasons eg during breeding season
- **Monitoring and data collection to determine indicators**
- **Management controls – dynamic - Decision Rules Needed:**

Low tier:

1. Catch-based Decision rule: for species-specific recommended biological catch
2. Joint TAC trigger-limit Decision rule: for lumped species category
3. Re-opening Decision rule: for re-opening a fishery or area

Middle tier:

4. Multiple Indicator Decision Rule: for adjusting species-specific TACs

High tier:

5. Survey-based Decision Rule

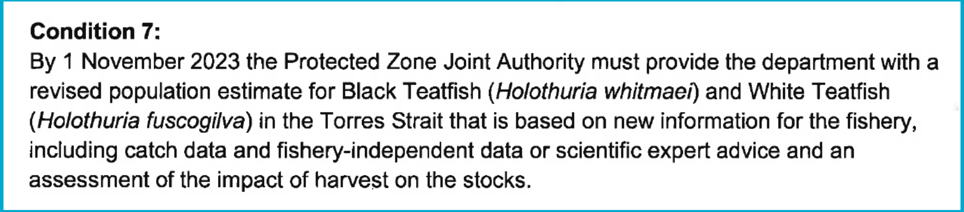
Primary Indicators

- **Catch per species**
- Effort
- CPUE (Catch Per Unit Effort)
- Size/mass
- Spatial footprint
- Species composition

Summary

- Total catch amounts were reliably and timeously reported
- Majority (55%) of the catch did not include details such as the area caught and no. fishers
- Missing data limits the usefulness of the data to support additional analyses related to the sustainability and productivity of the stock
- Harvest Strategy can't just rely on surveys – need additional indicators going forward especially for CITES-listed species

Part 13A conditions to the Torres Strait Protected Zone Joint Authority on the approved wildlife trade operation declaration for the Torres Strait Beche-de mer Fishery - December 2020



Condition 7:

By 1 November 2023 the Protected Zone Joint Authority must provide the department with a revised population estimate for Black Teatfish (*Holothuria whitmaei*) and White Teatfish (*Holothuria fuscogilva*) in the Torres Strait that is based on new information for the fishery, including catch data and fishery-independent data or scientific expert advice and an assessment of the impact of harvest on the stocks.

Thank you

Oceans and Atmosphere
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Brisbane, Australia

Nicole Murphy
Timothy Skewes

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Funding: AFMA, CSIRO

Pella-Tomlinson equation

Shape parameter

Total annual catch

$$N_{t+1} = N_t + r\,N_t\left(1-\left(\frac{N_t}{K}\right)^{\mu}\right)-C_t$$

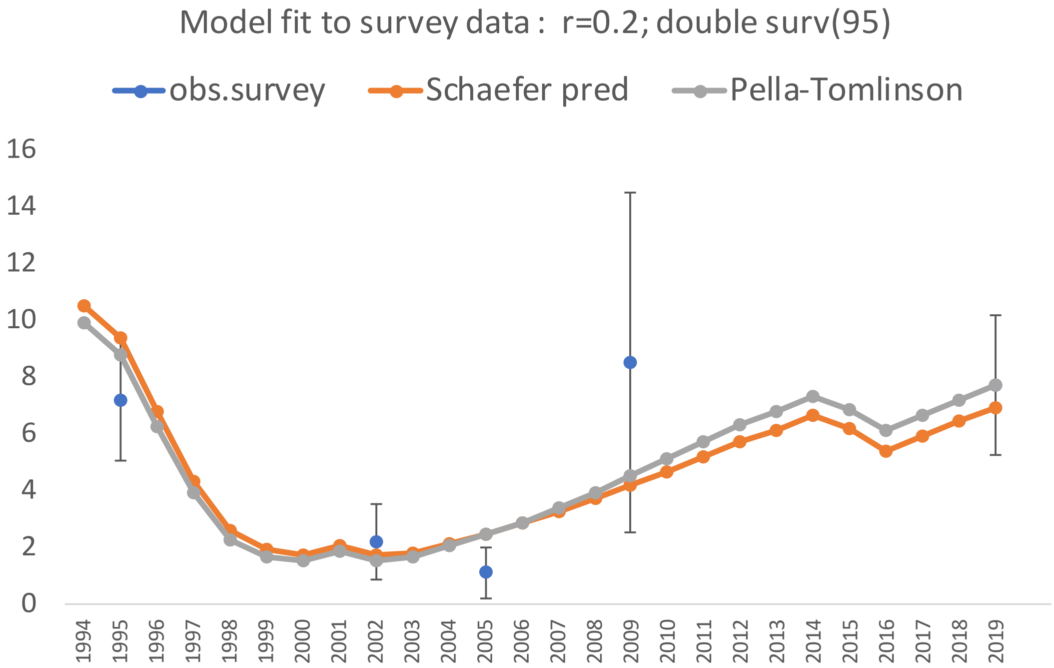
Total biomass of BTF per year

Intrinsic growth rate

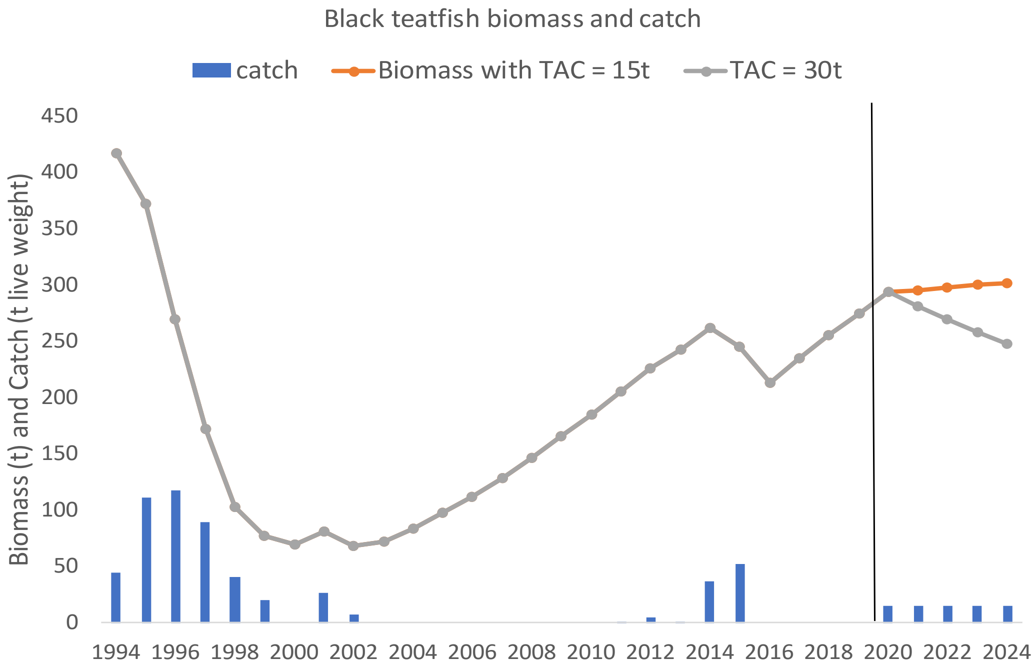
Carrying capacity (pristine biomass)

- Lumped biomass model
- Assumes growth is density-dependent
- The combination of *r* and *K* is more robust than these parameters on their own and informs on sustainable/replacement yield
- Implemented in ADMB

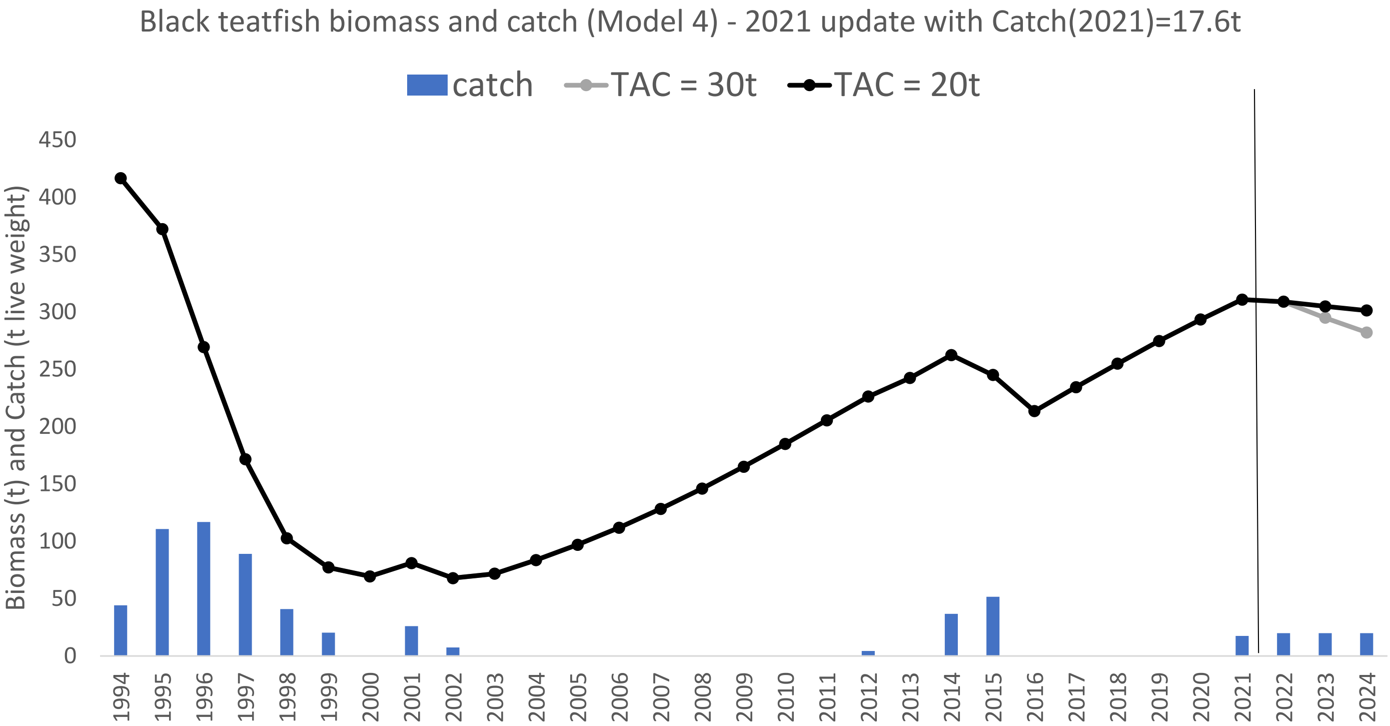
Model fit to survey data



Base-case model estimated biomass trajectory and forward projection



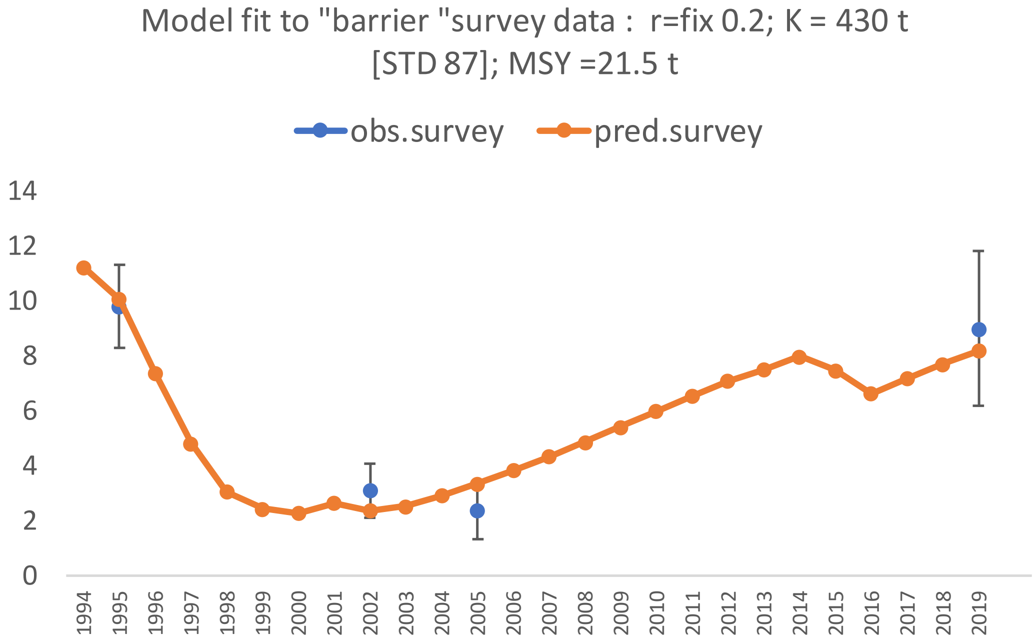
Updated 2021 Modelling Results



Model Results Summary: MSY

	Description	MSY (t)	BMSY (t)	B(2019) (t)	B2019/BMSY
Model 1	S; fix r	18.5	245.4	336.9	1.37
Model 2	double surv(95)	16.9	225	242.3	1.08
Model 3	S; fix r	15	300.5	385.7	1.28
Model 4	S; fix r; dbl	20.8	208.3	274.7	1.31
Model 5	S; est r,K	28.5	195.8	344.3	1.75
Model 6	S; est r,K; dbl	24.6	197.8	308.2	1.56
Model 7	P; est r,K,mu; dbl; mu=3.5	49.7	257.4	308.2	1.19
Model 8	Fix K, est r	19.9	410.2	647.8	1.57

Use survey series that includes outer barrier (less variable as less fishing there, but no data for 2009)



18th MEETING OF THE PZJA TORRES STRAIT HAND COLLECTABLES WORKING GROUP

28 (8:30 am – 5:00pm) - 29 October 2021 (8:30 am – 12:00 pm)

Video Conference and Whittington Room, Novotel Oasis Cairns

FINAL AGENDA

AGENDA ITEM 1 PRELIMINARIES

1.1 Acknowledgement of Traditional Owners, welcome and apologies

The Chair will welcome HCWG members, permanent observers, and casual observers to the 18th Torres Strait Hand Collectables Working Group.

1.2 Adoption of agenda

The working group is invited to consider and adopt the draft agenda.

1.3 Declarations of interest

Working group members are invited to declare any real or potential conflicts of interests to the group and determine whether a member may or may not be present during discussion of or decisions made on the matter which is the subject of the conflict.

1.4 Action items from previous meetings

The working group will note the status of action items arising from previous HCWG meetings.

AGENDA ITEM 2 WORKING GROUP UPDATES

2.1 Industry and Scientific members

This agenda item is an opportunity for the Working Group to develop a common understanding of Hand Collectable fisheries including recent fishing, economic, biological and ecological trends. Industry and scientific members are asked to provide a brief verbal update on any recent developments relevant to Hand Collectable fisheries. The Working Group will note the updates from industry and scientific members and observers.

2.2 Government Agencies

The Working Group will note updates from each of the PZJA government agency members on the latest developments relevant to Hand Collectable fisheries.

2.3 Native Title

The Working Group will note a verbal update from the Malu Lamar representative if in attendance.

2.4 Papua New Guinea National Fisheries Authority

The Working Group will note an update from the PNG NFA officials if in attendance.

AGENDA ITEM 3 BLACK TEATFISH TRIAL OPENING 30 APRIL – 3 MAY 2021 AND FUTURE OPENINGS

Having regard for advice from the Hand Collectable Resource Assessment Group (HCRAG) and the application of the Harvest Strategy, the Working Group will discuss and provide advice on the potential for a future black teatfish opening and any arrangements required to support an opening.

AGENDA ITEM 4 APPLYING THE HARVEST STRATEGY TO REVIEW TOTAL ALLOWABLE CATCHES

Having regard for advice from the HCRAG and applying the Harvest Strategy to all new information, the Working Group will discuss and provide advice TACs for the 2022 fishing season.

AGENDA ITEM 5 MANAGEMENT

5.1 Management options for the utilisation of white teatfish

The Working Group will discuss and provide advice on the relative management priority to develop advice to the PZJA on management options to support the utilisation of white teatfish TAC against other future management priorities. If recommended as a short-to-medium term priority the Working Group will discuss key considerations for assessing management options and an appropriate workplan.

5.2 Torres Strait Fisheries (Bech de Mer) Management Instrument

The *Torres Strait Fisheries Management Instrument No. 15* (the Instrument) needs to be remade to reflect the current management arrangements in the fishery including to give effect to the revised size limits in the BDM Harvest Strategy. The Working Group with discuss and provide advice on the proposed changes.

5.3 Ecological Risk Assessment for the BDM Fishery (CSIRO)

The CSIRO have completed a draft Ecological Risk Assessment for the fishery. The HCRAG has considered the draft assessment outcomes. The Working Group will note the outcomes and implications.

AGENDA ITEM 6 RESEARCH PRIORITIES

Having regard for HCRAG advice, the Working Group will discuss and provide advice to the TSSAC on research priorities for the beche-de-mer, trochus, mud crab and pearl shell fisheries under the Five-Year Rolling Research Plan. A five-year rolling research plan for Hand Collectable Fisheries is used to inform the Torres Strait Scientific Advisory Committee's (TSSAC) annual call for research funding proposals.

AGENDA ITEM 7 OTHER BUSINESS

The Working Group is invited to nominate any other business for discussion.

AGENDA ITEM 8 FUTURE PRIORITIES AND DATE FOR THE NEXT MEETING

The Working Group will discuss and provide advice on management priorities for Torres Strait Hand Collectable Fisheries. Having agreed management priorities and a work plan for Hand Collectable Fisheries aims to achieve a more efficient management process. The Working Group will consider a date and venue for HCWG19.

CLOSE OF MEETING

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting 2** **27-28 September 2022**
Total Allowable Catches (TACs) for the 2023 fishing season commencing 1 January	**Agenda Item 4** **For Discussion and Advice**

RECOMMENDATIONS

1. That the Hand Collectables Resource Assessment Group (RAG), **RECALL** that at its inaugural meeting on 6-7 October 2021, having considered the latest information available and the BDM Harvest Strategy:

    a. the RAG **RECOMMENDED**:
        i. no changes to the TACs for the 2022 BDM fishing season.
        ii. that the basket trigger limit for curryfish vastus be increased to 30t in light of the additional information available for the species and the survey results indicating a more even relative abundance.
        iii. that the HCWG continue to consider the review of the current hookah ban in relation to white teatfish and undertake further community consultation on management arrangements that would support sustainable harvesting of white teatfish using hookah.
        iv. the following short-medium term data, research and analysis needs:
            - stock assessment modelling to assess the potential (and extent) for an increase to the white teatfish TAC.
            - consistent with the BDM harvest strategy and where there is sufficient information available, a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible.
            - ongoing data collection to better understand fishing practices for lollyfish on Poruma as there may be some evidence of home reef depletion.

    b. the RAG **NOTED** that all species assessed remain in the low tier of the harvest strategy as transition to the middle tier:
        i. requires at least two primary indicators; and
        ii. is not applicable during the initial years of HS implementation as insufficient detailed historical fishery data are available.

2. That the RAG, **CONSIDER** all new information available for the 2021 and 2022 (as at 22 Sep) fishing seasons and the HCWG18's recommendation for the RAG:

    a. that the HCRAG revisit its advice to increase the curryfish vastus basket trigger limit from 15t to 30t given the modest standing stock biomass from the survey, relative to the 60t TAC for the curryfish basket. The WG sought further detail from the RAG to justify its recommendation to increase the trigger limit.
    b. that the HCRAG review the deepwater redfish and hairy blackfish TACs in light of the biomass results from the survey.
    c. that the HCRAG assess golden sandfish in line with the BDM Harvest Strategy at a future meeting.

3. That the RAG **DISCUSS** and **RECOMMEND** TACs for the 2023 fishing season commencing on 1 January 2023 (noting Black teatfish will be considered under Agenda item 3) or where relevant, further analysis to be undertaken, noting that:
    a. No TACs or individual basket species trigger limits were exceeded during the 2021 fishing season, therefore low tier overcatch deduction provisions in the BDM HS do not apply.

AFMA recommends that the RAG work through a Species Assessment Sheet provided as Attachment 4a to guide the formulation of its advice for each species.

KEY ISSUES

1. The RAG considered TACs for the 2022 fishing season commencing on 1 January in line with the BDM HS tiers and decision rules and taking into account new data and information available for the fishery since the HS was implemented.

2. Given the large number of species, the RAG agreed to prioritise the assessment of species where survey results have indicated a need for review, with the rest of the species to be reviewed at the RAG's next meeting. The species that were assessed included:

    - White teatfish (target species)
    - Prickly redfish (target species)
    - Deepwater redfish (target species)
    - Hairy blackfish (target species)
    - Curryfish Herrmanni (common) and Curryfish vastus (curryfish basket species)
    - Elephant's trunkfish (basket species)
    - Lollyfish (basket species)
    - Deepwater blackfish (basket species)
    - Pinkfish (basket species)

4. The RAG's advice on the species that were assessed, including any additional comments from the HCWG18 meeting and any new information available (i.e. 2021 catch data) are outlined in the species assessment sheets (SAS) provided at **Attachment 4a**. The SAS is designed to assist the RAG:
    a) compile and characterise all relevant information (for example adequacy of survey and catch data for a particular species);
    b) confirm the appropriate harvest strategy tier for each species;
    c) apply the harvest strategy decisions rules (otherwise known as control rules) within the tier OR recommend further analysis to be undertaken. Given the number of species being reviewed, the RAG is asked to prioritise any recommendations for further analysis across species; and
    d) identify any short to medium-term data and research needs.

5. An overview of each harvest strategy tier is provided in the Background.

BACKGROUND

6. The BDM Fishery Harvest Strategy is based on a tiered framework which accounts for improvements in data and information. The HS applies to 18 species (inclusive of the 3 closed species).

7. Current TAC's reflect the starting TACs recommended in the harvest strategy (Table 3 Starting HS TAC Recommendations).

8. Since the harvest strategy was agreed, a scientific survey has been undertaken and basic catch data has been collected for two fishing seasons (2020 and 2021) through the fish receiver system (a copy of the fish receiver TBDO2 Catch Disposal Record is at **Attachment 4b**). A preliminary stock assessment was undertaken for black teatfish (please note black teatfish is to be considered by the RAG under Agenda Item 3).

9. The Hand Collectables Working Group (HCWG) considered preliminary results of the scientific survey in August 2020 and were satisfied that the results did not raise immediate sustainability concerns that needed to be urgently addressed before the 2021 fishing season. As a result, the BDM HS was first applied to recommend TACs (except for black teatfish[1]) at the HCRAG01 meeting on 6-7 October 2021 since its commencement on 1 January 2020.

10. A summary of each harvest strategy tier is provided below

Low Tier

11. In the low tier, the minimum data needed for each species is the total catch taken each fishing season. The low tier has rules to guide:
    a) what happens to a species if the TAC is over caught or a trigger limit for a species within a joint TAC is reached; and
    b) what happens if there is no data reported for a species at all.

12. Depending on the information available, the low tier allows single species TACs to be maintained or reduced. For species with individual triggers, within a joint TAC, the low tier may allow changes to the joint TAC, or to individual species triggers (up or down).

Middle Tier

13. To transition to the middle tier, two or more primary indicators must be available. The harvest strategy states however that the middle tier is not applicable during the initial years of HS implementation as insufficient detailed historical fishery data is available.

14. For the purposes of the middle tier the primary indicators are:
    a) Catch per unit effort;
    b) Spatial footprint;
    c) Average size; and
    d) Catch proportion.

15. The information from these primary indicators will guide how much TACs should be varied. If the primary indicators suggest an increase is possible, there are pre-agreed rules that set a maximum level that the TAC can increase by before high-quality survey data is required (refer to Table 3 in the harvest strategy for the Max middle tier TAC increase).

High Tier

16. The high tier may be applied to all species if species-specific, high quality survey data becomes available. Under this tier, TACs may be adjusted upwards (in cases where there is evidence of

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[1] The harvest strategy reopening rule was applied to develop advice on the 2021 black teatfish opening TAC.

scope to increase TACs) or downwards (in cases where there are concerns about the status of a fished species).

Closed Species

17. A species may be closed to fishing if it has been overfished, the TAC has been significantly over caught, or if fishing has been occurring but there is no reported catch. The harvest strategy has rules to guide how to re-open a fishery if enough information is available.

Australian Government
Australian Fisheries Management Authority

Torres Strait Bêche-de-mer (BDM) Fishery

Species Assessment Sheets - 2022

Hand Collectables Resource Assessment Group (HCRAG) Meeting No.2
27-28 September 2022
Thursday Island

Table of Contents

Purpose

This document is intended to be used in conjunction with the *Torres Strait Beche-de-mer Harvest Strategy 2019* (the Harvest Strategy), applicable species stock assessments and annual catch and effort summaries.

The individual species assessment sheets (SAS) are aimed at guiding the Hand Collectables Resource Assessment Group's (HCRAG) assessment of commercial sea cucumber species in the BDM fishery in line with the Harvest Strategy, and to determine the recommended biological and/or total allowable catches for the fishing season commencing on 1 January each year.

The SAS provide a stepped application of the harvest strategy decision rules to recommend RBCs and/or TACs for each species, taking into account the latest scientific and fishing information available. The SAS also provides a summary of the basic information on stock status and assessment details for each species.

This resource is also intended to be used by the HCRAG to identify information gaps and research needs for each species that can feed into the TSSAC research need identification and prioritisation process for Torres Strait Fisheries.

Individual target species

White teatfish

<table>
<tr><th colspan="7">HCRAG Species Assessment Sheet</th></tr>
<tr><td>Common names</td><td colspan="6">White teatfish – <i>Holothuria fuscogilva</i></td></tr>
<tr><td>Pre-HS TAC</td><td colspan="6">15 tonnes</td></tr>
<tr><td>Status open/closed</td><td colspan="6">Open</td></tr>
<tr><td>Current TAC</td><td>15 tonne</td><td colspan="5">Based on harvest strategy starting TAC</td></tr>
<tr><td>Basket trigger</td><td colspan="6">N/A</td></tr>
<tr><td>Minimum size limit</td><td colspan="6">32cm</td></tr>
<tr><th colspan="7">New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)</th></tr>
<tr><td rowspan="4">Latest scientific survey data</td><th>Year</th><th colspan="2">Standing stock biomass (90th percentile) (t)</th><th colspan="2">Standing stock biomass above min species size limit (t)</th><th>Is standing stock biomass above the default limit reference point?</th></tr>
<tr><td>2019/20</td><td colspan="2">880</td><td colspan="2">142.9</td><td>Yes</td></tr>
<tr><th>Survey adequate for species</th><th colspan="2">Any unexpected results</th><th colspan="2">Any concerns with biomass trend or absolute abundance</th><th>Need for management response</th></tr>
<tr><td>Yes</td><td colspan="2">No</td><td colspan="2">No</td><td><i>Review current hookah prohibition</i></td></tr>
<tr><td>Comments on scientific survey findings</td><td colspan="6">CSIRO analysis: Deepwater survey undertaken for the first time in 2019/20. Confident that white teatfish population for East Torres Strait has been quantified. Survey trend for shallow reef population fairly constant over time. Review TAC – potential to increase, however some population modelling and/or fishery dependent data required. .</td></tr>
<tr><td>Catch data</td><td colspan="6">Available for 2020, 2021 and 2022 (as at 22 September 2022)</td></tr>
<tr><td>Price data (as advised by industry at HCRAG 1 meeting)</td><td colspan="6">Beach price is $30/kg (salted), $40 - $50/kg (gutted and salted)</td></tr>
<tr><td>Any other changes in the fishery?</td><td colspan="6">None identified</td></tr>
<tr><td>Any other sources of mortality apart from fishing?</td><td colspan="6">None identified</td></tr>
<tr><td>Other information</td><td colspan="6">Listed on Appendix II of CITES. Listed as vulnerable on the IUCN Red list due to a decreasing population trend globally.</td></tr>
<tr><th colspan="7">Low Tier</th></tr>
<tr><td rowspan="3">Total catch data</td><th>Fishing season</th><th>Catch (t)</th><th>TAC (t)</th><th>% TAC caught</th><th>TAC or basket trigger exceeded?</th><th>% of TAC overcatch</th></tr>
<tr><td>2020</td><td>1.77</td><td>15</td><td>11.8 %</td><td>TAC: No
Basket: N/A</td><td>N/A</td></tr>
<tr><td>2021</td><td>1.96</td><td>15</td><td>13.1 %</td><td>N/A</td><td>N/A</td></tr>
</table>

	2022	1.86	15	12.4%	N/A	N/A
Decision rules	No concerns from RAG and additional industry members regarding the total reported catch.					

Species specific data gaps and needs

General need to improve area and effort reporting in catch disposal records.

Species Specific Research and Priorities

Consistent with the BDM harvest strategy and where there is sufficient information available, the RAG recommended a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible. Modelling analysis to inform a sustainable TAC increase for white teatfish.

HCRAG 2 recommendations	**Fishing season**	**RBC (t)**	**Overcatch to be discounted (t)**	**Other source(s) of mortality (t)**	**TAC (t)**
	2023				

Insert HCRAG 2 recommendations

Prickly redfish

HCRAG Species Assessment Sheet

Common names	Prickly redfish – *Thelenota ananas*	
Pre-HS TAC	15 tonnes (changed from 20 tonnes to 15 tonnes in 2017)	
Status open/closed	Open	
Current TAC	15 tonnes	Based on harvest strategy starting TAC
Basket trigger	N/A	
Minimum size limit	35cm	

New information

	Year	Standing stock biomass (90th percentile) (t)	Standing stock biomass above min species size limit (t)	Is standing stock biomass above the default limit reference point?
Latest scientific survey data	2019/20	461	253.3	Yes
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	Yes	No	Yes	*HCWG to discuss*

Comments on scientific survey findings	CSIRO analysis: Slight decline (in slope – density over time), suggesting some concern given reports of sustained high catches. Close monitoring recommended. Stock assessment needed.
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)
Price data (as advised by industry at HCRAG 1 meeting)	Beach price is $61-$85/kg (clarify product type)
Any other changes in the fishery?	Industry use a voluntary rotational harvesting approach.
Any other sources of mortality apart from fishing?	None identified.
Other information	On the list for possible CITES listing consideration in the future and listed as endangered on the IUCN red list.

Low Tier

	Fishing season	Catch (t)	TAC (t)	% TAC caught	TAC or basket trigger exceeded?	% of TAC overcatch
Total catch data	2020	15.65	15	104.36 %	TAC: Yes Basket: N/A	4.36%
	2021	14.85	15	99 %	N/A	N/A
	2022	8.72	15	58.11%	TBA	TBA

Decision rules	No concerns from RAG and additional industry members regarding the total reported catch.

	Reported overcatch does not trigger any of the overcatch decision rules (refer to section 2.11.1.1 of the harvest strategy).
	RAG advised that a TAC reduction may need to be considered if the species continues to be overcaught in subsequent fishing seasons.

Species specific data gaps and needs

General need to improve area and effort reporting in catch disposal records.

Species Specific Research and Priorities

Consistent with the BDM harvest strategy and where there is sufficient information available, the RAG recommended a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible

	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC (t)
HCRAG 2 recommendations	2023				

Insert HCRAG 2 recommendations

Deepwater redfish

HCRAG Species Assessment Sheet		
Common names	Deepwater redfish – *Actinopyga echinites*	
Pre-HS TAC	Part of 80t basket species TAC	
Status open/closed	Open	
Current TAC	5 tonnes	Based on harvest strategy starting TAC
Basket trigger	N/A (previously 5t basket trigger limit)	
Minimum size limit	20cm	

New information				
Latest scientific survey data	**Year**	**Standing stock biomass (90th percentile) (t)**	**Standing stock biomass above min species size limit (t)**	**Is standing stock biomass above the default limit reference point?**
	2019/20	66	55	No evidence ~~to support~~ that the species is below the default LRP
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	Yes	No	No	*HCWG to discuss*
Comments on scientific survey findings	CSIRO analysis: Catches low relative to biomass. Increasing overall trend in density. No concern for TAC.			
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)			
Price data (as advised by industry at HCRAG 1 meeting)	Not targeted much due to low beach price of 3/kg (wet), $7/kg (boiled) and $80-$100/kg (dried)			
Any other changes in the fishery?	None identified			
Any other sources of mortality apart from fishing?	None identified			
Other information	Assessed as Uncertain by ABARES in the 2020 Fishery Status Reports – given its low density it is unclear if catches of this species would impede effective recruitment and recovery of the species. The species is listed as vulnerable on the IUCN red list.			

Low Tier						
Total catch data	**Fishing season**	**Catch (t)**	**TAC (t)**	**% TAC caught**	**TAC or basket trigger exceeded?**	**% of TAC overcatch**
	2020	0	5	0 %	TAC: No Basket: N/A	N/A
	2021	0.031	5	0.61 %	N/A	N/A
	2022	0	5	0	TBA	TBA

Decision rules	No concerns from RAG and additional industry members regarding the total reported catch.

Species specific data gaps and needs

General need to improve area and effort reporting in catch disposal records.

Species Specific Research and Priorities

Consistent with the BDM harvest strategy and where there is sufficient information available, the RAG recommended a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible

	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC (t)
HCRAG 2 recommendations	2023				

Insert HCRAG 2 recommendations

Hairy blackfish

HCRAG Species Assessment Sheet		
Common names	Hairy blackfish – *Actinopyga miliaris*	
Pre-HS TAC	Part of 80t basket species TAC	
Status open/closed	Open	
Current TAC	5 tonnes	Based on harvest strategy starting TAC
Basket trigger	N/A (previously 5t basket trigger limit)	
Minimum size limit	22cm	

New information since the TAC was last considered (in this it was the implementation of the Harvest Strategy)

	Year	**Landed (wet gutted) weight (t)**	**Standing stock biomass above min species size limit (t)**	**Is standing stock biomass above the default limit reference point?**
Latest scientific survey data	2019/20	15	-	*Insufficient information to assess the status of the stock in relation to the LRP*
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	Limited	No	Yes	*HCWG to discuss*

Comments on scientific survey findings	CSIRO analysis: Status still remains relatively unknown. Possible decline or natural variability. Stock assessment needed. Targeted survey sampling may need to be factored into future fishery surveys.
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)
Price data (as advised by industry at HCRAG 1 meeting)	Has a low beach price of $3 – $7.50/kg but dry product can fetch up to $80-100/kg. $15/kg (frozen whole? Seek clarification from industry)
Any other changes in the fishery?	None identified
Any other sources of mortality apart from fishing?	None identified
Other information	Assessed as Uncertain by ABARES in the 2020 Fishery Status Reports – given its low density it is unclear if catches of this species would impede effective recruitment and recovery of the species. The species is listed as vulnerable on the IUCN red list.

Low Tier

	Fishing season	**Catch (t)**	**TAC (t)**	**% TAC caught**	**TAC or basket trigger exceeded?**	**% of TAC overcatch**
Total catch data	2020	1.4	5	28 %	TAC: No Basket: N/A	N/A
	2021	0.5	5	10 %	N/A	N/A
	2022	0.58	5	11.6%	TBA	TBA

Decision rules	No concerns from RAG and additional industry members regarding the total catch.

Species specific data gaps and needs

General need to improve area and effort reporting in catch disposal records. Potential for cryptic behaviour to impact on surveys.

Species Specific Research and Priorities

Consistent with the BDM harvest strategy and where there is sufficient information available, the RAG recommended a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible

	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC (t)
HCRAG 2 recommendations	2023				

Insert HCRAG 2 recommendations

Greenfish (not assessed by HCRAG)

<table>
<tr><th colspan="7">HCRAG Species Assessment Sheet</th></tr>
<tr><td>Common names</td><td colspan="6">Greenfish – <i>Stichopus chloronotus</i></td></tr>
<tr><td>Pre-HS TAC</td><td colspan="6">Part of 80t basket species TAC</td></tr>
<tr><td>Status open/closed</td><td colspan="6">Open</td></tr>
<tr><td>Current TAC</td><td>40 tonnes</td><td colspan="5">Based on harvest strategy starting TAC</td></tr>
<tr><td>Basket trigger</td><td colspan="6">N/A</td></tr>
<tr><td>Minimum size limit</td><td colspan="6">nil</td></tr>
<tr><th colspan="7">New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)</th></tr>
<tr><td rowspan="4">Latest scientific survey data</td><th>Year</th><th colspan="2">Standing stock biomass (90th percentile) (t)</th><th>Standing stock biomass above min species size limit (t)</th><th colspan="2">Is standing stock biomass above the default limit reference point?</th></tr>
<tr><td>2019/20</td><td colspan="2">739</td><td>N/A</td><td colspan="2"><i>RAG to discuss</i></td></tr>
<tr><th>Survey adequate for species</th><th colspan="2">Any unexpected results</th><th>Any concerns with biomass trend or absolute abundance</th><th colspan="2">Need for management response</th></tr>
<tr><td>Yes</td><td colspan="2">No</td><td>No</td><td colspan="2"><i>RAG to discuss</i></td></tr>
<tr><td>Comments on scientific survey findings</td><td colspan="6">CSIRO analysis: Catches low. Generally increasing density trend. No concern for TAC.</td></tr>
<tr><td>Catch data</td><td colspan="6">Available for 2020, 2021 and 2022 (as at 22 September 2022)</td></tr>
<tr><td>Any other changes in the fishery?</td><td colspan="6">*<i>RAG members to provide advice. For example, fishing behaviour/market demand?</i> *</td></tr>
<tr><td>Any other sources of mortality apart from fishing?</td><td colspan="6">*<i>RAG members to provide advice</i>*</td></tr>
<tr><td>Other information</td><td colspan="6">*<i>RAG members to provide advice</i>*</td></tr>
<tr><th colspan="7">Low Tier</th></tr>
<tr><td rowspan="3">Total catch data</td><th>Fishing season</th><th>Catch (t)</th><th>TAC (t)</th><th>% TAC caught</th><th>TAC or basket trigger exceeded?</th><th>% of TAC overcatch</th></tr>
<tr><td>2020</td><td>0.015</td><td>40</td><td>0.04 %</td><td>TAC: No
Basket: N/A</td><td>N/A</td></tr>
<tr><td>2021</td><td>0</td><td>40</td><td>0</td><td>N/A</td><td>N/A</td></tr>
<tr><td></td><td>2022</td><td>0</td><td>40</td><td>0</td><td>TBA</td><td>TBA</td></tr>
<tr><td rowspan="2">Decision rules</td><td colspan="6">Is the total catch reliable? *<i>RAG members to provide advice</i>*</td></tr>
<tr><td colspan="6">Not overcaught so overcatch decision rules not triggered (refer to section 2.11.1.1 of the harvest strategy).</td></tr>
</table>

<table>
<tr><td></td><td colspan="5">For species with an individual TAC, should the TAC be reduced or maintained (refer to section 2.11.1 of the harvest strategy)? *RAG members to provide advice*</td></tr>
<tr><th colspan="6">Species specific data gaps and needs</th></tr>
<tr><td colspan="6">*to be completed at the meeting*</td></tr>
<tr><th colspan="6">Species Specific Research and Priorities</th></tr>
<tr><td colspan="6">*to be completed at the meeting*</td></tr>
<tr><td rowspan="2">HCRAG 2 recommendations</td><th>Fishing season</th><th>RBC (t)</th><th>Overcatch to be discounted (t)</th><th>Other source(s) of mortality (t)</th><th>TAC (t)</th></tr>
<tr><td>2023</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">*General RAG comments*</td></tr>
</table>

Basket species – curryfish

Curryfish common

HCRAG Species Assessment Sheet		
Common names	Curryfish common – *Stichospus herrmanni*	
Pre-HS TAC	Part of 80t basket species TAC	
Status open/closed	Open	
Current TAC	60 tonnes (Curryfish basket TAC)	Based on harvest strategy starting TAC
Basket trigger	N/A	
Minimum size limit	31cm	

New information

	Year	Standing stock biomass (90th percentile) (t)	Standing stock biomass above min species size limit (t)	Is standing stock biomass above the default limit reference point?
Latest scientific survey data	2019/20	667	632.4	Yes
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	Yes	No	Yes	*HCWG to discuss*

Comments on scientific survey findings	CSIRO paper: Possible decline (noting fairly negative trend fitted to survey data). Stock assessment needed. Close monitoring recommended – part of 'Curryfish mixed' (catch split 50:50 between Curryfish species when not identified). Appears that the *herrmanni:vastus* split is changing over time, with higher proportion of vastus. Could be an identification problem with *S. Vastus* during the 1995/96 survey.
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)
Price data (as advised by industry at HCRAG 1 meeting)	Beach price $15-22/kg (boiled and salted), $150/kg (dried)
Any other changes in the fishery?	While common curryfish used to make up most of the catch in the past, industry reported noticing a generally even split between the two curryfish species with some regional differences.
Any other sources of mortality apart from fishing?	None identified. Previously recorded high discard levels have reduced due to more appropriate species processing methods.
Other information	Listed as vulnerable on the IUCN red list

Low Tier

	Fishing season	Catch (t)	TAC (t)	% TAC caught	TAC or basket trigger exceeded?	% of TAC overcatch
Total catch data	2020	0.6 10.5 (mixed)	60	1 % 17.5 % (mixed)	TAC: No Basket: N/A	N/A
	2021	4.05	60	6.75% 11.15% (mixed)	N/A	N/A

		6.69 (mixed)				
	2022	0.4 1.53 (mixed)	60	0.7% 2.55% (mixed)	TBA	TBA

Decision rules	No concerns from RAG and additional industry members regarding the total catch. The RAG agreed to consider the need for a trigger limit for the species.

Species specific data gaps and needs

RAG agreed it is a high priority to improve species differentiation in catch disposal records as well as general improvements to area and effort reporting.

Species Specific Research and Priorities

The RAG further noted the ongoing research need to develop conversion ratios for curryfish species. Consistent with the BDM harvest strategy and where there is sufficient information available, the RAG recommended a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible

	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC (t)
HCRAG 2 recommendations	2023				

Insert HCRAG 2 recommendations

Curryfish vastus

<table>
<tr><th colspan="7">HCRAG Species Assessment Sheet</th></tr>
<tr><td>Common names</td><td colspan="6">Curryfish vastus – <i>Stichopus vastus</i></td></tr>
<tr><td>Pre-HS TAC</td><td colspan="6">Part of the 80t basket species TAC</td></tr>
<tr><td>Status open/closed</td><td colspan="6">Open</td></tr>
<tr><td>Current TAC</td><td colspan="2">60 tonnes (Curryfish basket TAC)</td><td colspan="4">Based on harvest strategy starting TAC</td></tr>
<tr><td>Basket trigger</td><td colspan="6">15 tonnes species trigger limit</td></tr>
<tr><td>Minimum size limit</td><td colspan="6">15cm</td></tr>
<tr><td colspan="7">New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)</td></tr>
<tr><td rowspan="4">Latest scientific survey data</td><td>Year</td><td colspan="2">Standing stock biomass (90th percentile) (t)</td><td>Standing stock biomass above min species size limit (t)</td><td colspan="2">Is standing stock biomass above the default limit reference point?</td></tr>
<tr><td>2019/20</td><td colspan="2">168</td><td>168</td><td colspan="2">Yes</td></tr>
<tr><td>Survey adequate for species</td><td colspan="2">Any unexpected results</td><td>Any concerns with biomass trend or absolute abundance</td><td colspan="2">Need for management response</td></tr>
<tr><td>Yes</td><td colspan="2">No</td><td>Yes</td><td colspan="2">HCWG to discuss</td></tr>
<tr><td>Comments on scientific survey findings</td><td colspan="6">CSIRO analysis: Higher ratio of curryfish vastus observed in 2019 survey. Close monitoring recommended – part of ‘Curryfish mixed’ (suggest splitting catch 50:50 between curryfish species when not identified).</td></tr>
<tr><td>Catch data</td><td colspan="6">Available for 2020, 2021 and 2022 (as at 22 September 2022)</td></tr>
<tr><td>Price data (as advised by industry at HCRAG 1 meeting)</td><td colspan="6">Beach price $15-22/kg (boiled and salted), $150/kg (dried)</td></tr>
<tr><td>Any other changes in the fishery?</td><td colspan="6">Industry reported noticing a generally even split between the two curryfish species with some regional differences and increasingly more curryfish vastus.</td></tr>
<tr><td>Any other sources of mortality apart from fishing?</td><td colspan="6">None identified</td></tr>
<tr><td>Other information</td><td colspan="6"></td></tr>
<tr><td colspan="7">Low Tier</td></tr>
<tr><td rowspan="4">Total catch data</td><td>Fishing season</td><td>Catch (t)</td><td>TAC (t)</td><td>% TAC caught</td><td>TAC or basket trigger exceeded?</td><td>% of TAC overcatch</td></tr>
<tr><td rowspan="2">2020</td><td rowspan="2">0.15
10.5 (mixed)</td><td rowspan="2">60
(15t trigger limit)</td><td rowspan="2">0.25 %
17.5 %
(mixed)</td><td>TAC: No</td><td rowspan="2">N/A</td></tr>
<tr><td>Basket: No</td></tr>
<tr><td>2021</td><td>1.86
6.69 (mixed)</td><td>60 (15t trigger limit)</td><td>3.1%
11.15%
(mixed)</td><td>N/A</td><td>N/A</td></tr>
<tr><td></td><td>2022</td><td>0.4
1.53 (mixed)</td><td>60 (15t trigger limit)</td><td>0.7%
2.55%</td><td>TBA</td><td>TBA</td></tr>
</table>

				(mixed)		

Decision rules	No concerns from RAG and additional industry members regarding the total catch. The RAG recommended increasing the trigger limit to 30t.

Species specific data gaps and needs

RAG agreed it is a high priority to improve species differentiation in catch disposal records as well as general improvements to area and effort reporting.

Species Specific Research and Priorities

The RAG further noted the ongoing research need to develop conversion ratios for curryfish species. Consistent with the BDM harvest strategy and where there is sufficient information available, the RAG recommended a tactical research project to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible

HCRAG 2 recommendations	**Fishing season**	**RBC (t)**	**Overcatch to be discounted (t)**	**Other source(s) of mortality (t)**	**TAC (t)**
	2023				

Insert HCRAG 2 recommendations

Basket species

Elephant’s trunkfish

<table>
<tr><th colspan="7">HCRAG Species Assessment Sheet</th></tr>
<tr><td>Common names</td><td colspan="6">Elephant trunkfish – <i>Holothuria fuscopunctata</i></td></tr>
<tr><td>Pre-HS TAC</td><td colspan="6">Part of 80t basket species TAC</td></tr>
<tr><td>Status open/closed</td><td colspan="6">Open</td></tr>
<tr><td>Current TAC</td><td colspan="2">Part of 50t basket species TAC</td><td colspan="4">Based on harvest strategy starting TAC</td></tr>
<tr><td>Basket trigger</td><td colspan="6">15 tonnes</td></tr>
<tr><td>Minimum size limit</td><td colspan="6">24cm</td></tr>
<tr><th colspan="7">New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)</th></tr>
<tr><td rowspan="4">Latest scientific survey data</td><th>Year</th><th colspan="2">Standing stock biomass (90th percentile) (t)</th><th>Standing stock biomass above min species size limit (t)</th><th colspan="2">Is standing stock biomass above the default limit reference point?</th></tr>
<tr><td>2019/20</td><td colspan="2">451t</td><td>-</td><td colspan="2">Not assessed</td></tr>
<tr><th>Survey adequate for species</th><th colspan="2">Any unexpected results</th><th>Any concerns with biomass trend or absolute abundance</th><th colspan="2">Need for management response</th></tr>
<tr><td>Yes</td><td colspan="2">No</td><td>Yes</td><td colspan="2"><i>HCWG to discuss</i></td></tr>
<tr><td>Comments on scientific survey findings</td><td colspan="6">CSIRO analysis: Catch rates low. Possible decline or natural variability. Stock assessment needed.</td></tr>
<tr><td>Catch data</td><td colspan="6">Available for 2020, 2021 and 2022 (as at 22 September 2022)</td></tr>
<tr><td>Price data (as advised by industry at HCRAG 1 meeting)</td><td colspan="6">Beach price $2/kg (wet-gutted)</td></tr>
<tr><td>Any other changes in the fishery?</td><td colspan="6">None identified</td></tr>
<tr><td>Any other sources of mortality apart from fishing?</td><td colspan="6">None identified.</td></tr>
<tr><td>Other information</td><td colspan="6"></td></tr>
<tr><th colspan="7">Low Tier</th></tr>
<tr><td rowspan="4">Total catch data</td><th>Fishing season</th><th>Catch (t)</th><th>TAC (t)</th><th>% TAC caught</th><th>TAC or basket trigger exceeded?</th><th>% of TAC overcatch</th></tr>
<tr><td rowspan="2">2020</td><td rowspan="2">No catch reported</td><td rowspan="2">50</td><td rowspan="2">-</td><td>TAC: No</td><td rowspan="2">N/A</td></tr>
<tr><td>Basket: No</td></tr>
<tr><td>2021</td><td>No catch reported</td><td>50</td><td>-</td><td>N/A</td><td>N/A</td></tr>
<tr><td></td><td>2022</td><td>No catch reported</td><td>50</td><td>-</td><td>TBA</td><td>TBA</td></tr>
</table>

Decision rules	No concerns from RAG and additional industry members regarding the total catch.

Species specific data gaps and needs

General improvements to area and effort reporting.

Species Specific Research and Priorities

None identified

	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC/trigger limit (t)
HCRAG 2 recommendations	2023				

Insert HCRAG 2 recommendations

Lollyfish

HCRAG Species Assessment Sheet		
Common names	Lollyfish – *Holothuria atra*	
Pre-HS TAC	Part of 80t basket species TAC	
Status open/closed	Open	
Current TAC	Part of 50t basket species TAC	Based on harvest strategy starting TAC
Basket trigger	40 tonnes	
Minimum size limit	15cm	

New information since the TAC was last considered (in this it was at the implementation of the Harves Strategy)				
Latest scientific survey data	**Year**	**Standing stock biomass (90th percentile) (t)**	**Standing stock biomass above min species size limit (t)**	**Is standing stock biomass above the default limit reference point?**
	2019/20	5,668	-	Yes
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	Yes	No	Yes	*HCWG to discuss*

Comments on scientific survey findings	CSIRO analysis: Noted catch increase. Possible decline or natural variability. Stock assessment needed.
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)
Price data (as advised by industry at HCRAG 1 meeting)	Beach price $2-$5/kg (wet-gutted)
Any other changes in the fishery?	Further information required from Poruma fishers on reduced catches to ascertain whether this is due to home reef depletion given its susceptibility to being caught.
Any other sources of mortality apart from fishing?	None identified
Other information	

Low Tier						
Total catch data	**Fishing season**	**Catch (t)**	**TAC (t)**	**% TAC caught**	**TAC or basket trigger exceeded?**	**% of TAC overcatch**
	2020	1.3	50 (40t basket trigger limit)	2.6 %	TAC: No Basket: No	N/A
	2021	0.42	50 (40t basket trigger limit)	0.84%	N/A	N/A
	2022	0	50 (40t basket trigger limit)	TBA	TBA	TBA

Decision rules	No concerns from RAG and additional industry members regarding the total reported catch.

Species specific data gaps and needs

General improvements to area and effort reporting.

Species Specific Research and Priorities

None identified

	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC/trigger limit (t)
HCRAG 2 recommendations	2023				

Insert HCRAG 2 recommendations

Burrowing blackfish (not assessed by HCRAG)

HCRAG Species Assessment Sheet

Common names	Burrowing blackfish – *Actinopyga spinea*	
Pre-HS TAC	Part of the 80t basket species TAC	
Status open/closed	Open	
Current TAC	Part of 50 tonne basket species TAC	Based on harvest strategy starting TAC
Basket trigger	5 tonnes	
Minimum size limit	22 cm	

New information since the TAC was last considered (in this it was the implementation of the Harvest Strategy)

	Year	Standing stock biomass (90th percentile) (t)	Standing stock biomass above min species size limit (t)	Is standing stock biomass above the default limit reference point?
Latest scientific survey data	2019/20	N/A	N/A	*RAG to discuss*
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	N/A	N/A	N/A	*RAG to discuss*

Comments on scientific survey findings	CSIRO paper (**attachment B of agenda item 5**): N/A
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)
Any other changes in the fishery?	**RAG members to provide advice. For example, fishing behaviour/market demand?* *
Any other sources of mortality apart from fishing?	**RAG members to provide advice**
Other information	

Low Tier

	Fishing season	Catch (t)	TAC (t)	% TAC caught	TAC or basket trigger exceeded?	% of TAC overcatch
Total catch data	2020	No catch reported	50 (5t trigger limit)	No catch reported	TAC: No Basket: No	N/A
	2021	No catch reported	50 (5t trigger limit)	No catch reported	N/A	N/A
	2022	0	50 (5t trigger limit)	TBA	TBA	TBA

Decision rules	Is the total catch reliable? **RAG members to provide advice**
	Not overcaught so overcatch decision rules not triggered (refer to section 2.11.1.1 of the harvest strategy).

<table>
<tr><td></td><td colspan="5">For species with individual triggers within a basket with a joint TAC, should the joint TAC or individual triggers be changed (up or down) (refer to section 2.11.1.2 of the harvest strategy)? **RAG members to provide advice**</td></tr>
<tr><th colspan="6">Species specific data gaps and needs</th></tr>
<tr><td colspan="6">*to be completed at the meeting*</td></tr>
<tr><th colspan="6">Species Specific Research and Priorities</th></tr>
<tr><td colspan="6">*to be completed at the meeting*</td></tr>
<tr><td rowspan="2">HCRAG 2 recommendations</td><th>Fishing season</th><th>RBC (t)</th><th>Overcatch to be discounted (t)</th><th>Other source(s) of mortality (t)</th><th>TAC/trigger limit (t)</th></tr>
<tr><td>2023</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6"><i>Insert HCRAG 2 recommendations</i></td></tr>
</table>

Deepwater blackfish

<table>
<tr><th colspan="5">HCRAG Species Assessment Sheet</th></tr>
<tr><td>Common names</td><td colspan="4">Deepwater blackfish – <i>Actinopyga palauensis</i></td></tr>
<tr><td>Pre-HS TAC</td><td colspan="4">Part of 80t basket species TAC</td></tr>
<tr><td>Status open/closed</td><td colspan="4">Open</td></tr>
<tr><td>Current TAC</td><td colspan="2">Part of 50t basket species TAC</td><td colspan="2">Based on harvest strategy starting TAC</td></tr>
<tr><td>Basket trigger</td><td colspan="4">0.5t</td></tr>
<tr><td>Minimum size limit</td><td colspan="4">22cm</td></tr>
<tr><th colspan="5">New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)</th></tr>
<tr><td rowspan="4">Latest scientific survey data</td><th>Year</th><th>Landed weight (wet gutted) (t)</th><th>Standing stock biomass above min species size limit (t)</th><th>Is standing stock biomass above the default limit reference point?</th></tr>
<tr><td>2019/20</td><td>104</td><td>-</td><td><i>Not assessed</i></td></tr>
<tr><th>Survey adequate for species</th><th>Any unexpected results</th><th>Any concerns with biomass trend or absolute abundance</th><th>Need for management response</th></tr>
<tr><td>Limited</td><td>No</td><td>Yes</td><td><i>HCWG to discuss</i></td></tr>
<tr><td>Comments on scientific survey findings</td><td colspan="4">CSIRO analysis: Status still remains relatively unknow. Stock assessment needed. Targeted survey sampling may need to be factored into future fishery surveys.</td></tr>
<tr><td>Catch data</td><td colspan="4">Available for 2020, 2021 and 2022 (as at 22 September 2022)</td></tr>
<tr><td>Price data (as advised by industry at HCRAG 1 meeting)</td><td colspan="4">Beach price $15/kg (wet-gutted)</td></tr>
<tr><td>Any other changes in the fishery?</td><td colspan="4">None advised</td></tr>
<tr><td>Any other sources of mortality apart from fishing?</td><td colspan="4">None identified</td></tr>
<tr><td>Other information</td><td colspan="4"></td></tr>
</table>

<table>
<tr><th colspan="7">Low Tier</th></tr>
<tr><td rowspan="4">Total catch data</td><th>Fishing season</th><th>Catch (t)</th><th>TAC (t)</th><th>% TAC caught</th><th>TAC or basket trigger exceeded?</th><th>% of TAC overcatch</th></tr>
<tr><td rowspan="2">2020</td><td rowspan="2">0.17</td><td rowspan="2">50
(0.5t trigger limit)</td><td rowspan="2">0.34 %</td><td>TAC: No</td><td rowspan="2">N/A</td></tr>
<tr><td>Basket: No</td></tr>
<tr><td>2021</td><td>0.18</td><td>50
(0.5t trigger limit)</td><td>0.36%</td><td>N/A</td><td>N/A</td></tr>
</table>

	2022	0.42	50 (0.5t trigger limit)	TBA	TBA	TBA
Decision rules	No concerns from RAG and additional industry members regarding the total reported catch.					

Species specific data gaps and needs

General improvements to area and effort reporting.

Species Specific Research and Priorities

May benefit from a dedicated survey in the future.

HCRAG 2 recommendations	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC/trigger limit (t)
	2023				

Insert HCRAG 2 recommendations

Golden sandfish (not assessed by HCRAG)

HCRAG Species Assessment Sheet		
Common names	Golden sandfish – *Holothuria lessoni*	
Pre-HS TAC	Part of 80t basket species TAC	
Status open/closed	Open	
Current TAC	Part of 50t basket species TAC	Based on harvest strategy starting TAC
Basket trigger	0.5 tonnes	
Minimum size limit	22cm	

New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)

Latest scientific survey data	**Year**	**Standing stock biomass (90th percentile) (t)**	**Standing stock biomass above min species size limit (t)**	**Is standing stock biomass above the default limit reference point?**
	Not included in 2019-20 survey	-	-	*RAG to discuss*
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	No	N/A	N/A	*RAG to discuss*

Comments on scientific survey findings	N/A
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)
Any other changes in the fishery?	**RAG members to provide advice. For example, fishing behaviour/market demand? **
Any other sources of mortality apart from fishing?	**RAG members to provide advice**
Other information	

Low Tier

Total catch data	**Fishing season**	**Catch (t)**	**TAC (t)**	**% TAC caught**	**TAC or basket trigger exceeded?**	**% of TAC overcatch**
	2020	No catch reported	50 (0.5t trigger limit)	-	TAC: No Basket: No	N/A
	2021	No catch reported	50 (0.5t trigger limit)	-	N/A	N/A
	2022	No catch reported	50 (0.5t trigger limit)	-	TBA	TBA

Decision rules	Is the total catch reliable? **RAG members to provide advice**
	Not overcaught so overcatch decision rules not triggered (refer to section 2.11.1.1 of the harvest strategy).

<table>
<tr><td></td><td colspan="5">For species with individual triggers within a basket with a joint TAC, should the joint TAC or individual triggers be changed (up or down) (refer to section 2.11.1.2 of the harvest strategy)? *RAG members to provide advice*</td></tr>
<tr><td colspan="6">Species specific data gaps and needs</td></tr>
<tr><td colspan="6">*to be completed at the meeting*</td></tr>
<tr><td colspan="6">Species Specific Research and Priorities</td></tr>
<tr><td colspan="6">*to be completed at the meeting*</td></tr>
<tr><td rowspan="2">HCRAG 2 recommendations</td><td>Fishing season</td><td>RBC (t)</td><td>Overcatch to be discounted (t)</td><td>Other source(s) of mortality (t)</td><td>TAC (t)</td></tr>
<tr><td>2023</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">*General RAG comments*</td></tr>
</table>

Brown sandfish (not assessed by HCRAG)

HCRAG Species Assessment Sheet				
Common names	Brown sandfish – *Bohadschia vitiensis*			
Pre-HS TAC	Part of the 80t basket species TAC			
Status open/closed	Open			
Current TAC	Part of the 50t basket species TAC	Based on harvest strategy starting TAC		
Basket trigger	3 tonnes			
Minimum size limit	25cm			
New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)				
Latest scientific survey data	**Year**	**Standing stock biomass (90th percentile) (t)**	**Standing stock biomass above min species size limit (t)**	**Is standing stock biomass above the default limit reference point?**
	Not included in 2019-20 survey	-	-	*RAG to discuss*
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	-	-	-	*RAG to discuss*
Comments on scientific survey findings	N/A			
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)			
Any other changes in the fishery?	**RAG members to provide advice. For example, fishing behaviour/market demand? **			
Any other sources of mortality apart from fishing?	**RAG members to provide advice**			
Other information				

Low Tier						
Total catch data	**Fishing season**	**Catch (t)**	**TAC (t)**	**% TAC caught**	**TAC or basket trigger exceeded?**	**% of TAC overcatch**
	2020	No catch reported	50 (3t trigger limit)	N/A	TAC: No Basket: No	N/A
	2021	No catch reported	50 (3t trigger limit)	N/A	N/A	N/A
	2022	No catch reported	50 (3t trigger limit)	TBA	TBA	TBA
Decision rules	Is the total catch reliable? **RAG members to provide advice**					
	Not overcaught so overcatch decision rules not triggered (refer to section 2.11.1.1 of the harvest strategy).					

	For species with individual triggers within a basket with a joint TAC, should the joint TAC or individual triggers be changed (up or down) (refer to section 2.11.1.2 of the harvest strategy)? **RAG members to provide advice**

Species specific data gaps and needs

to be completed at the meeting

Species Specific Research and Priorities

to be completed at the meeting

	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC/trigger limit (t)
HCRAG 2 recommendations	2023				

General RAG comments

Leopardfish (not assessed by HCRAG)

HCRAG Species Assessment Sheet

Common names	Leopardfish – *Bohadschia argus*	
Pre-HS TAC	Part of the 80t basket species TAC	
Status open/closed	Open	
Current TAC	Part of the 50t basket species TAC	Based on harvest strategy starting TAC
Basket trigger	40 tonnes	
Minimum size limit	30cm	

New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)

Latest scientific survey data	**Year**	**Standing stock biomass (90th percentile) (t)**	**Standing stock biomass above min species size limit (t)**	**Is standing stock biomass above the default limit reference point?**
	2019/20	508	-	*RAG to discuss*
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	Yes	No	No	*RAG to discuss*
Comments on scientific survey findings	Catches low. Generally increasing density trend. No concern for TAC.			
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)			
Price data	$15/kg (gutted-salted), $120/kg (dried)			
Any other changes in the fishery?	**RAG members to provide advice. For example, fishing behaviour/market demand? **			
Any other sources of mortality apart from fishing?	**RAG members to provide advice**			
Other information				

Low Tier

	Fishing season	Catch (t)	TAC (t)	% TAC caught	TAC or basket trigger exceeded?	% of TAC overcatch
Total catch data	2020	0.2	50 (40t basket trigger limit)	0.4%	TAC: No Basket: No	N/A
	2021	0.2	50 (40t basket trigger limit)	0.4%	N/A	N/A
	2022	0	50 (40t basket trigger limit)	TBA	TBA	TBA

<table>
<tr><td rowspan="3">Decision rules</td><td colspan="5">Is the total catch reliable? *<i>RAG members to provide advice</i>*</td></tr>
<tr><td colspan="5">Reported overcatch does not trigger any of the overcatch decision rules (refer to section 2.11.1.1 of the harvest strategy).</td></tr>
<tr><td colspan="5">For species with individual triggers within a basket with a joint TAC, should the joint TAC or individual triggers be changed (up or down) (refer to section 2.11.1.2 of the harvest strategy)? *<i>RAG members to provide advice</i>*</td></tr>
<tr><th colspan="6">Species specific data gaps and needs</th></tr>
<tr><td colspan="6"><i>*to be completed at the meeting*</i></td></tr>
<tr><th colspan="6">Species Specific Research and Priorities</th></tr>
<tr><td colspan="6"><i>*to be completed at the meeting*</i></td></tr>
<tr><td rowspan="2">HCRAG 2 recommendations</td><th>Fishing season</th><th>RBC (t)</th><th>Overcatch to be discounted (t)</th><th>Other source(s) of mortality (t)</th><th>TAC/trigger limit (t)</th></tr>
<tr><td>2023</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6"><i>*General RAG comments*</i></td></tr>
</table>

Pinkfish

HCRAG Species Assessment Sheet		
Common names	Pinkfish – *Holothuria edulis*	
Pre-HS TAC	Part of 80t basket species TAC	
Status open/closed	Open	
Current TAC	Part of 50t basket species TAC	Based on harvest strategy starting TAC
Basket trigger	N/A	
Minimum size limit	N/A	

New information

	Year	Standing stock biomass (90th percentile) (t)	Standing stock biomass above min species size limit (t)	Is standing stock biomass above the default limit reference point?
Latest scientific survey data	2019/20	85	-	*Not assessed*
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	Yes	No	Yes	*HCWG to discuss*

Comments on scientific survey findings	CSIRO paper: Possible decline or natural variability. Stock assessment needed.
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)
Price data (as advised by industry at HCRAG 1 meeting)	Currently no market demand for the species
Any other changes in the fishery?	None identified – this species is hardly fished
Any other sources of mortality apart from fishing?	None identified
Other information	

Low Tier

	Fishing season	Catch (t)	TAC (t)	% TAC caught	TAC or basket trigger exceeded?	% of TAC overcatch
Total catch data	2020	No catch reported	50	N/A	TAC: No Basket: N/A	N/A
	2021	No catch reported	50	TBA	TBA	TBA
	2022	No catch reported	50	TBA	TBA	TBA
Decision rules	No concerns from RAG and additional industry members regarding the catch data.					

Species specific data gaps and needs					
N/A					
Species Specific Research and Priorities					
None identified					
HCRAG 2 recommendations	**Fishing season**	**RBC (t)**	**Overcatch to be discounted (t)**	**Other source(s) of mortality (t)**	**TAC/trigger limit (t)**
	2023				
Insert HCRAG 2 recommendations					

Amberfish (not assessed by HCRAG)

HCRAG Species Assessment Sheet		
Common names	Amberfish – *Thelenota anax*	
Pre-HS TAC	Part of the 80t basket species TAC	
Status open/closed	Open	
Current TAC	Part of the 50t basket species TAC	Based on harvest strategy starting TAC
Basket trigger	N/A	
Minimum size limit	N/A	

New information since the TAC was last considered (in this it was at the implementation of the Harvest Strategy)				
Latest scientific survey data	**Year**	**Standing stock biomass (90th percentile) (t)**	**Standing stock biomass above min species size limit (t)**	**Is standing stock biomass above the default limit reference point?**
	2019/20	478	-	*RAG to discuss*
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	Yes	No	No	*RAG to discuss*
Comments on scientific survey findings	Catches low. No concern for TAC.			
Catch data	Available for 2020, 2021 and 2022 (as at 22 September 2022)			
Any other changes in the fishery?	**RAG members to provide advice. For example, fishing behaviour/market demand? **			
Any other sources of mortality apart from fishing?	**RAG members to provide advice**			
Other information				

Low Tier						
Total catch data	**Fishing season**	**Catch (t)**	**TAC (t)**	**% TAC caught**	**TAC or basket trigger exceeded?**	**% of TAC overcatch**
	2020	No catch reported	50	-	TAC: No Basket: N/A	N/A
	2021	No catch reported	50	TBA	TBA	TBA
	2022	No catch reported	50	TBA	TBA	TBA
Decision rules	Is the total catch reliable? **RAG members to provide advice**					

	Not overcaught so overcatch decision rules not triggered (refer to section 2.11.1.1 of the harvest strategy).
	For species with individual triggers within a basket with a joint TAC, should the joint TAC or individual triggers be changed (up or down) (refer to section 2.11.1.2 of the harvest strategy). **RAG members to provide advice**

Species specific data gaps and needs

to be completed at the meeting

Species Specific Research and Priorities

to be completed at the meeting

HCRAG 2 recommendations	Fishing season	RBC (t)	Overcatch to be discounted (t)	Other source(s) of mortality (t)	TAC/trigger limit (t)
	2023				

General RAG comments

Closed species

Surf redfish (closed)

<table>
<tr><th colspan="5">HCRAG Species Assessment Sheet</th></tr>
<tr><td>Common names</td><td colspan="4">Surf redfish – <i>Actinopyga mauritiana</i></td></tr>
<tr><td>Pre-HS TAC</td><td colspan="4">0 tonnes</td></tr>
<tr><td>Status open/closed</td><td colspan="4">Closed since 2003 due to sustainability concerns</td></tr>
<tr><td>Minimum size limit</td><td colspan="4">22cm</td></tr>
<tr><td colspan="5">New information</td></tr>
<tr><td rowspan="4">Latest scientific survey data</td><td>Year</td><td>Standing stock biomass (90th percentile) (t)</td><td>Standing stock biomass above min species size limit (t)</td><td>Is standing stock biomass above the default limit reference point?</td></tr>
<tr><td>2019/20</td><td>20</td><td>6.7</td><td><i>RAG to discuss</i></td></tr>
<tr><td>Survey adequate for species</td><td>Any unexpected results</td><td>Any concerns with biomass trend or absolute abundance</td><td>Need for management response</td></tr>
<tr><td>Yes</td><td>No</td><td>No</td><td><i>RAG to discuss</i></td></tr>
<tr><td>Comments on scientific survey findings</td><td colspan="4">Species remains closed – Harvest Strategy closed species rule applies.</td></tr>
<tr><td>Catch data</td><td colspan="4">This species is closed to fishing however ~200kg of catch was reported by a fisher in 2020. This matter was followed up by AFMA Compliance.</td></tr>
<tr><td>Other information</td><td colspan="4"></td></tr>
<tr><td colspan="5">Re-opening Decision Rule (2.11.4 section of the harvest strategy) – this rule can only be applied if, using all available and reliable information, it can be established that the stock is above a limit reference point level.</td></tr>
<tr><td colspan="5">Species specific data gaps and needs</td></tr>
<tr><td colspan="5"><i>*to be completed at the meeting*</i></td></tr>
<tr><td colspan="5">Species Specific Research and Priorities</td></tr>
<tr><td colspan="5"><i>*to be completed at the meeting*</i></td></tr>
<tr><td colspan="5"><i>*General RAG comments*</i></td></tr>
</table>

Sandfish (closed)

HCRAG Species Assessment Sheet				
Common names	Sandfish – *Holothuria scabra*			
Pre-HS TAC	0 tonnes			
Status open/closed	Closed since 1998 due to sustainability concerns			
Minimum size limit	18cm			
New information				
Latest scientific survey data	**Year**	**Standing stock biomass (90th percentile) (t)**	**Standing stock biomass above min species size limit (t)**	**Is standing stock biomass above the default limit reference point?**
	Planned for but not included in 2019-20 survey	unknow	unknown	*RAG to discuss*
	Survey adequate for species	**Any unexpected results**	**Any concerns with biomass trend or absolute abundance**	**Need for management response**
	-	-	-	*RAG to discuss*
Comments on scientific survey findings	No survey undertaken. Harvest Strategy closed species rule applies.			
Catch data	This species is closed to fishing			
Other information	Assessed as 'Overfished' but 'Not subject to overfishing' by ABARES in the Annual Fishery Status Reports as no recovery in overall density was observed between 1998 and 2010, and there is no other robust information to inform stock status.			
Re-opening Decision Rule (2.11.4 section of the harvest strategy) – this rule can only be applied if, using all available and reliable information, it can be established that the stock is above a limit reference point level.				
Species specific data gaps and needs				
to be completed at the meeting				
Species Specific Research and Priorities				
to be completed at the meeting				
General RAG comments				

Australian Government
Australian Fisheries
Management Authority

Torres Strait
PZJA
Protected Zone
Joint Authority

TORRES STRAIT FISHERIES CATCH DISPOSAL RECORD

TDB02

Business Name

Please remember

The pages in this book are self carbonating, place this flap under the original copy and the two duplicate pages to prevent writing transferring to the next set of forms.

SPECIES CODES:

Tropical Rock Lobster	TOB
Mud crab	CRM
Prickly redfish	CUP
White teatfish	CUW
Curryfish (all species basket)	CUC
Common curryfish (brown)	CUH
Curryfish vastus (green)	CUV
Hairy blackfish	CUK
Burrowing blackfish	CBB
Deepwater blackfish	CDB
Deepwater redfish	CUD
Golden sandfish	CUN
Brown sandfish	CBS
Greenfish	CUG
Elephant Trunkfish	CUE
Leopardfish	CLF
Stonefish	CUF
Lollyfish	CUL
Sandfish	CUS
Surf redfish	CUR
Black teatfish	CUB

Spanish Mackerel	SNM
School Mackerel	MAO
Spotted Mackerel	MAL
Grey/Broad Barred Mackerel	MAG
Salmon Mackerel	MSH
Coral Trout (mixed basket)	TCG
Common Coral Trout	TCO
Barcheek (Islander) Coral Trout	TCI
Passionfruit Coral Trout	TCL
Bluespotted Coral Trout	TCB
Cod	CRO
Barramundi Cod	COB
Red Emperor	RDE
Spangled Emperor	SPE
Other Emperors	RSE
Stripey Bass	SSB
Trochus	TCH
Pearl shell	PSH

PROCESSING CODES:

TRL and Crustaceans

Tail	T
Whole	W
Live	L

Finfish:

Fillets	F
Whole	W
Head and Gutted	HG
Gilled and Gutted	GG
Live	L

Molluscs

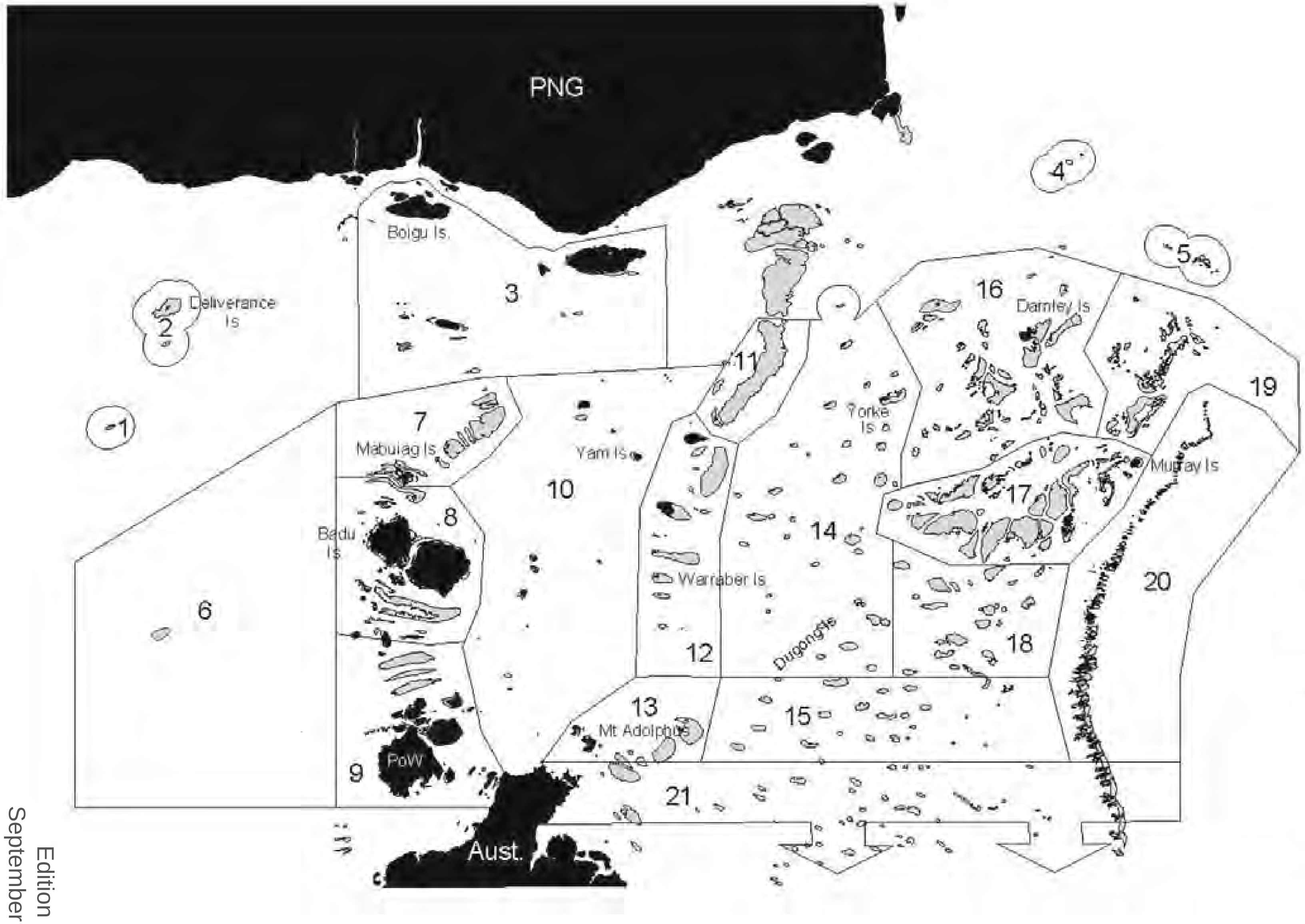
Whole	W
Shell Only	SH
Meat Only	MT

Beche de mer (BDM)

Boiled	B
Boiled and Salted	BS
Salted	S
Salted and Chilled	SC
Chilled	C
Boiled and Frozen	BF
Salted and Frozen	SF
Frozen and Green	FG
Boiled and Chilled	BC
Dried	DI

TORRES STRAIT CATCH DISPOSAL RECORD - TDB02

AREAS FOR TORRES STRAIT CATCH DISPOSAL RECORD



1. Turu Cay
2. Deliverance Island
3. Northern section
4. Bramble Cay
5. Anchor Cay
6. Western
7. Mabuiag
8. Badu
9. Thursday Island
10. Central
11. Warrior
12. Warraber
13. Mt Adulphos
14. Great North East Channel
15. South east
16. Darnley
17. Cumberland
18. Seven Reefs
19. Don Cay
20. Barrier
21. GBR

Edition Date:
September 2017

Use area where most catch was taken

Torres Strait Fisheries Catch Disposal Record TDB02

GENERAL INFORMATION

About this Catch Disposal Record

- This TDB02 Catch Disposal Record is designed to record verified landed information about fish catches - it does not replace any requirement for fishers to complete daily catch and effort logbooks.

- Information supplied on this Catch Disposal Record will be used for fisheries management purposes. AFMA may release data on specific returns in connection with the investigation and prosecution of offences against the *Torres Strait Fisheries Act 1984* and associated legislation or under a court order.

- All fields **must** be completed in part A of the form, fields in part B are not mandatory.

Who must complete this Catch Disposal Record?

- The licensed Torres Strait Fish Receiver (the Receiver) or their Registered Authorised Agent must complete the Catch Disposal Record.
  - a Registered Authorised Agent is a person who has been nominated by the licensed Torres Strait Fish Receiver to complete the TDB02 on their behalf. The Receiver must complete and lodge with AFMA the appropriate nomination form. **Note:** *all further references in this Catch Disposal Record to Receiver/s should be taken to also be a reference to a Registered Authorised Agent as prescribed by AFMA's Registered Authorised Agent Nomination process.*
  - the fish receiver (or agent) signing the CDR form must be a different person to fisher signing the fishing licence details.

- The Receiver must accurately determine the weight of the fish and complete the Catch Disposal Record for every consignment of fish received.

When must this Catch Disposal Record be completed?

- This Catch Disposal Record must be completed by the Receiver immediately upon receipt of the fish and before the fish are placed with any other fish that are not part of the consignment.

- Retaining the Catch Disposal Record – the Receiver must retain this Catch Disposal Record. Once completed the Receiver must keep this book for a minimum period of five years and make it available to any authorised officer on request.

Where and how must the forms be submitted?

- **White copy** – the Receiver must forward the white original copy to AFMA within 3 calendar days of the fish being received. Where the premises at which the fish were received was a boat, the Receiver must forward the white original copy to AFMA within 3 business days of that boat returning to port.

- **Pink Copy –** the holder of the Torres Strait commercial fishing licence (the Fisher) who is disposing of the fish retains the pink copy.

- **Green copy** – must remain in this book and be held by the Receiver.

Note: As each page of this Catch Disposal Record is numbered, any spoiled or incorrectly completed forms must be clearly marked 'cancelled' and returned to AFMA.

If you have any queries about completing this Catch Disposal Record please contact AFMA Direct on 1300 723 621.

FAILURE TO SUPPLY AN ACCURATE AND FULLY COMPLETED CATCH DISPOSAL RECORD FOR ALL FISH RECEIVED IS A BREACH OF THE LICENCE CONDITIONS OF YOUR FISH RECEIVER LICENCE. BREACH OF ANY LICENCE CONDITION(S) IS AN OFFENCE UNDER THE *TORRES STRAIT FISHERIES ACT 1984* AND PENALTIES APPLY.

How to Complete the Catch Disposal Record

INSTRUCTIONS FOR FISH RECEIVERS

You *must* provide details for ***PART A*** for each consignment of fish as follows:

- **Has a TDB02 been completed for this fish by another Receiver? No Not Sure**
  - If you know another receiver has completed a TDB02 for this consignment of fish then you do not need to complete a TDB02.
  - If you know another TDB02 has not been completed then circle NO and continue completing this form as required.
  - If you don't know if another form has been completed then circle Not Sure and continue completing this form as required.
- **Fishing Licence Holder Name** – enter the name of the person who holds the licence that is nominated to the boat from which the fish were caught. Enter their name as it appears on the fishing licence.
- **Fishing Licence Number** – enter the fishing licence number of the fishing licence that is nominated to the boat from which the fish were caught. Enter the number as it appears on their fishing licence.
- **Fisher Type** – circle one of the three options provided (TIB, TVH, or Sunset).
- **Boat Symbol** - enter the boat symbol that appears on the fishing licence nominated to the boat from which the fish were caught.
- **Fisher/or Agent Name** - enter the name of the person signing as the fisher/or agent.
- **Signature of Fisher/ or Agent** – Where fish are recdived directly from a fisher or their agent, the fishing licence holder (or agent) must sign the CDR form to verify their licence details.
- **Date** – Enter the date Fisher signed.
- **Fish Receiver** – enter the name of the Fish Receiver name as it appears on your Fish Receiver Licence.
- **Fish Receiver Licence Number** – enter your Fish Receiver Licence number.
- **Fish Receiver Address** – enter the address of the premise the fish were received.
- **Species** – species codes are shown on the cardboard page divider in this logbook. Enter either the species code or name of each species in the consignment.
- **Processing Code** – processing codes are shown on the cardboard page divider in this logbook. Where processing has occurred please indicate the nature of the processing (e.g. gutted and blanched, dried, headed and gutted, etc.).
- **Weight (kg)** – Weight must be determined by accurate scales
  - Where the fish have not been processed in any way, enter the accurate weight in kilograms of all the whole fish received of each individual species.
  - Where the fish have been processed prior to receiving, record the accurate processed weight in kilograms of all the fish received of each individual species.
  - Where only part of the catch of a species is processed, record the processed and unprocessed components of the species on separate rows.
  - Do not record processed and unprocessed forms in the same row.
- **Fish Number** – Enter the number of fish **for records of live Fin Fish** only.
- **Signature of Receiver –** The Receiver or their Registered Authorised Agent must sign this part to certify accurate completion of the Catch Disposal Record.
- **Printed name** of Receiver – enter the name of the Receiver or Registered Authorised Agent who signed this form.
- **Date** – Enter the date on which this form was completed.

The following information *may* also be completed in ***PART B***. These fields are not mandatory:

- **Number of Fishers** – enter the number of fishers who participated in the fishing trip for which the Catch Disposal Record relates.
- **Number of Days** – enter the duration of the fishing trip for which the Catch Disposal Record relates.
- **Area Fished** – enter the area where the fish were taken using the map shown at the start of this logbook. Enter more than one area if the fishing trip for which the Catch Disposal Record relates if applicable.
- **Start Date** – enter the start date of the fishing trip for which the Catch Disposal Record relates.
- **End Date** – enter the end date of the fishing trip for which the Catch Disposal Record relates.
- **Logbook Type** – record the logbook type that was completed. For example catches of tropical rock lobster may have been recorded in their Tropical Rock Lobster Daily Fishing Log TRL04.
- **Logbook Number and Page Number this catch relates to** – Record detail if this catch has also been entered into a daily fishing logbook. Please enter N/A (Not applicable) if this catch has not previously been entered in a daily fishing logbook.
- **Fishing Method** – tick (✓) the fishing method used to take the fish for the fishing trip for which the Catch Disposal Record relates. Tick (✓) more than one fishing method if applicable.

If you have any queries about completing this Catch Disposal Record please contact AFMA Direct on 1300 723 621.

