26th MEETING OF THE PZJA TORRES STRAIT TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG 26)

Tuesday 5 February 2019 (9:00 AM – 5:00 PM)

Rydges Plaza Cairns (Corner Grafton & Spence Streets, Cairns)

DRAFT AGENDA

1 PRELIMINARIES

1.1 Welcome and apologies
The Chair will welcome members and observers to the 26th meeting of the RAG.

1.2 Adoption of agenda
The RAG will be invited to adopt the draft agenda.

1.3 Declaration of interests
Members and observers will be invited to declare any real or potential conflicts of interest 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 RAG will be invited to note the status of action items arising from previous meetings.

1.5 Out-of-session correspondence
The RAG will be invited to note out of session correspondence on RAG matters since the previous meeting.

2 UPDATES FROM MEMBERS

2.1 Industry members
Industry members and observers will be invited to provide an update on matters concerning the Torres Strait TRL Fishery.

2.2 Scientific members
Scientific members and observers will be invited to provide an update on matters concerning the Torres Strait TRL Fishery.

2.3 Government agencies
The RAG will be invited to note updates from AFMA, TSRA and QDAF on matters concerning the Torres Strait TRL Fishery.

2.4 PNG National Fisheries Authority
The RAG will be invited to note an update from the PNG National Fisheries Authority.

2.5 Native Title

The RAG will be invited to note an update from Malu Lamar (Torres Strait Islander) Corporation RNTBC.

3 CATCH SUMMARY FOR THE 2018/19 FISHING SEASON

The RAG will be invited to note TRL Fishery catch data for the 2018/19 fishing season to date.

4 FINAL STOCK ASSESSMENT AND RECOMMENDED BIOLOGICAL CATCH

The RAG will be invited to consider the final results of the integrated stock assessment. A final recommended biological catch (RBC) for the 2018/19 fishing season will be provided based on the integrated stock assessment.

5 RAG DATA SUB-GROUP MEETING

The RAG will consider arrangements for the upcoming data sub-group meeting.

6 TERMS OF REFERENCE FOR PEER REVIEW OF SURVEY DESIGN

The RAG will be invited to consider draft terms of reference for an independent peer review of the Torres Strait TRL Fishery survey design.

7 RESEARCH PRE-PROPOSALS FOR 2019/20

The RAG will be invited to consider relevant research pre-proposals for funding in 2019/20, submitted in response to the 2019 call for research.

8 OTHER BUSINESS

The RAG will be invited to raise other business for consideration.

9 DATE AND VENUE FOR NEXT MEETING

The RAG will be invited to discuss a suitable date for the next meeting.

The Chair must approve the attendance of all observers at the meeting. Individuals wishing to attend the meeting as an observer must contact the Executive Officer – Natalie Couchman (natalie.couchman@afma.gov.au)

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
PRELIMINARIES **Welcome and apologies**	**Agenda Item 1.1** **For Information**

RECOMMENDATIONS

1. That the RAG **NOTE**:
    a. an opening prayer;
    b. an acknowledgement of Traditional Owners;
    c. the Chair's welcome address;
    d. the welcome for new members, James Ahmat (Industry Member and Traditional Inhabitant Maluialgal) and James Billy (Industry Member and Traditional Inhabitant Kulkalgal); and
    e. apologies received from members unable to attend.

BACKGROUND

2. Apologies have been received from:
    a. Danielle Stewart (QDAF Member);
    b. Harry Nona (Industry Member and Traditional Inhabitant Kaiwalagal);
    c. Aaron Tom (Industry Member and Traditional Inhabitant Gudumalulgal); and
    d. Jerry Stephen (TSRA Deputy Chair, TSRA Member for Ugar and TSRA Portfolio Member for Fisheries).

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	**MEETING 26** **5 February 2019**
PRELIMINARIES **Adoption of agenda**	**Agenda Item 1.2** **For Decision**

RECOMMENDATIONS

1. That the RAG consider and **ADOPT** the agenda.

BACKGROUND

2. A draft agenda was circulated to members on Friday 18 January 2019. No comments were received.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
PRELIMINARIES Declaration of interests	Agenda Item 1.3 For Decision

RECOMMENDATIONS

1. That RAG members and observers:
   a. **DECLARE** all real or potential conflicts of interest in the Torres Strait Rock Lobster Fishery at the commencement of the meeting (**Attachments 1.3a** and **1.3b**);
   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 RAG regarding the management of conflicts of interest; and
   d. **NOTE** that the record of the meeting must record the fact of any disclosure, and the determination of the RAG 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 (**Attachment 1.3c**).
3. RAG members are asked to confirm the standing list of declared interests (**Attachments 1.3a** and **1.3b**) is accurate and provide an update to be tabled if it is not.
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.