Australian Fisheries Management Authority
TDB02
October 2017

Australian Fisheries
Management Authority
Box 7051
Canberra Mail Centre
ACT 2610

CDR No.	38	**Page No.**	34

Torres Strait Fisheries Catch Disposal Record TDB02

Has a TDB02 been completed for this fish by another Receiver?
If you are certain the answer is yes - do not complete another TDB02 for the same fish **(Circle one)** [✓ **NO**] **NOT SURE**

PART A MANDATORY

Fisher Details

Fishing Licence Holder Name	Geoff Trout	Fishing Licence Number	3579
Fisher Type (Circle One)	TIB TVH [✓ Sunset]	Boat Symbol	FTVW
Signature of Fisher /or agent:	Geoff Trout	Printed name of Fisher /or agent and Date:	Geoff Trout 9 / 08 / 2017

Receiver Details

Fish Receiver Name	Island Seafoods	Fish Receiver Licence Number	2468
Fish Receiver Address	Lot 987 Thursday Island QLD 4875		

Details of Catch

Species (see code list)	Processing Code (see code list)	Weight (kg)	Fish Number (live finfish only)
SNM	W	200	
SNM	GG	45	
TCG	L		72
TOTAL		245	72

Signature of Receiver /or Agent: I certify that the information provided on this form is a true and accurate record.	Bob Smith	Printed Name of Receiver and Date:	Bob Smith 9 / 08 / 2017

PART B VOLUNTARY

Fishing Effort and Area

Number of Fishers	2	Number of Days	3		
Area Fished	16	Start and End Dates	8/8/17 to 9/8/17		
Logbook Type	TSF01	Logbook Number(s)	234	Page Number(s)	34, 35, 36

Has the catch been recorded on a daily fishing logbook? (Circle one) [✓ Yes] No

Fishing Method (tick the fishing methods used)

Hookah (MDH)		Handline (LHL)	✓	Drop Line (LDL)	✓	
Free Dive (MDF)		Rod and Reel (LRR)		Other (Specify)		
Lamp Fishing (MLF)		Troll (LTL)				

White Copy must go to AFMA within 3 days of receipt of fish Pink Copy Fisher to retain Green Copy remains in book (Receiver Copy)

For assistance please contact AFMA Direct 1300 723 621

Australian Fisheries
Management Authority
Box 7051
Canberra Mail Centre
ACT 2610

CDR No.	40	**Page No.**	34

Torres Strait Fisheries Catch Disposal Record TDB02

Has a TDB02 been completed for this fish by another Receiver?
If you are certain the answer is yes - do not complete another TDB02 for the same fish

(Circle one) [✓ **NO**] **NOT SURE**

PART A MANDATORY

Fisher Details

Fishing Licence Holder Name	Rob Kayar	Fishing Licence Number	4573
Fisher Type (Circle One)	[✓ TIB] TVH Sunset	Boat Symbol	TRAWQ9999
Signature of Fisher /or agent:	Rob Kayar	Printed name of Fisher /or agent and Date:	Rob Kayar 9 / 08 / 2017

Receiver Details

Fish Receiver Name	Island Lobster	Fish Receiver Licence Number	1234
Fish Receiver Address	Lot 987 Thursday Island QLD 4875		

Details of Catch

Species (see code list)	Processing Code (see code list)	Weight (kg)	Fish Number (live finfish only)
TOB	W	78	
TOB	T	23	
TOB	L	223	
TOTAL		324	

Signature of Receiver /or Agent: I certify that the information provided on this form is a true and accurate record.	John Smith	Printed Name of Receiver and Date:	John Smith 9 / 08 / 2017

PART B VOLUNTARY

Fishing Effort and Area

Number of Fishers	2	Number of Days	2		
Area Fished	10	Start and End Dates	8/8/17 to 9/8/17		
Has the catch been recorded on a daily fishing logbook? (Circle one) Yes [✓ No]					
Logbook Type		Logbook Number(s)	N/A	Page Number(s)	N/A

Fishing Method (tick the fishing methods used)

Hookah (MDH)	✓	Handline (LHL)		Drop Line (LDL)		
Free Dive (MDF)		Rod and Reel (LRR)		Other (Specify)		
Lamp Fishing (MLF)		Troll (LTL)				

White Copy must go to AFMA within 3 days of receipt of fish   Pink Copy Fisher to retain   Green Copy remains in book (Receiver Copy)

For assistance please contact AFMA Direct 1300 723 621

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Canberra Mail Centre
ACT 2610

CDR No.		**Page No.**	

Torres Strait Fisheries Catch Disposal Record TDB02

Has a TDB02 been completed for this fish by another receiver?
If you are certain the answer is yes - do not complete another TDB02 for the same fish

(Circle one) **NO** | **NOT SURE**

PART A MANDATORY

Fisher Details

Fishing Licence Holder Name		Fishing Licence Number	
Fisher Type (Circle One)	TIB TVH Sunset	Boat Symbol	
Signature of Fisher /or agent:		Printed name of Fisher /or agent and Date:	/ /

Receiver Details

Fish Receiver Name		Fish Receiver Licence Number	
Fish Receiver Address			

Details of Catch

Species (see code list)	Processing Code (see code list)	Weight (kg)	Fish Number (live finfish only)
TOTAL			

Signature of Receiver /or Agent: I certify that the information provided on this form is a true and accurate record.		Printed Name of Receiver and Date:	/ /

PART B VOLUNTARY

Fishing Effort and Area

Number of Fishers		Number of Days	
Area Fished		Start and End Dates	

Has the catch been recorded on a daily fishing logbook? (Circle one) Yes No

Logbook Type		Logbook Number(s)		Page Number(s)	

Fishing Method (tick the fishing methods used)

Hookah (MDH)		Handline (LHL)		Drop Line (LDL)		
Free Dive (MDF)		Rod and Reel (LRR)		Other		
Lamp Fishing (MLF)		Troll (LTL)		(Specify)		

White Copy must go to AFMA within 3 days of receipt of fish Pink Copy Fisher to retain Green Copy remains in book (Receiver Copy)

For assistance please contact AFMA Direct 1300 723 621

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No. 2** **27-28 September 2022**
Update on climate change work in Torres Strait Fisheries	**Agenda Item 5** **For NOTING & DISCUSSION**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG):

   a. **NOTE** the video presentation to be provided by Dr Leo Dutra (CSIRO) at the meeting on the outcomes of the project *Climate variability and change relevant to key fisheries resources in the Torres Strait — a scoping study* (climate change scoping project).

   b. **NOTE** the update on one of the Torres Strait Scientific Advisory Committee's (TSSAC) recently supported projects, '*Understanding climate variability and change relevant to key fisheries resources in the Torres Strait and adaptation and mitigation strategies'* (climate change modelling project) which is a follow up project to the climate change scoping project mentioned above.

   c. **NOTE** the update from AFMA's Climate Adaptation Senior Program Manager, Alice McDonald on a body of work that is looking to build climate change information into fisheries management advice and decisions in AFMA's other Commonwealth fisheries, with a view to implementing a similar process for Torres Strait Fisheries.

KEY ISSUES

Outcomes of the climate change scoping project

2. The need to better understand the species-specific effects of climate change and variability on Torres Strait Fisheries was initially identified as a research priority by TSSAC in December 2018 (meeting 71). TSSAC agreed that as a starting point, a scoping study should be undertaken on the possible methods and resources needed to build an information framework that can evaluate the implications of future climate variability and change scenarios on fisheries to better allow fisheries managers and industry to respond and adapt to any changes.

3. The project delivered an evaluation of the over-arching data requirements and framework that are needed to support a climate change model that will evaluate the implications of future climate variability and change scenarios on key fisheries. The study considered previous reviews of climate implications for Torres Strait, consulted extensively with relevant fishery researchers, managers and key stakeholders and convened a workshop, with relevant fishery modelling expert end-users and stakeholders.

4. The TSSAC considered the project's outcomes and recommendations at their 79th meeting on 9-10 June 2021 and agreed that if the project was to progress beyond this scoping phase, it would provide a range of information that is of value to fisheries management, including:

   - Understanding interactions between fisheries and ecosystems.
   - Understanding impacts that different climate change scenarios could have on fisheries/ species.
   - Understanding impacts of changes in catchment conditions and rainfall.
   - Understanding impacts of incidences.

- Assisting fisheries managers and communities with preparation for adaptation, where possible.

- Providing predictions of changes in abundance, growth, reproductive capacity and distribution.

- Helping to differentiate between the relative effects of fishing and environmental (climate) change on marine resources.

- Use existing, and new data to be collected, to generate information of value to other sectors beyond fisheries, e.g. water circulation, winds, predicted sea level rise, rainfall and wind speed.

5. The project scope that went out in the 2019-20 TSSAC call for research funding proposals is provided as **Attachment 5a** for the RAG's reference. The project was funded by AFMA and finalised on 31 January 2020. The full project report is provided as **Attachment 5b**.

6. The RAG is invited to note the video presentation on the outcomes of the scoping project from Dr Leo Dutra.

Climate change modelling project update

7. Following on from the TSSAC's recommendations on the climate change scoping project, a follow up call for research proposals (**Attachment 5c**) was made in February 2022 with one proposal received from CSIRO **(Attachment 5d)**. Having regard to feedback from all PZJA advisory committee RAGs and Working Groups out of session, the TSSAC considered this research proposal at their meeting on 6-7 April 2022 (TSSAC 81).

8. The project is intended to:
    a. enable fisheries managers and communities to better prepare for climate change mitigation and adaptation, where possible;
    b. integrate new and existing fisheries and environmental data within an over-arching data framework;
    c. provide estimates of the impacts that different climate change scenarios could have on the marine ecosystem and associated fisheries/species;
    d. provide estimates of the economic, social and other fisheries-related livelihood impacts of climate change on communities in the short (2 yrs), medium (5 yrs) and longer term (10+ yrs), and suggest some possible actions for adaptation; and
    e. help differentiate between the relative effects of fishing and climate change on marine resources.
    f. provide results in formats (e.g. graphical, video, written) which can be communicated to stakeholders (Torres Strait Island Communities, Fishers, Fisheries Managers and local and regional organisations).

9. Due to limited AFMA funding available to support all recommended research projects in 2022-23, the climate change modelling project is to be partially funded through a $500,000 co-contribution from the Torres Strait Regional Authority and the remainder of the project funds are being considered for funding through the Fisheries Research and Development Corporation (FRDC).

10. An outcome on FRDC funding is expected by the end of October 2022.

Building climate change information into fisheries management processes

11. In other Commonwealth fisheries (fisheries managed elsewhere in Australia by AFMA), a program of work is being undertaken to ensure that climate impacts are more strategically incorporated into the management of these fisheries to ensure that AFMA continues to meet legislative objectives relating to ecological sustainability. Structured integration of information, data and research on climate impacts into AFMA's decision-making processes is a necessary foundation to pursuing climate adaptive management across Commonwealth fisheries.

12. This work is a follow up action from the *Adaption of Commonwealth fisheries management framework to climate change project (FRDC 2016-059)* (the climate adaptation project) that looked at the readiness of Commonwealth Fisheries Management Arrangements to the potential impacts of climate change and options to adapt to changes. Its key output was a climate adaption handbook that provides detailed steps for fisheries and other stakeholders to conduct climate risk assessment of their fishery management arrangements and operations.

13. Recognising the priority that the Torres Strait community places upon management of climate change impacts and the vulnerability of Torres Strait fisheries to climate change, AFMA hopes to commence similar work for Torres Strait fisheries through the PZJA's advisory committees starting with the Tropical Rock Lobster fishery and gradually expanding to other Torres Strait Fisheries.

14. The RAG is invited to note the presentation from Alice McDonald on a body of work that is looking to build climate change information into fisheries management advice and decisions in AFMA's other Commonwealth fisheries. The RAG is invited to consider how this may apply to Torres Strait Fisheries.

BACKGROUND

Other relevant research to date on climate change impacts on Torres Strait Fisheries

15. In terms of assessing the likely impacts of climate change on Torres Strait Fisheries the following has been undertaken:
    a. Qualitative Sensitivity Analysis: Assessing the vulnerability of Torres Strait fisheries and supporting habitats to climate change (Welch and Johnson 2013);
    b. Management Strategy Evaluation to integrate climate changes into the TRL Stock Assessment: An Integrated Management Strategy Evaluation (MSE) for the Torres Strait Rock Lobster *Panulirus ornatus* fishery (Plaganyi *et al* 2012);
    c. System Modelling: Models of Intermediate Complexity of Ecosystems (MICE) – applied to TRL in the Torres Strait. Used in the following projects:
        i. AFMA project 2017/0816 – Environmental drivers of variability and climate projections for the Torres Strait tropical lobster *Panulirus ornatus.* (Plaganyi *et al* 2018).
        ii. Decadal-Scale Forecasting of Australian Fish and Fisheries (Fulton *et al 2018*)*.* A non-technical summary of the decadal-scale forecasting project[1] is provided at **Attachment 5e.**

16. In June 2018 the TSRA and National Environmental Science Programs (NESP) Earth Systems and Climate Change Hub convened a workshop on climate change implications for fisheries and marine ecosystems in the Torres Strait. The workshop identified initial thoughts on priority areas for

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[1] AFMA led project *Adaption of Commonwealth fisheries management framework to climate change project (FRDC 2016-059)*

research that may help fisheries and marine ecosystem management in the Torres Strait (**Attachment 5f**).

Adaption of Commonwealth fisheries management framework to climate change project (FRDC 2016-059) (the climate adaptation project)

17. The climate adaptation project was completed in 2021 and looked at the readiness of Commonwealth Fisheries Management Arrangements to the potential impacts of climate change and options to adapt to changes. Its key output is a climate adaption handbook that provides detailed steps for fisheries and other stakeholders to conduct climate risk assessment of their fishery management arrangements and operations. During the project, AFMA worked with the CSIRO, IMAS and other researchers to answer the following questions:
    a. *What changes does AFMA need to make to its regulatory system so that it can effectively deliver its management objectives?*
    b. *What are the consequences of those changes for the fishing industry and other fishery stakeholders?*
18. While AFMA's current management strategies have flexibility built in them, it was important to assess the extent to which the direct and indirect impacts of climate change will challenge Australian fisheries and the management framework that they are currently managed under. The climate adaptation project did this by developing a risk assessment approach that tests the adaptability of current and potential management arrangements to projected, climate driven, changes of fish stocks on three case study fisheries, the Northern Prawn, Heard and MacDonald Island and Southern Bluefin Tuna Fisheries as part of the project.
19. The project consulted with key stakeholders from those fisheries, as well as recreational, indigenous and state fishery stakeholders to develop the final approach.

Torres Strait Scientific Advisory Committee 2019-20 financial year research project scope

Project Title: Climate variability and change relevant to key fisheries resources in the Torres Strait — a scoping study.

Project Need:

Key commercial species in Torres Strait fisheries, such as tropical rock lobsters, prawn, finfish and beche-de-mer, are likely to be influenced by current and future climate variability and change. Fisheries management and assessments will need to take account of the implications of future variability and change that may affect stocks. These may manifest through effects on recruitment pathways, mortality rates, and critical habitats among other processes. Previous reviews have qualitatively assessed the vulnerability of the Torres Strait to climate change effects; however, future assessments need to account for these in a quantitative manner for fisheries management to respond appropriately. A quantitative MICE model (Model of Intermediate Complexity) has already been completed in the Torres Strait region for tropical rock lobster, as a part of understanding annual variability in abundance. Separate fishery specific assessment models for multiple species, will all require essentially the same over-arching regional-scale data. This data should cover future climate and environmental variability, potentially including currents, winds, temperature, rainfall etc, at an appropriate spatial extent and grid-resolution.

The requirement is to scope a future project that can deliver the over-arching data requirements that are needed from e.g. global atmospheric and/or oceanographic models, down-scaled to the broader Torres Strait region. This can be used as a framework to derive separate fishery specific models that will evaluate the implications of future climate variability and change scenarios on these fisheries. The down-scaled atmospheric and/or oceanographic outputs will need to be produced in way that meets the input data needs of the various fishery specific sub-models.

The scoping study will need to consider previous reviews of climate implications for Torres Strait; consult with relevant fishery researchers, managers and key stakeholders regarding the necessary inputs; identify a range of potential sources of co-investment funds to support the main future project. The scoping study could potentially include a workshop, if cost-effective, with relevant fishery modelling expert end-users and stakeholders.

Desired Outputs:

1. A detailed specification and costing for a future project that will produce the over-arching data framework at the appropriate spatial scales, as required to address future climate variability and change scenarios for Torres Strait fisheries.

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Australia's National
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Scoping a future project to address impacts from climate variability and change on key Torres Strait Fisheries

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Final Report for Project Climate variability and change relevant to key fisheries resources in the Torres Strait to Australian Fisheries Management Authority

31/01/2020 FINAL REPORT

Contents

Part 1: Background 9

Part 2: Threats to Torres Strait Fisheries 16

Executive Summary

Fishing is a critical activity in Torres Strait supporting both Indigenous and non-indigenous sectors through commercial, subsistence and traditional activities. Pressures on fisheries resources can be localised (e.g. overfishing, increased runoff and turbidity due to land-use changes and extreme rainfall events) and also related to climate change (e.g. ocean acidification, increase in sea surface temperature), which operates at larger scales. Localised and climate change pressures can act in isolation or synergistically to influence fishery resources.

The first objective of this report (presented in Parts 1 and 2) is to provide background information about Torres Strait and review previous projects and other relevant literature to identify environmental drivers that affect recruitment, growth, mortality rates, catches and relevant habitats of selected fisheries (tropical rock lobster (TRL), bêche-de-mer (BDM), finfish, prawns, turtles and dugongs), and potential effects of climate change on these environmental drivers. The review informs the second objective of the project, which is to provide a detailed technical specification of the over-arching data framework, and spatial scales for a future project scope that would address future climate variability and change scenarios for Torres Strait fisheries (Part 3).

Torres Strait is a narrow body of water situated between Papua New Guinea, Indonesia and Australia connecting the Gulf of Carpentaria to the Coral Sea via the continental shelf of the Great Barrier Reef and the Gulf of Papua. Its climate is influenced by considerable ocean and climate variability, dominated by the monsoon and El Niño–Southern Oscillation (contributing to year-to-year variability) and extreme weather events, including changes in sea level and marine heatwaves. Cyclones are relatively rare, but the area is influenced by cyclonic-related storms, strong winds, waves, surges and extreme rainfall. Both air and sea surface temperatures do not vary much throughout the year because of the tropical location. Mean annual rainfall is 1,750mm falling mostly between November and February.

The bathymetry and circulation in Torres Strait are complex, mostly shallow (between 5 and 25m deep) and characterised by high energy conditions and strong tidal currents. The region contains productive ecosystems, including coral reefs, sandbanks, and extensive areas of seagrasses and mangroves, supporting a variety of fisheries.

Anthropogenic impacts (other than climate change) in Torres Strait are relatively minor, but exist in specific locations. Torres Strait is, however, relatively highly vulnerable to shipping accidents, with this being recognised by TSRA, and oil spill risk may be important to consider in an ecosystem modelling framework. Local impacts include, localised oil contamination, mangrove cutting, alteration of hydrology, nutrient and sediment runoff, and chemical contamination.

Fishing is an additional anthropogenic impact source. Most marine living resources have been managed sustainably but there are examples of past overharvesting (most notably sandfish and black teatfish) and this needs to be considered.

Climate change is already affecting Torres Strait fisheries and culture. Expected impacts from climate change include higher sea levels and associated coastal erosion, warmer atmospheric and ocean temperatures, more acidic waters, changes in ocean circulation, and more intense rainfall events. Although relatively minor, simultaneous local impacts (e.g. untreated sewage, chemical, sediment and nutrient runoff, oil pollution, overfishing) act together with climate change impacts, such as sea-level rise, ocean warming, acidification, leading to interactive, complex and amplified impacts for species and ecosystems.

These pressures can manifest directly in the form of changes in abundance, growth, reproductive capacity, distribution and phenology (changes in cyclic and seasonal phenomena such as reproduction and migration), and indirectly through changes in habitats. Invertebrates (TRL, prawns, BDM) are likely to be more impacted by climate change than vertebrates (Finfish, turtles and dugongs). This is *inter alia* because although highly productive, their life spans are short, which makes it difficult for them to move out of a certain area severely impacted over many years before significant losses at the population level happen.

Climate change is likely to cause mostly negative direct effects on the fisheries investigated in this report, but some effects may also be positive, especially in the short to medium-term (e.g. relatively small warming may increase growth rates of sea cucumber and lobsters). If climate-related environmental changes exceed certain limits or ranges for species, they will either move when possible, or have their abundance reduced.

The second objective of the report was to produce an over-arching data and modelling framework at the appropriate spatial scales, as required to address future climate variability and change scenarios for Torres Strait fisheries (Part 3). The objectives of the modelling exercise are to simulate future climate scenarios and assess the impacts of these on fisheries and associated habitats and species through quantitative evaluation. It will support the exploration of responses and strategies to manage the selected Torres Strait fisheries, such as the evaluation of:

1) Interactions between different fisheries and broader ecosystem functioning, including consideration of communities that rely on these resources;

2) Impacts of climate change scenarios on the abundance and distribution of selected species;

3) Impacts of current and future river catchment conditions and management scenarios on fisheries;

4) Impacts of incidents (e.g. oil spills, ship groundings) on fisheries;

5) Combined scenarios of 1-4 to develop strategies that are robust across impacts and fisheries; and

6) Evaluation of alternative adaptation options.

In order to address objectives, some of the desirable features of the modelling framework include: 1) Catchment runoff; 2) Hydrodynamics and transport; 3) Physio-chemical water quality constituents; 4) Biogeochemistry, 5) Fisheries dynamics; and 6) Ecological and socio-ecological relationships.

Data requirements to simulate these desirable features include: 1) biological and fisheries data (catches, catch locations, target species, gear, age and size frequency of catches, species distribution, growth rates, reproduction and maturity, mortality and population size); 2) location, area and species of supporting habitats (mangroves, seagrasses and mangroves); and 3) physical and biogeochemical data (currents, turbidity, temperature (air and sea), tides and water level, light penetration, nutrients, salinity, sedimentation, pH, oxygen, grazing, extreme events, waves, moon phase, diseases and parasites).

There is significant information covering Torres Strait fisheries, key marine species, habitats, geology and physiochemical water quality parameters. However, datasets are sparse both in space and time. A large-scale monitoring program for Torres Strait would support the identification of long-term trends and improve understanding about local and regional processes affecting habitats, species and fisheries, including the impacts of climate change on these.

Most of the understanding about physical and biogeochemical cycles and processes (e.g. currents, tides, primary productivity, nutrients) in Torres Strait have been derived from remote sensing and hydrodynamic models developed in the 2000s and in the early 2010s, each with relatively well-known pros and cons. Limited physical long-term observational data is available as these data were collected mostly in the 1990s. It is therefore recommended to prioritise physical data collection to improve our understanding about regional dynamics and potential impacts of climate change on these.

Habitat, fisheries and ecological data are also sparse, but recent mapping of mangroves, seagrasses and coral reefs combined with survey data on substrate and species collected in large-scale BDM and TRL surveys offer valuable information about the location and health status of such habitats, which can support the development of models to explore impacts and adaptation options.

A number of modelling initiatives are already in place in Torres Strait and it would be worth considering capitalising on these efforts. Given issues with hydrodynamic models previously developed for the region it is recommended that a dedicated regional hydrodynamic model, including physics and biogeochemistry be constructed for Torres Strait (supported by appropriate oceanographic data collection), as the effort to re-run previously developed models will likely be similar to deploying an up-to-date state-of-the-art modelling platform such as eReefs, which has been developed for the Great Barrier Reef (GBR) region.

The Torres Strait region will likely need to integrate a mix of modelling approaches that feed into one another, built in a stepwise fashion. A cost-effective approach would be to couple a regional hydrodynamic model that simulates basic physical and biogeochemical processes with an ecological or socio-ecological model. Although complex to develop, if feasible a socio-ecological approach is preferred as it accounts for the human dimension and hence some of the complex socio-cultural relationships between traditional owners and their marine environment. Given there are already assessment models developed for some of the key species (e.g. TRL, BDM, prawns), a useful starting point would be to combine these in an integrated spatial model using models of intermediate complexity for ecosystem assessment (MICE) for the Torres Strait region. This can form the basis of a more complex ecosystem model or help to ground-truth a larger more complex model.

Starting the modelling exercise using MICE approach sooner rather than later would provide a framework to utilise existing datasets and investigate potential climate change impacts on the fisheries and there are sufficient data to start modelling. So, our recommended approach would be to build the models in a stepwise fashion, adding new data and complexity as these become available or necessary. This also allows time to start obtaining feedback from stakeholders on preliminary model results, which allows time to communicate the usefulness of models as well as how to draw on local knowledge to further refine models.

Many ecosystem models involve coupling together different components and this is also how we envisage development of an ecosystem model proceeding – hence the starting point is to extend and link the current biological models of key species (e.g. TRL, BDM, dugongs), add current known environmental drivers (e.g. SST), gradually add other species (e.g. seagrass, finfish, turtles) and link with prelim hydrodynamic models or model outputs to start adding complexity associated with the oceanographic setting. The development of fully integrated couple hydrodynamic model usually takes a few years and is an expensive process so we recommend starting small and gradually expanding.

The proposed data framework identifies how the physio-chemical and ecological data could be managed and delivered to support the development of models. Datasets can be managed on CSIRO IT infrastructure, utilising relational database systems and enterprise file servers. Datasets will be described using geonetwork (www.marlin.csiro.au) and these descriptions can be made public to allow third parties (non-CSIRO) to access data depending on level of permission granted (i.e. licence restrictions). Datasets can be shared using Open Geospatial Consortium (OGC) standards where appropriate, by using a standards-compliant webserver (geoserver) linked to the collated data. This framework is scalable, robust and compliant with open data/metadata standards, allowing a flexible data delivery method.

The following are the key recommendations from this report:

1. Prioritise physical data collection and further strengthen and expand a large-scale monitoring program for Torres Strait that would support the identification of long-term trends and improve understanding about local and regional processes affecting habitats, species and fisheries, and to support the development of models.
2. Staged approach in the development of an integrated ecosystem modelling framework to investigate the impacts of climate and local changes on fisheries in Torres Strait, via coupling together:
    a. Development and implementation of data framework to support future modelling efforts in Torres Strait
    b. Development of integrated ecological or socio-ecological models capable of integration with a regional hydrodynamic model:
        i. For example, start by combining existing data and models (TRL, BDM, and dugongs) into an integrated spatial MICE, which will form the basis for a hybrid MICE-ATLANTIS ecosystem model;
        ii. Dedicated regional hydrodynamic model, including physics and biogeochemistry for Torres Strait, for example similar to eReefs.

Part 1: Background

1 Introduction

Fishing is a critical activity in Torres Strait supporting both Indigenous and non-indigenous sectors through commercial, subsistence (food security) and traditional activities (Busilacchi et al. 2013). Commercial fishing is one of the most economically important activities in the Torres Strait, providing significant opportunities for financial independence, maintenance of traditions and lifestyle for traditional inhabitants of the region (Plaganyi et al. 2013b, van Putten et al. 2013b, Johnson and Welch 2016). Not surprisingly, impacts on Torres Strait fisheries have profound economic and social consequences to traditional and non-traditional inhabitants of the Torres Strait.

Pressures on fisheries resources can be localised (e.g. overfishing, increased runoff and turbidity due land-use changes and extreme rainfall events) and also related to climate change (e.g. ocean acidification, increase in sea surface temperature) (Welch and Johnson 2013). These pressures manifest directly in the form of changes in fish abundance, growth, reproductive capacity, distribution and phenology (changes in cyclic and seasonal phenomena such as reproduction and migrations)(Free et al. 2019)), and indirectly through changes in foodwebs and habitats (Welch and Johnson 2013, Fulton et al. 2018). Localised and climate change pressures can act in isolation or synergistically to influence fishery resources (Abelson 2019).

Localised and climate-change pressures affect Torres Strait habitats and fisheries indirectly via changes in sea level, sea surface temperature and extreme rainfall events (Marsh and Kwan 2008, Babcock et al. 2019, Smale et al. 2019). Some direct pressures include localised habitat destruction, pollution and over-exploitation (Plaganyi et al. 2013a, Duke et al. 2015, Patterson et al. 2018). Such impacts have reduced Torres Strait Islanders’ access to target species (Skewes et al. 2006, Plaganyi et al. 2013a) or caused reduction in catches (Marsh and Kwan 2008). Fisheries management and assessments will need to take account of the implications of future variability and change that may affect stocks. These may manifest through effects on recruitment pathways, growth and mortality rates, and critical habitats among other processes.

Anthropogenic impacts in Torres Strait are minimal, but exist in specific locations. The main drivers are the modernisation and urbanisation of Island communities, and need to connect to mainland Australia and markets. These require built infrastructure such as piped water and sewerage facilities, better housing, jetties, roads/air strips, and shipping routes. Land clearing and associated increase in land-based runoff, localised pollution, changes in water flow and oil spills are some of the risks affecting Torres Strait fisheries (Duke et al. 2015).

Climate change also threatens Torres Strait Islands, their people, fisheries and industries. Current and expected impacts from climate change likely to affect Torres Strait fisheries include higher seas, warmer atmospheric and ocean temperatures, more acidic waters, and changes in ocean circulation (CSIRO-BOM 2015). Climate change is expected to substantially influence marine ecosystems and fisheries in Australia (Fulton et al. 2018). There is no single most important factor affecting all of Torres Strait fisheries as they are site- and fishery-specific. Instead, multiple climate and non-climate stressors interact in various ways to impact fisheries and habitats (Bonebrake et al. 2019). Although localised impacts on ecosystems and fisheries are relatively small in Torres Strait (see Part 2), changes in land-use, resource over-exploitation, and pollution interact with climate change to contribute to changes in Torres Strait habitats and fisheries, influencing ecosystem functioning, services, and human well-being (Duce et al. 2010, Pecl et al. 2017).

Climate change is an emerging issue affecting key ecosystem processes and fisheries resources world-wide, with a relatively large and growing knowledge base, but still with important uncertainties and knowledge gaps (Fulton et al. 2018, Free et al. 2019, Johnson et al. 2020) that need to be addressed, hence the climate change focus of this report.

Predicting exactly how climate will change and the effects of these changes in ecosystems and fisheries is very difficult in Torres Strait because the region lacks high-quality, long-running meteorological records (Green et al. 2010) and its ecosystems are highly variable and poorly studied (Harris et al. 2008, Duce et al. 2010) despite recent progress on the understanding of fisheries, environmental and governance regimes (e.g. Wolanski et al. 2017, NESP Earth Systems and Climate Change Hub 2018, Plaganyi et al. 2018c, Butler et al. 2019, Plaganyi et al. 2019c, Rodgers et al. 2019). The lack of full knowledge about how Torres Strait will change in the future does not preclude action. There is likely enough information from studies in Torres Strait to support decision-making in the short term, but information at the appropriate scale is required for longer-term strategic decisions (NESP Earth Systems and Climate Change Hub 2018). The climate change signal is clear (Suppiah et al. 2010, CSIRO-BOM 2015, Cheng et al. 2019, IPCC 2019b) and expected to affect fisheries in Torres Strait (Norman-Lopez et al. 2013, Plaganyi et al. 2013a, Johnson and Welch 2016, Plagányi et al. 2018). Torres Strait fisheries management will require relevant information to support adaptation planning. The first step in this process is to review the literature to understand potential impacts of localised and climate change on fisheries and supporting ecosystems (Part 2).The review offered in Parts 1 and 2 of the report is used in Part 3 to assess data needs and the spatial and temporal scales required to develop a future data and modelling platform to assess potential climate change (and localised) impacts on the selected fisheries. This future study will be an important aspect required for climate adaptation planning in Torres Strait.

1.1 Objectives of this report

This report will build on detailed findings from a literature review of the main climate change drivers in Torres Strait affecting tropical rock lobster, bêche-de-mer (sea cucumber), finfish, prawns, turtles and dugongs (Table 1) to provide detailed specification and costings for a future project that will produce the over-arching data framework at the appropriate spatial scales, as required to address future climate variability and change scenarios for Torres Strait fisheries. The report will also include detailed information about data availability, and specifications on data storage, management and data accessibility issues.

Table 1. Fisheries investigated in this report. Fishery type: C (commercial), S (subsistence), R (recreational) (from: Johnson and Welch 2016), plus additional Holothurians - Prickly redfish and White teatfish given their increasing economic value and harvest.

Fishery	Common name	Scientific name	Fishery type
Tropical Rock Lobster	Tropical Rock Lobster	*Panulirus ornatus*	C, S
Prawns	Brown tiger prawn	*Penaeus esculentus*	C
	Blue endeavour prawn	*Metapenaeus endeavouri*	C
Finfish	Spanish mackerel	*Scomberomorus commerson*	C, S, R
	Common coral trout	*Plectropomus leopardus*	C, S, R
	Barcheek coral trout	*Plectropomus maculatus*	C, S, R
	Passionfruit coral trout	*Plectropomus areolatus*	C, S, R
	Bluespot coral trout	*Plectropomus laevis*	C, S, R
Beche-de-mêr	Sandfish	*Holothuria scabra*	C
	Black teatfish	*Holothuria whitmaei*	C
	Prickly redfish	*Thelenota ananas*	C
	Curryfish	*Stichopus herrmanni* and *S. vastus*	C
	White teatfish	*Holothuria fuscogilva*	C
Turtle	Green Turtle	*Chelonya midas*	S
	Hawksbill Turtle	*Eretmochelys imbricata*	S
Dugong	Dugong	*Dugong dugon*	S

1.2 Why this report is needed

Semi-quantitative fisheries assessments of climate change impacts and vulnerability have been conducted in Torres Strait (Green et al. 2010, Welch and Johnson 2013, Johnson and Welch 2016, Fulton et al. 2018). However, quantitative considerations are still sparse (but see, Plaganyi et al. 2011, Plagányi et al. 2017a) despite being essential for fisheries management to adequately respond and plan for the future.

2 Approach

This report will synthesise results from previous projects about climate implications for Torres Strait and other relevant literature to identify environmental drivers that affect recruitment, growth, mortality rates, catches and relevant habitats for selected fisheries (rock lobsters, prawns, finfish, *bêche-de-mer*, dugongs and turtles).

In 2010, two major reports about climate change observations and predictions, impacts and adaptation for Torres Strait were published (Duce et al. 2010, Suppiah et al. 2010). These were based on IPCC AR5 models. We will provide a synthesis from the literature identifying key advancements in knowledge since the publication of these reports. References were gathered using search in End Note of Web of Science database using the keywords “Torres Strait” and “Climate Change” and also includes a web search on both climate change impacts and fisheries in Torres Strait (e.g. reports from major research programs, such as the National Environmental Research Program (NESP), as well as State and Commonwealth agencies). References selected for review have their abstracts screened based on their relevance to the focus of the report (climate change impacts on fisheries and supporting habitats) and include information about both observations and models related to climate change, potential impacts on physio-chemical, ecological and biological drivers influencing the selected fisheries.

The main source of information for climate change predictions for Torres Strait is web resource ‘Climate Change in Australia’ (CSIRO-BOM 2015), which presents information for the Wet Tropics of Australia. More recent predictions from peer-reviewed sources are used to update climate change predictions when appropriate.

A draft version of this report was presented in a video-conference technical workshop held on the 14th of October 2020 with relevant scientists and managers to get their inputs and feedback for incorporation into the final report.

3 Torres Strait environmental setting

Torres Strait is a narrow body of water lying between Papua New Guinea (PNG; Western Province), Indonesia (Papua Province), and Australia (Queensland) covering an area of approximately 48,000km^2 (Duce et al. 2010, Butler et al. 2019). It connects the Gulf of Carpentaria (GoC) to the Coral Sea via the continental shelf of the Great Barrier Reef (GBR) and the Gulf of Papua (Wolanski et al. 2013) (Figure 1). Its deeper channels form a major shipping route in which a large proportion of goods flow from and to Australia (Duce et al. 2010, Wolanski et al. 2013).

Torres Strait contains productive ecosystems, including about 750 coral reefs, sandbanks, and extensive areas of seagrasses and mangroves, with more than 270 islands in which 17 are inhabited with a total population of about 8,500 people (Harris et al. 2008, Duce et al. 2010, Butler et al. 2019). The region is culturally, ecologically and economically important (Wolanski et al. 2013), supporting traditional and commercial fisheries, including Tropical Rock Lobster, finfish, crab, trochus and *bêche-de-mer*, marine turtles and dugongs (van Putten et al. 2013b, Johnson and Welch 2016).

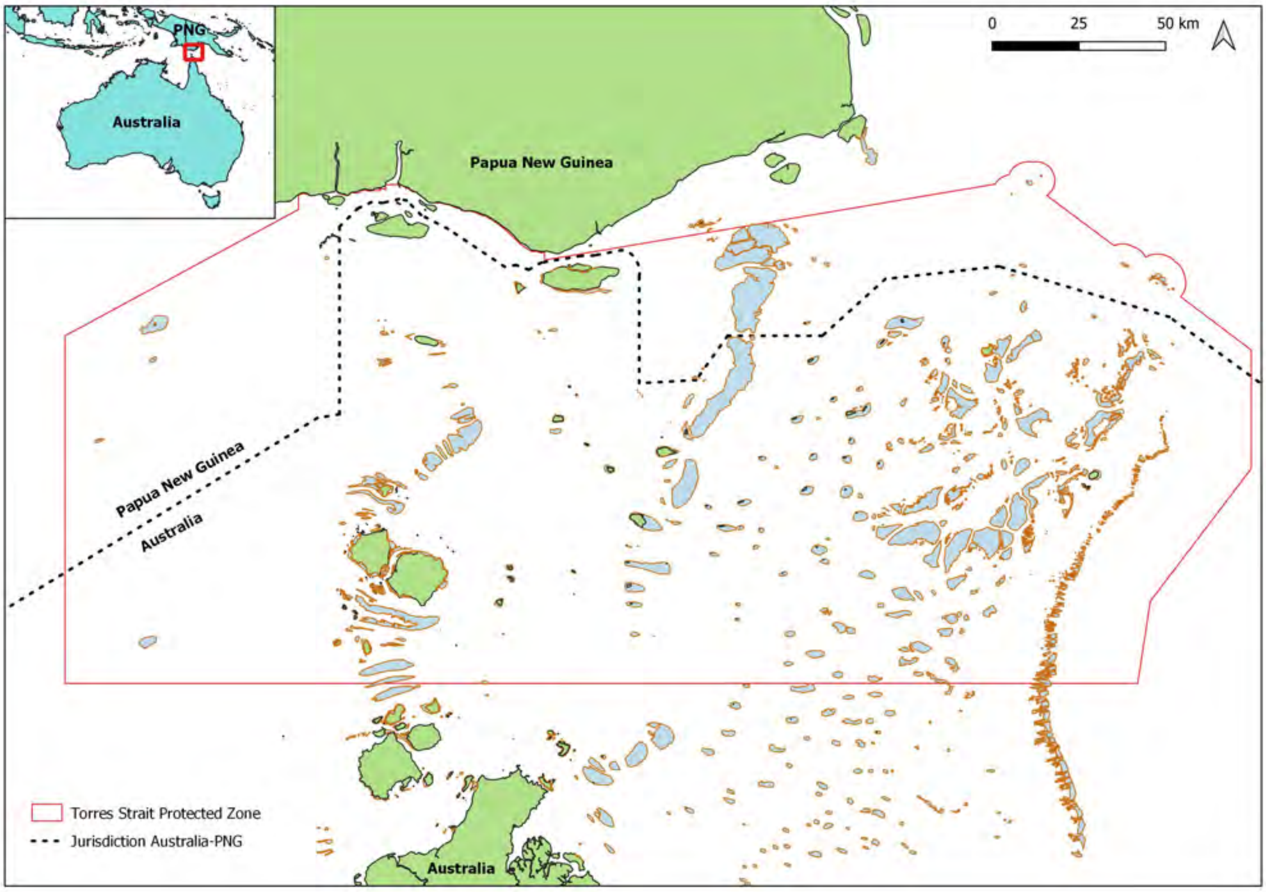

Figure 1. Map of Torres Strait (source: http://www.tsra.gov.au/news-and-resources/annual-reports/annual-report-2016-2017/section-report-of-operations/where-we-operate).

3.1 Climate

The Torres Strait climate is influenced by considerable ocean and climate variability. It is dominated by the monsoon and El Niño–Southern Oscillation (ENSO; contributing to year-to-year variability) and extreme weather events, including changes in sea level, marine heatwaves, tropical storms with associated strong winds, waves and storm surges and extreme rainfall. During ENSO, northern Australia is drier than normal, while during La Niña events it is wetter than normal (NESP Earth Systems and Climate Change Hub 2018).

The Torres Strait climate experiences seasonally reversing winds separated in two seasons: the monsoonal wet season dominated by prevailing north-westerly winds between December and April, and the dry season dominated by prevailing south-easterly winds from May to November (CSIRO-BOM 2015), where north westerlies driven by the monsoon dominate for around 15% of the year (Duce et al. 2010). Winds are stronger in the dry season (April-June), with mean maximum wind speeds up to 15ms^{-1}. Wet season winds are considerably lower with maximum speeds ranging between 10-11 ms^{-1}, while mean wind speeds are less than 4 ms^{-1}(Duce et al. 2010).

Both air and sea surface temperatures do not vary much throughout the year because of the tropical location. Average daily temperatures are 29^{o}C (maximum mean 31.2^{o}C and mean minimum 25.4^{o}C). Wet and dry season mean maximum and (minimum) vary from about 28 (22)^{o}C to 32 (25) ^{o}C (Green et al. 2010). Sea surface temperatures range from 29^{o}C (summer) to 25^{o}C (winter). Mean annual rainfall is 1,750mm falling mostly during the wet season between November and February (Duce et al. 2010).

Cyclones are relatively rare in the region because Torres Strait is located north of the main cyclone belt. However, the area receives cyclonic-related storms and strong wind events, which influence surges (Duce et al. 2010, NESP Earth Systems and Climate Change Hub 2018).

3.2 Bathymetry and circulation

The bathymetry and circulation in Torres Strait are complex, mostly shallow (between 5 and 25m deep) – especially along the axis of the western Torres Strait Islands (~142^{o}15'E) – and characterised by high energy conditions and strong tidal currents (Green et al. 2010, Daniell 2015). The region contains productive ecosystems, including coral reefs, sandbanks, and extensive areas of seagrasses and mangroves (Harris et al. 2008, Duce et al. 2010).

The complexity of oceanographic conditions in Torres Strait is often under-estimated. Tides, currents and waves influence sediment transport and larval dispersion, affecting geomorphology and fish stocks (Duce et al. 2010). Currents are the major mechanism connecting ecosystems by facilitating dispersal of larvae, supporting biogeochemical processes, and the propagation of climate features (Wolanski et al. 2013, Johnson et al. 2018). Water circulation is still poorly understood in the region because of its complex bathymetry (Wolanski et al. 2013). The net flow through is determined by the wind and the sea level difference (Figure 2) – mean sea level (MSL) rises by about 0.1m on the Coral Sea with increasing easterly winds; MSL decreases or increases 0.2-0.3m in the Gulf of Carpentaria according to whether southeast winds (decrease in MSL) or monsoonal winds (increase in MSL) prevail (Wolanski et al. 2013). ENSO also plays a strong role in year to year variability of sea level (NESP Earth Systems and Climate Change Hub 2018).

The complex bathymetry steers the net currents to form zones of net through flow, zones of stagnation, and zones of recirculation (Li et al. 2015). During the dry season, southeast trade winds raise MSL in the northwest Coral Sea and the wind and waves on the outer GBR generate a landward flow from the Coral Sea. The wind pushes the incoming Coral Sea water longshore northward on the GBR shelf. At the latitude of Cape York, a fraction of the wind-driven current waters turns westwards to form the Through Torres Strait current, which flows into the GoC (Gulf of Carpentaria). The remaining wind-driven current waters keep flowing northwards to form the Through Great Northeast Channel Current, exiting Torres Strait and entering the Gulf of Papua (Wolanski et al. 2013). Non-linear interactions between wind and tidal currents in shallow coastal waters in the GoC result in the formation of a coastal Boundary layer on the GoC side of the Torres Strait – these waters are ultimately exported from the GoC and is replaced by an inflow of water from the Arafura Sea. The plumes from the Fly River are entrained in the Coral Sea and at least during strong southeast trade winds this forms an eddy in the Gulf of Papua (Figure 2). A small fraction of the Fly River plume is entrained in Torres Strait by the currents of the Great North East Channel (Wolanski et al. 2013). The East-West flowing currents can reach up to 2-4m.s^{-1} within narrow passages during spring tides (Duce et al. 2010, Daniell 2015).

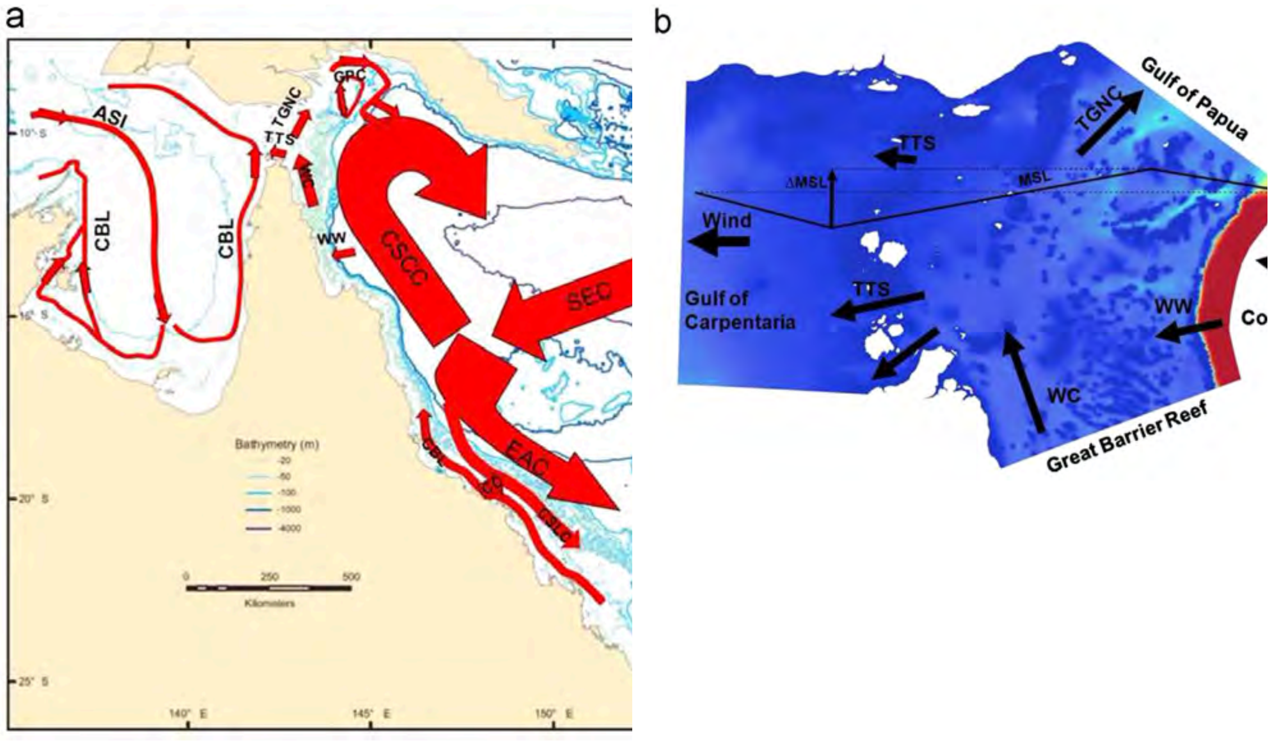

Figure 2. A sketch map of the general surface water circulation during southeast trade winds in (a) the Great Barrier Reef and (b) Torres Strait. MSL (mean sea level; ΔMSL (sea level difference between the Coral Sea and the Gulf of Carpentaria. SEC (South Equatorial Current); EAC (East Australian Current). CSLC (Coral Sea Lagoonal Current) ; CC (Cross Shelf Current as discovered by Andutta et al.(2013); CBL (wind-driven) Coastal Boundary Layer current; CSCC (Coral Sea Coastal Current); WW (inflow from the wind raising these a level in the Coral Sea and wave breaking on the outer reefs); WC (Wind-driven Current). TTS (Through Torres Strait current); TGNC (Through Great North East Channel current; GPC (Gulf of Papua current); ASI (Arafura Sea inflow).The CSCC was the original name given to that current by oceanographers (Andrews and Clegg, 1989) and it is also known as the Hiri current (source: Wolanski et al. 2013).

Tidal regime in Torres Strait is complex and variable because of the combination of strong currents and bathymetry and location of the Strait between two Ocean basins with different tidal regimes (semi-diurnal in the Pacific/Coral Sea and diurnal tides propagating from the Gulf of Carpentaria and the Indian Ocean) (Hemer et al. 2004, Daniell 2015). Tidal range in the Torres Strait depends on location. In the Gulf of Carpentaria it varies between 1.5-6m and in the Coral Sea and Gulf of Papua it varies between 3-7m (Duce et al. 2010).

Part 2: Threats to Torres Strait Fisheries

4 Local threats

Local impacts in Torres Strait include metal pollution from the Fly River (PNG) associated with mining, and construction of future oil and gas facilities, oil palm plantation and associated infrastructure building to support these industries. The required land clearing will increase sediment and pollution runoff, destruction of habitats with impacts on ecosystems and connectivity (Wolanski et al. 2013). Threats to Torres Strait fisheries include oil contamination, ship accidents, mangrove cutting, alteration of hydrology, nutrient and chemical contamination, and over-harvest of marine living resources (detailed below).

4.1 Oil contamination

Ship-and land-based related oil contamination occurs in Torres Strait but seems to be contained to small areas close to boat loading facilities (Duke et al. 2015). Major oil spills have occurred in the past (e.g. 'Oceanic Grandeur' oil spill in 1970) and have the potential to occur again in the region especially because of increased traffic since then.

4.2 Ship accidents

In addition to the risk from oil spills, the physical impact from ship grounding can cause structural habitat damage (e.g. coral reefs, seagrasses) (Carter et al. 2018). Antifouling paint (AFP) scrapped from hulls of grounded vessels (as smears and flakes) is also known to pose a significant risk for marine life. For instance, the exposure of marine life to contaminants present in AFP can cause: a) extensive mortality of resident communities (e.g. corals (Smith et al. 2003)); b) decrease in growth rates of molluscs (Alzieu 1998), corals (Smith et al. 2003), fish (Triebskorn et al. 1994, Shimasaki et al. 2003) and microalgae (Beaumont and Newman 1986); c) negative effects on reproduction, such as inhibition of reproduction in molluscs (Alzieu 1998), reduced sperm counts in fish (Haubruge et al. 2000), reduced coral fertilisation (Reichelt-Brushett and Harrison 1999), larval survival (Negri and Heyward 2001), larval settlement (Negri et al. 2002), larval metamorphosis (Reichelt-Brushett and Harrison 1999, Negri and Heyward 2001, Negri et al. 2002), induced sex reversal (increased masculinisation) in fish (Shimasaki et al. 2003) and molluscs (Horiguchi et al. 1998); and d) hampered recovery of adult populations from other stresses (Smith et al. 2003).

4.3 Mangrove cutting

Mangrove cutting affects a large proportion of mangroves on Boigu, Dauan and Mabuiag and seems to be mostly restricted to these islands. Mangroves are mostly harvested for timber resources (firewood, building material and for carving) (Duke et al. 2015: 71).

4.4 Alteration of hydrology

This is a relatively minor issue associated with the building of infrastructure (mainly air strips, dams and roads), which restrict natural freshwater, overland, and tidal flow into coastal ecosystems such as mangroves, causing localised die-offs (Duke et al. 2015:72).

4.5 Nutrient and sediment runoff and chemical contamination

Sewage treatment plants in Torres Strait have been upgraded in the early 2010s but it has been reported that despite the upgrades they still experience frequent maintenance issues resulting in leaks and untreated sewage discharge, negatively affecting nearby ecosystems (Waterhouse et al. 2013, Duke et al. 2015). The Islands mainly affected by nutrient contamination from sewage treatment plants are Boigu and Iama (Duke et al. 2015).

Chemical leachate in Torres Strait is associated with landfills often located within or directly adjacent to tidal wetland habitats and subjected to tidal inundation during king tides and runoff from heavy rainfall events. Evidence of chemical leachate (albino mangrove propagules) has been found in Saibai and Boigu Islands. Dauan, Boigu, Saibai and Iama Islands have landfills in close proximity of mangroves (Duke et al. 2015).

There is ongoing concern over the implications of sediment-related pollution originating from the Fly River. Saibai, Dauan and Boigu are most affected, though results are currently inconclusive and some species may be more sensitive to impacts from Fly River plumes than others (Waterhouse et al. 2018). Future research is needed to investigate common food sources for metal contamination as well as work to determine historical levels of metals in sediment and corals (NESP Earth Systems and Climate Change Hub 2018).

4.6 Over-harvest of marine living resources

While most fishery stocks in Torres Strait have not been overfished or subject to overfishing (Patterson et al. 2020), unsustainably high harvest levels have occurred in at least two stocks.

Sandfish (*Holothuria scabra*): Catch levels peaked in 1995 but were unsustainable leading to fishing closure (Skewes et al. 2006, Plaganyi et al. 2013a). The fishery is still closed but classified as “not subject to overfishing”, because there were no reports of illegal fishing in 2017 (Patterson et al. 2018, Patterson et al. 2020) (see chapter 7.4).

Sea turtles (Chapter 7.5): Hawksbill turtle nesting population in Torres Strait is in severe decline mostly due overharvest in neighbouring nations and potential overharvest of eggs in Torres Strait and in neighbouring nations (NESP Earth Systems and Climate Change Hub 2018). Similarly, Northern Great Barrier Reef stock of Green turtles which utilise Torres Strait is likely to decline due to failing hatchling production at key index sites at Raine Island and Moulter Cay. Targeting of adult females for harvest and overharvest of eggs in some locations in PNG, Solomon Islands and Torres Strait are also primary contributors (NESP Earth Systems and Climate Change Hub 2018).

5 Climate change

The planet is clearly warming (Cheng et al. 2019). Global concentrations of greenhouse gases in the atmosphere continue to increase mainly due to emissions from fossil fuels, and are unlikely to be drastically reduced in the short term because of the inertia of governments (Climate Transparency 2018). Greenhouse gas emissions have increased on average 1.5 percent per year in the last 10 years (United Nations Environment Programme 2019). The opposite was expected if the world is to achieve the Paris agreement goal of limiting warming below 2^{o}C and pursuing efforts to limit warming to 1.5 ^{o}C above pre-industrial levels.

The planet has warmed by over 1 °C since records began in 1850, resulting in mass loss from ice sheets and glaciers and sea level rise (over 20 cm since 1880), with the rate of sea level rise accelerating in recent decades (Commonwealth of Australia 2018, IPCC 2019b). A major contributor of global sea level rise is the melting of the Greenland Ice Sheet, driven by oceanographic and atmospheric warming. Greenland Ice sheets are melting seven times faster now than in 1992, with the rate of melting expected to increase due to global warming, on track to reach IPCC's predicted rates for high-end climate warming scenario (Shepherd et al. 2019). As the frozen soil starts to thaw, it releases more organic carbon than what summer plants can sequestrate. This carbon is converted into carbon dioxide and methane (greenhouse gases) further exacerbating climate change (Schuur 2019).

Not surprisingly, long-term observations show that the last 5 years (2015-2019) were the hottest on record and climate change projections made in the last 10 years appear to be conservative as climate is changing faster and stronger and expected to continue this strong warming path, reaching 3-5^{o}C by 2100 (World Meteorological Organization 2019), despite the Paris agreement to limit warming to below 2^{o}C (Lenton et al. 2019). Recent advances in climate science are reducing uncertainties about ice melting in Antarctica and Greenland, and are pointing to faster rates of ice melting compared to predictions in the IPCC 5th Assessment Report (AR5; IPCC 2014) with strong implications to the ice contribution of sea level rise (Shepherd et al. 2018). For example, between 1984 and 2018, sea ice coverage in the Arctic Ocean has declined by one third (Moore et al. 2019) and there appears to be a redistribution of heat from the Earth's atmosphere into the ocean interiors (up to 2,000m deep) (Cheng et al. 2019). Ocean warming appears to be increasing the energy of ocean currents in the last 25 years (Hu et al. 2020).

The future is uncertain but models and observations depict a future in which climate will continue to change, interact with climate variability and non-climate drivers affecting the interactions between oceans, cryosphere and atmosphere, ecosystem goods and services, and people (Commonwealth of Australia 2018, Coffey et al. 2019, IPCC 2019b). Changes in climate and ecosystems are already affecting fisheries worldwide (Pecl et al. 2014, Pecl et al. 2017, Lindegren and Brander 2018). Although some species will benefit from climate change–especially with warming waters– the majority of species will be negatively affected through changes in growth, abundance and distribution (Free et al. 2019).

5.1 Climate Change in Australia

Climate is changing much faster in Australia than in most of the world's oceans (Fulton et al. 2018). Since 1910, air temperatures have risen on average by about 1°C, with most warming post 1950. This has resulted in more extreme events such as heat waves, extreme rainfall events and cyclones (CSIRO-BOM 2015, Frolicher et al. 2018, Babcock et al. 2019, Smale et al. 2019). Natural climate variability in Australia's Tropical Pacific Ocean region is associated with El Niño and La Niña events, which now occurs on top of the warming trend with the potential to modify climate-ocean interactions with flow-on effects on Australia's climate (CSIRO-BOM 2015).

Since 1900 there has been a general increasing trend in rainfall during the northern wet season. There is evidence that heavy rainfall (rainfall extremes) are becoming more extreme, with a higher proportion of total annual rainfall coming from heavy rain days (Commonwealth of Australia 2018). Extreme rainfall events are expected to become more intense because of the relationship between increase in temperature and the water holding capacity of the atmosphere. Total rainfall in heavy rain days is expected to increase by around 7% per degree of warming. For short-duration, hourly, extreme rainfall events, observations in Australia generally show a larger than 7% increase. Short-duration rain extremes are often associated with flash flooding (Commonwealth of Australia 2018).

As a result of climate change, Australian marine ecosystems are already experiencing poleward redistributions of species across taxa and throughout latitudes worldwide (Hobday et al. 2016, Marzloff et al. 2016, Pecl et al. 2017, Fulton et al. 2018).

5.2 Climate change in Torres Strait

Climate change expresses in Torres Strait via extreme events, such as extreme high tides and sea surface temperature (T. Skewes, D. Brewer and J. Rainbird pers. observations). Climate change is impacting fisheries and cultural sites, impacting the exchange of cultural knowledge (Nursey-Bray et al. 2019). Given the current unprecedented emissions and trends (see Chapter 5), we are likely in a high emission scenario path (i.e. in line with IPCC representative impact pathway (RCP) 8.5). We therefore present results for RCP8.5 noting that if trends change it is possible to explore predictions for low and mid-range emission scenarios in the existing tools used in this review (CSIRO-BOM 2015, BOM-CSIRO 2018) (Table 2).

Table 2. Current and future climate change projections for Australia Wet Tropics for RCP 8.5 (CSIRO-BOM 2015). Climate data for Present conditions are for Horn Island station (http://www.bom.gov.au/climate/averages/tables/cw_027058.shtml)

Climate Change Attributes	Present (Period)	Prediction 2030	Prediction 2070	Prediction 2090	Recent updates
Annual Mean Surface Temperature (1995-2019)	27.6°C	0.8±0.2°C	2.3±0.5°C	3.2±0.6°C	

Mean Surface Temperature (Wet – Nov-Apr)	32^{o}C	0.8±0.2^{o}C	2.3±0.5^{o}C	3.1±0.7^{o}C	
Mean Surface Temperature (Dry – May-Oct)	28^{o}C	0.8±0.2^{o}C	2.3±0.4^{o}C	3.2±0.7^{o}C	
Annual Rainfall (1995-2019)	1,791mm	0% (-3.2±7.2)	0% (-2.0±14.0)	0% (-5.6±17)	
Mean Rainfall (wet) (1995-2019)	1645mm	0% (-3.2±8.2)	0% (-2.1±14.6)	0% (-3±17.3)	
Mean Rainfall (dry)	114mm	0% (-5.5±13.7)	0% (-5.5±26.6)	0% (-5.6±17.0)	
Wind Speed (Mean Annual) (1995-2010)	6.18m/s	1 – 3.09% (1.0±2.2)	> 3.09% (2.1±4.4)	>3.09%	
Wind Speed (Wet) (1995-2010)	5m/s	0% (0.6±3.7)	0% (0.9±7.5)	>3.09% (2.4±5.4)	
Wind Speed (Dry) (1995-2010)	7.4m/s	1 – 3.09% (1.3±1.7)	> 3.09 (2.9±2.9)	>3.09% (2.4±5.4)	
Maximum Daily Temperature (Annual)(1995-2019)	37.9^{o}C	0.5 – 1.5^{o}C (0.8±0.2)	1.5 – 3^{o}C (2.2±0.5)	1.5 – 3^{o}C (2.9±0.7)	
Maximum Daily Temperature (Wet) (1995-2019)	37.9^{o}C	0.5 – 1.5^{o}C (0.8±0.2)	1.5 – 3^{o}C (2.2±0.6)	1.5 – 3^{o}C (2.9±0.8)	
Maximum Daily Temperature (Dry) (1995-2019)	35.8 ^{o}C	0.5 – 1.5^{o}C (0.8±0.2)	1.5 – 3^{o}C (2.2±0.4)	1.5 – 3^{o}C (2.9±0.6)	
Sea Level Rise	0	0.12m (0.06 – 0.18m)		0.61m (0.41 – 0.84)	0.84m (0.61-1.1m) by 2100 (IPCC 2019a)
Sea Surface Temperature (Annual)		0.7 ^{o}C (0.5-1^{o}C)		2.6^{o}C (2.3 – 3.6)	
Sea Surface Salinity		0.05 g/kg (-0.12 – 0.96g/kg)		-0.28g/kg (-0.81 – 0.89)	
Ocean pH		-0.07 (-0.08 – -0.06)		-0.31 (-0.31 – -0.26)	
Aragonite Saturation		-0.41 (-0.45 – -0.24)		-1.57 (-1.67 – -1.19)	

5.2.1 Air Temperature

Temperatures have increased by around 1.1^{o}C over the past century (1910-2013) in the Wet Tropics, with the rate of warming increasing since 1960 (CSIRO-BOM 2015). Temperatures are expected to continue to rise in Torres Strait, increasing about 1^{o}C by 2030, 2.3 ^{o}C by 2070 and >3 ^{o}C by 2100 (CSIRO-BOM 2015).

5.2.2 Sea surface temperature

Late in the 21st century warming of the Wet Tropics coastal waters poses a significant threat to the marine environment through biological changes in marine species, including local abundance, community structure, and enhanced coral bleaching risk. Sea surface temperature is projected to increase in the range of 2.2 to 3.6 °C by the end of the century (RCP8.5; Table 2) (CSIRO-BOM 2015).

5.2.3 Rainfall

In the early 20th century the Wet Tropics of Australia experienced prolonged periods of extensive drying, but annual long-term rainfall shows no long-term trend between 1910-2013 (CSIRO-BOM 2015). Since 1998, despite a general increase in rainfall in northern Australia during the dry season, no changes in rainfall have occurred in Torres Strait. During the wet season, however, Torres Strait has experienced an increase in rainfall in the last 20 years (Commonwealth of Australia 2018).

Future rainfall predictions are highly variable. The high variability in rainfall predictions suggest that little change in mean annual rainfall is expected, but more variable and extreme rainfall events are expected to intensify (CSIRO-BOM 2015, NESP Earth Systems and Climate Change Hub 2018) (Table 2).

The high variability in rainfall projections means that fisheries models need to consider the risk of both increase and decrease in rainfall in the region (CSIRO-BOM 2015).

5.2.4 Extreme Climate Events

These are characterised as statistically rare or unusual climate periods that alter ecosystem function or structure outside normal variability (Smith 2011). In this sense, Torres Strait may be affected by temperature-related and cyclone-related extreme climate events.

Heat Waves

Climate change is likely to bring more hot days and warm spells to the Wet tropics region (CSIRO-BOM 2015). Extreme temperatures are expected to rise at the same pace as mean temperatures. In addition to an increase in mean temperature, changes in seasonal temperature patterns are also expected as well as an increase in the number of hot days (days with temperatures over 35°C) – which can triple in the region by the end of the century (CSIRO-BOM 2015).

Heavy rainfall

The intensity of extreme rainfall events is expected to increase despite the high uncertainty in future rainfall projections for the region. The magnitude of the increases therefore, cannot be confidently calculated (CSIRO-BOM 2015).

Cyclones

Tropical cyclones are projected to become less frequent, but the proportion of the most intense storms is projected to increase (CSIRO-BOM 2015).

5.2.5 Sea level rise

The dominant cause of sea level rise (SLR) since 1970 is Anthropogenic (IPCC 2019a). SLR is driven by a combination of a decrease in land-water storage, thermal expansion of the oceans, melting of glaciers and Greenland and Antarctic Ice sheets (Church et al. 2013, Clark et al. 2016). Global sea level has risen by over 0.20 m since 1880, and the rate has been accelerating in recent decades (IPCC 2019a). The rate of SLR is not uniform across the globe. For example, in Groote Eylandt in Northern Australia, the rate of sea level rise measured between 1993 and 2011 was 9mm/yr-^{1} (NTC 2011), which is consistent, but higher than global trends in accelerating sea levels since 1993 (3.2mm.yr-^{1} between 1993-2015) (Church and White 2006, 2011, IPCC 2019a). In Torres Strait, the rate of SLR is 6mm.yr^{-1} (1993-2010), twice the global average (Suppiah et al. 2010)

Predicting future sea level change is difficult because these drivers respond to climate change at different timescales, ranging from decades to centuries for glacier melting to centuries to millennia for thermal expansion and ice sheets (Clark et al. 2016). The speed of melting of ice has led to alterations in the Earth’s gravitational field resulting in regional sea level fluctuations as the land rises with ice melts (Carlson et al. 2008, Church et al. 2013). Other factors that make future sea level projections complex are the effects of the dynamic variations of physical parameters in the water column associated with variations in wind change, changes in atmospheric pressure and oceanic circulation, and associated differences in water density and rates of thermal expansion on the relative sea level, resulting in large-scale temporal and spatial variability in of sea level (Zhang and Church 2012). Therefore, sea level rise depends not only on the complex ocean-atmosphere interactions and time-delays associated with these interactions, but also on the combination of past, present and future greenhouse gas emissions (Nauels et al. 2019). Despite all complexities in predicting future sea levels, confidence in sea level projections have been increasing (Church et al. 2013, IPCC 2019a).

By 2030, the projected range of sea-level rise for the Torres Strait region is 0.06 to 0.18 m above the 1986–2005 level, with only minor differences between emission scenarios (CSIRO-BOM 2015). Between 2031 and 2050, global mean sea level is expected to rise 0.2m (0.15-0.26m under high emission scenario RCP8.5) (IPCC 2019a, Kulp and Strauss 2019 and references within). Beyond 2050, uncertainty in model predictions increases substantially because of uncertainties in emission scenarios and Antarctic ice sheet responses (IPCC 2019a).

Predictions from AR5 suggest that by 2090 sea level will rise 0.40 to 0.87m (RCP8.5), with higher seas expected under certain circumstances (CSIRO-BOM 2015).However, under a high emission scenario (RCP8.5), sea level rise will be greater than in AR5 by 0.1m due to a larger contribution from the Antarctic Ice sheet (IPCC 2019a). In this recent IPCC report, global mean sea level by 2100 is expected to rise 0.84m (0.61-1.1m under high emission scenario RCP8.5) (IPCC 2019a). Sea level rise predictions for 2100 can diverge even more, with some authors estimating the range from 0.7-1m (RCP4.5) and 1-1.80m (RCP 8.5) (Kulp and Strauss 2019, and references within) and other authors proposing a sea level rise exceeding 2m at the end of the century when incorporating Antarctic and Greenland ice sheet melting (Foster and Rohling 2013, Steffen and Hughes 2013, Kopp et al. 2017, Le Bars et al. 2017).

5.2.6 Ocean acidification

Ocean acidification is the increase of partial pressure of CO_2 and associated decline in seawater pH (Enochs et al. 2016). Ocean acidification can affect organisms that secrete calcium carbonate as it decreases the concentration of carbonate ions (CO_3^{2-}) (Evenhuis et al. 2015). Impacts of ocean acidification on fisheries may be direct or indirect. There is already evidence that ocean acidification is directly impacting important fisheries through carapace dissolution (Bednaršek et al. 2020). However, contrary to what has been previously postulated, it has negligible effects on important behaviours of coral reef fishes (Clark et al. 2020a).

Indirect responses are associated with changes in habitats, for example through negative effects of acidification on coral skeletons. Several laboratory studies suggest that more acidified waters impair calcification and accelerate the dissolution of coral skeletons thus weakening coral skeletons, and triggering stress-response mechanisms, which affect the rates of tissue repair, feeding rate, reproduction, and early life-stage survival (Fabry et al. 2008, Kroeker et al. 2010, D'Angelo et al. 2012, Enochs et al. 2015). Possible responses of reef building corals to reduced calcification include a) decreased linear extension rate and skeletal density (Cooper et al. 2008), b) the maintenance of physical extension rate, but reduced skeletal density, leading to greater erosion (Szmant and Gassman 1990), and c) maintenance of linear extension and density but greater investment of energy diverting resources from other processes such as reproduction (Szmant and Gassman 1990, Albright and Mason 2013). By the end of the century the waters of Torres Strait are expected to become more acidic, with acidification proportional to emissions growth (CSIRO-BOM 2015).

6 Critical habitats and identified Impacts

Mangroves, seagrasses and coral reefs support the selected fisheries examined in this report. These three ecosystems are intrinsically connected and impacts on one of them will have consequences to the other two ecosystems (Guannel et al. 2016). In this section we describe each of these ecosystems, focusing in Torres Strait and looking at the fisheries they support, their spatial distribution, current status, impacts and trends.

6.1 Seagrasses

Seagrasses are highly dynamic, responding to a complex suite of physical environmental factors including tides, currents, turbidity, temperature, light, nutrient (N and P), salinity, exposure, and substrate availability that affect the quality and quantity of light reaching seagrass communities (Campbell et al. 2008, Rasheed et al. 2008, Collier et al. 2011, Griffiths et al. 2020). Both day length and maximum air temperature are positively correlated with the monthly seagrass standing crop (Rasheed et al. 2008). However, extreme temperatures and reduced light availability negatively affect photosynthesis, nutrient uptake, flowering and germination (Duarte 2002, Poloczanska et al. 2007). Decrease in salinity due to large flood events has been associated with a decline in seagrasses (Carruthers et al. 2002). Excessive nitrogen loading from terrestrial sources such as sewerage and agricultural run-off can inhibit seagrass growth and survival through direct physiological response and by stimulating growth of epiphytes, phytoplankton and macroalgae leading to reduction of light (Schaffelke et al. 2005, Sheppard et al. 2008) and nutrient fluxes to the seagrass leaf blades, reducing seagrass productivity, density and above- and below-ground biomass (Richardson 2006, Brodersen et al. 2015, Green et al. 2015).

Torres Strait extensive seagrass meadows represent about one quarter of Australia's seagrass area (Carter et al. 2018). These habitats are dynamic, varying seasonally and annually spreading from between 13,425 km^2 and 17,500 km^2 (Carter et al. 2014, Marsh et al. 2015).

Twelve seagrass species from 3 families occur in intertidal and subtidal meadows in Torres Strait (Carter et al. 2014). Seagrass flora include species that are highly adapted to high-light conditions (*Syringodium isoetifolium* and *Cymodocea serrulate*) and low-light conditions (*Halophila ovalis* and *H. decipiens* and *Halodule uninervis*) (Campbell et al. 2008). Species adapted to low-light conditions tend to be opportunistic, colonizing new substrate after disturbances, nutritious and less fibrous and preferred by marine herbivores such as dugongs and turtles (see Chapters 7.5 and 7.6). Taller species that are adapted to high-light conditions are unable to maintain biomass and survive in low-light conditions. These characteristics optimize survival of smaller species during periods of reduced light penetration (e.g. due to strong rainfall events associated with sediment and nutrient runoff) (Campbell et al. 2008), benefiting herbivores such as turtles and dugongs (Campbell et al. 2008).

Torres Strait seagrasses are influenced by sporadic environmental stress (strong currents, tidal exposure, extreme rainfall affecting salinity) and herbivory (e.g. dugongs and turtles) (Bridges et al. 1982). Their abundance seems to increase during the north-west monsoon, possibly a consequence of elevated nutrients, lower tidal exposure times, less wind, and higher air temperatures. Their abundance diminishes during the dry season, which coincides with the presence of greater winds and longer periods of exposure at low tides (Mellors et al. 2008).

Seagrass and algae dominate the epibenthos of Western Torres Strait and are commonly found in less than 10m deep in sandy substrate (Haywood et al. 2008). Regions containing high seagrass biomass include the Warrior Reefs, the eastern edge of the Dugong Sanctuary subtidal meadow, and reef top meadows and surrounding islands between Prince of Wales Island and Orman Reefs, while very little is known about seagrasses in the North of the Dugong Sanctuary, Prince of Wales Island to western Cape York, and Eastern Cape York and south east Torres Strait (Carter et al. 2014).

6.1.1 Key fisheries

- Dugongs
- Turtles
- Bêche-de-mer
- Prawns
- Tropical Rock Lobster

6.1.2 Total Area

13,425 km^2 - 17,500 km^2

6.1.3 Ecosystem services

Seagrasses provide the following key ecosystem services in Torres Strait (Carter et al. 2014):

1. Food for herbivores like dugongs and sea turtles
2. Cycling of nutrients
3. Stabilisation of sediments
4. Improving water quality
5. Marine carbon sinks
6. Provision of critical habitats and food sources for commercial and traditional fisheries in Torres Strait such as globally significant populations of green turtles (*Chelonya midas*), largest dugong (*Dugong dugon*) population in the world, bêche-de-mer, prawns and tropical rock lobster (Carter et al. 2014, Marsh et al. 2015, Carter et al. 2018).
7. Cultural and spiritual links
8. Food and income: Torres Strait Islanders rely on seagrasses as they support subsistence, commercial and traditional fisheries and income and have also strong cultural and spiritual links with them (Carter et al. 2018).

6.1.4 Current status and impacts

Torres Strait seagrasses are generally in very good condition (Carter et al. 2014, Marsh et al. 2015, Carter et al. 2018). Substantial diebacks of seagrasses have occurred in Torres Strait in the early 1970s, 1991-1992, and 1999-2000. The cause of the first dieback was never confirmed, but likely to be associated with overgrazing by an unusually large number of dugongs and green turtles (Marsh and Kwan 2008). The last two dieback episodes were associated with high turbidity and reduced light penetration resulting from increased rainfall and sediment runoff from rivers in Papua New Guinea coincident with an El Niño Southern Oscillation (ENSO) (Long et al. 1997, Marsh et al. 2004). Turbidity-related light stress and reduced salinity due to excessive rainfall and river flow has been identified as a major driver of seagrass habitat structure in northern Australia (Campbell et al. 2008, Carter et al. 2018). Such diebacks are believed to be natural (Marsh and Kwan 2008), known to have increased local dugong mortality (Marsh et al. 2004) and were also associated with dramatic declines in tropical rock lobster abundance in Torres Strait in 1991 and 1992 (Long et al. 1997).

Epiphytes benefit from increased nutrient inputs, which can negatively impact seagrasses. Nutrients also increase primary productivity and phytoplankton, thus reducing light availability with negative effects on seagrasses. In most cases, epiphytes do not seem to cause any harm to the seagrass host. However, increased nutrient enrichment can cause phytoplankton, macroalgae and epiphyte 'blooms', reducing light and nutrient fluxes to the seagrass leaf blades, reducing seagrass productivity, density and above- and below-ground biomass (Richardson 2006, Brodersen et al. 2015, Green et al. 2015). Threats to seagrasses in Torres Strait include ship-related oil spills and structural habitat damage, climate change and diebacks (Carter et al. 2018).

6.1.5 Climate change implications

Reduction in the extent of seagrasses meadows or diebacks are expected as temperature increases and sea level rises due to climate change. Sea level rise will increase coastal erosion and turbidity, which will negatively affect seagrasses due to reduction in light penetration. Increase in water depth may also open up new areas for seagrass colonisation, but the increased turbidity associated with coastal erosion can prevent seagrass expansion to new areas.

Seagrass loss is expected to adversely affect life history and reproductive rate of female dugongs, the effect of which cannot be separated from a possible density-dependent response to changes in dugong population size (Marsh and Kwan 2008).

Climate change effects such as increase in intensity of extreme rainfall events (see Chapter 5.2.4) will affect river discharge volumes. In the GBR, six consecutive very wet years 2007-2012 where annual discharges were ~65% higher than normal have negatively affected seagrass communities because the impacts of prolonged (multi-year) and associated continuous resuspended material within the coastal zone obliterates light penetration thereby shrinking seagrass meadow areas. The prolonged reduction in water clarity reduces the capacity of seagrass to build energy storage which negatively affects reproduction and seed production. With a healthy seedbank and adequate light seagrass meadows recovery time ranges from 1-2 years (dominated by *Halophila* spp.), however, recovery times are less predictable when seedbanks and adult populations are lost (Wooldridge 2017).

6.2 Mangroves

Mangroves are the most common vegetation community in the Torres Strait (Stanton et al. 2008). They cover an area of 26,054 ha (in 2014), represented by 35 mangrove species from 18 genera, 14 families, including 2 varieties and 2 hybrids (Duke et al. 2015). This is considered as 'high diversity for a numerically small plant habitat assemblage' (Duke et al. 2015). The description of mangroves presented below is based on Duke et al. (2015) unless otherwise stated.

Boigu, Saibai, Sassie, Zagai and Buru are the five predominantly 'mangrove' islands in Torres Strait, with dense and tall (>20 m height) mangrove forests, which have developed on shallow sandy substrate deposited on, and adjacent to, exposed coral reef flat, providing important habitat and breeding grounds for fish and mud crabs, shorebirds, bats, reptiles, Torres Strait Pigeon, Saltwater Crocodile and Turtles (Sassie Island – a mangrove Island– is the world's largest Hawksbill Turtle rookery).

Mangroves are influenced by wind, waves and tidal currents, type and size of sediments, nutrients, sedimentation, and chemical pollution. They are threatened by direct human impacts in Torres Strait including pollution (e.g. nutrients from sewage treatment plants and septic tanks and chemical leachate from poorly located refuse sites), urban development (land clearing to accommodate air strips and roads), mangrove cutting (for firewood, building material and traditional carving) and alteration of coastal zone hydrology. Other factors influencing mangroves in the region include feral animal, root burial, fire, vehicle damage, and sea level rise (Duke et al. 2015). They are also linked with Torres Strait Island culture and are a strong component of the Islanders identity.

6.2.1 Key fisheries

Mangroves sustain a variety of fisheries, such as crabs and a variety of fish species. However, no direct link has been found with the key fisheries investigated in this report, apart from Sassie Island (mangrove Island) being the world's largest Hawksbill Turtle rookery (Duke et al. 2015) and that king prawns may be more abundant in sparse seagrasses close to mangroves (Skilleter et al. 2005)

6.2.2 Total Area

26,054 ha

6.2.3 Ecosystem services

Mangroves provide the following ecosystem services to Torres Strait Islanders (Ewel et al. 1998, Shnukal 2004, Duke et al. 2015 and references within, Himes-Cornell et al. 2018):

1. Fish and wildlife habitats for commercial and traditional species (e.g. Hawksby turtles; prawns, crabs, fish)
2. Provision of food: Biyu sama are slimy balls of cooked mangrove seed-pod pulp, soaked and then cooked in an earth-oven to render it edible
3. Medicinal resources
4. Provision of raw material: timber to make tools, arts and crafts, for firewood and construction
5. Provision of water
6. Erosion control / Shoreline protection: including maintenance of soil fertility / nutrient cycling, moderation of extreme events, regulation of water flow, and trap sediments
7. Regulate air quality
8. Biological control
9. Climate regulation
10. Water quality improvement
11. Carbon storage
12. Support local and genetic biodiversity, coastal productivity and direct connectivity (fringing mangroves) with adjacent terrestrial habitats
13. Maintenance of life cycles of migratory species
14. Aesthetic information
15. Resting places on long sea voyages

16. Information for cognitive development
17. Spiritual experience
18. Opportunities for tourism and recreation

6.2.4 Current status and impacts

Duke et al. (2015) provides a useful summary of current status and impacts on Torres Strait mangroves and is used unless otherwise specified. Mangroves are subjected to high levels of stress (wind and wave activity) and are also very dynamic with some forests expanding (e.g. Erub and Iama Islands) and others retreating (e.g. Gebar Island). About 59% of mangroves in Torres Strait are considered ‘healthy’, while mean shoreline mangrove in ‘poor condition’ is 18%. The proportion of poor condition shoreline mangroves is relatively high given the minimal human environmental modification and influence.

Mangrove expansion likely reflects a recent drop in sea level during the 1980’s and 1990’s and has potentially been facilitated by elevated nutrient loads. Mangroves exposed to excessive nutrients are more susceptible to stem breakage, which reduce their ability to respond to natural wind and wave impacts, sea level rise, cyclones and storm surges, limiting their effectiveness in protecting coastlines because they become more likely to topple. Conversely, nutrient enrichment can assist mangrove accretion in response to elevated sea level and may also improve osmoregulatory function in some species increasing mangrove tolerance to increased salinity from greater tidal exposure.

Mangrove cutting is the most frequent human impact in Torres Strait, mostly for timber resources (firewood, building material and for carving). Mangroves are protected plants under State Fisheries Legislation (Section 54; Queensland Fisheries Act 1994) but in Torres Strait it is unclear whether they fall under similar traditional use exemptions as exists for turtles and dugong (Duke et al. 2015: 71).

Chemical leachate from waste disposal is likely entering mangrove habitat. Dauan Boigu, Saibai and Iama Islands have landfills in close proximity of mangroves and may be contaminated – albino propagules indicate contamination by heavy metals and hydrocarbons and were found in Saibai and Boigu Islands. Chemical leachate is likely to be affecting mangrove fauna and poses a localised threat to human health.

Only a small proportion of mangroves (<1%) are at risk from localized oil and fuel spills due to close proximity to boat loading facilities affecting (e.g. Mua Island). Major oil spills have occurred in the past (e.g. ‘Oceanic Grandeur’ oil spill in 1970) and have the potential to occur again in the region especially because of increased traffic since then. Of concern are the ecologically sensitive and important mangrove areas on Sassie and Zagai Islands and traditional and commercial fisheries that may be affected if a large oil spill occurs in Torres Strait.

Sea level rise may be exacerbating the effects of wind on shoreline mangrove forest, resulting in reduced resilience in Torres Strait (Duke et al. 2015). Mangroves are sensitive and respond rapidly to sea level variations. Sea level affects mangroves both directly (e.g. erosion and accretion of sediments) and indirectly (e.g. changes in salinity and frequency of inundation). Assumed sea level impacts were observed in all mangrove islands in Torres Strait, except Tudu. About 10% of mangroves were observed to be potentially impacted by sea level rise. Root burial may also be associated with sea level rise as transgressive coastlines may deposit sand within the mangrove forest smothering mangrove aerial roots, with the potential to cause death.

The construction of infrastructure (e.g. air strips, dams and roads) is a minor issue affecting mangroves in Torres Strait via the alteration of local hydrology. It restricts natural freshwater, overland, and tidal flow into mangrove channels, causing localised die-offs.

6.2.5 Climate change implications

Duke et al. (2015) found that mangroves have expanded in Torres Strait between 2008 and 2014 by 6% (average annual expansion rate of 2%). This is contrary to global measurements, which show declining mangrove areas on an average rate of 1% per year. Mangrove extension in Torres Strait seems to be associated with i) low level of direct anthropogenic pressure on mangrove habitats, and ii) a localised drop in sea level between 1987 and 1998, which helped establish new mangrove communities. Excess nutrients from sewage treatment plants may have caused a positive impact on the new established mangroves. Sea level rise that has been occurring at a fast rate since the late 1990s is likely to cause the retreat of the newly established mangroves in the coming years, despite localised mangrove expansion observed in some Islands (e.g. Erub and Iama).

The low topographic relief of these islands makes them highly susceptible to sea level rise and their future is uncertain. Mangrove resilience to climate change is dependent on maintaining healthy habitat such that the ecosystem can adequately and effectively respond to change (Duke et al. 2015).

Sea level rise in the Torres Strait may be exacerbating the effects of wind on shoreline mangrove forest, resulting in reduced resilience. Salinity is another important factor likely to be altered with climate change. Improving the understanding of salinity dynamics in mangroves will be important to monitor changes in mangroves low-lying islands (e.g. Boigu and Saibai)(Duke et al. 2015). Rising sea levels may increase mangrove vulnerability to strong winds during the monsoonal season through toppling. The expected increase in the incidence of heat waves (see chapter 5.2.4) may pose a threat to mangroves in Torres Strait.

6.3 Coral Reefs

In Torres Strait there are about 750 coral reefs (Harris et al. 2008) – with 684 reefs larger than 0.15 km^2 – covering an area of 3,972 km^2 (Lawrey and Stewart 2016). These reefs produce about 8.7 million tonnes of $CaCO_3$ per year, which are comparable to those reported at the GBR (Leon and Woodroffe 2013). Recent surveys have documented 275 coral species, of which approximately 75 are new records for the region. The reefs are in good to excellent condition with high coral cover, presence of the major taxonomic and functional groups and minimal incidence of coral disease (Bainbridge et al. 2015). They have the highest diversity of fungiid corals (mushroom corals) in the Eastern Coast of Australia (Hoeksema 2015). For both corals and reef fishes, the communities from central sites differed from those in eastern sites, reflecting a gradient in turbidity and wave exposure (Osborne et al. 2013).

Local morphology and spatial distribution of reef platforms are controlled by the strong tidal currents flowing through Torres Strait, shallow water depth and narrow dimensions of the shelf (Leon and Woodroffe 2013).