TRLRAG Declarations of Interest from most recent meetings

Name	Position	Declaration of interest
Members		
Dr Ian Knuckey	Chair	Chair / Director of Fishwell Consulting Pty Ltd and Olrac Australia (electronic logbooks). Chair / member of other RAGs and MACs. Conducts various AFMA and FRDC funded research projects including FRDC Indigenous Capacity Building project. Nil interests in TRL Fishery and no research projects in the Torres Strait. May deliver components of upcoming induction program for new Traditional Inhabitant members on PZJA advisory committees. Full declaration of interests provided at **Attachment 1.3b**.
Selina Stoute	AFMA Member	Nil.
Allison Runck	TSRA Member	Nil. TSRA holds multiple TVH TRL fishing licences on behalf of Torres Strait Communities but does not benefit from them.
Danielle Stewart	QDAF Member	Not applicable, will not be in attendance.
Dr Eva Plaganyi	Scientific Member	Lead scientist for PZJA funded TRL research projects conducted by CSIRO.
Dr Andrew Penney	Independent Scientific Member	Research consultant (Pisces Australis), member of other AFMA RAGs (SPFRAG and SESSFRAG). Nil pecuniary or research interests in the Torres Strait.
Aaron Tom	Industry Member	Not applicable, will not be in attendance.
Les Pitt	Industry Member	Traditional Inhabitant Kemer Kemer Meriam and TIB licence holder.
Harry Nona	Industry Member	Not applicable, will not be in attendance.
James Ahmat	Industry Member	New member, to be advised.
James Billy	Industry Member	New member, to be advised.
Daniel Takai	Industry Member	Pearl Island Seafoods, Tanala Seafoods, TIB licence holder and lessee of TSRA TVH licence in 2017/18 fishing season.
Brett Arlidge	Industry Member	General Manager MG Kailis Pty Ltd. MG Kailis Pty Ltd is a holder of 5 TVH licences.
Dr Ray Moore	Industry Member	Industry representative, Torres Strait Master Fisherman licence holder and East Coast TRL Fishery licence holder

Natalie Couchman	Executive Officer	Nil.

Observers		
Joseph Posu	PNG National Fisheries Authority (NFA)	Nil.
Robert Campbell	CSIRO	Nil pecuniary interests. Project staff for PZJA funded TRL research projects.
Charles Edwards	CSIRO	Project staff for PZJA funded TRL research projects conducted by CSIRO.
Jerry Stephen	TSRA Deputy Chair, TSRA Member for Ugar and TSRA Portfolio Member for Fisheries	Not applicable, will not be in attendance.

Declaration of interests
Dr Ian Knuckey – October 2018

Positions:

Director –	Fishwell Consulting Pty Ltd
Director –	Olrac Australia (Electronic logbooks)
Deputy Chair –	Victorian Marine and Coastal Council
Chair / Director –	Australian Seafood Co-products & ASCo Fertilisers (seafood waste)
Chair –	Northern Prawn Fishery Resource Assessment Group
Chair –	Tropical Rock Lobster Resource Assessment Group
Chair –	Victorian Rock Lobster and Giant Crab Assessment Group
Scientific Member –	Northern Prawn Management Advisory Committee
Scientific Member –	SESSF Shark Resource Assessment Group
Scientific Member –	Great Australian Bight Resource Assessment Group
Scientific Member –	Gulf of St Vincents Prawn Fishery Management Advisory Committee
Scientific participant –	SEMAC, SERAG

Current projects:

AFMA 2018/08	Bass Strait Scallop Fishery Survey – 2018 and 2019
FRDC 2017/069	Indigenous Capacity Building
FRDC 2017/122	Review of fishery resource access and allocation arrangements
FRDC 2016/146	Understanding declining indicators in the SESSF
FRDC 2016/116	5-year RD&E Plan for NT fisheries and aquaculture
AFMA 2017/0807	Great Australian Bight Trawl Survey – 2018
Traffic Project	Shark Product Traceability
FRDC 2018/077	Implementation Workshop re declining indicators in the SESSF
FRDC 2018/021	Development and evaluation of SESSF multi-species harvest strategies
AFMA 2017/0803	Analysis of Shark Fishery E-Monitoring data
AFMA 2016/0809	Improved targeting of arrow squid

10

PROTECTED ZONE JOINT AUTHORITY

FISHERIES MANAGEMENT PAPER No. 1

(PZJA FMP No.1)

MANAGEMENT ADVISORY COMMITTEES, SCIENTIFIC ADVISORY COMMITTEES, WORKING GROUPS AND RESOURCE ASSESSMENT GROUPS

MAY 2008

Prepared by the Australian Fisheries Management Authority
on behalf of the Protected Zone Joint Authority

CONTENTS

LIST OF ATTACHMENTS

1. ACRONYMNS/DEFINITIONS

For the purposes of this document:

AFMA	Australian Fisheries Management Authority
DAFF	Department of Agriculture, Fisheries and Forestry
EO	Executive Officer
FMP	Fisheries Management Paper
MAC	Management Advisory Committee
PNG	Papua New Guinea
PZJA	Protected Zone Joint Authority
QDPI&F	Queensland Department of Primary Industries and Fisheries
RAG	Resource Assessment Group (including Stock Assessment Group, species Assessment Group or any scientific group).
SAC	Scientific Advisory Committee
TSFMAC	Torres Strait Fisheries Management Advisory Committee
TSPMAC	Torres Strait Prawn Management Advisory Committee
TSPZ	Torres Strait Protected Zone
TSRA	Torres Strait Regional Authority
WG	Working Group

2. PURPOSE

This Fisheries Management Paper sets out the Torres Strait Projected Zone Joint Authority's (PZJA) policy for the operation and administration of Management Advisory Committees (MACs), Scientific Advisory Committees (SACs), Working Groups (WGs) and Resource Assessment Groups (RAGs) or other associated consultative groups.

This paper also outlines key decision making processes associated with the delivery of advice in the pursuit of the Protected Zone Joint Authority's (PZJA) legislative objectives. This includes the interactive processes, respective roles and responsibilities between the PZJA, MACs, SACs, WGs and RAGs.

3. INTRODUCTION

Sections 40(7-8) of the *Torres Strait Fisheries Act 1984* (the Act) provide for the establishment of advisory committees "….to provide information and advice to the Protected Zone Joint Authority on scientific, economic and technical matters related to any fishery."

In the Australian area of jurisdiction, traditional fishing and the commercial fisheries are managed by the Torres Strait Protected Zone Joint Authority (PZJA). The PZJA, established under the *Torres Strait Fisheries Act 1984* (the Act), comprises the Federal and State (Queensland) Ministers responsible for fisheries, and the Chair of the Torres Strait Regional Authority (TSRA). The PZJA is responsible for managing fisheries in the Torres Strait Protected Zone (TSPZ). The PZJA has delegated day-to-day management of the fisheries to the Australian Fisheries Management Authority (AFMA) and compliance and licensing in the fisheries to the Queensland Department of Primary Industries and Fisheries (QDPI&F) under a cost sharing arrangement. Five of the fisheries currently being managed are known as Article 22 fisheries and are jointly managed by PNG and Australia. The two countries share the catches of Article 22 commercial fisheries according to formulae set out in the Torres Strait Treaty.

The PZJA agencies include AFMA, the Queensland Department of Primary Industries and Fisheries (QDPI&F), the Torres Strait Regional Authority (TSRA) and the Department of Agriculture, Fisheries and Forestry (DAFF). Recreational fishing is still managed under Queensland law.

The PZJA is responsible for monitoring the condition of the designated fisheries and for the formulation of policies and plans for their management. The PZJA has regard to the rights and obligations conferred on Australia by the Torres Strait Treaty, in particular the protection of the traditional way of life and livelihood of the traditional inhabitants, including their traditional fishing.

4. CONSULTATIVE STRUCTURE

The consultative structure for Torres Strait fisheries incorporates Australian Traditional Inhabitant commercial and traditional fishers, non-Traditional Inhabitant commercial fishers, Australian and Queensland Government officials, and technical experts.

The PZJA may be advised by Management Advisory Committees (MAC), Scientific Advisory Committees (SAC), and Resource Assessment Groups (RAG) on issues associated with TSPZ fisheries (Figure 1).