Coral reefs are intrinsically linked with mangroves and seagrasses. They form a mosaic of habitats which sustain fish productivity, supporting fishing industries and livelihoods. Healthy coral reefs interconnected with seagrass meadows and mangroves effectively protect the coastline against erosion (Moberg and Folke 1999, Guannel et al. 2016). In Torres Strait, the geological reef structures and hydrodynamic characteristics facilitate the deposition of soft sediments on reef tops and reef flats, often covered by seagrass; while reef edges and slopes are dominated by consolidated substrate and corals (Welch and Johnson 2013:27)

Coral reef distribution is limited by water temperature, pH, light, turbidity/sedimentation, salinity, and water depth (Aronson and Precht 2016), predation (e.g. the Crown-of-Thorns-Starfish (COTS) and *Drupella* spp.; both well-known corallivores (Berthe et al. 2016, Bruckner et al. 2017)), intra and inter-specific competition (e.g. competition between corals and algae, and between different coral species for space), reproductive and regenerative capacity, and their ability to cope with pollutants, nutrients and sediments (Rogers 1990, Kleypas et al. 1999, Guinotte et al. 2003). This means that alterations to any of these factors seriously threaten the existence of corals and their ability to build reefs.

Coral reefs around the world have been declining since the 1970s due to climatic and non-climatic factors. World-wide mass bleaching events are related to above average sea surface temperatures and heat waves (Obura and Mangubhai 2011, Lough 2012, Hughes et al. 2017). Loss of coral reefs is expected with rising sea surface temperatures, owing to interactions between warming, extreme events, ocean acidification, sea level rise and pollution (Barros and Field 2014, Babcock et al. 2019, IPCC 2019a, Lenton et al. 2019). Climate-related events cause mixed effects on coral reefs and adjacent ecosystems upon which corals interact (e.g. seagrasses and mangroves) (Hassenruck et al. 2015, Guannel et al. 2016, Albert et al. 2017), act synergistically with non-climate drivers further impacting reef corals (Wiedenmann et al. 2013, Chazottes et al. 2017, Wooldridge et al. 2017), and are expected to increase due to increased carbon dioxide (CO_2) emissions (causing ocean acidification) and consequent warming of the oceans (Gattuso et al. 2015).

Coral responses to climatic and non-climatic pressures are similar and include bleaching (expulsion of zooxanthellae that live in their tissue (Aronson and Precht 2016, Chazottes et al. 2017)), reproductive and growth impairments (Albright and Mason 2013, Sheridan et al. 2014, Fabricius et al. 2017), and coral-algal phase shifts (from coral-dominated to algae-dominated reefs) (Done 1992, Hughes et al. 2007). The end result of sustained stresses on corals is a simplification of coral community structure and reductions in live coral cover (Bruno and Selig 2007) and species coral trait diversity (Darling et al. 2013), with negative consequences for fisheries that depend on these ecosystems.

6.3.1 Key fisheries

- Bêche-de-mer
- Finfish (coral trout and Spanish mackerel (highly dependent on coral reefs for spawning and feeding)

- TRL
- Prawns
- Dugongs
- Turtles

6.3.2 Total Area

About 750 coral reefs (Harris et al. 2008), occupying an area of 3,972 km^2 (Lawrey and Stewart 2016).

6.3.3 Ecosystem services

Coral reefs provide the following ecosystem goods and services (Moberg and Folke 1999):

1. Provision of renewable resources such as Seafood, Pharmaceutical (anticancer, AIDS-inhibiting, antimicrobial, anti-inflammatory and anticoagulating), agar and carrageenan, manure, mother-of-pearls, souvenirs (red coral), marine aquarium market. Corals were used as bone graft operations. corals were used as bone graft operations.
2. Provision of building materials, production of lime, mortar and cement
3. Provision of physical structure services: protection of the shoreline, wave energy dissipation, creation of favourable conditions to the development of mangroves and seagrasses ecosystems, sediment generation
4. Biotic services: spawning, nursery, breeding and feeding areas for a multitude of organisms, maintenance of biological diversity, genetic library, keystone species that regulate ecosystem processes and functions, provision of species or group of species responsible to keep reef resilience
5. Biotic services between ecosystems: migration back and forth between adjacent ecosystems, such as mangroves and seagrass meadows
6. Biogeochemical services: Nitrogen fixation, carbon dioxide sinker, calcium precipitation
7. Information Services: long-term chemical recorder of temperature, metals, salinity and climate
8. Social/cultural services: recreation, aesthetic values, support of cultural and spiritual values

6.3.4 Current status and impacts

Despite the lack of long-term coral reef data (e.g. composition and abundance of coral species, bleaching, diseases), surveys have shown that Torres Strait reefs are in good to excellent condition (Bainbridge et al. 2015). Resurvey of sites have shown a decline in the abundance of temperature-sensitive corals (e.g. genus *Seriatopora*) (Osborne et al. 2013, Bainbridge et al. 2015).

Extensive coral bleaching was observed for the first time in Torres Strait in 2010 (Bainbridge et al. 2015) and subsequently in 2016 and 2020 (Hughes and Pratchett 2020). Bleaching, outbreaks of

COTS and coral diseases have been observed in the region and are considered the major threats to Torres Strait coral reefs (Osborne et al. 2013, Bainbridge et al. 2015, Hughes and Pratchett 2020).

6.3.5 Climate change implications

Simultaneous climate change drivers, such as sea-level rise, ocean warming, acidification, act together with local drivers (e.g. untreated sewage, chemical, sediment and nutrients runoff, oil pollution, overfishing) leading to interactive, complex and amplified impacts for species and ecosystems (Barros and Field 2014, Valmonte-Santos et al. 2016). For example, calcification rates are affected by both ocean pH and temperature. Current maximum calcification rates are just 2-3 ^{o}C below the maximum temperature corals can withstand before thermal bleaching (Evenhuis et al. 2015). When corals bleach, calcification is further supressed because photosynthetic products from the zooxanthellae are essential for the calcification process (Evenhuis et al. 2015).

Despite the evident negative effect of sea level rise (SLR) on coral reefs (Nurse et al. 2014), it may also provide some opportunities to corals (Saunders et al. 2016). Corals grow vertically and, in principle, additional depth provides extra ‘accommodation space’, in which corals could expand in intertidal areas and also colonise new inundated areas – provided that suitable substrate is available (Woodroffe and Webster 2014, van Woesik et al. 2015, Saunders et al. 2016) – thus increasing live coral cover (Albert et al. 2017). Some reefs can persist under SLR rates of around 4mm.yr^{-1} (commensurate with RCP 2.6 scenario) (Kench et al. 2018). However, it is unclear whether islands (including in Torres Strait) will continue to maintain their sizes under rising seas of 1.1+m by 2100 (RCP 8.5) (Kench et al. 2018, IPCC 2019a). Under such scenario it is more likely than not that rising seas will inundate coastal areas, destruct mangrove forests (see chapters 5 and 6) and further increase coastal erosion in a positive feedback loop (Barros and Field 2014, Kench et al. 2018), thus increasing turbidity and sedimentation in coastal waters and negatively affecting corals and other reef organisms (De'ath and Fabricius 2010, Brown et al. 2017a, Brown et al. 2017b).

There is high scientific confidence that anthropogenic-induced ocean warming is impacting coral reefs through thermal coral bleaching (Davies et al. 1997, Cumming et al. 2000, Rotmann 2001, Adjeroud et al. 2009, Obura and Mangubhai 2011, Kleypas et al. 2015). During bleaching events, corals stop growing and can die by starvation as it depends on photosynthetic products from an algal symbiont. Coral bleaching affects colony size (favours smaller size corals), the time of coral spawning (Paxton et al. 2016) and reduces coral calcification rates (De'ath et al. 2009, Nurse et al. 2014). Bleaching can also affect coral reproduction as it slows down swimming of coral larvae and reduces the number of viable recruits (Singh 2018), thus influencing mass coral spawning events over large geographical areas (Keith et al. 2016). Higher temperatures also lead to increase in bioerosion (Chaves-Fonnegra et al. 2017), and acts synergistically with nutrients and sediments amplifying bleaching effects and also influencing the recovery period from bleaching (Riegl et al. 2015).

Underwater heatwaves in the summers of 2015/2016 and 2016/17, as part of the longest global coral bleaching event on record, devastated coral reefs worldwide (Hughes et al. 2019). Widespread thermal coral bleaching occurred in the Torres Strait in 2009-2010 (Osborne et al. 2013, Bainbridge and Berkelmans 2014, Bainbridge et al. 2015). Coral loss in Torres Strait can have nuance but important negative consequences to reef fish. For example, it can lead to unstable energetic shifts (Morais et al. 2020), causing negative social-ecological consequences, such as decreased fish catches and coastal protection, and biodiversity loss (Adam et al. 2014). These consequences are very relevant to Torres Strait due to the reliance Islanders have on coastal and marine resources for cultural reasons, income and food (Busilacchi et al. 2013, Plaganyi et al. 2013b, McNamara et al. 2017, Johnson et al. 2018).

Ocean acidification can also negatively impact Torres Strait coral reefs. The most significant consequence of ocean acidification to corals is the decrease in the concentration of carbonate ions (CO_3^{2-}) which decreases calcification rates as coral skeletons are made of calcium carbonate (Pandolfi et al. 2011). Weaker reef systems will be far more susceptible to other pressures including bioerosion, eutrophication, coral disease, intense storms and bleaching because coral skeletons become more fragile (Meissner et al. 2012, van Hooidonk et al. 2014, Nuttall and Veitayaki 2015).

By 2100, Torres Strait coral reef fish and invertebrates communities will be highly vulnerable as they are likely to exceed their upper realised thermal limit (Stuart-Smith et al. 2015). Changes in circulation in Torres Strat (see Chapter 3.2 and also Johnson et al. (2018)) may also affect sediment transport and deposition processes, burying reefs and negatively affecting TRL habitats.

7 Key fisheries and identified impacts

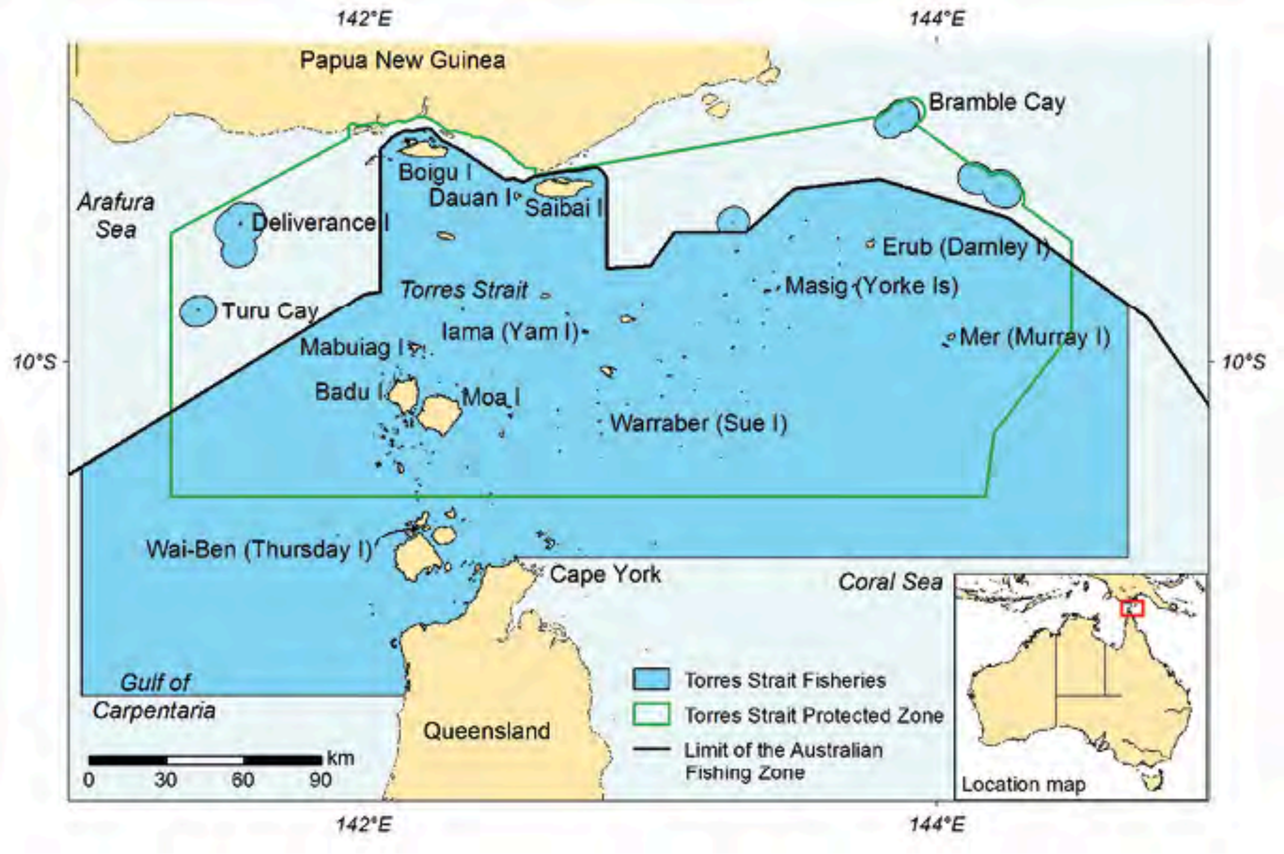

Figure 3 Area of the Torres Strait Fishery (from: Patterson et al. (2018))

7.1 Rock Lobster (*Panulirus ornatus*)

7.1.1 Description

Torres Strait Islanders and Papua and New Guineans have traditionally relied on the tropical rock lobster (TRL) *Panulirus ornatus* for subsistence and cultural uses, and it is currently the region's most economically important fishery. In general, palinurids show significant recruitment variability due to environmental factors, including currents, temperature, winds and moon phase (Plaganyi et al. 2018c). Lobsters are ecologically important in a range of marine habitats, playing a key role in mediating regime shifts, prey on benthic species such as sea urchins, and are prey of larger fish and sharks (see Plaganyi et al. 2018c and references therein).

The TRL fishery is comprised of three sectors; two in Australian waters and a third in PNG. In Australia, the two main Torres Strait fishing sectors are the Traditional Inhabitant Boat (TIB) licence holders, who typically conduct day trips harvesting lobster from dinghies only (van Putten et al. 2013b), and the Transferable Vessel (licence) Holders (TVH) sector consisting mostly of non-indigenous owned commercial vessels (a mother-ship with tenders/dinghies).

As TRL is a shared stock, within Australia it is managed by the Commonwealth. The same species is also fished to the south of Torres Strait, off Queensland's East Coast but is separately managed by the Queensland State Government.

Management recommendations for the past 31 years have been underpinned by scientific surveys of the lobster population and targeted ecological research (Ye et al. 2005, Dennis et al. 2015). The survey and stock assessment methods have been developed through consultation with traditional owners and their representative bodies, in addition to federal and state fisheries managers, independent scientists, non-indigenous fisher representatives and flow-on business stakeholders. Representatives from these groups, and particularly the Tropical Rock Lobster Resource Assessment Group (TRLRAG), have made significant contributions to the development of the fishery-independent surveys, commercial catch and effort monitoring and the integrated fishery model through consultative meetings.

Extensive tagging studies (~20,000 tags) were conducted in Torres Strait and Queensland waters and recaptures showed the 550 km breeding migration that starts in August and September, from Torres Strait to the eastern part of the Gulf of Papua, as well as clear separation of the Torres Strait and Queensland sub-populations (Moore and Macfarlane 1984, Skewes et al. 1997b, Dennis et al. 2001). As a result of the complex life-history comprising a 6 month larval life, the stock is naturally highly variable and the fishery focuses largely on a single 2 year old age-class only.

Recommended Biological Catch (RBC) needs to be set annually in such a way as to ensure biological and economic sustainability consistent with the principles of the Australian Commonwealth Harvest Strategy as well as the TRL fisheries and Protected Zone Joint Authority (PZJA) objectives. An annual pre-season survey of one-year old recruits is conducted as close to the start of the fishing season as possible (November) to inform on the likely biomass of the fishable cohort the next year. The recently implemented empirical (data-based) Harvest Control Rule (eHCR) uses catch, survey indices and CPUE (Catch-Per-Unit-Effort) as inputs (https://pzja.govcms.gov.au/sites/default/files/final_topical_rock_lobster_harvest_strategy_nov_2019.pdf).

7.1.2 Trends and current status

The stock assessment uses an Age Structured Production Model (ASPM) and is an integrated assessment that takes into account all available sources of information (Plaganyi et al. 2019a). The most recent stock assessment was conducted in 2019, and with the switch to use of an eHCR to produce an RBC, stock assessments will be conducted every three years. The stock is naturally highly variable but is considered to have been fluctuating about a high average mean throughout most of the stock's history, with the exception of a concerning downward trend in 2017 and 2018 that has been attributed to anomalous environmental factors (Plaganyi et al. 2019a). However, the 2018 and 2019 preseason surveys recorded high recruitment of 1+ lobsters, resulting in much higher TACs being set for 2019 and 2020.

The most recent stock assessment results indicate that the TRL spawning biomass $B(2019)^{sp}$ is approximately 93% of relative unfished biomass $B\ (1973)^{sp}$, which is well above the agreed target reference point of 65 per cent unfished biomass under the harvest strategy. The target reference point is relatively higher compared with other Australian fisheries and guidance under the Commonwealth Harvest Strategy Policy. This was deliberately designed to meet the objectives of the TRL fishery and protect the traditional way of life, and livelihoods of traditional inhabitants in Torres Strait. The model estimated a spawning stock biomass $B\ (2019)^{sp}$ of 4,467 tonnes.

Based on the eHCR, the 2019-20 season RBC is 582 tonnes. Most of the lobsters that are caught are exported live to China, but under travel restrictions imposed in repose to the 2019/2020 coronavirus outbreak, exports have ceased at the time of writing this report and the consequences on this year's fishery catch, economics and livelihood of dependent stakeholders are not currently known.

7.1.3 Value

Most lobsters are now caught live for export to China which has substantially increased the value of the fishery (Plagányi et al. 2017b). The average annual total catch from 2010 to 2019 was 632t. The gross value of production (GVP) of the Australian fishery (not including PNG) fluctuates annually due to the large variability in the stock, with annual estimates ranging from around $12.2 to $20 million.

7.1.4 Issues

Larval circulation models suggest that, depending on the Coral Sea gyre and local currents influencing the broader Coral Sea and Great Barrier Reef regions, some of the larvae may settle off Australia's north-east coast and, similarly, some of the larvae spawned by the East Coast *P. ornatus* component may be advected into Torres Strait due to the predominant northerly direction of the current (Plagányi et al. 2018, Plagányi et al. 2019). The complexity of the oceanographic processes in combination with diverse life histories makes predictions of changes in recruitment success as a function of large-scale oceanographic changes difficult. Using 23 years of continuous survey and climate data, Plaganyi et al. (2019) found no clear relationship between population size and the predictions of the CONNIE3 oceanographic model. However, the BRAN model used is a global model with a daily time step so it does not adequately capture the complex dynamics of the tides in the Torres Strait (http://www.bom.gov.au/australia/tides/about/p4b-torres-strait.shtml) which may influence larval advection in this area. CONNIE3 uses archived currents from oceanographic models and particle tracking techniques to resolve spatial displacement of particles and estimate connectivity statistics from user-specified source regions (or to user-specified sink regions). A range of physical and biological behaviours can be specified including vertical migration, horizontal propulsion or swimming (user-specified random or constant velocity). But the model used cannot be considered reliable in terms of predictions of the exact final distribution of larvae in Torres Strait itself because the model does not resolve tides. Finer resolution oceanographic models are therefore needed to establish relationships between oceanographic processes and recruitment, as a basis for projected changes due to future changes in currents and tides.

Growth in all life history stages (larval, juvenile and adults) have been assessed (Norman-Lopez et al. 2013) as being at high risk due principally to a likely increase in sea temperatures. This effect was assessed as being mostly positive based on experimental studies demonstrating the enhancement of growth by warmer sea surface temperatures up to 30^{o}C (Dennis et al. 1997, Skewes et al. 1997a). Medium risks contained both positive and negative effects. Positive effects were associated with an increase in larval growth due to projected increases in primary production in the Coral Sea (Brown et al. 2010), and faster adult growth and bigger lobsters resulting in an increase in adult reproduction. Negative effects were associated with increased larval and juvenile mortality related to higher sea surface temperatures and detrimental effects on the juvenile lobsters' seagrass habitats. Norman-Lopez et al. (2013) also highlighted that climatic changes to rock lobster catches will have a direct effect on the employment and income (wages and profits) of Islanders (TIB) and non-Islander fishers (TVH), and in turn have a flow on effect to other sectors through changes in demand from these two fishing groups.

More recently, TRL projections to 2050 were run using the same decadal climate projections as the project 'Decadal scale projection of changes in Australian fisheries stocks under climate change.' The projections are available from the CSIRO decadal forecasting project (Matear and Zhang), with international models accessed from the CMIP5 archive. The March 2017 TRL stock assessment model was refitted by linking with climate data available from 1992, and model results suggest strong support for the hypotheses that growth and survival of lobsters are affected by changes in SST (Plagányi et al. 2018). The parameters of the latter functional form were estimated in the model, and used to forward project the lobster spawning biomass to 2050. The model estimated small changes only in lobster mortality over the temperature range 25-29°C, but a fairly steep increase in mortality as SST increased above the likely optimum SST of 29°C. Overall, in the short to medium-term, the TRL spawning biomass is predicted to remain roughly at current levels, with large inter-annual fluctuations as observed in the past, but a decrease is predicted in the longer term (Plagányi et al. 2018). The model fit improved substantially when introducing the hypothesized relationships between SST and growth and mortality, suggesting that changes in SST may already have been influencing TRL dynamics over the recent past, and also that the hypothesized relationships are consistent with available data to date. The model estimated a fairly steep increase in mortality as SST increased above the likely optimum SST of 29°C, although the model relationship was estimated using data up to a maximum of 32°C whereas future SST is predicted to increase to approximately 34°C by the end of the century, and hence is outside the range of current observations (meaning extrapolations are less certain).

However ongoing work will continue to refine these projections. These modelling results incorporate first order effects only, and more work is needed to account for more complex impacts of climate change shifting temperature beyond the thermal envelope for TRL, including moult frequency and increment, timing of larval release and potential mismatch with optimal food conditions and circulation patterns.

Torres Strait waters are expected to increase in acidity in future, with acidification proportional to emissions growth (CSIRO-BOM 2015). Although the exact effects on TRL are not known at present, ocean acidification is considered an important threat to marine species, including crustaceans (Keppel et al. 2012, Green et al. 2014). Negative impacts on lobsters and other crustaceans are increasingly being documented (Whiteley 2011, Agnalt et al. 2013, Bednaršek et al. 2020). A recent study (Bednaršek et al. 2020) demonstrated conclusively using an *in situ* study that increasing ocean acidity is impacting the shells of crab larvae, making them more vulnerable to predation as well as weakening support structures for muscles and possibly leading to loss of important sensory and behavioural functions.

Biophysical understanding is essential for planning responses to climate change but this is not sufficient as the full range of opportunities and threats that will confront fisheries are not limited to biophysical changes at the production phase of fisheries (Hobday et al. 2015). Consideration of the impacts of climate change along seafood supply chains, the steps a product takes from capture to consumer, is thus vital to ensuring the ongoing supply of seafood (Hobday et al. 2015). A quantitative metric for comparing key features and critical elements in wild fisheries and aquaculture supply chains under a changing climate was developed by Plagányi et al. (2014), and applied to case studies including TRL. The Supply Chain Index (SCI) identifies critical elements as those elements with large throughput rates, as well as greater connectivity. Identification of key elements along the supply chain may assist in informing adaptation strategies to reduce anticipated future risks posed by climate change. The SCI identified airports, processors and Chinese consumers as the key elements in lobster supply chains that merit attention to enhance stability and potentially enable growth. For TRL, the SCI identified the Chinese and U.S. markets as key elements, suggesting that the key mechanism for stabilising this supply chain is to reduce uncertainty in supplying these markets. This study underscored that maintaining and strengthening relationships with international markets may thus be key to underpinning the success of this supply chain.

7.1.5 Opportunities

Some environmental factors (eg. temperature) and habitats (eg. hard substrate) have obvious influences on lobster growth and survival and for this reason concurrent qualitative seabed habitat monitoring has been conducted during all lobster population surveys completed since 1989. Data from these surveys have provided insights into the major influencing factors; such as the 1991-1993 seagrass dieback event which impacted the lobster population in north-west Torres Strait (Dennis et al. 2013). However, these data are only collected once or twice a year and the seasonal dynamics of any environmental change are not measured. Since 1994 the habitat monitoring protocol was refined to include a standard set of abiotic and biotic categories so that inter-annual comparisons were consistent.

As an example, fishers operating on the deep Kircaldie fishing grounds have reported the strong influence of shell beds on lobster abundance through aggregation. Hence, the incorporation of influential environmental variables has potential implications for improved management of the TRL stock and improved forecasting of stock abundance for fishers. But the Dennis et al. (2013) and Plaganyi et al. (2018) studies found no strong relationships between the environmental variables recorded and lobster abundance, although percent consolidated rubble and seagrass cover were weakly correlated and more dramatic increases or declines in these variables would impact the lobster population. Likewise, more dramatic increases in water temperature, as forecast due to climate change may influence lobster growth and survival (see for example Norman-Lopez et al. (2013)) and there is evidence from recent anomalously high temperatures that this can impact lobster natural survival rates, capture, and handling mortalities (particularly because of the reduction in available oxygen as water temperatures increase) (Plagányi et al. 2018, Plagányi et al. 2019).

Based on results to date, none of the environmental variables recorded in the survey could be used as covariates in the integrated fishery model to significantly improve the precision of the lobster stock forecasts. This result is perhaps not surprising given that although variable, the densities of recruiting (1+) and fished (2+) lobsters have not trended up or down over long periods during 1989 to at least 2017. Further, the Torres Strait fishery is managed at quite conservative levels thereby eliminating the possibility of cascading effects (as documented in many temperate fisheries due to the lobster/urchin/kelp inter-dependence). Further, in contrast to the relatively simple trophic inter-actions documented in the temperate lobster fisheries it is likely that a multitude of complex environmental factors influence the Torres Strait tropical rock lobster population. The diet of *P. ornatus* for example is broad and opportunistic and lobsters would be capable of compensating for a decline in one component by selecting another. Nevertheless, the observed influence of seasonal shell beds (at least in attracting and aggregating lobsters) and the cause of their seasonal abundance deserve further study. In the past few years anomalously high temperatures have had impacts on the stock and ongoing monitoring will be valuable for future forecasting of impacts on the lobster population.

Changing environmental drivers may also have substantial impacts on the availability of stocks to fishers (and indeed may bias survey results too), such that improved understanding of these complex relationships could assist in improving the stock assessments and methods used to support the sustainable management.

7.2 Prawns

7.2.1 Description

Brown tiger, blue-tailed endeavour and red-spot king prawns are abundant in the Torres Strait region (2009-2018 average annual catch for each species was 338, 98 and 7 t, respectively; average 1960 days fished) (Turnbull and Cocking 2019). However, the ratio of species in the catch and hours fished have changed significantly since the 1990s and early 2000s (1991-2003 average annual catch of the three species was 668, 1044 and 70t, respectively; average 9,699 days fished). The prawns are fished in the inter-reef lagoon, east of the Warrior Reefs in the eastern region of Torres Strait; but west of the myriad of reefs and coral cays and terrigenous islands further east (Watson and Turnbull 1993). Their juvenile phase migrate from the shallow reef-top habitats associated with the Warrior Reefs; both from west and east of the reefs to deeper waters where they are fished (Watson and Turnbull 1993). The nursery source of juvenile king prawns is less well known. The CPUE of endeavour prawns declined significantly over 2005-18, while that of tiger prawns has remained steady, and increased markedly from the 1990s (Turnbull and Cocking 2019).

The Torres Strait Prawn Fishery is an industrial fishery undertaken from mechanised trawlers (~15-20 m length) with significant freezer capacity. They are self-contained for weeks of operation at sea and are serviced by a mothership from Cairns, Queensland. The Torres Strait Protected Zone Joint Authority limits vessel licences to 61. Licences can only be granted to Australian citizens. Fishing capacity is defined by units, which equal boat-days available to be fished (9200 Units). The units are divided as 6,867 Australian Units and 2,333 Papua New Guinea Units.

A feature of all commercial penaeid prawns is ontogenetic habitat shift during their life history (Dall et al. 1990); the juvenile phase inhabits littoral substrates within a range of micro-habitats, the adult phase inhabits shallow coastal water ~10-50 m deep. In Torres Strait, commercial prawn juveniles inhabit shallow reef-top seagrass communities (Blyth et al. 1990, Turnbull and Mellors 1990). The dependence of their juvenile-phase on littoral seagrass habitats renders the prawns vulnerable to Climate Change; particularly as their seagrass community habitats are vulnerable to direct and indirect climate impacts (Duarte 2002, Poloczanska et al. 2007) (see also Chapter 6.1).

Tiger and endeavour prawns are dependent on the refuge structure of seagrass shoots and leaves, which provide them shelter from predators, food, and an ameliorated physical environment (Kenyon et al. 1995, Haywood et al. 1998, Loneragan et al. 1998). Juvenile tiger prawns benefit from large, broad-leaved seagrasses which provide camouflage structures on which to hide and avoid silhouette and capture (Kenyon et al. 1995). The prawn's small, post-settlement stage does not bury to avoid predation; small juveniles are pigmented for camouflage against seagrass leaves (large juveniles and adults do bury)(Wassenberg and Hill 1994, Kenyon et al. 1995). Large juvenile tiger and endeavour prawns and the adult phase bury to avoid predation (Park and Loneragan 1999). In 1999 in Exmouth Gulf, Western Australia, cyclonic disturbance removed the majority of the shallow-inshore seagrass community and created a natural experiment to show the dependence of the tiger prawn population on their inshore seagrass nursery habitats. The loss of the seagrass nurseries deprived the benthic juveniles of critical refuge and forage habitat. Fishery catch declined markedly in 2000 (82 tonnes, down from 450 tonnes in 1999) as a consequence of failure of the juvenile phase due to inshore habitat loss, despite a strong spawning index and likely abundant pelagic larvae the previous year (Loneragan et al. 2013). Over the next three years, the shallow, inshore seagrass community re-established. As the habitat components recolonised the disturbed sediments, the juvenile tiger prawn critical seagrass habitat, the juvenile prawn population, the adult population's recruitment index, and the tiger prawn fishery catch (~200 to 600 tonnes, 2001 to 2006) re-established to pre-cyclonic levels, demonstrating a clear dependency of tiger prawns on seagrass habitat.

Juvenile king prawns inhabit bare substrates and seagrass communities; particularly short, thin-leaved seagrasses, and their distribution preference among bare vs vegetated habitats varies during the day verses the night (Young 1978, Tanner and Deakin 2001, Ochwada-Doyle et al. 2011). Small juvenile king prawns are transparent with speckles, camouflage to be 'invisible' and mimic sand grains on un-vegetated substrates. They bury as small juveniles to avoid predators (Tanner and Deakin 2001) and so vegetated habitats are not critical to them. Although a preference for bare or sparsely vegetated habitats is not consistent in all localities. In Moreton Bay, Skilleter et al. (2005) found eastern king prawns more abundant on dense seagrass than sparse, and sparse seagrass close to mangroves; so microhabitat interactions that affect local density distributions can occur. King prawns can use both bare substrates and (possibly sparse) seagrass habitats and the natural cyclone-induced experiment in Exmouth Gulf (described by Loneragan et al. 2013) did not reduce their local catch immediately after cyclonic disturbances (see Kangas et al. (2015)). Despite inshore seagrass nursery habitats being removed, king prawn catch and hence their population did not decline, demonstrating that their juvenile phase was not critically dependent on vegetated littoral nursery habitat.

In Torres Strait, juvenile tiger and endeavour prawns were found among the seagrass community on the reef-tops of the Warrior Reefs and the York Island reef (Turnbull and Mellors 1990, Turnbull and Watson 1990). Fewer tiger prawns were collected from the sparse seagrass at Yorke Island than the dense seagrasses at Warrior Reef (see Turnbull and Mellors 1990), a carrying-capacity relationship between sparse and dense seagrass identified elsewhere in Australia's tropical coasts (Loneragan et al. 1998).

Information on the habitats of juvenile king prawns is more difficult to determine in Torres Strait. However, Turnbull and Watson (1990) conducted comparisons of beam trawls catch efficiency on both the Warrior Reefs and Yorke Island seagrass communities. Catches from the dense seagrass habitats at Warrior Reefs were comprised of tiger, endeavour and greasyback prawns. In contrast, catches at Yorke Island were comprised of tiger, endeavour and red-spot king prawns. The presence of king prawns at Yorke Island matches the presence of bare substrate or sparse seagrass habitats on the Atoll's reef-top (their Site 111), benthic habitats as reported by Turnbull and Mellors (1990).

7.2.2 Trends and current status

Since 2010, the annual landings of prawns from the Torres Strait fishery have been mostly ≤500 t and comprised of a majority (70-80%) tiger prawns (Turnbull and Cocking 2019). Over the same period, fishing effort has ranged from about 1,000 to 3,000 boat-days a year. By both of these measures, the Torres Strait fishery has recently operated at much reduced levels compared to the 1990–2010 period. From 1990 to 2010, prawn landings were often in the range of 1,500 – 2,000t and the proportion of tiger prawns was 40-50%; the remainder of the catch dominated by endeavour prawns. From 1990 to 2000, annual fishing effort reached 10,000 to 12,000 boat days and was regularly > 6,000 boat days. Fishing effort declined steadily from 2000 to 2010. Since 2010, landings of king prawn were negligible compared to the period 1990-2000. The Torres Strait Prawn Fishery is managed by Total Allowable Effort (TAE), though the effort levels set for 2016-2018 (9200 boat days) were roughly three times actual effort (https://www.pzja.gov.au/the-fisheries/torres-strait-prawn-fishery). The fishery operates under a Management Plan (2009) and a Harvest Strategy (2011) (available from the Torres Strait Protected Zone Joint Authority website; see https://www.pzja.gov.au).

7.2.3 Value

The Torres Strait Prawn Fishery was valued at $4.6 million in 2017-18 (278 t) (Patterson et al. 2018).

7.2.4 Issues

If Torres Strait seagrass communities are impacted by climate change, then the dependence of the juvenile stage of Torres Strait commercial prawns on littoral seagrass habitats exposes them to critical habitat loss. A summary of climate change impacts on prawns is presented in Table 3. Temperature extremes, both air temperature and SST, are likely to affect shallow littoral habitats in Torres Strait by 2030. A surface air temperature increase between 0.5 and 1.5^{o}C, and a sea surface temperature (SST) increase by 1.0^{o}C under emission scenario RCP8.5 are predicted (CSIRO-BOM 2015). By the end of the century, SST increases are predicted in the range of 2.2 to 3.6°C under a high emissions scenario (RCP8.5).

Seagrass growth and survival is influenced by temperature, light, nutrient (N and P), salinity, and substrate availability. Thermal optimum temperature for seagrass ranges from 15 to 33^{o}C (Collier et al. 2011) and SST in Torres Strait reached 30-32 ^{o}C in 2019. By 2090, SST may exceed the upper thermal tolerance of seagrass communities. Extreme temperatures affect photosynthesis, nutrient uptake, flowering and germination in seagrasses (Duarte 2002, Poloczanska et al. 2007). Moreover, regional air-temperature heatwaves and marine heatwaves will elevate shallow sea temperatures for short periods (Frolicher et al. 2018) and cause seagrass community to decline.

In addition, extreme rainfall events are predicted to increase in frequency in the Australian tropics (see Chapter 5.2.4). Decreases in salinity due to large local flood events have been associated with a decline in seagrasses. Hence, the exposure of local reef-top seagrass communities to freshwater pulsed runoff is likely and seagrass community decline is a likely consequence (Carruthers et al. 2002). By 2100, global sea levels are predicted to increase by 1.1m (IPCC 2019a) with subsequent impacts on the average depths of coral reefs that support the seagrass communities; and limiting the light penetration to the then deeper seagrass communities. In addition, cyclones are expected to increase in intensity, which have the capacity to uproot and destroy seagrass communities (Poiner et al. 1993), and hence the juvenile habitats of tiger and endeavour prawns.

The bare-substrate habitats of juvenile king prawns might expand in extent due to the loss of seagrass extent. Greater areas of bare substrate may benefit the juvenile king prawn population in Torres Strait. Cyclonic impact on the prawn community in Exmouth Gulf Western Australia provides a natural 'experiment' to illustrate these benefits (Loneragan et al. 2013). In March 1999 the category 5 Cyclone 'Vance' bisected Exmouth Gulf and removed seagrass habitats that were prolific on the eastern shallows of the Gulf. Prior to 1999, the tiger prawn:king prawn ratio in Exmouth Gulf was 50:50. In 1999, the tiger prawn population remained strong as the 1998/99 juvenile recruitment and inshore growth had occurred prior to cyclonic impact. However, the March 1999 cyclone disturbed the littoral habitats of Exmouth Gulf and by the 1999/2000 juvenile recruitment time window (October to March), their critical seagrass habitats were non-existent (Loneragan et al. 2013). The 2000 and 2001 commercial prawn catches were dominated by king prawns (Kangas et al. 2015) as they had taken advantage of the extensive bare substrates exposed by cyclonic impact (tiger prawn:king prawn ratio was roughly 20:80 in 2000). Over subsequent years, the seagrass habitats re-established in extent, and as they did the population of tiger prawns re-established. By 2005, the tiger prawn:king prawn proportions of the community had returned to similar proportions to what it was in 1995. Hence, if littoral seagrass extent in Torres Strait was to decline, king prawns may benefit and be reflected as increased catches taken over those years.

In addition to the impact of marine heatwaves on the seagrass habitats of commercial prawns, marine heatwaves may impact the postlarval and juvenile phase of the prawns directly. The temperature of shallow sub-littoral waters may exceed the thermal tolerance of pelagic prawn larvae and postlarvae, impeding their development. As the prawns develop to their benthic juvenile phase, they immigrate to shallow nursery habitats and settle from the plankton. Among shallow reef-top seagrass habitats, their exposure to local temperature spikes would continue. Both marine and atmospheric heatwaves are expected to increase in frequency and duration (Coumou and Robinson 2013, Frolicher et al. 2018); the temperature of shallow-water recruitment habitats of juvenile prawns will spike as air temperature spikes. Shallow water temperatures above 40°C would exceed the thermal tolerance of juvenile prawns (Obrien 1994). Torres Strait reef-top waters and shallow inter-reef waters are candidates for localised elevated SST and prawn physiological stress. In 2015 and 2016, shallow water temperatures above 40°C were recorded within *Enhalus acoroides* seagrass beds within the Embley River estuary, Cape York; relatively close by Torres Strait (Skye McKenna, Michael Rasheed; Port of Weipa long-term seagrass monitoring program - 2017, pers. comm.)

A second facet of climate change that may directly impact on the prawn community of Torres Strait would be physiological stress on the larval and juvenile stage of their life histories due to ocean acidity associated with increasing levels of dissolved CO_2. Planktonic prawn larvae feed on phytoplankton and zooplankton and the calcification of the calcareous skeletons of plankton will be impaired interrupting planktonic prawn larval growth under increasingly acidic oceans (Poloczanska et al. 2007). In tank experiments, reduced growth of the larvae of the shrimp *Pandalus borealis* has been measured (Bechmann et al. 2011). In addition, ocean acidification may affect the development of the exoskeleton of juvenile commercial prawns. To date, the characterisation of possible impacts on a prawn's chitinous exoskeleton remains under investigation. Carapace dissolution of crustaceans have been recorded in the West coast of the United States (Bednaršek et al. 2020). However, the exoskeleton of shrimp is dominated by chitin with calcium carbonate impregnation of the chitinous matrix (Taylor et al. 2015). Experimentation reducing seawater pH has shown that calcification increases within the exoskeleton of caridean shrimp in the short term (21 days), but with no effect on moult or growth (Taylor et al. 2015). Body translucency is reduced, which may affect the shrimp's ability to remain cryptic in natural habitat. Changes in circulation in Torres Strait may affect prawn larvae dispersion (Johnson et al. 2018).

Table 3. Observed and expected effects of climate change on prawns.

FISHERY	PHYSICAL DRIVER	CLIMATE CHANGE EFFECT	ECOLOGICAL EFFECT	INDIRECT EFFECTS	FISHERY EFFECT	NOTES	SOURCE
Tiger and endeavour prawns	Sea Temperature	Increase in SST	Extreme temperatures affect photosynthesis, nutrient uptake, flowering and germination in seagrasses	Habitat loss for seagrass-dependent prawns such as tiger and endeavour prawns. Possible increase in habitat for King prawns as they are less dependent on vegetation as juvenile habitat.	Reduction in catch: prawn mortality due to habitat loss/ loss of structured habitat protection from predation; loss of foraging habitat. Tiger and endeavour prawns are a majority of the Torres Strait catch. King prawn catch may be sustained.	Thermal optimum temperature – for seagrass range from 15 to 33°C (Collier et al. 2011)	(Duarte 2002, Poloczanska et al. 2007) Expert opinion http\\www.climatechangeinaustralia.gov.au
Tiger and endeavour prawns	Temperature – marine heat waves (MHW)	High temperature water mass (+2.5°C) moves over Torres Strait	Extreme temperatures affect photosynthesis, nutrient uptake, flowering and germination in seagrasses Seagrass loss – water temperature above seagrass upper thermal tolerance; loss of dynamic ecosystem	Habitat loss for seagrass-dependent prawns such as tiger and endeavour prawns.	Reduction in fishery catch: prawn mortality due to habitat loss/ loss of structured habitat protection from predation; loss of foraging habitat. Catch may be modified depending on the seasonality of MHW impact and regeneration of seagrass.	Marine heatwave impacts evident in Australia.	(Carruthers et al. 2002)
Tiger and endeavour prawns	Air Temperature	Increase in air temperature; exposure of	Extreme temperatures in shallow littoral and tidally-	Habitat loss for seagrass-dependent prawns such as	Reduction in catch: prawn mortality due to habitat loss/ loss	Thermal optimum temperature – for seagrass range from 15 to 33°C	(Duarte 2002, Poloczans

		shallow littoral waters to localised increased temperature and insolation.	exposed seagrass habitats caused elevated air temperature and solar radiation - affects photosynthesis, nutrient uptake, flowering and germination in seagrasses; seagrass mortality	tiger and endeavour prawns. Prawn mortality due to habitat loss.	of structured habitat protection from predation; loss of foraging habitat	(Collier et al. 2011)	ka et al. 2007) Expert opinion http\\www.climatechangeinaustralia.gov.au
King prawns	Sea and air temperature	Increase in sea surface temperature.	Extreme temperatures affect photosynthesis, nutrient uptake, flowering and germination in seagrasses	Possible increase in habitat for King prawns as they are less dependent on vegetation as juvenile habitat.	Sustained king prawn catch perhaps an increase in cath. However, king prawns comprise a small proportion of the catch, so population increase due to habitat would have to be large to be material for fishery catch.	Based on habitat suitability models for Northern Australia	(Carruthers et al. 2002).
Tiger prawns	Ocean acidity	Increase in Ocean acidity due to increased carbon dioxide in solution	Interrupted calcification of phytoplankton and zooplankton – the food of prawn larvae food	Reduction in the quanta of food resources for prawn larvae	Reduction in prawn catch: prawn larval mortality – reduction in postlarval recruitment to juvenile nursery habitats	Based on global oceanographic predictions	(Duarte 2002, Poloczanska et al. 2007) Expert opinion
Tiger prawns	Extreme rainfall events	Decrease in salinity and sedimentation due to large flood events (possibly from Fly River in PNG; Increase in sedimentation and turbidity due to local flood events causing erosion and sediment transport/deposition	Decline in seagrasses abundance and extent due to turbidity; local scale juvenile prawn population loss	Increased turbidity reduces light penetration and photosynthesis. Turbidity impacts seagrass epifloral and fauna.	Reduction in local prawn catch: local juvenile prawn population depletion	Based on climate impact projections for Northern Australia	(Carruthers et al. 2002) http\\www.climatechangeinaustralia.gov.au Expert opinion
Tiger prawns	Sea level rise	Inundation and erosion of coasts increasing sediment transport and deposition; deeper waters over	Deeper reef-top habitats; increase in turbidity; reduction in light penetration and hence the ability of seagrass to photosynthesise.	Habitat loss for seagrass-dependent prawns such as tiger and endeavour prawns.	Reduction in catch: prawn mortality due to habitat loss/ loss of structured habitat protection from predation; loss	Based on climate models and habitat impact models for Northern Australia	(Duarte 2002, Poloczanska et al. 2007) Expert opinion

		reefs and littoral habitats			of foraging habitat.		http\\www.climatechangeinaustralia.gov.au
Tiger prawns	Increase in the frequency of intense cyclones	Inundation and coastal erosion due to cyclone storm surge, Removal of seagrass habitat due to mechanical erosion during cyclonic activity;	Loss of seagrass habitat due to mechanical wave impacts; increase in smothering and turbidity which reduces light penetration and hence photosynthesis.	Habitat loss for seagrass-dependent prawns such as tiger and endeavour prawns.	Reduction in tiger prawn catch; Prawn mortality due to habitat loss/ loss of structured habitat protection from predation; loss of foraging habitat.	Based on climate models for Northern Australia	(Carruthers et al. 2002) http\\www.climatechangeinaustralia.gov.au

7.2.5 Opportunities

As seagrasses photosynthesize, an increase in atmospheric CO_2 may increase community productivity and depth limits. Increased seagrass community productivity may benefit juvenile tiger and endeavour prawns as their habitat potentially could support higher abundances of meiofauna and macrofauna (Poloczanska et al. 2007). However, seagrass communities would be subject to many other stressors associated with climate change (see Chapter 6.1 and also Carruthers et al. (2002)).

If juvenile prawn seagrass nursery habitats declined under a warmer climate, the greater areas of bare shallow substrates that resulted may benefit the juvenile king prawn population in Torres Strait. Greater habitat extent may enhance the abundance of king prawns in the fishery. However, all shallow-water habitats would be subject to extreme events such as marine heatwaves, cyclonic impacts, and extreme rainfall/runoff events.

7.3 Finfish

7.3.1 Description

There are two main finfish fisheries that operate in the eastern Torres Strait: the Torres Strait Reef Line Fishery (TSRLF) and the Torres Strait Spanish Mackerel Fishery (TSSMF) with two commercial sectors participating in the fishery: the Traditional Inhabitant Boat (TIB) and non-TIB sectors (Williams et al. 2020). Coral trout (*Plectropomus* spp.) are the main target species for commercial fishers in the TSRLF. The four species of coral trout harvested in the TSRLF (*Plectropomus leopardus*, *P. maculatus*, *P. areolatus* and *P. laevis*) are currently managed as a single species in Torres Strait, as catch records reported by fishers do not require the catch of individual coral trout species to be recorded. A large number of other reef fish species (see Welch and Johnson (2013) and Williams et al. (2008) are also harvested in the TSRLF. Spanish mackerel (*Scomberomorus commerson*) is the primary target species in the TSSMF fishery, although other mackerel species are occasionally captured. Commercial fishing occurs mostly on the north-eastern side of Torres Strait with a large area to the west currently closed (Williams et al. 2020) (Figure 4).

Fishing methods mostly involves trolling from small boats tendered to larger vessels in the case of Spanish mackerel. Hook-and-line is the predominate method to target species in the TSRLF with common coral trout making up more than 90% of the retained commercial catches (by weight) for both TIB and non-TIB sectors (Williams et al. 2020).

Fishing effort (and catches) has decreased from peaks in the early 2000s due to diverse factors such as the voluntary surrender of Transferable Vessel Holder (TVH) licences and structural adjustments in the fishery (Williams et al. 2020).

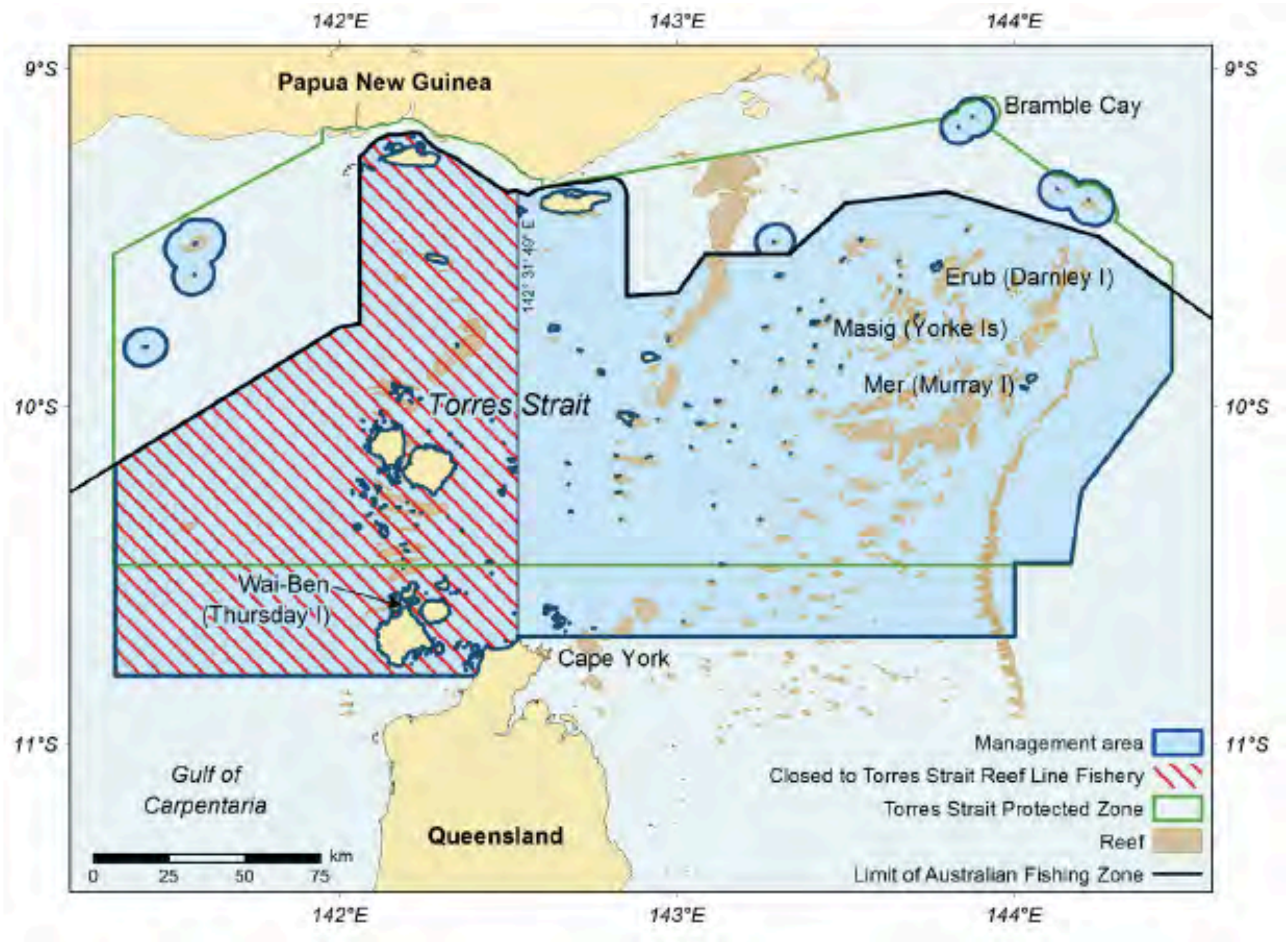

Figure 4. Area of the Torres Strait Finfish Fishery (from: Williams et al. 2020).

The following summary of climate related impacts on the Torres Strait fisheries is based on information from NESP Earth Systems and Climate Change Hub (2018), considering the following assumptions:

1. The Spanish mackerel population in Torres Strait is independent of other populations of Spanish mackerel in Northern Australia, the Gulf of Carpentaria and the East coast of Australia, and potential impacts of climate change are summarised for the Torres Strait population only.
2. Since we are unable to separate the catches of individual coral trout species (as they are not reported in fisheries logbooks), the impact on all coral trout species is assumed to be consistent among species – i.e. the assumption is that all coral trout species will be

impacted approximately the same as common coral trout. This is a high-risk approach, as the other species may be impacted differently, however there is limited information on the other species noting that Williams et al. (2008) offer information on distributions of each species which can potentially be used to identify some of the potential impacts, and

3. All other species of reef fish will be impacted in a similar way. The exception to this is rabbitfish, which form a major part of the food fish for Islanders. Where possible, we will provide reference material on future climate impacts that are specific to that type of fish.

7.3.2 Trends and current status

Spanish mackerel

Spanish mackerel is mostly fished by commercial non-indigenous fishers on the eastern side of Torres Strait (Bramble Cay), where catches are formed mostly by aged 2 to 4 years (Begg et al. 2006). It is assumed that the Spanish mackerel biological stock in Torres Strait is separate from Spanish mackerel in the eastern coast of Queensland and further west across northern Australia. The quota for Spanish mackerel was recently reduced to about 80 tonnes annually, down from 125 tonnes, due to the stock assessment indicating falling biomass levels, driven by a declining CPUE over the 8 years prior to 2018-19. Stock assessments determined that the fishery is classified as ‘not overfished’ but the Torres Strait Finfish Resource Assessment group recommended biological catch for 2020-21 season to be further reduced to either 56 t (F_{48}) or 71 t(F_{40}) due to model projections falling below limit reference points (Williams et al. 2020).

Coral trout (and food fish)

The peak of commercial catches for TSFRLF was in the 2003-04 fishing season at 132t, before falling to 50t in the 2007-08 season. Although the quotas were set at about 140t in the last 10 years, catches remained below 50t since then and in the 2018-19 fishing season it was 17.3t (Williams et al. 2020).

Catch reporting became mandatory in December 2017. TIB catches are likely to have been under-reported before–because catch-and-effort data reporting was not mandatory for this sector– then and have increased in recent years. Despite the need to closely monitor catch levels, recent research has shown the stock is classified as ‘not overfished’ and ‘not subjected to overfishing’ (Williams et al. 2020).

7.3.3 Value

In the 2018-19 fishing season catches for both coral trout and Spanish mackerel declined (by 35,9% and 12.2%, respectively) from catches in 2017-18, resulting in the lowest gross value of production since the 2012-13 fishing season, consistent with falls in catch and effort (Williams et al. 2020). Individual fishery value is not available but total value of the Torres Strait Finfish fishery (2018) was around $1M in the 2017-18 fishing season (Patterson et al. 2018), declining to $0.9M in the 2018-19 fishing season (Williams et al. 2020).

7.3.4 Issues

Spanish Mackerel

The population of Spanish mackerel in Torres Strait is highly vulnerable to climate change. Increases in water temperature could result in a net southward movement of the stock, which would limit access to the stock for Indigenous fishers who cannot move south to follow the stock. Spawning of Spanish mackerel is strongly influenced by sea surface temperatures, with optimal spawning temperatures < 30°C happening mostly during the wet season (Creighton et al. 2013). South migration of Spanish mackerel in response to increases in water temperatures have been suggested since 2011 (unpublished data cited in Creighton et al. 2013). Evidence of a southward range extension due to increasing water temperature has already been documented for Spanish mackerel in Western Australia (Caputi et al. 2015).

In the last 8 years there has been a significant decline in the standardised catch rate (catch per unit of effort – CPUE) from the commercial fleet in Torres Strait (Williams et al. 2020) which may be linked to a long period of drought in PNG (Tony Vass pers comm. and statements and Finfish RAG meeting). Projections of rainfall are highly variable (see Chapter 5.2.3) and fisheries models need to consider the risk of both increase and decrease in rainfall in the region. Although some downscaled rainfall modelled outputs are available (Katzfey and Rochester 2012), data (flow from Fly River and Rainfall) are generally not available to adequately investigate effects of rainfall and flow on Spanish mackerel (R. Buckworth pers. observation).

Data are currently being collated and a statistical analysis undertaken within a new project (2020 project – Buckworth and O'Neil *pers comm*.) to evaluate potential impacts of environmental variables on Spanish mackerel catch rates. Rainfall and river flow data are not of high quality and there is limited information on prey biomass (baitfish, sardines etc). Recruitment of Spanish mackerel on the Queensland East coast appears to be linked to SST with cooler years positively influencing recruitment, although the causal mechanism for this relationship is unclear (Welch et al. 2014).

The Spanish mackerel stock in the Torres Straits is unique in other regards, as well, in that the collection of age data from commercial fishing harvests in some years since the late 1990s has shown that the 'fishable' biomass of Spanish mackerel in Torres Strait is mostly dependent on only a few year classes (2-5 years), in contrast to the fishery on the Queensland east coast which is largely supported by single strong year classes that occasionally propagate through the population (O'Neill et al. 2018).

Coral trout (and food fish)

Tobin et al. (2010) provide detail on the potential impacts of climate change on coral trout. They provide evidence of declines in CPUE associated with cyclones and resulting changes in SST – an impact that is less likely in Torres Strait because cyclones are rare and not expected to increase in frequency (see chapter 5.2.4). Based on a recent study, it is postulated that heatwaves are likely to decrease biomass and increase catch rates independent of changes in habitat (Brown et al. 2020). Indirect climate change impacts on coral trout include an increase in abundance of prey species (e.g. damselfish) following coral bleaching events due to the dead coral providing additional algae substrate which damselfish eat and decline in coral reefs that provide settlement habitats for *P.*

maculatus (Wen et al. 2013, Wismer et al. 2019). However, in the long-term, species of damselfish are expected to be negatively impacted by warmer waters (Pankhurst and Munday 2011). Such ecological impacts via increased growth and prey dynamics are contradictory. Increasing temperatures lead to faster growth rates of coral trout; however, increased temperatures is also expected to cause direct negative impacts on their prey (Johansen et al. 2015).

Samoilys (1997) found that coral trout spawning aggregations and spawning does not occur below a temperature threshold of 24°C. However, the study did not establish an upper spawning temperature (measuring a maximum of 28°C). Large increases in temperature could decrease spawning potential or change the time of spawning (which may not be in phase with currents for eggs and larvae and out-of-phase with primary productivity)(Pratchett et al. 2013). Other negative impacts on coral trout result from acidification–via an increase in metabolic demand, especially of early larval development, and a decline in coral reef habitats–and temperature, where coral trout is not able to cope with high physical activity at temperatures above 30°C (Munday et al. 2008). Also important to consider are the indirect impacts of climate change on behavioural attributes of the fishes (e.g. activity, feeding rates or escape responses), which will affect catchability. For example, if catchability increases a fishery can maintain CPUE even as biomass declines which can result potentially in a collapse as high catch rates cannot indefinitely be maintained (Brown et al. 2020 and references therein).

7.3.5 Opportunities

As a general point, references to previous scientifically reviewed studies on Spanish mackerel are from overseas work (Hare et al. 2016, Cisneros-Mata et al. 2019); whereas for coral trout (due to its dominance as an iconic species on the Great Barrier Reef) all of our references to previous scientifically reviewed studies on coral trout are from Australia. This is important as it appears the work on Spanish mackerel does not provide a good indication of the possible impacts, and if anything, local research in Australia could provide more in-depth knowledge to the real issues.

Spanish Mackerel

Not all predictions of climate change impacts on Spanish mackerel are likely to be negative. Some learnings from responses of other species of Spanish mackerel may provide useful insights on their potential responses to changes in climate. In a study on fish stocks in the Northeast US continental shelf and using *S. maculatus* as an example although we acknowledge it is a different species, Hare et al. (2016) suggest that while Spanish mackerel ‘climate exposure’ metric is Very High, their biological sensitivity is Low. They rate Spanish mackerel as a species with High species distribution change and therefore on the basis of this and the fact that they can move and fishers could follow them, a positive directional impact on their productivity and implied fishery catches. However, this is not necessarily the case for the stock in the Torres Straits and considerable uncertainty exists as to likely impacts. In terms of regional studies Nguyen and Nguyena (2017) (using data from Vietnam) correlate sea surface temperature (SST), moon phase, and fishing season against observed Spanish mackerel CPUE. The SST is related to ENSO/La Niña changes during the same time period and the authors admit they have no explanation for the biological linked environmental variables. In summary, Nguyen and Nguyena (2017) found a negative relationship between SST and CPUE indicating that if SST increases, Spanish mackerel biomass will decrease.

Townhill et al. (2019) quote unpublished reports (Creighton et al. 2013) that state Spanish mackerel is resilient to climate change impacts (which is possible if it is a relative metric).

Coral trout

For coral trout, changes in temperatures (including heat waves) pose a serious threat to the fishery. Declining biomass is expected along with increases in catch rates (Brown et al. 2020). The impacts from increased growth and prey dynamics are contradictory. Increasing temperatures lead to faster growth rates of coral trout; however increased temperatures impact negatively on their prey via direct links on these species and indirect links on habitats via coral bleaching. To complicate matters, expected decline in coral reefs will also affect settlement and, although overall impacts will likely be negative to the fishery, it is not known what the outcome will be in these circumstances. Although cyclones occur less frequently in the Torres Strait, where coral bleaching is more common, one could postulate a strong negative impact, yet fishing pressure in the Torres Strait on coral trout is low. There is also deep cooler water to the east. Therefore, a better understanding of impacts of temperature on coral trout growth, and its indirect effects on coral trout abundance and distribution due to changes in habitat will offer useful opportunities in Torres Strait.

Future research

Future research should be focused on the following:

1. For Spanish mackerel – data on rainfall, and river flow in PNG, data on prey abundance, data on cohort strength in Spanish mackerel over a long time period
2. For Coral trout – species-specific catch information and abundance estimates for each species. Data on the status of reefs and changes in the Torres Strait and changes in coral trout prey species over time

Note for both species, the biological-environmental links (that could capture the complex effects of climate change) lead to analyses that will be two stage, first stage – environmental drivers on prey of these predators and then second stage – links between prey abundance and Spanish mackerel and coral trout abundance.

7.4 Bêche-de-mer

7.4.1 Description

In Torres Strait, sea cucumber processed into *bêche-de-mer* (BDM) brings important socio-economic benefits to Torres Strait Islanders (Plaganyi et al. 2013a). Despite being a smaller fishery when compared to other high-value species such as the tropical rock lobster, the BDM fishery is wholly traditionally owned and contributes to regional economic development, improves quality of life and autonomy of Islanders, especially on the Eastern Islands (Skewes et al. 2002).

Sea cucumbers are sessile gonochoric (separate sexes) broadcast spawners (release sperms and eggs in mass events; usually once a year). Therefore, they need to be in close proximity to mates for successful fertilization of gametes; In low-density populations (e.g. a few individuals per ha), they may fail to get close enough to conspecifics in breeding periods, resulting in asynchronous spawning (Purcell et al. 2013). Most of the Torres Strait sea cucumbers spawn during warmer (summer) months, with some (e.g. Black teatfish and Lollyfish) also spawning during colder months (Murphy et al. 2019a). There is increasing evidence showing that sea cucumbers improve the health and resilience of coral reefs, soft-bottom and deep-water habitats (Purcell et al. 2013). They play important roles in ecosystems, most notably due to bioturbation involving ingestion, excretion and burrowing within sediments, thereby cleaning sand and keeping organic matter in check. Other important roles include nutrient cycling, oxygenation, alkalizing water which has a positive effect on coral production, and acting as hosts for a number of other species and as prey for several species such as sea stars and fish (Lee et al. 2018, Murphy et al. 2019b). The conversion of organic detritus into animal tissue and nitrogenous wastes, which can be taken up by algae and seagrasses increasing their productivity, thus producing more available food for herbivores, is highly significant for coral reefs where nutrients may be a limiting factor. Not surprisingly, declines in sea cucumber populations may reduce primary production with cascading effects to food webs and sediment infauna via the reduction of the aerobic layer of sediments (Purcell et al. 2013).

They are easy to harvest and aggregate to reproduce (Marquet et al. 2018). Such characteristics, combined with scattered landing places and wide reach of buyers make the fishery difficult to manage and maintain sustainable yields (Hair et al. 2016a). Overfishing of sea cucumber often results in reduction in their density and biomass (Uthicke and Benzie 2001), which negatively affect reproductive success, with cascading effects on the function and productivity of ecosystems (Lee et al. 2018). In Torres Strait, overfishing led to management responses including fishery closures and minimum catch sizes (Skewes et al. 2006, Murphy et al. 2014, PZJA no date). In addition to overfishing, the fishery is also threatened by climate and environmental change, which pose risks to its future (Lee et al. 2018).

Collected animals are processed to *bêche-de-mer* (ready for market) in a range of ways that may include gutting, salting, boiling and drying. The value and demand for sessile marine resources such as sea cucumber is rising (Purcell et al. 2013) resulting in the general over-exploitation and even high extinction risk for some sea cucumber populations globally (Purcell et al. 2013, Purcell et al. 2014, Purcell et al. 2018), even in seemingly well managed fisheries such as in the Great Barrier Reef Marine Park (Eriksson and Byrne 2013, Plagányi et al. 2015, Plaganyi et al. 2015, Purcell et al. 2015).

Torres Strait has two Hand Collectable Fisheries – trochus and *bêche-de-mer* which have both historically been characterised by boom and bust cycles as the result of resource depletion or price fluctuations. The trochus (*Trochus niloticus*) population in Torres Strait appears to be at least stable at present compared to historical data. A survey in 2009 showed densities were similar to 1995 survey data and healthy populations elsewhere (Murphy et al. 2010).

Historically, Sandfish (*Holothuria scabra*) on Warrior Reef provided the bulk of the early catches for the Torres Strait *bêche-de-mer* fishery (TSBDMF), which peaked at over 1,200 t (wet gutted weight) in 1995. A survey in 1998 (Skewes et al. 2000) found that the population was severely depleted and the sandfish fishery was closed. Subsequent surveys found a small recovery in the population, especially of the breeding cohort, but the current status is unknown (Murphy et al. 2011) and has remained closed. After the closure of sandfish in 1998, the fishery mostly targeted Black teatfish (*H. whitmaei*), Deepwater redfish (*Actinopyga echinites*), Surf redfish (*A. mauritiana*), Blackfish (mostly *A. miliaris*) and White teatfish (*Holothuria fuscogilva*). A stock survey in March 2002 found that Black teatfish and Surf redfish were probably overexploited (Skewes et al. 2003), and a prohibition on the harvest of these species was introduced in January 2003. Further surveys in 2009 found that the density of Black teatfish had recovered to near natural (unfished) densities (Skewes et al. 2010) and it was recommended that this species be reopened to fishing, but with a modest TAC of 25t and community-based harvest strategies to manage the spatial effort of this species (Skewes et al. 2010). Trial openings of the Black teatfish fishery with a maximum catch of 15 tonnes were conducted in 2014 and 2015. However, on both occasions the catch limit was exceeded and the fishery was closed again.

Given concerns regarding the effectiveness of catch monitoring systems, considerable effort has been invested in recent years in establishing a more reliable catch reporting system. As a result, the Torres Strait Fish Receiver System was implemented for the Torres Strait on 1 December 2017. A new harvest strategy for the Torres Strait Bêche-de-mer (sea cucumber) Fishery (TSBDMF) was implemented form 1 January 2020, known as the Torres Strait Bêche-de-mer Harvest Strategy (TSBDMHS) and is a set of pre-agreed rules that provides clear and practical guidance for sustainably managing the fishery, including what data are needed and whether the fishery can be expanded (Plaganyi et al. 2019b). It was put together based on scientific evidence from CSIRO, Australia's national science agency, and in consultation with the Hand Collectables Working Group (HCWG), AFMA, TSRA, Malu Lamar and other stakeholders (https://www.pzja.gov.au/the-fisheries/torres-strait-beche-de-mer-fishery).

7.4.2 Trends and current status

The Eastern part of Torres Strait has been historically associated with the fishery as the Western side of Torres Strait, although included in the fishery, is documented as having naturally low abundance of sea cucumbers (Figure 5) (Skewes et al. 2006, Patterson et al. 2018). Most of the catch is typically taken from the Great North East Channel, Don Cay, Darnley Island, Cumberland Channel and Great Barrier Reef regions (Patterson et al. 2018).

Twenty-three commercial sea cucumber species have been recorded in Torres Strait. There has been a demonstrated change in species fished over the last twenty years (Long et al. 1996, Skewes et al. 2000, Skewes et al. 2004, Skewes et al. 2010), with high value species harvested more regularly than medium and low value species, putting them at risk of overfishing.

In recent years there has been a shift to harvesting medium and low value species due to high value species being closed to fishing or limited TAC. The development of new processing techniques has also seen increased catches of Curryfish and more Greenfish taken.

Current catch records show Curryfish as the most caught species, followed by Prickly redfish, Lollyfish and Blackfish. This is a noticeable change in targeted species since 2018, where Leopardfish and White teatfish were the two most commonly caught species after Curryfish and Prickly redfish.

Having a formal harvest strategy (TSBDMHS) is a key building block for the future of the TSBDMF. It provides certainty to fishers, communities, scientists and managers about how the fishery will be managed. It outlines what data are needed and how the information will be used to adjust total allowable catches. A tiered (or step-wise) approach is used for how fishery data can be used to manage the fishery to reduce the risk to a resource and potentially support higher TACs (Plaganyi et al. 2019b). The HS also specifies the requirements for monitoring, with agreement that a fishery will be closed if no data are provided by fishers and fish receivers. Mixed species/basket catches are managed through the monitoring of as many individual target species as possible. The HS includes rules for re-opening a fishery/species that has been closed. For the Sandfish species that was previously overfished, there are guidelines for supporting species recovery as well as how surveys (either full scale scientific surveys or smaller experimental surveys with local participation) can be used to inform whether the fishery could be re-opened.

The HS also included the introduction of a number of new individual TAC's for species that had been previously managed in the 80 tonne catch 'basket', these included Hairy blackfish, Deepwater redfish, Greenfish and Curryfish (*Stichopus herrmanni* and *Stichopus vastus*). Curryfish and Prickly redfish are of present management concern in Torres Strait, with anecdotal evidence of local depletion reported at fishery meetings.

The implementation of more elaborate management strategies is of timely importance with teatfish species currently being considered for listing under the Convention on International Trade of Endangered Species, due to international exploitation (past and present) for the species (Conand 2018, CITES 2019). Any future international trade would be subject to strict guidelines through export permit authorisation and a non-detriment finding of the source fishery demonstrating measures for species sustainability (Korwin et al. 2019).

Two extensive sea cucumber surveys have been conducted in 2019 and 2020 and will be used to provide an updated assessment of trends and current status of a number of key fished species in Torres Strait.

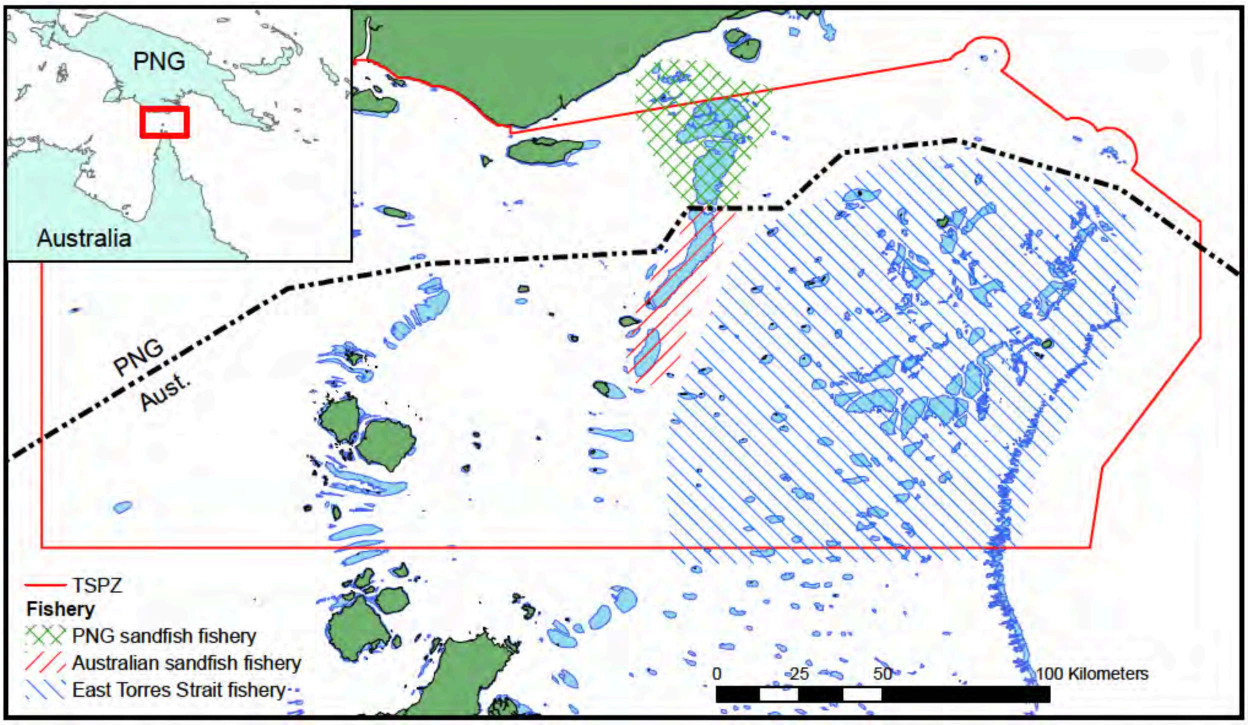

Figure 5. Map of Torres Strait showing approximate locations of sea cucumber fisheries (from (Skewes et al. 2006)

7.4.3 Value

There are no available estimates of net economic returns or gross value of production for the TSBDMF and the value of the catch is not available (Patterson et al. 2018). However, following the recent implementation of the Torres Strait Fish Receiver System as well as new TSBDMHS, these estimates may become available in future.

Most of the product landed in Torres Strait is exported to China, with particularly high retail prices in Hong Kong (Purcell et al. 2018). Prices were also found to be higher for larger animals, particularly for the three high-value species, *Holothuria fuscogilva* (White teatfish), *H. lessoni* (Golden sandfish) and *H. scabra* (Sandfish) (Purcell et al. 2018). Curryfish have only been fished more recently in Torres Strait due to earlier challenges in processing, but catches of Curryfish have been increasing (Plaganyi et al. 2019b) and this species now has a relatively high market value (Purcell et al. 2018).

7.4.4 Issues

Much of the sea cucumber fishing occurs on coral reefs and lagoons, which are under particular threat from global impacts such as climate change and ocean acidification (Purcell et al. 2013). Their calcareous skeletal structures are directly affected by seawater CO_2 concentrations and resulting ocean acidification (Dupont et al. 2010, Yuan et al. 2015). Sea cucumbers are considered to have high vulnerability to climate change (Johnson and Welch 2016, Cochrane et al. 2019), which means that ongoing improvements to harvest strategies will need to ensure that they are climate-smart (Plaganyi et al. 2013a, Punt et al. 2013). Recent studies have shown that considerable uncertainty exists for the potential impacts on sea cucumbers for most combinations of physical and biological variables (Plagányi et al. 2013). Climate change impacts may have both negative and positive effects on sea cucumbers, when they were assessed on the various life history stages of sea cucumber in combination (see Table 4 below), the net effect was slightly more negative for most species (Plagányi et al. 2013). Negative effects were associated with increased larval and juvenile mortality related to higher sea surface temperatures and detrimental effects on the juvenile Sandfish seagrass habitats. Sea level rise was assessed as being mostly positive for shallow water species (e.g. Sandfish, Black teatfish). Climate change is expected to affect distribution and phenology (likely changes in timing of spawning), and to a lesser extent in abundance of Sandfish (Fulton et al. 2018).

Table 4. Summary modified from (Plagányi et al. 2013) on potential changes due to high and medium risks from climate impacts on different life stages of sea cucumber populations in Torres Strait. Values obtained from the literature and expert opinion.

RISK	LIFE STAGE	LIFE HISTORY COMPONENT	SPECIES	EXPLANATION
High	Larvae	Growth	All	Development and growth of invertebrate larvae are generally temperature sensitive. Higher SST will speed growth up to physiological tolerances. Faster growth will mean faster development and larvae ready to metamorphose into settling juveniles quicker. This will likely increase larval supply back to settling habitats.

High	Juvenile/ Adult	Growth	All	Warmer SST generally mean faster growth up to a physiological tolerance. Very little information on the upper limits to growth in the literature, however these species are found in equatorial tropical waters.
High	Larvae	Mortality	All	Higher SST could increase mortality rates due to physiological thresholds, though interactions with other factors (i.e. higher phytoplankton) could ameliorate this impact to some extent.
High	Juvenile/ Adult	Mortality	All	Higher SST, physiological thresholds, disease and parasites may result in higher mortality, though predation pressure will be reduced due to faster growth.
High	Adult	Reproduction	All	Faster growth and bigger sea cucumbers will mean an increased fecundity due to size fecundity relationship. Higher SST could also result in an earlier and longer reproductive season.
Medium	Larvae	Growth/ mortality	All	Projected increases in phytoplankton density in the Coral Sea may influence the Torres Strait and result in faster growth and faster development of sea cucumber larvae. This in turn could increase larval supply.
Medium	Juvenile	Habitat: seagrass	Sandfish	Seagrass habitats may be negatively impacted by increased SST (mostly shallow) and sea level rise (driven by light and species niches) (Connolly, 2009). Settling juvenile sandfish rely on seagrass for habitat.
Medium	Juvenile/ Adult	Carrying capacity	Sandfish, Black teatfish, Surf redfish.	Shallow reef tops may become more available for sea cucumber species that use that habitat (Sandfish, BlackTeat Fish, Surf redfish).

7.4.5 Opportunities

There is a need for new management paradigms and instruments to safeguard reproductive capacity of sea cucumber stocks (Purcell et al. 2013)

It is increasingly important to develop models to link climatic effects over a range of life history components and critical habitats for fisheries (e.g. seagrasses, coral reefs), and quantify the resultant impact on fisheries productivity using alternative emission scenarios (Plaganyi et al. 2013a). This can help identify which kinds of management strategies, monitoring and adaptive feedback are likely to perform best in managing under future climate change. The TSBDMF is a multispecies fishery and the different species have very different distributions, depth preferences and life histories. They will thus be affected differently by climate change drivers, and it’s possible that these may have a much smaller impact on deeper water species such as White teatfish.

Management interventions and aquaculture techniques can be used to increase yields of sea cucumber. The foci of management interventions are on minimum sizes, spatial and temporal closures and may also include artificial aggregation of adults to increase the chances of reproductive success. Induced spawning in hatcheries and rearing have become relatively simple (Mazlan and Hashim 2015) and may also be employed to improve wild stocks.

The relative easiness of management initiatives and aquaculture techniques mean that there is potential to establish small or community-based enterprises to cost-effectively enhance stocks in overfished areas (Aalbersberg et al. 2005, Hair et al. 2016b, Han et al. 2016). However, high costs, market access, species choice, inadequate capacity and planning, and poor stakeholder engagement, communication and consultation are some of the barriers reported for small-scale community-based initiatives (Toral-Granda et al. 2008, Hair et al. 2016b). Lack of appropriate monitoring programs to measure effectiveness of initiatives of management and aquaculture techniques for stock enhancement is also common (but see Hair et al. 2016b).

7.5 Turtles

7.5.1 Description

The Torres Strait Turtle Fishery is operated by local Torres Strait residents as an artisanal fishery (Johnson and Welch 2016) that has supplied a large proportion of the daily food intake for Torres Strait islanders for 1000s of years (Hagihara et al. 2016). Turtles are hunted for domestic consumption only. Green Turtles make up ~98% of the catch, with Hawksbill Turtles (~1%) also taken (Harris et al. 1994). The islands of Torres Strait are insignificant nesting locations for both of these species (Limpus et al. 1989). Green Turtles nest in the Great Barrier Reef region (Commonwealth of Australia 2017). However, remote islands in north-west Torres Strait are major nesting sites for the flatback turtle (Limpus et al. 1989), though only their eggs are harvested. The threat of Climate Change is rated as 'very high' for Green Turtles in the northern Great Barrier Reef region (Commonwealth of Australia 2017) and Torres Strait is noted as a major foraging habitat for the stock.

In the 1990s, about 5,000 person-days were spent hunting each of turtle and dugong each year. This effort was much less than the ~30,000 person days spent handlining for fish. Other species such as tropical crayfish (*Panulirus ornatus*) were hunted for commercial sale (~9,000 person days y^{-1}). The majority of the turtle catch in Torres Strait is taken between September and February annually (Harris et al. 1994).

7.5.2 Trends and current status

In the 1990s, the number of turtles harvested in Torres Strait was $2{,}504 \pm 358.y^{-1}$ with a bimodal size distribution (with peaks at 45 and 105 cm carapace length) (Harris et al. 1994). Turtles were the second highest catch by percent composition (26%), only exceeded by dugong (28%) and much higher than finfish, crustaceans and molluscs (18%, 16%, 11%, respectively). The proportion of artisanal catch made up of turtle varies regionally in Torres Strait. In the eastern islands, over 50% of the daily catch is comprised of turtle, while in the central and western Island, turtles comprise about 25% or less of the daily catch. More contemporary data on the fishery taken by species-group composition of the annual resource harvest in Torres Strait are not available, though estimates of a harvest of about $3{,}000 \pm 1{,}000$ turtles.y^{-1} remain reasonable (Hagihara et al. 2016).

7.5.3 Value

Turtle and Dugong fisheries are customary subsistence fisheries whereby only indigenous inhabitants of Torres Strait are allowed access to harvest. Turtles are important to a traditional way of life and provide a major source of protein in the diet of Torres Strait peoples.

7.5.4 Issues

Turtles are particularly vulnerable to the impacts of Climate Change as they are dependent on both the marine and terrestrial environments. A phase of their life history includes terrestrial nesting. Terrestrial sea turtle nests are particularly vulnerable to sea level rise causing erosion, inundation and higher groundwater levels (Fuentes et al. 2010). Elevated temperature is also critical; they and their niche are subject to both air temperature and sea surface temperature increases (both of which are predicted as ambient conditions in Torres Strait through 2050 to 2100). Highly dependent on terrestrial environmental conditions, the temperature of nests is critical to incubation success, sex-structure of the population and hatchling fitness (Booth and Evans 2011, Cavallo et al. 2015, Rivas et al. 2019, Staines et al. 2019). In addition, their nests are subject to coastal and terrestrial large-scale processes such as coastal erosion and extensive rainfall events.

Optimally, turtle nests range in temperature from about 27-30^{o}C over the duration of incubation (about 60 days). However, nest temperature depends on variables such as shaded vs non-shaded location, rainfall incidence and duration, depth of egg burial, and surface vegetation vs bare sand. For example, tree shade can reduce the temperature of nests by 2^{o}C compared to un-shaded nest locations (Booth and Evans 2011, Rivas et al. 2019, Staines et al. 2019). Under current environmental conditions, unshaded turtle nests can reach a sustained 32^{o}C and might reach 34^{o}C for several days. Crucially, the lethal temperature for turtle embryo survival is ~34-36^{o}C (Staines et al. 2019), though reduced incubation success occurs at lower temperatures. Consequently, an ambient temperature rise of 2^{o}C may cause nest temperature to rise to lethal levels; or near-lethal levels that dramatically reduce incubation success and hatchling fitness (Staines et al. 2019).

Nest temperatures ~31^{o}C (compared to 28^{o}C) reduce the incubation period (by ~15%), the percent incubation success (by ~16%), cause the feminisation of the population; and reduce the carapace length of hatchlings (by ~4%), and their crawl speed, self-righting success and swimming speed/thrust (Booth and Evans 2011, Cavallo et al. 2015, Rivas et al. 2019, Staines et al. 2019). Turtles reproduce from October/November to February/March annually in Australia; the hottest season of the year, the late-dry and wet seasons. Climate prediction for tropical Australia suggests that by 2070 and 2100 mean annual temperature, mean ‘early-wet’ season and ‘late-wet’ season ambient air temperatures will increase by 3^{o}C, possibly increasing turtle nest temperatures by a significant amount (buried at ~45-50 cm depth). In addition, worldwide heatwave frequency and duration are predicted to increase three- to five-fold by 2100 (Coumou and Robinson 2013), causing prolonged temperature spikes that may impact incubation success, sex-ratios and hatchling fitness.

Green turtles (*Chelonia mydas*), for example, develop into females if the temperature of the nest is higher than 29°C. Recent surveys have found 65-69% of turtles hatching from beaches in the southern Great Barrier Reef female, but 99% of those hatching from northern beaches are female. It seems that the northern rookeries have been producing primarily females for more than two decades, and that complete ‘feminisation’ of the population may occur in the very near future, with disastrous consequences (Hughes et al. 2019).

Monsinjon et al. (2019) modelled the impacts of climate change (RCP4.5 and 8.5) on key indicators of stable turtle populations across seven nest sites worldwide (using indicators such as incubation success and hatchling fitness). Their model outcomes showed that future climate impacts that would destabilise turtle populations would be crucial at six of the seven nesting sites; from feminisation at RCP4.5 to much reduced incubation success at RCP8.5. The model outcomes implied that a temporal shift in the annual breeding cycle (earlier and cooler) would be required to sustain populations, and questioned the adaptability of turtle populations.

A major indirect impact of rising temperature on turtle populations is the impacts on their food sources, both herbivory and carnivory. In particular, herbivorous turtles (e.g. the Green Turtle) feeds on the extensive seagrass communities that exist in Torres Strait. Herbivorous turtles make up >95% of the turtle harvest as a food resource by Torres Strait human communities and they are dependent on reef-top seagrasses. For example, on the Orman Reefs in Torres Strait, Green Turtles consume both seagrasses (especially *Thalassia hemprichii* and *Enhalus acoroides*) and algae (mainly *Hypnea* spp., *Laurencia* spp. and *Caulerpa* spp.) (Andre et al. 2005).

Higher temperatures will impact turtles indirectly via changes in seagrass abundance given they are close to their temperature tolerance limit (see details in Chapter 6.1). As their food resources reduce, so will the local populations of turtles, either by mortality or movement to more productive seagrass communities (as has been documented for dugongs (see Marsh et al. (2004)).

As well, Torres Strait seagrass communities may suffer sedimentation and deposition impacts due to pulsed nutrient and sediment loads from Papua New Guinea's Fly River associated with extreme rainfall events (Suppiah et al. 2010, Johnson and Welch 2016).

Carnivorous turtles feeding on crustaceans and molluscs will be impacted as warming Sea Surface Temperatures inflict coral bleaching of the reefs of Torres Strait (see Hoegh-Guldberg 1999, Bainbridge et al. 2015, Hughes et al. 2017). Bleached reefs interrupt fundamental nutrient cycles and food webs in coral reef ecosystems and reduce the species richness and abundance of many benthic and demersal fauna, including crustaceans and molluscs (Hoegh-Guldberg 1999). Coral bleaching is a relatively short-term process; it can occur if reefs are exposed to temperature > 30^{o}C for 24-48 hours, increasing in intensity as duration of exposure to above-ambient temperature increases (Hoegh-Guldberg 1999, Hughes et al. 2017). Marine heat waves are predicted to increase in tropical Australia (Frolicher et al. 2018) and short-term air temperature heatwaves are a culprit to induce spikes in littoral waters over 3-5 days. As a consequence, the frequency and extent of coral bleaching is expected to increase across the Australian tropics with broad ecosystem consequences. The abundance of the reef-dependent crustacean and mollusc prey of carnivorous turtles will reduce. As for herbivorous turtles, carnivores will move to locations where reefs are less impacted and their key diet species are more abundant.

Sea turtle populations will also be impacted by sporadic environmental phenomena, the effects of which are less defined both temporally and spatially. Extreme rainfall events are predicted to increase in frequency to 2100 and beyond. In addition, the intensity of tropical cyclones is predicted to increase. These stochastic events can impact both the nests and the adult phase of turtle populations; particularly when they overlay a predicted to increase in sea level by 1.1 m worldwide by 2100 (see Chapter 5.2.5).

Heavy rainfall lowers the temperature of turtle nests and may saturate the sands surrounding the eggs (Staines et al. 2019). Too low temperatures and the drowning of nests are lethal to embryonic development (Rivas et al. 2019). The storm surge associated with cyclones, overlapping with seas level rise may inundate turtle nests and drown the incubating eggs (Fuentes et al. 2010). Moreover, the storm surge associated with intense tropical cyclones strand turtles (and dugong) on nearby shores, particularly when nearby coasts are extensive salt flats only a metre or two above sea level (Limpus and Reed 1985, Marsh 1989). In the Northern Territory coast in the vicinity of the McArthur River estuary, Cyclone Kathy (1984) beached an estimated 1,000 turtles and 500 remained stranded and disorientated up to 9 km inland on the low supratidal mudflats, a week after the cyclone. They would have died without human assistance back to coastal waters. All of the stranded turtles were green turtles and >90% were large females, presumably feeding of the extensive seagrass beds in the littoral habitats along the coastline when Cyclone Kathy struck (Limpus and Reed 1985). Green turtles are vulnerable to both cyclonic-stranding and hunting by indigenous peoples as they make up mostly 100% of shallow-water seagrass-feeding turtles in both Torres Strait and the Gulf of Carpentaria (Limpus and Reed 1985, Harris et al. 1994). Green Turtles also make up 73% of coastal stranding that occurs daily along the Queensland coast (Meager and Limpus 2012). Therefore, the turtle species that is key to support a Torres Strait customary food source is the same species that is most vulnerable to stranding. Note however, that the area of mudflats available for stranding as a percentage of costal habitats is not as great in Torres Strait as it is in the Gulf of Carpentaria; probably lessening the chance of stranding in Torres Strait habitats.

Table 5. Observed and expected effects of climate change on turtles.

PHYSICAL DRIVER	CLIMATE CHANGE EFFECT	ECOLOGICAL EFFECT	INDIRECT EFFECTS	FISHERY EFFECT	NOTES	SOURCE(S)
Air Temperature	Increase in air temperature	Extreme temperatures affect sex ratio of hatchlings; reduced hatching success; feminisation of population; individual size and locomotion capacity	Seasonal reproductive shift	Changed population structure: seasonal behavioural changes	Sex ratio of population may change; optimal hatching success 25 to 35°C long generation time limits adaptability; tropical ecosystems already at upper thermal tolerance	Duarte (2002), Poloczanska et al. (2007) Collier et al. (2011) Expert opinion http\\www.climatechangeinaustralia.gov.au Monsinjon et al. (2019) Babcock et al. (2018)
Sea Temperature	Increase in sea tempertures	Mollusc/ crustacean population impacts due to niche decline; especially food	Coral bleaching; loss of dynamic reef ecosystem	Reduction in loggerhead turtle population and catch; starvation and turtle relocation	Expert opinion – ecosystem effects	Carruthers et al. (2002); . http\\www.climatechangeinaustralia.gov.au
Sea Temperature	Increase in SST	Extreme temperatures affect photosynthesis, nutrient uptake, flowering and germination in seagrasses	Spikes in air temperature impact seagrass habitat in shallow littoral waters	Reduction in turtle catch: increase in Turtle mortality due to starvation / Turtle relocation	Thermal optimum temperature – for seagrass range from 15 to 32-33°C	Duarte (2002), Poloczanska et al. (2007) http\\www.climatechangeinaustralia.gov.au Expert opinion Collier et al. (2011)
Salinity	Decrease in salinity due to large flood events	Decrease in salinity due to large flood events have	large scale turtle relocation and	Reduction in catch: turtle mortality due to starvation /	Based on habitat suitability models for Northern Australia	Carruthers et al. (2002) GoC cyclone Sandy.

PHYSICAL DRIVER	CLIMATE CHANGE EFFECT	ECOLOGICAL EFFECT	INDIRECT EFFECTS	FISHERY EFFECT	NOTES	SOURCE(S)
	(possibly from PNG)	been associated with a decline in seagrasses	mortality due to lack of food	turtle relocation		http\\www.climatechangeinaustralia.gov.au
Temperature	Increase in SST; Increase in the number / intensity of marine heat wave (MHW)	Sea temperature over migration routes Sea temperature above thermal tolerance	na	Seasonal behavioural changes Reduction in catch: Turtle mortality not likely as sea temperature within thermal tolerances MHW-mortality unknown.	Green Turtles don't nest in Torres Strait. They migrate there to forage; they nest in Great Barrier Reef waters	Duarte (2002), Poloczanska et al. (2007) Collier et al. (2011)
Extreme rainfall events	Increase in sedimentation and turbidity due to regional and local flood events causing erosion and sediment transport/deposition	possible increase in turtle mortality due to limited visual detection of large predators. Local scale turtle relocation	Decline in seagrasses abundance and extent due to turbidity – less fod for turtles	Reduction in local catch: Turtle relocation	Based on climate impact projections for Northern Australia	Carruthers et al. (2002) Expert opinion http\\www.climatechangeinaustralia.gov.au
Extreme temperature (heatwave) events	Increase in frequency of series of very hot days. (days over 35°C, Expected to increase threefold in Cairns).	Poor incubation success (terrestrial nests) due to heat stress	Thermal stress on just-emerged hatchlings before they reach seawater	Reduction in catch: Turtle hatchling mortality; poor locomotion by hatchlings, reduced access to the sea; lower individual weight	Extreme heat days estimated under RCP4.5 to ~2090 (website). ~34°C nest temperature lethal threshold for early stage embryos (Collier et al. 2011)	Duarte (2002), Poloczanska et al. (2007) Expert opinion http\\www.climatechangeinaustralia.gov.au
Sea level rise and frequency of intense cyclones	Combined inundation or erosion of nests due to sea level rise and cyclone-associated storm surge;	Poor incubation or mortality of embryos due to temperature drop associated with sea water inundation or anoxia due to semi-permanent inundation; erosion/ exposure of eggs in nests-100% mortality	Stranding of adult turtles due to storm surge and wave action during intense cyclones.	Reduction in catch: turtle hatchling mortality resulting in long-term population decline; adult mortality due to beaching	Based on climate models and habitat impact models for Northern Australia; stranding during cyclonic impact in the Gulf of Carpentaria.	Carruthers et al. (2002) http\\www.climatechangeinaustralia.gov.au

7.5.5 Opportunities

A caveat of the possibility of stochastic weather events impacting turtle populations is that turtles have survived for > 100 million years; over which temperature increases and ice-ages have come and gone. During times of ecosystem stress on Earth, turtles must have adapted to change in the locations of environmental conditions that support nests, either by locating nesting activity to more facilitative latitudes, or by changing the timing of nesting activities seasonally to benefit from favourable temperatures (Poloczanska et al. 2007). However, in the 2000s, spatial and temporal caveats exist on their ability to adapt. From now until the 2100s and ongoing, the rate of temperature change will be much greater than over past biome-wide fluxes; and today, urbanisation and coastal infrastructure, coastal modification and human use has rendered much of their historically-used natural habitat unavailable for undisturbed nesting activity.

7.6 Dugongs

7.6.1 Description

Torres Strait contains the largest Dugong population in the world. Dugongs have been hunted by Islanders since at least 4,000 years ago (Crouch 2015). They are considered the most significant and highest ranked marine food in the traditional subsistence economy (Carter et al. 2014). Dugongs are known as 'cultivation grazers' (Preen 1995). An adult dugong eats about 7 per cent of their body weight in seagrass per day (Department of Environment and Heritage Protection 2016). They feed in a way that promotes growth of *Halophila ovalis*; their preferred seagrass species. Pulling out the seagrass aerates the sea floor and increases the amount of organic matter in the area, thereby encouraging regrowth of the seagrass (Department of Environment and Heritage Protection 2016). Dugongs in Torres Strait were found to feed exclusively on seagrasses (mainly *Thalassia hemprichii*, *Cymodocea* spp. and *Syringodium isoetifolium*), suggesting slight differences in diet to other areas, based on abundance and palatability of seagrass species (Andre et al. 2005).

7.6.2 Trends and current status

Data on dugong population estimates from aerial surveys in Torres Strait are scarce and the absolute population size is unknown (Marsh et al. 2015), but estimates suggest the dugong population in 2013 was ca. 16,000 and stable with a seagrass area of 30,560km^2 (Sobtzick et al. 2014). Data on dugong harvest is sparse but the fishery is sustainable (although it was considered unsustainable in the past) (Marsh et al. 2015).

The area of dugong habitat that supports very high densities of dugongs in Torres Strait is large (5,268 km^2) and hunting is largely restricted to a very low percentage of that habitat (5%) due to the input control on the fishery and socio-economic reasons (Marsh et al. 2015).

7.6.3 Value

Dugong fisheries are customary subsistence fisheries whereby only indigenous inhabitants of Torres Strait are allowed access to harvest. Dugongs are considered the most significant and highest ranked marine food in TS traditional subsistence economy (Carter et al. 2014). The cultural services associated with hunting have been reported by Torres Strait traditional owners to be more important than provisioning services (Delisle et al. 2018).

7.6.4 Issues

Seagrasses provide critical habitats and are a critical food resource for dugongs (Carter et al. 2014) that feed almost exclusively on shallow water seagrasses, particularly on pioneer species from genera such as *Halophila* and *Halodule* (Wooldridge 2017; Preen, 1995). This means that dugongs are highly vulnerable to changes in seagrass abundance.

It is hard to predict the exact response of dugongs to changes in seagrass abundance because a combination of factors, such as age, sex, physical condition, matrilineally transmitted learned behavior can all contribute to apparently highly individualistic movement patterns (Marsh et al., 2011; Wooldridge 2017).

Effects of climate change on dugongs found in the literature were mostly indirect, showing changes in location, abundance and biomass of dugongs associated with changes in abundance and distribution of seagrasses (Table 6). Dugongs themselves are also sensitive to changes in water temperature and known to undertake meso-scale thermoregulatory movements in response to changes in temperature (Sheppard et al. 2006). Direct effects include stranding associated with extreme weather events (e.g., cyclones and flooding) (Marsh 1989, Fuentes et al. 2016). Boat strikes is a localised direct threat to dugongs (Marsh and Sobtzick 2019)

Table 6. Observed and expected effects of climate change on dugongs.

PHYSICAL DRIVER	CLIMATE CHANGE EFFECT	ECOLOGICAL EFFECT	FISHERY EFFECT	NOTES	REFERENCE(S)
Temperature	Increase in SST	Extreme temperatures affect photosynthesis, nutrient uptake, flowering and germination in seagrasses Dugongs are sensitive to changes in water temperature and known to undertake meso-scale thermoregulatory movements in response to changes in temperature	Reduction in catch: Dugong mortality due to starvation / Dugong relocation	Thermal optimum temperature –for seagrass range from 15 to 33^{o}C (Collier et al. 2011)	Duarte (2002), Poloczanska et al. (2007) Sheppard et al. (2006)
Salinity	Decrease in salinity due to large flood events	Decrease in salinity due to large flood events have been associated with a decline in seagrasses which led to large scale dugong relocation and mortality	Reduction in catch: Dugong mortality due to starvation / Dugong relocation	Based on habitat suitability models for Northern Australia	Carruthers et al. (2002)
Water clarity	Increase in extreme events	Reduced abundance of seagrass is associated with deteriorating water clarity due to: (a) floods and (b) longer-term impact of terrestrial fine sediment exports due to poor land practices.	Reduction in catch: Dugong mortality due to starvation / Dugong relocation	Burdekin region (GBR)	Wooldridge (2017)

Water clarity		Mean daily irradiance (I_d) above 5 and 8.4 mol m_{-2} d_{-1} was associated with gains in seagrass. Percent of days below 3 mol m_{-2} d_{-1}, correlated with change in seagrass cover with 16–18% of days below 3 mol m_{-2} d_{-1} being associated with more than 50% seagrass loss. Number of hours of light saturated irradiance (H_{sat}) correlated well with change in seagrass abundance; where H_{sat} of 4 associated with increases in seagrass abundance, and < 4 H_{sat} with more than 50% loss	Reduction in catch: Dugong mortality due to starvation / Dugong relocation	Experimental work in the GBR	Collier et al. (2011)
Extreme events (cyclone & flooding)	Stranding	Extreme weather events (e.g., cyclones and flooding) have been associated with mass stranding of dugongs	Reduction in catches		Fuentes et al. (2016)
Temperature	Increase in temperature	Conditions such as warm sea temperatures and low rainfall (promoting seagrass growth) may be facilitating explorative ranging south by dugongs.	Reduction in catches due to relocation of dugongs to cooler waters	New South Wales	Allen et al. (2004)

7.6.5 Opportunities

Understanding the indirect impacts of habitat degradation and food availability is important to manage dugong populations under climate change. Seagrasses are highly dynamic, subjected to seasonal changes in Torres Strait. Climate, localised impacts and harvest act synergistically, affecting seagrass communities and dugong populations in Torres Strait. Understanding these processes and behavioural responses thresholds (e.g. migration) will support the management of this important traditional fishery.

Seabed habitat has been monitored annually along transects by CSIRO divers undertaking TRL surveys since 1989, and although snapshots only, these data complement aerial survey data and provide valuable insights into abundance and trends in seagrass in Torres Strait. For example, Plaganyi et al. (2016) reported that seagrass declined to 2001 (from 1994) but increased post 2001. By species, the overall trend in seagrass cover for the repeated sites was not as evident, although the dominant species *Halophila spinulosa* showed a similar increasing trend post 2001. Seagrass composition also changed between years with *H. spinulosa* dominant in most years, but *S. isoetifolium* and *T. hemprichii* also dominant in three of the 19 years.

8 Conclusion of Part 2

This report identified a range of localised and climate change impacts potentially affecting the key fisheries selected for consideration. Anthropogenic impacts in Torres Strait are minimal, but exist in specific locations. Local impacts include sediment runoff and metal pollution from the Fly River (PNG), localised oil contamination, mangrove cutting, alteration of hydrology, nutrient and sediment runoff, chemical contamination, and over-harvest of marine living resources.

Climate change is already affecting Torres Strait fisheries and culture. Expected impacts from climate change include higher seas, warmer atmospheric and ocean temperatures, more acidic waters, changes in ocean circulation, and more intense rainfall events. Although minimal, simultaneous local impacts (e.g. untreated sewage, chemical, sediment and nutrients runoff, oil pollution, overfishing) act together with climate change impacts, such as sea-level rise, ocean warming, acidification, leading to interactive, complex and amplified impacts for species and ecosystems.

These pressures manifest directly in the form of changes in abundance, growth, reproductive capacity, distribution and phenology (changes in cyclic and seasonal phenomena such as reproduction and migrations)), and indirectly through changes in foodwebs and habitats. Invertebrates (TRL, prawns, BDM) are likely to be more impacted by climate change than vertebrates (Finfish, turtles and dugongs), although responses are species specific (Fulton et al. 2018). For example, TRL has wide ranging life history circulation pattern which gives it some flexibility to “move” whereas BDM are more sedentary with more localised recruitment.

Climate change will likely cause mostly negative direct effects on the fisheries investigated in this report, but some effects may also be positive. If climate-related environmental changes go beyond certain limits or ranges for species, they will simply move or have their abundance reduced (Pecl et al. 2014, Fulton et al. 2018). For example, changes in ocean currents and circulation in Torres Strait will likely affect larval transport and distribution of TRL, BDM, prawns and finfish. High water temperature can cause mortality, affect growth (relatively small warming may increase growth rates of sea cucumber and TRL), reproduction and its timing, and negatively affect supporting habitats (coral reefs, seagrasses) of finfish, invertebrates, dugongs and turtles. Elevated air temperatures can also reduce incubation success, shift timing of annual breeding cycle and increase ‘feminisation’ of Green turtle populations. Higher seas and extreme weather events can uproot mangrove trees and cause erosion and increase in turbidity, with consequent reduction in light penetration and salinity and an increase in sediment deposition, negatively affecting seagrasses and coral reefs. Some organisms, such as sea cucumbers may benefit from higher seas, but others like turtles and dugongs can be negatively effects via changes in abundance of preferred food (e.g. seagrass) and also via the inundation of nesting sites (turtles) and stranding (turtles and dugongs) associated with extreme weather events.

Although recent studies have shown that ocean acidification does not alter reef fish behaviour (Clark et al. 2020a, Clark et al. 2020b), there is strong evidence that it is already affecting carapaces of crustaceans in other parts of the world (Bednaršek et al. 2020). This can have potential ramifications for TRL and prawns, and, to a lesser extent, sea cucumbers.

Table 7. Main drivers causing changes in Torres Strait ecosystems and fisheries.

CLIMATE CHANGE IMPACT	DRIVER	ECOSYSTEMS	FISHERY
Change in ocean circulation	Currents	Seagrass, Mangroves, Coral Reefs	TRL, Prawns, Finfish (CT), BDM

CLIMATE CHANGE IMPACT	DRIVER	ECOSYSTEMS	FISHERY
Increase in intensity of extreme rainfall events	Turbidity	Seagrass, Coral Reefs	Indirect fishery effect via changes in seagrass and coral reefs (Dugongs, prawns, Turtles, TRL, BDM, Finfish)
Increase in air and sea temperature	Temperature	Seagrass, Coral Reefs	Prawns, Finfish (SM, CT), Turtles, BDM, TRL
Sea level rise	Tides / water level	Seagrass, Mangroves, Coral Reefs	TRL, BDM
Increase in intensity of extreme rainfall events	Light	Seagrass, Coral Reefs	Indirect fishery effect via changes in seagrass and coral reefs (Dugongs, prawns, Turtles, TRL, BDM, Finfish)
Increase in intensity of extreme rainfall events	Nutrients (N & P)	Seagrass, Coral Reefs, Mangroves	Finfish (SM, CT)
Increase in intensity of extreme rainfall events	Salinity	Seagrass, Mangroves, Coral Reefs	Indirect fishery effect via changes in seagrass and coral reefs (Dugongs, prawns, Turtles, TRL, BDM, Finfish)
Increase in intensity of extreme rainfall events	Sedimentation	Seagrass, Coral Reefs	Indirect fishery effect via changes in seagrass and coral reefs (Dugongs, prawns, Turtles, TRL, BDM, Finfish)
Ocean acidification	pH	Coral Reefs	TRL, Prawns, Finfish (SM, CT), BDM
Increase in sea temperature	Oxygen		TRL
Changes in ENSO / La Niña patterns	Exposure to the air	Seagrass, Coral Reefs	Turtles
-	(Over)grazing	Seagrass	
Increase in intensity of extreme rainfall events	Extreme events (e.g. rainfall, cyclones)	Seagrass, Coral Reefs, Mangroves	Finfish (CT), Turtles, Dugongs
Increase in intensity of extreme rainfall events	Waves / tidal surges	Seagrass, Mangrove	Dugongs and Turtles
-	Moon phase		TRL
Anthropogenic impact	Overfishing		BDM
Potentially associated with increase in temperatures	Diseases & parasites		Finfish, Prawns, BDM

Part 3: Scoping a future data framework project

Part 3 scopes a future project that would provide an over-arching data framework (e.g. from global atmospheric and oceanographic models, down-scaled to the broader TS region as appropriate) needed as a foundation for future work. Subsequent projects could ultimately use modelling approaches to quantitatively evaluate the effects of future climate change scenarios on the selected fisheries, and explore alternative adaptation options. More specifically, Part 3 presents the modelling requirements to simulate impacts of climate and non-climate drivers on the key fisheries to guide the development of a future data framework project. Based on the review provided in Part 2, Chapter 9 presents simulation requirements and identifies data gaps. Chapter 10 presents the proposed modelling and supporting data framework, followed by preliminary costs presented in Chapter 11. Finally, Chapter 12 provides the main conclusions and recommendations from the project.

9 Requirements for modelling and data framework

9.1 Modelling questions

The data framework will be specified in a way that meets the input data needs of various future fishery-specific and ecological modelling, addressing issues associated with changes in local and climate drivers and modelling needs presented in Part 2. In this Chapter, we first provide the key question that the future models need to address, the simulation requirements to address the research questions (Chapter 9.2), and an assessment of the minimum requirements versus available data (Chapter 9.3).

The data and modelling framework will primarily be designed to answer the following question: *What are the potential consequences associated with changes in local conditions, including climate variability and change, on the selected Torres Strait Fisheries, ecosystems and dependent communities?*

The objectives of the modelling exercise are to simulate future climate scenarios and assess the impacts of these on fisheries and associated habitats and species through quantitative evaluation. The modelling framework will support the exploration of responses and strategies to manage the selected Torres Strait fisheries, such as the evaluation of:

1. Interactions between different fisheries and broader ecosystem functioning;
2. Impacts of climate change scenarios on the abundance and distribution of selected species;
3. Impacts of current and future catchment conditions and management scenarios on fisheries;
4. Impacts of incidents (e.g. oil spills, ships run aground) on fisheries;

5. Combined scenarios of 1-4 to develop strategies that are robust across impacts and fisheries;
6. Evaluation of alternative adaptation options

9.2 Simulation requirements

Based on the summary of threats to Torres Strait provided in Part 2 and questions and objectives identified in Chapter 9.1, the modelling framework is expected to simulate the following processes:

1. *Catchment runoff:* The model should be able to represent catchment runoff (river flows, sediment and nutrients) to test scenarios associated with: a) changes in rainfall (annual average and changes in frequency/intensity of extreme rainfall events), and b) changes in land-use and practices. Ideally the model should incorporate runoff from main river systems entering the Gulf of Papua, especially turbidity and optionally mine tailings from the Fly River system. Sediments (and associated decline in light penetration), nutrients and pollutants from catchments can affect habitats (seagrasses, mangroves and coral reefs) directly with flow-on effects on targeted species, their prey and predators.
2. *Hydrodynamics and transport*: Understanding oceanographic processes such as currents, waves, sea level, tides and tidal surges, and how these affect turbidity, sediment plumes, suspension / resuspension and deposition of sediments, and larvae dispersal would be important to evaluate individual and synergistic impacts from localised impacts (e.g. changes in land-use and practices, oil spills) and climate change on habitats and fisheries. For a more holistic representation of catchment and coastal/oceanic connections, such models can use point-source outputs from the catchment model, such as flows, and loads of sediment, nutrients and other pollutants.
3. *Physio-chemical water quality constituents*: Variables, such as pH, dissolved oxygen, water and air temperature, total suspended solids, and salinity would be useful to include in the model to assist in the prediction of their direct and indirect impacts on key species and habitats.
4. *Biogeochemistry*: It may be advantageous if a model is capable of simulating the reactive transport and transformation of common parameters such as nitrogen, phosphorus, oxygen, carbon and inorganic suspended solids. Another desirable feature would be to simulate sediment-water column interactions for these parameters and assimilation of nutrients by primary producers. Simulating parameters such as bacteria, pathogens, algae and zooplankton is also desirable.
5. *Fisheries dynamics*: Simulation of fisheries processes (e.g. catch, effort, gear) and the interactions between ecosystems, species and fisheries is essential to understand direct and indirect effects of localised and climate change impacts.
6. *Ecological relations*: Simulation of higher order functions, such as interactions between targeted species and their predators and prey, and indirect impacts of changes in habitats on targeted species (e.g. coral bleaching and impacts on fishery or prey, impacts of climate change on nursery function of mangroves) are highly desirable. Simulation of mega-fauna trophodynamics, such as the dynamics between dugong, turtles and seagrass is important in

understanding impacts of localised and climate change impacts on habitats and flow-on effects in food chain and fisheries.

The various processes to be represented in the modelling framework are shown in Figure 6. This includes catchment processes, environmental effects (hydrodynamics, transport of sediments and nutrients, physical and biogeochemical processes), fisheries and interacting species and habitat dynamics, and trophodynamics.

We have outlined a suite of desirable model features that will facilitate in-depth understanding of the Torres Strait marine ecosystem. We note, however, that this is an ambitious list that may not be possible with all model frameworks, given limited available information and the level of detail that could be included depends on available funding for model construction. The model should also consider the specific high priority questions that need addressing, and hence whereas some of the features we overview may be essential, others are not or may simply be stretch objectives that could be built on at a later stage.

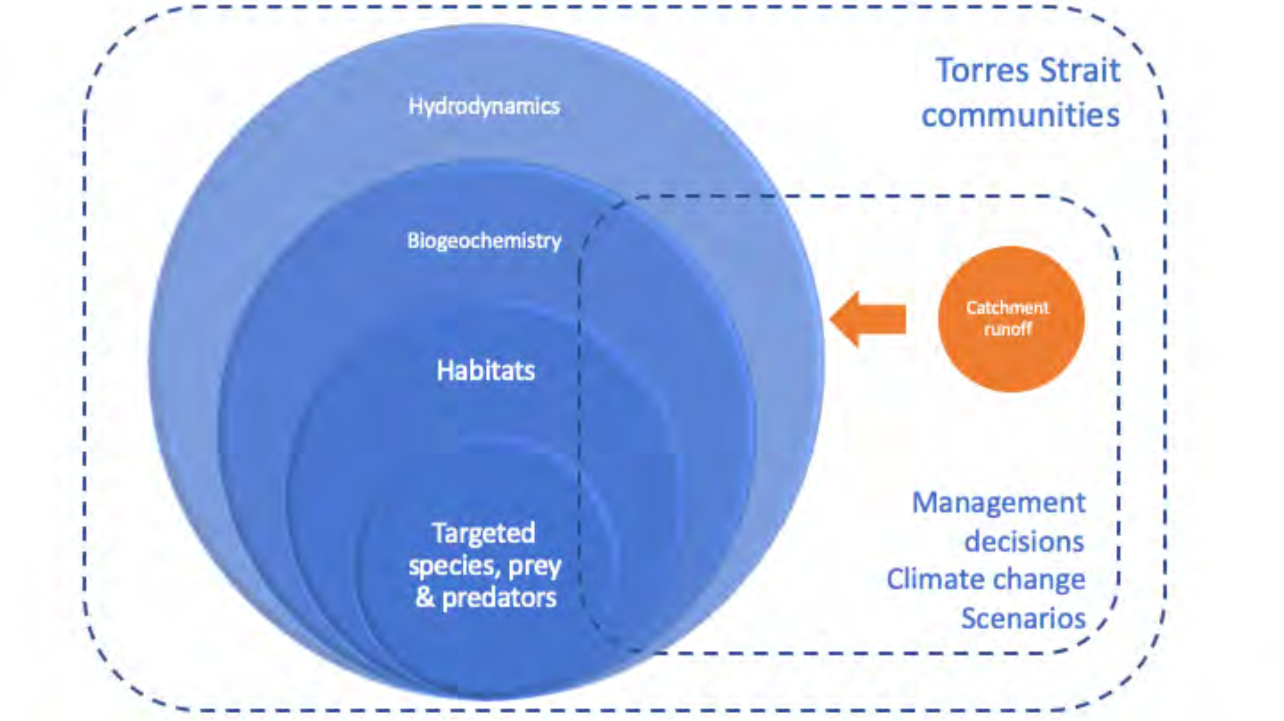

Figure 6. Torres Strait conceptual modelling framework.

9.3 Assessment of data requirements

9.3.1 Data requirements

Biological / Fisheries data

Fishery-dependent data such as catch and effort (and preferably also fishery-independent survey data), are required to simulate populations of the target species, on which potential impacts of localised and climate change scenarios can be assessed. Having a good understanding of biomass of the fishery is important. In general, long-term data is sparse and restricted to certain species but there has been substantial improvements in recent times. Data collection of catches of all commercially fished species in Torres Strait communities has been mandated since 1 December 2017 using the Torres Strait Fish Receiver System and provides valuable information to communities and scientists. Additional voluntary information on changes in fishing behaviour and effort by community sectors would provide important data that can be incorporated in models to communicate information back to communities on status of fisheries, seafood consumption, catches / consumption trends over time. This would support local adaptation efforts and decisions, including the use of traditional knowledge to fishing practices, as well as the identification of socio-economic development needs, which will benefit traditional owners, non-traditional recreational sector and resource managers in Torres Strait (Bedford et al. 2020). The availability of fisheries and related biological data for each of the fisheries investigated in this report is presented in Table 8. The information provided in Table 8 refers only to presence/absence, not on the quantity or quality of data or its limitations. These are provided in Appendix A.

Table 8. Availability of essential data for each of the selected fisheries investigated in this report (TRL: Tropical Rock Lobster, FFISH: Finfish; BDM: Bêche-de-mer). Note that 'availability' may indicate fairly limited data. Details include period of data, references, spatial extent, with more specific information presented in Appendix A.

	TRL	PRAWNS	FFISH	BDM	TURTLES	DUGONGS
Catch location	Y	Y	Y	Y	N	N
Harvest numbers	Y	Y	Y	Y	N	N
Target species identification	Y	Y	Y	Y	N	N
Gear type	Y	Y	Y	Y	Y	Y
Age / Size frequency of catches	Y	N	Y	N	N	N
Species distribution	Y	Y?	Y	Y	N	N
Recruitment survey	Y	N	N	N	N	N
Population size	Y	N	N	Y	N	Y
Growth	Y	Y	Y	N	N*	N**
Reproduction	Y	Y	N	Y	N	Y
Maturity	Y	Y	Y	Y	N	Y

*Data exists for Green turtles in the Southern GBR (Chaloupka et al. 2008).

**Growth rates have been estimated from other sources in the literature (Hagihara et al. 2016).

Habitat data

Distribution and abundance data about habitats supporting the fisheries investigated can be used to assess direct impacts of climate-related events on habitats (e.g. marine heat waves; Duke et al. (2017), Babcock et al. (2019)) and potential flow-on effects (e.g. changes in abundance and distribution) on the fisheries (Plaganyi et al. 2019c). The availability of habitat data for Torres Strait is presented in Table 9. The information provided in Table 9 refers only to presence/absence, not on the quantity or quality of data or its limitations. These are provided in Appendix A.

Table 9. Availability of essential data for habitats supporting selected fisheries investigated in this report. Note that 'availability' may indicate fairly limited data. Details include period of data, references, spatial extent, with more specific information is presented in Appendix A.

	MANGROVES	SEAGRASSES	CORAL REEFS
Location	Y	Y	Y
Area	Y	Y	Y
Species	Y	Y	Y

Physio-chemical data

The following processes (identified in Chapter 8, Table 7) are desirable to incorporate in the modelling framework to evaluate potential impacts of climate change on system functioning and flow-on effects on habitats and species. The availability of physio-chemical data in Torres Strait is shown in Table 10. The information provided in Table 10 refers only to presence/absence, not the quantity or quality of data or its limitations. These are provided in Appendix A. In a general sense, there is limited data showing spatial differences in physical characteristics (e.g. depths and tides), which are important to understand Torres Strait dynamics.

Table 10. Availability of essential physio-chemical data to simulate localised and climate change impacts on fisheries of the Torres Strait region. Details including period of data, references, spatial scale and more specific information are presented in Appendix A.

	DATA AVAILABILITY IN TORRES STRAIT
Currents	Models, Observations
Turbidity	Models, Observations
Temperature	Models, Observations
Tides / water level	Models, Observations
Light	Models, Observations
Nutrients (N & P)	Models, Observations
Salinity	Models, Observations
Sedimentation	Models, Observations
pH	Models, Observations
Oxygen	Models, Observations
Exposure to the air	Related to water level
(Over)grazing	Observations
Extreme events (e.g. rainfall, cyclones)	Observations
Waves / tidal surges	Models, Observations
Moon phase	Modelled
Overfishing	Models, Observations
Diseases & parasites	Limited Observations?

The review of datasets available for Torres Strait revealed significant information covering Torres Strait fisheries, marine species, habitats, geology and physiochemical water quality parameters (Appendix A). However, datasets are sparse both in space and time and, with few exceptions (e.g.

Torres Strait Rock Lobster survey, recent Logbooks and catch disposal records) data have been collected opportunistically mostly due to financial and logistical limitations. A large-scale monitoring program for Torres Strait would support the identification of long-term trends and improve understanding about local and regional processes affecting habitats, species and fisheries (Pitcher et al. 2004), including the impacts of climate change on these. Modelling projects would also provide important insights into where to collect oceanographic data.

Most of the understanding about physical and biogeochemical cycles and processes (e.g. currents, tides, primary productivity, nutrients) in Torres Strait have been derived from remote sensing and hydrodynamic models developed in the 2000s (Hemer et al. 2004, Saint-Cast and Condie 2006, Saint-Cast 2008) and in the early 2010s (Wolanski et al. 2013), each with pros and cons relatively well-known (see Chapter 10.1.2). Limited physical long-term observational data are available and were mostly collected in the 1990s (Wolanski et al. 2013). These models would also benefit from a coherent monitoring program for data collection to reduce uncertainties, validate and improve such models (Pitcher et al. 2004, Margvelashvili et al. 2008, Wolanski et al. 2013).

Habitat, fisheries and ecological data are also sparse, but recent mapping of mangroves, seagrasses and coral reefs (Chapter 6) combined with survey data on substrate and species (Murphy et al. 2020, Plagányi et al. 2020b) offer valuable information about the location and health status of such habitats, which can support the development of models to explore impacts and adaptation options. It takes a long time to gather the financial means to run surveys, and collect adequate time series of data but we do have sufficient data to start modelling to investigate potential climate change impacts on fisheries. In what follows, we proposed a modelling and data framework to answer the research question presented in Chapter 9.1.

10 Proposed modelling and data framework

10.1Modelling framework

The conceptual modelling framework presented in Figure 7 shows an example of how the different processes could be represented and their impacts on habitats and species, including on different life stages. We present below a summary of common modelling approaches that can be used in the framework based on simulation requirements presented in Chapter 9.2 and data availability for Torres Strait presented in Chapter 9.3. Important to note is that a number of modelling initiatives are already in place in Torres Strait and it would be worth considering capitalising on these efforts. We note also that a modular approach to modelling whereby different detailed components are coupled together rather than developing an entirely new model, may also be a productive method to address integrated modelling needs.

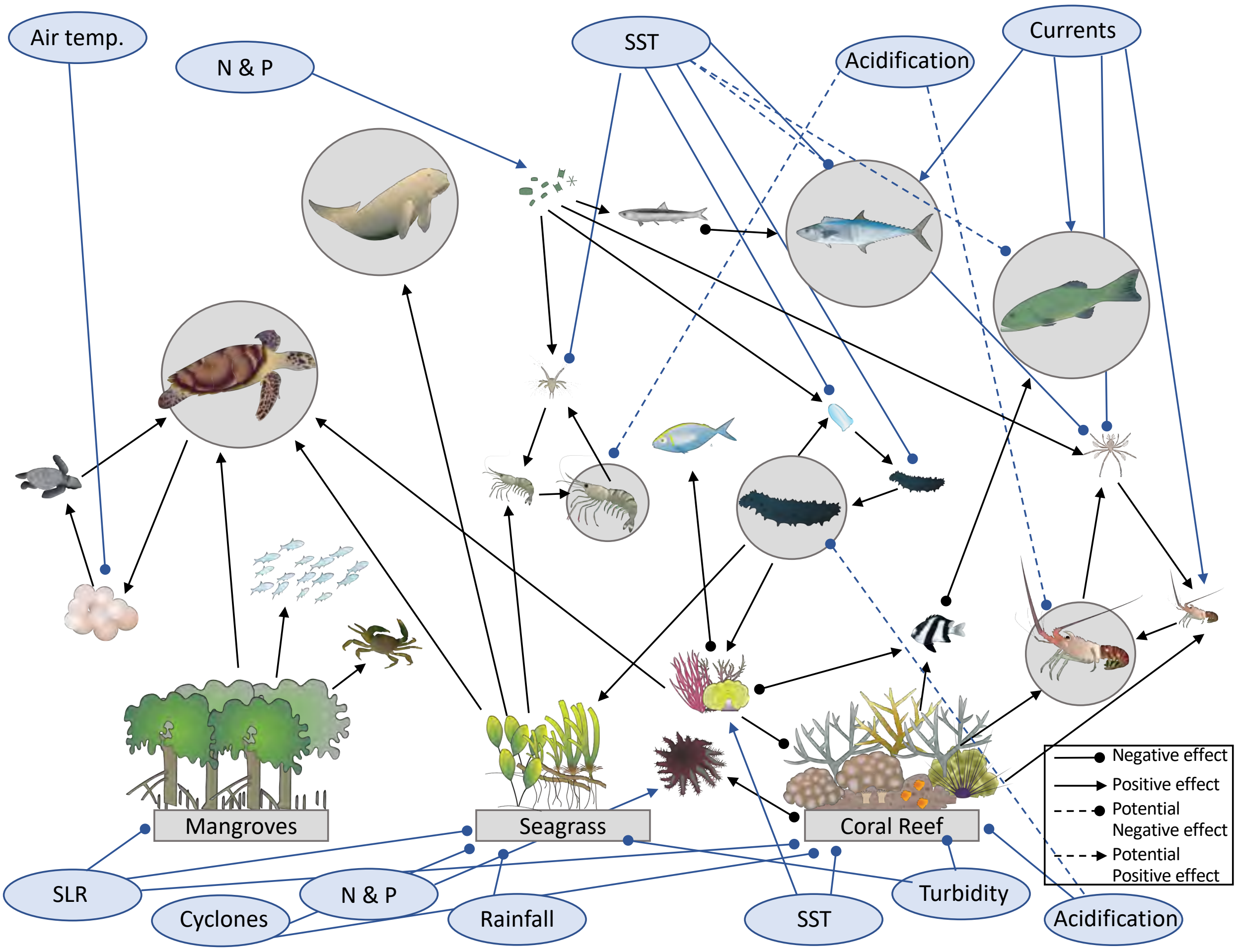

Figure 7. Torres Strait conceptual model framework. Symbols obtained from the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/). Blue lines: direct physio-chemical impacts; black lines: indirect biological / ecological impacts.

10.1.1 Catchment runoff

Catchment models generate outputs of freshwater flows and catchment runoff (nutrients, sediments and other pollutants) using data on soil characteristics, land-use and rainfall as inputs. In terms of impacts on some northern regions of Torres Strait, it is important to evaluate climate change and local impacts on Torres Strait fisheries in the simulation of catchment runoff from the rivers entering the Gulf of Papua (Fly, Purari and Kikori Rivers, and two smaller rivers: the Aramia and Era Rivers; especially mine tailings pollution from the Fly River) (Li et al. 2017), including the impacts of changes in rainfall due to climate change on catchment runoff. There are concerns that plumes from main rivers entering the Gulf of Papua may enter Torres Strait waters (Li et al. 2017), which can potentially impact fisheries resources and critical habitats in Torres Strait (Wolanski et al. 2013, NESP Earth Systems and Climate Change Hub 2018). A recent water quality study by Waterhouse et al. (2018) found trace metal enrichment originating from PNG rivers around the islands of Boigu and Saibai, but the trace metal analysis did not indicate that there was widespread deposition of mine-derived sediments in Torres Strait. Waterhouse et al. (2018) divided Torres Strait into six zones for which the potential risk of influence of Fly River waters varied form very likely to low risk (Appendix B).

10.1.2 Hydrodynamics and transport

A three-dimensional (3-D) fine-resolution hydrodynamic model coupled with a sediment transport model can potentially capture much of spatial and temporal variability of currents, waves, tides and sea level, as well as the sediment, light penetration and pollution characteristics on the shelf. Hydrodynamic models have previously been implemented in the Torres Strait region in the early 2000s and 2010s, using datasets from the 1990s. These models have a number of limitations and effort to address such limitations or re-run these models under different scenarios is likely to be similar to developing a new regional model (N. Margvelashvili pers. communication, June 2020). For example, Saint-Cast and Condie (2006), and Saint-Cast (2008) developed a regional circulation model for Torres Strait based on an 8-year hindcast period (i.e. 01/03/1997–31/12/2004) using realistic forcing fields, including winds, waves, tides, and large-scale regional circulation. Their model is an update from a model developed by Hemer et al. (2004). The model uses a curvilinear grid of approximately 4km resolution. This resolution may not reliably solve hydrodynamic processes in topographically complex areas such as Torres Strait (Wolanski et al. 2017) and would require nesting approaches to improve model resolution. Model outputs include 3-D distributions of velocity, temperature, salinity, and mixing coefficients, as well as two-dimensional fields such as sea level and bottom friction. Wolanski et al. (2013, 2017) developed a depth- averaged 2-D oceanographic hydrodynamic model on an unstructured mesh for Torres Strait. The unstructured mesh allows the spatial resolution to be made locally higher in shallow areas and near coastlines, where small-scale flow features are important, and lower in deeper areas, where the flow is more uniform. However, their modelling approach does not resolve vertical flow structure, which constrains its ability to simulate 3-D processes, thereby resulting in less realistic outputs.

More recently, CSIRO developed a modified Ocean Forecasting Australia Model version 3 (OFAM-v3), a near-global (does not include Arctic region) oceanographic model run under standard IPCC emissions scenarios to project future ocean states around Australia (Zhang et al. 2017, Fulton et al. 2018). These scenarios are taken from global ocean-atmosphere models (CMIP5 climate models), which set the context for the finer scale OFAM-v3 model, which focuses on the Australian region in more detail. The OFAM-v3 model was originally developed for upper-ocean short-range operational forecasting (e.g. ocean forecasts of the type found at the www.bom.gov.au website) and was adapted for climate change studies (Oke et al. 2013). The downscaling simulations run with OFAM-v3 provide monthly surface high-resolution (10km, 0.1°) outputs that can resolve important oceanographic features (e.g. eddies) and how these may change under future climate change. Outputs for two scenarios are available for regions across Australia, including Torres Strait: a) a control scenario without emissions (control) and 2) a high emission scenario (RCP8.5) (Fulton et al. 2018). There were differences between observations in Torres Strait and outputs from downscaled models (Plaganyi et al. 2018b), which suggests the need to develop a regional hydrodynamic model to capture local dynamics (see Chapters 10.1.3, 10.1.4 and Figure 8).

Uncertainty in model predictions in previously deployed hydrodynamic models was high due to lack of adequate data in Torres Strait to specify initial and boundary conditions, as well as poor knowledge of the empirical parameters (Margvelashvili et al. 2008, Saint-Cast 2008, Wolanski et al. 2017). There is a strong need for a monitoring program with extensive spatial and temporal coverage to improve hydrodynamic modelling efforts in the region (Saint-Cast 2008).

Given recent improvements in hydrodynamic modelling capability, it is recommended that a dedicated regional model be constructed for Torres Strait. This will also help resolve differences in observations and predictions from ecosystem models developed for the region (Fulton et al. 2018, Plaganyi et al. 2018b). The effort to re-run previously developed models will likely be similar to deploying an up-to-date state-of-the-art modelling platform such as eReefs, a comprehensive interoperable information platform that has been developed for the Great Barrier Reef (GBR) region (Steven et al. 2019). eReefs is a CSIRO modelling platform that runs hydrodynamic models, sediments and biogeochemistry of the GBR shelf in near real time, routinely producing 3D hydrodynamic fields of the GBR environment on a 4km x 4km grid and building up an archive of such data. It is possible to extend boundaries of eReefs to cover the Torres Strait region and increase model resolution in eReefs by nesting high resolution models (10s to 100s of meters) inside eReefs, through the relocatable coastal ocean model (RECOM) (Steven et al. 2019) in a subset of the regional grid encompassing Torres Strait.

10.1.3 Physio-chemical water quality constituents

Modelling physio-chemical water constituents is important to investigate impacts of future climate (e.g. temperature, pH, salinity, light penetration) on critical habitats supporting the fisheries (Chapter 6), targeted species (Chapter 7) and their predators and prey in Torres Strait (see Chapters 10.1.5 and 10.1.6). Previously deployed hydrodynamic models implemented in Torres Strait have incorporated basic physio-chemical parameters. For example, Saint-Cast (2008) 3-D model simulates temperature and salinity and OFAM-v3 (see description in Chapter 10.1.2) model simulates temperature and salinity for base case and different climate change scenarios. Plaganyi et al. (2018b) analysed observations from Thursday Island, MODIS remotely sensed SST and full time series of CIMP5 outputs. They found that the modelled results exceeded the maximum temperature from observations and MODIS SST each year (Figure 8). Again, these differences between observations and model outputs highlight the paucity of data for the area and difficulties in downscaling oceanic models to a unique strait. This also underscores the need to prioritise data collection of physical variables through a monitoring program to improve modelling efforts in Torres Strait. A range of global and regional observations and model outputs for physio-chemical water quality and specific products are available through special licence arrangements or free of charge that can be used to build new or update existing physio-chemical models (Table 10 , Appendix A).

10.1.4 Biogeochemistry

Biogeochemical models coupled with hydrodynamics are important to understand the links between oceans, land and atmosphere. Such models are important to assess local and climate change impacts on biological and chemical cycles and flow-on impacts on food chains and fisheries in Torres Strait. A biogeochemical model that represents nutrient flows and plankton components of the ocean food web (primary producers such as phytoplankton, some bacteria and zooplankton consumers) was coupled with OFAM-v3 to produce patterns of primary productivity, nutrient cycling and carbon fluxes consistent with observations across Australia (outputs were extracted for Torres Strait). The OFAM-v3 outputs provide downscaled climate change projections for all common ocean state variables including currents, temperature (^{o}C), phytoplankton (mmol Nm^{-3})

and primary productivity (mmol C m^{-2}day^{-1}). These outputs were then used as input to ecosystem and fisheries models used to assess impacts of climate change on fisheries across Australia, including Torres Strait (Fulton et al. 2018).

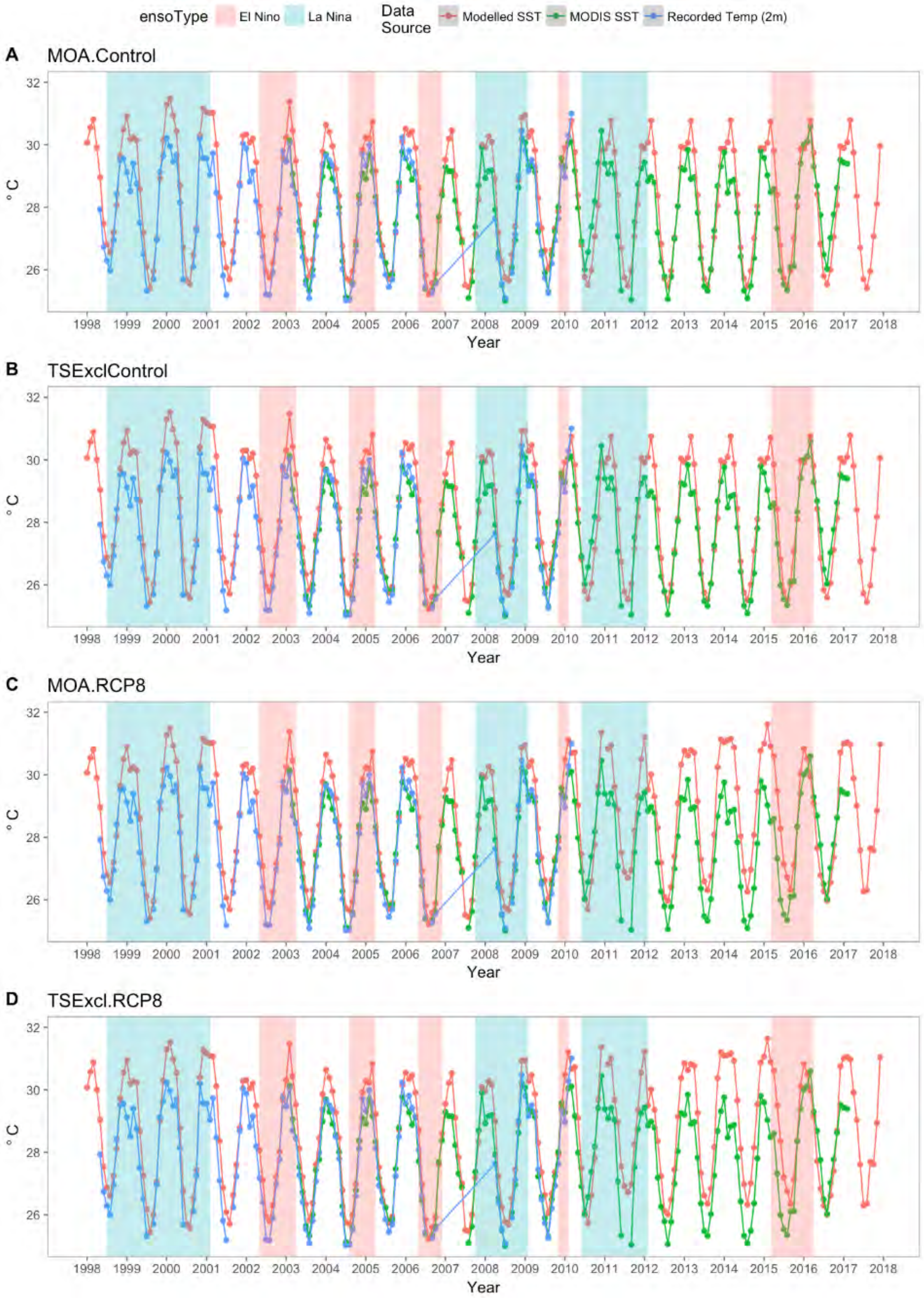

Figure 8. Plots of water temperature (modelled SST, remotely sensed (MODIS) SST and actual water temperature at 2 m depth at Thursday Island). The modelled SST is shown for the Torres Strait model output area (MOA) and the MOA minus the exclusion zone (TSExcl) under two future climate scenarios: no change (Control) and RCP8.5 (RCP8). Major ENSO events are overlaid (Figure from (Plaganyi et al. 2018b).

Sediment transport models have been developed to understand source and fate of sediments, processes maintaining naturally high turbidity in some parts of Torres Strait and the behaviour of sediment plumes from the Gulf of Papua into Torres Strait (Hemer et al. 2004, Margvelashvili et al. 2008, Saint-Cast 2008, Wolanski et al. 2013, Li et al. 2017, Wolanski et al. 2017).

10.1.5 Fisheries dynamics

The dynamics of fish stocks and how they are impacted by fishing can be simulated using models. For key fisheries across the world these are routinely performed as stock assessments. Three main groups of models are used in stock assessments – biomass dynamic models, age-structured models and size-based models (Hilborn 1992). These models, and their derivations, range in complexity and require key biological information on the species modelled, as well as indices of abundance such as catch and effort data generated from the fishery, and where possible, fishery independent survey data. In the Torres Strait region, stock assessment models have been developed for TRL (Plaganyi et al. 2013b, Plaganyi et al. 2018a, Plaganyi et al. 2019a); BDM (Plagányi et al. 2011b, Plaganyi et al. 2013a); Prawns (O'Neill and Turnbull 2006, Turnbull et al. 2009) and Fin Fish (Holden and Leigh 2019, O'Neill 2019).

It is usually difficult to correlate environmental variables with fish stock abundance, particularly for highly variable species such as prawns and TRL, and consequently many stock assessments do not explicitly incorporate environmental variables to help with the prediction of stock abundance. In Torres Strait, this has been the case for the TRL reference case stock assessment model, but there are model versions presented as sensitivities that explicitly incorporate an environmental driver (Plaganyi et al. 2013b)(see section 7.1.5). For the BDM fishery, Plaganyi et al. (2013a) used a set of operating models that incorporated environmental drivers in a Management Strategy Evaluation approach (Rademeyer et al. 2007, Punt et al. 2016) to evaluate the performance of alternative fisheries management strategies under varying climate scenarios.

When considering broader ecosystem impacts on fisheries, ecosystem models of varying complexity, depending on the questions being asked and data available, can be used to simulate changes in the environment, including from climate and flow-on effects to fisheries and vice-versa.

Fishery ecosystem models range from those that are simple in structure and complexity, representing only a simplified part of the system (e.g. one or two species), to those that have high complexity and capture many components of the system (e.g. whole of ecosystem models; see Chapter 10.1.6) (Collie et al. 2016). The former are usually fitted to fishery data (e.g. stock assessment models) and thus used for tactical (i.e. day-to-day) decision making, while the latter, which are not always fitted to data, often display large parameter uncertainty and are used more for strategic purposes (Collie et al. 2016). Models of intermediate complexity for ecosystem assessments (MICE; Plagányi et al. 2011a) fall somewhere in the middle. MICE aim to simulate key components of the system and thus only the most important species are represented e.g. the fished species and those that most closely interact with it. Where possible, these components are fitted to data, allowing these models to also be used for tactical decision-making purposes, with the benefit of considering other components such as habitats in the ecosystem.

Stock assessment models are a useful start for capturing the dynamics of key resources in the TS region, which can then be used to “ground-truth” larger whole of system models or can be added to by including other components of interest or for which there are data available, for example using a MICE model.

10.1.6 Ecological relations

Simple qualitative network-based representations of ecosystems, including ecological relations and system drivers, are a useful start to conceptualise the system and highlight key components and stressors (Plagányi et al. 2011a, Melbourne-Thomas et al. 2013, Metcalf et al. 2014, Dambacher et al. 2015, Fulton et al. 2019). Conceptual and qualitative models therefore provide better insight into ecosystem form and function before moving to more complex models. Information for these simple network models can be (and is) sourced from literature and engagement with stakeholders such as fishers, researchers and other sources of local ecological knowledge. These qualitative network models can then be developed into quantitative models, whose form and complexity will depend on their purpose and data available.

Ecosystem models commonly applied to marine systems include complex whole of system models such as Ecopath with Ecosim (EwE)(Christensen and Walters 2004) and Atlantis (Fulton et al. 2011a), and models of intermediate complexity such as MICE (Plagányi et al. 2011a). Socio-ecological models are increasingly being developed to account for the human dimension (Fulton et al. 2011b, Plagányi et al. 2014, van Putten et al. 2018, Hornborg et al. 2019).

EwE is a mass-balanced model, typically representing the entire ecosystem from detritus through to top-predators using built-in trophic relationships that track the flow of energy through the system. The model is forced by primary productivity and typically doesn’t include links to environmental variables. Various sources of data are required for each species/trophic group and are usually gathered from research in the region of interest, or if not available, from similar systems elsewhere. EwE models have been created for many marine ecosystems around the world (e.g. Colleter et al. 2015). EwE models therefore have many advantages such as being relatively quick and easy to implement, but they also have a number of disadvantages such as those outlined in Plaganyi and Butterworth (2004).

Similar to EwE, Atlantis represents the whole system, but at a finer resolution including age and size components. Atlantis is a dynamic system model that attempts to represent both bottom-up (physical) and top-down (biological) forces interacting in an ecosystem (Fulton et al. 2011a). It is forced by environmental variables such as temperature, salinity and physical oceanographic variables. Anthropogenic activities can also be included in the system. Atlantis has a range of successful applications to support strategic decisions around the world and is highly regarded by modellers as one of the best approaches for addressing very broad ecosystem issues (Plagányi et al. 2011a). Atlantis models have the advantage of including a very large amount of complexity and components of the ecosystem. The disadvantage though is that there is considerable uncertainty associated with several components and hence these models are more suited for addressing strategic insights than tactical applications. These models are also relatively expensive with a long development time typically needed. An Atlantis model has been developed for the Coral Sea to look into fisheries management and climate change impacts (Hutton et al. 2017). A Torres Strait Atlantis model would need to be adapted/fine-tuned for just the Torres Strait region, which is quite distinct from the rest of the east Australian coast (Wolanski et al. 1988).

Unlike whole of system models, MICE only focus on representing key components in a system. Both trophic and non-trophic relationships can be modelled and are custom added as necessary (i.e. not already built-in as with EwE trophic relationships). MICE can include both temporal and spatial resolution, and if data are available, they can link environmental variables (e.g. temperature) to a species, e.g. through linking to recruitment or survival. MICE rely on stakeholder input to help capture key processes and links within the ecosystem and importantly they rely on fitting to data and thus can better account for uncertainty than many whole-of-system models, an important requirement in fisheries and ecosystem management. A limitation of this approach is that it does not consider all components in an ecosystem, but as a result these models are more question focussed, quicker to develop than Atlantis models, and they provide more rigorous predictions which can be used in ecosystem assessments (rather than broad strategic insights only).

MICE have been developed for a range of ecosystems, including coral reefs south of Torres Strait on the GBR to assess effectiveness of various measures in controlling Crown-of-Thorns Starfish (COTS) outbreaks (Morello et al. 2014). A spatial MICE is also currently being developed for the Gulf of Carpentaria to the west of Torres Strait, looking at impacts of reduced riverine water flow on prawns and other key species and associated fisheries (Plagányi et al. 2020a).

Morello et al. (2014) used a MICE to model trophic interactions between COTS and two types of coral on a reef in the GBR. By fitting to data, they were able to quantify COTS prey-switching between two types of coral prey. Parameters from this model were then used to help model trophic interactions in a larger metacommunity model, i.e. scaled to the whole GBR (Condie et al. 2018). This is an example of how models can be combined at different scales to address questions pertaining to local through to more regional scales. Some simple MICE (seagrass-dugongs and TRL) have been developed in Torres Strait, covering the areas to the west and east of Torres Strait (Fulton et al. 2018)

Modelling approaches can produce different outputs for similar fisheries (e.g. Atlantis model predicts that lobster populations will increase with climate change (Fulton et al. 2018), while MICE predicts a decline (Plaganyi et al. 2018b). Such discrepancies can be resolved by constructing a specific regional ecosystem model to assess climate change impacts on Torres Strait fisheries.

A more suitable strategy to develop ecosystem models for Torres Strait would be to develop some sort of hybrid MICE-Atlantis approach drawing on features from both approaches. There are existing examples of MICE that have successfully been coupled with general circulation models (Tulloch et al. 2019). Approaches such as these and other system-level hybrid models, which bring together the strengths of various modelling approaches, can represent each component of the system in a way that best captures that system and the data available (Fulton et al. 2019). The Torres Strait region will likely need a mix of modelling approaches that feed into one another. For example, it could start with conceptual / qualitative model of the ecosystem representing key fished species and other components of the ecosystem which are important for / linked to them, including drivers and stressors. Different model structures can be tested using qualitative network or other models to inform the development of a MICE or more complex ecosystem model(s).

A more pragmatic and cost-effective approach would be to develop a regional hydrodynamic model that simulates basic physical and biogeochemical processes coupled to fisheries, ecological or ecosystem models. Given there are already assessment models developed for some of the key species (e.g. TRL, BDM, prawns), a useful starting point would be to combine these in an integrated spatial MICE for the Torres Strait region. Modelling key species using MICE can include uncertainties and provide valuable information on their ecological status and integrating this information with stock assessments. Outputs/parameters from MICE can be fed into a more complex ecosystem model or help to ground-truth a larger more complex model. The modelling approach should be iterative with models developed and refined with improved understanding about the system.

Traditionally most marine ecosystem models have focused on physical and ecological components but it is increasingly recognised that the human dimension is important too (Fulton et al. 2011b). This is particularly the case in Torres Strait because of the close relationship with and custodianship of traditional owners towards their marine environment, as well as dependency on marine resources. Socio-ecological models are still in the early stages of development (Thebaud et al. 2017), but to the extent feasible, it would be advantageous to integrate social and cultural considerations into any ecosystem modelling approach. It may also be possible to draw on previous work as part of the Torres Strait lobster MSE project which integrated economics considerations, as well as coupling a Bayesian Belief Network (BBN) approach (van Putten et al. 2013b) with ecological and economic components (Pascoe et al. 2013), thereby integrating aspects of the social dimension to support operationalising a triple bottom line approach (Plaganyi et al. 2013b, Van Putten et al. 2013a).

10.2Data framework

In order to support future modelling work to explore impacts of climate change in Torres Strait fisheries we propose the development of a data framework that identifies how the physio-chemical and ecological data should be managed and delivered to support the development of models. Consideration of confidentiality of some data (e.g. fisheries data) will be required. The assumption used to describe the future data framework project is that datasets will be managed on CSIRO IT infrastructure, utilising relational database systems and enterprise file servers. Datasets will be described using geonetwork (www.marlin.csiro.au) and these descriptions can be made public to allow third parties (non-CSIRO) to access data depending on level of permission granted (i.e. licence restrictions). Datasets can be shared using Open Geospatial Consortium (OGC) standards where appropriate, by using a standards-compliant webserver (geoserver) linked to the collated data. This framework is scalable, robust and compliant with open data/metadata standards, allowing a flexible data delivery method. The detailed specification of how the physical data should be managed and delivered is therefore the key output of the project, and is specified below and Figure 9.

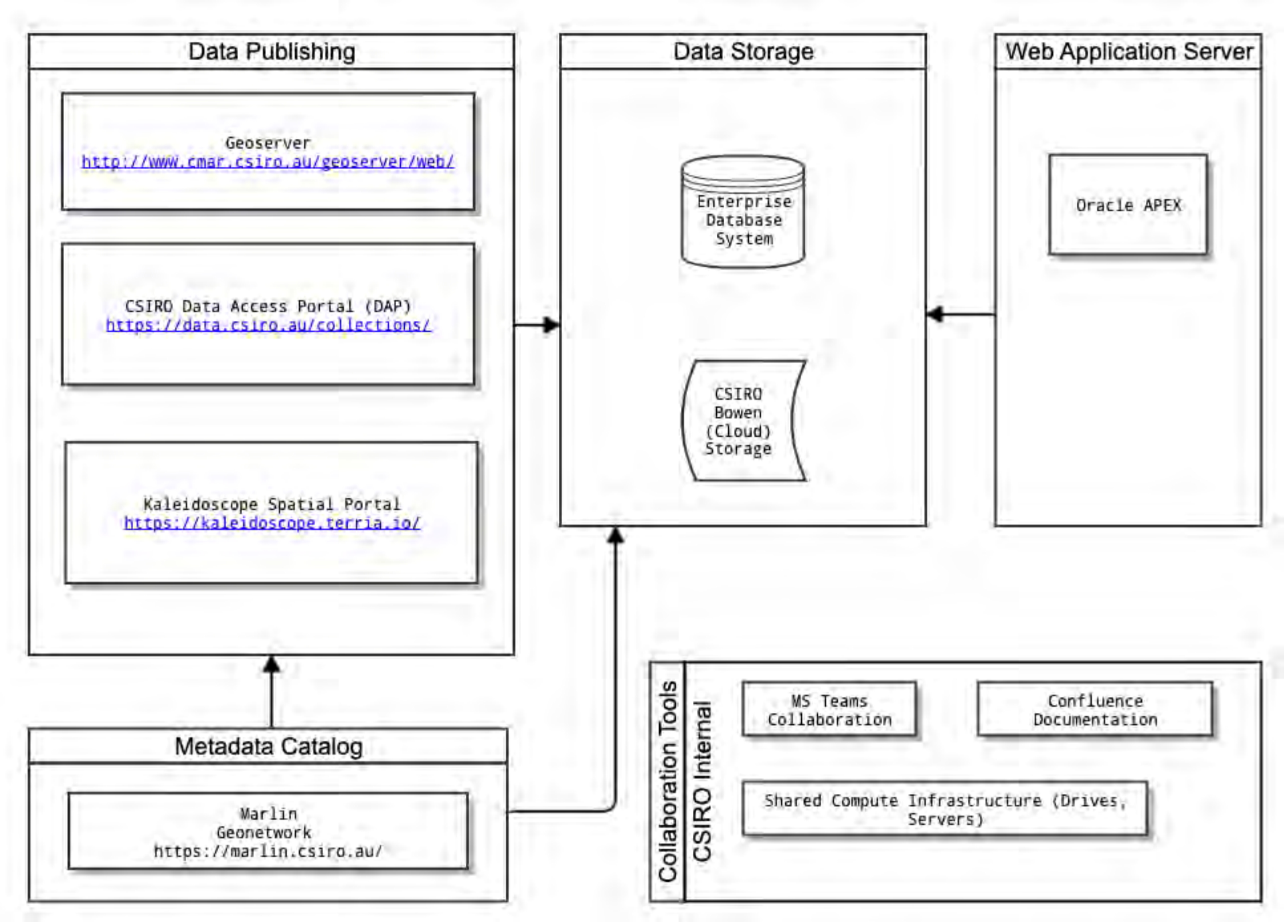

Figure 9. Data and modelling connections.

10.2.1 Data storage

Datasets are managed on CSIRO infrastructure where possible, making use of relational database systems, enterprise file systems and CSIRO's Bowen Cloud infrastructure (cloud-based storage systems). This ensures that data services are available to scientists, secure and provide a scalable platform to meet the expected data growth demands. The Bowen Research Cloud is an internal cloud resource that provides cloud storage for projects and virtual compute resources for data processing. The storage capability caters for datasets up to multiple terabytes. The Oracle database run by CSIRO Oceans & Atmosphere Business Unit is used to store structured information in a relational database system, and can provide an environment to manage information on the range of targeted datasets.

10.2.2 Data access / web services

To facilitate access to data across different analysis tools and platforms, data services will be configured to provide access to the various datasets. The open source Geoserver software will be used where the data is predominantly spatial in nature, and Geoserver supports the Open Geospatial Consortium (OGC) Web Feature Service (WFS) and Web Mapping (WMS) specifications. WFS and WMS provide a standard mechanism to exchange vector and image data respectively over http(s). Provision of fine-grained access to the data allows additional services - particularly spatial mapping or "spatial portals" - to be developed utilising standard data ingestion methods, leading to additional data visualisation tools.

10.2.3 Metadata (marlin)

The CSIRO marlin metadatabase is based on open standards, and provides a mechanism to store information on datasets in a standard way, and share this information with other web applications. It is based on Geonetwork (https://geonetwork-opensource.org/), an open source metadata system, and stores information using the Marine Community Profile, which is a profile of the latest ISO standard for encoding Geographic metadata information (ISO 19115-1:2014). This enables information to be exchanged readily with other services that are based on these open standards - in particular the Australian Ocean Data Network (AODN; https://portal.aodn.org.au/).

10.2.4 Visualisation (spatial portal / Kaleidoscope)

Datasets that are actively stored and managed within this project will be connected to allow visualisation and provide access to a broad range of users. CSIRO's Ocean & Atmosphere and Data61 business units are partnering to develop a spatial portal - Kaleidoscope - that is based on TerriaJS. This software is open source, and backs other portals such as Australia's National Maps data initiative (https://nationalmap.gov.au). This software uses open protocols and open data formats to access data, and provides a web-based platform for spatial data visualisation and analytics. This portal will provide capacity, as an ongoing service, to host, display and distribute spatial data from our centralised repositories, to support the ongoing requirements of data users.

A web-based database will be developed to track details on the datasets and model outputs that were identified in the initial stages of this project. Datasets will be managed on CSIRO infrastructure where possible, including relational database systems, enterprise file systems and CSIRO's Bowen Cloud infrastructure. This ensures that data services will be available to scientists, will be backed up, and will be secure.

10.2.5 Spatial scale

The boundaries for regional hydrodynamic model should include all important fishery areas in Torres Strait (https://www.pzja.gov.au/the-fisheries). We propose to use such regional scale coarser grid using boundaries defined in Plaganyi et al. (2018b)(Figure 10):

A. Top left coordinates: 9° 08’ 24.83” S / 141° 01’ 0.00” E

B. Bottom Right coordinates: 11° 10’ 0.00” S / 144° 28’ 0.00” E

The quadrants defined in the Tropical Rock lobster survey (Plagányi et al. 2020b/ Figure 11) are the primary spatial units (or areas) for ecological modelling and finer-scale (RECOM) hydrodynamics because of North/South differences in lobster growth rates, different fisheries in West and East, different oceanographic processes influencing the Eastern part of the Torres Strait (e.g. cooler upwelling intrusions into the area prevented bleaching), and northern region more influenced by runoff from PNG rivers and then also captures differences in underlying strata and habitat types. We would consider extending the eastern border of the Tropical Rock lobster survey quadrants or adding an additional spatial unit further to the east to include fisheries in the eastern Torres Strait, depending on how finely resolved the underlying oceanography is.

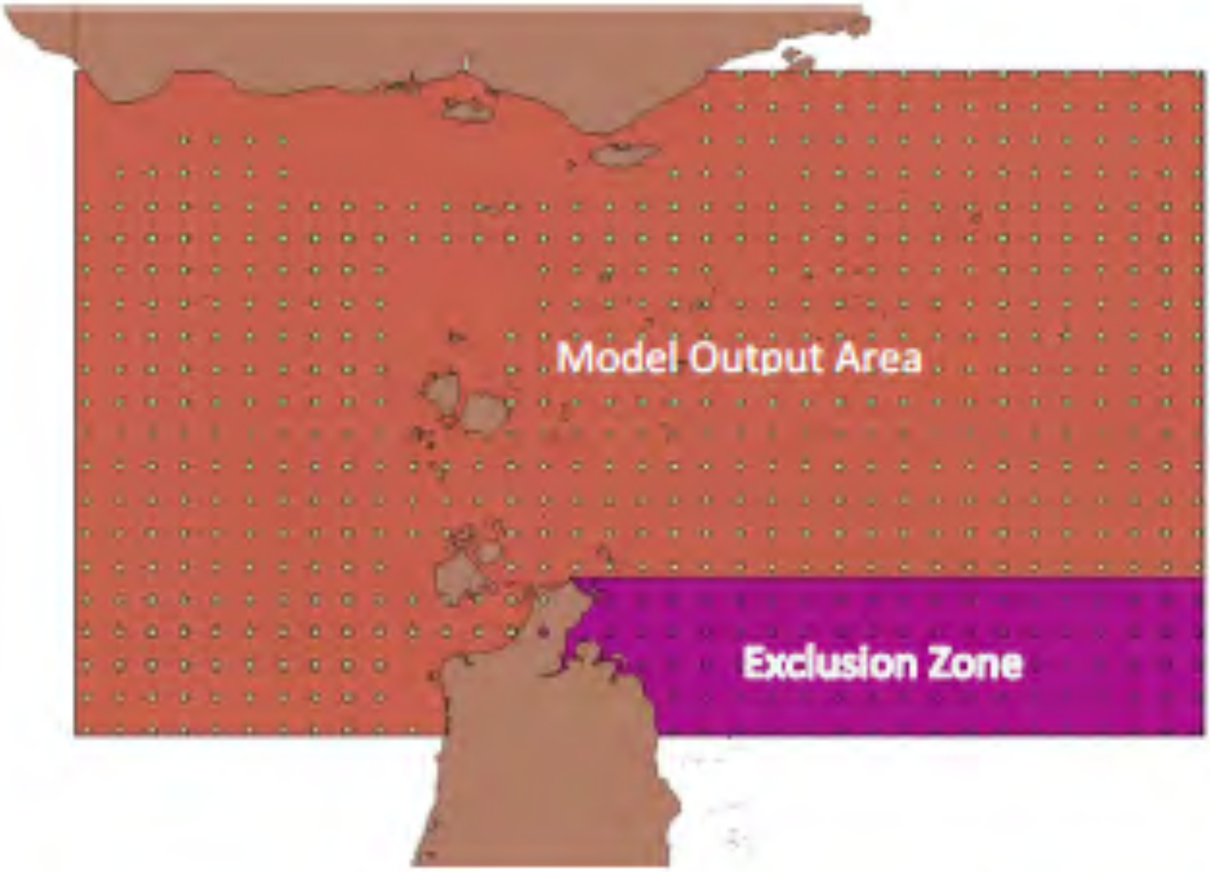

Figure 10. Proposed modelling region defined by: A) Top left coordinates: 9° 08’ 24.83” S / 141° 01’ 0.00” E, and B) Bottom Right coordinates: 11° 10’ 0.00” S / 144° 28’ 0.00” E.

For finer spatial scale within each quadrant if wanting to capture more localised oceanographic drivers and ecological processes, or if wanting to model the impacts on fisheries in the eastern side of Torres Strait, ecological modellers can opt to use the Management Strategy Evaluation sub-areas as previously implemented by Plagányi et al. (2020b) (Figure 12). These sub-divisions align broadly with fishery data and habitat characteristics although are not perfectly aligned with community spatial locations. Such subdivisions can facilitate the development of even finer-scale (e.g. RECOM) hydrodynamic models to support the evaluation of specific questions around particular ecosystems or fisheries.

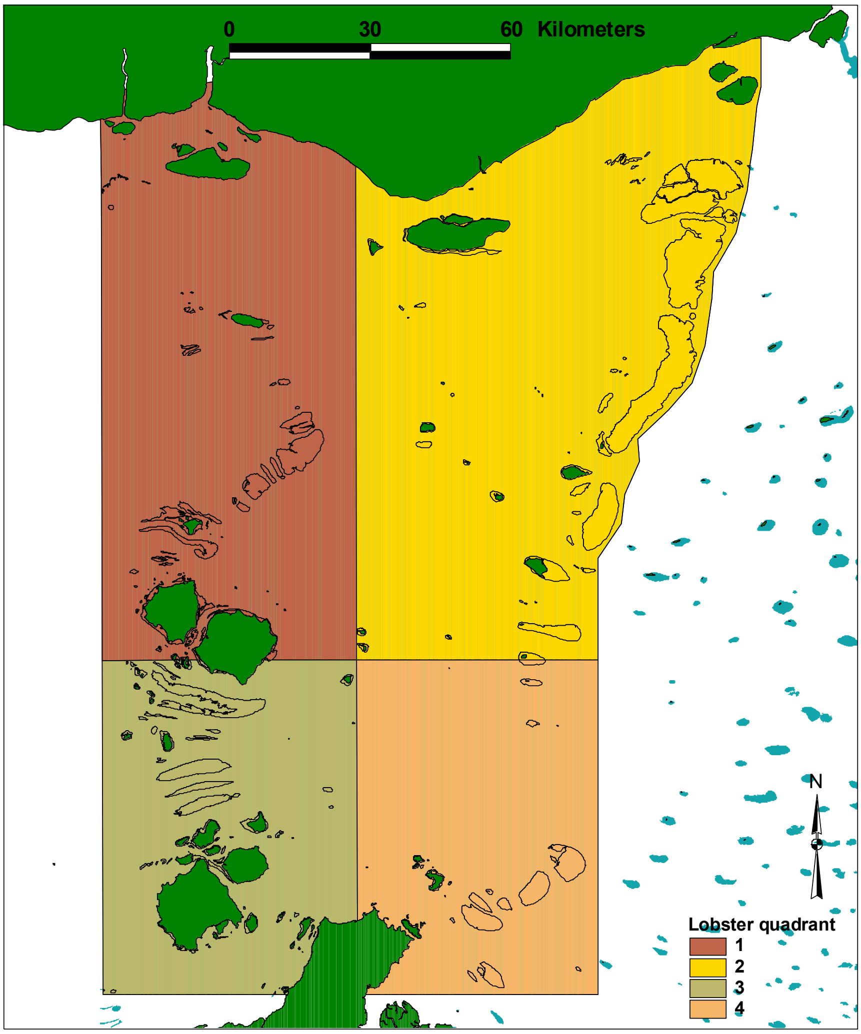

Figure 11. The area of the Torres Strait lobster survey split into four quadrants centered on 10.21 degrees S and 142.5 degrees E (from Plagányi et al. 2020b).

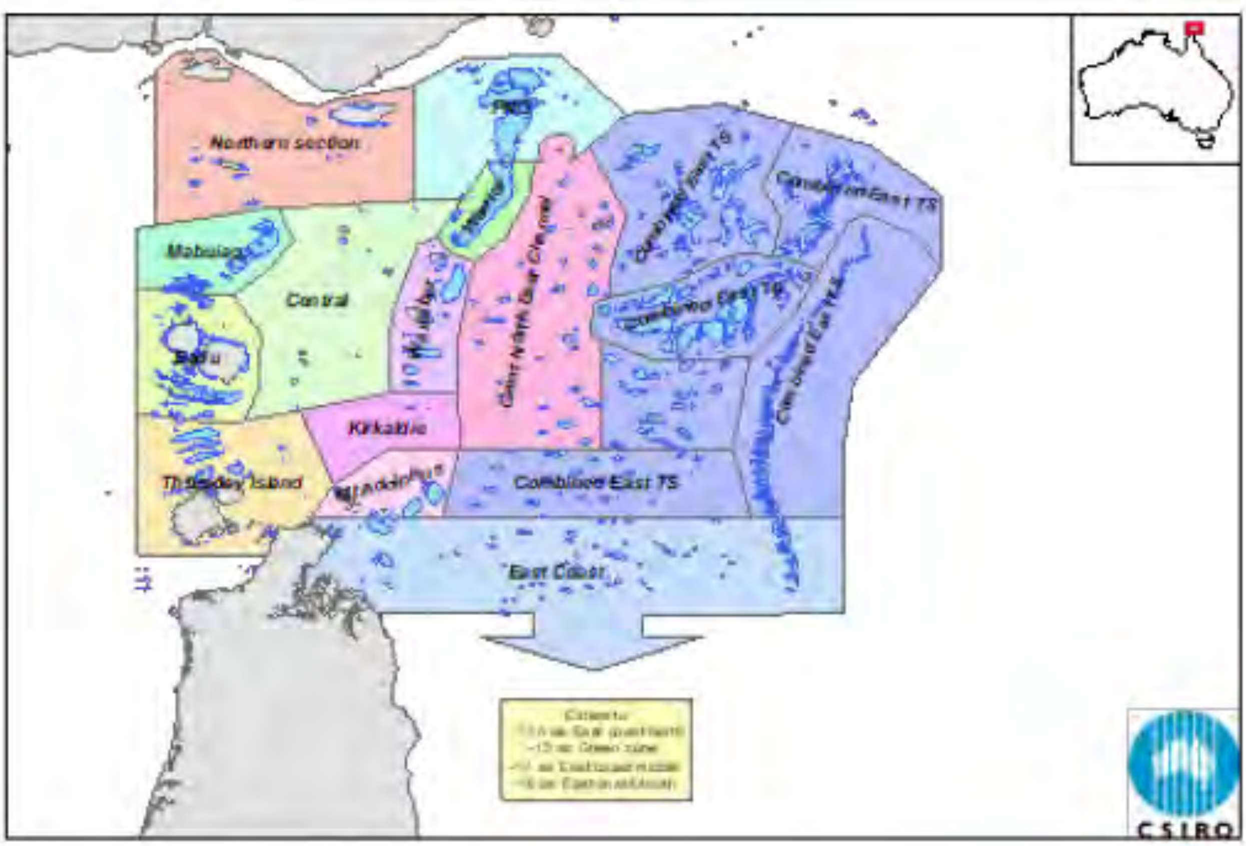

Figure 12. Proposed modelling sub-areas (source: Plaganyi et al. 2018b).

Modelling approaches were developed for TRL, BDM and dugongs in the past, considering environmental (including climate change drivers) and these can be improved as more data is now available since these models were developed. It takes a long time to organise surveys and collect adequate time series of data but as discussed in Chapter 9, sufficient data are available to start modelling. Efforts to improve data collection should be done in parallel so model refinements can be done when data from such monitoring program becomes available.

In summary, starting the modelling exercise sooner rather than later would provide a framework to utilise existing datasets and investigate potential climate change impacts on the fisheries and there are sufficient data available to start modelling. Our recommended approach would be to build the models in a stepwise fashion, adding new data and complexity as these become available or necessary. This also allows time to start obtaining feedback from stakeholders on preliminary model results, which allows time to communicate the usefulness of models as well as how to draw on local knowledge to further refine models.

The data framework described is needed to support the proposed modelling exercise to investigate impacts of climate change on the selected fisheries, but will also support other future research efforts in the region. Many ecosystem models involve coupling together different components and this is also how we envisage development of an ecosystem model proceeding – hence the starting point is to extend and link the current biological models of key species (e.g. TRL, BDM, dugongs), add current known environmental drivers (e.g. SST), gradually add other species (e.g. seagrass, finfish, turtles) and link with prelim hydrodynamic models or model outputs to start adding complexity associated with the oceanographic setting. A fully integrated couple hydrodynamic model usually takes a few years and is an expensive process so we recommend starting small and gradually expanding.

11 Preliminary costs of future project/s

1) The cost of a future project that will produce the over-arching data framework at the appropriate spatial scales, as required to address future climate variability and change scenarios for Torres Strait fisheries (i.e. deliver on Chapter 10.2) is approximately 0.4-0.5 FTE for 1 year or rough estimate of A$130k
2) We also strongly recommend a parallel project to initiate development of an integrated MICE-ATLANTIS modelling framework based on existing data to consolidate knowledge, fill gaps and support planning and adaptation in Torres Strait. Consideration should be given to drawing on existing assessment models available for some of the key species (e.g. TRL, BDM and dugongs). This would require approximately 0.5-0.7 FTE over each of 2 years, or rough estimate of $460k.
3) Developing a regional hydrodynamic modelling platform, such as eReefs, to provide link with ecological models would require approximately 0.3-0.5FTE over each of 2 years, or rough estimate of $350k

12 Conclusions and recommendations

12.1Conclusions

The first objective of this report was to detail findings from a literature review on the main climate change drivers in Torres Strait affecting tropical rock lobster, bêche-de-mer, finfish, prawns, turtles and dugongs, including a review on local and climate change threats to habitats and species (Parts 1 and 2).

- Anthropogenic impacts (other than climate change) in Torres Strait are relatively minor, but exist in specific locations. Torres Strait is, however, relatively highly vulnerable to shipping accidents, with this being recognised by TSRA (Carter et al. 2013) and oil spill risk may be important to consider in an ecosystem modelling framework.
- Local impacts include sediment runoff and metal pollution from the Fly River (PNG), localised oil contamination, mangrove cutting, alteration of hydrology, nutrient and sediment runoff, and chemical contamination.
- Fishing is an additional anthropogenic impact source. Most marine living resources have been managed sustainably but there are examples of past overharvesting (most notably Sandfish and Black teatfish) and this needs to be considered.
- Climate change is already affecting Torres Strait fisheries and culture. Impacts from climate change include higher sea levels and associated coastal erosion, warmer atmospheric and

ocean temperatures, more acidic waters, changes in ocean circulation, and more intense rainfall events.

- Although relatively minor, simultaneous local impacts (e.g. untreated sewage, chemical, sediment and nutrients runoff, oil pollution, overfishing) can act together with climate change impacts, such as sea-level rise, ocean warming and acidification, leading to interactive, complex and amplified impacts for species and ecosystems.
- These pressures manifest directly in the form of changes in abundance, growth, reproductive capacity, distribution and phenology (changes in cyclic and seasonal phenomena such as reproduction and migrations), and indirectly through changes in habitats.
- Invertebrates (Tropical Rock Lobster, prawns, bêche-de-mer) are likely to be more impacted by climate change than vertebrates (Finfish, turtles and dugongs). This is *inter alia* because although highly productive, their life spans are short, which makes it difficult for them to move out of a certain area severely impacted over many years before significant losses at the population level happen (Fulton et al. 2018).
- Climate change is likely to cause mostly negative direct effects on the fisheries investigated in this report, but some effects may also be positive, especially in the short to medium-term. If climate-related environmental changes exceed certain limits or ranges for species, they will either move if possible or have their abundance reduced (Pecl et al. 2014, Fulton et al. 2018).
- High water temperature can cause mortality, affect growth (relatively small warming may increase growth rates of sea cucumber and lobsters), reproduction and its timing, and negatively affect supporting habitats (coral reefs, seagrasses) of Finfish, invertebrates, dugongs and turtles. Elevated air temperatures can also reduce incubation success, shift timing of annual breeding cycle and increase ‘feminisation’ of Green turtle populations.
- Higher seas and extreme weather events can uproot mangrove trees and cause erosion and increase in turbidity, with consequent reduction in light penetration and salinity and an increase in sediment deposition, negatively affecting seagrasses and coral reefs. Some organisms, such as sea cucumbers may benefit from higher seas, but others like turtles and dugongs may be negatively affected via changes in abundance of preferred food (e.g. seagrass) and also via the inundation of nesting sites (turtles) and stranding (turtles and dugongs) associated with extreme weather events.