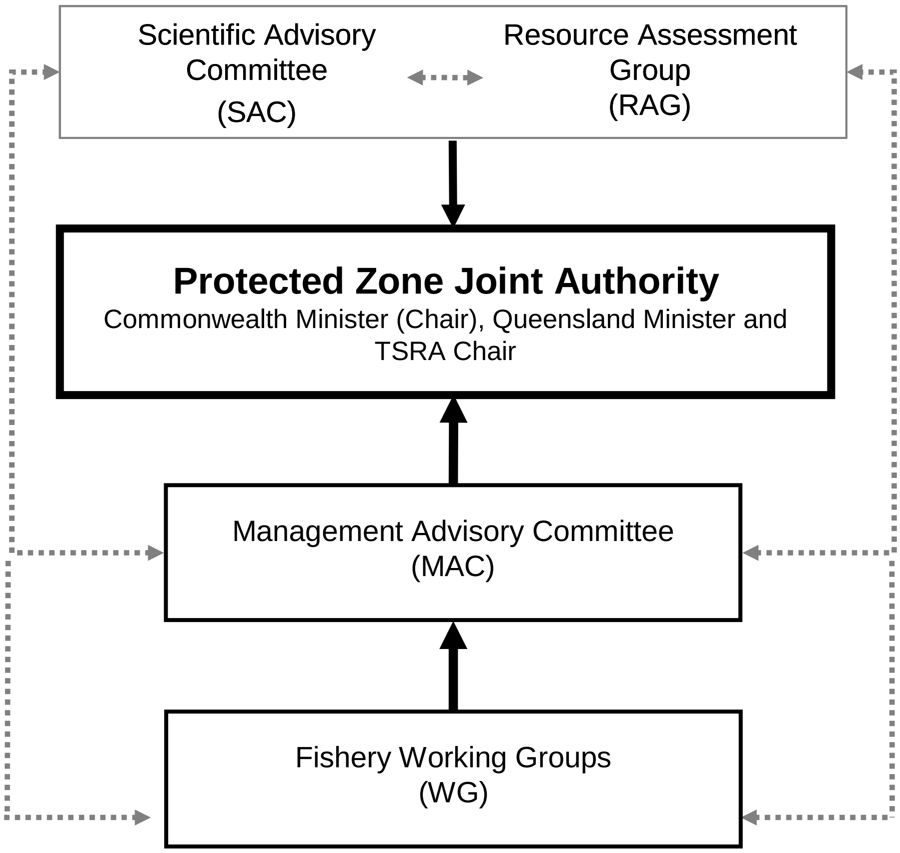

Figure 1. The consultative structure of the Torres Strait Protected Zone Joint Authority (PZJA). Solid lines and dashed lines indicate primary and secondary lines of communication respectively.

Consultation and communication can be difficult across all islands of the Torres Strait, but are important elements in the effective management of the region's fisheries. The consultative committees are, therefore, complemented by meetings between fisheries officers and fishermen in communities around the Torres Strait. These meetings are occasionally supplemented by fisheries programs broadcast on Radio Torres Strait and articles/advertisements in the Torres News.

While the Committee’s and Groups outlined in Figure 1 are the main means of the PZJA obtaining advice and information, it is not the only means. The PZJA may seek advice and views from others with relevant expertise or interest. This includes PZJA Agencies, other government agencies, independent consultants, operators in fisheries more broadly and representatives of the broader community.

Key principles that should be observed in relation to the respective committees/groups within the PZJAs decision-making framework are:

i. All committees/groups are advisory rather than decision-making;
ii. Committees/groups should provide expert advice that best pursues PZJAs legislative and policy objectives;
iii. The PZJA seeks, through its consultative processes, to obtain best quality information and advice;
iv. The PZJA will make decisions based on the best advice (and information) available at the time;
v. Committees/groups should have defined roles and there should be minimum overlap in responsibilities; and
vi. Advice and reporting should be a transparent and open process.

4.1 Role and functions of a Management Advisory Committee (MAC)

Management Advisory Committees (MAC) are the principal source of advice for the PZJA on fishery-specific management issues in all Torres Strait fisheries. A MAC and its working group/s have specific functions that support the decision making process.

A MAC advises the PZJA on fishery objectives, strategies, reference points, risk profiles and management arrangements for achieving fishery-specific goals. For the PZJA to be able to make decisions based upon MAC advice, the PZJA has to be confident that a MAC has put in place rigorous processes to determine the best package of measures in pursuit of the PZJA’s objectives. Good governance and business efficiency demand that the PZJA is normally able to approve MAC advice without delving into MAC business details, or needing to seek clarification from a MAC.

The role of a MAC is to advise the PZJA on management issues for the fisheries managed under the Act. It provides the forum where issues relating to the fisheries are discussed, problems identified and possible solutions developed. The outcome of these deliberations determines the recommendations a MAC will make to the PZJA concerning the management of relevant fisheries.

All MAC members must be aware of the PZJAs legislative objectives and functions (as contained in Attachment A) and of the continuing need to take these into account in their deliberations.

4.2 Role and functions of a Scientific Advisory Committee (SAC)

A Scientific Advisory Committee's (SAC) main role is to advise the PZJA on the strategic directions, priorities and funding for research relevant to meeting information needs and objectives of the PZJA and its relevant consultative bodies.

The committee normally provides a review process for research conducted by research providers to ensure that milestones are met and that the research outcomes represent good value for money. The committee may also be called upon to make its own assessments of fisheries data and comment on stock assessment advice. The committee may also solicit external review when the questions asked fall outside the committee's area of expertise.

A SAC may also provide advice to the MACs, WGs, and RAGs on scientific and research issues in the Torres Strait Protected Zone (TSPZ).

4.3 Role and functions of Working Groups (WG)

To assist in the operations of a MAC, Working Groups (WG) have been established to provide advice on particular matters relevant to individual fisheries. The task of a WG is to discuss, negotiate and debate issues relevant to individual fisheries. In order to be manageable and cost effective, WGs will be no larger than is necessary to ensure the appropriate blend of knowledge and expertise is available to provide the required advice to a MAC.

Ordinarily the WGs deal with the fishery specific issues, including the specification of management objectives, research priorities for the particular fishery, management issues and strategies, and compliance issues. In addition to these tasks the WGs deal with a range of ad hoc issues. These are reported to a MAC and/or SAC as appropriate.

4.4 Role and functions of a Resource Assessment Group (RAG)

The main role of Resource Assessment Groups (RAG) is to provide advice on the status of fish stocks, sub-stocks, species (target and non-target species) and on the impact of fishing on the marine environment. Advice provided by a RAG should address biological, economic and wider ecological factors impacting on the fishery.