The second objective of the report was to use findings from the literature review to provide a detailed specification and costings for a future project that will produce an over-arching data framework at the appropriate spatial scales, as required to address future climate variability and change scenarios for Torres Strait fisheries, including detailed information about data availability, and specifications on data storage, management and data accessibility issues (Part 3).

- The data and modelling framework will primarily be designed to answer the following question: *What are the potential consequences associated with changes in local conditions, including climate variability and change, on the selected Torres Strait Fisheries and ecosystems?*
- The objectives of the modelling exercise are to simulate future climate scenarios and assess the impacts of these on fisheries and associated habitats and species through

quantitative evaluation. It will support the exploration of responses and strategies to manage the selected Torres Strait fisheries, such as the evaluation of:

1) Interactions between different fisheries and broader ecosystem functioning, including consideration of communities that rely on these resources;

2) Impacts of climate change scenarios on the abundance and distribution of selected species;

3) Impacts of current and future catchment conditions and management scenarios on fisheries;

4) Impacts of incidents (e.g. oil spills, ships run aground) on fisheries;

5) Combined scenarios of 1-4 to develop strategies that are robust across impacts and fisheries; and

6) Evaluation of alternative adaptation options.

- In order to address objectives, some of the desirable features of the modelling framework include: 1) Catchment runoff; 2) Hydrodynamics and transport; 3) Physio-chemical water quality constituents; 4) Biogeochemistry, 5) Fisheries dynamics; and 6) Ecological and socio-ecological relationships.
- Data requirements to simulate these desirable features include: a) biological and fisheries data (catches, catch locations, target species, gear, age and size frequency of catches, species distribution, growth rates, reproduction and maturity, mortality and population size); b) location, area and species of supporting habitats (mangroves, seagrasses and mangroves); and c) physical and biogeochemical data (currents, turbidity, temperature (air and sea), tides and water level, light penetration, nutrients, salinity, sedimentation, pH, oxygen, grazing, extreme events, waves, moon phase, diseases and parasites).
- There is significant information covering Torres Strait fisheries, key marine species, habitats, geology and physiochemical water quality parameters. However, datasets are sparse both in space and time. A large-scale monitoring program for Torres Strait would support the identification of long-term trends and improve understanding about local and regional processes affecting habitats, species and fisheries (Pitcher et al. 2004), including the impacts of climate change on these (NESP Earth Systems and Climate Change Hub 2018).
- Most of the understanding about physical and biogeochemical cycles and processes (e.g. currents, tides, primary productivity, nutrients) in Torres Strait have been derived from remote sensing and hydrodynamic models developed in the 2000s and in the early 2010s, each with pros and cons relatively well-known. Limited physical long-term observational data is available as was collected mostly in the 1990s (Wolanski et al. 2013).
- Habitat, fisheries and ecological data are also sparse, but recent mapping of mangroves, seagrasses and coral reefs (Chapter 6) combined with survey data on substrate and species collected in large-scale sea cucumber and Tropical Rock Lobster surveys (Murphy et al. 2020, Plagányi et al. 2020b) offer valuable information about the location and health status of such habitats, which can support the development of models to explore impacts and adaptation options.
- A number of modelling initiatives are already in place in Torres Strait and it would be worth considering capitalising on these efforts.

- It is recommended that a dedicated regional hydrodynamic model, including physics and biogeochemistry be constructed for Torres Strait as the effort to re-run previously developed models will likely be similar to deploying an up-to-date state-of-the-art modelling platform such as eReefs, which has been developed for the Great Barrier Reef (GBR) region (Steven et al. 2019).
- A suitable strategy to develop ecosystem models for Torres Strait would be to develop some sort of hybrid MICE-Atlantis approach drawing on features from both approaches and coupled with a regional hydrodynamic model.
- The Torres Strait region will likely need to integrate a mix of modelling approaches that feed into one another, built in a stepwise fashion, such as the development of conceptual / qualitative model of the ecosystem, representing key fished species and other components of the ecosystem which are important for/linked to them, including drivers and stressors. Different model structures can be tested using qualitative network or other models to inform the development of a MICE or more complex ecosystem models.
- A cost-effective approach would be to couple a regional hydrodynamic model that simulates basic physical and biogeochemical processes with an ecological or socio-ecological model. Given there are already assessment models developed for some of the key species (e.g. Tropical Rock Lobster, bêche-de-mer, prawns), a useful starting point would be to combine these in an integrated spatial MICE for the Torres Strait region. This can form the basis of a more complex ecosystem model or help to ground-truth a larger more complex model.
- The proposed data framework identifies how the physio-chemical and ecological data could be managed and delivered to support the development of models. Datasets will be managed on CSIRO IT infrastructure, utilising relational database systems and enterprise file servers. Datasets will be described using geonetwork (www.marlin.csiro.au) and these descriptions can be made public to allow third parties (non-CSIRO) access data depending on level of permission granted (i.e. licence restrictions). Datasets can be shared using Open Geospatial Consortium (OGC) standards where appropriate, by using a standards-compliant webserver (geoserver) linked to the collated data. This framework is scalable, robust and compliant with open data/metadata standards, allowing a flexible data delivery method.

12.2 Key Recommendations

1. Prioritise physical data collection and further strengthen and expand a large-scale monitoring program for Torres Strait that would support the identification of long-term trends and improve understanding about local and regional processes affecting habitats, species and fisheries, and to support the development of models.
2. Staged approach in the development of an integrated ecosystem modelling framework to investigate the impacts of climate and local changes on fisheries in Torres Strait, via coupling together:

a. Development and implementation of data framework to support future modelling efforts in Torres Strait

b. Development of integrated ecological or socio-ecological models capable of integration with a regional hydrodynamic model:

    i. For example, combining existing data and models (Tropical Rock Lobster, bêche-de-mer, and dugongs) into an integrated spatial MICE, which will form the basis for a hybrid MICE-ATLANTIS ecosystem model;

    ii. Dedicated regional hydrodynamic model, including physics and biogeochemistry for Torres Strait, for example similar to eReefs.

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PZJA advisory committee	**Position**	**Name**
TRL RAG	Chairperson	Ian Knuckey
TRL RAG	Scientific member	Eva Plaganyi
FF RAG and FFWG	Chairperson and Sci Member	David Brewer
FF RAG and FF WG	Scientific member	Michael O'Neill
FF RAG	Scientific member	Rik Buckworth
FF RAG	Scientific member	Ashley Williams
FF WG	Permanent observer, scientific	Trevor Hutton
HCWG	Scientific member	Tim Skewes
HCWG	Scientific member	Steven Purcell
TSSAC	Chairperson	Ian Cartwright
TSSAC	Scientific member	Roland Pitcher
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-	Climate and Coastal, TSRA	John Rainbird
-	AFMA	Selina Stoute
-	AFMA	Danait Ghebrezgabhier
-	AFMA	Georgia Langdon
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Appendix A Available data

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
1	Fisheries	Prawn	AFMA	Logbooks and catch disposal records	Observational	1978	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005. Data is scattered until 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
2	Fisheries	Prawn - Tiger	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
3	Fisheries	Prawn - Endeavour	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
4	Fisheries	Prawn - King	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
5	Fisheries	Prawn - Vessels	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
6	Fisheries	By-Catch Flatback Turtle	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
7	Fisheries	By-Catch Green Turtle	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
8	Fisheries	By-Catch Hawksbill Turtle	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
9	Fisheries	By-Catch Loggerhead Turtle	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
10	Fisheries	By-Catch Pacific (Olive) Turtle	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
11	Fisheries	By-Catch Turtles	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
12	Fisheries	By-Catch Sawfish	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
13	Fisheries	By-Catch Seasnakes	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
14	Fisheries	By-Catch Seahorses and Pipefish	AFMA	Logbooks and catch disposal records	Observational	2015	2019	catch and effort information for the Torres Strait Prawn Fishery (TSPF) from the 2019 fishing season in comparison to previous years.The PZJA collect data for the TSPF through both operator completed daily fishing logbooks and an automatic Vessel Monitoring System (VMS) established in 2005.	on request to AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia.
15	Fisheries	Sea cucumbers	AFMA	Bêche-de-mer Fishery-dependent data (logbooks)	Observational	2017	2020		on request to AFMA	https://www.afma.gov.au/fisheries-services/logbooks-and-catch-disposal

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
16	Fisheries	*Coral trout (Plectropomus spp.)*	partly in the paper	Population biology of coral trout species in eastern Torres Strait: Implications for fishery management	Modelled and Observational	2004	2005	Information on the catch composition of coral trout species was obtained during observer surveys on board Islander and nonindigenous. Authors used modelled growth curves for coral trout. commercial vessels operating in the ETS		Williams, A. J., L. M. Currey, G. A. Begg, C. D. Murchie and A. C. Ballagh (2008). "Population biology of coral trout species in eastern Torres Strait: Implications for fishery management." Continental Shelf Research 28(16): 2129-2142.
17	Fisheries	*Dugong dugon*	CSIRO NERP	Quantification of risk from shipping to large marine fauna across Australia. Dugong	Modelled	2013	2015	Broadscale and finescale dugong vessel strike risk maps (2013-15). Also for other species: humpback whale, green turtle, seagrass locations and generic species	unknown	https://www.marlin.csiro.au/geonetwork/srv/eng/search#!40e7e293-e5e2-4d46-9611-c2db22182b24
18	Fisheries	*Dugong dugon*	Not clear. Needs search	The Torres Strait Dugong Fishery	Modelled	1991	1993	Population estimates and yield. 1994 Torres Strait Dugong fishery report	unknown	http://www.cmar.csiro.au/datacentre/torres/AFMA1980_2003/DVDVer101/Reports/r494.pdf
19	Fisheries	*Dugong dugon*	Not clear. Needs search	1991 The Status of the Dugong in Torres Strait	Observational	1987	1988	Observed count. Population estimate	unknown	researchgate.net/publication/237260190_The_Status_of_the_Dugong_in_Torres_Strait
20	Fisheries	*Dugong dugon*	https://dugongs.tropicaldatahub.org/	JCU Dugong aerial survey database	Observational	1984	2013	Online database of aerial surveys	Near CC. Details at https://dugongs.tropicaldatahub.org/	https://research.jcu.edu.au/researchdata/default/detail/70987a255de5bba750bd671901009ac3/
21	Fisheries	*Dugong dugon*	Not clear. Needs search	Stock Assessment Report on Dugong in the Torres Strait 1994	Modelled	1994	1994	Stock assessment report. Population estimates and yield	Copyrighted	http://dugong.id.au/publications/TechnicalReports/Marsh%201995.%20Torres%20Strait%20Dugong%20Stock%20Assessment%20Report.%20T~1.pdf
22	Fisheries	*Dugong dugon*	In the paper	Temporal variability in the life history and reproductive biology of female dugongs in Torres Strait: The likely role of sea grass dieback	Observational	1978	1982	Indigenous catch from 2 islands. 35+ specimens	unknown	https://www.sciencedirect.com/science/article/pii/S0278434308001349#fig1
23	Habitat	*Seagrass*	In the paper	Spatial patterns of sub-tidal seagrasses and their tissue nutrients in the Torres Strait, northern Australia:	Observational			Forraging sites	unknown	https://www.sciencedirect.com/science/article/pii/S0278434308001441#fig3

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
				Implications for management						
24	Fisheries	*Dugong dugon*	In the paper	Aerial surveys and the potential biological removal technique indicate that the Torres Strait dugong fishery is unsustainable	Observational	1987	2001	Population estimates from aerial surveys	unknown	https://zslpublications.onlinelibrary.wiley.com/doi/epdf/10.1017/S1367943004001635
25	Fisheries	*Dugong dugon*	In the paper	Diving behaviour of dugongs, Dugong dugon	Observational			Diving behaviour. One site is in the GOC	unknown	http://apps.webofknowledge.com/full_record.do?product=WOS&search_mode=GeneralSearch&qid=1&SID=F3cEpMRxEhS9IDR3OHk&page=4&doc=35&cacheurlFromRightClick=no
26	Fisheries	*Dugong dugon*	In the paper	Pathological findings in wild harvested dugongs Dugong dugon of central Torres Strait, Australia	Observational	2011	2011	Six dugongs hunted legally examined on Mabuiag Island in 2011	unknown	https://www.int-res.com/articles/dao2015/113/d113p089.pdf
27	Fisheries	*Dugong dugon*	Shapefile at: https://eatlas.org.au/pydio/public/0a6f55.php	Satellite Tracking of Sympatric Marine Megafauna Can Inform the Biological Basis for Species Co-Management	Observational	2009	2010	Tagging and tracking 6 dugongs at Mabuiag Isl.	unknown	https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0098944&type=printable
28	Fisheries	*Dugong dugon*	In the paper	Movements and distribution of dugongs (Dugong dugon) in a macro-tidal environment in northern Australia	Observational	2002	2002	Dugong sightings from aerial surveys in the TS 2002	unknown	https://www.publish.csiro.au/zo/pdf/ZO08033

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
29	Fisheries	*Dugong dugon*	On team share and in https://biocache.ala.org.au/occurrences/search?q=qid:1590003182716#tab_recordsView	ALA collection records search	Observational	1936	2007	Data search in ALA provides 26 records (in Excel file) from QM, AM, WAM, National Whale and Dolphin Sightings and Strandings Database, Australian Antarctic Data Centre, NT DENR, Fauna Atlas N.T.	CC-BY	On file
30	Fisheries	*Dugong dugon*	In the paper	Estimating Animal Abundance in Heterogeneous Environments: An Application to Aerial Surveys for Dugongs	Modelled		Uses previous surveys	Population estimates from aerial surveys	unknown	https://wildlife.onlinelibrary.wiley.com/doi/pdf/10.2193/0022-541X%282006%2970%5B255%3AEAAIHE%5D2.0.CO%3B2
31	Fisheries	*Dugong dugon*	In the paper	The Sustainability of the Indigenous Dugong Fishery in Torres Strait, Australia/Papua New Guinea		1987	1993	Sustainability of TS population. Based on previous studies	unknown	https://conbio.onlinelibrary.wiley.com/doi/epdf/10.1046/j.1523-1739.1997.95309.x
32	Fisheries	*Dugong dugon*	Needs search. Not easily found online. Data.gov does not provide it.	SPRAT Species Profile and Threats Database - Dugong	Australian distribution		From various sources		CC-BY	environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=28
33	Fisheries	*Dugong dugon*	eAtlas	Dugong relative density 1987-2011 (JCU, NERP-TE1.2)	Modelled	1987	2011	Modelled distibution density	CC-BY	https://eatlas.org.au/data/uuid/70e21d20-cc5e-4d1d-9d2b-7b08f4b061a2
34	Fisheries	*Dugong dugon*	eAtlas	Dugong relative density 1987-2013 (JCU, NERP-TE2.1)	Modelled	1987	2013	Modelled distibution density	CC-BY	https://eatlas.org.au/data/uuid/8a49e81b-0f88-43b4-8599-fc371da4063a

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
35	Fisheries	*Dugong dugon*	Table 1 is a good overview of the aerial surveys conducted on Dungon in the TS	Informing Species Conservation at Multiple Scales Using Data Collected for Marine Mammal Stock Assessments	Observational			Species conservation	unknown	https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0017993#pone-0017993-g001
36	Fisheries	*Dugong dugon*	Fig. 8 in eAtlas, rest unknown	Aerial survey of Torres Strait to evaluate the efficacy of an enforced and possibly extended Dugong Sanctuary as one of the tools for managing the dugong fishery.	Modelled	2011	2011	Distribution modelling	unknown	https://data.marinemammals.gov.au/common/documents/grants/2010/Marsh_2.pdf
37	Fisheries	*Dugong dugon*	Figs. in the paper. Repository unknown	Condition, status and trends and projected futures of the dugong in the Northern Great Barrier Reef and Torres Strait; including identification and evaluation of the key threats and evaluation of available management options to improve its status	Observational			Temporal changes and desity. Some evidence that seagrass abundance affects reproductive rates in females.	copyrighted	http://rrrc.org.au/wp-content/uploads/2014/06/141-JCU-2007-Marsh-et-al-Dugong-status-and-trends.pdf
38	Fisheries	*Dugong dugon*		Analysis of Stomach Contents of Dugongs from Queensland	Observational	1968	1978	Stomach content, diet of 2 dugong from the TS	copyrighted	https://www.publish.csiro.au/wr/pdf/WR9820055

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
39	Fisheries	*Dugong dugon*	Access is via registration and registration is not provided. Requires emailing JCU.	Dugong Tropical Data Hub. Dugong Aerial Survey Database. DOI: 10.4225/28/557F7B61ED8E1	Observational	1984	2013	Observations from aerial surveys	contact researchdata@jcu.edu	https://dugongs.tropicaldatahub.org/
40	Fisheries	*Dugong dugon*	Some in eAtlas, rest unknown	An assessment of the distribution and abundance of dugongs in the Northern Great Barrier Reef and Torres Strait	Observational	1985	2013	Distribution and abundance		http://www.nerptropical.edu.au/sites/default/files/publications/files/An%20assessment%20of%20the%20distribution%E2%80%A6%20Sobtzick%20et%20al%202014.pdf
41	Fisheries	*Dugong dugon*	Partly in the paper	Improving the estimates of abundance of dugongs and large immature and adult-sized green turtles in Western and Central Torres Strait	Observational	2006	2013	Distribution and abundance		http://www.tsra.gov.au/__data/assets/pdf_file/0007/13975/JCU-TSRA-2016-Improving-the-Estimates-of-Abundance-of-Dugongs-Green-Turtles-in-Western-and-Central-Torres-Strait.pdf
42	Fisheries	*Tropical Rock Lobster*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2019	CSIRO has been engaged, for the past 30 years, by AFMA to undertake annual diving surveys to determine the relative abundance of Tropical Rock Lobsters (TRL) (Panulirus ornatus). Divers complete a census of lobster along transects at pre-determined sampling sites, with a subset of lobster collected for additional measurements. Data collected: The number and age-class of lobsters observed, but not collected; The number of lobsters collected per age-class; The size (tail width in mm), sex and moult stage of the collected lobsters	Contact CSIRO	Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.

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43	Habitat	*Algae*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2019	Torres Strait		Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
44	Habitat	*Coral reefs*		Marine resources, biophysical processes, and environmental management of a tropical shelf seaway: Torres Strait, Australia-Introduction to the special issue				Torres Strait		Harris, P. T., A. J. Butler and R. G. Coles (2008). "Marine resources, biophysical processes, and environmental management of a tropical shelf seaway: Torres Strait, Australia-Introduction to the special issue." Continental Shelf Research 28(16): 2113-2116.
45	Habitat	*Coral reefs*	eAtlas: https://eatlas.org.au/ts/maps/torres-strat-islands-reefs-poster	Mapping the Torres Strait Reef and Island Features: Extending the GBR Features (GBRMPA) dataset. Report to the National Environmental Science Programme.	Observational		2015	historical landsat images		Lawrey, E. P. and M. Stewart (2016). Mapping the Torres Strait Reef and Island Features: Extending the GBR Features (GBRMPA) dataset. Report to the National Environmental Science Programme. Cairns, Reef and Rainforest Research Centre Limited.
46	Habitat	*Coral reefs*	CSIRO	Mapping and characterisation of the inter-reefal benthic assemblages of the Torres Strait	Observational	2004	2004	Torres Strait	unknown	Haywood, M. D. E., C. R. Pitcher, N. Ellis, T. J. Wassenberg, G. Smith, K. Forcey, I. McLeod, A. Carter, C. Strickland and R. Coles (2008). "Mapping and characterisation of the inter-reefal benthic assemblages of the Torres Strait." Continental Shelf Research 28(16): 2304-2316.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
47	Physiochemical	*Water depth*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Data from various surveys since 1989	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
48	Physiochemical	*Slope of the seabed*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

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49	Physiochemical	*Nitrate*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
50	Physiochemical	*Oxygen*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
51	Physiochemical	*Phosphate*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
52	Physiochemical	*Silicate*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
53	Physiochemical	*Salinity*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
54	Physiochemical	*Water temperature*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
55	Physiochemical	*Currents*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
56	Physiochemical	*Tides*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
57	Physiochemical	*Carbonate concentration*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
58	Physiochemical	*Bottm Sediments*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
59	Physiochemical	*Chlorophyl a*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
60	Physiochemical	*Suspended sediments*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
61	Ecological	*Benthic irradiance*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	2004	2004	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
62	Fisheries	*Prawn Trawling effort*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	1987	2002	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
63	Habitat	*Epibenthos*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	1987	2002	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
64	Habitat	*Seagrass*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	1987	2002	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
65	Habitat	*Algae*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	1987	2002	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/
66	Ecological	*Seabed fishes*	CSIRO	Torres Strait seabed and water-column data collation, biophysical modeling and characterization	Models and Observations	1985	1986	Torres Strait	unknown	Pitcher, C. R., S. Condie, N. Ellis, I. McLeod, M. Haywood, S. R. Gordon, T. D. Skewes, J. Dunn, D. Dennis, E. Cotterell, M. Austin, W. Venables and T. Taranto (2004). Torres Strait seabed and water-column data collation, biophysical modeling and characterization. Final Report to the National Oceans Office. Cleveland: 117. https://parksaustralia.gov.au/marine/management/resources/scientific-publications/torres-strait-seabed-and-water-column-data-collation-bio-physical-modeling-and/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
67	Habitat	*Coral reefs*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2020	Torres Strait		Pitcher, C. R., T. D. Skewes, D. M. Dennis and J. H. Prescott (1992). "Distribution of Seagrasses, Substratum Types and Epibenthic Macrobiota in Torres Strait, with Notes on Pearl Oyster Abundance." Australian Journal of Marine and Freshwater Research 43(2): 409-419.
68	Fisheries	Rock Lbster (*Panulirus ornatus*)	CSIRO	Tropical Rock Lobster recent catches	Observational	1973	2019			Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
69	Fisheries	*Prawns*	AFMA	Trawl effort data - AFMA fisheries logbook	Observational				on request to AFMA	https://www.afma.gov.au/resources/catch-data
70	Fisheries	*Prawns: Brown tiger*	on paper	Migration and growth of two tropical penaeid shrimps within Torres Strait, northern Australia	Observational	1986	1988			Watson, R. A. and C. T. Turnbull (1993). "Migration and growth of two tropical penaeid shrimps within Torres Strait, northern Australia." Fisheries Research 17(3): 353-368.
71	Fisheries	*Prawns: Blue-tailed endeavour*	Queensland Department of Primary Industries	Settlement of juvenile Penaeus esculentus	Observational	1986	1988	Information on settlement, maturity, growth and reproduction for Torres Strait.		Turnbull, C. T. and J. E. Mellors (1990). Settlement of juvenile Penaeus esculentus (Haswell, 1879) on nursery grounds in Torres Strait. Torres Strait Prawn Project: A review of research 1986-88. J. E. Mellors. Brisbane, Fisheries Branch, Queensland Departmnet of Primary Industries, Information series Q190018.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
72	Fisheries	*Prawns: Red-spot king prawn*	Queensland Department of Primary Industries	Experimental beam trawls for sampling juvenile prawns	Observational	1986	1988			Turnbull, C. T. and R. A. Watson (1990). Experimental beam trawls for sampling juvenile prawns. Torres Strait Prawn Project: A review of research 1986-88, Information series Q190018. J. E. Mellors. Brisbane, Fisheries Branch, Queensland Departmnet of Primary Industries.
73	Fisheries	*Prawns*	AFMA	Torres Strait Prawn Fishery Data Summary 2015	Observational	2015	2015		Contact AFMA	Cocking, L. and C. Turnbull (2016). Torres Strait Prawn Fishery Data Summary 2015. Canberra, Australia.
74	Fisheries	*Prawns*	AFMA	Torres Strait Prawn Fishery Data Summary 2016	Observational	2016	2016		Contact AFMA	Cocking, L. and C. Turnbull (2017). Torres Strait Prawn Fishery Data Summary 2016. Canberra, Australia: 22.
75	Fisheries	*Prawns*	AFMA	Torres Strait Prawn Fishery Data Summary 2017	Observational	2017	2017		Contact AFMA	Turnbull, C. and L. Cocking (2018). Torres Strait Prawn Fishery Data Summary 2017. Canberra, Australia.
76	Fisheries	*Prawns*	AFMA	Torres Strait Prawn Fishery Data Summary 2018	Observational	2018	2018		Contact AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2018. Canberra, Australia.
77	Fisheries	*Prawns*	AFMA	Torres Strait Prawn Fishery Data Summary 2019	Observational	2019	2019		Contact AFMA	Turnbull, C. and L. Cocking (2019). Torres Strait Prawn Fishery Data Summary 2019. Canberra, Australia: 33p.
78	Fisheries	Sea cucumbers	PZJA website	Beche-de-mer catch watch reports	Observational	2019	2020		available through website	https://www.pzja.gov.au/fishery-catch-watch-reports
79	Fisheries	Sea cucumbers	CSIRO	Stock survey of sea cucumbers in East Torres Strait	Observational	2019	2020	Fishery independent survey across Torres Strait		Murphy, N., T. Skewes, E. Plaganyi, S. Edgar, K. Salee and C. Wildermuth (2020). Stock survey of sea cucumbers in East Torres Strait. Progress report. May 2020. . Brisbane, Australia.
80	Fisheries	Sea cucumbers	CSIRO	Stock survey of sea cucumbers in East Torres Strait	Observational	2009	2009	Fishery independent survey across Torres Strait		Skewes, T. D., N. E. Murphy, I. McLeod, E. Dovers, C. Burridge and W. Rochester (2010). Torres Strait Hand Collectables, 2009 survey: Sea cucumber - Final Report. Cleveland: 70p.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
81	Fisheries	Sea cucumbers	CSIRO	Survey and stock size estimates of the shallow reef (0-15 m deep) and shoal area (15–50 m deep) marine resources and habitat mapping within the Timor Sea MOU74 Box	Observational	1995	1996	Fishery independent survey		Skewes, T. D., D. M. Dennis, D. R. Jacobs, S. R. Gordon, T. J. Taranto, M. Haywood, C. R. Pitcher, G. P. Smith, D. Milton and I. R. Poiner (1999). Survey and stock size estimates of the shallow reef (0-15 m deep) and shoal area (15–50 m deep) marine resources and habitat mapping within the Timor Sea MOU74 Box. Cleveland, Australia: 71p.
82	Fisheries	Sea cucumbers	CSIRO	Stock survey and Sustainable Harvest Strategies for the Torres Strait Beche-de-Mer	Observational	2002	2002	Fishery independent survey across Torres Strait		Skewes, T., D. Dennis, A. Koutsoukos, M. Haywood, T. Wassenberg and M. Austin (2004). Stock survey and Sustainable Harvest Strategies for the Torres Strait Beche-de-Mer. Report prepared for the Australian Fisheries Management Authority and Queensland Fishery Service. Thursday Island, Queensland, CSIRO Marine and Atmospheric Research.
83	Fisheries	Sea cucumbers	CSIRO	Torres Strait Hand Collectables, 2009 survey: Sea cucumber	Observational	2005	2009	Fishery independent survey across Torres Strait. Only for years 2005 and 2009		Skewes, T. D., N. E. Murphy, I. McLeod, E. Dovers, C. Burridge and W. Rochester (2010). Torres Strait Hand Collectables, 2009 survey: Sea cucumber - Final Report. Cleveland: 70p.
86	Physiochemical	Sea Surface Temperature	UK Met Office		Modelled	1850	2020	Global dataset for land and sea surface temperature (HADCRUT4)	Free download	https://crudata.uea.ac.uk/cru/data/temperature/#datdow
87	Physiochemical	Sea Surface Temperature	UK Met Office		Modelled	1851	2020	Global dataset for sea surface temperature anomaly (HADST3)	Free download	https://www.metoffice.gov.uk/hadobs/hadsst3/data/download.html
88	Physiochemical	Sea Surface Temperature	Bureau of Meteorology		Modelled	1900	2020	Sea surface temp (SST) time series data is available for boxed region round Australia and six regions within this box. Relevant to Torres Strait are the Northern Tropics and Coral Sea regions.	Mean SST values for Northern Tropics and Coral Sea can be requested to BoM	http://www.bom.gov.au/climate/change/about/sst_timeseries.shtml

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
89	Physiochemical	Sea Surface Temperature	QLD DSITIA	QLD storm tides monitoring sites	Observational	2011	2020	Obervations every minute for Sea surface temp (SST) is available for the following stations: 1) Boigu Island monitoring site, 2) Ugar Island monitoring site, 3) Iama Island monitoring site, 4) Moa Island (St Pauls) monitoring site, 5) Moa Island (Kubin) monitoring site, and 6) Thursday Island monitoring site.	Data can be obtained by contacting Daryl Metters from the Queensland Department of Science Information Technology Innovation and the Arts (DSITIA)	1- Boigu Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/boigu): Installation 23 November 2013 2- Ugar Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/ugar): Installation 22 November 2013 3- Iama Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/iama): Installation 22 November 2013 4- Moa Island (St Pauls) monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/stpauls): Installation 23 November 2013, not currently recording 5- Moa Island (Kubin) monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/kubin): Installation 22 November 2013 6- Thursday Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/thursday-island): Installation 13 May 2011

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
90	Physiochemical	Sea Surface Temperature	Geosciences Australia		Modelled	1997	2004	outputs include three-dimensional distributions of velocity, temperature, salinity, and mixing coefficients, as well as two-dimensional fields such as sea level and bottom friction	Not known	Saint-Cast, F. (2008). "Multiple time-scale modelling of the circulation in Torres Strait-Australia." Continental Shelf Research 28(16): 2214-2240.
91	Physiochemical	Sea Surface Temperature	IMOS		Modelled		check	SST maps obtained from satellite data based on AVHRR instruments on a 2D grid with a cell size of 0.02deg. X 0.02deg., with each cell representing SST averaged over 14 days.	Free access	https://portal.aodn.org.au/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
92	Physiochemical	Sea Surface Temperature	CSIRO		Modelled	1992	2099	The modified Ocean Forecasting Australia Model version 3 (OFAM-v3) run under standard IPCC emissions scenarios to project future ocean states around Australia. These scenarios are taken from global ocean-atmosphere models (CMIP5 climate models, which set the context for the finer scale OFAMv3 model, which focuses on the Australian region in more detail. The OFAM-v3 model was originally developed for upper-ocean short-range operational forecasting (e.g. ocean forecasts of the type found at the bom.gov.au website) and was adapted for climate change studies. The downscaling simulations run with OFAM-v3 provide high-resolution (10km, 0.1º) outputs that can resolve important oceanographic features (e.g. eddies) and how these may change under future climate change. A biogeochemical model that represents nutrient flows and plankton components of the ocean food web (primary producers such as phytoplankton, some bacteria and zooplankton consumers) was coupled with OFAM-v3 to produce patterns of primary productivity, nutrient cycling and carbon fluxes that are consistent with observations. The OFAM3 outputs provide downscaled climate change projections for all common ocean state variables including currents, temperature (ºC), phytoplankton (mmol Nm-3) and primary productivity (mmol C m-2day-1). These outputs were then used as input to the ecosystem models.Data were modelled for the Torres Strait as defined by: A. Top left coordinates: 9o 08’ 24.83” S / 141o 01’ 0.00” E B. Bottom Right coordinates: 11o 10’ 0.00” S / 144o 28’ 0.00” E	on request to Richard Matear and Xuebin Zhang (CSIRO)	Fulton, E. A., A. J. Hobday, H. Pethybridge, J. Blanchard, C. Bulman, I. Butler, W. Cheung, L. X. C. Dutra, R. Gorton, T. Hutton, H. Lozano-Montes, R. Matear, G. Pecl, E. E. Plagányi, C. Villanueva and X. Zhang (2018). Decadal scale projection of changes in Australian fisheries stocks under climate change. Canberra. Plaganyi, E., M. Haywood, B. Gorton and S. Condie (2018). Environmental drivers of variability and climate projections for Torres Strait tropical lobster Panulirus ornatus. Brisbane: 156.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
93	Physiochemical	Nutrient	CSIRO		Modelled	1992	2099	The modified Ocean Forecasting Australia Model version 3 (OFAM-v3) run under standard IPCC emissions scenarios to project future ocean states around Australia. These scenarios are taken from global ocean-atmosphere models (CMIP5 climate models, which set the context for the finer scale OFAMv3 model, which focuses on the Australian region in more detail. The OFAM-v3 model was originally developed for upper-ocean short-range operational forecasting (e.g. ocean forecasts of the type found at the bom.gov.au website) and was adapted for climate change studies. The downscaling simulations run with OFAM-v3 provide high-resolution (10km, 0.1º) outputs that can resolve important oceanographic features (e.g. eddies) and how these may change under future climate change. A biogeochemical model that represents nutrient flows and plankton components of the ocean food web (primary producers such as phytoplankton, some bacteria and zooplankton consumers) was coupled with OFAM-v3 to produce patterns of primary productivity, nutrient cycling and carbon fluxes that are consistent with observations. The OFAM3 outputs provide downscaled climate change projections for all common ocean state variables including currents, temperature (ºC), phytoplankton (mmol Nm-3) and primary productivity (mmol C m-2day-1). These outputs were then used as input to the ecosystem models.Data were modelled for the Torres Strait as defined by: A. Top left coordinates: 9o 08’ 24.83” S / 141o 01’ 0.00” E B. Bottom Right coordinates: 11o 10’ 0.00” S / 144o 28’ 0.00” E	on request to Richard Matear and Xuebin Zhang (CSIRO)	Fulton, E. A., A. J. Hobday, H. Pethybridge, J. Blanchard, C. Bulman, I. Butler, W. Cheung, L. X. C. Dutra, R. Gorton, T. Hutton, H. Lozano-Montes, R. Matear, G. Pecl, E. E. Plagányi, C. Villanueva and X. Zhang (2018). Decadal scale projection of changes in Australian fisheries stocks under climate change. Canberra. Plaganyi, E., M. Haywood, B. Gorton and S. Condie (2018). Environmental drivers of variability and climate projections for Torres Strait tropical lobster Panulirus ornatus. Brisbane: 156.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
94	Physiochemical	Primary Productivity	CSIRO		Modelled	1992	2099	The modified Ocean Forecasting Australia Model version 3 (OFAM-v3) run under standard IPCC emissions scenarios to project future ocean states around Australia. These scenarios are taken from global ocean-atmosphere models (CMIP5 climate models, which set the context for the finer scale OFAMv3 model, which focuses on the Australian region in more detail. The OFAM-v3 model was originally developed for upper-ocean short-range operational forecasting (e.g. ocean forecasts of the type found at the bom.gov.au website) and was adapted for climate change studies. The downscaling simulations run with OFAM-v3 provide high-resolution (10km, 0.1º) outputs that can resolve important oceanographic features (e.g. eddies) and how these may change under future climate change. A biogeochemical model that represents nutrient flows and plankton components of the ocean food web (primary producers such as phytoplankton, some bacteria and zooplankton consumers) was coupled with OFAM-v3 to produce patterns of primary productivity, nutrient cycling and carbon fluxes that are consistent with observations. The OFAM3 outputs provide downscaled climate change projections for all common ocean state variables including currents, temperature (ºC), phytoplankton (mmol Nm-3) and primary productivity (mmol C m-2day-1). These outputs were then used as input to the ecosystem models.Data were modelled for the Torres Strait as defined by: A. Top left coordinates: 9o 08’ 24.83” S / 141o 01’ 0.00” E B. Bottom Right coordinates: 11o 10’ 0.00” S / 144o 28’ 0.00” E	on request to Richard Matear and Xuebin Zhang (CSIRO)	Fulton, E. A., A. J. Hobday, H. Pethybridge, J. Blanchard, C. Bulman, I. Butler, W. Cheung, L. X. C. Dutra, R. Gorton, T. Hutton, H. Lozano-Montes, R. Matear, G. Pecl, E. E. Plagányi, C. Villanueva and X. Zhang (2018). Decadal scale projection of changes in Australian fisheries stocks under climate change. Canberra. Plaganyi, E., M. Haywood, B. Gorton and S. Condie (2018). Environmental drivers of variability and climate projections for Torres Strait tropical lobster Panulirus ornatus. Brisbane: 156.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
95	Physiochemical	Phytoplankton	CSIRO		Modelled	1992	2099	The modified Ocean Forecasting Australia Model version 3 (OFAM-v3) run under standard IPCC emissions scenarios to project future ocean states around Australia. These scenarios are taken from global ocean-atmosphere models (CMIP5 climate models, which set the context for the finer scale OFAMv3 model, which focuses on the Australian region in more detail. The OFAM-v3 model was originally developed for upper-ocean short-range operational forecasting (e.g. ocean forecasts of the type found at the bom.gov.au website) and was adapted for climate change studies. The downscaling simulations run with OFAM-v3 provide high-resolution (10km, 0.1º) outputs that can resolve important oceanographic features (e.g. eddies) and how these may change under future climate change. A biogeochemical model that represents nutrient flows and plankton components of the ocean food web (primary producers such as phytoplankton, some bacteria and zooplankton consumers) was coupled with OFAM-v3 to produce patterns of primary productivity, nutrient cycling and carbon fluxes that are consistent with observations. The OFAM3 outputs provide downscaled climate change projections for all common ocean state variables including currents, temperature (ºC), phytoplankton (mmol Nm-3) and primary productivity (mmol C m-2day-1). These outputs were then used as input to the ecosystem models.Data were modelled for the Torres Strait as defined by: A. Top left coordinates: 9o 08’ 24.83” S / 141o 01’ 0.00” E B. Bottom Right coordinates: 11o 10’ 0.00” S / 144o 28’ 0.00” E	on request to Richard Matear and Xuebin Zhang (CSIRO)	Fulton, E. A., A. J. Hobday, H. Pethybridge, J. Blanchard, C. Bulman, I. Butler, W. Cheung, L. X. C. Dutra, R. Gorton, T. Hutton, H. Lozano-Montes, R. Matear, G. Pecl, E. E. Plagányi, C. Villanueva and X. Zhang (2018). Decadal scale projection of changes in Australian fisheries stocks under climate change. Canberra. Plaganyi, E., M. Haywood, B. Gorton and S. Condie (2018). Environmental drivers of variability and climate projections for Torres Strait tropical lobster Panulirus ornatus. Brisbane: 156.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
96	Physiochemical	Currents	CSIRO		Modelled	1992	2099	The modified Ocean Forecasting Australia Model version 3 (OFAM-v3) run under standard IPCC emissions scenarios to project future ocean states around Australia. These scenarios are taken from global ocean-atmosphere models (CMIP5 climate models, which set the context for the finer scale OFAMv3 model, which focuses on the Australian region in more detail. The OFAM-v3 model was originally developed for upper-ocean short-range operational forecasting (e.g. ocean forecasts of the type found at the bom.gov.au website) and was adapted for climate change studies. The downscaling simulations run with OFAM-v3 provide high-resolution (10km, 0.1º) outputs that can resolve important oceanographic features (e.g. eddies) and how these may change under future climate change. A biogeochemical model that represents nutrient flows and plankton components of the ocean food web (primary producers such as phytoplankton, some bacteria and zooplankton consumers) was coupled with OFAM-v3 to produce patterns of primary productivity, nutrient cycling and carbon fluxes that are consistent with observations. The OFAM3 outputs provide downscaled climate change projections for all common ocean state variables including currents, temperature (ºC), phytoplankton (mmol Nm-3) and primary productivity (mmol C m-2day-1). These outputs were then used as input to the ecosystem models.Data were modelled for the Torres Strait as defined by: A. Top left coordinates: 9o 08’ 24.83” S / 141o 01’ 0.00” E B. Bottom Right coordinates: 11o 10’ 0.00” S / 144o 28’ 0.00” E	on request to Richard Matear and Xuebin Zhang (CSIRO)	Fulton, E. A., A. J. Hobday, H. Pethybridge, J. Blanchard, C. Bulman, I. Butler, W. Cheung, L. X. C. Dutra, R. Gorton, T. Hutton, H. Lozano-Montes, R. Matear, G. Pecl, E. E. Plagányi, C. Villanueva and X. Zhang (2018). Decadal scale projection of changes in Australian fisheries stocks under climate change. Canberra. Plaganyi, E., M. Haywood, B. Gorton and S. Condie (2018). Environmental drivers of variability and climate projections for Torres Strait tropical lobster Panulirus ornatus. Brisbane: 156.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
97	Physiochemical	Currents	Geosciences Australia		Modelled	1997	2004	outputs include three-dimensional distributions of velocity, temperature, salinity, and mixing coefficients, as well as two-dimensional fields such as sea level and bottom friction	Not known	Saint-Cast, F. (2008). "Multiple time-scale modelling of the circulation in Torres Strait-Australia." Continental Shelf Research 28(16): 2214-2240.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
98	Physiochemical	Tides	QLD DSITIA	QLD storm tides monitoring sites	Observational	2011	2020	Obervations every minute of Tide actual, predicted and residuals plotted against predicted Lowest Astronomical Tide datum (LAT), and also plotted on the Australian Height Datum (AHD) is available for the following stations: 1) Boigu Island monitoring site, 2) Ugar Island monitoring site, 3) Iama Island monitoring site, 4) Moa Island (St Pauls) monitoring site, 5) Moa Island (Kubin) monitoring site, and 6) Thursday Island monitoring site. 1- Boigu Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/boigu): Installation 23 November 2013 2- Ugar Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/ugar): Installation 22 November 2013 3- Iama Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/iama): Installation 22 November 2013 4- Moa Island (St Pauls) monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/stpauls): Installation 23 November 2013, not currently recording 5- Moa Island (Kubin) monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/kubin): Installation 22 November 2013 6- Thursday Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/thursday-island): Installation 13 May 2011	Data can be obtained by contacting Daryl Metters from the Queensland Department of Science Information Technology Innovation and the Arts (DSITIA)	https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
99	Physiochemical	Tides	Geosciences Australia	Development of a bathymetric grid for the Gulf of Papua and adjacent areas	Modelled			bathymetric grid for the Gulf of Papua and northern Australia was produced for the area 140°–150°E, 6°–14°S, with a 3.6″ (~110 m) cell size.	Not known	Daniell, J. J. (2008). "Development of a bathymetric grid for the Gulf of Papua and adjacent areas: A note describing its development." Journal of Geophysical Research: Earth Surface 113(F1).
100	Physiochemical	Tides	Geosciences Australia / Partly in the report	Circulation modelling in Torres Strait	Modelled and Observational	1997	2002	The circulation model incorporated realistic atmospheric and oceanographic forcing, including winds, waves, tides, and large-scale regional circulation taken from global model outputs. Simulations covered a hindcast period of eight years, allowing the tidal, seasonal, and interannual flow characteristics to be investigated		Saint-Cast, F. and S. Condie (2006). Circulation modelling in Torres Strait: 82.
101	Physiochemical	Currents	Geosciences Australia / Partly in the report	Circulation modelling in Torres Strait	Modelled and Observational	1997	2002	The circulation model incorporated realistic atmospheric and oceanographic forcing, including winds, waves, tides, and large-scale regional circulation taken from global model outputs. Simulations covered a hindcast period of eight years, allowing the tidal, seasonal, and interannual flow characteristics to be investigated		Saint-Cast, F. and S. Condie (2006). Circulation modelling in Torres Strait: 82.
102	Physiochemical	Sea level	Geosciences Australia / Partly in the report	Circulation modelling in Torres Strait	Modelled and Observational	1997	2002	The circulation model incorporated realistic atmospheric and oceanographic forcing, including winds, waves, tides, and large-scale regional circulation taken from global model outputs. Simulations covered a hindcast period of eight years, allowing the tidal, seasonal, and interannual flow characteristics to be investigated		Saint-Cast, F. and S. Condie (2006). Circulation modelling in Torres Strait: 82.
103		Temperature	Geosciences Australia / Partly in the report	Circulation modelling in Torres Strait	Modelled and Observational	1997	2002	The circulation model incorporated realistic atmospheric and oceanographic forcing, including winds, waves, tides, and large-scale regional circulation taken from global model outputs. Simulations covered a hindcast period of eight years, allowing the tidal, seasonal, and interannual flow characteristics to be investigated		Saint-Cast, F. and S. Condie (2006). Circulation modelling in Torres Strait: 82.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
104		Salinity	Geosciences Australia / Partly in the report	Circulation modelling in Torres Strait	Modelled and Observational	1997	2002	The circulation model incorporated realistic atmospheric and oceanographic forcing, including winds, waves, tides, and large-scale regional circulation taken from global model outputs. Simulations covered a hindcast period of eight years, allowing the tidal, seasonal, and interannual flow characteristics to be investigated		Saint-Cast, F. and S. Condie (2006). Circulation modelling in Torres Strait: 82.
105	Physiochemical	Tides	Geosciences Australia		Modelled	1997	2004	outputs include three-dimensional distributions of velocity, temperature, salinity, and mixing coefficients, as well as two-dimensional fields such as sea level and bottom friction	Not known	Saint-Cast, F. (2008). "Multiple time-scale modelling of the circulation in Torres Strait-Australia." Continental Shelf Research 28(16): 2214-2240.
106	Physiochemical	Mean Sea Level	Aviso	Altimeter Mean Sea Level Data	Modelled	2015	2016	Altimetry-derived surface currents in the NCS were obtained from NOAA OSCAR. The spatial and temporal resolution of the data was 1/3 and 5 days respectively, from mid-November 2015 to mid-April 2016.	unknown	Wolanski, E., F. Andutta, E. Deleersnijder, Y. Li and C. J. Thomas (2017). "The Gulf of Carpentaria heated Torres Strait and the Northern Great Barrier Reef during the 2016 mass coral bleaching event." Estuarine Coastal and Shelf Science 194: 172-181. (http://www. aviso.altimetry.fr/
108	Physiochemical	Light penetration	CSIRO; Partly in the paper		Modelled	1997	2000	The 3-D sediment transport model was driven by a 3-D nonlinear, non-stationary hydrodynamic model, which solved Reynolds' equations with a free surface boundary condition, using the Boussinesq approximation and the hydrostatic assumption.	None mentioned	Margvelashvili, N., F. Saint-Cast and S. Condie (2008). "Numerical modelling of the suspended sediment transport in Torres Strait." Continental Shelf Research 28(16): 2241-2256.
109	Physiochemical	Salinity	Geosciences Australia		Modelled	1997	2004	outputs include three-dimensional distributions of velocity, temperature, salinity, and mixing coefficients, as well as two-dimensional fields such as sea level and bottom friction	Not known	Saint-Cast, F. (2008). "Multiple time-scale modelling of the circulation in Torres Strait-Australia." Continental Shelf Research 28(16): 2214-2240.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
110	Geological	Sediment	CSIRO; partly in the paper	Sediment mobility due to currents and waves in the Torres Strait Gulf of Papua region	Modelled and Observational	1990	1994			Hemer, M. A., P. T. Harris, D. Coleman and J. Hunter (2004). "Sediment mobility due to currents and waves in the Torres Strait Gulf of Papua region." Continental Shelf Research 24(19): 2297-2316.
111	Physiochemical	Currents	CSIRO; partly in the paper	Sediment mobility due to currents and waves in the Torres Strait Gulf of Papua region	Modelled and Observational	1990	1994			Hemer, M. A., P. T. Harris, D. Coleman and J. Hunter (2004). "Sediment mobility due to currents and waves in the Torres Strait Gulf of Papua region." Continental Shelf Research 24(19): 2297-2316.
112	Physiochemical	Tides	CSIRO; partly in the paper	Sediment mobility due to currents and waves in the Torres Strait Gulf of Papua region	Modelled and Observational	1990	1994			Hemer, M. A., P. T. Harris, D. Coleman and J. Hunter (2004). "Sediment mobility due to currents and waves in the Torres Strait Gulf of Papua region." Continental Shelf Research 24(19): 2297-2316.
113	Geological	Sediment	CSIRO; Partly in the paper	Numerical modelling of the suspended sediment transport in Torres Strait	Modelled	1997	2000	Torres trait region. The 3-D sediment transport model was driven by a 3-D nonlinear, non-stationary hydrodynamic model, which solved Reynolds' equations with a free surface boundary condition, using the Boussinesq approximation and the hydrostatic assumption.		Margvelashvili, N., F. Saint-Cast and S. Condie (2008). "Numerical modelling of the suspended sediment transport in Torres Strait." Continental Shelf Research 28(16): 2241-2256.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
114	Physiochemical	Barometric pressure	QLD storm tides monitoring sites		Observational	2011	2020	Obervations every minute for Sea barometric pressure is available for the following stations: 1) Boigu Island monitoring site, 2) Ugar Island monitoring site, 3) Iama Island monitoring site, 4) Moa Island (St Pauls) monitoring site, 5) Moa Island (Kubin) monitoring site, and 6) Thursday Island monitoring site. 1- Boigu Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/boigu): Installation 23 November 2013 2- Ugar Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/ugar): Installation 22 November 2013 3- Iama Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/iama): Installation 22 November 2013 4- Moa Island (St Pauls) monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/stpauls): Installation 23 November 2013, not currently recording 5- Moa Island (Kubin) monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/kubin): Installation 22 November 2013 6- Thursday Island monitoring site (https://www.qld.gov.au/environment/coasts-waterways/beach/storm-sites/thursday-island): Installation 13 May 2011	Data can be obtained by contacting Daryl Metters from the Queensland Department of Science Information Technology Innovation and the Arts (DSITIA)	https://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
115	Habitat	Mangroves	ESRI grid: https://www.agriculture.gov.au/abares/forestsaustralia/forest-data-maps-and-tools/spatial-data/forest-cover	Forests of Australia 2018 dataset	Observational (Landsat Foliage cover 30x30m)	2018	2018		CC BY4.0	https://www.agriculture.gov.au/sites/default/files/abares/forestsaustralia/documents/datasets/sofr2018/Forests_of_Australia_2018_Metadata.pdf
116	Habitat	Mangroves	527 MB data download on CM's PC: Queensland Spatial Catalogue Data Request (JobID: 20200525_132500028000-67480, Date: 25/05/2020)	REDD Regional Ecosystem Database (Excel, Access)	Observational (Ecosystem (vegetation) distribution observed, multiple sources)	2019	2019		CC	https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/descriptions/download

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
117	Habitat	Mangroves	1.6 GB data download on CM's PC: Queensland Spatial Catalogue Data Request (JobID: 20200525_130636315000-30676, Date: 25/05/2020)	Remnant 2017 broad vegetation groups - Queensland	Observational (Ecosystem (vegetation) distribution observed, multiple sources)	2020	2020		CC	http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={43A2CB31-9D83-4BB9-ACE7-05E7BD271FE3}
118	Habitat	Mangroves	http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={F5CF90D6-5881-4D8F-9581-D8F55D25F9CE}	Remnant vegetation cover - 2017 - Queensland	Observational	2017	2017	Ecosystem mapping	CC BY 4.0	http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={F5CF90D6-5881-4D8F-9581-D8F55D25F9CE}
119	Habitat	Mangroves	http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=Queensland+wetland+data+series	Wetland data - version 5 - Queensland series	Observational	2019	2019	Mapping of water bodies and wetland regional ecosystems at 1:100,000 scale across Queensland	CC BY 4.0	http://qldspatial.information.qld.gov.au/catalogue/custom/search.page?q=Queensland+wetland+data+series

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
120	Habitat	Mangroves	https://wetlandinfo.des.qld.gov.au/ is another portal with wetland v5 maps. Check source and if it has more than qldspatial	Wetland data - version 5 - Queensland series	Observational	2019	2019	Mapping of water bodies and wetland regional ecosystems at 1:100,000 scale across Queensland	CC BY 4.0	https://wetlandinfo.des.qld.gov.au/
121	Habitat	Mangroves	553 MB data download on CM's PC: Queensland Spatial Catalogue Data Request (JobID: 20200525_144339773000-67480, Date: 25/05/2020)	Map of Queensland wetland environmental values		2020	2020		cc	qldspatial.information.qld.gov.au/catalogue/custom/search.page?q="Map+of+Queensland+wetland+environmental+values"

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
122	Habitat	Mangroves	Can be downloaded as xls file. Search in approximate TS area returned 137 record from approx. 15 institutions which are on CM's PC	Atlas of Living Australia	Observational	2020	2020		CC	https://www.ala.org.au/
123	Habitat	Mangroves	eAtlas. Downloaded to GIS on CM's PC	Map of research work undertaken by NERP project 2.2.	Locations and tracks of mangrove surveys	2015	2015		CC	https://eatlas.org.au/nerp-te/ts-jcu-mangrove-freshwater-status-torres-strait-islands-2-2
124	Habitat	Mangroves	Excel spreadsheet. Downloaded on CM's PC: https://eatlas.org.au/pydio/public/ts_nerp-te-2-2_jcu_mangrove-species-surveys_1981-2013-zip.php	Mangrove species in Torres Strait (list of species per island) (NERP TE 2.2, JCU)	Observational				Not clear	https://eatlas.org.au/node/1525

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
125	Habitat	Mangroves	In paper	Mangrove and Freshwater Wetland Habitat Status of the Torres Strait Islands Biodiversity, Biomass, Changing Condition of Wetlands	Observations (percentage coverage by island)	2012	2014		Not clear	https://www.researchgate.net/publication/309721863_Mangrove_and_Freshwater_Wetland_Habitat_Status_of_the_Torres_Strait_Islands_Biodiversity_Biomass_Changing_Condition_of_Wetlands
126	Habitat	Mangroves	Data source given as 'in publication'. Location of spatial layers not clear. Requires search	Distribution of Mangroves in Torres Strait	Observations (Mapping based on Landsat TM satellite imagery)	1997	1997		Not clear	http://www.marlin.csiro.au/geonetwork/srv/eng/search#!e2d96ace-98da-76c3-e043-08114f8c0f19
127	Habitat	Mangroves	data.gov	Queensland - National Intertidal-Subtidal Benthic NISB Habitat Map (PLUS)		2007	2007		CC	http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B3C2A5C8D-8AC6-43EC-B603-8150F2B2BBD1%7D
128	Fisheries	Turtles	eAtlas	Marine turtles and dugongs of the Torres Strait - Spatial models of dugong and turtle distribution and relative density of aerial surveys from 1987 - 2013 (NERP TE 2.1, JCU)	Modelled and Observational	1987	2013	raster spatial model of the distribution and relative density of dugongs (Dugong dugong) in the Torres Strait region based on an aggregate of 27 years (1987 - 2013) of systematic aerial surveys; and (2) a raster spatial model of the distribution and relative density of marine turtles (green turtles, Chelonia mydas) in the Torres Strait based on an aerial survey conducted in 2013. https://eatlas.org.au/geonetwork/srv/eng/metadata.show?uuid=939cb936-68b9-4d9f-925e-f5ce12a3bf34&currTab=complete	CC	https://eatlas.org.au/data/uuid/939cb936-68b9-4d9f-925e-f5ce12a3bf34

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
129	Habitat	Seagrass	JCU	Torres Strait Mapping: Seagrass Consolidation, 2002 – 2014	Modelled and Observational	2002	2014		The large seagrass spatial composite is not available publically but may be obtained through special request to Dr Alex Carter, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER)	Carter, A. B., H. A. Taylor and M. A. Rasheed (2014). Torres Strait Mapping: Seagrass Consolidation, 2002 – 2014. Carins, Centre for Tropical Water & Aquatic Ecosystem Research: 47pp. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+55+Torres+strait+mapping+seagrass+consolidation+(2).pdf&subfolder_nav_tracking=1
130	Habitat	Seagrass	JCU	Torres Strait Seagrass 2019 Report Card	Modelled and Observational	2018	2019	Data used in this report card was collected from mid-2018 to mid-2019 for the Torres Strait Seagrass Monitoring Program (TSSMP). The TSSMP incorporates the Torres Strait Seagrass Observers Program, Ranger Subtidal Monitoring Program, Queensland Ports Seagrass Monitoring Program, and Reef-top Monitoring Program. Twenty-seven sites/meadows were classified for the 2019 report card across four Torres Strait Island Clusters.		Carter, A. B., J. M. Mellors, C. Reason and M. A. Rasheed (2019). Torres Strait Seagrass 2019 Report Card. Cairns: 62p.. https://www.dropbox.com/s/uydzgt5jk40rirj/19%2016%20Torres%20Strait%20seagrass%202019%20report%20card.pdf?dl=0
131	Habitat	Seagrass	JCU	The effects of climate on seagrass in the Torres Strait – 2011-2014 Report	Modelled and Observational	2011	2014	An intertidal seagrass monitoring site was established at Mabuiag Island where information on seagrass biomass and species composition, and environmental data including irradiance (light), global solar exposure, daytime tidal air exposure, mean and maximum daily water temperature, rainfall, wind speed and salinity, were collected		Carter, A. B., H. A. Taylor, S. A. McKenna, P. Y. York and M. A. Rasheed (2014). The effects of climate on seagrass in the Torres Strait – 2011-2014 Report. Cairns: 36p. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+48+The+effect+of+climate+on+seagass+in+the+Torres+Strait.pdf&subfolder_nav_tracking=1

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
132	Physiochemical	Light penetration	JCU	The effects of climate on seagrass in the Torres Strait – 2011-2014 Report	Observational	2011	2014	An intertidal seagrass monitoring site was established at Mabuiag Island where information on seagrass biomass and species composition, and environmental data including irradiance (light), global solar exposure, daytime tidal air exposure, mean and maximum daily water temperature, rainfall, wind speed and salinity, were collected		Carter, A. B., H. A. Taylor, S. A. McKenna, P. Y. York and M. A. Rasheed (2014). The effects of climate on seagrass in the Torres Strait – 2011-2014 Report. Cairns: 36p. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+48+The+effect+of+climate+on+seagass+in+the+Torres+Strait.pdf&subfolder_nav_tracking=2
133	Physiochemical	Solar exposure	JCU	The effects of climate on seagrass in the Torres Strait – 2011-2014 Report	Observational	2011	2014	An intertidal seagrass monitoring site was established at Mabuiag Island where information on seagrass biomass and species composition, and environmental data including irradiance (light), global solar exposure, daytime tidal air exposure, mean and maximum daily water temperature, rainfall, wind speed and salinity, were collected		Carter, A. B., H. A. Taylor, S. A. McKenna, P. Y. York and M. A. Rasheed (2014). The effects of climate on seagrass in the Torres Strait – 2011-2014 Report. Cairns: 36p. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+48+The+effect+of+climate+on+seagass+in+the+Torres+Strait.pdf&subfolder_nav_tracking=3
134	Physiochemical	Daytime tidal air exposure	JCU	The effects of climate on seagrass in the Torres Strait – 2011-2014 Report	Observational	2011	2014	An intertidal seagrass monitoring site was established at Mabuiag Island where information on seagrass biomass and species composition, and environmental data including irradiance (light), global solar exposure, daytime tidal air exposure, mean and maximum daily water temperature, rainfall, wind speed and salinity, were collected		Carter, A. B., H. A. Taylor, S. A. McKenna, P. Y. York and M. A. Rasheed (2014). The effects of climate on seagrass in the Torres Strait – 2011-2014 Report. Cairns: 36p. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+48+The+effect+of+climate+on+seagass+in+the+Torres+Strait.pdf&subfolder_nav_tracking=4

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
135	Physiochemical	Water temperature	JCU	The effects of climate on seagrass in the Torres Strait – 2011-2014 Report	Observational	2011	2014	An intertidal seagrass monitoring site was established at Mabuiag Island where information on seagrass biomass and species composition, and environmental data including irradiance (light), global solar exposure, daytime tidal air exposure, mean and maximum daily water temperature, rainfall, wind speed and salinity, were collected		Carter, A. B., H. A. Taylor, S. A. McKenna, P. Y. York and M. A. Rasheed (2014). The effects of climate on seagrass in the Torres Strait – 2011-2014 Report. Cairns: 36p. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+48+The+effect+of+climate+on+seagass+in+the+Torres+Strait.pdf&subfolder_nav_tracking=5
136	Physiochemical	Rainfall	JCU	The effects of climate on seagrass in the Torres Strait – 2011-2014 Report	Observational	2011	2014	An intertidal seagrass monitoring site was established at Mabuiag Island where information on seagrass biomass and species composition, and environmental data including irradiance (light), global solar exposure, daytime tidal air exposure, mean and maximum daily water temperature, rainfall, wind speed and salinity, were collected		Carter, A. B., H. A. Taylor, S. A. McKenna, P. Y. York and M. A. Rasheed (2014). The effects of climate on seagrass in the Torres Strait – 2011-2014 Report. Cairns: 36p. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+48+The+effect+of+climate+on+seagass+in+the+Torres+Strait.pdf&subfolder_nav_tracking=6
137	Physiochemical	Wind speed	JCU	The effects of climate on seagrass in the Torres Strait – 2011-2014 Report	Observational	2011	2014	An intertidal seagrass monitoring site was established at Mabuiag Island where information on seagrass biomass and species composition, and environmental data including irradiance (light), global solar exposure, daytime tidal air exposure, mean and maximum daily water temperature, rainfall, wind speed and salinity, were collected		Carter, A. B., H. A. Taylor, S. A. McKenna, P. Y. York and M. A. Rasheed (2014). The effects of climate on seagrass in the Torres Strait – 2011-2014 Report. Cairns: 36p. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+48+The+effect+of+climate+on+seagass+in+the+Torres+Strait.pdf&subfolder_nav_tracking=7

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
138	Physiochemical	Salinity	JCU	The effects of climate on seagrass in the Torres Strait – 2011-2014 Report	Observational	2011	2014	An intertidal seagrass monitoring site was established at Mabuiag Island where information on seagrass biomass and species composition, and environmental data including irradiance (light), global solar exposure, daytime tidal air exposure, mean and maximum daily water temperature, rainfall, wind speed and salinity, were collected		Carter, A. B., H. A. Taylor, S. A. McKenna, P. Y. York and M. A. Rasheed (2014). The effects of climate on seagrass in the Torres Strait – 2011-2014 Report. Cairns: 36p. https://www.dropbox.com/sh/mo8dcq1322qv5c3/AACBP7wEpNeQfiI2f8RqT8MOa/2014?dl=0&preview=14+48+The+effect+of+climate+on+seagrass+in+the+Torres+Strait.pdf&subfolder_nav_tracking=8
139	Habitat	Seagrass	JCU	Seagrass Habitat in the Port of Thursday Island: Annual Monitoring Report 2019	Observational	2019	2019	Aerial and boat surveys of seagrass meadows were conducted between 26th – 30th March 2019. The surveys included a whole of port survey as well as a survey of the annual monitoring meadows		Wells, J. N., M. A. Rasheed and R. G. Coles (2019). Seagrass Habitat in the Port of Thursday Island: Annual Monitoring Report 2019. Cairns: 43p. https://www.dropbox.com/s/4jcufvc75gfs7bw/19%2027%20Seagrass%20habitat%20in%20the%20port%20of%20Thursday%20Island.pdf?dl=0
142	Physiochemical	Water temperature	AIMS	AIMS weather stations	Observational	2017	2020		Freely available on website	https://weather.aims.gov.au/#/overview
143	Physiochemical	Wind	AIMS	AIMS weather stations	Observational	2017	2020		Freely available on website	https://weather.aims.gov.au/#/overview
144	Physiochemical	Air temperature	AIMS	AIMS weather stations	Observational	2017	2020		Freely available on website	https://weather.aims.gov.au/#/overview
145	Physiochemical	Rainfall	AIMS	AIMS weather stations	Observational	2017	2020		Freely available on website	https://weather.aims.gov.au/#/overview
146	Physiochemical	Atmospheric pressure	AIMS	AIMS weather stations	Observational	2017	2020		Freely available on website	https://weather.aims.gov.au/#/overview
147	Physiochemical	Humidity	AIMS	AIMS weather stations	Observational	2017	2020		Freely available on website	https://weather.aims.gov.au/#/overview

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
148	Physiochemical	Light	AIMS	AIMS weather stations	Observational	2017	2020		Freely available on website	https://weather.aims.gov.au/#/overview
149	Physiochemical	Sea level	BoM	About ACCESS model	Modelled		3 hours to 240 hours	3-day predictions; from 12km to 24km grid resolution. ACCESS output is available in map form or as gridded data products	on request to BoM	http://www.bom.gov.au/australia/charts/about/about_access.shtml
150	Physiochemical	Wind	BoM	About ACCESS model	Modelled		3 hours to 240 hours	3-day predictions; from 12km to 24km grid resolution. ACCESS output is available in map form or as gridded data products	on request to BoM	http://www.bom.gov.au/australia/charts/about/about_access.shtml
151	Physiochemical	Rainfall	BoM	About ACCESS model	Modelled		3 hours to 240 hours	3-day predictions; from 12km to 24km grid resolution. ACCESS output is available in map form or as gridded data products	on request to BoM	http://www.bom.gov.au/australia/charts/about/about_access.shtml
152	Physiochemical	Air temperature	BoM	About ACCESS model	Modelled		3 hours to 240 hours	3-day predictions; from 12km to 24km grid resolution. ACCESS output is available in map form or as gridded data products	on request to BoM	http://www.bom.gov.au/australia/charts/about/about_access.shtml
153	Physiochemical	Humidity	BoM	About ACCESS model	Modelled		3 hours to 240 hours	3-day predictions; from 12km to 24km grid resolution. ACCESS output is available in map form or as gridded data products	on request to BoM	http://www.bom.gov.au/australia/charts/about/about_access.shtml
154	Physiochemical	Sea Surface Temperature	BoM	About the sea surface temperature timeseries graphs	Modelled and Observational	1900	2020			http://www.bom.gov.au/climate/change/about/sst_timeseries.shtml
155	Physiochemical	Sea Surface Temperature	NOAA	NOAA Extended Reconstructed Sea Surface Temperature (SST) V5	Modelled	1854	2020	A global monthly SST analysis from 1854 to the present derived from ICOADS data with missing data filled in by statistical methods	Access through website	https://psl.noaa.gov/data/gridded/data.noaa.ersst.v5.html
156	Physiochemical	Air temperature	BoM	Horn Island Station ID 027058	Observational	1995	2020		Access through website	http://www.bom.gov.au/climate/averages/tables/cw_027058.shtml
157	Physiochemical	Rainfall	BoM	Horn Island Station ID 027058	Observational	1995	2020		Access through website	http://www.bom.gov.au/climate/averages/tables/cw_027058.shtml

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
158	Physiochemical	Wind speed	BoM	Horn Island Station ID 027058	Observational	1995	2020		Access through website	http://www.bom.gov.au/climate/averages/tables/cw_027058.shtml
159	Physiochemical	Atmospheric pressure	BoM	Horn Island Station ID 027058	Observational	1995	2020		Access through website	http://www.bom.gov.au/climate/averages/tables/cw_027058.shtml
160	Physiochemical	Air temperature	BoM	Thursday Island Station ID 200892	Observational		?			http://www.bom.gov.au/products/IDQ60801/IDQ60801.94181.shtml
161	Physiochemical	Wind speed	BoM	Thursday Island Station ID 200892	Observational		?			http://www.bom.gov.au/products/IDQ60801/IDQ60801.94181.shtml
162	Physiochemical	Atmospheric pressure	BoM	Thursday Island Station ID 200892	Observational		?			http://www.bom.gov.au/products/IDQ60801/IDQ60801.94181.shtml
163	Physiochemical	Air temperature	BoM	Coconut Island Station ID 027054	Observational	1995	2020			http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=027054
164	Physiochemical	Atmospheric pressure	BoM	Coconut Island Station ID 027055	Observational	1995	2020			http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=027054
165	Physiochemical	Rainfall	BoM	Coconut Island Station ID 027056	Observational	1995	2020			http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=027054
166	Physiochemical	Sea Surface Temperature	BoM	OceanMaps	Modelled		7-day forecasts	OceanMAPS produces 7-day forecasts of the ocean circulation around Australia (900-180E, south of 20N) every day.	Site registration	http://www.bom.gov.au/oceanography/forecasts/index.shtml
167	Physiochemical	Currents	BoM	OceanMaps	Modelled		7-day forecasts	OceanMAPS produces 7-day forecasts of the ocean circulation around Australia (900-180E, south of 20N) every day.	Site registration	http://www.bom.gov.au/oceanography/forecasts/index.shtml
168	Physiochemical	Sea level	BoM	OceanMaps	Modelled		7-day forecasts	OceanMAPS produces 7-day forecasts of the ocean circulation around Australia (900-180E, south of 20N) every day.	Site registration	http://www.bom.gov.au/oceanography/forecasts/index.shtml

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
169	Physiochemical	Salinity	BoM	OceanMaps	Modelled		7-day forecasts	OceanMAPS produces 7-day forecasts of the ocean circulation around Australia (900-180E, south of 20N) every day.	Site registration	http://www.bom.gov.au/oceanography/forecasts/index.shtml
170	Physiochemical	Sea level	CSIRO / BoM	Climate Change in Australia	Modelled and Observational	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/
171	Physiochemical	Sea Surface Temperature	CSIRO / BoM	Climate Change in Australia	Modelled and Observational	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/
172	Physiochemical	Aragonite Saturation	CSIRO / BoM	Climate Change in Australia	Modelled and Observational	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/
173	Physiochemical	Rainfall	CSIRO / BoM	Climate Change in Australia	Modelled and Observational	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/
174	Physiochemical	Air temperature	CSIRO / BoM	Climate Change in Australia	Modelled and Observational	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/
175	Physiochemical	Ocean pH	CSIRO / BoM	Climate Change in Australia	Modelled	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
176	Physiochemical	Wind Speed	CSIRO / BoM	Climate Change in Australia	Modelled and Observational	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/
177	Physiochemical	Humidity	CSIRO / BoM	Climate Change in Australia	Modelled and Observational	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/
178	Physiochemical	Solar radiation	CSIRO / BoM	Climate Change in Australia	Modelled and Observational	1900	2020	Climate change projections show how Australia's climate may change in the future. Using up to 40 global climate models, the projections found here represent the most comprehensive analysis of Australia's future climate ever undertaken	Mostly freely accessible with areas that require registration	https://www.climatechangeinaustralia.gov.au/
179	Physiochemical	Air temperature	WorldClim	WorldClim	Modelled	1970	2000	This is WorldClim version 2.1 climate data for 1970-2000. This version was released in January 2020. There are monthly climate data for minimum, mean, and maximum temperature, precipitation, solar radiation, wind speed, water vapor pressure, and for total precipitation. There are also 19 “bioclimatic” variables. The data is available at the four spatial resolutions, between 30 seconds (~1 km2) to 10 minutes (~340 km2). Each download is a “zip” file containing 12 GeoTiff (.tif) files, one for each month of the year (January is 1; December is 12).	Free download	https://worldclim.org/data/worldclim21.html

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
180	Physiochemical	Rainfall	WorldClim	WorldClim	Modelled	1970	2000	This is WorldClim version 2.1 climate data for 1970-2000. This version was released in January 2020. There are monthly climate data for minimum, mean, and maximum temperature, precipitation, solar radiation, wind speed, water vapor pressure, and for total precipitation. There are also 19 "bioclimatic" variables. The data is available at the four spatial resolutions, between 30 seconds (~1 km2) to 10 minutes (~340 km2). Each download is a "zip" file containing 12 GeoTiff (.tif) files, one for each month of the year (January is 1; December is 12).	Free download	https://worldclim.org/data/worldclim21.html
181	Physiochemical	Solar radiation	WorldClim	WorldClim	Modelled	1970	2000	This is WorldClim version 2.1 climate data for 1970-2000. This version was released in January 2020. There are monthly climate data for minimum, mean, and maximum temperature, precipitation, solar radiation, wind speed, water vapor pressure, and for total precipitation. There are also 19 "bioclimatic" variables. The data is available at the four spatial resolutions, between 30 seconds (~1 km2) to 10 minutes (~340 km2). Each download is a "zip" file containing 12 GeoTiff (.tif) files, one for each month of the year (January is 1; December is 12).	Free download	https://worldclim.org/data/worldclim21.html

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
182	Physiochemical	Wind speed	WorldClim	WorldClim	Modelled	1970	2000	This is WorldClim version 2.1 climate data for 1970-2000. This version was released in January 2020. There are monthly climate data for minimum, mean, and maximum temperature, precipitation, solar radiation, wind speed, water vapor pressure, and for total precipitation. There are also 19 "bioclimatic" variables. The data is available at the four spatial resolutions, between 30 seconds (~1 km2) to 10 minutes (~340 km2). Each download is a "zip" file containing 12 GeoTiff (.tif) files, one for each month of the year (January is 1; December is 12).	Free download	https://worldclim.org/data/worldclim21.html
183	Physiochemical	Air temperature	WorldClim	WorldClim	Modelled		2021-2100	The data available here are CMIP6 downscaled future climate projections. The downscaling and calibration (bias correction) was done with WorldClim v2.1 as baseline climate. Monthly values of minimum temperature, maximum temperature, and precipitation were processed for nine global climate models (GCMs): BCC-CSM2-MR, CNRM-CM6-1, CNRM-ESM2-1, CanESM5, GFDL-ESM4, IPSL-CM6A-LR, MIROC-ES2L, MIROC6, MRI-ESM2-0, and for four Shared Socio-economic Pathways (SSPs): 126, 245, 370 and 585. The monthly values were averages over 20 year periods (2021-2040, 241-2060, 2061-2080, 2081-2100). The following spatial resolutions are available (expressed as minutes of a degree of longitude and latitude): 10 minutes, 5 minutes, 2.5 minutes. Data at 30-seconds spatial resolution is expected to be available by the end of March, 2020. CMIP6 terms of use and citation information.	Free download	https://worldclim.org/data/cmip6/cmip6climate.html

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
184	Physiochemical	Rainfall	WorldClim	WorldClim	Modelled	2021	2100	The data available here are CMIP6 downscaled future climate projections. The downscaling and calibration (bias correction) was done with WorldClim v2.1 as baseline climate. Monthly values of minimum temperature, maximum temperature, and precipitation were processed for nine global climate models (GCMs): BCC-CSM2-MR, CNRM-CM6-1, CNRM-ESM2-1, CanESM5, GFDL-ESM4, IPSL-CM6A-LR, MIROC-ES2L, MIROC6, MRI-ESM2-0, and for four Shared Socio-economic Pathways (SSPs): 126, 245, 370 and 585. The monthly values were averages over 20 year periods (2021-2040, 241-2060, 2061-2080, 2081-2100). The following spatial resolutions are available (expressed as minutes of a degree of longitude and latitude): 10 minutes, 5 minutes, 2.5 minutes. Data at 30-seconds spatial resolution is expected to be available by the end of March, 2020. CMIP6 terms of use and citation information.	Free download	https://worldclim.org/data/cmip6/cmip6climate.html
185	Ecological	fish	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.
186	Ecological	Seagrass	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
187	Ecological	Live coral cover	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.
188	Ecological	Algae	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.
189	Geological	Sand	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.
190	Geological	Rubble	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.
191	Geological	Boulders	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.
192	Geological	Consolidated rubble	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.
193	Geological	Pavement	CSIRO	Influence of coastal processes on large scale patterns in reef fish communities of	Observational	1995	1996	Underwater visual transects at 276 sites on 41 reefs. Data stored in excel /shared drive	Contact CSIRO	Milton, D. A. and B. G. Long (1997). Influence of coastal processes on large scale patterns in reef fish communities of Torres Strait, Australia. Cleveland.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
				Torres Strait, Australia						
194	Fisheries	Finfish - Spanish Mackerel	AFMA	Spanish Mackerel Catch data	Observational	1989	2019	Data on Torres Strait Spanish mackerel harvests were from two sources: 1) AFMA compulsory logbook (Log) database and 2)AFMA docket (Doc) book records. The docket (Doc) book records are important information for harvest reporting through community processor/freezer establishments. At the time of this report, the Doc data recorded mostly harvests from Islander commercial fishers. Historically, docket book reporting was noncompulsory and database maintenance was not frequent	Contact AFMA	O'Neill, M. F. (2019). Appendix B - Torres Strait Spanish mackerel stock assessment. In: Harvest Strategies for the Torres Strait Finfish fishery, T. Hutton, M. O'Neill, G. Leigh et al. Brisbane, AFMA
195	Fisheries	Finfish - Spanish Mackerel	AFMA	Spanish Mackerel CPUE data	Observational	2013	2019	Data on Torres Strait Spanish mackerel harvests were from two sources: 1) AFMA compulsory logbook (Log) database and 2)AFMA docket (Doc) book records. The docket (Doc) book records are important information for harvest reporting through community processor/freezer establishments. At the time of this report, the Doc data recorded mostly harvests from Islander commercial fishers. Historically, docket book reporting was noncompulsory and database maintenance was not frequent	Contact AFMA	O'Neill, M. F. (2019). Appendix B - Torres Strait Spanish mackerel stock assessment. In: Harvest Strategies for the Torres Strait Finfish fishery, T. Hutton, M. O'Neill, G. Leigh et al. Brisbane, AFMA

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
196	Fisheries	Finfish - Spanish Mackerel	AFMA	Spanish Mackerel Length data	Observational	2000	2002	Data on Torres Strait Spanish mackerel harvests were from two sources: 1) AFMA compulsory logbook (Log) database and 2)AFMA docket (Doc) book records. The docket (Doc) book records are important information for harvest reporting through community processor / freezer establishments. At the time of this report, the Doc data recorded mostly harvests from Islander commercial fishers. Historically, docket book reporting was noncompulsory and database maintenance was not frequent	Contact AFMA	O'Neill, M. F. (2019). Appendix B - Torres Strait Spanish mackerel stock assessment. In: Harvest Strategies for the Torres Strait Finfish fishery, T. Hutton, M. O'Neill, G. Leigh et al. Brisbane, AFMA
197	Fisheries	Finfish - Coral Trout	AFMA	Coral Trout Catch Data	Observational	1992	2019		Contact AFMA	Holden, M. H. and G. M. Leigh (2019). Appendix E - Preliminary Stock Assessment for Coral Trout in Torres Strait - Project No. 2016/0824. In: Harvest Strategies for the Torres Strait Finfish fishery, T. Hutton, M. O'Neill, G. Leigh et al. Brisbane, AFMA.
198	Fisheries	Finfish - Coral Trout	AFMA	Coral Trout CPUE Data	Observational	1992	2019		Contact AFMA	Holden, M. H. and G. M. Leigh (2019). Appendix E - Preliminary Stock Assessment for Coral Trout in Torres Strait - Project No. 2016/0824. In: Harvest Strategies for the Torres Strait Finfish fishery, T. Hutton, M. O'Neill, G. Leigh et al. Brisbane, AFMA.
199	Physiochemical	Sea level	AIMS	Water circulation in the Gulf of Papua	Observational	1990	1992	Aanderaa water level recorders were bottom mounted at Tirere at the mouth of the Fly River estuary, as well as at the mouth of the two other channels of the estuary. Temperature and salinity profiles were obtained using a Seabird profiler.	unknown	Wolanski, E., A. Norro and B. King (1995). "Water circulation in the Gulf of Papua." Continental Shelf Research 15(2): 185-212.
200	Physiochemical	Currents	AIMS	Water circulation in the Gulf of Papua	Observational	1990	1992	two current meters were deployed, at least some of the time, to measure the current velocity both in and below the river plume. At site F, three meters were deployed, two above and one below the thermocline.	unknown	Wolanski, E., A. Norro and B. King (1995). "Water circulation in the Gulf of Papua." Continental Shelf Research 15(2): 185-212.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
201	Physiochemical	Water temperature	AIMS	Water circulation in the Gulf of Papua	Observational	1990	1992	Temperature profiles were obtained using a Seabird profiler.	unknown	Wolanski, E., A. Norro and B. King (1995). "Water circulation in the Gulf of Papua." Continental Shelf Research 15(2): 185-212.
202	Physiochemical	Salinity	AIMS	Water circulation in the Gulf of Papua	Observational	1990	1992	Salinity profiles were obtained using a Seabird profiler.	unknown	Wolanski, E., A. Norro and B. King (1995). "Water circulation in the Gulf of Papua." Continental Shelf Research 15(2): 185-212.
203	Physiochemical	Currents	AIMS	Water Circulation and Shelf Waves in the Northern Great Barrier Reef Lagoon	Observational	1979	1979	Currents and sea levels were measured at a number of locations in the Great Barrier Reef (GBR) lagoon from about 10 to 13°S., during the period October-December 1979.	unknown	Wolanski, E. and B. Ruddick (1981). "Water Circulation and Shelf Waves in the Northern Great Barrier Reef Lagoon." Marine and Freshwater Research 32(5): 721-740.
204	Physiochemical	Sea level	AIMS	Water Circulation and Shelf Waves in the Northern Great Barrier Reef Lagoon	Observational	1979	1979	Currents and sea levels were measured at a number of locations in the Great Barrier Reef (GBR) lagoon from about 10 to 13°S., during the period October-December 1979.	unknown	Wolanski, E. and B. Ruddick (1981). "Water Circulation and Shelf Waves in the Northern Great Barrier Reef Lagoon." Marine and Freshwater Research 32(5): 721-740.
205	Physiochemical	Currents	AIMS	Tidal Period Upwelling within Raine Island Entrance Great Barrier-Reef	Observational	1981	1982	Temperature and current measurements collected from November 1981 to May 1982 at the head of Raine Island Entrance	unknown	Thomson, R. E. and E. J. Wolanski (1984). "Tidal Period Upwelling within Raine Island Entrance Great Barrier-Reef." Journal of Marine Research 42(4): 787-808.
206	Physiochemical	Water temperature	AIMS	Tidal Period Upwelling within Raine Island Entrance Great Barrier-Reef	Observational	1981	1982	Temperature and current measurements collected from November 1981 to May 1982 at the head of Raine Island Entrance	unknown	Thomson, R. E. and E. J. Wolanski (1984). "Tidal Period Upwelling within Raine Island Entrance Great Barrier-Reef." Journal of Marine Research 42(4): 787-808.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
207	Physiochemical	Salinity	AIMS	River plumes, Coral Reefs and mixing in the Gulf of Papua and the northern Great Barrier Reef	Observational	1979	1982	Oceanographic cruises were completed in the area in November 1981, April-May 1982 and October 1982. Salinity, temperature and silicate concentration were measured from water samples (Mitchell et al., 1982) and, for salinity and temperature, also with a profiler and a thermosalinograph.	unknown	Wolanski, E., G. L. Pickard and D. L. B. Jupp (1984). "River plumes, Coral Reefs and mixing in the Gulf of Papua and the northern Great Barrier Reef." Estuarine, Coastal and Shelf Science 18(3): 291-314.
208	Physiochemical	Water temperature	AIMS	River plumes, Coral Reefs and mixing in the Gulf of Papua and the northern Great Barrier Reef	Observational	1979	1982	Oceanographic cruises were completed in the area in November 1981, April-May 1982 and October 1982. Salinity, temperature and silicate concentration were measured from water samples (Mitchell et al., 1982) and, for salinity and temperature, also with a profiler and a thermosalinograph.	unknown	Wolanski, E., G. L. Pickard and D. L. B. Jupp (1984). "River plumes, Coral Reefs and mixing in the Gulf of Papua and the northern Great Barrier Reef." Estuarine, Coastal and Shelf Science 18(3): 291-314.
209	Physiochemical	Silicate	AIMS	River plumes, Coral Reefs and mixing in the Gulf of Papua and the northern Great Barrier Reef	Observational	1979	1982	Oceanographic cruises were completed in the area in November 1981, April-May 1982 and October 1982. Salinity, temperature and silicate concentration were measured from water samples (Mitchell et al., 1982) and, for salinity and temperature, also with a profiler and a thermosalinograph.	unknown	Wolanski, E., G. L. Pickard and D. L. B. Jupp (1984). "River plumes, Coral Reefs and mixing in the Gulf of Papua and the northern Great Barrier Reef." Estuarine, Coastal and Shelf Science 18(3): 291-314.
210	Physiochemical	Currents	AIMS	Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea	Observational	1992	1992	Oceanographic moorings were maintained over 8 weeks in 1992 in the southeast trade wind season a number of stations in the Fly River mouth. Each mooring comprised one or two vector-averaging current meters.	unknown	Wolanski, E., R. J. Gibbs, S. Spagnol, B. King and G. Burnskill (1998). "Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea." Mangroves and Salt Marshes 2(2): 85-98.
211	Physiochemical	Salinity	AIMS	Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea	Observational	1992	1992	Oceanographic moorings were maintained over 8 weeks in 1992 in the southeast trade wind season a number of stations in the Fly River mouth. Each mooring comprised a Dataflow self-logging salinometer	unknown	Wolanski, E., R. J. Gibbs, S. Spagnol, B. King and G. Burnskill (1998). "Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea." Mangroves and Salt Marshes 2(2): 85-98.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
212	Physiochemical	Turbidity	AIMS	Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea	Observational	1992	1992	Oceanographic moorings were maintained over 8 weeks in 1992 in the southeast trade wind season a number of stations in the Fly River mouth. Each mooring comprised three nephelometers spread from 0.2 to 2.2 m above the bottom.	unknown	Wolanski, E., R. J. Gibbs, S. Spagnol, B. King and G. Burnskill (1998). "Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea." Mangroves and Salt Marshes 2(2): 85-98.
213	Physiochemical	Currents	AIMS	Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea	Observational	1995	1995	Oceanographic moorings were maintained over 8 weeks in 1992 in the southeast trade wind season a number of stations in the Fly River mouth. Each mooring comprised three nephelometers spread from 0.2 to 2.2 m above the bottom.	unknown	Wolanski, E., R. J. Gibbs, S. Spagnol, B. King and G. Burnskill (1998). "Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea." Mangroves and Salt Marshes 2(2): 85-98.
214	Physiochemical	Salinity	AIMS	Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea	Observational	1995	1995	Oceanographic moorings were maintained over 8 weeks in 1992 in the southeast trade wind season a number of stations in the Fly River mouth. Each mooring comprised three nephelometers spread from 0.2 to 2.2 m above the bottom.	unknown	Wolanski, E., R. J. Gibbs, S. Spagnol, B. King and G. Burnskill (1998). "Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea." Mangroves and Salt Marshes 2(2): 85-98.
215	Physiochemical	Turbidity	AIMS	Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea	Observational	1995	1995	Oceanographic moorings were maintained over 8 weeks in 1992 in the southeast trade wind season a number of stations in the Fly River mouth. Each mooring comprised three nephelometers spread from 0.2 to 2.2 m above the bottom.	unknown	Wolanski, E., R. J. Gibbs, S. Spagnol, B. King and G. Burnskill (1998). "Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea." Mangroves and Salt Marshes 2(2): 85-98.
216	Physiochemical	Water depth	AIMS	Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea	Observational	1995	1995	Oceanographic moorings were maintained over 8 weeks in 1992 in the southeast trade wind season a number of stations in the Fly River mouth. Each mooring comprised three nephelometers spread from 0.2 to 2.2 m above the bottom.	unknown	Wolanski, E., R. J. Gibbs, S. Spagnol, B. King and G. Burnskill (1998). "Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea." Mangroves and Salt Marshes 2(2): 85-98.
217	Physiochemical	Water depth	AIMS	Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea	Observational	1992	1992	Oceanographic moorings were maintained over 8 weeks in 1992 in the southeast trade wind season a number of stations in the Fly River mouth. Each mooring comprised three nephelometers spread from 0.2 to 2.2 m above the bottom.	unknown	Wolanski, E., R. J. Gibbs, S. Spagnol, B. King and G. Burnskill (1998). "Inorganic sediment budget in the mangrove-fringed Fly River Delta, Papua New Guinea." Mangroves and Salt Marshes 2(2): 85-98.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
218	Physiochemical	Salinity	AIMS	Patchiness in the Fly River plume in Torres Strait	Observational	1994	1995	Four oceanographic cruises were completed, each about 12 days long, in August 1994, September 1994, January–February 1995 and February-March 1995. On each mooring a vector-averaging current meter, three optical-fibre backscattering nephelometers and one Dataflow salinometer were deployed.	unknown	Wolanski, E., S. Spagnol, B. King and T. Ayukai (1999). "Patchiness in the Fly River plume in Torres Strait." Journal of Marine Systems 18(4): 369-381.
219	Physiochemical	Currents	AIMS	Patchiness in the Fly River plume in Torres Strait	Observational	1994	1995	Four oceanographic cruises were completed, each about 12 days long, in August 1994, September 1994, January–February 1995 and February-March 1995. On each mooring a vector-averaging current meter, three optical-fibre backscattering nephelometers and one Dataflow salinometer were deployed.	unknown	Wolanski, E., S. Spagnol, B. King and T. Ayukai (1999). "Patchiness in the Fly River plume in Torres Strait." Journal of Marine Systems 18(4): 369-381.
220	Physiochemical	Turbidity	AIMS	Patchiness in the Fly River plume in Torres Strait	Observational	1994	1995	Four oceanographic cruises were completed, each about 12 days long, in August 1994, September 1994, January–February 1995 and February-March 1995. On each mooring a vector-averaging current meter, three optical-fibre backscattering nephelometers and one Dataflow salinometer were deployed.	unknown	Wolanski, E., S. Spagnol, B. King and T. Ayukai (1999). "Patchiness in the Fly River plume in Torres Strait." Journal of Marine Systems 18(4): 369-381.
221	Physiochemical	Sea level	AIMS	Patchiness in the Fly River plume in Torres Strait	Observational	1994	1995	Four oceanographic cruises were completed, each about 12 days long, in August 1994, September 1994, January–February 1995 and February-March 1995. On each mooring a vector-averaging current meter, three optical-fibre backscattering nephelometers and one Dataflow salinometer were deployed.	unknown	Wolanski, E., S. Spagnol, B. King and T. Ayukai (1999). "Patchiness in the Fly River plume in Torres Strait." Journal of Marine Systems 18(4): 369-381.
222	Physiochemical	Water temperature	AIMS	Patchiness in the Fly River plume in Torres Strait	Observational	1994	1995	Four oceanographic cruises were completed, each about 12 days long, in August 1994, September 1994, January–February 1995 and February-March 1995. On each mooring a vector-averaging current meter, three optical-fibre backscattering nephelometers and one Dataflow salinometer were deployed.	unknown	Wolanski, E., S. Spagnol, B. King and T. Ayukai (1999). "Patchiness in the Fly River plume in Torres Strait." Journal of Marine Systems 18(4): 369-381.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
223	Habitat	*Coral reefs*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2019	Torres Strait		Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
224	Habitat	*Seagrass*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2020			Pitcher, C. R., T. D. Skewes, D. M. Dennis and J. H. Prescott (1992). "Distribution of Seagrasses, Substratum Types and Epibenthic Macrobiota in Torres Strait, with Notes on Pearl Oyster Abundance." Australian Journal of Marine and Freshwater Research 43(2): 409-419.
225	Physiochemical	Alkalinity	IMOS	IMOS ARGOS Profile	Modelled	1990	2020		Free download	https://portal.aodn.org.au/search
226	Physiochemical	Nutrient	IMOS	IMOS ARGOS Profile	Modelled	1990	2020		Free download	https://portal.aodn.org.au/search
227	Physiochemical	Oxygen	IMOS	IMOS ARGOS Profile	Modelled	1990	2020		Free download	https://portal.aodn.org.au/search
228	Physiochemical	Salinity	IMOS	IMOS ARGOS Profile	Modelled	1990	2020		Free download	https://portal.aodn.org.au/search
229	Physiochemical	Temperature	IMOS	IMOS ARGOS Profile	Modelled	1990	2020		Free download	https://portal.aodn.org.au/search
230	Physiochemical	Water Pressure	IMOS	IMOS ARGOS Profile	Modelled	1990	2020		Free download	https://portal.aodn.org.au/search
231	Physiochemical	Acoustics	IMOS	IMOS - Australian National Mooring Network (ANMN) Facility - Current velocity time-series	Modelled	2007	2020		Free download	https://portal.aodn.org.au/search
232	Physiochemical	Currents	IMOS	IMOS - Australian National Mooring Network (ANMN) Facility - Current velocity time-series	Modelled	2007	2020		Free download	https://portal.aodn.org.au/search
233	Physiochemical	Water Pressure	IMOS	IMOS - Australian National Mooring Network (ANMN)	Modelled	2007	2020		Free download	https://portal.aodn.org.au/search

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
				Facility - Current velocity time-series						
234	Ecological	Phytoplankton	IMOS	IMOS - AusCPR: Phytoplankton Abundance	Observational	2008	2020	Vessel	Free download	https://portal.aodn.org.au/search
235	Physiochemical	Sea Surface Temperature	IMOS	IMOS - SRS - SST - L3S - Single Sensor - 6 day - day and night time - Australia	Modelled	2002	2020		Free download	https://portal.aodn.org.au/search
236	Physiochemical	Chlorophyl a	IMOS	IMOS - SRS - MODIS - 01 day - Chlorophyll-a concentration (OC3 model)	Modelled	2002	2020		Free download	https://portal.aodn.org.au/search
237	Physiochemical	Alkalinity	IMOS	Ocean acidification historical reconstruction	Modelled	1870	2013		Free download	https://portal.aodn.org.au/search
238	Physiochemical	Salinity	IMOS	Ocean acidification historical reconstruction	Modelled	1870	2013		Free download	https://portal.aodn.org.au/search
239	Physiochemical	Carbon	IMOS	Ocean acidification historical reconstruction	Modelled	1870	2013		Free download	https://portal.aodn.org.au/search
240	Physiochemical	Sea Surface Temperature	IMOS	Ocean acidification historical reconstruction	Modelled	1870	2013		Free download	https://portal.aodn.org.au/search
241	Physiochemical	Currents	IMOS	IMOS - OceanCurrent - Gridded sea level anomaly - Near real time	Modelled	2011	2020		Free download	https://portal.aodn.org.au/search
242	Physiochemical	Sea Surface Height	IMOS	IMOS - OceanCurrent - Gridded sea level anomaly - Near real time	Modelled	2011	2020		Free download	https://portal.aodn.org.au/search
243	Physiochemical	Sea Surface Temperature	IMOS	SST Atlas of Australian Regional Seas (SSTAARS) - Daily climatology fit	Modelled	1992	2016		Free download	https://portal.aodn.org.au/search
244	Physiochemical	Sea Surface Temperature	IMOS	IMOS - SRS - SST - L3S - Single Sensor - 1 day - night time - Australia	Modelled	1992	2020		Free download	https://portal.aodn.org.au/search

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
245	Ecological	Phytoplankton	IMOS	The Australian Phytoplankton Database (1844 - ongoing) - abundance and biovolume	Modelled	1844	2020		Free download	https://portal.aodn.org.au/search
246	Physiochemical	Chlorophyl a	IMOS	IMOS - SRS - MODIS - 01 day - Net Primary Productivity (OC3 model and Eppley-VGPM algorithm)	Modelled	2002	2020		Free download	https://portal.aodn.org.au/search
247	Physiochemical	Density	IMOS	CARS 2009 - CSIRO Atlas of Regional Seas - Australian weekly	Modelled	1985	2009		Free download	https://portal.aodn.org.au/search
248	Physiochemical	Nutrient	IMOS	CARS 2009 - CSIRO Atlas of Regional Seas - Australian weekly	Modelled	1985	2009		Free download	https://portal.aodn.org.au/search
249	Physiochemical	Oxygen	IMOS	CARS 2009 - CSIRO Atlas of Regional Seas - Australian weekly	Modelled	1985	2009		Free download	https://portal.aodn.org.au/search
250	Physiochemical	Salinity	IMOS	CARS 2009 - CSIRO Atlas of Regional Seas - Australian weekly	Modelled	1985	2009		Free download	https://portal.aodn.org.au/search
251	Physiochemical	Sea Surface Temperature	IMOS	CARS 2009 - CSIRO Atlas of Regional Seas - Australian weekly	Modelled	1985	2009		Free download	https://portal.aodn.org.au/search
252	Physiochemical	Air Pressure	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - delayed mode data	Observational	2008	2020	Vessels	Free download	https://portal.aodn.org.au/search
253	Physiochemical	Carbon	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - delayed mode data	Observational	2008	2020	Vessels	Free download	https://portal.aodn.org.au/search
254	Physiochemical	Salinity	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - delayed mode data	Observational	2008	2020	Vessels	Free download	https://portal.aodn.org.au/search

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
255	Physiochemical	Sea Surface Temperature	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - delayed mode data	Observational	2008	2020	Vessels	Free download	https://portal.aodn.org.au/search
256	Physiochemical	Wind	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - delayed mode data	Observational	2008	2020	Vessels	Free download	https://portal.aodn.org.au/search
257	Physiochemical	Sea Surface Temperature	IMOS	IMOS - SRS - SST - L3S - Single Sensor - 1 month - day and night time - Australia	Modelled	1992	2020	Satellite	Free download	https://portal.aodn.org.au/search
258	Physiochemical	Chlorophyl a	IMOS	IMOS - SRS - MODIS - 01 day - Chlorophyll-a concentration (GSM model)	Modelled	2002	2020		Free download	https://portal.aodn.org.au/search
259	Physiochemical	Wind	IMOS	IMOS - SRS Surface Waves Sub-Facility - scatterometer wind	Modelled	1992	2020		Free download	https://portal.aodn.org.au/search
260	Physiochemical	Sea Surface Temperature	IMOS	AIMS Sea Water Temperature Observing System (AIMS Temperature Logger Program)	Modelled	1991	2020		Free download	https://portal.aodn.org.au/search
261	Physiochemical	Sea Surface Temperature	IMOS	MARVL3 - Australian shelf temperature data atlas	Modelled	1994	2015		Free download	https://portal.aodn.org.au/search
262	Physiochemical	Air Pressure	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - Near real-time raw data	Observational	2017	2020	Vessel	Free download	https://portal.aodn.org.au/search
263	Physiochemical	Carbon	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - Near real-time raw data	Observational	2017	2020	Vessel	Free download	https://portal.aodn.org.au/search
264	Physiochemical	Salinity	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group -	Observational	2017	2020	Vessel	Free download	https://portal.aodn.org.au/search

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
				Near real-time raw data						
265	Physiochemical	Sea Surface Temperature	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - Near real-time raw data	Observational	2017	2020	Vessel	Free download	https://portal.aodn.org.au/search
266	Physiochemical	Wind	IMOS	IMOS - SOOP Underway CO2 Measurements Research Group - Near real-time raw data	Observational	2017	2020	Vessel	Free download	https://portal.aodn.org.au/search
267	Physiochemical	Air Pressure	IMOS	Northern Australia Automated Marine Weather and Oceanographic Stations	Observational	1980	2020	Automated weather and oceanographic stations	Free download	https://portal.aodn.org.au/search
268	Physiochemical	Air temperature	IMOS	Northern Australia Automated Marine Weather and Oceanographic Stations	Observational	1980	2020	Automated weather and oceanographic stations	Free download	https://portal.aodn.org.au/search
269	Physiochemical	Humidity	IMOS	Northern Australia Automated Marine Weather and Oceanographic Stations	Observational	1980	2020	Automated weather and oceanographic stations	Free download	https://portal.aodn.org.au/search
270	Physiochemical	Optical Properties	IMOS	Northern Australia Automated Marine Weather and Oceanographic Stations	Observational	1980	2020	Automated weather and oceanographic stations	Free download	https://portal.aodn.org.au/search
271	Physiochemical	Precipitation	IMOS	Northern Australia Automated Marine Weather and Oceanographic Stations	Observational	1980	2020	Automated weather and oceanographic stations	Free download	https://portal.aodn.org.au/search
272	Physiochemical	Evaporation	IMOS	Northern Australia Automated Marine Weather and Oceanographic Stations	Observational	1980	2020	Automated weather and oceanographic stations	Free download	https://portal.aodn.org.au/search

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
273	Physiochemical	Sea Surface Temperature	IMOS	Northern Australia Automated Marine Weather and Oceanographic Stations	Observational	1980	2020	Automated weather and oceanographic stations	Free download	https://portal.aodn.org.au/search
274	Physiochemical	Wind	IMOS	Northern Australia Automated Marine Weather and Oceanographic Stations	Observational	1980	2020	Automated weather and oceanographic stations	Free download	https://portal.aodn.org.au/search
275	Physiochemical	Salinity	IMOS	Royal Australian Navy (RAN) - CTD profiles	Observational	2004	2016	Vessel	Free download	https://portal.aodn.org.au/search
276	Physiochemical	Water temperature	IMOS	Royal Australian Navy (RAN) - CTD profiles	Observational	2004	2016	Vessel	Free download	https://portal.aodn.org.au/search
277	Physiochemical	Water Pressure	IMOS	Royal Australian Navy (RAN) - CTD profiles	Observational	2004	2016	Vessel	Free download	https://portal.aodn.org.au/search
278	Physiochemical	Wave	IMOS	IMOS - SRS Surface Waves Sub-Facility - SAR wave - Near real-time data	Modelled	2019	2020	Satellite	Free download	https://portal.aodn.org.au/search
279	Physiochemical	Pigment	IMOS	The Australian Chlorophyll a Database (1965 - 2017)	Modelled	1965	2017		Free download	https://portal.aodn.org.au/search
280	Physiochemical	Salinity	IMOS	MARVL3 - Australian shelf salinity data atlas	Modelled	1994	2015		Free download	https://portal.aodn.org.au/search
281	Physiochemical	Chlorophyl a	IMOS	Marine Plastic Pollution in Waters around Australia	Modelled	2013	2013		Free download	https://portal.aodn.org.au/search
282	Physiochemical	Salinity	IMOS	Marine Plastic Pollution in Waters around Australia	Modelled	2013	2013		Free download	https://portal.aodn.org.au/search
283	Physiochemical	Sea Surface Temperature	IMOS	Marine Plastic Pollution in Waters around Australia	Modelled	2013	2013		Free download	https://portal.aodn.org.au/search
284	Physiochemical	Turbidity	IMOS	Marine Plastic Pollution in Waters around Australia	Modelled	2013	2013		Free download	https://portal.aodn.org.au/search
285	Ecological	Ocean Biota	IMOS	Redmap - Sightings of range shifting marine species	Observational	2010	2020		Free download	https://portal.aodn.org.au/search

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
286	Ecological	Ocean Biota	IMOS	Seamap Australia - a national seafloor habitat classification scheme	Observational	1966	2017		Free download	https://portal.aodn.org.au/search
287	Habitat	Seagrass	IMOS	Seagrass Presence Absence Australia (ACEAS)	Modelled	1983	2012	Presence / Absence	Free download	https://portal.aodn.org.au/search
288	Habitat	Seagrass	IMOS	Torres Strait Seagrass Mapping Consolidation	Modelled	1983	2012		Free download	https://portal.aodn.org.au/search
289	Fisheries	Tropical Rock Lobster	AFMA	Torres Strait Tropical Rock Lobster Fishery Daily Fishing Log (transferrable vessel holder; TVH)	Observational	1994	2019	catch and effort data to be recorded for individual fishing operations related to each vessel tender	on request to AFMA	Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
290	Fisheries	Tropical Rock Lobster	AFMA	TIB Docket-Book Data	Observational	2004	2017	used in the TIB sector of the Torres Strait rock lobster fishery to record the catch sold by fishers (known as sellers on the Docket-Book) at the end of a fishing trip. It was replaced on 1 December 2017 by the mandatory Torres Strait Catch Disposal Record.	on request to AFMA	Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
291	Fisheries	Tropical Rock Lobster	AFMA	Torres Strait Catch Disposal Record	Observational	2017	2019	require only aggregate catch and effort data to be recorded at the end of each trip.	on request to AFMA	Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
292	Habitat	*Seagrass*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2019	Torres Strait		Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
293	Physiochemical	*Salinity*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2019	Torres Strait		Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
294	Physiochemical	*Visibility*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2019	CSIRO has been engaged, for the past 30 years, by AFMA to undertake annual diving surveys to determine the relative abundance of Tropical Rock Lobsters (TRL) (Panulirus ornatus). Divers complete a census of lobster along transects at pre-determined sampling sites, with a subset of lobster collected for additional measurements. Data collected: The number and age-class of lobsters observed, but not collected; The number of lobsters collected per age-class; The size (tail width in mm), sex and moult stage of the collected lobsters	Contact CSIRO	Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
295	Physiochemical	*Water depth*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2019	CSIRO has been engaged, for the past 30 years, by AFMA to undertake annual diving surveys to determine the relative abundance of Tropical Rock Lobsters (TRL) (Panulirus ornatus). Divers complete a census of lobster along transects at pre-determined sampling sites, with a subset of lobster collected for additional measurements. Data collected: The number and age-class of lobsters observed, but not collected; The number of lobsters collected per age-class; The size (tail width in mm), sex and moult stage of the collected lobsters	Contact CSIRO	Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
296	Physiochemical	*Water temperature*	CSIRO	Torres Strait Tropical Rock Lobster Mid- and Pre-season surveys and commercial catch samples	Observational	1989	2019	Torres Strait		Plagányi, É., M. Tonks, N. Murphy, R. Campbell, R. Deng, S. Edgar, K. Salee and J. Upston (2020). Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825 - Draft Final Report 2020. Cleveland: 183.
297	Health	*Diseases*	Centre for Tropical Environmental and Sustainability Studies	Detecting Emerging Infectious Diseases in the Torres Strait: a review of mosquito-borne disease studies	Modelled and Observational	1995	2011	Review on mosquitoe borne diseases with insights into risks of dispersal from PNG into Australia from other organisms	Not known	Laurance, S. G. W., D. Meyer-Steiger and S. Ritchie (2014). Detecting Emerging Infectious Diseases in the Torres Strait: a review of mosquito-borne disease studies. Report to the National Environmental Research Program. Cairns: 17.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
298	Physiochemical	rainfall	Queensland Government	Queensland Future Climate	Modelled	2030	2050	downscaled models from CMIP5 from RCP8.5 and 4.5 for a range of different metrics: queensland futureclimatedashboard. Website: Resolution is 10km x 10km grid regionalised at council scale. But also time series base on information on grid-based scale for TERN. Products have been developed to provide information for the land (not water), but they have capability to link with ocean information. Differs from climate change in Australia because the areas of interest are based on council areas so better regionalised outputs. SLR and SST are expected to be developed in the future and Ralph and Jacqui are keen to collaborate on this. Problem is time commitment and availability to do this. By late November another person from the group will be back from leave and can provide better information on this. Working with this group will have the advantage of using already made products with a better resolution than Climate in Australia website. Need to consider the need of a dedicated data person to extract downscaled model outputs if not available in the portal.	none: data can be accessed via login on website	https://www.longpaddock.qld.gov.au/qld-future-climate/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
299	Physiochemical	evaporation	Queensland Government	Queensland Future Climate	Modelled	2030	2050	downscaled models from CMIP5 from RCP8.5 and 4.5 for a range of different metrics: queensland futureclimatedashboard. Website: Resolution is 10km x 10km grid regionalised at council scale. But also time series base on information on grid-based scale for TERN. Products have been developed to provide information for the land (not water), but they have capability to link with ocean information. Differs from climate change in Australia because the areas of interest are based on council areas so better regionalised outputs. SLR and SST are expected to be developed in the future and Ralph and Jacqui are keen to collaborate on this. Problem is time commitment and availability to do this. By late November another person from the group will be back from leave and can provide better information on this. Working with this group will have the advantage of using already made products with a better resolution than Climate in Australia website. Need to consider the need of a dedicated data person to extract downscaled model outputs if not available in the portal.	none: data can be accessed via login on website	https://www.longpaddock.qld.gov.au/qld-future-climate/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
300	Physiochemical	temperature	Queensland Government	Queensland Future Climate	Modelled	2030	2050	downscaled models from CMIP5 from RCP8.5 and 4.5 for a range of different metrics: queensland futureclimatedashboard. Website: Resolution is 10km x 10km grid regionalised at council scale. But also time series base on information on grid-based scale for TERN. Products have been developed to provide information for the land (not water), but they have capability to link with ocean information. Differs from climate change in Australia because the areas of interest are based on council areas so better regionalised outputs. SLR and SST are expected to be developed in the future and Ralph and Jacqui are keen to collaborate on this. Problem is time commitment and availability to do this. By late November another person from the group will be back from leave and can provide better information on this. Working with this group will have the advantage of using already made products with a better resolution than Climate in Australia website. Need to consider the need of a dedicated data person to extract downscaled model outputs if not available in the portal.	none: data can be accessed via login on website	https://www.longpaddock.qld.gov.au/qld-future-climate/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
301	Physiochemical	solar radiation	Queensland Government	Queensland Future Climate	Modelled	2030	2050	downscaled models from CMIP5 from RCP8.5 and 4.5 for a range of different metrics: queensland futureclimatedashboard. Website: Resolution is 10km x 10km grid regionalised at council scale. But also time series base on information on grid-based scale for TERN. Products have been developed to provide information for the land (not water), but they have capability to link with ocean information. Differs from climate change in Australia because the areas of interest are based on council areas so better regionalised outputs. SLR and SST are expected to be developed in the future and Ralph and Jacqui are keen to collaborate on this. Problem is time commitment and availability to do this. By late November another person from the group will be back from leave and can provide better information on this. Working with this group will have the advantage of using already made products with a better resolution than Climate in Australia website. Need to consider the need of a dedicated data person to extract downscaled model outputs if not available in the portal.	none: data can be accessed via login on website	https://www.longpaddock.qld.gov.au/qld-future-climate/

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
302	Physiochemical	vapour pressure deficit	Queensland Government	Queensland Future Climate	Modelled	2030	2050	downscaled models from CMIP5 from RCP8.5 and 4.5 for a range of different metrics: queensland futureclimatedashboard. Website: Resolution is 10km x 10km grid regionalised at council scale. But also time series base on information on grid-based scale for TERN. Products have been developed to provide information for the land (not water), but they have capability to link with ocean information. Differs from climate change in Australia because the areas of interest are based on council areas so better regionalised outputs. SLR and SST are expected to be developed in the future and Ralph and Jacqui are keen to collaborate on this. Problem is time commitment and availability to do this. By late November another person from the group will be back from leave and can provide better information on this. Working with this group will have the advantage of using already made products with a better resolution than Climate in Australia website. Need to consider the need of a dedicated data person to extract downscaled model outputs if not available in the portal.	none: data can be accessed via login on website	https://www.longpaddock.qld.gov.au/qld-future-climate/

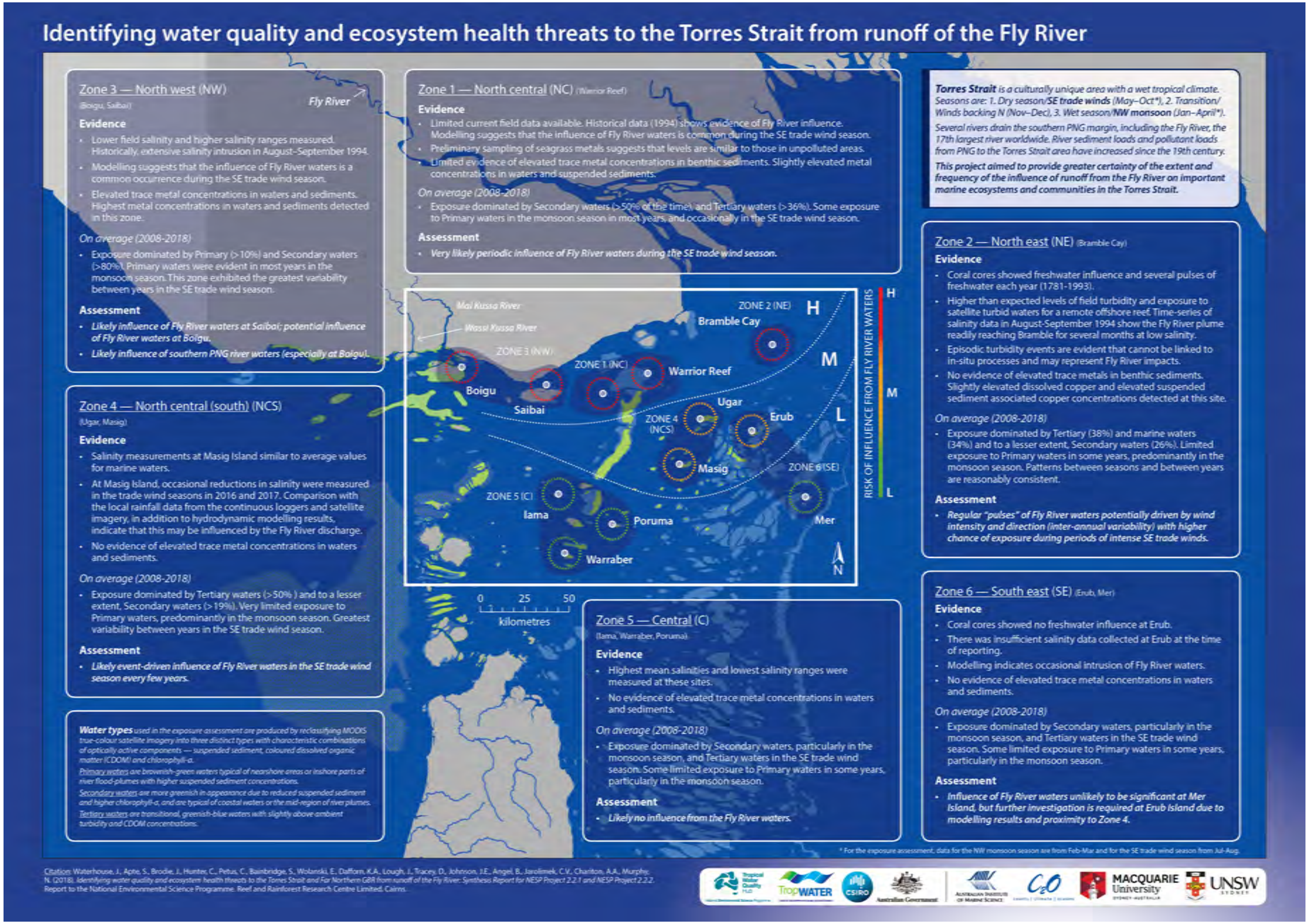
#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
303	Physiochemical	Trace metals	NESP	Identifying water quality and ecosystem health threats to the Torres Strait from runoff arising from mine-derived pollution of the Fly River	Observational	2018	2018	habitats located in the northeast corner of the Torres Strait Protection Zone, north of Masig Island and northwest as far as Boigu Island, are located in a higher potential risk area of exposure to brackish and turbid waters from or derived from the Fly River, as well as from/or derived from local PNG river discharges. While this movement of water from the Fly River is a historic pattern, the estimated 40% increase in sediment discharge associated with the operation of Ok Tedi mine is likely to have changed the characteristics of sediment and contaminant concentrations in this region. Despite the increased load, water and sediment quality is generally excellent across the region. Increased metal concentrations in waters and sediments were only observed around Boigu and Saibai islands.	contact authors	Waterhouse, J., et al. (2018). Identifying water quality and ecosystem health threats to the Torres Strait from runoff arising from mine-derived pollution of the Fly River: Synthesis Report for NESP Project 2.2.1 and NESP Project 2.2.2. Report to the National Environmental Science Programme. Cairns: 25p.
304	Physiochemical	Turbidity	NESP	Identifying water quality and ecosystem health threats to the Torres Strait from runoff arising from mine-derived pollution of the Fly River	Observational	2018	2018	habitats located in the northeast corner of the Torres Strait Protection Zone, north of Masig Island and northwest as far as Boigu Island, are located in a higher potential risk area of exposure to brackish and turbid waters from or derived from the Fly River, as well as from/or derived from local PNG river discharges. While this movement of water from the Fly River is a historic pattern, the estimated 40% increase in sediment discharge associated with the operation of Ok Tedi mine is likely to have changed the characteristics of sediment and contaminant concentrations in this region. Despite the increased load, water and sediment quality is generally excellent across the region. Increased metal concentrations in waters and sediments were only observed around Boigu and Saibai islands.	contact authors	Waterhouse, J., et al. (2018). Identifying water quality and ecosystem health threats to the Torres Strait from runoff arising from mine-derived pollution of the Fly River: Synthesis Report for NESP Project 2.2.1 and NESP Project 2.2.2. Report to the National Environmental Science Programme. Cairns: 25p.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
305	Physiochemical	Mean Surface Temperature	CSIRO	Downscaled Climate Projections for the Torres Strait Region: 8 km results for 2055 and 2090	Modelled	2055	2090	Three global models (GFDL-CM2.1, UKMO-HadCM3 and ECHAM5 60 km CCAM global simulations) were selected for further downscaling to 8 km resolution. Of the six host models, these show a low, middle and high amount of global warming into the future, respectively. Due to the very high demand for computer resources when downscaling at 8 km resolution, the temporal and spatial extent of the simulations was limited. Only the 1980-1999, 2046-2065 and 2080-2099 time periods were simulated for seven 1000 km x 1000 km regions, including Papua New Guinea, East Timor, Fiji, Solomon Islands, Vanuatu, Samoa and the Federated States of Micronesia. The results from the PNG simulation were used in this study because they also cover the Torres Strait region.	Contact Authors	Katzfey, J. and W. Rochester (2012). Downscaled Climate Projections for the Torres Strait Region: 8 km results for 2055 and 2090. Thursday Island.
306	Physiochemical	Rainfall	CSIRO	Downscaled Climate Projections for the Torres Strait Region: 8 km results for 2055 and 2091	Modelled	2055	2090	Three global models (GFDL-CM2.1, UKMO-HadCM3 and ECHAM5 60 km CCAM global simulations) were selected for further downscaling to 8 km resolution. Of the six host models, these show a low, middle and high amount of global warming into the future, respectively. Due to the very high demand for computer resources when downscaling at 8 km resolution, the temporal and spatial extent of the simulations was limited. Only the 1980-1999, 2046-2065 and 2080-2099 time periods were simulated for seven 1000 km x 1000 km regions, including Papua New Guinea, East Timor, Fiji, Solomon Islands, Vanuatu, Samoa and the Federated States of Micronesia. The results from the PNG simulation were used in this study because they also cover the Torres Strait region.	Contact Authors	Katzfey, J. and W. Rochester (2012). Downscaled Climate Projections for the Torres Strait Region: 8 km results for 2055 and 2090. Thursday Island.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
307	Physiochemical	Relative humidity	CSIRO	Downscaled Climate Projections for the Torres Strait Region: 8 km results for 2055 and 2092	Modelled	2055	2090	Three global models (GFDL-CM2.1, UKMO-HadCM3 and ECHAM5 60 km CCAM global simulations) were selected for further downscaling to 8 km resolution. Of the six host models, these show a low, middle and high amount of global warming into the future, respectively. Due to the very high demand for computer resources when downscaling at 8 km resolution, the temporal and spatial extent of the simulations was limited. Only the 1980-1999, 2046-2065 and 2080-2099 time periods were simulated for seven 1000 km x 1000 km regions, including Papua New Guinea, East Timor, Fiji, Solomon Islands, Vanuatu, Samoa and the Federated States of Micronesia. The results from the PNG simulation were used in this study because they also cover the Torres Strait region.	Contact Authors	Katzfey, J. and W. Rochester (2012). Downscaled Climate Projections for the Torres Strait Region: 8 km results for 2055 and 2090. Thursday Island.
308	Physiochemical	Wind Speed	CSIRO	Downscaled Climate Projections for the Torres Strait Region: 8 km results for 2055 and 2093	Modelled	2055	2090	Three global models (GFDL-CM2.1, UKMO-HadCM3 and ECHAM5 60 km CCAM global simulations) were selected for further downscaling to 8 km resolution. Of the six host models, these show a low, middle and high amount of global warming into the future, respectively. Due to the very high demand for computer resources when downscaling at 8 km resolution, the temporal and spatial extent of the simulations was limited. Only the 1980-1999, 2046-2065 and 2080-2099 time periods were simulated for seven 1000 km x 1000 km regions, including Papua New Guinea, East Timor, Fiji, Solomon Islands, Vanuatu, Samoa and the Federated States of Micronesia. The results from the PNG simulation were used in this study because they also cover the Torres Strait region.	Contact Authors	Katzfey, J. and W. Rochester (2012). Downscaled Climate Projections for the Torres Strait Region: 8 km results for 2055 and 2090. Thursday Island.

#	Domain	Parameter / species / habitat	Where is the data	Title	Obervation / Model	Date start	Date end	Metadata (e.g. Scale / Location)	Licence use	Source/ reference
309	Ecological	Growth: Panulirus ornatus	CSIRO	Long-Term Variation of Tropical Rock Lobster Panulirus Ornatus (Decapoda, Palinuridae) Growth in Torres Strait, Australia	Modelled and Observational	1989	2009	In the past two decades, growth rates have fluctuated inter-annually without displaying any distinctive trend. Associated uncertainties are large, suggesting that sampling will need to be intensified in order to detect an effect of climate change	Contact authors	Kienzle, M., et al. (2012). "Long-Term Variation of Tropical Rock Lobster Panulirus Ornatus (Decapoda, Palinuridae) Growth in Torres Strait, Australia." Crustaceana 85(2): 189-204.
310	Ecological	*Growth: Brown tiger prawn*	on paper	Migration and growth of two tropical penaeid shrimps within Torres Strait, northern Australia	Observational	1986	1988		Contact authors	Watson, R. A. and C. T. Turnbull (1993). "Migration and growth of two tropical penaeid shrimps within Torres Strait, northern Australia." Fisheries Research 17(3): 353-368.
311	Ecological	*Growth: Spanish mackerel*	on paper	Stock assessment of the Torres Strait Spanish mackerel fishery	Modelled and Observational	1988	2003	Stock assessment report that used published growth rates specific for Torres Strait in models.	Contact authors	Begg, G. A., et al. (2006). Stock assessment of the Torres Strait Spanish mackerel fishery. CRC Reef Research Centre Technical Report No. 66. Townsville.
312	Ecological	Reproduction: sea cucumbers	On Book	Torres Strait Beche-de-mer (Sea cucumber) species ID guide	Observational			Data on age at maturity, spawning season for species found in Torres Strait	Contact authors	Murphy, N., et al. (2019). Torres Strait Beche-de-mer (Sea cucumber) species ID guide. Brisbane, Commonwealth Scientific and Industrial Research Organisation
313	Ecological	Reproduction: Panulirus ornatus	on paper	Reproductive cues in Panulirus ornatus	Observational	2002	2003	Experimental work which reviews Panulirus ornatus reproductive behaviour for application in aquaculture	Contact authors	Sachlikidis, N. G., et al. (2005). "Reproductive cues in Panulirus ornatus." New Zealand Journal of Marine and Freshwater Research 39(2): 305-310.
314	Ecological	Finfish - Spanish Mackerel	on paper	Stock assessment of the Torres Strait Spanish mackerel fishery	Modelled and Observational	2000	2004	Summary of data for growth, sex ratios, maturity, reproduction, and age structure	Contact authors	Begg, G. A., et al. (2006). Stock assessment of the Torres Strait Spanish mackerel fishery. CRC Reef Research Centre Technical Report No. 66. Townsville.

Appendix B Water quality and ecosystem health threats to the Torres Strait from runoff of the Fly River (Waterhouse et al. 2018)



Identifying water quality and ecosystem health threats to the Torres Strait from runoff of the Fly River

***Torres Strait** is a culturally unique area with a wet tropical climate. Seasons are: 1. Dry season/**SE trade winds** (May–Oct*), 2. Transition/ Winds backing N (Nov–Dec), 3. Wet season/**NW monsoon** (Jan–April*).*

Several rivers drain the southern PNG margin, including the Fly River, the 17th largest river worldwide. River sediment loads and pollutant loads from PNG to the Torres Strait area have increased since the 19th century.

This project aimed to provide greater certainty of the extent and frequency of the influence of runoff from the Fly River on important marine ecosystems and communities in the Torres Strait.

Zone 1 — North central (NC) (Warrior Reef)

Evidence

- Limited current field data available. Historical data (1994) shows evidence of Fly River influence. Modelling suggests that the influence of Fly River waters is common during the SE trade wind season.
- Preliminary sampling of seagrass metals suggests that levels are similar to those in unpolluted areas.
- Limited evidence of elevated trace metal concentrations in benthic sediments. Slightly elevated metal concentrations in waters and suspended sediments.

On average (2008-2018)

- Exposure dominated by Secondary waters (>50% of the time) and Tertiary waters (>36%). Some exposure to Primary waters in the monsoon season in most years, and occasionally in the SE trade wind season.

Assessment

- *Very likely periodic influence of Fly River waters during the SE trade wind season.*

Zone 2 — North east (NE) (Bramble Cay)

Evidence

- Coral cores showed freshwater influence and several pulses of freshwater each year (1781-1993).
- Higher than expected levels of field turbidity and exposure to satellite turbid waters for a remote offshore reef. Time-series of salinity data in August-September 1994 show the Fly River plume readily reaching Bramble for several months at low salinity.
- Episodic turbidity events are evident that cannot be linked to in-situ processes and may represent Fly River impacts.
- No evidence of elevated trace metals in benthic sediments. Slightly elevated dissolved copper and elevated suspended sediment associated copper concentrations detected at this site.

On average (2008-2018)

- Exposure dominated by Tertiary (38%) and marine waters (34%) and to a lesser extent, Secondary waters (26%). Limited exposure to Primary waters in some years, predominantly in the monsoon season. Patterns between seasons and between years are reasonably consistent.

Assessment

- *Regular "pulses" of Fly River waters potentially driven by wind intensity and direction (inter-annual variability) with higher chance of exposure during periods of intense SE trade winds.*

Zone 3 — North west (NW)

(Boigu, Saibai)

Evidence

- Lower field salinity and higher salinity ranges measured. Historically, extensive salinity intrusion in August–September 1994.
- Modelling suggests that the influence of Fly River waters is a common occurrence during the SE trade wind season.
- Elevated trace metal concentrations in waters and sediments. Highest metal concentrations in waters and sediments detected in this zone.

On average (2008-2018)

- Exposure dominated by Primary (>10%) and Secondary waters (>80%). Primary waters were evident in most years in the monsoon season. This zone exhibited the greatest variability between years in the SE trade wind season.

Assessment

- *Likely influence of Fly River waters at Saibai; potential influence of Fly River waters at Boigu.*
- *Likely influence of southern PNG river waters (especially at Boigu).*

Zone 4 — North central (south) (NCS)

(Ugar, Masig)

Evidence

- Salinity measurements at Masig Island similar to average values for marine waters.
- At Masig Island, occasional reductions in salinity were measured in the trade wind seasons in 2016 and 2017. Comparison with the local rainfall data from the continuous loggers and satellite imagery, in addition to hydrodynamic modelling results, indicate that this may be influenced by the Fly River discharge.
- No evidence of elevated trace metal concentrations in waters and sediments.

On average (2008-2018)

- Exposure dominated by Tertiary waters (>50%) and to a lesser extent, Secondary waters (>19%). Very limited exposure to Primary waters, predominantly in the monsoon season. Greatest variability between years in the SE trade wind season.

Assessment

- *Likely event-driven influence of Fly River waters in the SE trade wind season every few years.*

Zone 5 — Central (C)

(Iama, Warraber, Poruma)

Evidence

- Highest mean salinities and lowest salinity ranges were measured at these sites.
- No evidence of elevated trace metal concentrations in waters and sediments.

On average (2008-2018)

- Exposure dominated by Secondary waters, particularly in the monsoon season, and Tertiary waters in the SE trade wind season. Some limited exposure to Primary waters in some years, particularly in the monsoon season.

Assessment

- *Likely no influence from the Fly River waters.*

Zone 6 — South east (SE) (Erub, Mer)

Evidence

- Coral cores showed no freshwater influence at Erub.
- There was insufficient salinity data collected at Erub at the time of reporting.
- Modelling indicates occasional intrusion of Fly River waters.
- No evidence of elevated trace metal concentrations in waters and sediments.

On average (2008-2018)

- Exposure dominated by Secondary waters, particularly in the monsoon season, and Tertiary waters in the SE trade wind season. Some limited exposure to Primary waters in some years, particularly in the monsoon season.

Assessment

- *Influence of Fly River waters unlikely to be significant at Mer Island, but further investigation is required at Erub Island due to modelling results and proximity to Zone 4.*

***Water types** used in the exposure assessment are produced by reclassifying MODIS true-colour satellite imagery into three distinct types with characteristic combinations of optically active components — suspended sediment, coloured dissolved organic matter (CDOM) and chlorophyll-a.*

Primary waters are brownish-green waters typical of nearshore areas or inshore parts of river flood-plumes with higher suspended sediment concentrations.

Secondary waters are more greenish in appearance due to reduced suspended sediment and higher chlorophyll-a, and are typical of coastal waters or the mid-region of river plumes.

Tertiary waters are transitional, greenish-blue waters with slightly above ambient turbidity and CDOM concentrations.

* For the exposure assessment, data for the NW monsoon season are from Feb-Mar and for the SE trade wind season from Jul-Aug.

Citation: Waterhouse, J., Apte, S., Brodie, J., Hunter, C., Petus, C., Bainbridge, S., Wolanski, E., Dafforn, K.A., Lough, J., Tracey, D., Johnson, J.E., Angel, B., Jarolimek, C.V., Chariton, A.A., Murphy, N. (2018). *Identifying water quality and ecosystem health threats to the Torres Strait and Far Northern GBR from runoff of the Fly River: Synthesis Report for NESP Project 2.2.1 and NESP Project 2.2.2.* Report to the National Environmental Science Programme. Reef and Rainforest Research Centre Limited, Cairns.

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Torres Strait Scientific Advisory Committee 2020-2023 financial year research project scope

Project Title: Understanding climate variability and change relevant to key fisheries resources in the Torres Strait and adaptation and mitigation strategies.

Project Need:

Due to their strong connection to the marine environment, Torres Strait Island communities are uniquely reliant on their only significant renewable resource, fisheries. Key commercial species in Torres Strait fisheries, such as tropical rock lobsters, prawns, finfish and beche-de-mer, and the environment they rely on, will be influenced by current and future climate variability and change. These changes have the potential to disrupt fishers and fishing communities livelihoods and threaten food security, and understanding their likely extent is essential to enable mitigation and adaptation to occur, to secure the long term economic and social benefits for Torres Strait communities. There has been relatively little investment in research on fisheries-related climate change issues in the Torres Strait, compared to other areas of Australia.

Fisheries management and assessments will need to take account of the implications of future variability and change that may affect stocks. These may manifest through effects on recruitment pathways, mortality rates, and critical habitats among other processes. Previous reviews have qualitatively assessed the vulnerability of the Torres Strait to climate change effects; however, there is a need to account for these in a quantitative manner for fisheries management and communities to respond appropriately. A quantitative MICE model (Model of Intermediate Complexity) has already been completed in the Torres Strait region for tropical rock lobster, as a part of understanding the annual variability in abundance. Separate fishery specific assessment models for multiple species, will all require essentially the same over-arching regional-scale data. This data should cover future climate and environmental variability, including currents, winds, temperature, rainfall etc, at an appropriate spatial extent and grid-resolution.

If this project is funded, the model which is developed should be transferrable to other fisheries around Australia. The outcomes of the project will also provide climate variability information which is likely to have widespread benefits to support the communities of the Torres Strait to adapt, beyond just fisheries management.

Progress to date:

AFMA has completed a scoping study that has delivered an evaluation of the over-arching data requirements and framework that are needed to support a climate change model that will evaluate the implications of future climate variability and change scenarios on key fisheries. The study considered previous reviews of climate implications for Torres Strait, consulted extensively with relevant fishery researchers, managers and key stakeholders and convened a workshop, with relevant fishery modelling expert end-users and stakeholders. The final report provided a specification and preliminary costing for a climate change project on which this project scope is based.

Desired outcomes

The proposed project and resulting model and findings should:

i) enable fisheries managers and communities to better prepare for climate change mitigation and adaptation, where possible;

ii) integrate new and existing fisheries and environmental data within an over-arching data framework;

iii) provide estimates of the impacts that different climate change scenarios could have on the marine ecosystem and associated fisheries/species;

iv) provide estimates of the economic, social and other fisheries-related livelihood impacts of climate change on communities in the short (2 yrs), medium (5 yrs) and longer term (10+ yrs), and suggest some possible actions for adaptation; and

v) help differentiate between the relative effects of fishing and climate change on marine resources.

vi) provide results in formats (e.g. graphical, video, written) which can be communicated to stakeholders (Torres Strait Island Communities, Fishers, Fisheries Managers and local and regional organisations).

While the full proposed project would take 3-5 years to complete, there is an urgent need to gain early estimates of climate change impacts, noting that these estimates will be refined over time as the model is further developed and new data included.

Project outputs, time frame and cost estimates

The proposed project would consist of four stages/ components, which would be scheduled according to funding and researcher availability.

Steps 1 and 2 would need to commence simultaneously and be capable of providing preliminary estimates of climate change impacts within two years.

If funding was available, it would be preferred (but not essential) if Step 4 could be commenced at the start of the project. This will allow the project to be completed more quickly, which is the preference of Torres Strait communities and fishery managers.

Other than the data collected under Step 4, the proposed project could use existing and ongoing (funded) data, including those from global climate models, the Bureau of Meteorology and Torres Strait weather and marine monitoring data which has been collected by TSRA and AIMS. The already available data will allow the project team to begin modelling sooner if the project goes ahead. New data sources, including exploring opportunities to work with the Integrated Marine Observing System (IMOS) to establish sites within Torres Strait will also be considered.

1. Production of an over-arching data framework (approx. one year)
2. Development of an integrated modelling framework that would combine existing data and models (tropical rock lobster, beche-de-mer and dugongs) into an integrated MICE (approx. two years)
3. Development of a regional hydrographic modelling platform resulting in a high-resolution physical circulation model (approx. two years)
4. A short term data acquisition programme using moored data loggers and conductivity temperature depth (CTD) casts to collect additional physical data (including temperature, salinity currents and surface elevation) over at least one set of wet and dry seasons

Torres Strait Scientific Advisory Committee research application 2021

Please note TSSAC research applications have changed. There are no longer pre proposals. As such, please complete all sections of this proposal. You are also required to attach a copy of your stakeholder engagement strategy and community consultation plan with your proposal. See Attachment A for instructions on completing these documents.

SECTION 1 - ADMINISTRATIVE SUMMARY

Project title:	Understanding climate variability and change relevant to key fisheries resources in the Torres Strait and adaptation and mitigation strategies
Applicant (organisation or person):	CSIRO Oceans and Atmosphere
Contacts	

Administrative

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Principal Investigator (person)

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Co-investigator (s)

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Planned Start and End Date

Start Date:	01/07/2022	End Date: 01/03/2026

SECTION 2 – PROJECT BUDGET

PROJECT BUDGET: (Excluding GST)

Financial Year	AFMA	Applicant (in kind)	Applicant	Other
2022-23	$270,561	$114,407		$0.00
2023-24	$405,687	$171,545		$0.00
2024-25	$235,000	$99,370		$0.00
2025-26	$137,711	$58,231		$0.00
Totals	$1,048,959	$443,553		$0.00

SECTION 3 – PROJECT DESCRIPTION

Background and need (max 250 words) - *detail any important background relating to the project. Why it is important and being proposed (need). Any related projects or other information the TSSAC should know when considering it for funding.*

Fisheries in Torres Strait strongly support lifestyles, livelihoods and economic activities, but are at risk from climate change. Understanding the nature and extent of climate change impacts, and their socio-economic and livelihood consequences will help stakeholders better manage risks and adapt.

The research proposed will provide to fishers and managers up-to-date evidence-based information about current and future risks to fisheries associated with climate change. It will develop an integrated model of intermediate complexity for ecosystem assessment (i-MICE) to estimate climate change impacts on selected fisheries/species. Model development follows a stepwise approach. In **Phase 1** available data and models will be combined in a data framework, i-MICEv.1 will be developed by extending and linking current biological models of key species (TRL, BDM, dugongs), known environmental drivers (SST) and habitat (seagrass). i-MICEv.1 will investigate the impacts of climate change scenarios on fisheries/species in the short (2yr), medium (5yr) and long-term (20 yrs), also considering socio-economic and livelihood metrics. **Phase 2** will develop a 3-dimensional ocean model to generate additional oceanographic data, based on climate change scenarios. The new data will feed into a refined i-MICEv.2 to investigate broader implications (i.e. not only related to SST) of climate change on the selected fisheries. Model results in both phases will be used to inform stakeholders and co-develop adaptation strategies via workshops.

Phases 1 and 2 are designed to be ‘stand-alone’ sequential exercises, but could be done in parallel which would allow the generation of timely results to stakeholders and development of adaptation strategies.

Objectives / performance indicators (max 250 words) **-** *list the major objectives or planned outcomes of the project. These will form your project milestones (Section 5):*

Phase 1

1. Establish a project steering committee (PSC) with guidance from AFMA and TSRA.
2. Develop data framework which will include collated fisheries and environmental datasets identified in the scoping study.
3. Integrate available data and models for Tropical Rock Lobster, bêche-de-mer, dugongs and seagrass into an integrated spatial MICE (i-MICEv.1) for the Torres Strait region and provide estimates of relative impacts from climate change (sea surface temperature for base case and a high emission scenario) on fisheries resources in the short (2yrs), medium (5yrs) and longer term (10+ yrs).
4. Refine social, economic and livelihood metrics (from previous Torres Strait Lobster MSE project) with PSC and link these metrics with the i-MICEv.1 model and present results from i-MICEv.1 to stakeholders and based on results, co-develop adaptation actions during workshops (if Phase 2 is funded, adaptation strategies will be finalized at a later stage (8).

Phase 2

5. Establish a monitoring program to collect physical data needed to calibrate the 3-dimensional ocean model of Torres Strait. Publish calibration data in Torres Strait data framework (2).
6. Develop and calibrate 3-dimensional ocean models (to cover the Torres Strait area). Generate outputs for physical processes for baseline and climate change scenarios. Deliver model outputs in the Torres Strait data framework (2).
7. Build i-MICEv.2 based on new variables from Torres Strait 3-dimensional ocean models and update estimated impacts.
8. Present results of the project to stakeholders and communities and co-develop adaptation strategies via stakeholder workshop(s).

Consultation and Engagement – *Note: community consultation is required with key Torres Strait community stakeholders as a part of a TSSAC research project application being considered for funding.*

This consultation will be required following conditional approval of a research proposal by the TSSAC. In order to facilitate this consultation, you are asked to develop a "stakeholder engagement strategy" and "community consultation package" as part of this research application. Please follow the instructions at Attachment A.

If there has been any initial consultation and engagement with Torres Strait communities already for this project, or for similar projects in the past, please outline with whom and the key outcomes. Please also outline any other consultation you have completed with other stakeholders too. (.

In 2021 CSIRO delivered the scoping study “Scoping a future project to address impacts from climate variability and change on key Torres Strait Fisheries” to AFMA which evaluated the availability and suitability of existing data required to develop future models to assess the impacts of climate change in Torres Strait fisheries. The findings from the scoping study included extensive consultation with fishery researchers, managers and key Torres Strait stakeholders, and included a technical workshop organised in October 2020 to present the proposed data and modelling frameworks, where input from participants were used in the final project scope specifications and preliminary costs provided.

The scoping study found that some datasets and models are available to start the modelling exercise. It recommended the consolidation of the available data into an overarching data framework and integration of existing data and models into a model of intermediate complexity for ecosystem assessment (MICE). The scoping study also recommended the construction of MICE in a stepwise fashion, adding new data and complexity as these become available or necessary, and engage with stakeholders to communicate model results at early stages and draw on local knowledge to further refine models. Also, given the paucity of hydrodynamic and physical data for the region, the scoping study recommended the development of a dedicated hydrodynamic model for Torres Strait because previous hydrodynamic models and supporting data are outdated. The Torres Strait hydrodynamic model would provide new oceanographic predictions at scales relevant to the management of fisheries by dynamically downscaling climate change scenarios that could then be used to refine and further develop MICE. As discussed during presentation of the scoping study with TSSAC in 2021, developing 3-dimensional ocean models and collecting the necessary data for its calibration and validation is expensive, but would be useful to investigate broader impacts of climate change in the region. For example, on other fisheries, different ecosystems and communities. The current proposal implements the recommended stepwise approach in the developments of models, also incorporating local knowledge, community and management needs via actively engaging with stakeholders.

Methods (max 250 words) – *Detail the methods that will be used to undertake this project.*

Phase 1

A project steering committee (PSC) will be established with support from AFMA and TSRA. The PSC will meet at least for 2h, 3 times/year to guide and advise on progress, stakeholder engagement, communication, adaptation strategies and other relevant matters.

The overarching data framework will use CSIRO IT infrastructure to collate, manage and describe datasets identified in the scoping study. These descriptions will be made public to allow non-CSIRO researchers to access and visualise data.

i-MICEv.1 will extend and link current biological models of key species (TRL, BDM, dugongs), known environmental drivers (sea surface temperature) and habitat (seagrass). The model will provide quantitative estimates of impacts from baseline and climate change scenarios on habitat and fisheries/species in the short (2yr), medium (5yr) and long-term (20 yrs). Previous social, economic and other fisheries-related livelihoods metrics will be refined with PSC and linked to i-MICE.

i-MICEv.1 results will be presented to stakeholders in a workshop, where adaptation strategies will be co-developed. Techniques such as scenario planning, impact and livelihood adaptation pathways will be applied in the workshop. Adaptation actions will only be developed here if Phase 2 is not funded.

Phase 2

Field work: Two moorings will be deployed for two months each over wet and dry seasons to collect the required physical data to extend boundaries, calibrate and validate a 3-dimensional ocean model of Torres Strait. The model will run baseline and climate change scenarios to generate new oceanographic data to develop i-MICEv.2, and updated results will be presented to stakeholders in a workshop where adaptation strategies will be co-developed.

Planned outcomes and benefits (max 150 words) – *this should include how the research will be used by management to benefit the fishery and other stakeholders:*

The research will integrate existing and new data and models into a data framework and develop i-MICE to estimate changes in fisheries and ecosystem resources due to climate change. It will integrate these results with socio-economic and livelihood metrics, present research results back to stakeholders, and draw on local knowledge to further refine models. Model results will be presented and discussed with stakeholders and used to co-develop adaptation actions and to inform existing planning and adaptation processes. This will allow local communities and fisheries management to proactively prepare for short-long term changes anticipated under climate change. All data collected and produced in the project will be securely stored and managed via the proposed overarching data framework, where stakeholder information (e.g. local knowledge) will only be used with formal consent.

Project extension (max 100 words) - *are there possible future research options that could result from this project?*

Several research projects can result or benefit from this project. For example, the i-MICE modelling framework will allow the addition of complexity (e.g. new habitats, species and environmental conditions) depending on needs and data availability in the future. The combined i-MICE and ocean models will provide new hydrodynamic data and quantified impacts from climate change scenarios that could be used to support a broad range of further research on impacts and adaptation in Torres Strait. For example, they will allow the investigation of: (a) interactions between different fisheries and ecosystem functioning, (b) climate change impacts on abundance and distribution of a broader range of fisheries and species, (c) impacts of incidents (e.g. oil spills, ships running aground), (d) synergistic and cumulative climate and non-climate impacts on species, ecosystems and livelihoods, and e) the evaluation of alternative adaptation options.

Risk Analysis - *be sure to consider risks specific to conducting research in the Torres Strait including community support or lack there-of.*

The project team has a long history of research and stakeholder engagement in the region, and this considerably reduces the risk of a lack of support for the research. The project scope in which this proposal is based has invested time and effort to engage with stakeholders and the technical and fisheries management communities, inviting their inputs, and involving them in the research scope to the extent possible. As a result, there is strong interest and support from TSSAC to better understand climate change impacts in the fisheries of Torres strait and more broadly. There are a number of risks associated with conducting fieldwork in a remote region to collect the environmental data needed to develop the ocean model, such as strong currents, remote locations, and prevailing weather conditions, but CSIRO has strong expertise and experience in managing and avoiding any risks as they arise, plus stringent protocols in place to minimize these, which include mothership compliance with AMSA regulations, survey equipment inspection checklists, regular equipment servicing, and field work management.

Related Projects and Research Capacity (max 100 words) - *Are there any past or current projects relevant to this proposal funded through the TSSAC, TSRA, FRDC or other organisation? Outline the Investigators' experience in the proposed research and Torres Strait region.*

CSIRO has conducted research (e.g. surveys, assessment and harvest strategy development projects) on Rock Lobsters, bêche-de-mer and other fisheries in Torres Strait, including seabed habitat monitoring (including seagrass) and subsequent stock assessments since 1989 (PIs: Eva Plaganyi, Nicole Murphy et al.). This project builds also on a recent project led by Leo Dutra (CSIRO): Climate variability and change relevant to key fisheries resources in the Torres Strait and is also complemented by an FRDC project (led by Leo Dutra), which aims to build research capacity in the Torres Strait by engaging Torres Strait Islanders and CSIRO researchers in the co-production and presentation of research at international conferences.

CSIRO has collaborated with Torres Strait islander communities, organizations and individuals throughout its history working in the area to ensure research outcomes are relevant to Torres Strait. Torres Strait islanders are provided with results of the research projects.

SECTION 4 - Schedule of Payments

As a general rule, up to 10% of the total project cost may be provided as an initial payment and a minimum of 30% of the total project cost must be left for the final report.

Milestones	**Deliverable date (Please refer to instructions)**	**Schedule of AFMA payment(s) (excluding GST)**
Initial payment on signing of contract	01/07/2022	$0.00
Establish project steering committee	01/11/2022	$0.00
PHASE 1		
Data framework	30/07/2023	$87,356
Fisheries and socioecological estimates of climate change impacts on ecosystem and fisheries (iMICEv.1)	30/09/2024	$360,107
Presentation of model results to stakeholders and adaptation strategies	30/10/2024	$35,108
Phase 1 report	30/11/2024	-
PHASE 2		
Data collection to calibrate and validate hydrodynamic model	01/04/2025	$157,929
Hydrodynamic model runs for climate change scenarios	30/07/2025	$277,185
Assessment of climate change impacts using new oceanographic data from TS hydrodynamic model (i-MICEv.2	27/02/2026	$95,460
Presentation of model results to stakeholders and development of adaptation strategies	31/03/2026	$35,814
Draft final report	15/04/2026	-
Final report	30/04/2026	-
TOTAL		$1,048,959

SECTION 5 - Description of Milestones

Details on each milestone must provide sufficient information to justify the milestone cost and should match the performance indicators. The description field will describe the work to be completed for that milestone with the justification field elaborating further on the categories of cost - for example salary.

Milestone: Initial payment on signing of contract **Date:** 01/07/2022

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: Establish project steering committee **Date:** 01/11/2022

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

A project steering committee (PSC) composed of fisheries managers, fishers, community members and other relevant stakeholders will be established at the beginning of the project. Lisa Cocking (AFMA) agreed to further discuss the process to establish a steering committee with TSRA and the project team if the project is funded. The PSC is expected to meet at least 3 times a year for 2h, where meetings can be conducted online or face-to-face depending on funds, time and needs of PSC members. **Please note that no funds were budgeted in the proposal** to cover travel, incidentals, sitting fees or any other costs for PSC members (assumed to be voluntary).

Justification:

Climate change is a contentious issue in Torres Strait and requires adequate mechanisms to ensure expectations about the project are adequately managed. A PSC will be important to address these issues by providing advice to the project team on research results, and guidance to select relevant metrics for fisheries and livelihood impacts that could be used to support management and planning processes. The PSC will also guide the project team about appropriate communication of research results and limitations, stakeholder engage during the development of the adaptation strategies and provide advice on extra-ordinary matters if they arise.

Milestone: Data framework **Date:** 30/07/2023

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$60,098	$0.00	$2,108	$0.00	**$62,206**
2023-24	9,226				9,226
2024-25	9,486				9,486
2025-26	6,438				6,438
TOTAL					$87,356

Description:

The proposed data framework identifies how the physio-chemical and ecological data will be managed and delivered to support the development of the proposed integrated MICE models and other research in Torres Strait. Datasets will be managed on CSIRO IT infrastructure, utilising relational database systems and enterprise file servers. Datasets will be described using geonetwork (www.marlin.csiro.au) and these descriptions will be made public to allow third parties (non-CSIRO) to access data depending on level of permission granted (i.e. licence restrictions). Datasets will be shared using Open Geospatial Consortium (OGC) standards where appropriate, by using a standards-compliant webserver (geoserver) linked to the collated data. This framework is scalable, robust and compliant with open data/metadata standards, allowing a flexible data delivery method to data visualisation portals, such as Torres Strait eAtlas and the Australian Ocean Data Network (AODN) portal (to be decided with PSC). The project will ensure confidentiality of local knowledge, which will only be used in the project or stored in the data framework with formal consent, following strict human ethics protocols.

Justification:

The data framework described will support the development of the integrated MICE model to investigate impacts of climate change on the selected fisheries, and other future research efforts in the region. It will also be the repository of data generated in the project, including calibration data for the hydrodynamic model and its outputs. The data framework will include metadata to allow the identification of datasets, access or permissions required to access data, restrictions, and spatial-temporal coverage of datasets. The data framework is flexible and has the potential to be deployed in other regions of interest.

Milestone: Fisheries and socio-ecological estimates of climate change impacts on ecosystem and fisheries (iMICEv.1) **Date:** 30/09/2024

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$125,430	$0.00	$2,109	$0.00	**$127,539**
2023-24	$182,661	$0.00	$0.00	$0.00	**$182,661**
2024-25	$49,907	$0.00	$0.00	$0.00	**$49,907**
TOTAL					**$360,107**

Description:

i-MICEv.1 will extend and link current biological models of key species (TRL, BDM, dugongs), known environmental drivers (sea surface temperature) and habitat (seagrass). The model will provide quantitative estimates of impacts from baseline and climate change scenarios on habitat and fisheries/species in the short (2yr), medium (5yr) and long-term (20 yrs). Social, economic and other fisheries-related livelihoods metrics from previous Lobster MSE project will be refined with PSC and linked to i-MICEv.1. Risk statistics from climate change scenarios relative to base line will be produced. This will allow stakeholders to understand, for example, under climate change, how frequently the abundance or catch of a certain species might be expected to change compared to baseline scenario and to compare the relative risks for each spatial (e.g. fishing) region and socio-economic consequences.

The custom-designed modelling framework will be flexible and scalable, will account for uncertainty, and complexity could be added if needed by including additional species, and new climate, oceanographic and environmental data, as they become available (e.g. from Stage 2).

Justification:

i-MICEv.1 will provide the modelling framework linked to existing data and models to generate quantitative estimates of impacts from climate change scenarios on selected habitats and fisheries. This modelling framework will be extended into i-MICEv.2 if Phase 2 is funded which would allow the further investigation of climate change impacts considering a broader range of oceanographic conditions (e.g. currents, sea level, rainfall, etc.). Outputs will be presented and discussed with stakeholders during workshops and adaptation actions will be co-developed with them (adaptation actions will only be finalised here if Phase 2 is not funded).

Milestone: Presentation of Phase 1 model results to stakeholders and adaptation strategies **Date:** 30/10/2024

Financial Year	Salaries	Travel	Operating	Capital	Total
2024-25	$22,106	$8,082	$4,920	$0.00	**$35,108**

Description:

Regular updates and results from i-MICEv.1 will be presented to PSC and to broader stakeholders at workshops to provide an opportunity for Q&A, feedback, and discussions including how to communicate results suitable to inform existing planning processes. Methods such as scenario planning and impact and livelihood adaptation pathways will also use i-MICEv.1 results to co-develop adaptation actions with stakeholders. Communication methods will be previously developed with PSC and discussed with broader stakeholder groups during the workshop.

If Phase 2 is funded, this workshop will involve: (a) information session to provide and discuss i-MICE results to guide the developments in the next phase, and (b) refinement of communication methods with stakeholders.

Justification:

There is a need to adequately and regularly communicate i-MICEv.1 results to PSC and broader stakeholders to inform the process to develop adaptation strategies. Stakeholders will have the opportunity to provide inputs into the delivery of climate change information to the different audiences in Torres Straits, thus making the information more salient to stakeholders.

Milestone: Phase 1 report **Date:** 30/11/2024

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Final report containing results from assessment of climate change impacts on ecosystem and fisheries/species, feedback from stakeholders on results collected during workshop and adaptation strategies (if Phase 2 is not funded).

Justification:

This will be final report of project if Phase 2 is not funded and a preliminary report to inform development of models in Phase 2 if proposal is fully funded.

Milestone: Data collection to calibrate and validate hydrodynamic model **Date:** 01/04/2025

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$42,317	$5,271	$33,228	$0.00	**$80,816**
2023-24	$37,828	$5,271	$34,015	$0.00	**$77,114**
TOTAL					**$157,929**

Description:

A monitoring program to collect physical data to calibrate the hydrodynamic model will involve 2 deployments of moorings (ADCP, CTD to collect physical data such temperature, salinity, currents (velocity, direction), surface elevation) at sea surface and bottom. Each deployment will last for 2 months over the wet and a dry seasons of years 2022-23.

Justification:

Developing the ocean model will require a data collection program for model calibration. The ocean model will provide valuable oceanographic data under different climate conditions that will improve our understanding about tides, currents sea temperature, salinity, pH and other physical drivers. Such data could be integrated in i-MICEv.2 to investigate, for example, the influence of physical drivers on reproduction, growth, larval dispersal and settlement, recruitment, abundance and distribution.

Milestone: Hydrodynamic model runs for climate change scenarios **Date:** 30/07/2025

Financial Year	Salaries	Travel	Operating	Capital	Total
2023-24	$134,579	$0.00	$2,108	$0.00	**$136,687**
2024-25	$138,390	$0.00	$2,108	$0.00	**$140,498**
TOTAL					**$277,185**

Description:

CSIRO will apply a full 3 dimensional ocean model to simulate oceanographic conditions for a baseline and climate change scenarios. The ocean model will produce 3D hydrodynamic fields of the environment on a variable resolution grid that can be nested within operational Ocean models and CMIP style ocean models. The grid will be designed to resolve the area of interest for the MICE study. If needed, model resolution for specific fisheries areas will be increased by nesting high resolution models (10s to 100s of meters) inside the regional ocean model, through the relocatable coastal ocean model.

Outputs from the hydrodynamic model will be produced for the Torres Strait Region at a minimum of 1km grid cell resolution (finer in specific areas if required) as monthly averages for specific regions of interest (e.g. MSE sub-regions, or fishing sub-areas). New data generated will be used to add complexity to i-MICEv.2 to evaluate the effects of climate change on a broader range of oceanographic conditions and their impacts on the selected ecosystem and fisheries/species.

Justification:

Currently, only existing datasets for sea surface temperature have adequate spatial and temporal resolution to be used in i-MICE. Timeseries of other oceanographic variables exist but cover limited temporal or spatial scale. There are model outputs from downscaled models that are also available, but discrepancies between model outputs and observations were previously identified and need careful consideration and calibration before their use. Ocean model outputs will be used to extend the range of climate change variables to be explored in i-MICEv.2 to provide outputs that can support additional research in Torres Strait.

Milestone: Assessment of climate change impacts using new oceanographic data from TS Hydrodynamic model (i-MICEv.2)

Date: 27/02/2026

Financial Year	Salaries	Travel	Operating	Capital	Total
2025-26	$95,460	$0.00	$0.00	$0.00	**$95,460**

Description:

Phase 1 is the starting point to initiate the investigation of climate change impacts in Torres Strait fisheries. Phase 2 is about generating new oceanographic data to allow for a more comprehensive investigation of climate impacts on physical variables and their effects on fisheries. New oceanographic data generated with the ocean model will be used to add complexity in the i-MICEv.2 to further investigate climate change impacts on the fisheries. Updated results will be presented to stakeholders.

Justification:

We use a step-wise approach in the development of i-MICE where in Phase 1, existing data are currently available to start modelling and investigate potential climate change impacts on the selected fisheries. In Phase 2, we add new data and complexity (from the ocean model) as these become available. This step-wise process allows time to obtain feedback from stakeholders on model development/assumptions/results in i-MICEv.1 and incorporate this into i-MICEv.2, allowing time to communicate model results, as well as drawing on local knowledge to further refine models and the information they generate.

Milestone: Presentation of model results to stakeholders and development of adaptation strategies

Date: 31/03/2026

Financial Year	Salaries	Travel	Operating	Capital	Total
	$25,623	$5,271	$4,920	$0.00	**$35,814**

Description:

If funds for Phase 2 are available, a second workshop will be organised to present and discuss updated results from i-MICEv.2 and to co-develop adaptation actions using scenario planning, and impact and livelihood adaptation pathways techniques.

Justification:

There is a need to adequately present and discuss research findings with stakeholders and identify ways of providing information to support existing planning and management process. I-MICEv.2 results will also support a process to co-develop adaptation strategies.

Milestone: Draft report **Date:** 15/05/2026

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: Final report **Date:** 10/06/2026

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Section 6 – Special Conditions

If relevant, this field will be used to assist in contract preparation for any special conditions. Examples of special conditions *may relate to marine spatial closures (including access) or any other clauses not specifically contained in the contract.*

N/A

Section 7 - Data management

Identify the appropriate Intellectual Property category applicable to this application. Choose ONE from below:

Code	Description
1	Published, widely disseminated and promoted, and/or training and extension provided. Relates mainly to outputs that will be available in the public domain.
2	Published, widely disseminated and promoted, and/or training and extension provided. Related products and/or services developed. Relates mainly to outputs that will largely be available in the public domain, but components may be commercialised or intellectual property protected.
3	Published, widely disseminated and promoted, and/or training and extension provided. Related products and/or services developed. Relates mainly to outputs that may have significant components that are commercialised or intellectual property protected.

The following IP category applies to this application:

1. Published, widely disseminated and promoted, and/or training and extension provided. Relates mainly to outputs that will be available in the public domain.

I have searched for existing data (refer to guidelines on how to search the Australian Spatial Data Directory and Oceans Portal):

[Yes]

Provide a brief description of the data to be generated from the project and how this data will be stored for future protection and access, including:

- information on data security or privacy issues and applying to the data

- Nominated data custodian

Physio-chemical data from monitoring program to calibrate ocean model (e.g. profiles of temperature, salinity, currents, etc) will be entered into and stored in the future overarching data framework that will also be delivered as part of the project. Data storage, protection and access is governed and managed according to CSIRO policy guidelines, in accordance with CSIRO rules and regulations.

- Document how research data, traditional knowledge and intellectual property will be handled during your project, including but not limited to:
- Acknowledging where the data or information used in research comes from, so that any income made from selling a concept in the future will be adequately linked to a community's contribution/ knowledge so they also receive financial or other benefit from "selling" a concept onward.
- How you will negotiate use and publish of traditional knowledge with communities. For example do traditional inhabitants allow public publication of information or only for project activities and reported on in internal reports? This will depend on data sensitivity and privacy (such as fishing grounds etc).
- Are there any other ethical considerations you have identified for this project which need to be managed?
- Are you committed to gaining ethics approval for this project from a suitable body such as a university or AIATSIS?

Acknowledging where the data or information used in research comes from, so that any income made from selling a concept in the future will be adequately linked to a community's contribution/ knowledge so they also receive financial or other benefit from "selling" a concept onward.
N/A – research will not include commercialisation of any products.

- How you will negotiate use and publish of traditional knowledge with communities. For example do traditional inhabitants allow public publication of information or only for project activities and reported on in internal reports? This will depend on data sensitivity and privacy (such as fishing grounds etc).

Special consideration will be taken with any Traditional Knowledge (TK) collected during the project. TK will only be used with the express permission and consent of the traditional owners. Guidance will be sought from local Island leaders and the TSRA to ensure full local support and agreement over the handling of TK information.

- Are there any other ethical considerations you have identified for this project which need to be managed?

Yes, participation in planned workshop sessions will be voluntary and participants will be given the opportunity to withdraw form participation at any time during or after the workshop. The project will follow established ethical guidelines prepared by the CSIRO Human Ethics committee.

- Are you committed to gaining ethics approval for this project from a suitable body such as a university or AIATSIS?

Yes – CSIRO has its own Human Research Ethics committee which considers the Code of Ethics for Aboriginal and Torres Strait Islander Research from AIATSIS. The project will seek human ethics approval from the CSIRO human ethics committee.

STAKEHOLDER ENGAGEMENT STRATEGY AND COMMUNITY CONSULTATION PACKAGE

Planning & development – who to engage and how

Researchers are required to develop a stakeholder engagement strategy as part of their TSSAC research proposal application process, which will include a short community consultation package which will be provided to the relevant stakeholders. This plain English package will be reviewed by the TSSAC along with your research application. You are required to work with the TSSAC Secretariat on the development of these documents. You **are not** required to undertake this consultation until conditional approval is given to your project and this engagement strategy. However, your full proposal submitted to the TSSAC can detail engagement and consultation undertaken with stakeholders and communities in developing the proposal to date, or relevant consultation from past projects, if this is an extension project, or continuing project.

Stakeholder engagement strategy

The stakeholder engagement strategy should detail the level of engagement required with the key stakeholders throughout the stages of the project (including the preliminary consultation phase as part of this research proposal, project implementation, updates about project progress and results dissemination following project completion).

The strategy should be no more than 2 pages and include:

- the areas in the Torres Strait region where the proposed research activities may occur (i.e. eastern or central communities, specific islands/ communities); and which Torres Strait community groups or individuals you will engage/involve from these areas during your research project? e.g. does your project involve community workshops or meetings? Will it employ any Torres Strait Islanders (paid or on a voluntary basis) and if not - why not, will your project interview Torres Strait Islanders? Will your project require you to visit any Torres Strait communities (or is it solely at sea)?
- The types of engagement you plan to use during different phases of the project (e.g. during the initial consultation, for updates during the project, to disseminate results of the project). The project such as posting community notices, developing plain English summary reports, recording short educational videos or infographics, phone calls or emails);
- how research data, traditional knowledge and intellectual property will be handled during the project;
- how researchers will show respect for Traditional Inhabitant culture at all times.

The strategy should consider the projects' schedules and fieldwork and allow for extra lead-time, longer engagement periods in the community and appropriate response times when drafting milestones.

Note, depending on the level of engagement with the RNTBCs this may be on a fee for service basis. Researchers need to factor in any potential fee for service rates into the research project budget.

Example stakeholder engagement strategy

Timing	Task	Method of communication
March	Complete engagement with communities about proposed project seeking feedback	Community notices, email to key stakeholders, follow up with phone calls at least twice if no response
August	Email key stakeholders to provide plain English project progress information	email to key stakeholders with contact number if they wish to discuss.
December	Email key stakeholders to provide plain English project progress information	email to key stakeholders with contact number if they wish to discuss.

June	Create and disseminate plain English summary of project outcomes.	Email to key stakeholders, community notice with QR code to website with summary.
June	Create short video with slides showing main project outcomes	Email video to key stakeholders, place community notice with QR code to website with the video link.

Community Consultation Package

The community consultation package should contain plain language information about the proposed research, be no more than two pages and may include:

- a process for clearly noting, upfront, that the project is in the application stage which is why you are seeking community views and consideration;
- the research objectives and timeframes;
- areas to be accessed for the study, and a detailed description of areas and details of what will be done there;
- materials, equipment and techniques to be used and how you will minimise risk of negative impacts on the area (environment and communities);
- involvement of key stakeholders (including local knowledge informants, local research assistants, and community information- sharing and research dissemination intentions) OR a brief explanation of why community involvement does not fit the nature of the project);
- anticipated outcomes including direct or indirect benefits* to key stakeholders such as any future benefit-sharing expectations, protections for traditional knowledge sources. AFMA may use the project summary for developing papers to communicate the research at relevant PZJA forums;
- likelihood and details of any extension activities following the research;
- how research data and intellectual property will be handled; and
- seeking advice about relevant traditional knowledge which could assist the project, or suggest changes to improve the projects' plan or success.

*For example, a) a greater understanding of a fishery through participation (potentially employment) in the research project and extension activities following the research (direct); b) improved understanding of stock status may lead to less precautionary Total Allowable Catch therefore increased utilisation of resource (indirect).

What happens following community engagement, as a part of my research application process?

Once you have undertaken the community consultation (following conditional approval of your project), provide a clear summary of the results to the TSSAC secretariat detailing:

- A list of Torres Strait communities you consulted and how this occurred including engagement methods.
- The feedback provided by each individual or group (or the number of attempts of contact if you didn't not receive a response).
- Any perceived risks or stakeholder considerations with the project.
- Any changes to be made to the proposal based on feedback.
- How traditional knowledge might be considered or incorporated to enhance the project, its outcomes and benefits including IP issues associated with this
- How the research outcomes will benefit Traditional Inhabitants directly or indirectly, or why it is not relevant/ applicable.

CSIRO OCEANS & ATMOSPHERE
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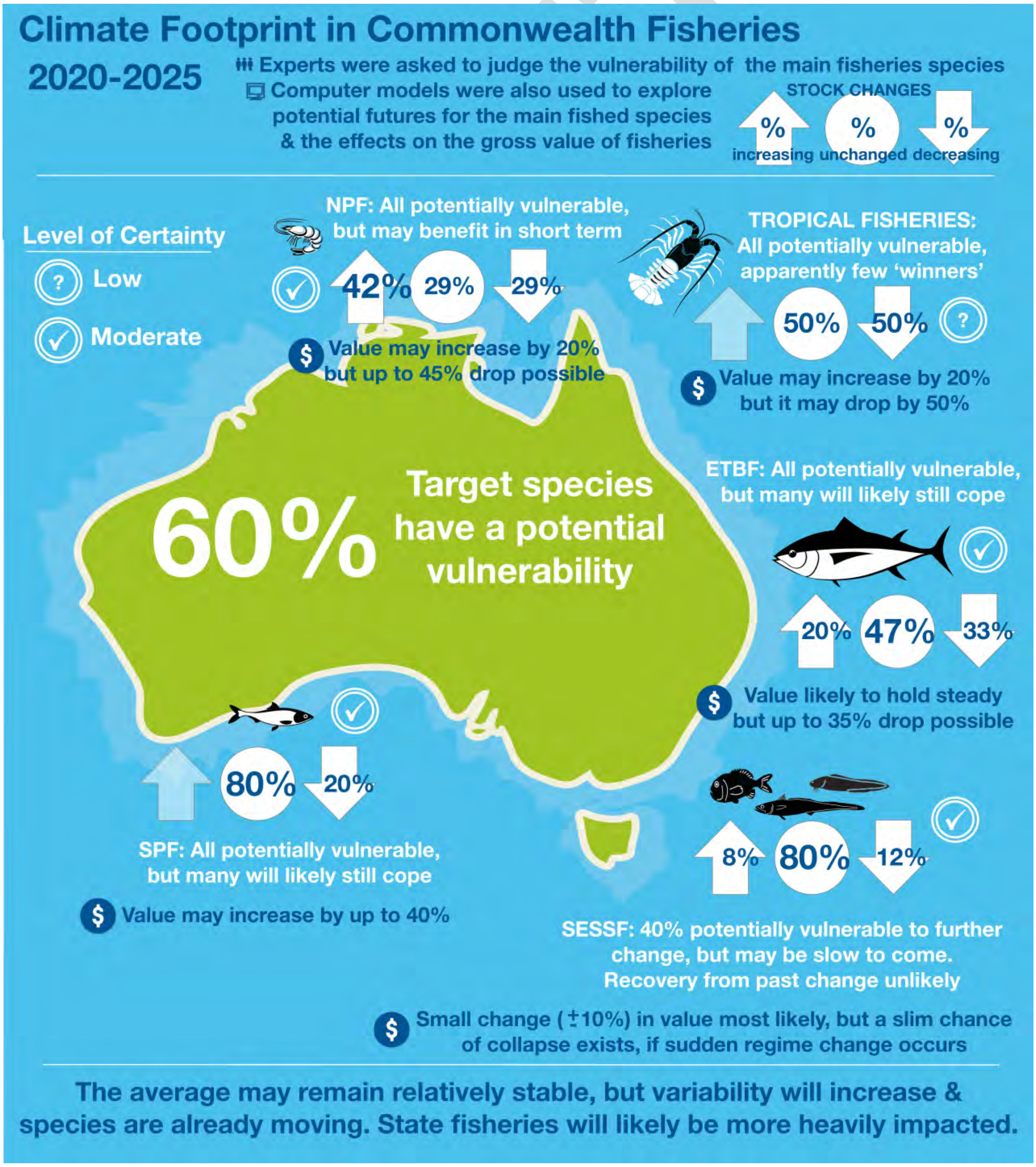
Australian fisheries stocks under climate change

Over the next twenty years Australia's marine ecosystems are expected to exhibit some of the largest climate-driven changes in the Southern Hemisphere. These changes will extend from the ecosystems to the local communities and businesses of the Australian fisheries sector. The CSIRO and its collaborators have pulled together all available information on how climate may affect fished species in Australia – identifying those most sensitive to climate. This information helps highlight those species that may be at risk and those that might benefit, allowing fisheries to be better prepared.



Climate Footprint in Commonwealth Fisheries

2020-2025

Experts were asked to judge the vulnerability of the main fisheries species

Computer models were also used to explore potential futures for the main fished species & the effects on the gross value of fisheries

Level of Certainty

? Low

✓ Moderate

NPF: All potentially vulnerable, but may benefit in short term

$ Value may increase by 20% but up to 45% drop possible

TROPICAL FISHERIES: All potentially vulnerable, apparently few 'winners'

$ Value may increase by 20% but it may drop by 50%

60% Target species have a potential vulnerability

ETBF: All potentially vulnerable, but many will likely still cope

$ Value likely to hold steady but up to 35% drop possible

SPF: All potentially vulnerable, but many will likely still cope

$ Value may increase by up to 40%

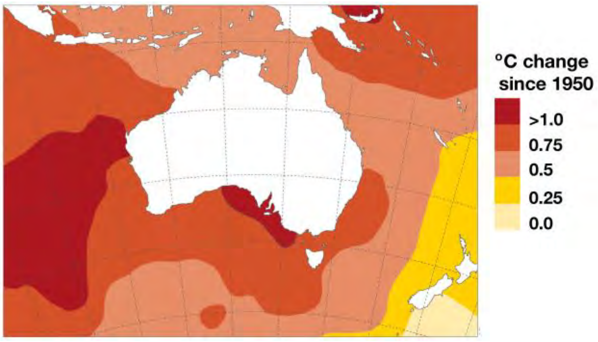
SESSF: 40% potentially vulnerable to further change, but may be slow to come. Recovery from past change unlikely

$ Small change (±10%) in value most likely, but a slim chance of collapse exists, if sudden regime change occurs

The average may remain relatively stable, but variability will increase & species are already moving. State fisheries will likely be more heavily impacted.