RAGs should also evaluate alternative harvest options proposed by the relevant fishery WG and/or MAC. This includes advising on the impact over time of different harvest strategies (for example, the time required for a particular fish stock to reach a reference point), stock depletion or recovery rates, the confidence levels of the fishery assessments, and risks to the attainment of approved fishery objectives.

A RAG reports to the PZJA. It also informs relevant SACs, MACs or WGs of work on stock assessments in progress or potential issues, but is not restricted by them. This ensures that the potential conflict of interest generated by the assessment roles of RAGs and the management advisory roles of other consultative bodies does not impact on the quality of advice provided to the PZJA. A MAC (including its WGs) and associated RAG are likely to have some common membership, therefore it is essential that members' roles be recognised and differentiated by the respective chairs.

5. TERMS OF REFERENCE

5.1 Management Advisory Committees and Working Groups

The following terms of reference are to be utilised by Management Advisory Committees (MAC) and Working Groups (WG) as operating guidelines.

1. To provide a forum for the discussion of matters relevant to the management of Torres Strait fisheries and to act as a medium for the flow of information between all stakeholders;
2. To provide advice and make recommendations to the PZJA (in the case of a MAC) or MAC (in the case of a WG) with respect to:
   i. the management of the fishery;
   ii. the development of fishery management plans;
   iii. ongoing measures required to manage the fishery in accordance with the provisions of management plans; and
   iv. amendments to management plans as required;
3. To provide advice and make recommendations to the PZJA (in the case of a MAC) or MAC (in the case of a WG) on research priorities and projects for the fishery. MACs and WGs are to ensure that processes are in place for industry and other interested stakeholders to receive advice from researchers in a form that will be easily understood by the audience;
4. To establish sub-committees as required ensuring that the range of management issues is given proper attention;
5. To liaise with PZJA Agency staff and provide assistance as necessary to ensure approved management measures are implemented; and
6. To undertake additional functions on behalf of the PZJA as determined by the Authority.

5.2 Scientific Advisory Committee (SAC)

The following terms of reference are to be utilised by a Scientific Advisory Committee (SAC) as operating guidelines.

1. Identify and document research gaps, needs and priorities for fisheries in the Torres Strait;
2. Provide a forum for expert consideration of scientific issues referred to the SAC by a MAC;
3. Provide a forum for detailed consideration of scientific issues raised by WGs and relevant stakeholder representative bodies and advise WGs and relevant stakeholders on the feasibility and merits of suggested research;
4. Develop and update a strategic plan for Torres Strait Fisheries research;
5. Solicit and review research proposals in line with the strategic plan and recommend proposals for implementation to the AFMA Research Committee (ARC) and/or other relevant funding organisations;
6. Provide other advice to the MACs on matters consistent with SAC functions;
7. Review research / consultancies, stock assessments, and other reports and outputs relevant to Torres Strait fisheries and advise the appropriate MAC and WG, on their technical merit;
8. Advise the MACs and WGs on the management implications identified by the research projects or the SACs own assessment of fisheries data;
9. Convene Fisheries Assessment workshops as appropriate to review and address assessment needs for Torres Strait fisheries and recommend research priorities for future assessments;

10. Provide advice to research providers and the MACs on appropriate mechanisms and protocols for engaging research providers in the Torres Strait fisheries;
11. Provide advice on effective delivery of research results to stakeholders; and
12. Provide advice on a range of issues including stock assessment advice.

5.3 Resource Assessment Groups (RAG)

A Resource Assessment Groups' (RAG) Terms-of-Reference (TOR) should be tailored according to their specific fishery requirements. However, general TOR for RAGs are:

1. Analyse, assess, and report on the fishery status against agreed reference points, including target and non-target stocks, impacts on the marine environment from fishing, and the economic efficiency with which stocks are fished;
2. Identify improvements and refinements to assessment methodology;
3. Evaluate alternative harvest strategies or TAC settings. This includes providing advice on confidence limits or risk levels associated with particular management/harvest strategies;
4. Assist the relevant MAC and/or the WG to develop, test, and refine sustainability reference points and performance indicators for the fishery. Advise on stock status and trends relative to these reference points and indicators;
5. Identify and document fishery assessment and monitoring gaps, needs and priorities. These should be communicated to the SAC so that they can be incorporated in the Torres Strait strategic research plan;
6. Provide advice and recommendations to the SAC on issues consistent with RAG functions;
7. Facilitate peer review of assessment outputs;
8. Facilitate/drive a collaborative stock assessment with adjacent jurisdictions;
9. Maintain awareness of current issues by promoting close links with the MACs, SACs and any other Torres Strait RAGs; and
10. Liaise with other researchers, experts and key industry members.

6. Cost Recovery

Under the existing Australian Government cost-recovery policy, MACs and their subcommittees (WGs) are funded largely by industry levies as their functions are attributable to industry as the principal beneficiary.