Climate change in Australian Waters

Australia's oceans are undergoing rapid change. The waters off south-east and south-west Australia are hotspots, warming much more rapidly than most of the world’s oceans. Australia’s tropical ocean is also warming rapidly, almost twice as fast as average for the rest of the world. It is important to understand what this means for the ecosystems in these warming waters if we are to continue to be sustainably manage Australian fisheries. Understanding the changes and being climate ready is important for both industry and management, because it allows them to plan their operations to avoid or mitigate negative impacts and to make the most of new opportunities that arise.



Water temperature change around Australia since 1950. Image updated from BOM data. These temperature increases mean water temperatures often record breaking.

Australian fish species have already begun to move. Over 100 Australian species have already started migrating south towards cooler southern waters. There have also been a series of marine heatwaves and other extreme events that have harmed Australia’s seagrass, kelp forests, mangroves and coral reefs. These changes in the distribution, abundance and species composition in Australia’s marine ecosystems mean that Australia’s commercial fisheries are being affected by climate change. It is unavoidable. The ocean also has a long memory, which means that the effects of past and present human activities have already locked the world in to a further 0.5-1 °C warming. This is why fisheries managers (e.g. at AFMA) have asked for a rapid and thorough update of information so that they can base their strategic planning on the latest and best information.

Sensitivity of Australian Fisheries Target Species

Australian fisheries catch more than 100 species. There is not enough data or resources available to perform fine scale assessments for each species. Instead experts on the fisheries and target species were asked identify the key target species in State and Commonwealth fisheries. The experts then had to rank each species in terms of how sensitive it was to climate change. This sensitivity was judged in terms of factors that affect:

- abundance (how old they are when they mature, how often they reproduce, number of eggs, diet and habitat needs);
- movement and spatial distributions (distance they can move, how widely spread they are already, available habitats):
- behaviour (needing special triggers for reproduction or migration, having special behaviours that only happen for short periods)

Across all Australia 70% of all key target species are have moderate to high sensitivity in one of these factors. Within the AFMA managed fisheries at least 50% of the target species per fishery are moderately to highly sensitive and in many AFMA managed fisheries all the target species are sensitive in one way or another.

Most species were sensitive to factors determining their distribution or behaviour, while only about 25% were sensitive in terms of factors that directly influence abundance. The greatest sensitivity to the timing of key behaviours was along the coastline of eastern Australia (north and south), while shifts in distribution are the most likely responses in the west and in the tropical north. Invertebrates had higher sensitivity scores than other species. As a consequence, dive – and other gears targeting invertebrate – show the highest sensitivities. Purse seine fisheries for small pelagic species has the lowest sensitivities.

The sensitivity analysis suggests that fisheries should first consider how changes in distribution and the timing of key events affect them and their management and then consider potential than changes in abundance.

Sensitivity of Species Targeted by Australian Fisheries

Summary of sensitivity per fishery. Low sensitivity is for those species with a low rating across all 3 factors – abundance, distribution and behaviour. Moderate sensitivity indicates that a species had 1 factor that was scored as being moderately sensitive to climate change. High sensitivity covered both the case where a species was rated as having a factor that was highly sensitive to climate change or they had multiple factors rated as moderately sensitive. Sensitivity does not automatically indicate a likely decline it indicates the potential for change (including possible increases)

Commonwealth Fishery	**Low**	**Moderate**	**High**
Bass Strait Scallop			Scallops: behaviour and distribution
Coral Sea			Coral trout: distribution and abundance
Eastern Tuna and Billfish		Behaviour of all target species	
Northern Prawn			Behaviour and distribution of all target species
South and Eastern Scalefish and Shark	Species already showing shifts (warehou, morwong, redfish, ling) show low sensitivity to further climate driven change	Gemfish: abundance. Trevalla, flatheads, and whiting behaviour.	**All/majority** of properties of squids, sharks, blue grenadier and orange roughy.
Small Pelagics		Behaviour of sardine and blue mackerel	Jack mackerel and red bait behaviour and distribution
Torres Strait			**All** properties of tropical rock lobster
State Fisheries			
New South Wales, Victoria, South Australia		Behaviour of snapper, tuna and some small pelagics.	Many small pelagic, estuarine and invertebrate species (mainly via behaviour and distribution). **All** properties of sharks and blue grenadier.
Queensland		Behaviour of estuarine and shelf fish, as well as Spanish mackerel and billfish.	Behaviour and distribution of all reef fish. **All** properties of the majority of invertebrates and sharks.
Gulf of Carpentaria (Queensland and Northern Territory)	Bream and sharks	Majority of mackerels, estuarine fish and mangrove associated species (due to a mix of factors).	**All/majority** of properties of snappers, emperors and all valuable invertebrate species (prawns, lobster, sandfish).
Northern Territory and Western Australia	Many sharks, estuarine and large pelagic fish	Large sharks: abundance. Behaviour or distribution of fish non-reef shelf fish	**All/majority** of properties of reef associated fish and all invertebrates.
Western Australia		Distribution or behaviour of herring, reef associated predators, some abalone, octopus and sandfish.	**All/majority** of properties of prawns, crabs, many small pelagics, some abalone, oysters, bream and dhufish.

Fisheries projections

The other approach to consider the future climate change effects on Australia's fisheries was to take existing models of Australian marine ecosystems (which together cover the entire EEZ) and run them under the conditions that might exist over the next 40 years. The results of these models were then used to see how species abundance and distribution might change and how ecosystems might restructure.

The modelling work found that the different ecosystems around Australia face different types and levels of climate change – including temperature changes, changes in rainfall patterns, ocean acidification, shifting ocean oxygen levels. For fisheries as large as the SESSF different parts of a fishery will be undergoing different levels of change. In most instances, larger changes in the climate led to larger model responses. The tropics, however, might see some large changes despite only small shifts because those shifts will influence the productivity of phytoplankton that supports the entire food web.

Those models that only look at the physical environments preferred by species predicted there would be reasonably large declines for the majority of fish populations around Australia. However, once all the other processes that occur in ecosystems (e.g. feeding, movement, habitat use) were included in the models the picture is more complicated – some species decline, but others benefit and grow in abundance, though perhaps living in new locations.

The models also predict that the ecosystems will become more variable. The Tasman Sea, for example, could have strings of very productive years interspersed by series of years with exceptionally low production. This variability is reflected across the entire food web, with many of the species shifting their distributions in response – seeking out desirable habitats and food sources.

For many species the different models are in agreement, increasing confidence in the robustness of results. When the models disagree this highlights uncertainty and where more information is needed. Many of the species ranking highly in the sensitivity analysis also show enhanced responses to climate change in the models. In the short term many of the models predict little further change for most species (noting that this means that already depleted species do not show signs of recovery). Further in to the future (30-40 years) things become more uncertain, with the different models not always agreeing on whether species will increase or decrease in abundance. This is because simple physical responses alone may not dictate a species response to climate change. As abundances change, predation and competition within food webs will also change. This means that new or novel food webs may form, changing ecosystems unexpected ways. In some regions (such as south eastern Australia) the ecosystem may eventually shift into a new state that is quite different to today, though this will be dependent on exactly how the physical climate drivers interact with the many different responses of all the species making up the food web and habitats in that region.

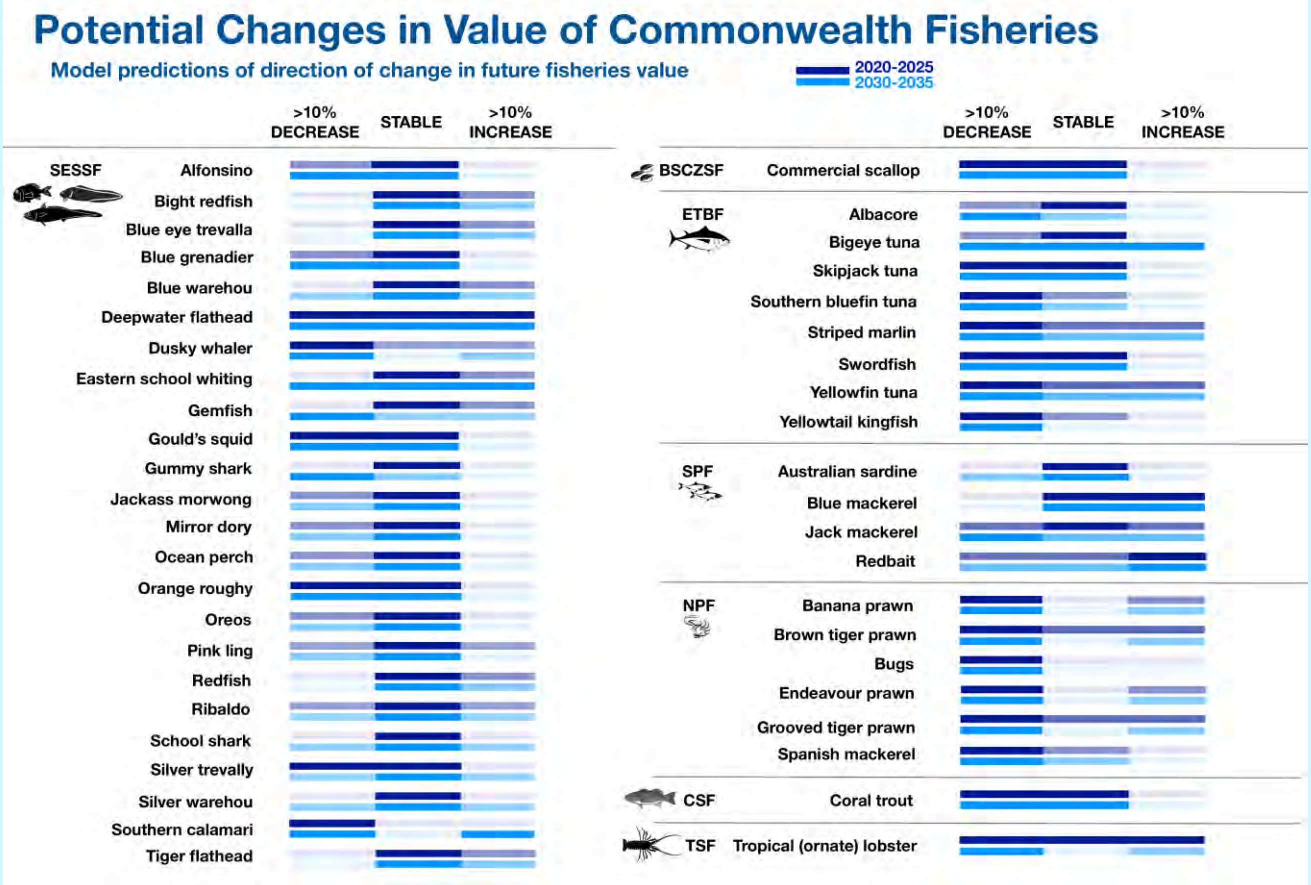
Implications of Climate Change

It is clear from the changes that have already occurred, and what the sensitivity and models predict, that there will be strong differences in the level of effects and responses across different species and food webs. Demersal food webs, those species that live near to or amongst habitats on the seabed, appear to be more strongly affected by climate change. Invertebrates, who are amongst Australia's most valuable target species, are particularly sensitive. Pelagic food webs, where species live up in the water column, appear less sensitive and may even benefit from the environmental changes.

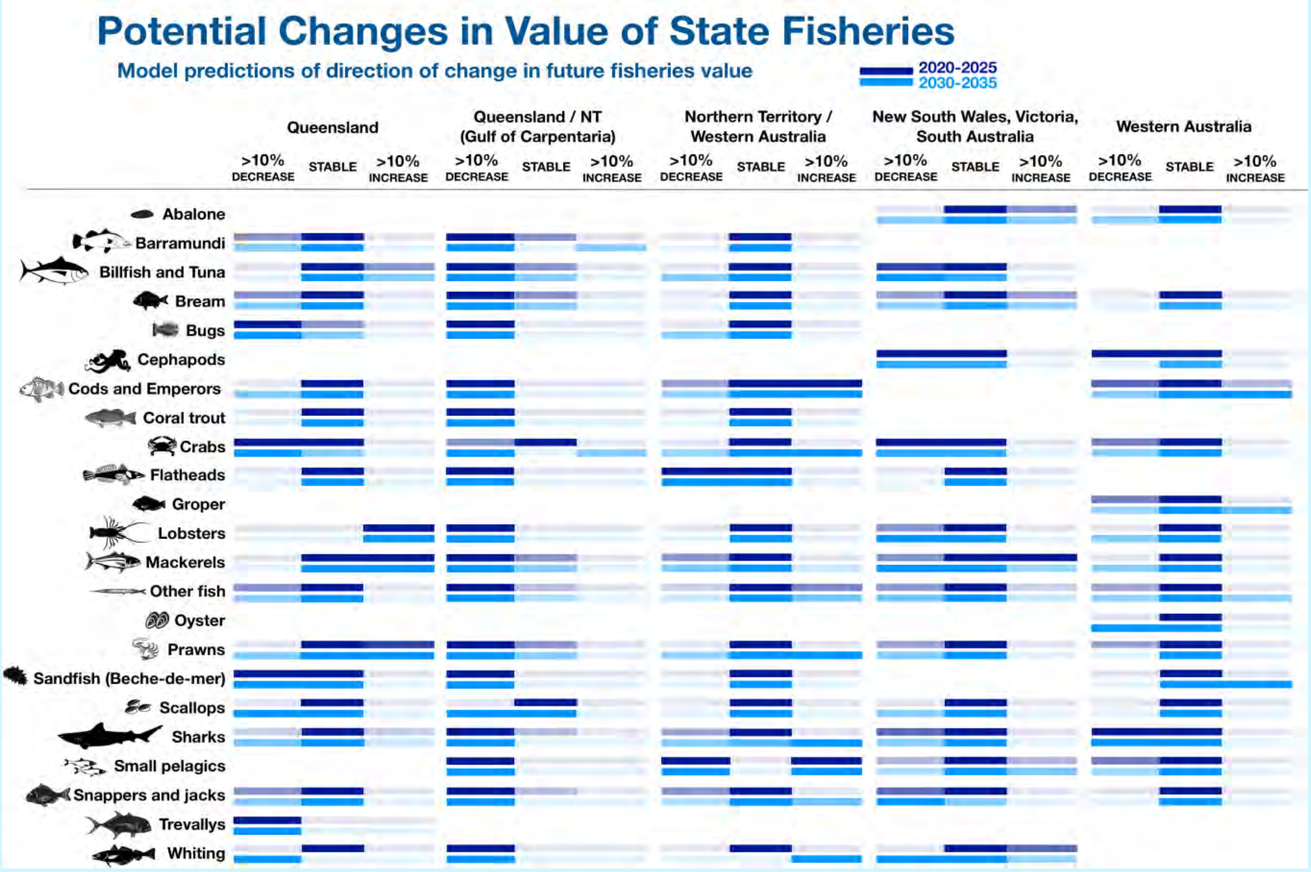
This is a concerning finding as much of Australia's seafood is sourced from species that are members of demersal food webs or reliant upon them. Individuals in shallower (more effected) waters, or already living on the edge of what they can tolerate, will be the first to respond and will show the greatest magnitude of response. Some of these changes have already begun. The decline of species such as abalone associated with marine heatwaves and tens of species already observed to be moving south (e.g. into Tasmania and other places where they have not previously been recorded).

Invertebrates may be among the most heavily impacted species. They are often highly productive, but with relatively short life spans; meaning they can respond quickly, but often have little buffering capacity (they cannot ride out many poor years before suffering significant decline at the population level). Many invertebrates also have specific habitat requirements. Altogether these characteristics mean that invertebrates are more volatile and are quite sensitive to variation in climate and extreme events.

Both Commonwealth and State fisheries will face changes in gross value as a result of climate change effecting both the fish stocks and (potentially) the behaviour of the fishers. While the majority of the model results suggest little change in the short term, some simulations did suggest that larger changes (both positive and negative) were possible.


Potential Changes in Value of Commonwealth Fisheries

Model predictions of direction of change in future fisheries value


Potential Changes in Value of State Fisheries

Model predictions of direction of change in future fisheries value

Ecosystem responses will not only respond to changes in temperature, precipitation or to ocean acidification. Variability in primary production (i.e. production by the plants and algae at the bottom of the food web) will also be important. For instance, if there is little change in primary production then ecosystems will likely show little change (so long as temperatures do not shift beyond what may species can physically tolerate). Unfortunately, it is not yet clear what future primary productivity will look like around Australia – as some important processes are still not completely understood. This means that understanding and predicting future changes in primary production remains an active area of research and updates will be provided as rapidly as possible.

Many mechanisms can lead to changes in ecosystems – whether through behaviour, distribution or abundance of the species and habitats in them. The drivers causing the changes can be different species to species. For some it will be due to changes in environmental conditions, this can cause the timing of seasonal events (like spawning) to move which can affect the success of those behaviours. If environmental conditions move beyond preferred ranges species will move to more favourable conditions or dwindle in abundance. For many species change will result from a loss (or shift) in habitat but for others changes will occur because the availability of their prey changes. For still other species it could be due to a shift in what their predator(s) are doing – if a predator moves away the prey abundance might grow, whereas if a predator starts to eat more of the prey (due to a shift in diet) then the prey population might decline. As frustrating as it may be for managers, industry and researchers looking for simple explanations and a way to make things more straight forward, it will likely come down to a case-by-case basis (which may even vary spatially across a species' geographic range).

Human responses to all these changes could also complicate things. Well informed decisions are one of the best ways of avoiding negative outcomes and maximising opportunities. A nested approach – where models and vulnerability assessments are used to identify the most at risk species and locations – appears to be the best way of targeting monitoring and management responses.

Given existing understanding of ecosystems, climate change and the sensitivities highlighted in this project a small set of management recommendations can be made:

i. A staged response might be necessary, where fishing activities are first adjusted due to shifts in behaviour (e.g. changing the timing of seasonal closures to make sure they continue to line up with seasonal behaviours like spawning or migrations), before looking to respond to changes in spatial distributions.

ii. Not all fisheries and operators will be exposed to the same level of change. Likewise, not everyone will have the same capacity to adapt. This will compound the differential outcomes seen across species and fisheries. One option is to simply accept uneven social and economic consequences. A more attractive alternative is to have information services (websites, newsletters, radio updates) to help explain what is going on, what the options are and the need for change as well as to provide support mechanisms to help those that are struggling to adjust.

iii. Successful management will require a diverse set of good scientific tools. No single approach will be sufficient due to existing uncertainty and the interplay of climate and fishing with the ecosystem components and processes. New management and assessment tools will also be needed. The complexity of possible species responses and the increasing importance of environmental drivers means that current models used in stock assessments to advise on acceptable catch levels maybe insufficient for understanding stock patterns under climate change. Key interactions and dependencies may need to be included to better reflect how the species is responding. This means that models used in fisheries assessments will likely need to be extended along the lines of the approach known as "MICE", which are models that not only include the target species but also the most important environmental (and other) drivers that set the context for the species' responses.

iv. Existing management strategies and objectives must be reviewed in terms of whether they help or hinder long term ecological and resources management objectives. Are they likely to deliver as desired into the future, if a stock is depleted can they rebuild it or help to recover degraded ecosystems? These considerations must go beyond focusing on fisheries to think about the structure of the whole ecosystem and which species are needed to maintain ore rebuild them. Such a rethink will require a greater coordination between conservation and fisheries management.

v. Fisheries policy, management and assessment methods need to allow for the concept of regime shifts and extreme events and for contextual management decision making. Taking lessons from locations that have already faced such challenges suggests that indicators that can track what state the environment is in can be used to let managers know when they need to adjust acceptable levels of fishing pressure and protection.

vi. Fisheries management methods should be made as flexible as possible, so they can change as rapidly as need to respond to changing system state. The speed of change means a no (or at least minimal) regrets approach to management needs to be taken, with updates as new information comes to light. Management instruments may also need to be adapted. Reference points defining an overfished state or a desirable state for target species might need to be modified if there is a regime shift in ecosystem state or stock productivity. Fisheries closures may need to be based on water bodies (large areas of water of a specific temperature) rather than simply relying on the protection of fixed geographic locations.

vii. Management decision making will need to (i) more explicitly prioritize resources and awareness around vulnerable/ sensitive species and fisheries or (ii) have a clear discussion around whether some species are beyond management (as the environment has made it impossible for the species to recover). Such decisions can't be taken lightly but might be necessary if large environmental changes occur.

viii. Australia-wide coordination of management will be imperative as species shift or environmental changes span State and Commonwealth boundaries. Without such coordination (or centralised management) local stress for fishing communities could become significant and new opportunities will likely be missed.

ix. Fisheries management will need to interlink with the management of other uses of the marine environment – that is Australia will need to use ***integrated marine management***. The number of uses of the marine environment is rapidly expanding and growing to a scale not seen before in the oceans. Mining, energy generation, transport, aquaculture (farming), recreation etc. are now all competing for space and resources in the oceans and along increasingly crowded coastlines. It is important for fisheries to see themselves in the context of all of this activity so they respond appropriately given that bigger picture.

Providing information to industry operators and managers so they can address all these changes will require good data sources. There are still many things we do not know about Australia's ecosystems and how they respond. Fishers and managers (and the scientists helping them) will require as much information as possible if they are to understand what is happening and act wisely to mitigate undesirable outcomes and make the most of any new opportunities. Such a climate robust approach to fisheries will require the combination of a number of different sources of information, including:

- Measurements and forecasts of the physical environment (temperature, salinity, rainfall, storm patterns) extending what is already provided by the Bureau of Meteorology. Sharing the data from net net sensors (for example) can help provide a more accurate picture of the current conditions and the conditions fish prefer.
- Satellite images of ocean colour (which can be used to estimate how much plankton is in the water) can help predict where fish will be and can also forewarn of coming issues with stock productivity and recruitment. Plankton recorders voluntarily mounted on ships (e.g. tankers) can also help collect very useful information about what is happening at the bottom of the food web (this can help us understand how that effects the rest of the food web including those fish that are targeted by fisheries).
- Good quality catch and effort data is the longest and one of the best sources of information on target species in Australia.
- Survey data is also important as it helps give a more complete picture of what is going on. Catch data is very useful but having a second set of information from surveys helps to be sure about what is going on – catches don't always reflect what the fish are doing, especially of the fishers have changed their behaviour in response to markets (for example).
- Citizen science data collected by Australians using smart phones and cameras represents a new source of potential data. Nearly every Australian citizen now owns a 'smart phone' which has sensors and an on-board computer that is more powerful than what was available to scientists as little as a decade ago. Data collected via photographs and voluntary reporting can be a very valuable source of information once it has been processed and scientifically collated. Australians see themselves as an ocean loving people so we shouldn't turn down any help they are eager to provide.

Looking Forward

Australian fisheries are in the midst of a period of rapid environmental change. This change is going to continue into the future and will differ place to place around Australia. Fishers and managers will need to be flexible if they are to cope with these changes. A failure to do so will bring economic (and likely social) hardship. Management will need to allow for spatial shifts and potentially for shifts in targeting and relevant management reference points. Management that is coordinated across State and Commonwealth fisheries and that links with the other users of marine waters is likely to do better than if those links are ignored. Healthy fisheries will also require good information services that are updated regularly with the latest understanding of what Australia's climate, fish, ecosystems and fisheries are doing. This is the summary of the latest (2018) update. If you would like more information please contact us (details below) or check out the websites listed below.

Useful Websites

Redmap (Range Extension Database & Mapping project) – www.redmap.org.au – this website invites the Australian community to spot, log and map marine species that are uncommon in Australia, or along particular parts of our coast. This helps keep everybody up to date on how Australia's species are moving. The website includes useful summarise on what climate change is and what it means for Australia's oceans.

BOM – www.bom.gov.au/climate – this website has a long list of climate time series and updates, including annual reports on what Australia's climate is doing.

Images: Shutterstock.com

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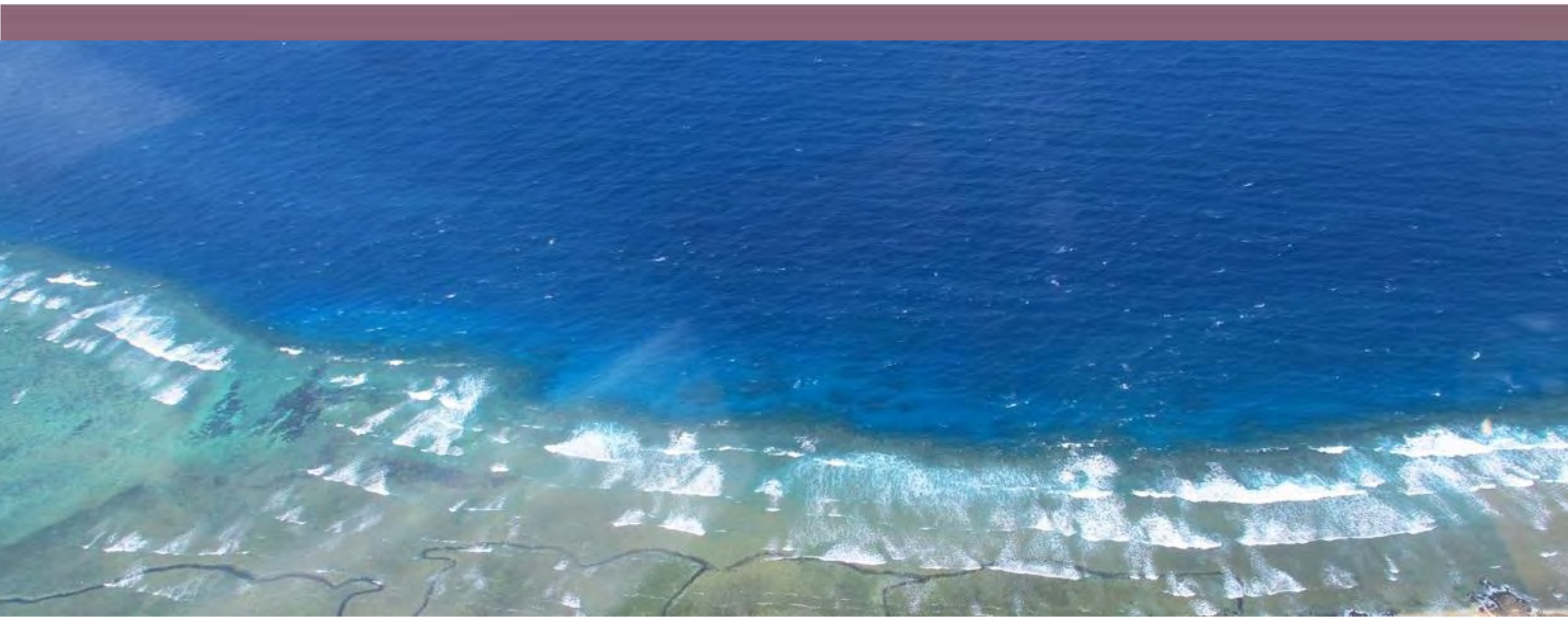

WORKSHOP REPORT

Climate change in the Torres Strait

Implications for fisheries and marine ecosystems

June 2018

Earth Systems and Climate Change Hub Report No. 4

Australian Government
National Environmental Science Programme

The Earth Systems and Climate Change Hub is supported by funding through the Australian Government's National Environmental Science Program. The Hub is hosted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and is a partnership between CSIRO, Bureau of Meteorology, Australian National University, Monash University, University of Melbourne, University of New South Wales and University of Tasmania. The role of the Hub is to ensure that Australia's policies and management decisions are effectively informed by Earth systems and climate change science, now and into the future. For more information visit www.nespclimate.com.au.

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Contents

AT A GLANCE

Key messages from the workshop

The climate is changing in the Torres Strait. Research shows that it is changing, communities see it on country (land and sea) and fishers see it in the changing state of natural resources.

Marine impacts from climate change in the Western and Central Torres Strait will include coastal erosion and declines in reef health and diversity, loss of critical inshore habitat, increased sea temperatures and sea levels and changes to currents and water quality; all of which will have a variety of direct and indirect impacts on fish stocks and marine ecosystems. Climate change will affect fisheries productivity, species distributions and seasonality, so subsistence and commercial fishery practices will need to be able to adapt to shifting circumstances.

It is important that all relevant parties are engaged in conversations about what climate change means for fisheries and marine ecosystems in order to prepare for the changes. Local traditional knowledge and scientific knowledge from the research community are important tools which can and should be integrated to help understand and prepare for future changes.

Torres Strait fisheries and marine ecosystems

- Torres Strait has diverse, productive and commercially, ecologically and culturally valuable fisheries and marine resources.
- There are complex traditional and regulatory management and resource sharing arrangements.
- Marine resources are likely to constitute a large proportion of protein for local communities.
- Traditional values of marine resources are very important to Torres Strait communities.

Climate change and impacts

- Being island based and heavily dependent on their marine resources, Torres Strait communities have certain inherent vulnerabilities in relation to climate change impacts compared to other parts of Australia.
- Climate change will strongly impact the Torres Strait marine environments and fisheries due to increased frequency and intensity of extreme events such as marine heatwaves, sea-level rise and changes to ocean oxygen content and ocean pH.
- Possible changes to ocean circulation and currents could have major ramifications fisheries and marine ecosystems.

Managing impacts

- Traditional fishers already practice many of the approaches needed to help ensure they can adjust to some of the likely impacts of climate change, such as providing

spatial flexibility in fishing effort by observing Traditional boundaries between each community's sea country.
- Community values have an important role to play in determining management and adaptive responses to the impacts of climate change.
- Traditional cultural spatial management of resources between Australia and Papua New Guinea, while effective when observed and well supported, could contribute to conflict between the haves and the have-nots as climate change impacts increase.

Information to support management and adaptation

- There are already many climate projections data and information products available for the region, ranging from relatively large spatial scale (e.g. global and regional climate projections located at www.climatechangeinaustralia.gov.au) to smaller scale (e.g. downscaled CCAM projections for some parts of northern Australia and Papua New Guinea) and some regional ocean and fisheries modelling, but it is not necessarily accessible.
- Global model projections have limited value for the Torres Strait Islands because of the geography (small size and limited topography) of the islands and the poor resolution of El Niño–Southern Oscillation/Pacific Decadal Oscillation influences. Instead, higher resolution modelling (including ocean modelling and fisheries modelling) is needed to provide information at the appropriate spatial scale.
- Tidal dynamics need to be further taken into account to improve the climate downscaling in the Torres Strait region.
- Important oceanographic and environmental data are intermittent and/or absent, and there is a need for dedicated Torres Strait modelling across a range of applications related to fisheries.
- Although a lot of climate information is being continually generated, very little targeted information at required intervals is available to Torres Strait fishers to inform their seasonal fishing practices.
- Provision of regular climate, adaptation and management information via an annual forum or other updates may be useful.
- Managers seeking to adapt to climate/climate change issues in Torres Strait can glean valuable information from relevant projects around Australia and in the Pacific.
- Researchers need to have due diligence to present information appropriately for local communities so useful information can be placed in the hands of the local decision makers who are the traditional custodians of the resource.
- Communities in the Torres Strait are keen to be involved in discussions about how a changing climate affects fisheries.
- There is enough information now from studies in Torres Strait and adjacent areas (as proxies and examples) to make management decisions in the short term. Filling some key knowledge gaps and downscaling climate change projections will provide information to refine actions, but we don't need to wait for this information to act now.
- Consultation and engagement with traditional owners and fishers is paramount to appropriately target actions for key fisheries and vulnerabilities.

Background

The National Environmental Science Program (NESP) Earth Systems and Climate Change (ESCC) Hub and Torres Strait Regional Authority (TSRA) jointly convened a workshop in December 2017 to bring together key researchers and managers to review the current state of relevant scientific knowledge about climate change impacts on communities of the Torres Strait Islands, with a particular emphasis on inshore fisheries and marine ecosystems. This is the first time that climate and fisheries researchers and managers working in the Torres Strait have come together in this way.

The workshop is the first in a series of engagements that aim to:

- build relationships and raise awareness and understanding of key stakeholders (including traditional owners/local fishers, natural resource managers, other local communities of interest and scientists)
- identify data and information gaps and needs where appropriate
- develop options for the delivery of relevant science-based products and services to target end-users to inform policy development, management/adaptation planning and associated decision-making.

The objectives of this workshop are to:

1. Assess current state of knowledge and understanding on climate projections and impacts as they relate to the marine environment in the Torres Strait.
2. Capture knowledge of any observed or reported shifts in environmental variables
3. Identify key data and knowledge gaps and assess priority areas and issues from a scientific and managerial perspective and make recommendations for further focus or investigation
4. Determine communication products that should be developed to increase awareness and understanding of key stakeholders of climate change impacts on Torres Strait marine fisheries and ecosystems
5. Improve coordination and collaboration across relevant agencies and stakeholders and scope next steps in the proposed series of engagements.
6. Determine the nature of ongoing engagement with traditional owners on this issue. In practice, it will likely be facilitated through the TSRA and the fisheries working groups/management forums.

The workshop program and participant list are included in the appendices of this report.

This report, which provides a brief synthesis of the workshop presentations and key discussion points, is the primary workshop output.

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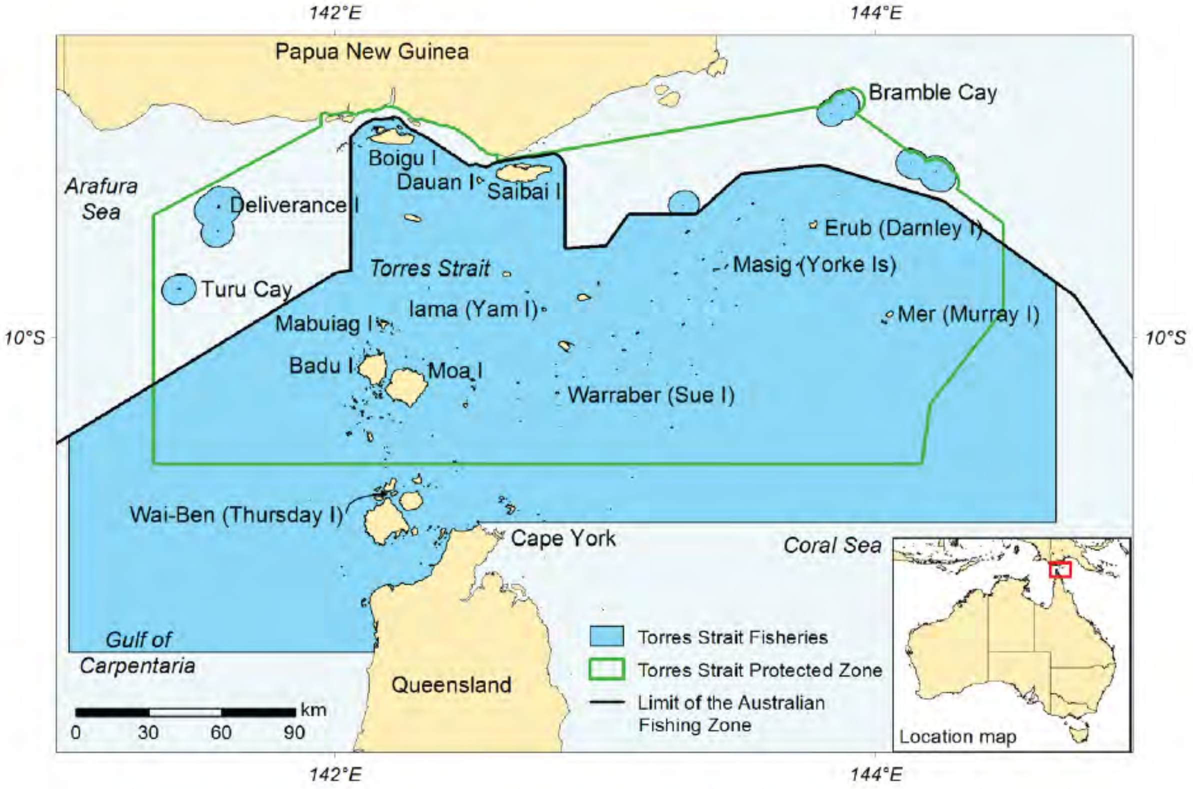
Fisheries in Torres Strait

Ian Butler, AFMA

- Torres Strait fisheries have complex arrangements for resource sharing.
- Torres Strait fisheries cover a diverse range of species.
- Historical catch data have been difficult to obtain, but improvements are being made (fish receiver data).

Region



The Torres Strait Protected Zone (TSPZ) is jointly managed by Australia and Papua New Guinea (PNG) through bilateral discussions. Within Australian waters in the TSPZ, traditional and commercial fishing are managed by the Protected Zone Joint Authority.

The fisheries in this region are shared between traditional inhabitant commercial fisheries, traditional artisanal fisheries, PNG fisheries and recreational fishers. Formal catch arrangements between Australian and PNG fishers are established under the Treaty.

The fisheries have commercial, cultural and lifestyle value.

Key fisheries

Torres Strait Finfish Fishery	Spanish mackerel but some other species	Trolling lure	2016 catch: 86.9 t Value: n/a (total finfish $1.2 m)
Torres Strait Finfish Reef Line Fishery	Mostly coral trout but also other groupers, snapper, emperor, barramundi and trevally	Hook and line, spear, nets and traps	2016 catch: 38.7 t Value: n/a (total finfish $1.2 m)
Torres Strait Tropical Rock Lobster Fishery	Tropical rock lobster	Hand diving (surface air supply, free diving); 306 commercial licenses (294 traditional inhabitants); artisanal; shared resource with PNG	2015–16 catch: 445 t Value: $14.3 m
Torres Prawn Fishery	Brown tiger prawns, blue endeavour prawns, also other prawn species, bugs, octopus and squid	Caught at night using demersal otter trawl	2016 catch: 412 t Value: $8.9 m
Torres Strait Beche-de-Mer Fishery	Sea cucumber (e.g. black teatfish, prickly redfish, sandfish, white teatfish, surf redfish)	Collected by hand free diving or on reef flats; scuba and hookah banned; traditional inhabitant and artisanal fishers only	2016 catch: 14.9 t Value: not assessed Illegal fishing from other countries
Trochus	Trochus	Collected by hand free diving or on reef flats; scuba and hookah banned; traditional inhabitant and artisanal fishers only	Catch: 0 t Illegal fishing from other countries
Pearl shell	Gold-lipped and black-lipped pearl shells	By hand for use in farming (Qld); traditional inhabitants only (with PNG)	Catch: limited to small amounts
Torres Strait Crab Fishery	Mostly mud crabs, some blue swimmer	Hand or scoop net; traditional inhabitants and artisanal fishers	Value: unknown
Turtle		Traditional artisanal fishers	Culturally important for food
Dugong		Traditional artisanal fishers	Culturally important for food

Understanding Torres Strait stakeholders

Charles David, TSRA

- The Torres Strait economy benefits significantly from the ocean. Jobs etc. often stem from the health of and access to fisheries – traditional fishing is commercial fishing.
- Climate change impacts shift movement patterns of fish and directly affect the health of coral and other less mobile aquatic resources.
- Wild stocks, in some cases, are at lower levels than recently observed and others are not recovering from past overfishing. To what degree these are attributed to or compounded by the impacts of climate change is unknown. Employment opportunities for Islanders could reduce as a consequence of continued decline in stocks.
- There are implications for ownership and management arrangements, aspiration and the current status of the fishery.
- Traditional knowledge considerations are important for management of Torres Strait Island fisheries.
- A summation of climate change in Torres Strait and what to expect in a given timeframe needs to be delivered to traditional owners and/or full-time commercial and community fishermen.

The Torres Strait Treaty and *Torres Strait Fisheries Act 1984* (Commonwealth) are in place to acknowledge and protect the traditional way of life in the Torres Strait and the traditional inhabitants.

The Protected Zone Joint Authority (PZJA) is responsible for management of commercial and traditional fishing in the Australian area of the Torres Strait Protected Zone (TSPZ) and designated adjacent Torres Strait waters.

The PZJA is comprised of the Commonwealth and Queensland Ministers with responsibility for fisheries and the Chairperson of the TSRA. The PZJA is advised by a framework of management advisory committees made up of Torres Strait Islander fishers, commercial fishers, fishery managers and scientists. Recreational fishing is managed under Queensland law.

The Torres Strait fisheries management structure does not exist anywhere else in the country. The structure can make it seem difficult to get things done; however, this is not the case – you just have to have the traditional owners at the table.

There are five cluster groups in the Torres Strait. Traditionally you seek permission to go into someone else’s sea country, but commercial fishing licences are for the whole zone so there’s a disconnect between the two systems.

Roadmap to 100% fisheries ownership

The TSRA is working with key regional stakeholders and traditional inhabitants to achieve 100% ownership of the region’s fisheries for traditional inhabitants. Both the finfish and bêche-de-mer fisheries are 100% owned by traditional inhabitants. The tropical rock lobster fishery is 66.18% owned by traditional inhabitants (at 20 November 2017, as reported on the TSRA website).

Traditional management of Torres Strait fisheries

Traditional areas and boundaries are important to traditional owners and their maintenance can be advantageous both culturally and for sustainability. Traditional owners want traditional boundaries and management to be recognised (which is why bringing traditional owners to the table is important).

Torres Strait Islanders have seen the changes, especially in fish stocks – and believe this is a strong reason why returning to traditional management (because it’s more sustainable) is crucial. Turtle and dugong are success stories for traditional management.

Things in the past have resulted in some distrust of the science and ’westerners’; this is being overcome slowly.

The climate context: variability, extremes, change and risk relevant to impacts on marine systems in the Torres Strait

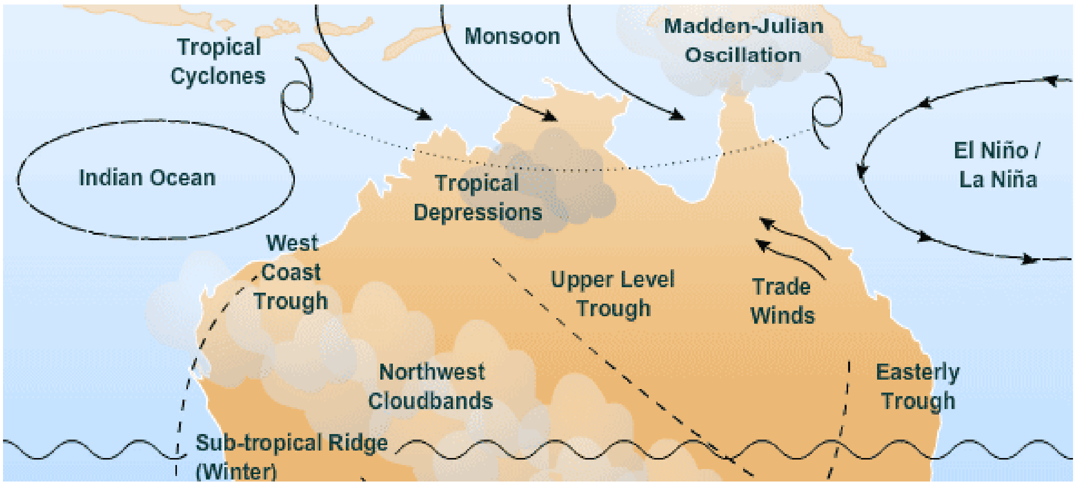
Neil Holbrook, ESCC Hub

- Torres Strait Islands are subjected to considerable ocean and climate variability (dominated by the monsoon and El Niño–Southern Oscillation) and extremes (including sea-level extremes, marine heatwaves, tropical cyclones and storms – and the associated winds, waves and storm surges – and extreme rainfall.
- Impacts of long-term changes in ocean temperatures (surface and deep), sea level and storminess will be both physical (e.g. inundation, erosion, coral damage) and ecological (affecting habitats, communities and species).
- Ocean acidification (reduction of ocean pH) affects calcifying organisms.

Variability

The climate of the Torres Strait is characterised by the monsoon wet season (December–April) with north-westerly winds and the dry season (May–November) with south-easterly winds.

The El Niño–Southern Oscillation (ENSO) contributes to year-to-year variability. During El Niño events, northern Australia is drier than normal, while during La Niña events it is wetter than normal. ENSO also plays a strong role in year to year variability of sea level.



(Source: Commonwealth of Australia 2010, Bureau of Meteorology. http://www.bom.gov.au/climate/about/)

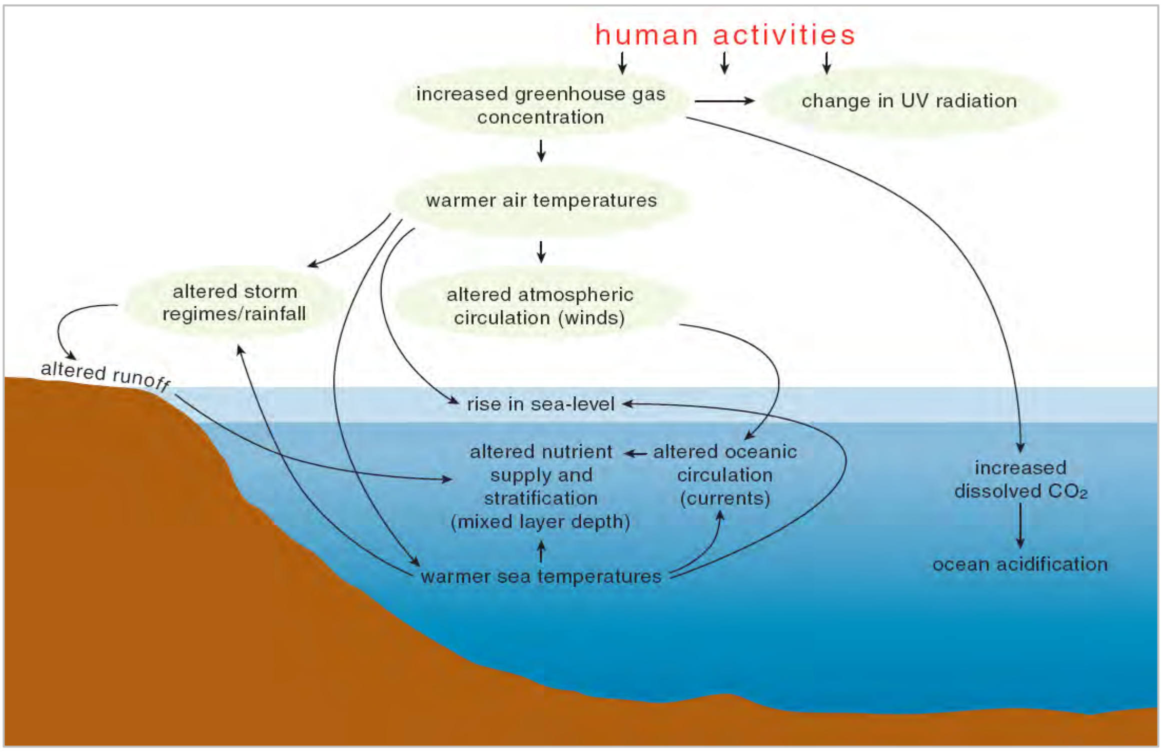
Extremes

By definition, extremes are rare and intense. They include tropical cyclones, storm surge, heatwaves (including marine heatwaves) and heavy rainfall.

Climate change, sea level rise and extremes

The impacts of sea-level rise will be felt most profoundly during extreme sea-level events. Increased sea level will increase the frequency of these events and the frequency of coastal inundation and erosion. Extreme sea levels may also change due to changes in storms (their frequency and intensity may change).

Climate change will also increase the frequency of extreme El Niño and La Niña events.

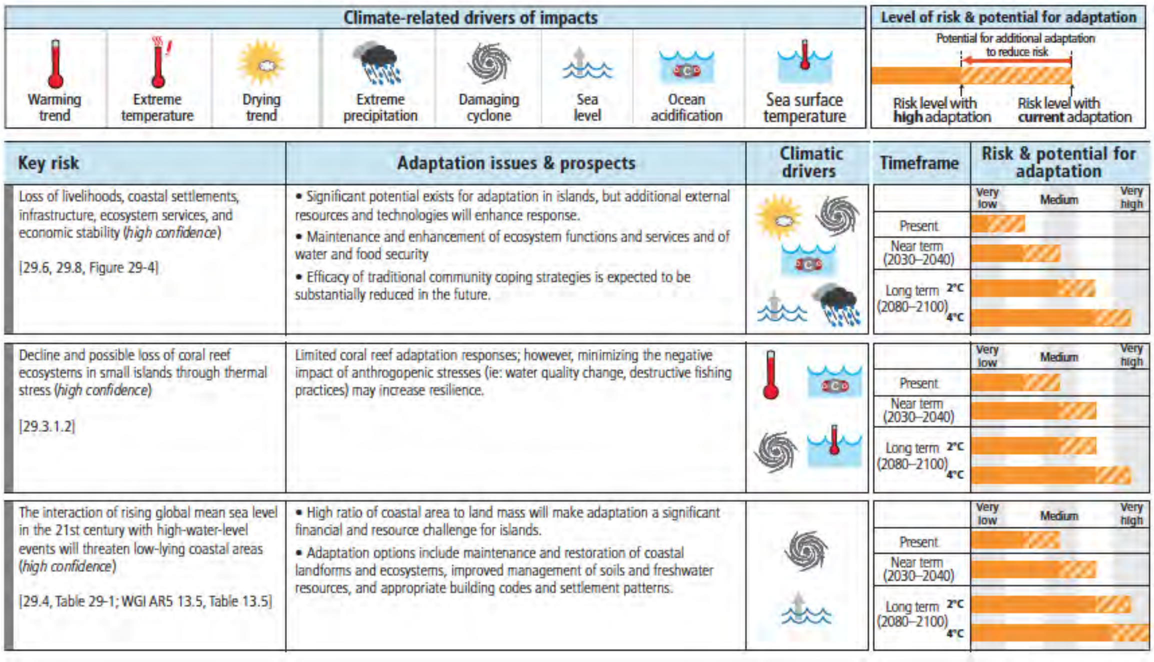


Physical and chemical changes in atmosphere and oceans due to climate change (Source: Poloczanska *et al*. 2007)

Implications

Coastal systems are particularly sensitive to sea-level rise, warming oceans and ocean acidification. The Intergovernmental Panel on Climate Change Working Group 2 contribution to the fifth assessment report gives examples of key risks.

Table 29-4 | Selected key risks and potential for adaptation for small islands from the present day to the long term.



Climate-related drivers of impacts							
Warming trend	Extreme temperature	Drying trend	Extreme precipitation	Damaging cyclone	Sea level	Ocean acidification	Sea surface temperature

Level of risk & potential for adaptation

Potential for additional adaptation to reduce risk

Risk level with **high** adaptation

Risk level with **current** adaptation

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Loss of livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (*high confidence*) [29.6, 29.8, Figure 29-4]	• Significant potential exists for adaptation in islands, but additional external resources and technologies will enhance response. • Maintenance and enhancement of ecosystem functions and services and of water and food security • Efficacy of traditional community coping strategies is expected to be substantially reduced in the future.			Very low Medium Very high
			Present	
			Near term (2030–2040)	
			Long term (2080–2100) 2°C	
			4°C	
Decline and possible loss of coral reef ecosystems in small islands through thermal stress (*high confidence*) [29.3.1.2]	Limited coral reef adaptation responses; however, minimizing the negative impact of anthrogopenic stresses (ie: water quality change, destructive fishing practices) may increase resilience.			Very low Medium Very high
			Present	
			Near term (2030–2040)	
			Long term (2080–2100) 2°C	
			4°C	
The interaction of rising global mean sea level in the 21st century with high-water-level events will threaten low-lying coastal areas (*high confidence*) [29.4, Table 29-1; WGI AR5 13.5, Table 13.5]	• High ratio of coastal area to land mass will make adaptation a significant financial and resource challenge for islands. • Adaptation options include maintenance and restoration of coastal landforms and ecosystems, improved management of soils and freshwater resources, and appropriate building codes and settlement patterns.			Very low Medium Very high
			Present	
			Near term (2030–2040)	
			Long term (2080–2100) 2°C	
			4°C	

(Source: Table 29-4 in Nurse et al. 2014)

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Climate trends and projections for the Torres Strait Islands

Josephine Brown, ESCC Hub

- There is an observed warming trend in both air and sea-surface temperatures in the Torres Strait.
- Rainfall is highly variable, with a strong influence from the El Niño–Southern Oscillation. A trend due to global warming cannot be identified in the observations.
- Regional projections for the Torres Strait include warmer sea-surface temperatures and higher sea level. Rainfall will become more variable with more intense extreme events.

Climate projections

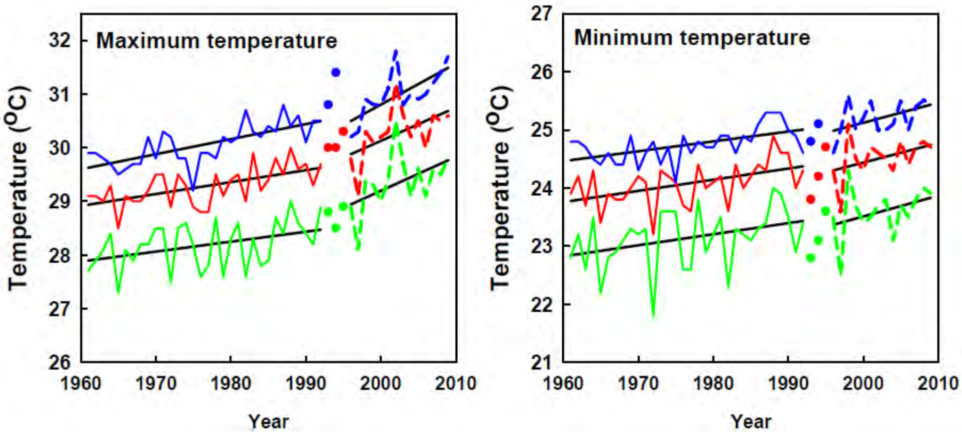
Projections based on global climate models generally cannot resolve the details of islands, topography or ocean currents in the Torres Strait. Global model information can be useful for some applications, while higher resolution (downscaled) model output may be needed for other applications. It is also important to evaluate whether the model can reproduce the observed present-day climate of the variable of interest (e.g. rainfall, temperature), and to consider the influence of model biases and errors on the climate of the Torres Strait.

Climate drivers

Climate in the Torres Strait is heavily influenced by the monsoon and the El Niño–Southern Oscillation (ENSO). In the future, monsoon rainfall is likely to be more variable than it is now and the influence of ENSO on rainfall will be greater.

Temperature

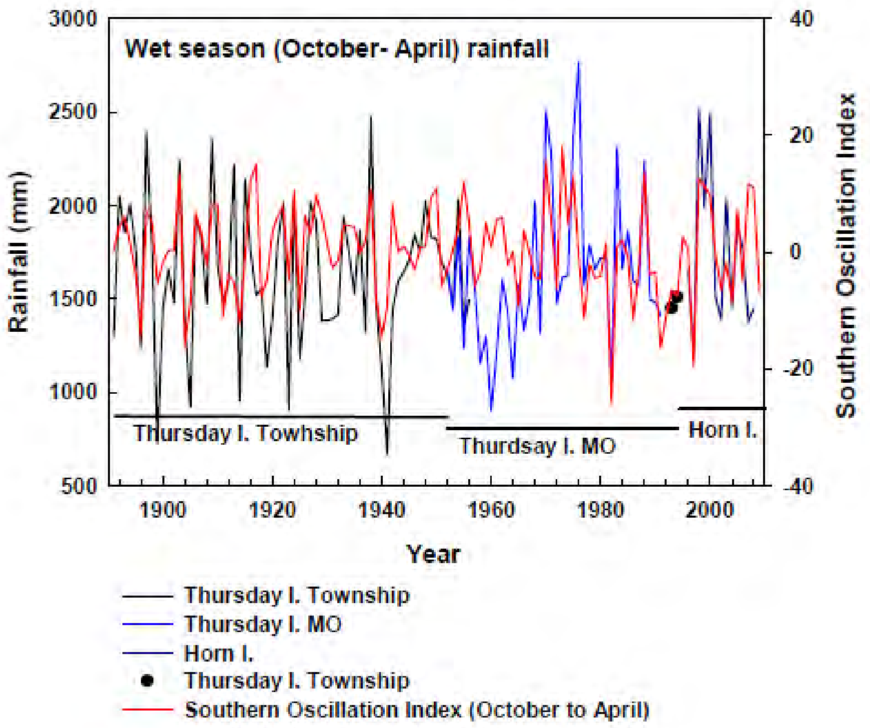
Mean temperature currently ranges annually from about 22–25 °C (min) to 28–32 °C (max). Temperatures have increased over the past century, with the rate of warming higher since 1960. Average temperatures will continue to increase in all seasons as a result of long term climate change, and there will be more hot days and warm spells.



Observed temperatures. Solid lines are records taken at Thursday Island MO. The observation site changed to Horn Island (dotted lines).

Rainfall

Rainfall has a strong seasonal cycle due to the influence of the monsoon. ENSO also influences rainfall, with drier years during El Niño events and wetter years during La Niña events. Changes to rainfall as a result of climate change are possible but unclear, but intensity of extreme daily rainfall events will increase.



Sea-surface temperature

The oceans around Australia have warmed. In the Torres Strait, this warming has occurred at 0.08–0.12 °C per decade since 1950. Sea-surface temperature will continue to increase as a result of climate change.

Ocean acidification

The pH of waters around Australia is decreasing (i.e. becoming more acidic). In the Torres Strait, the pH has dropped by 0.085–0.095 between 1880–89 and 2000–09, and ocean acidification will continue as a result of climate change.

Tropical cyclones

Tropical cyclones are generally located south of Torres Strait, but six have tracked through Torres Strait since1906 and many more over Cape York. Since the 1970s there has been an overall trend for fewer tropical cyclones in the Australian region, and it is expected that there will be fewer but more intense tropical cyclones in the future as a result of climate change.

Sea level

In the period 1993–2015, sea level has increased in the Torres Strait by 6–7 mm per year. Mean sea level will continue to rise as a result of climate change, and height of extreme sea-level events will also increase.

References/more information

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- Pacific Climate Futures https:/www.pacificclimatefutures.net

Vulnerability of Torres Strait fisheries to climate change

Johanna Johnson, Tropical Water Quality Hub

- Torres Strait fishers already operate under climate variability and practice flexible approaches that will help with adaptation to future climate change impacts.
- There is enough information now from studies in Torres Strait and adjacent areas (as proxies and examples) to make management decisions immediately. Filling some key knowledge gaps and downscaling climate change projections will provide information to refine actions, but we don't need to wait for this information to act now.
- Consultation and engagement with traditional owners and fishers is important to target appropriate actions to key fisheries and vulnerabilities (and within the local/cultural context)

Potential climate change impacts on species

Species	Key potential impacts of climate change (2030)
Coral trout – common/barcheek/ passionfruit	• Reduced catchability after intense storms • Reduced survival/development of early life stages due to increased sea-surface temperature (SST+) • Adult movements into deeper waters due to SST+ • Impacts on coral reef habitat may affect juvenile survival
Dugong	• Declines in seagrass negatively impact dugong due to: o primary food source o preferred habitat • Increased stranding mortality due to intense storms
Blue endeavour prawn & brown tiger prawn	• Impacts on seagrass may decrease juvenile growth and survival • Compromised growth and survival due to SST+ (near northern limit)
Turtle	• Female biased populations due to higher air temperatures during egg incubation • Decrease in available nesting sites/disrupt successful nesting due to sea-level rise (SLR), more intense storms and extremes in rainfall • Increased stranding mortality due to intense storms • Impacts on seagrass may decrease growth and survival
Trochus	• Unknown and previously assessed as minor
Sandfish	• Generally unknown
Black teatfish	• Reproductive success may be compromised (winter spawner) with SST+

Species	Key potential impacts of climate change (2030)
Tropical rock lobster	• Faster growth and higher larval supply, but decreased juvenile survival due to SST+. Net result reduced spawning biomass • Adult movement into deeper water due to SST+ • Settlement areas and recruitment rates may change due to altered north-west Coral Sea currents
Mud crab	• Higher catch rates due to SST+ • Possible population increases due to increases in rainfall
Spanish mackerel	• Possible links between SST and larval survival but generally unknown
Gold-lipped pearl oyster	• Reduced larval growth due to increased rainfall/lower salinity
Black-lipped pearl oyster	• Lower abundance due to upper thermal limits of ~32 °C for adults and reduced larval growth >29 °C

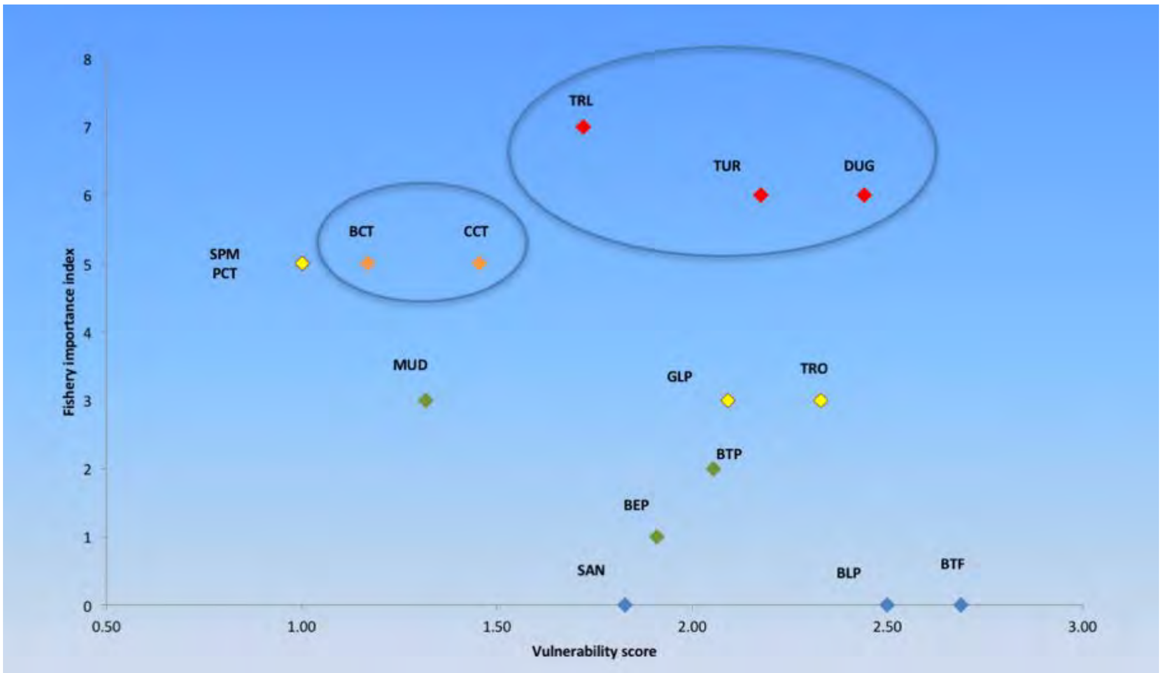
Vulnerability of supporting habitats

	SST	Rainfall/ river flow	Sea level	Cyclones & storms	Ocean pH	Solar radiation	Productivity /circulation
Coastal wetlands	very low	moderate	high – very high	moderate	very low	low	moderate
Seagrass	high	moderate	moderate	high	very low	high	moderate
Coral reefs	very high	high	low	high	very high	low	moderate

Prioritising species for management

Fisheries were ranked according to vulnerability and an ‘importance’ index that considered cultural and economic value. This process identified three species as management priorities – dugong, turtle and tropical rock lobster (red diamonds on the following figure). Second order priorities were coral trout (common and barcheek; orange diamonds on the following figure).

Importantly, any changes to fishing effort and therefore the pressure and value of fisheries could change the management priorities. For example, the reopening of the *bêche-de-mer* (specifically black teatfish) fishery since the assessment was conducted is likely to have increased the management priority of the main target species, and therefore requires a review and possible adaptations.



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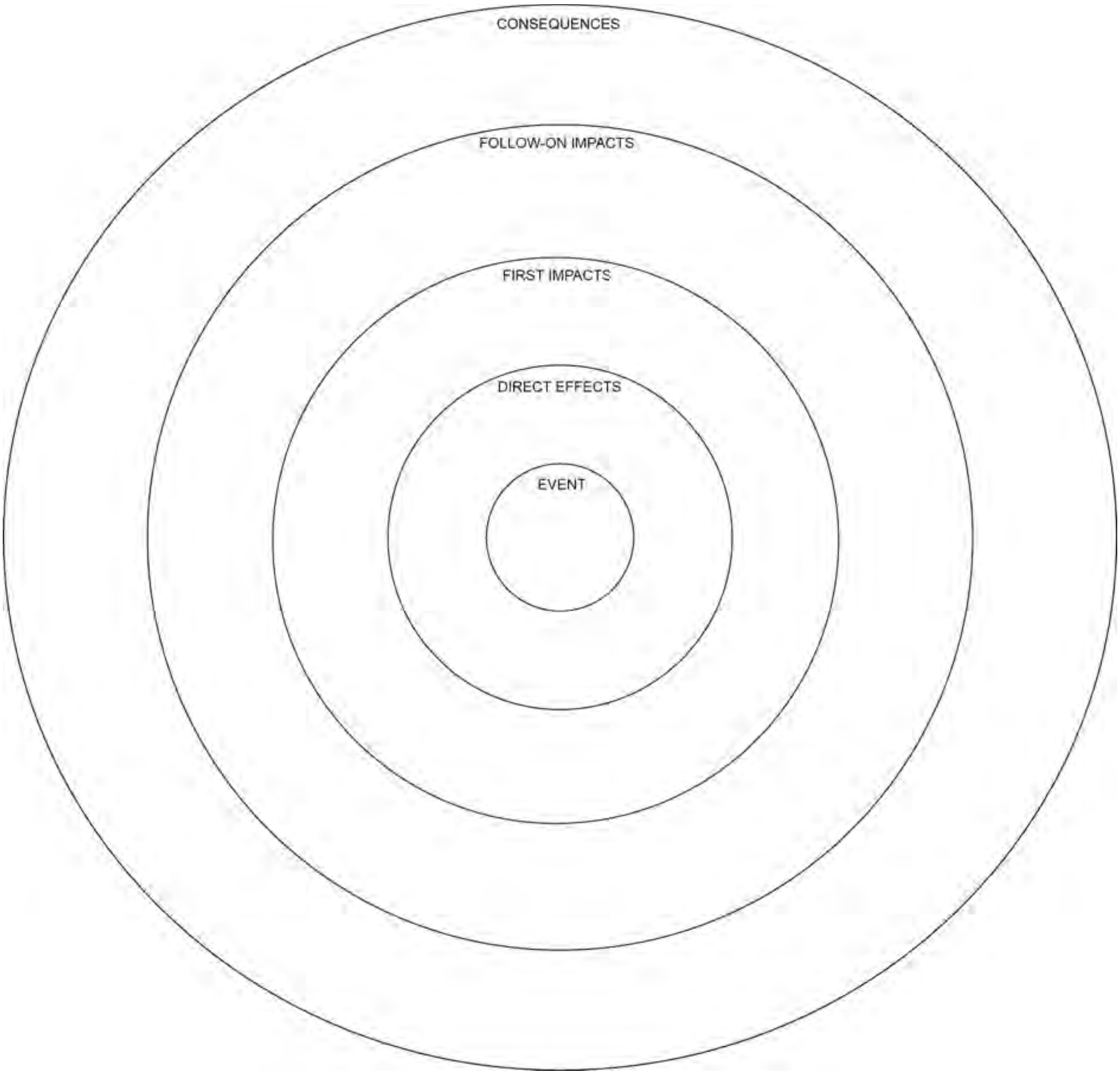
Cascading consequences

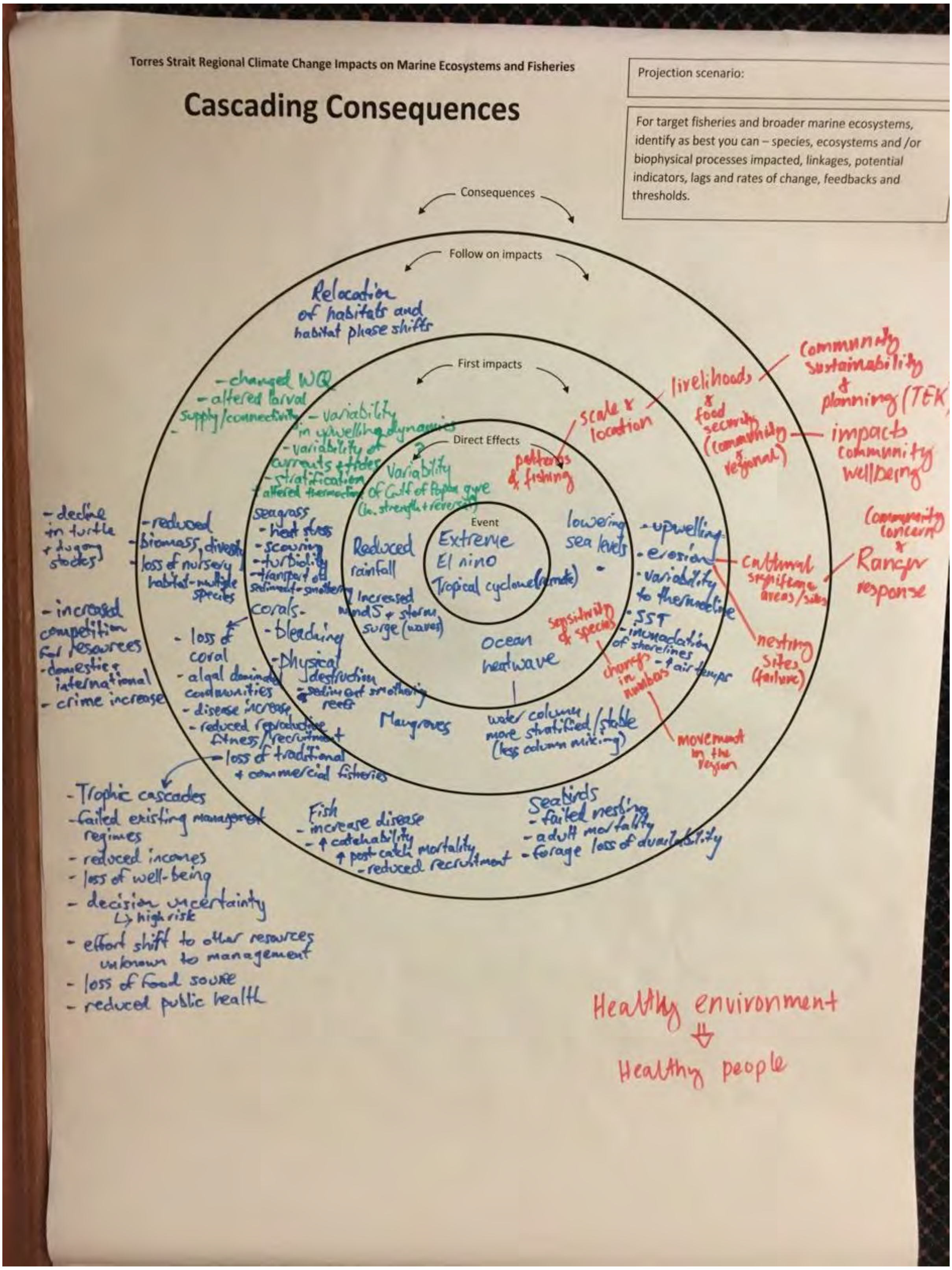
The impacts of climate change in the Torres Strait are not limited to the direct impact of climate events, and the ‘ripples’ or flow-on effects can be more significant than the primary impacts – particularly when considering co-incident climate events or impacts.

The consequences of two climate scenarios were explored in a ‘cascading consequences’ exercise, where workshop participants split into groups to map the impacts and consequences of climate change on Torres Strait fisheries and marine ecosystems. The following template was used.

(This template is also a useful community engagement tool and can serve as the basis of insightful discussions when communities think about the consequences of climate events in their context.)



SCENARIO 1: Tropical cyclone occurring during an extreme El Niño event



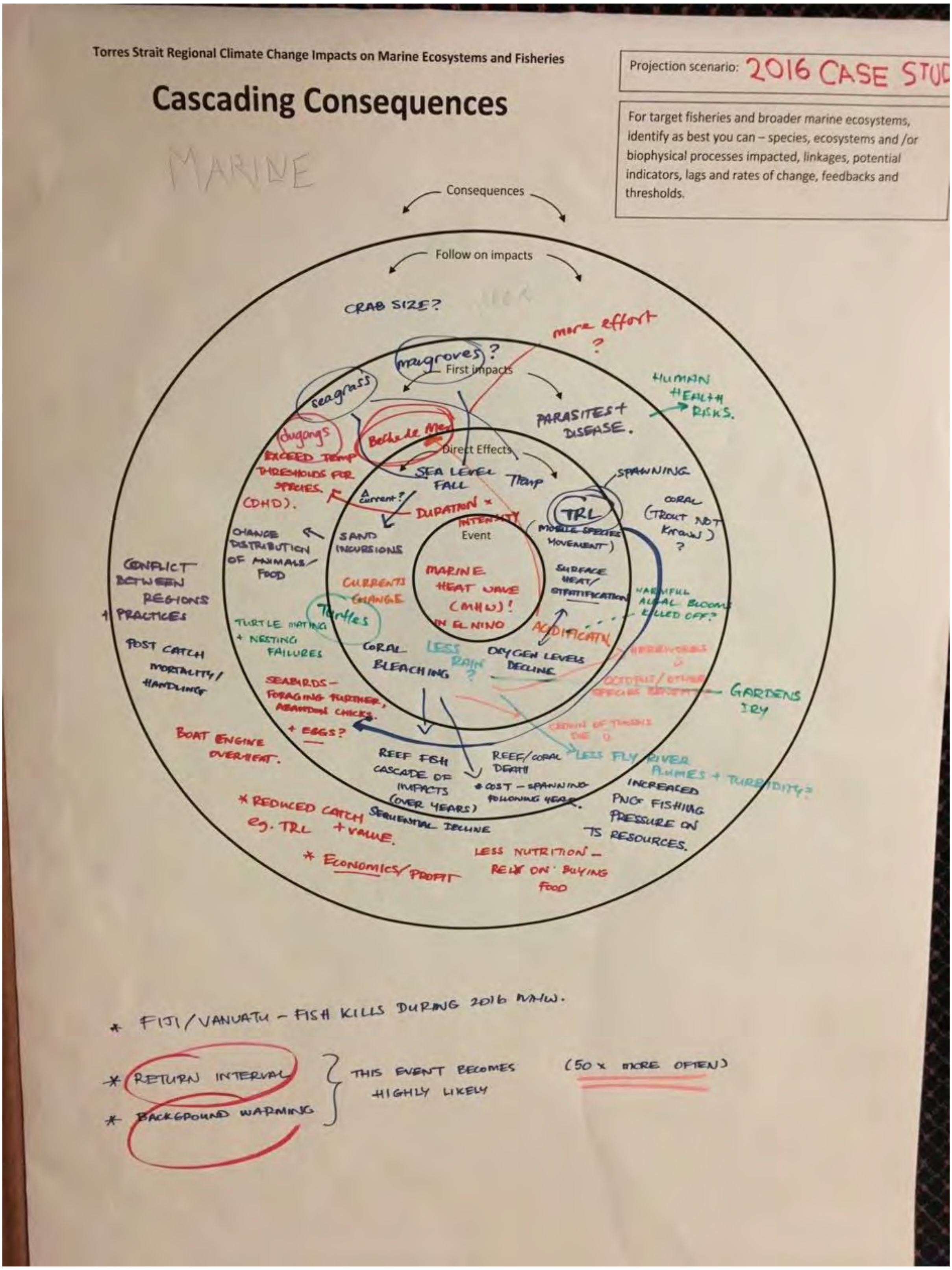
Torres Strait Regional Climate Change Impacts on Marine Ecosystems and Fisheries

Cascading Consequences

Projection scenario:

For target fisheries and broader marine ecosystems, identify as best you can – species, ecosystems and /or biophysical processes impacted, linkages, potential indicators, lags and rates of change, feedbacks and thresholds.

SCENARIO 2: Marine heatwave during an El Niño event



Torres Strait Regional Climate Change Impacts on Marine Ecosystems and Fisheries

Cascading Consequences

MARINE

Projection scenario: 2016 CASE STUD

For target fisheries and broader marine ecosystems, identify as best you can – species, ecosystems and /or biophysical processes impacted, linkages, potential indicators, lags and rates of change, feedbacks and thresholds.

* FIJI/VANUATU – FISH KILLS DURING 2016 MHW.

* RETURN INTERVAL
* BACKGROUND WARMING } THIS EVENT BECOMES HIGHLY LIKELY (50 x MORE OFTEN)

This example was based on an event examined in this paper: Oliver ECJ, Perkins-Kirkpatrick SE, Holbrook NJ, Bindoff NL (2017) Anthropogenic and natural influences on record 2016 marine heat waves. *Bulletin of the American Meteorological Society*, 98(12), S44-S48, DOI:10.1175/BAMS-D-17-0118.1 (and 10.1175/BAMS-D-17-0118.2).

Adapting to a changing environment: learning with the Torres Strait community to understand future impacts on wellbeing

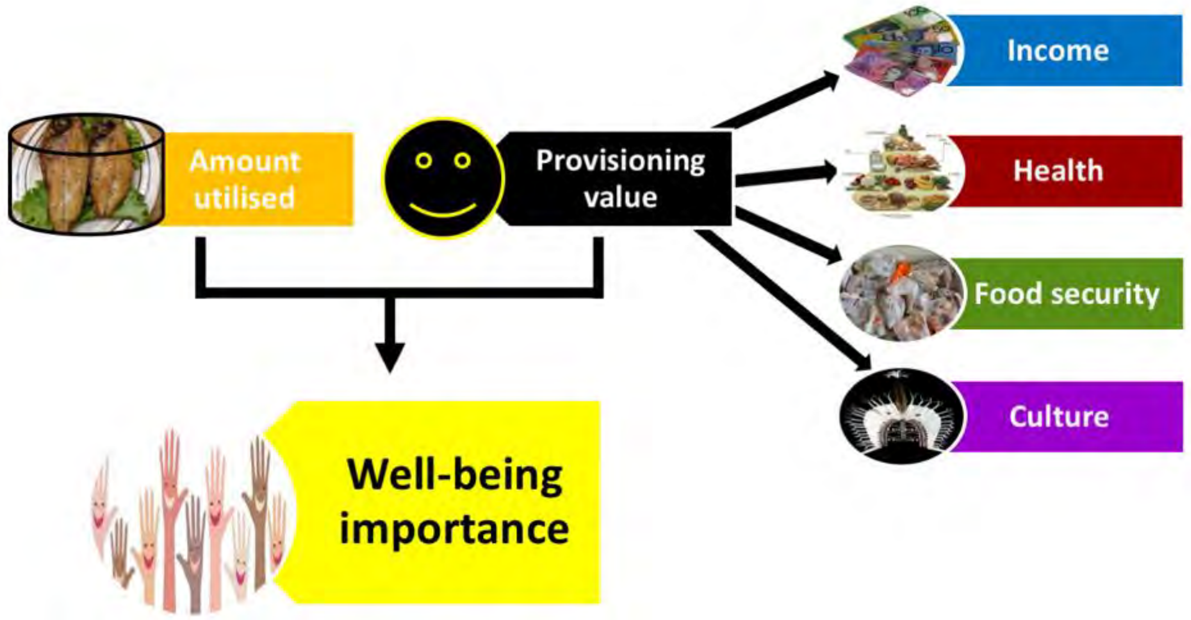
Cass Hunter, CSIRO

- Our science engagement and information needs to be relevant to communities by incorporating local views into the discussions
- Turning community visions about adaptation into reality involves being prepared to work across multiple sectors and the TSRA Climate Program
- Getting the right narrative for adaptation to climate change is about more than just our precision with science predictions.

Understanding impacts

- What are the drivers of change for livelihoods?
- What are the desired possible futures?
- What impact will the ‘business as usual’ (climate) future have on well-being?
- What is the resilience of the community today?
- What are the priority adaptation strategies to build resilience?

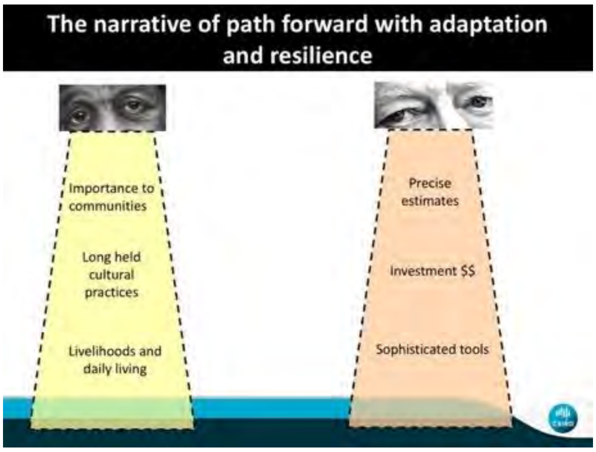
Understanding the importance of ecosystem goods and services



Adaptation strategies

Make it relevant – communities want to see their views and importance factored into climate conversations.

Culture is key – keeping culture strong helps the community to be sustainable and self-reliant.



The narrative of path forward with adaptation and resilience

Importance to communities

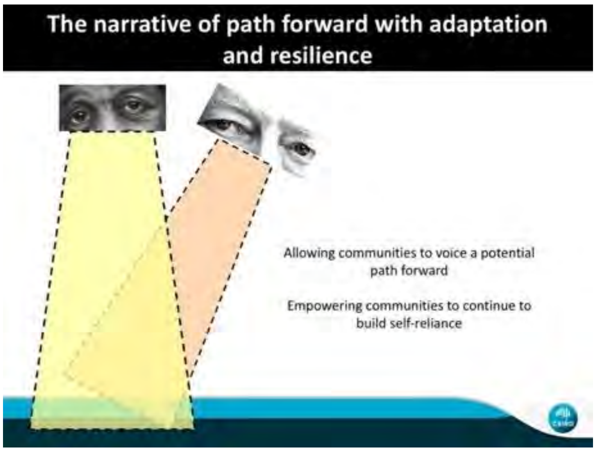
Long held cultural practices

Livelihoods and daily living

Precise estimates

Investment $$

Sophisticated tools

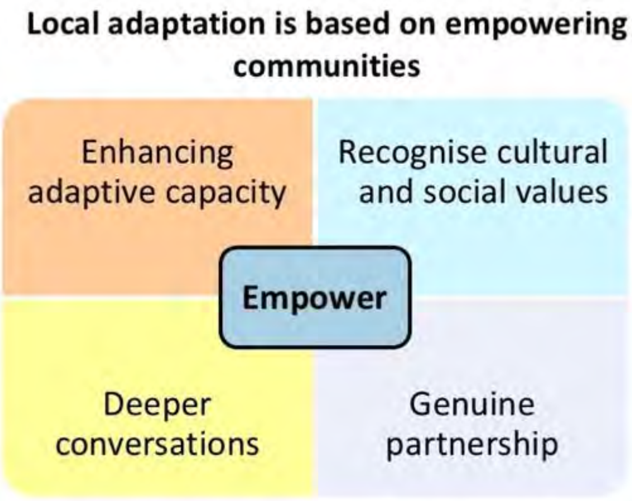


The narrative of path forward with adaptation and resilience

Allowing communities to voice a potential path forward

Empowering communities to continue to build self-reliance

Need collaborative partnerships to advance forward – to turn visions into reality (conversations into actions) we need to work across sectors (e.g. land use planners, renewables, sustainable housing, employment)



Local adaptation is based on empowering communities

Enhancing adaptive capacity

Recognise cultural and social values

Empower

Deeper conversations

Genuine partnership

Lessons from the Pacific

Johanna Johnson, TWQ Hub and Mandy Hopkins, ESCC Hub

The Torres Strait is more like the Pacific than Australia – islands are geographically remote with decentralised and dispersed populations, and communities are critically dependent on marine resources for food and income.

In addition to the direct impacts, climate change is affecting habitats, which in turn affects fisheries, which in turn affects livelihoods and income, food security and economic development. It follows that Pacific Islands are highly exposed and vulnerable to climate change.

So, it is useful to consider how communities in the Pacific are using projections science to drive risk assessments, and how this informs adaptation planning and associated decision-making and on-ground actions.

Case studies

Food security

Pacific per capita fish consumption (98–147 kg/person/year) is 3–5 times the global average. Projected climate-related habitat declines (loss of coral cover, reduced seagrass, reduced mangrove area) will affect fisheries. Some Pacific nations are better placed than others to deal with this.