In Torres Strait, only the costs of the prawn fishery are attributed to Industry and recovered at the present time. It should be noted however that the PZJA agreed in principle that cost recovery should extend to other Torres Strait fisheries in line with AFMAs Cost Recovery Impact Statement (CRIS). A policy on the cost recovery is being developed for the PZJAs consideration.

7. OPERATIONAL GUIDELINES

7.1 Membership Composition

The PZJA or delegate has final responsibility for determining the actual membership of MACs, SACs, WGs and RAGs and will consider membership in relation to the needs of the Torres Strait Fisheries.

7.1.1 Management Advisory Committee (MAC)

The minimum requirements for MAC membership are as follows:

- 1 x Chair;
- 1 x Executive Officer;
- 2 x Staff members from AFMA;
- 2 x Staff members from QDPI&F;
- 1 x Scientific member;
- 6 x Traditional Inhabitant members*;
- 5 x Non-Traditional Inhabitant Industry members#;
- 1 x TSRA support member.

* The exact number of Traditional Inhabitant members may vary for each MAC as determined by the PZJA or delegate depending upon the needs of the fisheries (e.g. TSFMAC = 6 rotational from 24 communities; TSPMAC = 3).

The composition of Non-Traditional Inhabitant Industry Members may vary for each MAC as determined by the PZJA or delegate depending upon the needs of the fisheries covered by the MAC (e.g. TSFMAC = 4 x Fishing licence holders, 1 x Industry processor; TSPMAC = 4 x Fishing licence holders, 1 x Industry processor).

7.1.2 Scientific Advisory Committee (SAC)

In view of the special circumstances of the Torres Strait, especially in relation to the multiple jurisdictional arrangements for management and the provisions for economic development favouring Torres Strait Islanders in the Torres Strait Treaty (1985) and the Torres Strait Fisheries Act (1984), the Torres Strait Scientific Advisory Committee (SAC) should reflect a balance between stakeholder representation and research expertise. The SAC might be expected to have a greater representative function than other AFMA Scientific Committees. Accordingly, minimum requirements for a SAC membership are as follows:

- 1 x Chair;
- 1 x Executive Officer;
- 1 x Staff member from AFMA;
- 1 x Staff member from QDPI&F;
- 4x Scientists*;
- 1 x Independent industry member;
- 1 x Community Fisher Representative nominated by the TSRA;
- 1 x Papua New Guinea Representative.

*The exact number of Scientific members may vary for each SAC as determined by the PZJA or delegate depending upon the needs of the committee.

Other experts included on a register of experts maintained by AFMA may be called to attend specific SAC meetings based on their specific areas of expertise as required.

7.1.3 Working Group (WG)

The minimum requirements for WG membership are as follows:

- 1 x Chair;
- 1 x Executive Officer;
- 1 x Staff member from AFMA;
- 1 x Staff member from QDPI&F;

- 1 x Scientific member;
- 6 x Traditional fishing members*;
- 3 x Non-Traditional Inhabitant Industry members#;
- 1 x TSRA support member.

* The exact number of Traditional Inhabitant members may vary for each WG as determined by the PZJA or delegate depending upon the needs of the fishery.

The composition of Non-Traditional Inhabitant Industry Members may vary for each WG as determined by the PZJA or delegate depending upon the needs of the fishery.

7.1.4 Resource Assessment Group (RAG)

A stock assessment that engenders a strong management response may bring the RAG into conflict with sectors of industry or attract political attention. Therefore, members of the RAG must be credible, expert and impartial in undertaking their assessments.

The minimum requirements for RAG membership are as follows:
- 1 x Chair;
- 1 x Executive Officer;
- 1 x Staff member from AFMA;
- 1 x Staff member from QDPI&F;
- 1 x Traditional fishing member;
- 1 x Non-Traditional Inhabitant Industry member;
- 1 x Scientific member;
- 1 x Independent Scientific member;
- 1 x Conservation member;
- 1 x PNG NFA member;
- 1 x TSRA support member.

7.2 Term of appointment

The PZJA or delegate makes all appointments to MACs, SAC, WGs and RAGs, with Members generally appointed for terms of up to three years. In order to ensure continuity, Members will not normally be appointed for a period of less than two years. Subsequent re-appointment may be permitted.

8. Responsibilities and obligations of Members

8.1 Responsibilities of Members

Being appointed to a PZJA consultative committee or group brings with it a number of important responsibilities. Specifically, members must be prepared to meet the following requirements:
- they must be able to put views clearly and concisely and be prepared to negotiate to achieve acceptable outcomes and compromises where necessary;
- they must act in the best interests of the fisheries as a whole, rather than as an advocate for any particular organisation, interest group or regional concern;
- they must be prepared to observe confidentiality and exercise tact and discretion when dealing with sensitive issues;

- they must contribute to discussion in an objective and impartial manner and avoid pursuing personal agendas or self-interest;
- they must be prepared to make the necessary commitment of time to ensure that they are fully across matters which are the subject of consideration by the committee;
- Industry Members must not have commercial interests in the same company as other members on the same MAC, SAC, WG or RAG;
- Industry members must have the wider industry's confidence and authority to undertake their functions as a MAC, SAC, WG or RAG member. They must also be prepared to consult with members of industry through port-level associations, regional associations and peak industry bodies as necessary; and
- Traditional inhabitant members must have the community's confidence and authority to undertake their functions as a MAC, SAC, WG or RAG member. They must also be prepared to consult with members of community through local associations and meetings as necessary.

8.2 Reaching consensus

A co-operative approach to MAC, SAC, WG and RAG discussions is essential. While this does not mean that there won't be disagreements from time to time, it does mean that agreement is ultimately to be reached through reasoned discussion, consultation and negotiation having regard to what is best for the fishery.

A MAC, SAC, WG or RAG should reach agreement through consensus and not use voting as a mechanism for achieving outcomes. Where agreement cannot be reached, members are encouraged to reconsider the issue and seek further information if necessary before making their recommendation. If a deadlock cannot be avoided, the views of members and general discussion should be well documented in the minutes of the meeting and highlighted in recommendations that are put before the PZJA (in the case of a MAC, RAG or the SAC) or MAC (in the case of a WG). MACs and WGs are the best means to achieve agreement on management issues. Ownership of the formal process by its members is vital to successful fisheries management.

8.3 Disclosure of interests

8.3.1 Types of interests

MAC, SAC, WG and RAG members are appointed to provide input based on their knowledge and expertise and as a consequence, it is inevitable that members may face potential or direct conflicts of interest. There may be a conflict of interest where a member:

- has a material personal interest, including a direct or indirect financial or economic interest, in a matter being considered, or about to be considered, by the MAC, SAC, WG or RAG; and
- the interest could conflict with the proper performance of the member's duties in relation to the consideration of the matter.

There may often be a level of general conflict simply because members come from areas of the industry that may be affected as a result of a recommendation. For example, industry members may be participants in the fishery, TSRA members may represent the geographical region under discussion or scientific members may face a conflict related to a research proposal. To assist in identifying areas of potential conflict, a MAC, SAC, WG or RAG may consider it appropriate to maintain registers of members' interests that could possibly lead to conflicts.

Of greater concern is the specific conflict created where a member is in a position to derive direct benefit from a MAC, SAC, WG or RAG recommendation if it is subsequently implemented. In either case, members should recognise the potential for conflict to occur and its possible impact on the operations of the Committee/Group.

8.3.2 Declaring an interest

When a MAC, SAC, WG or RAG member recognises that a real or potential conflict of interest exists, the conflict must be disclosed as soon as possible to other members. Where this relates to an issue on the agenda of a meeting this disclosure can normally wait until that meeting, but where the conflict relates to decisions already made, members must be informed immediately. If there is any doubt, a specific conflict of interest and its nature should be declared and recognised in the discussions of the meeting and recorded in the minutes of the meeting.

8.3.3 Dealing with an interest

To facilitate the smooth operation of meetings, it is suggested that conflicts of interest are dealt with at the start of each meeting. Members receive agenda and associated papers prior to the meeting and should be able to make disclosures of potential conflicts of interest and their nature (including, for example, the type and quantity of fishing concessions held by industry members) at the commencement of meetings.

Where it is determined that a direct conflict of interest exists, the MAC, SAC, WG or RAG may allow the member to continue to participate in the discussions relating to the matter but not in any decision making process. The member or the Committee/Group may also determine that, having made his/her contribution to the discussions, the member should retire from the meeting for the remainder of discussions on that issue.
As a guide, members with a direct conflict of interest should only be excluded from decision making if the matter being considered only affects the individual member rather than all persons involved in the fishery.

Finally, the Chair must ensure that the minutes of the meeting show the disclosure of interest, reflect the meeting's subsequent decision(s) and demonstrate that these are put into effect at the appropriate point in the meeting. If members become aware of a potential conflict of interest during the course of the meeting, they must immediately disclose the conflict of interest and the members present must consider how best to deal with the disclosure at that point.

8.4 Other Obligations of Members

Members must:

- act in good faith in the best interests of the PZJA;
- act honestly and exercise a reasonable degree of care and diligence in the discharge of their duties; and
- not make improper use of inside information to gain an advantage for themselves or someone else or cause harm to the Authority or to another person.

Members must not use their position, or information obtained as a member of a MAC, SAC, WG or RAG, dishonestly or with the intention of directly or indirectly gaining an advantage for themselves or someone else, or with the intention of causing harm to the PZJA or to another person.

8.5 Personal and professional behaviour

MAC, SAC, WG or RAG members should perform all duties associated with their positions diligently, impartially, conscientiously, in a civil manner and to the best of their ability.

In the performance of their duties they should:

- act in such a way, at meetings, in the field and at official functions that will be held in a high regard by the community and by industry;
- treat other members and stakeholders with courtesy and sensitivity; and
- not take, or seek to take, improper advantage of official information gained in the course of their membership.