Food security implications

Group 1:
Coastal fisheries are expected to meet the increased demand for fish

- Cook Islands
- Marshall Islands
- New Caledonia
- Palau
- Pitcairn Islands
- Tokelau

Group 2:
Difficult to distribute fish to urban centres from remote islands & atolls

- FSM
- French Polynesia
- Kiribati
- Niue
- Tonga
- Tuvalu
- Wallis & Futuna

Group 3:
Coastal fisheries cannot meet the increased demand for fish

- American Samoa
- Fiji
- Guam
- Nauru
- CNMI
- PNG
- Samoa
- Solomon Islands
- Vanuatu

Vanuatu has undertaken a number of adaptation activities in response, including:

- Structured monitoring of coastal fish habitats (reefs, seagrass, mangroves) commenced in 2015/16
- National Fisheries Policy 2016–2031 (ecosystem-based approach to coastal fisheries management)
- Trial of solar dryers for improved post-harvest fish preservation in north Efate and Santo
- New freshwater pond aquaculture for tilapia in villages
- Transfer fishing effort to target nearshore pelagic species using fish attracting devices (FADs); mostly local ‘Vatuika’ (‘Fish and Wealth’) design; 30 FADS installed/replaced since 2014

Papua New Guinea Treaty Villages

There are 13 Treaty Villages in the South Fly District of Papua New Guinea, where the low human development index is second only to the Congo. These villages are only 4 km from the northern Torres Strait Islands (Saibai and Boigu), and are highly exposed to climate variability and change.

Challenges for Treaty Villages include: water contamination, salinity intrusion, lack of sanitation, increasing demand/competition for natural resources (due to population growth), flooding and inundation during extreme sea level events, declining fisheries due to fish poaching, habitat loss and overfishing, high human disease prevalence (TB, malaria, cholera), isolation and lack of income opportunities – all serious cross-cutting issues that cannot be dealt with in isolation of climate change or each other.

A Community Ranger program is building a resilience platform for these villages with community-based and community-led activities to improve food security, water, health, livelihoods and well-being.

Outreach

The Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) program developed *The Pacific Adventures of the Climate Crab*, an animation and communication resource toolkit to raise awareness of the science and impacts of El Niño and La Niña to encourage Pacific Islanders to take early action in preparing for these extreme climate events.

The resource was developed in close consultation with in-country stakeholders, and its success as a community-level information tool demonstrates the importance of getting in the room and talking to people when developing content to facilitate outreach of the science.

The animation and toolkit are available on the Pacific Climate Change Science website at www.pacificclimatechangescience.org.

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- Pacific Climate Change Science – www.pacificclimatechangescience.org

Work being done in or relevant to Torres Strait fisheries and climate change

Australian Fisheries Management Authority

Ian Butler

AFMA's has a three-phase approach for adapting Commonwealth fisheries management to climate change.

1. Now

***Industry perspectives* –** AFMA recently completed a survey of fishers in south-eastern Australia (Lakes Entrance) and found that climate change was not perceived as a major issue, even though the region is a climate change 'hot spot'. More important issues were economics, quotas, fishing costs and competition.

***Non-recovering undercaught species* –** a collaboration between AFMA, Fishwell Consulting, CSIRO, the South East Trawl Fishing Industry Association and the Department of Agriculture and Water Resources is investigating the causes of undercaught total allowable catches (TACs) and non-recovering species in the Southern and Eastern Scalefish and Shark Fisheries.

***Updated modelling* –** a CSIRO-led project involving AFMA, the University of Tasmania, the University of British Columbia and the Fisheries Research and Development Corporation is underway to update existing models to account for decadal and regional variation. The project will provide analyses of species sensitivity to climate change impacts and provide a set of recommendations based on findings.

2. 2018–20: Adaptation project

The objectives of AFMA's adaptation project are to:

- Determine how well the existing Commonwealth fisheries management framework copes with climate change impacts (i.e. risk assessment)
- Develop methodology and approach for AFMA (and other fisheries) to adapt the regulatory environment to climate change impacts.
- Develop strategies and priorities to account for the effects of climate change in management of fisheries.

This project does not directly apply to Torres Strait, but can fit in with some effort.

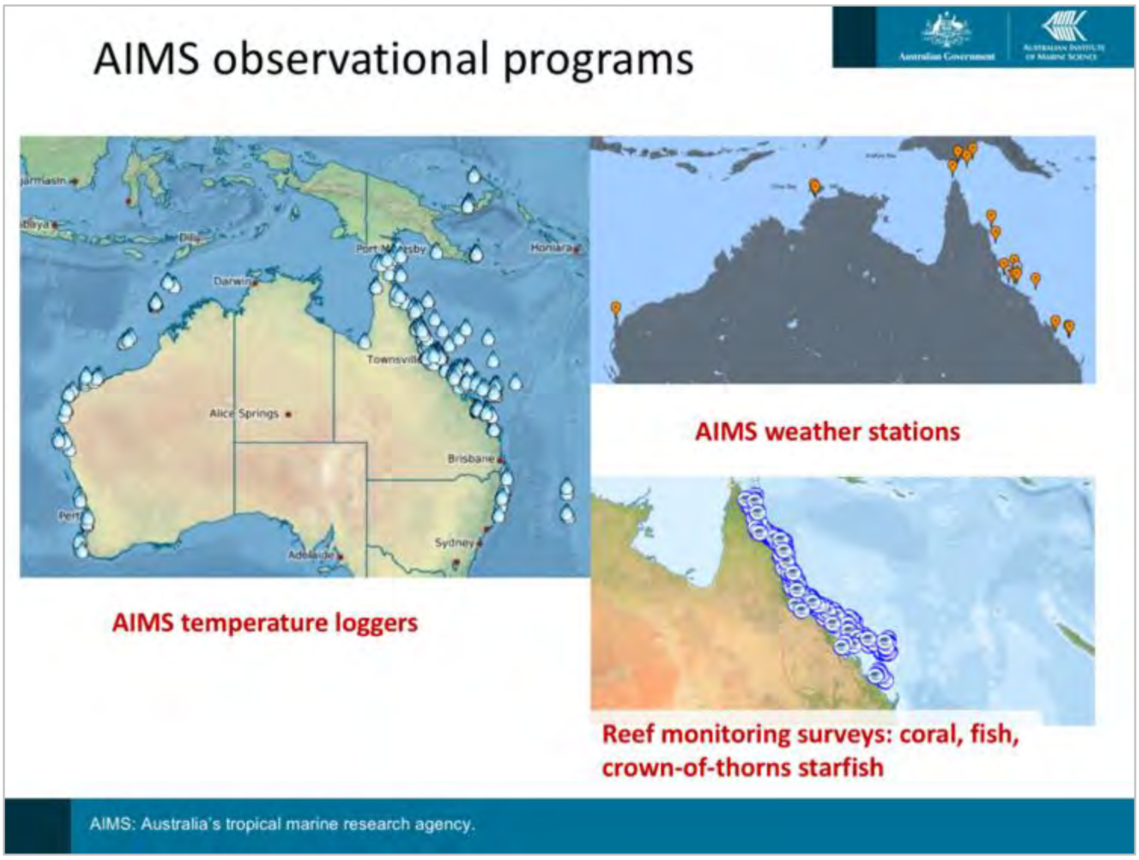
3. 2020+: Implementation

Flexible management is likely to be a key for future fisheries management with features such as a one-fishery approach (flexible management techniques with fewer boundaries) and mobile boundaries (e.g. Southern Bluefin tuna). Another feature is integration of forecasting of optimal fishing conditions.

Australian Institute of Marine Science

Craig Steinberg

One of AIMS's strengths is in its observational programs, which includes temperature loggers, weather stations and surveys of coral, fish and crown-of-thorns starfish.



AIMS observational programs

AIMS temperature loggers

AIMS weather stations

Reef monitoring surveys: coral, fish, crown-of-thorns starfish

AIMS: Australia's tropical marine research agency.

Modelling currents, sea surface temperatures and sea-level anomalies allows analysis of marine heatwaves and coral bleaching events. Some results to come out of this work:

- The 2016 bleaching event on the Great Barrier Reef was the most severe on record and heat anomalies persisted to the following winter
- Micro-climates created by small scale upwelling can create persistent thermal refugia for coral from a variety of oceanographic processes
- The Gulf of Papua current can reverse, and the current is predicted to intensify in winter in the future. The fate of larvae will be dependent on these changes.

An environmental data gateway has been developed to bring together existing near-realtime data from many sources – IMOS, eReefs, NOAA, AIMS – into one location. The gateway is at http://eatlas.org.au/gbr-gateway-temp.

CSIRO

Eva Plaganyi

There is a long history of fisheries research in Torres Strait and several long time series of fisheries and habitat information collected as part of scientific surveys.

CSIRO has worked closely with traditional owners in the region for several decades in advancing fisheries science and management in the region, and there is a reasonably good two-way flow of information via workshops and meetings.

Torres Strait tropical rock lobster	• Biological and climate data (CSIRO/AFMA surveys since 1989) • Mapping climate impacts on life history stages (2010 study) • Use of management strategy evaluation (2010–13) • Changes in oceanic currents and larval advection (current Environmental Influences project co-funded by AFMA & CSIRO) • Model projections under future climate change (current project that links also with AFMA decadal projections project)
Bêche de mer	• Mapping climate impacts on life history stages (2011 study) • Examples of the use of management strategy evaluation to test the performance of alternative marine monitoring and management strategies to detect and respond to ecological changes caused by climate change (2009–11, part of RUSS project)

There are gaps in some of the physical and oceanographic models that are needed to couple with the biological population dynamics for species of interest in order to reliably make predictions of impacts under climate change for fisheries and ecosystems (e.g. need to resolve tides in the region).

Management strategy evaluation as a risk management tool

Climate-smart strategies build resilience to multiple stresses. Management strategy evaluation (MSE) has been and continues to be used as one effective risk assessment method for road-testing the 'climate-smartness' of management strategies. This involves:

- Using climate risk assessment as an input to dynamic models
- Using a reference set of models (ensemble rather than single model) to capture key uncertainties
- Demonstration of use of MSE to test the performance (and adaptability),especially in the face of uncertainty, of alternative harvest strategies in meeting fishery management objectives, such as ensuring:
    - low risk of stock depletion (overall and local)
    - high probability of good catch / average profits
    - low risk of changing the multi-species community composition
    - high probability of managing through climate variability and change.

Torres Strait Regional Authority

Andrew Simmonds

Climate change is impacting vulnerable species and habitats in the Torres Strait and Great Barrier Reef.

Seagrass meadows to date have not shown a negative response to climate change as trends in biomass and species diversity remain consistently high across the region. Seagrass could be vulnerable to climate extremes in the future and this would then impact the Torres Strait **dugong** population – currently low risk. Aerial surveys indicate the population is stable. There is a need to maintain five-yearly survey effort.

Isolated locations of **mangroves** on Torres Strait islands have shown local-scale dieback from coastal erosion/sea-level rise.

Hawksbill turtle nesting population in Torres Strait is in severe decline mostly due anthropogenic impacts of overharvest in neighbouring nations and potential overharvest of eggs in Torres Strait and in neighbouring nations.

Northern Great Barrier Reef stock of **green turtles** is likely heading for a steep decline as a result of failing hatchling production at key index sites at Raine Island and Moulter Cay. Targeting of adult females for harvest and overharvest of eggs in some locations in PNG, Solomons and Torres Strait are also primary contributors. Climate change is drastically skewing the sex of marine turtle hatchlings (all species nesting in Torres Strait) to female via the effects of increased temperatures on incubating eggs. This may lead to negative population outcomes once current hatchling cohorts reach maturity. Funding to support ongoing monitoring of vulnerable marine turtle species in Torres Strait is at risk. If monitoring of key nesting index sites were to cease, this would be a bad outcome for these stock as community-based management would cease to have access to population trends.

Impacts on **coral reefs** from broad-scale severe bleaching will likely have an impact on supporting habitat for commercial fish species. A fisheries management response may be necessary in the future if harvest levels decline. However, there is a lack of information in Torres Strait fisheries regarding amount and value of catches which limits certainty in accurate management responses. There may be refugia for corals at the north-eastern corner of the Torres Strait where waters remain cooler and this may need special management arrangements for future conservation.

Certain low-lying islands in Torres Strait are experiencing **sea-level-related coastal erosion**, which TSRA LSMU is monitoring. There are real concerns in these communities.

There is ongoing **water quality** research into the implications of sediment-related pollution originating from the Fly River. Saibai, Dauan and Boigu are most affected, though results are currently inconclusive. Working with JCU TropWater. Future directions may include investigation of common food sources for metal contamination as well as work to determine historical levels of metals in sediment and corals.

NESP Tropical Water Quality Hub

Johanna Johnson

Previous water quality research

- Torres Strait baseline study (1993) – survey of trace metals in marine seafood, seagrass and sediments
- Apte & Day (1998) – first accurate data on trace metal concentrations in waters (Cu, Cd and Ni only)
- Haynes & Kwan (2002) – 28 sediment samples collected in 2000 and analysed for metals
- NERP WQ hazards (2011–13) – hydrodynamic modelling, predictions of water flow, hazard assessment based on previous data

Current relevant Tropical Water Quality Hub projects

Influence of the Fly River on the Torres Strait region (Projects 2.2.1 and 2.2.2)

Runoff from the Fly River in Papua New Guinea influences water quality conditions in the Torres Strait region; however, the extent and frequency of this influence, and the potential ecological impacts, are not well understood. This project builds on previous efforts to determine the spatial extent, temporal patterns and constituent pollutants of Fly River discharge, and assess the vulnerability of ecosystems in the Torres Strait exposed to the discharge.

A related project is using state of the art procedures to determine trace metal concentrations in marine waters and sediments at locations across the Torres Strait. Chemical signatures of mine pollution are being measured in Torres Strait waters and sediments and hotspots of contamination identified. The water quality data generated will allow informed management decisions to be made on how to best address trans-boundary mining related pollution and potential ecological impacts.

Connectivity and inter-dependencies of values in the northeast Australia seascape: Great Barrier Reef, Torres Strait, Coral Sea, Great Sandy (Project 3.3.3)

This project is identifying and assessing the ecological, cultural, social and economic values of four marine jurisdictions – Great Barrier Reef, Torres Strait, Coral Sea, Great Sandy Straits – and characterising the processes and attributes that influence the values and their connectivity at a regional scale. In doing so, the project will deliver a resource that can inform cross-jurisdictional planning and management.

References/more information

- NESP Tropical Water Quality Hub – www.nesptropical.edu.au

Science, data and research priorities

Workshop participants identified six priority areas for research that will help inform fisheries and marine ecosystem management in Torres Strait (and thereby to inform science-based adaptation response).

The following table summarises initial thoughts with regards to these priority areas. It is anticipated that ideas in this table will further refined over time.

Biological understanding	• Limited understanding of species responses to combinations of changing environmental variables (e.g. bêche-de-mer) (lab, desktop, field) • Seagrass sensitivities
Monitoring	• Tidal gauges – to analyse and add • Drifters – inform on complexity • Integrated Marine Observing System • Moorings (upwellings) – strings of loggers • Himawari satellite information – 1 picture/10 minutes • Turbidity using Secchi discs (cheap and easy)
Population modelling	• Coupling with high-resolution current/climate • Follow similar approaches to those used for corals, crown-of-thorns starfish • Additional models for species (e.g. turtles, dugongs) at appropriate spatial scales • Coral trout correlations with coral abundance or habitat
Climate modelling	• Downscaling of projections for Torres Strait and in particular, tides • Produce regional rainfall projections from CMIP5 models selected for skill/low biases (and maybe CCAM model runs)
Adaptation responses/ communities	• Communication • Community consultation regarding adaptation • Industry and traditional owner advice/experience with regard to fishing behaviour • Management of fisheries – parallel AFMA projects, fishery by fishery; adaptation
Fly River	• Plume prediction • Metals/health risks

Science-based information products and services

Existing information and tools

While additional science will help inform management decisions in the Torres Strait, there is a great deal of information and a number of communication products and decision support tools currently available.

Data collected in the region	• AIMS – in-situ collection (water temperature, weather) – online gateway • BoM – heatwave mapping • AMSA – tide gauges • AFMA – fisheries data • Climate Change in Australia – climate projections • PACCSAP – climate projections for Papua New Guinea and various technical and non-technical climate change communication products and resources • TSRA – reef monitoring, crown-of-thorns starfish monitoring, bleaching, beach profiling • TropWater (James Cook University) – in-situ seagrass surveys • CSIRO – annual habitat surveys (including numbers of pearl oyster, crown-of-thorns starfish and holothurians, and percent cover of standard substratum and biota (including seagrass and algae species) categories
Tools/ programs that make use of the information	• ADWIM (impacts and wellbeing) –> CSIRO • Torres Strait vulnerability assessment • NESP ESCC Hub (www.nespclimate.com.au)

The challenge lies in identifying which information is most useful and delivering it to the people that need it in ways that they can use it.

Communication and outreach ideas

It was agreed that a useful communication and outreach model is needed to develop information resources for the communities and stakeholder groups to provide information that can be easily understood and delivered to stakeholders. A number of ideas for ways this might occur were identified at the workshop.

As is the case with the ideas for science, data and research priorities, it is anticipated that these ideas will be refined over time as follow-up to the workshop.

Support	• Outreach specialist in climate supporting TSRA in disseminating information
Engagement/ outreach activities	• TSRA staff discussing the outcomes of this workshop in fisheries working group meetings and canvasing interest in engagement • More targeted outreach effort to discuss key climate change messages in Torres Strait communities • Building local climate change capacity -> drive local adaptation plans -> climate champion -> who wants to be involved in the communities • Annual event (pre-season gathering of key stakeholders) to provide timely climate information relevant to local communities/the fishery sector
Communication/ knowledge brokering products	• Workshop report • Climate change themed ‘comic book’ as a communication resource for local communities • Video – explain the science and communicate traditional knowledge (communities explain what they see)

Appendix 1: Workshop agenda

Technical workshop

CLIMATE CHANGE IN THE TORRES STRAIT: IMPLICATIONS FOR FISHERIES AND MARINE ECOSYSTEMS

Pullman Cairns International, 17 Abbott Street, Cairns
7–8 December 2017

DAY 1: THU 7/12/17 13:00–17:30

Time	Agenda item	Who	Session purpose
13:00	**LUNCH**		
Introduction			
14:00	Welcome	Geoff Gooley (ESCC Hub)	
14:05	Welcome to country	Gudju Gudju	
14:10	Introduction	Geoff Gooley (ESCC Hub)	
Setting the context			
14:20	Overview: Climate change impacts on oceans, fisheries and marine systems	Neil Holbrook (ESCC Hub)	To ensure all workshop participants understand what aspects of climate change impact oceans and marine systems and what the impacts could be (starting with the global 'big picture' and including all aspects of climate change relevant to TS including SLR, coastal hazards, ocean temp extremes, acidification, extreme events, coral bleaching risk)
14:50	Overview: Torres Strait fisheries and marine ecosystems	TSRA/AFMA	To ensure all workshop participants understand the nature and extent of TS fisheries and marine ecosystems, including and key features and related considerations (e.g. social, political, economic).
Current and future climate in the Torres Strait			
15:20	Climate trends and projections for Torres Strait Islands	Jo Brown (ESCC Hub)	To provide an overview of the current climate of the TS, how it has changed and how it could change in the future, drawing on the latest climate change science. This information will provide an important basis for later discussions in the workshop.

Time	Agenda item	Who	Session purpose
15:50	Climate change impacts on key TS resources – ADWIM model	Cass Hunter (CSIRO)	To share outputs from the CSIRO ecosystem goods and services model to show how climate change is likely to impact key marine resources for TS communities.
16:20	Vulnerability of fisheries to climate change – report summary	Jo Johnson (TWQ Hub)	To provide an overview of climate change hazards, vulnerability and risk specific to fisheries and marine ecosystems in the TS.
16:50	Day 1 wrap-up	Geoff Gooley (ESCC Hub)	
17:00	**Close Day 1**		

DAY 2: FRI 8/12/17 9:00–16:30

Time	Agenda item	Who	Session purpose
Snapshots: Understanding climate change and impacts in the Torres Strait			
9:00	Issues and impacts Including: • impacts of the last coral bleaching event • decadal scale projection of changes in fisheries stocks under climate change • adaptation of fisheries to climate change	Craig Steinberg (AIMS) Eva Plaganyi (CSIRO) Ian Butler (AFMA) John Rainbird and Andrew Simmonds (TSRA) Jo Johnson (TWQ Hub)	To provide a brief overview of current projects and monitoring activities that are helping us to understand climate change and impacts in the TS, as well as discussion of current issues and impacts. Each presenter will have 15 mins to talk about work from their respective organisations, with time for discussion at the end. Outcomes/findings reported here will feed into the following discussions.
10:40	**Morning tea**		
Looking ahead: what does the future hold for TS fisheries and marine ecosystems?			
11:00	Understanding TS stakeholders	Charles David (TSRA)	To identify TS stakeholder groups and their needs
11:30	Activity: Cascading consequences	Facilitator: John Rainbird (TSRA)	To identify possible consequences of climate change and coincident events in TS. Participants will break into two groups for this activity.
12:30	Discussion: Cascading consequences activity	Facilitator: John Rainbird (TSRA)	To discuss the outcomes of the previous activity. As well as being included in the workshop report, responses will inform post-workshop technical meeting discussions.
13:00	**Lunch**		
Preparing for the future			
13:30	Lessons from the Pacific	Jo Johnson (TWQ Hub) and Mandy Hopkins (ESCC Hub)	To share how communities in the Pacific are using projections/science to drive risk assessments, and how

Time	Agenda item	Who	Session purpose
			this feeds into adaptation planning and associated decision-making
14:00	Identified knowledge gaps and prioritised needs	Facilitator: Geoff Gooley (ESCC Hub)	To learn about some knowledge gaps and needs that have already been identified and prioritised. These will inform the following discussion.
14:20	Small group discussions: Knowledge gaps and knowledge products	Facilitator: Mariana Nahas (TSRA)	To identify knowledge gaps and needs in light of what has been presented at the workshop, and how they may be able to be addressed. What [information] resources/ knowledge products are needed to convey the learnings from this workshop to TS stakeholders (including TOs/local fishers, natural resource managers, other local communities of interest and scientists) and what information do we need from TOs?
15:00	Report back – Knowledge gaps and knowledge products	Facilitator: Mariana Nahas (TSRA)	To record ideas for management responses and information needs. As well as being included in the workshop report, responses will inform post-workshop technical meeting discussions.
15:30	Group discussion: Options for further engagement including priority actions and responsibilities	Facilitators: Geoff Gooley (ESCC Hub), John Rainbird (TSRA)	Emphasis on options for further strategic engagement, collaborative partnerships and delivery
Workshop wrap-up			
16:15	Closing remarks (including next steps)	Geoff Gooley (ESCC Hub), John Rainbird (TSRA)	To provide a brief recap of what has been covered and why, and what the next steps will be.
16:30	**Workshop close**		

Appendix 2: Workshop participants

- Shaun BARCLAY, TSRA (Day 2 only)
- Josephine BROWN, ESCC Hub
- Ian BUTLER, AFMA
- Charles DAVID, TSRA
- Geoff GOOLEY, ESCC Hub
- Rohan HAMDEN, Consultant (Day 1 only)
- Neil HOLBROOK, ESCC Hub
- Mandy HOPKINS, ESCC Hub
- Cass HUNTER, CSIRO
- Johanna JOHNSON, TWQ Hub
- Phil LAYCOCK, GBRMPA
- Mariana NAHAS, TSRA
- Karen PEARCE, ESCC Hub (Day 2 only)
- Eva PLAGANYI, CSIRO
- John RAINBIRD, TSRA
- Andrew SIMMONDS, TSRA
- Selina SOUTE, AFMA (Day 2 only)
- Craig STEINBERG, AIMS

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TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No.2** **27-28 September 2022**
FISHERY RESEARCH PRIORITIES	**Agenda Item 6** **For DISCUSSION & ADVICE**

RECOMMENDATIONS

1. That the Resource Assessment Group (the RAG):
   a. **NOTE** that details of the outcomes of the 2022-23 funding round, and changes to the Torres Strait Scientific Advisory Committee (TSSAC) research cycle timeline were circulated to RAG members out of session on 2 September 2022 (refer to Agenda Item 1.5 – Out of session correspondence);
   b. **NOTE** that AFMA sought advice from RAG and Hand Collectables Working Group (HCWG) members out of session on a proposal for the 2023-24 limited research budget funding cycle with approximately $110,000 available to fund new research in the 2023-24 financial year.
      i. The TSSAC has suggested releasing a limited call for research for a project relating to *Management Strategy Evaluation of Spanish mackerel for the Torres Strait Finfish Fishery.*
   c. **NOTE** the current status of identified research priorities and needs for the Torres Strait Beche-de-mer Fishery (BDM Fishery) as previously advised by Hand Collectables RAG 1 and the Hand HCWG (**Table 1**).
2. Having regard to **Table 1**, **DISCUSS** and **PROVIDE ADVICE** on research priorities for a rolling five-year research plan for Hand Collectable Fisheries (**Attachment 6a**) (to be updated following advice from HCRAG 2 and HCWG 19) including advice on the feasibility, timing and indicative costing of essential, unfunded research project(s) to inform the TSSAC annual call for research funding proposals in 2024-25.
3. **NOTE** updates on other broader research priorities applicable across all Torres Strait Fisheries.

KEY ISSUES

Research priorities for Hand Collectable Fisheries

4. The HCRAG last met on 6-7 October 2021, and HCWG on 18 October 2022 to consider research priorities for Hand Collectable Fisheries and specifically, the 2022-23 TSSAC research funding round. The latest advice from both HCRAG and HCWG is that:
   a. the highest priority research needs for the BDM Fishery is to **determine the current status of sea cucumber stocks in relation to the BDM Harvest Strategy reference points**. This project is only possible where sufficient information is available.
   b. Additional **analysis on white teatfish** remains a high priority to develop a rationale on the status of the stock in relation to harvest strategy reference points and modelling analysis on a sustainable TAC increase.

        i. This project was supported by the TSSAC and funded for the 2022-23 financial year. The results are expected to be presented at a future HCRAG meeting in 2023.

    c. Undertaking representative **sampling of black teatfish** to collect size and weight frequencies during black teatfish openings also remains a high priority.

        i. This project was also supported by the TSSAC for the 2022-23 financial year. The results of the 2022 sampling will be presented under Agenda Item 3.

    d. The **development of curryfish conversion ratios** with industry based sampling also remains a high priority.

        i. This project was supported by the TSSAC for the 2022-23 financial year. The results are expected to be presented at a future HCRAG meeting in 2023.

    e. Subject to confirmation of support from Iama and Tudu Island Prescribed Body Corporates (PBCs), Gur A Baradharaw Kod Sea and Land Council (GBK), Traditional Owners and fishers, **undertaking a stock survey of sandfish at Warrior Reef** also remains a high priority to better understand its stock status.

        i. As per an action item arising from HCRAG 1, AFMA wrote to Iama TO's, PBC and Fishers on 20 September 2022 seeking confirmation of support with an invitation to attend HCRAG 2.

5. HCRAG and HCWG also discussed socioeconomic knowledge gaps in the fishery, noting that data (including but not limited to those obtained from socioeconomic surveys on fishing effort, fishing activities, motivations of fishers, fishing costs, supply chain and value chain issues, trade issues, cultural issues, changes in fishing strategies, and fishing gear use can be used to strongly inform the management of the fishery. These discussions have since been reflected in **Table 1** and the RAG is invited to provide further advice to aid in developing an appropriate research scope for consideration for funding in the 2024-25 financial year.

6. Further detail on medium and lower research priorities are also outlined in **Table 1**.

Broader research priorities for Torres Strait Fisheries

7. The TSSAC also funds projects that are applicable across Torres Strait Fisheries. Two such projects that were funded in 2019-20 are the *Climate variability and change relevant to key fisheries resources in the Torres Strait – a scoping study)* (the outcomes of which are to be presented under Agenda Item 5) and *Measuring non-commercial fishing (indigenous subsistence fishing and recreational fishing) in the Torres Strait in order to improve fisheries management and promote sustainable livelihoods*.

8. At their meeting on 6-7 April 2022, the TSSAC provided further support for extensions of both the climate change project and non-commercial catch project subject to potential co-funding opportunities from the Fisheries Research and Development Corporation (FRDC) and other avenues including the TSRA.

9. The climate change modelling project (an extension of the initial climate change scoping project) is hoped to be co-funded through a contribution from the TSRA ($500,000) and the remainder of the funds are being considered by the FRDC. An outcome on FRDC funding is expected by soon**.**

10. Phase 2 of the non-commercial catch project (*Measuring non-commercial fishing catches (traditional subsistence fishing) in the Torres Strait in order to improve fisheries management and promote sustainable livelihoods))* has also been supported for funding by the FRDC for funding in 2022-23, subject to conditions.

11. Although, as AFMA understands it, there is no non-commercial catch of sea cucumbers, it may still be relevant for the RAG to provide feedback to TSSAC on the outcomes and recommendations from this project. This is because the project relates to developing a catch data collection method for the region.

BACKGROUND

TSSAC Fisheries Strategic Research Plan 2018-2023 and rolling five-year fishery-specific research plans

12. TSSAC operates under a Strategic Research Plan (SRP) which guides priority setting for research in Torres Strait fisheries over a five-year period (**Attachment 6b**). The SRP specifies the research priorities and strategies summarised in **Table 2** that the PZJA intend to pursue in Torres Strait fisheries and provides background to the processes used to call for, and assess, research proposals. The research priorities can be broad, covering all topics within the SRP, some of which may be funded by AFMA, and some of which may require funding from other funding bodies.

13. There are 3 research themes within the SRP, under which the HCRAG and HCWG could identify research priorities for Hand Collectable fisheries. There are several strategies under each theme and suggested ideas to help RAGs and Working Groups to think about the sorts of projects which may fit within these themes and strategies.

14. The TSSAC requires each fishery to develop a rolling five-year research plan, which fits into the themes identified in this SRP.

15. The TSSAC has an annual research cycle, which fits with the AFMA budgeting cycle (**Attachment 6c**).

Table colour key	Completed	Funded and underway	Scoped and/or costed	Not scoped/not costed

Table 1. Overview and status update of research needs identified or discussed for Hand Collectable Fisheries at previous HCRAG and HCWG meetings and the rolling five-year research plan *(it does not include recommendations from survey or priorities that might be discussed during this HCRAG meeting).*

	Research activity	**Detail**	**Status**	**Comments/questions**	**Latest RAG & WG advice**
1	Status of BDM stocks in relation to harvest strategy reference points	Consistent with the BDM harvest strategy and where there is sufficient information available, a tactical research project is needed to determine the current status of sea cucumber stocks in relation to the harvest strategy reference points, noting that the first step is to define the reference points for the species for which it may be possible.	Not scoped/not costed		**High priority**
2	White teatfish modelling	Additional analysis on white teatfish to develop a rationale on the status of the stock in relation to harvest strategy reference points and modelling analysis on a sustainable TAC increase.	Funded and underway in 2022-23 FY		**High priority**
3	Black teatfish sampling 2022	Representative sampling to collect size and weight frequencies during the black teatfish openings.	Funded and underway in 2022-23 FY		**High priority**
4	Development of curryfish conversion ratios	Project to develop conversion ratios for curryfish with industry undertaking the sampling process.	Funded and underway in 2022-23 FY		**High priority**
5	Sandfish stock survey	Outstanding stock survey of Sandfish at Warrior Reef to better understand its status	Not scoped/not costed	Identified as a research need for the fishery by HCWG17 at its meeting 12 October 2020. Was part of the 2019-20 stock survey but did not proceed.	**High priority** subject to confirmation of support from Iama and Tudu Island PBC, GBK, Traditional Owners and fishers.

	Research activity	Detail	Status	Comments/questions	Latest RAG & WG advice
7	Socio-economic metrics	Collecting data on socioeconomic indicators for the fishery through recall surveys.	Not scoped/not costed		**High priority.** Subject to: • further HCRAG advice on the scope and additional work to be done to support it. • more clarity on questions being asked, data required and indicative cost. Project may fall within the remit of ACR.
8	Management Strategy Evaluation (MSE) of the Beche-de-mer Harvest Strategy	1. Collate all data and biological information; 2. Update and extend the spatial multispecies TS BDM operating model developed earlier (or construct a new model); 3. Use MSE to evaluate how well the HS achieves the pre-specified objectives; 4. In consultation with stakeholders, use the MSE framework to investigate ways to improve the current HS.	Not scoped Est cost – $130k	Requires 3-5 years of BDM HS implementation.	**Medium priority** and to be held off until the harvest strategy has been in place for a few years. Interacts with no.1
9	Supply chain	Better understanding of the supply chains as per other fisheries to better understand vulnerabilities and help develop an industry that is resilient to fluctuating export market conditions.	Not scoped/not costed		**Not prioritised**
10	Exploring sea ranching/re-seeding opportunities		Not scoped/not costed		**To be removed from the research plan** - Aquaculture falls outside the remit of the PZJA. PZJA can provide support through provision of information and permitting collection of broodstock. With regarding to Sandfish aquaculture, the PZJA will initially want to establish the

	Research activity	Detail	Status	Comments/questions	Latest RAG & WG advice
					status of the sandfish stock on Warrior reef.
11	Ecological Risk Assessment (ERA) – Torres Strait Pearl Shell Fishery	Conduct an ERA for the Torres Strait Pearl Shell (TSPF) Fishery	Not scoped Est cost - $20,400	Identified as an essential research priority by HCWG in the rolling five-year research plan for Hand Collectable Fisheries	**To be retained in research plan** and activated when fishing for pearl oysters commences. There is some information on Pearl shell stock estimates from Tropical Rock Lobster surveys.
12	Understanding biological parameters of BDM species, including growth, mortality, size and breeding seasonality	Identifying gaps in knowledge of biological parameters of BDM species and investigating options for collaborative research	Not scoped/not costed		Low priority and proposed that it be addressed as the need arises. There are conservative proxies that are best addressed through other avenues such as University students.
13	Stock Status Survey	To undertake a stock survey of all Torres Strait beche-de-mer species with a focus on deeper water species	Completed in 2019 - 2020	-	-
14	Ecological Risk Assessment (ERA)	Conduct an ERA for the TSBDM Fishery	Final report completed on 21 Dec 2021	The draft report was presented to HCRAG 1	-
15	Climate Change impacts and vulnerability	Scoping study across all Torres Strait	Completed	-	-
16	Data analysis	Further analysis of catch data collected during the 2021 trial reopening of black teatfish to inform future openings and follow up work from the stock survey.	Completed	-	-

Table 2. Torres Strait fisheries strategic research themes, strategies and research activities

Theme 1: Protecting the Torres Strait marine environment for the benefit of Traditional Inhabitants	
Aim: Effective management of fishery stocks based on understanding species and their biology and ecological dependencies so it can support Traditional Inhabitant social and economic needs.	
Strategy 1a - Fishery stocks, biology and marine environment	Possible research activities under this theme may include: a. Stock assessment and fishery harvest strategies for key commercial species. b. Ecological risk assessments and management strategies for fisheries. c. Minimising marine debris in the Torres Strait. d. Addressing the effects of climate change on Torres Strait fisheries through adaptation pathways for management, the fishing industry and communities. e. Incorporating Traditional Ecological Knowledge into fisheries management. f. Methods for estimating traditional and recreational catch to improve fisheries sustainability.
Strategy 1b – Catch sharing with Papua New Guinea	Possible research activities under this theme may include: a. Status of commercial stocks and catches by all sectors within PNG jurisdiction of the TSPZ. b. Good cross-jurisdictional fisheries management through better monitoring and use of technology.
Theme 2: Social and Economic Benefits	
Aim: Increase social and economic benefits to Traditional Inhabitants from Torres Strait Fisheries.	
Strategy 2a - Promoting social benefits and economic development in the Torres Strait, including employment opportunities for Traditional Inhabitants	Possible research activities under this theme may include: a. Models for managing/administering Traditional Inhabitant quota b. Understanding what influences participation in commercial fishing by Traditional Inhabitants. c. Understanding the role and contribution of women in fisheries. d. Capacity building for the governance of industry representative bodies e. Methods for valuing social outcomes for participation in Torres Strait fisheries. f. Identifying opportunities and take-up strategies to increase economic benefits from Torres Strait fisheries.
Theme 3: Technology and Innovation	
Aim: To have policies and technology that promote economic, environmental and social benefits from the fishing sector.	
Strategy 3a – Develop technology to support the management of Torres Strait fisheries.	Possible research activities under this theme may include: a. Electronic reporting and monitoring in the Torres Strait, including for small craft. b. Technologies or systems that support more efficient and effective fisheries management and fishing industry operations.

	TSSAC PROCESS	**AFMA budget process**	**Example dates**
July **(START)**	July - RAGs, WGs and MACs to update five year rolling research plan and specify their priority research needs for funding in the next financial year (12 months time). **Provide to TSSAC EO by end July. Note this may require RAGs to consider priorities at November meeting the preceding year.**		July 2023 (consider at December 2022 meetings)
August	Start to mid-August, Annual Research Statement (ARS; containing all Torres Strait fishery research priorities) and TSSAC papers sent for consideration before end August meeting. **Late August - TSSAC meets** (face to face or via teleconference) to finalise the PZJA ARS and agree on priorities/ scopes for the TSSACs call for research proposals.		August 2023
September	**Early sept - call for research opens** (6-8 weeks given due to more complex proposal for Torres Strait research).		September 2023
October	**end October - proposals due**		October 2023
November	RAGs and WGs to meet and consider research priorities for the next financial year funding round	AFMA DRAFT budgets due. Enter budgets based on budget estimates in project proposals	November 2023 (considering research priorities for 2025-26 financial year)
December	Mid December - RAG comments due on proposals (6 weeks)		December 2023
January	TSSAC papers sent ahead of meeting		January 2024
February	**Early February- TSSAC meet face to face** to consider research priorities for conditional support (priority to community consultation occuring). Mid-Feb – researchers notified of conditional support for project, which requires community consultation before final funding support is considered. Comments on proposals provided to researchers for amendment. Researchers to develop and provide community consultation package to TSSAC EO (2 weeks). TSSAC EO to send community consultation packages to relevant PBC, councillors and fishers associations (for	Early-mid Feb - budgets finalised, for consultation and final support. Submitted based on full proposals submitted.	February 2024

	TSSAC PROCESS	**AFMA budget process**	**Example dates**
	relevant projects). PIs to follow up with phone calls (2 weeks).		
March	Late March – researchers submit a summary of feedback from community consultation to TSSAC EO. .		March 2024
Early April	**TSSAC meet via teleconference to discuss outcomes of community consultation**. If no / minimal and supportive comments received only, then send out of session for consideration instead of teleconference. Mid-April – researchers notified of final endorsement of project and process for contracting. EO to work with research team to arrange drafting of contracts		April 2024

Five-year Research Plan 2022/23 – 2026/27

Torres Strait Hand Collectable Fisheries

Beche-de-mer
Pearl shell
Crab
Trochus

COMPILED BASED ON ADVICE FROM THE HAND COLLECTABLES RESOURCE ASSESSMENT (HCRAG) AND WORKING GROUPS (HCWG)

October 2021

ABOUT THIS PLAN

The Torres Strait Scientific Advisory Committee (TSSAC) seeks input from each fishery advisory body (Resource Assessment Group (RAG), Management Advisory Committee (MAC) or Working Group (WG)) to identify research priorities over five year periods from 2022/23 to 2026/27. This template is to be used by the relevant advisory body to complete their five-year plan. The plans are to be developed in conjunction with the TSSAC Five-year Strategic Research Plan (SRP) with a focus on the three research themes and associated strategies within the SRP.

All fishery five-year plans will be assessed by the TSSAC using a set of criteria, and used to produce an Annual Research Statement for all Torres Strait fisheries.

The TSSAC then develop scopes for the highest ranking projects in order to publish its annual call for research proposals. There are likely to be more scopes that funding will provide for so TSSAC can consider a number of proposals before deciding where to commit funding.

The fishery five-year plans are to be reviewed and updated annually by the Torres Strait forums to add an additional year onto the end to ensure the plans maintain a five year projection for priority research. Priorities may also change during the review if needed.

Table 1. Research priorities for Torres Strait Hand Collectable Fisheries for 2022/23 – 2026/27.

Proposed Project	Objectives and component tasks	Year project to be carried out and indicative cost						Evaluation	
		2022/23	2023/24	2024/25	2025/26	Notes on project timings	Other funding bodies	Priority essential /desirable	Theme
Black teatfish size sampling and stock assessment update	Design and conduct a black teatfish representative size sampling program during fishery openings in 2022 and 2023. Analyse size frequency data and catch data and update the stock assessment model.	~ $40,000-$80,000				Project needs to commence in 21/22 FY as size sampling needs to be conducted during black teatfish opening in 2022 (subject to PZJA approval)		Essential	1
White teatfish modelling	Stock assessment modelling for white teatfish to support the potential review of the current total allowable catch	~$60,000						Essential	1
Determining conversion ratios for Curryfish species	Undertake field sampling of curryfish species (*Stichopus herrmanni and S. vastus*) to develop conversion ratios for boiled and salted weight to gutted weight.	$12,000				Seeking CSIRO advice as PIs on original proposal whether project can proceed in 22/23 FY.	5,129 (CSIRO in-kind)	Essential	1
Status of BDM stocks in relation to harvest strategy reference points	Determine if there is enough information available to assess the status of sea cucumber stocks in relation to the harvest strategy reference points.		Indicative cost TBA			Scope of project requires further consideration by the HCRAG		Essential	1, 2
Sandfish stock survey	Outstanding stock survey of Sandfish at Warrior Reef to better understand its status.		~$150,000			Subject to support of Iama/Tudu Traditional Owners for the project, to be sought in writing.		Essential	1
Follow up surveys of black and white teatfish	Follow up black and white teatfish surveys focusing on specific areas and potentially including areas not surveyed previously namely the deep water reefs of the South east and Barrier zones of Torres Strait.		~$290,000			To be considered after another black teatfish opening		Desirable	1

Socio-economic	Collection and analysis of socio-economic data for the fishery from interview-based questionnaire surveys of fishers and other stakeholders involved in the fishing industry.					Needs to be informed by AFMA's review of participation data reported in CDRs. to date and by social science expertise Needs further consideration by the HCRAG and HCWG.		Essential	2, 1
Management Strategy Evaluation (MSE) of the Beche-de-mer Harvest Strategy	1. Collate all data and biological information; 2. Update and extend the spatial multispecies TS BDM operating model developed earlier (or construct a new model); 3. Use MSE to evaluate how well the HS achieves the pre-specified objectives; 4. In consultation with stakeholders, use the MSE framework to investigate ways to improve the current HS.			$130k ^[1]		Will require 3-5 years of BDM HS implementation before MSE testing is achievable. However, can be undertaken sooner if external pressure requires (e.g. CITES Appendix II listing)		Essential	1
Supply chain	Better understanding of the supply chains as per other fisheries to better understand vulnerabilities and help develop an industry that is resilient to fluctuating export market conditions.					Yet to be scope and prioritised		Desirable	2
Ecological Risk Assessment (ERA)	Conduct an ERA for the Torres Strait Pearl Shell (TSPF) Fishery					Est cost is ~$20,400 but there is no immediate ecological risk due to low - no fishing activity.	CSIRO (in-kind)	Desirable	1
Understanding biological parameters of BDM species, including growth, mortality, size and breeding seasonality	Identifying gaps in knowledge of biological parameters of BDM species and investigating options for collaborative research					Not costed – to be addressed as the need arises.		Desirable	1

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[1] Advice from CSIRO: Rough costing takes into account time needed to collate all fishery-dependent and fishery-independent data, develop and refine existing operating model and MSE framework, costs of attending at least 2 meetings to consult with stakeholders

Torres Strait Fisheries Strategic Research Plan 2018-2023

TORRES STRAIT
PZJA
PROTECTED ZONE
JOINT AUTHORITY

Australian Government
Australian Fisheries Management Authority

Box 7051, Canberra Business Centre, ACT 2610 / Ph (02) 6225 5555 / Fax (02) 6225 5500 / AFMA Direct 1300 723 621

CONTENTS

Torres Strait Scientific Advisory Committee

The Torres Strait Scientific Advisory Committee (TSSAC) includes members from each of the three main Protected Zone Joint Authority (PZJA) agencies (the Australian Fisheries Management Authority, the Torres Strait Regional Authority and Fisheries Queensland), industry members and scientific research members. TSSAC is responsible for providing advice to the Australian Fisheries Management Authority (AFMA) Executive on the use of AFMA research funds for Torres Strait fisheries research. This Torres Strait research provides critical information to the Minister and the Protected Zone Joint Authority (PZJA) for the management of Torres Strait commercial fisheries.

As part of its role the TSSAC:

- develops research priorities for PZJA fisheries in conjunction with the Resource Assessment Groups (RAGs) (or Management Advisory Committees (MACs) and Working Groups (WG)) and addresses PZJA's management needs and objectives as specified in the *Torres Strait Fisheries Act 1984* (the Act) and this plan;
- reviews and advises (where required) on individual fishery research plans for PZJA managed fisheries;
- advises the AFMA Executive on the allocation of research funds, and provides milestone reports and accounts against the use of funds.
- informs Torres Strait communities of project outcomes.

AFMA provides the TSSAC secretariat duties, including organising meetings and managing research contracts and projects milestones.

The TSSAC relies on the assistance of the various PZJA advisory groups (MACs, RAGs and Working Groups) to develop fishery-specific research plans and priorities based on this Strategic Research Plan (SRP). These groups provide current and up to date scientific and operational advice to the TSSAC as it relates to research proposals and fishery. More information about the advisory groups is provided at section 2.4 below.

The Terms of Reference for the TSSAC is at (Appendix A)

About this plan

This plan specifies the research priorities and strategies that the PZJA intend to pursue in Torres Strait fisheries, and provides background to the processes used to call for, and assess, research proposals.

This SRP has been developed by AFMA in consultation with TSSAC to assist the PZJA to pursue the objectives of the *Torres Strait Fisheries Act 1984* (the Act) through research.

This document sets out the five year strategic plan (2018-2023) for research in Torres Strait fisheries to support a framework for fishery-specific, five-year research plans, and a TSSAC annual research statement.

1. Part one sets out the research planning and priorities, including the current research themes, strategies and possible research activities (Part 1 and Appendix B). It also provides guidance to researchers developing applications for research funding.
2. Part two provides guidance for the TSSAC and PZJA advisory groups when assessing research applications (see Appendix C).

Supporting information for the TSSAC and researchers can be found in appendices and referenced documents, which are useful when developing research applications.

It is intended that the SRP be a living document that responds to a changing environment. In line with this intent, this plan will be reviewed by the TSSAC as needed, but not later than 2022.

Part 1 Research planning and priorities

1.1 Role of five year fishery research plans and link to the TSSAC Strategic Research Plan

The three research themes described in this section are strategic priorities for Torres Strait and provide a basis for advisory forums (RAGs, MACs and working groups) when developing their five-year fishery research plans (see section 2.3.2).

The five year fishery research plans will vary between fisheries depending on the status of the fishery, its information requirements and particular knowledge gaps. Although it is a five year plan, the advisory forums are required to review and update the fishery plan annually so the plan will always have a five year projection.

The TSSAC uses both the strategic priorities in the SRP and the specific priorities within individual fisheries research plans to compile the TSSAC Annual Research Statement (ARS). The ARS is the list of priority research for a given year that researchers will focus on when developing research proposals. The ARS is also the key document for RAGs, MACs and WGs in their prioritisation of research applications for TSSAC funding consideration. All groups including TSSAC and researchers should refer to the 'criteria for assessing research investment' (Appendix C) when developing, assessing and ranking research proposals.

1.2 Torres Strait Fisheries Research Themes, Strategies and Research Activities

The TSSAC has identified three research themes, related strategies and possible research activities (basis for proposals) for the next five years that will help the PZJA to pursue the objectives of the *Torres Strait Fisheries Act 1984* (Appendix A) and improve fisheries management in the Torres Strait.

Researchers are encouraged to use this SRP and the five year fishery plans when considering and planning their proposed research in the Torres Strait, regardless of where they may seek funding. The TSSAC process ensures robust consultation with a broad range of stakeholders regarding funding priorities through the PZJA advisory forums.

Theme 1: Protecting the Torres Strait marine environment for the benefit of Traditional Inhabitants

Aim

Effective management of fishery stocks based on understanding species and their biology and ecological dependencies so it can support Traditional Inhabitant social and economic needs.

Strategy 1a - Fishery stocks, biology and marine environment

Possible research activities under this theme may include:

- Stock assessment and fishery harvest strategies for key commercial species.
- Ecological risk assessments and management strategies for fisheries.
- Minimising marine debris in the Torres Strait.
- Addressing the effects of climate change on Torres Strait fisheries through adaptation pathways for management, the fishing industry and communities.
- Incorporating Traditional Ecological Knowledge into fisheries management.
- Methods for estimating traditional and recreational catch to improve fisheries sustainability.

Strategy 1b – Catch sharing with Papua New Guinea

Possible research activities under this theme may include:

- Status of commercial stocks and catches by all sectors within PNG jurisdiction of the TSPZ.
- Good cross-jurisdictional fisheries management through better monitoring and use of technology.

Theme 2: Social and Economic Benefits

Aim

Increase social and economic benefits to Traditional Inhabitants from Torres Strait Fisheries.

Strategy 2a - Promoting social benefits and economic development in the Torres Strait, including employment opportunities for Traditional Inhabitants

Possible research activities under this theme may include:

- Models for managing/administering Traditional Inhabitant quota
- Understanding what influences participation in commercial fishing by Traditional Inhabitants.
- Understanding the role and contribution of women in fisheries.
- Capacity building for the governance of industry representative bodies
- Methods for valuing social outcomes for participation in Torres Strait fisheries.
- Identifying opportunities and take-up strategies to increase economic benefits from Torres Strait fisheries.

Theme 3: Technology and Innovation

Aim

To have policies and technology that promote economic, environmental and social benefits from the fishing sector.

Strategy 3a – Develop technology to support the management of Torres Strait fisheries.

Possible research activities under this theme may include:

- Electronic reporting and monitoring in the Torres Strait, including for small craft.
- Technologies or systems that support more efficient and effective fisheries management and fishing industry operations.

Part 2 Research management and administration

The PZJA, established under the Act, is responsible for the management of fisheries in the Australian Jurisdiction of the Torres Strait Protected Zone (Figure 1). The PZJA members comprise the Commonwealth and Queensland Ministers responsible for fisheries, and the Chair of the Torres Strait Regional Authority.

Fisheries research findings are critical to the PZJA exercising its functions, and in particular, for monitoring the condition of the Torres Strait fisheries, Good research more broadly assists the PZJA to pursue the legislated objectives. For more information about the PZJA or the PZJA agencies responsible for the day to day management of Torres Strait fisheries see annual reports on the PZJA website (www.pzja.gov.au).

The TSSAC is the only committee that is solely focused on Torres Strait fisheries research, although other committees or agencies (see below) may sometimes fund and manage research projects relevant to Torres Strait fisheries. The different funding sources and management are discussed below.

Research in the Torres Strait comes with a unique set of challenges. The traditional way of life and Torres Strait Island culture are critically important to the communities residing across the many remote islands in the Protected Zone. Consequently, research needs to pay special attention to the social and economic contexts which are unique to the region. This includes consideration of the potential impacts that research may have on Torres Strait communities, both overt through direct interaction with communities and the more subtle emotional or psychological impacts of research activities taking place in and around culturally significant places.

2.1 Research Funding Environment

Torres Strait fisheries operate in a complex management environment with social, economic and cultural objectives being pursued alongside contemporary environmental and fisheries management objectives.

Therefore, the scope of potential fisheries research is necessarily broad. Research ranges from assisting Traditional Inhabitants to pursue their aspirations within local fisheries, undertaking routine science stock assessments and surveys, adaptation to the effects of climate change and ways to improve sustainability of, and economic and social benefits from the Torres Strait fisheries.

2.2 AFMA research funds

The TSSAC primarily funds research through AFMA's annual research contribution (currently at $410 000 annually).

These funds are allocated at the discretion of the AFMA executive, based on recommendations of the TSSAC. The TSSAC considers research proposals based on the priorities set in this SRP and the ARS. When the TSSAC is unable to recommend funding for a project due to funding constraint, it may recommend that researchers go to other funding bodies. Depending on the priority and degree of funding constraint the TSSAC may support the project but ask the researcher to seek co-funding from another body.

Research priorities identified by the TSSAC in its SRP are also intended to implicitly influence other funding agencies in the research they may fund as it relates to Torres Strait fisheries. Equally, the TSSAC should be mindful of research being funded by other bodies, particularly where it may overlap with TSSAC priorities.

It is not possible to meet all Torres Strait research needs through the AFMA funds. Funding constraints are not likely to change and it would be beneficial for the TSSAC to play a greater role in supporting researchers to find other funding opportunities in order to broaden research delivery in the Torres Strait. This could be achieved through improved collaboration among research providers with an interest in the Torres Strait region. AFMA will actively engage in seeking greater collaboration between the TSSAC and other bodies.

2.3 Other funding bodies

Funding for Torres Strait fisheries related projects is sometimes provided by other government agencies or external funding bodies for Torres Strait research. This can take the form of contributions towards AFMA funded TSSAC projects, or be completely funded external to TSSAC and AFMA. In these cases, the funding body will manage the project themselves with little or no TSSAC comment. Information on some of these funding bodies and agencies is provided below. Further information about their role and research programs can be found on the agency websites.

2.3.1 Government Agencies

The Department of Agriculture and Water Resources, along with the Torres Strait Regional Authority and the Queensland Government may provide funding support for certain Torres Strait fisheries projects based on the relevance to their jurisdiction and their current priorities. Sometimes these projects and funds are managed by the TSSAC. TSRA in particular inject significant funds for Torres Strait fisheries research on a regular basis. TSRA funded projects generally have a focus on capacity building and traditional fisheries, or commercial fisheries with an indigenous interest, and generally compliment the TSRA core program work.

2.3.2 The Fisheries Research and Development Corporation (FRDC)

The FRDC is a statutory authority within the portfolio of the Federal Minister for Agriculture and Water Resources, jointly funded by the Australian Government and the commercial fishing The FRDC may fund projects in the Torres Strait if such projects fit within the FRDC's Research, Development and Extension (RD&E) plan. The FRDC uses Commonwealth, State and Territory research advisory committees at to assess and recommend projects for funding in line with the RD&E Plan.

The Indigenous Reference Group (IRG), FRDC

The IRG is the FRDC's Indigenous Fishing sub-program advisory partner. The IRG was established by the FRDC in 2012 to assist in working towards a

RD&E plan for indigenous Australians to improve economic, environmental and social benefits to Australia's indigenous people. The current priorities for the IRG, can be found at the FRDC website (www.frdc.com.au) Some of these priorities are highly relevant to Torres Strait fisheries, including;

- Primacy for Indigenous People
- Acknowledgement of Indigenous Cultural Practices
- Self-determination of indigenous rights to use and manage cultural assets and resources
- Economic development opportunities arising from Indigenous peoples cultural assets and associated rights
- Capacity building opportunities for Indigenous people are enhanced.

Human Dimensions Program, FRDC

The FRDC also has a new Human Dimensions Program, focusing on social-science and economic research related to fisheries. Information on this program can also be found on the FRDC website (www.frdc.com.au).

2.3.4 The Commonwealth Scientific and Industrial Research Organisation (CSIRO)

The CSIRO has a long history of contributing funding support for CSIRO-led Torres Strait research. This generally occurs as a co-funding of project managed through the TSSAC.

2.3.6 Collaboration among research providers

There are both formal and informal links between staff from many of these external funding bodies and agencies that contributes to successful funding of research in the Torres Strait. Improved collaboration among research providers may lead to more efficient use of research funds.

AFMA, as a key funding agency for Torres Strait fisheries research, will consult with external research providers and key research stakeholders in an effort to improve collaboration among these groups and transparency about proposed Torres Strait fisheries research.

2.4 MACs, RAGs and Working Groups

MACs, RAGs and WGs are actively involved in the PZJA's research planning process for the Torres Strait.

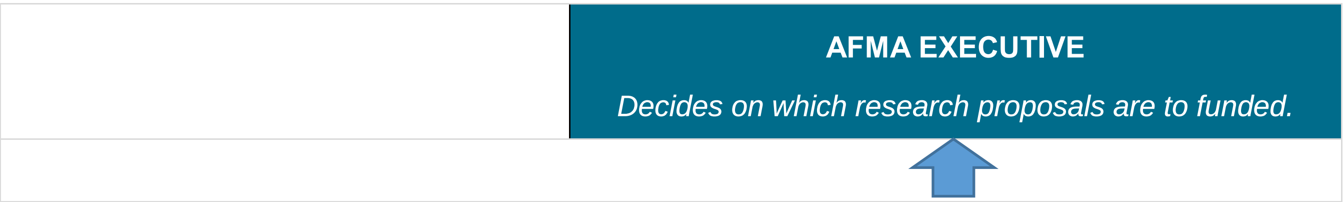
The roles of these different groups are less distinct than in the AFMA Commonwealth fisheries forums, as the working groups and MAC (there is currently only one MAC operating in Torres Strait) have a very similar function. There are now two RAGs within Torres Strait fisheries. Both Torres Prawn MAC and the hand collectible working group also perform RAG functions (primarily scientific advice).

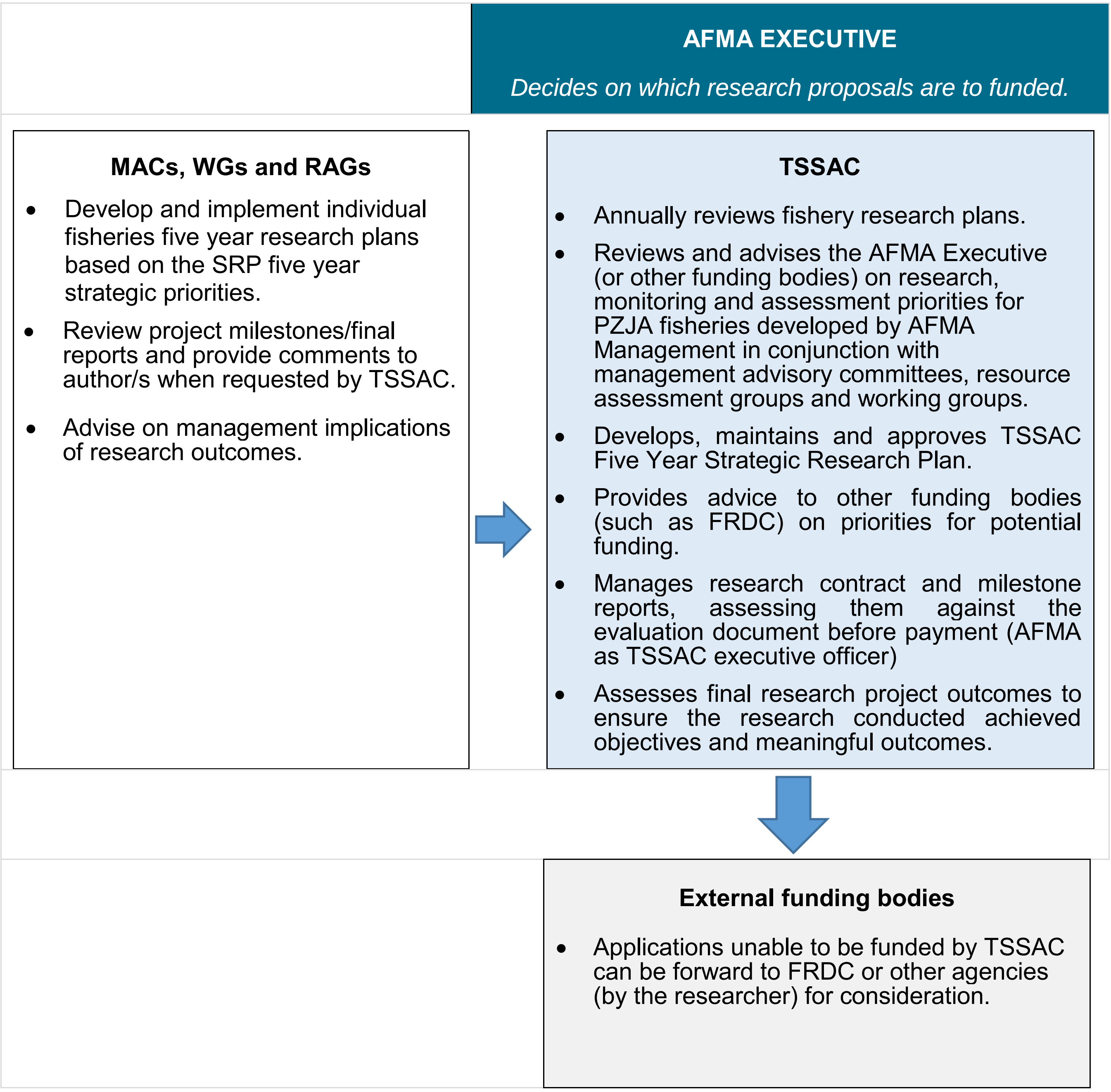
The collective scientific functions of these groups are to review scientific data and information and provide advice to the PZJA on the status of fish stocks, sub-stocks, species (target and non-target species) and the impact of fishing on the marine environment. This advice assists the Minister and PZJA in the role of managing commercial fishing within PZJA fisheries, particularly in relation to monitoring the condition of the Torres Strait fisheries.

The collective management advisory function is to provide advice on fishery-specific management policies and plans to assists the Minister and PZJA in the role of managing commercial fishing across the PZJA fisheries.

In relation to the TSSAC function, each of these groups will lead the preparation of the rolling five year, fishery-specific research plans which are underpinned by the SRP. See Figure 2 below for a map of roles and responsibilities during the TSSAC funding application process.

Figure 2. Roles and responsibilities of key participants in the PZJA's annual research cycle for Torres Strait fisheries





AFMA EXECUTIVE

Decides on which research proposals are to funded.

MACs, WGs and RAGs

- Develop and implement individual fisheries five year research plans based on the SRP five year strategic priorities.
- Review project milestones/final reports and provide comments to author/s when requested by TSSAC.
- Advise on management implications of research outcomes.

TSSAC

- Annually reviews fishery research plans.
- Reviews and advises the AFMA Executive (or other funding bodies) on research, monitoring and assessment priorities for PZJA fisheries developed by AFMA Management in conjunction with management advisory committees, resource assessment groups and working groups.
- Develops, maintains and approves TSSAC Five Year Strategic Research Plan.
- Provides advice to other funding bodies (such as FRDC) on priorities for potential funding.
- Manages research contract and milestone reports, assessing them against the evaluation document before payment (AFMA as TSSAC executive officer)
- Assesses final research project outcomes to ensure the research conducted achieved objectives and meaningful outcomes.

External funding bodies

- Applications unable to be funded by TSSAC can be forward to FRDC or other agencies (by the researcher) for consideration.

2.4 Confidentiality of community fishing data and intellectual property

Data collected during research projects can be regarded as confidential to local communities, or non-indigenous fishers. Confidentiality requirements should be considered for all research projects that may generate intellectual property related to traditional knowledge, or contain data, such as fishing grounds or catch data, of individual communities or fisheries. This data should be treated in the same way as commercial in confidence commercial fishing data. Researchers should consider the types of data they will be collecting, and gain prior agreement from each community or relevant stakeholder/s as to how the data will be used for example. only for decision making or to be published in the public domain.

TSSAC's annual research cycle

Table 1. TSSAC funding Cycle

	TSSAC PROCESS
February	Research providers submit pre-proposals for assessment, which meet the scopes provided by TSSAC in November. EOIs submitted are circulated to fisheries managers/ RAGs & MACs for comment; Fisheries Managers, RAGs/MACs identify any additional research priorities for potential FRDC funding.
March	TSSAC meets via teleconference to assess pre-proposals and Management/RAG/MAC comments. Applicants notified of TSSAC comments on their pre-proposals and asked to develop the consultation package (for review by AFMA by end of March) for use during full proposal development.
April	Researchers to complete full proposal (6 weeks total with consultation period)
May	Late May/ early June. TSSAC meet face to face to review full proposals and endorse final applications, or suggest necessary changes before endorsement. Applicants advised of the TSSAC's final evaluation.
June	
July **(START)**	TSSAC confirm the research budget for the new financial year (it doesn't generally change from year to year - $410 000). New contracts and variations for essential research projects prepared and put in place, confirming forward budgets. RAGs, WGs and MACs to identify THEIR PRIORITY RESEARCH NEEDS for funding in the next financial year by updating their *five year rolling fisheries research plan*. This should be framed around strategies in the 5 year strategic research plan. Provide to TSSAC EO by end August.
August	RAGs/MACs submit their five year rolling fishery research plan to the TSSAC

	Executive Officer, currently lisa.cocking@afma.gov.au, by end August.
September	TSSAC EO drafts the TSSAC Annual Research Statement (ARS) with each fisheries priorities for the current year.
October	TSSAC meets (face to face or via teleconference) to finalise the PZJA ARS and agree on priorities for the TSSACs call for applications in November. AFMA develop scopes for the priority research projects and send to TSSAC out of session for consideration.
November	The annual research call opens in November. Scopes sent to researchers seeking pre-proposals.

Appendix A: TSSAC Terms of Reference

Terms Of Reference

i. Identify and document research gaps, needs and priorities for fisheries in the Torres Strait in conjunction with the PZJA advisory groups.
ii. develop, maintain and approve the Torres Strait Five Year Strategic Research Plan. This includes balancing tactical short term needs and strategic needs to identify research gaps and priorities.
iii. review rolling five (5) year research plans for Torres Strait fisheries
iv. provide advice to the AFMA executive on priorities for the allocation of AFMA research funds and potential risks to achieving intended outcomes.
v. Provide advice on effective consultation strategies with communities regarding research projects to ensure engagement throughout the project.
vi. Consider the level of community support for research proposals and advise researchers on any actions needed to improve community consultation before a project is supported.
vii. ensure research outcomes are communicated to community stakeholders.
viii. provide advice to FRDC or other research providers on Torres Strait research priorities for potential funding consideration.
ix. assess research investment and outcomes for the Torres Strait fisheries to measure the extent to which intended sustainability, social and economic needs are being met.
x. provide a forum for expert consideration of scientific issues referred to the TSSSAC by the Torres Strait advisory groups.
xi. provide other advice to the Torres Strait advisory groups on matters consistent with TSSAC functions.
xii. review research / consultancies, stock assessments, and other reports and outputs relevant to Torres Strait fisheries and advise the Torres Strait advisory groups on their technical merit.
xiii. convene Fisheries Assessment workshops as appropriate to review and address assessment needs for Torres Strait fisheries.

Appendix B: Key factors influencing Torres Strait fisheries research needs

In developing this plan and the drivers for research in the Torres Strait, there are a number of factors which have been taken into account. This includes whole of Government policies and objectives relevant to the Torres Strait. These are explained in some detail below.

The Torres Strait Fisheries Act 1984 (the Act)

The PZJA is created under the Act; the legislation used by the Australian and Queensland Governments when managing Torres Strait fisheries.

The Act makes the PZJA responsible for monitoring the condition of the fisheries under its control and formulating policies and plans for their good management. In performing these functions, the Act requires the PZJA to have regard to the rights and obligations conferred on Australia by the Torres Strait Treaty' (https://www.legislation.gov.au/Details/C2016C00677), and in particular, the following management priorities:

(a) to acknowledge and protect the traditional way of life and livelihood of traditional inhabitants, including their rights in relation to traditional fishing;

(b) to protect and preserve the marine environment and indigenous fauna and flora in and in the vicinity of the Protected Zone;

(c) to adopt conservation measures necessary for the conservation of a species in such a way as to minimise any restrictive effects of the measures on traditional fishing;

(d) to administer the provisions of Part 5 of the Torres Strait Treaty (relating to commercial fisheries) so as not to prejudice the achievement of the purposes of Part 4 of the Torres Strait Treaty in regard to traditional fishing;

(e) to manage commercial fisheries for optimum utilisation;

(f) to share the allowable catch of relevant Protected Zone commercial fisheries with Papua New Guinea in accordance with the Torres Strait Treaty;

(g) to have regard, in developing and implementing licensing policy, to the desirability of promoting economic development in the Torres Strait area and employment opportunities for traditional inhabitants.

Australian Government priorities

The Australian Government has identified priorities for research that are significant in shaping fisheries research effort and its reporting, namely:

- Global trends
- National Research Priorities
- Rural Research and Development Priorities

Global Trends

The five major trends that are expected to influence primary industries globally during the next 20 years, as identified by the Rural Industries Research and Development Corporation in its report *Rural Industry Futures – Megatrends impacting Australian agriculture over the coming twenty years*, include:

A hungrier world: Population growth will drive demand for food and fibre

A bumpier ride: Globalisation, climate change and environmental change will reshape the risk profile for agriculture

A wealthier world: A new middle class will increase food consumption, diversify diets and eat more protein

Transformative technologies: Advances in digital technology, genetic science and synthetics will change the way food and fibre products are made and transported

Choosy customers: Information-empowered customers of the future will have expectations for health, provenance, sustainability and ethics

National RD&E Strategy for Fishing and Aquaculture

The National Fishing and Aquaculture RD&E Strategy 2015-20 provides direction to improve the focus, efficiency and effectiveness of RD&E to support Australia’s fishing and aquaculture industry.

The identified goals and key strategies are:

- Australia's fisheries and aquaculture sectors are managed, and acknowledged, to be ecologically sustainable.
- Security of access and resource allocation.
- Maximising benefits and value from fisheries and aquaculture resources.
- Streamlining governance and regulatory systems.
- Maintain the health of habitats and environments upon which fisheries and aquaculture rely.
- Aquatic animal health, and biosecurity (inclusive of pests) Aquaplan 2015-2019.

FRDC Research Development and Extension Plan 2015-20

The FRDC's RD&E Plan 2015-20[1] is focused on maximising impacts by concentrating on knowledge development around three national priorities:

1. Ensuring that Australian fishing and aquaculture products are sustainable and acknowledged to be so.
2. Improving productivity and profitability of fishing and aquaculture.
3. Developing new and emerging aquaculture growth opportunities.

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[1] http://frdc.com.au/research/Documents/FRDC_RDE-Plan_2015-20.pdf

Appendix C: Criteria for assessing research investment in Torres Strait fisheries

The TSSAC will apply these criteria in assessing and ranking research proposals. Researchers should use the criteria as a guide when developing research applications and RAGs, MACs and WGs should also use these criteria when assessing proposals.

	Strongly disagree -------------------------→ strongly agree											Notes
Attractiveness	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**N/A**	
1. Is there a priority need for the research (does it align with the Torres Strait Strategic Research Plan and Annual Research statement)?												
2. Is/are the end-user/s identified?												
3. Do the outcomes have relevance and are they appropriate to the end-users?												
4. Do the outputs contribute towards outcomes and are they measureable?												
5. Does the proposal actively engage Traditional Inhabitants and Torres Strait Islanders in the research?												
6. Are there employment opportunities for Traditional Inhabitants and Torres Strait Islanders?												
7. Does the research contribute to the knowledge that underpins ecosystem based fisheries management (EBFM) to improve the quality of decisions made?												

8. Does the project involve capacity development for Communities? If so, TSSAC to discuss if there is funding from other agencies such as the IRG or TSRA that could support this project.												
Feasibility												
9. Does the applicant and their team / resources have the capacity to produce the outputs?												
10. Is the budget appropriate to meet the outputs and outcomes?												
11. Does the proposal outline a coherent strategy surrounding data collection, analysis, and storage?												
12. Does the proposal include appropriate plans (for example, adoption, communication and/or commercialisation plans) to ensure that the full potential of the research is realised through adoption of research outputs by end-users?												
13. Are the methods scientifically sound, well described and consistent with the projects objectives?												

14. Research will be most effective when there is effective engagement with fishery stakeholders, particularly Traditional Inhabitants of the Torres Strait, and where the research has widespread stakeholder support (refer to procedural framework for undertaking research in the Torres Strait and the TSSAC research proposal application). Does the project identify the key stakeholders and how they will be engaged regarding the project in a culturally appropriate way?												

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No.2** **27-28 September 2022**
NEW APPLICATION TO UNDERTAKE AQUARIUM FISHING IN THE TORRES STRAIT	**Agenda Item 7** **For NOTING & DISCUSSION**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG):
   a. **CONSIDER** the application from Aus Fish Coral Pty Ltd to undertake aquarium fishing in the Torres Strait (**Attachment 7a**), including a presentation at the HCRAG 2 meeting from Aus Fish Coral Pty Ltd.
   b. **NOTE** that fishing for corals, soft rock and any other species currently covered by a Fisheries Management Plan or Notice is not permitted under this licence.
   c. **NOTE** that the proposed fishing activity is not covered by established arrangements to manage and regulate the sustainable harvest of ornamental and aquarium species. Therefore, licence conditions and management arrangements that are consistent with the objectives of the TSFA and the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) must be developed before fishing activities can commence. This will involve AFMA taking a number of steps including:
      a. developing an application to the Department of Agriculture, Water and the Environment seeking Part 13 and Part13A EPBC Act approval of the activity.
      b. seeking Hand Collectables Resource Assessment and Working Group advice on the requirements that need to be met to ensure the sustainability of the proposed activity, including management, monitoring and reporting arrangements.
      c. undertaking Native Title Notification of the proposed conditions.

   d. **DISCUSS and PROVIDE ADVICE on:**
      a. The level of take of the species proposed to be fished that would be considered sufficiently precautionary in the absence of fishery and/or scientific information to set catch limits.
      b. If (a) above is not possible, a mechanism through which the fishery and/or scientific information required to set sustainable catch limits may be obtained.
      c. data collection and monitoring arrangements for the activity that would support future assessment needs of aquarium and ornamental species harvest in the Torres Strait.

KEY ISSUES

2. In March 2022, AFMA received an application from Aus Fish Coral Pty Ltd seeking to fish for ornamental aquarium species.
3. As there are currently no management arrangements that regulate the targeting of these ornamental aquarium species, it therefore requires the development and implementation of licence conditions and management arrangements that are consistent with the objectives of the *Torres Strait Fisheries Act 1984* (the Act) and the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Agenda Item 7 - Attachment 7a – Aus Fish Coral Pty Ltd application for aquarium fishing in the Torres Strait

Aus Fish Coral Pty Ltd

Torres Strait Fishing Licence 123480

Principle species	Ornamental Clam • Tridacna crocea (length 15cm or less) • Tridacna maxima (length 15cm or less) • Tridacna squamosa (length 15cm or less) • Tridacna derasa (length 15cm or less) Ornamental Shrimp • Lysmata spp • Stenopus spp • Urocaridella sp • Hymenocera picta Ornamental sponge • Trikentrion flabelliforme
Secondary species	Gastropod • Cerithium spp • Nassarius spp Sea Star • Fromia spp • Echinaster spp Sea Urchin • Mespilia spp • Lytechinus spp Feather Star • Class: Crinoidea
Fishing method	• Hookah; diving assisted by surface supply breathing apparatus and hand collection • Free diving; diving with breath hold only and hand collection • The use of handheld implements such as a hammer, chisel, barrier net, dip net
Primary markets	Live ornamental - domestic market Live ornamental – export to Europe, Hong Kong, China, Japan, South Korea, USA
Fishing area	Comprised of tidal waters within the Torres Strait Protected Zone (TSPZ) and the area declared under the TSF Act to be ‘outside but near’

Target Species

The most important species are ornamental clams (tridacna spp) and ornamental shrimp (Lysmata spp and stenopus spp) for example, Lysmata amboinensis, Stenopus hispidus. These species are important for both Australian and export markets.

Area

Torres Strait Protected Zone and the 'Outside but near' areas. Same as the Tropical Rock Lobster Fishery area.

Fishing method

Hookah diving or free-diving with the use of handheld implements. Harvest of clams takes place from 0-7m deep, ornamental shrimp from 0 to 20m deep.

Impact of Harvest

Some information is available from Cocos and Keeling islands about optimal and precautionary harvest rates for Tridacna maxima. The optimal harvest rate of T. maxima for Cocos (Keeling) Islands (total area of 14 square kilometres) is 55,271 individuals per year (see Assessment of the Western Australian Tycraft Giant Clam Wildlife Trade Operation April 2019).

Aus Fish Coral plans to harvest far less than the identified optimal harvest estimate for Cocos (Keeling) Island of T. maxima. The Torres Strait encompasses a far greater area (approximately 40,000 square kilometres). Aus Fish Coral is seeking to harvest a maximum of 5,000 tridacna individuals annually.

Recreational and Traditional Catch

Giant clams (tridacna gigas) are recognised as an important species for traditional fishing. It is proposed that these species are no take.

Bycatch

Highly selective multiple species fishery with no bycatch due to its hand collection fishing methods. Only target species will be harvested.

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No. 2** **27-28 September 2022**
HCRAG PRIORITIES AND DATE FOR THE NEXT MEETING	**Agenda Item 10** **For DISCUSSION & ADVICE**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG):
    a. **DISCUSS** and **PROVIDE ADVICE** on priorities for the RAG together with a work plan for addressing recommended priorities; and

    b. **NOMINATE** a date and a venue for the next meeting.

KEY ISSUES

2. Having agreed priorities (RAG issues to focus on) and a corresponding work plan aims to achieve a more efficient RAG process. At its inaugural meeting on 6-7 October 2021, the RAG agreed to defer the discussion on HCRAG priorities to its next meeting.

3. The RAG may have a standing item at its meetings to discuss assessment, data collection and research needs for Torres Strait Hand Collectables Fisheries. This may be informed by the RAG's meeting discussions, advice from individual members of the RAG and/or advice from the Hand Collectable Working Group (HCWG).

4. Where possible, the RAG should aim to prioritise and set a timeline for any identified items, having regard for resourcing.

5. In considering its priorities, the RAG may wish to note the summary of management priorities identified by the HCWG provided in Table 1 and their progress to date.

6. Having regard for the outcomes of this meeting (including the assessment and management requirements stipulated in the WTO conditions), the RAG may recommend an alternate list of priorities. Table 2 provides a summary of key due dates for the BDM fishery that the RAG may wish to consider in developing its work plan.
7. As far as practical AFMA proposes that a work plan be developed in-session.

8. AFMA proposes the next HCRAG meeting be held in the second half of 2023.

Table 1. Comments relating to any progress against each management priority previously identified by the HCWG. Management priorities are listed chronologically and not in order of importance.

Management Priority			**Progress to date and comments**
1	HCWG9 June 2016	Development of a harvest strategy and recovery plans for overfished species	**Complete.** CSIRO, together with AFMA, the HCWG and broader industry

Management Priority			Progress to date and comments
			stakeholders have developed a Beche-de-mer Harvest Strategy. The BDM Harvest Strategy was endorsed by the PZJA in November 2019 and implemented on 1 January 2020.
2	HCWG9 June 2016	Future management arrangements for Black Teatfish and White Teatfish	**Ongoing.** The TSRA supported PZJA Traditional Inhabitant members to undertake cluster consultations in late 2019 which sought feedback from communities on the use of hookah to fish for white teatfish. Given the strongly divided community views on this matter, the HCWG recommended that it be further discussed at a Malu Lamar led broader industry workshop which was scheduled for April 2020 but did not proceed due to COVID-19 related restrictions. See also management priority #9 **Completed** Fishing for black teatfish occurred on a trial basis during 30 April – 3 May 2021 in accordance with the BDM Harvest Strategy.
3	HCWG9 June 2016	Review the size limits set for the Torres Strait Beche-de-mer Fishery taking into consideration the size limits in place for the Queensland and the Commonwealth Coral Sea Fishery	**Complete.** This work was progressed under the Harvest Strategy project. Proposed changes to minimum size limits of beche-de-mer will be considered by the PZJA as part of the Harvest Strategy.
4	HCWG9 June 2016	Review weight conversion ratios for gutted and dried beche-de-mer species	**Ongoing.** This work was progressed under the Harvest Strategy project. Updates to weight conversion ratios are captured within the new Beche-de-mer Species Identification Guide. CSIRO is continuing to work with industry on understanding weight conversion ratios for curryfish species. A full proposal was developed and allocated funding in 2019/20 but did not proceed due to COVID-19.
5	HCWG9 June 2016	Develop communication materials to assist industry members with the requirements of the new Fish Receiver	**Complete.**

Management Priority			Progress to date and comments
		System being implemented on 1 December 2017 and on current management arrangements and proposed future management priorities for the fishery.	As part of the 2019 Fish Receiver System community visits, AFMA developed some educational material such as fact sheets and and frequently asked questions (FAQs) sheets on the FRS and harvest strategies for industry, as well as consulting on the draft BDM Harvest Strategy. A number of PZJA Traditional Inhabitant (TI) members also accompanied AFMA during the community visits and assisted in communicating the importance and benefits of the FRS. During the TSRA cluster visits in late 2019 and January 2020, PZJA TI members presented on each fishery, including management priorities and the FRS. AFMA and PZJA TI members undertook further community visits in late 2020 – early 2021 leading up to the black teatfish trial opening during which the FRS was also discussed and communication material provided.
6	HCWG13 July 2018	Developing a Beche-de-mer management plan.	**Not progressed.** The development and implementation of the BDM Harvest Strategy and mandatory fish receiver system was progressed as the highest immediate priority. Further consideration by the HCWG on the need on intende purpose of developing a statutory management plan for the BDM Fishery. A key purpose for implementing such a plan is to implement quota (or effort unit) management.
7	HCWG13 July 2018	Continuing education and awareness training with the Fish Receiver System	**Ongoing.** AFMA undertook a round of community visits in April and May 2019 to discuss the Fish Receiver System with industry and communities and AFMA continues to liaise with industry on how to improve reporting through the FRS.
8	HCWG13 July 2018	Improving communication and engagement with industry on current management arrangements and	**Ongoing.** In addition to the comments provided at #5 above, AFMA Thursday Island is continuing to work with the AFMA

Management Priority			Progress to date and comments
		proposed future management priorities for the fishery.	communications team to improve communications on a range of fisheries topics, including segments on Radio 4MW, the PZJA website and a fisheries notice board outside the AFMA Torres Strait office.
9	HCWG14 October 2018	Some industry members expressed support for Malu Lamar to develop their own proposal on the use of hookah to fish for white teatfish and fast track the issue to the PZJA for consideration, separate to the work that the TSRA is undertaking in this regard.	**Ongoing.** AFMA stands ready to consider Malu Lamar's proposal and will work with Malu Lamar to undertake further industry consultation, and/or workshops similar to that undertaken in the lead up to the trial opening of black teatfish in 2021. See also management priority #2
10	HCWG15 August 2019	AFMA to arrange a half/full day future management priorities workshop in conjunction with the next Hand Collectables Working Group meeting. Participants to the meeting should include HCWG members, other industry stakeholders including factory processors and/or buyers, and should also include discussions on pearl shell and trochus fisheries.	**Ongoing.** The highest priority for 2020-21 was the trial opening of black teatfish which occurred on 30 April – 3 May 2021. AFMA will continue to work with the HCWG and industry to progress discussions on future management priorities for Hand Collectables Fisheries. AFMA considers this a high priority.
11	HCWG18 October 2021	The HCWG **recommended:** • that the assessment and development of management options for the utilisation of white teatfish is a high short-medium term priority for the fishery requesting AFMA consider directing resources towards this management activity. • an industry workshop be held to enable industry to develop its preferred management options for the utilisation of white teatfish, while acknowledging the need for AFMA's assessment of the administrative feasibility of the preferred management option(s).	**Ongoing.** An industry workshop was scheduled for 15-17 February 2022 to discuss: • the timing for future black teatfish openings – 2022 and beyond. • management options for the utilisation of white teatfish • strategic management priorities for the Torres Strait Beche-de-mer Fishery (time permitting) It had to be postponed due to the COVID-19 situation in the Torres Strait Region at the time and the advice from Queensland Health and the Torres Strait Shire and Regional Councils for businesses and agencies to: • consider returning to work-from-home arrangements, where practical. • reconsider non-essential travel into, within and out of the region

Management Priority			Progress to date and comments
			to help reduce chances of further COVID-19 cases and transmission in the Torres Strait; and • refrain from hosting large gatherings and community consultations. AFMA was still able to progress a black teatfish opening in 2022 and will continue to work with the HCWG and industry to progress discussions on management options for the utilisation of white teatfish.

Table 2. Key dates for the TS BDM Fishery in 2023.

Key date	Activity
1 January 2023	Start of the BDM fishing season
January 2023 (date TBA)	PZJA January meeting
February 2023	Industry workshop and consultation regarding the timing for future black teatfish openings and management options for the utilisation of white teatfish
April/May 2023 (very tentative)	Black teatfish opening (subject to PZJA approval and industry advice on opening time/date)
September 2023 (date TBA)	RAG/WG advice on TACs for the 2024 fishing season and annual and five-year research priorities.
1 November 2023	New application due to the Department of Environment for the assessment of the Torres Strait Beche-de-mer Fishery for ongoing export accreditation, including a revised population estimate for Black Teatfish (*Holothuria whitmaei*) and White Teatfish (*Holothuria fuscogilva*) in the Torres Strait that is based on new information for the fishery, including catch data and fishery-independent data or scientific expert advice and an assessment of the impact of harvest on the stocks. https://www.legislation.gov.au/Details/F2021N00177

TORRES STRAIT HAND COLLECTABLES RESOURCE ASSESSMENT GROUP	**Meeting No. 2** **27-28 September 2022**
OTHER BUSINESS	**Agenda Item 9** **For DISCUSSION**

RECOMMENDATIONS

1. That the Resource Assessment Group (RAG):

   a. **NOTE** a presentation from the Torres Strait Regional Authority titled "Balancing the Dimensions of Sustainable BDM Fisheries Management".

   b. **NOMINATE** any further business for discussion.