8.5.1 Fairness and equity

MAC, SAC, WG and RAG members are not permitted to discriminate against or harass any colleague, client or member of the public, particularly on the basis of:

- Race;
- Religion;
- Gender;
- Political or union affiliation;
- Sexual preference;
- Political opinion;
- Marital status;
- Pregnancy;
- Social origin;
- Criminal record;
- Age; or
- Physical, intellectual or mental disability or impairment.

Behaviour, which is shown to be discriminatory, or which constitutes harassment will not be tolerated and may result in the members' appointment to MACs, SACs, WGs and/or RAGs being terminated by the PZJA or delegate.

8.5.2 Public comment

Public comment includes public speaking engagements, comments on radio and television and expressing views in letters to newspapers or in books, journals or notices or where it might be expected that the publication or circulation of the comment would spread to the community at large.

Whilst MAC, SAC, WG and RAG members, as members of the community, have the right to make public comment and to enter into public debate on political and social issues, there are some circumstances in which public comment is inappropriate. These circumstances would be where there is an implication that the public comment, although made in a private capacity, is in some way an official comment of a MAC, SAC, WG or RAG. Members should avoid making private statements about matters relating to a MAC, SAC, WG or RAG unless it is made clear that they are speaking as a private citizen.

9. Confidentiality and Non-Disclosure

9.1 General

Material made available to Members is generally public information. In some instances, members will have access to information that is confidential; however members will be advised accordingly. Members must not publish or communicate to any unauthorised person any fact or document which comes to their knowledge, or possession by virtue of being a MAC, SAC, WG or RAG member.

9.2 Resource Assessment Groups (RAG)

Members of RAGs may sometimes require access to confidential fishery catch and effort data and will have access to draft reports, materials or working papers that are unready or not intended for wider circulation.

The Chair should warn members when matters of a confidential nature are tabled, and ensure that discussion documents are not used for any purpose not related to the business of the RAG. Exceptions should only occur with the written consent of the RAG Chair. However, all members are obliged to maintain standards of confidentiality and non-disclosure relating to data. Note that industry members, non-government organisation personnel (NGO), and other fishery stakeholders may not be given access to confidential data.

Scientific members who are custodians of data for the purposes of analyses must apply best practice to ensure security, confidentiality, and non-disclosure of the data. This includes prevention of loss, theft, corruption and unapproved duplication. Data received from AFMA for the purposes analyses will be subject to the conditions set forth in the contract between the research provider and AFMA. Similar arrangements may exist between other data providers and research providers using data provided by the other party.

It is the responsibility of the Chair to ensure that data contained in all public documents, assessment reports or other publications is aggregated sufficiently to preserve commercial confidentiality and privacy.

10. Role and appointment procedures for Members

On behalf of the PZJA, AFMA administers the overall appointment process. The PZJA or delegate, however, makes the appointments. Nominations for Members are sought from both individuals and associations.

10.1 The Chair

10.1.1 Role

The Chair of a MAC, SAC, WG or RAG plays a key role in ensuring effective and thorough discussion of factors affecting the performance of a particular fishery (e.g. implementation of ecological sustainable development factors, and impacts of management strategies on, the particular fishery) and is the primary communication link between the MAC/SAC/WG/RAG and the PZJA. Accordingly, the Chair must:

- Be independent of commercial or other interests with the particular fishery/fisheries, including industry association(s);

- Have a demonstrated capacity to chair meetings, including a sound understanding of the meeting procedures and practices necessary for the efficient conduct of meetings (including the rules of debate);
- Have an ability to identify strategic goals and objectives and facilitate their achievement through the MAC, SAC, WG or RAG process;
- Have a demonstrated capacity to communicate clearly and concisely to a wide cross-section of people, particularly with respect to acting as the MAC, SAC, WG or RAG spokesperson and representing MAC, SAC, WG or RAG views to the PZJA, industry, Government, the media and the general community in a balanced and rational manner;
- have an understanding of industry and public policy;
- preferably, have some fisheries (or resource management) experience; and
- not be a staff member of the PZJA Agencies, although this is allowed for SACs, WGs and RAGs.

An explanation of the procedural matters relating to the conduct of MAC, SAC, WG and RAG meetings, including the requirement to give notice of a meeting and to circulate papers, is provided at Attachment C.

The roles and responsibilities of a Chair include:

- Ensuring members are aware of their responsibilities under this PZJA FMP No. 1;
- Ensuring members remain aware of and consider the PZJAs legislative objectives in the deliberations of the MAC, SAC, WG or RAG;
- Ensure the timely availability of agenda papers before meetings and the preparation and circulation of minutes and Chair's Summaries after meetings;
- Formally communicating meeting outcomes, recommendations and matters for information to the PZJA (in the case of a MAC, RAG or SAC Chair) or to a MAC (in the case of the WG Chairs) for consideration and to the industry for information. In undertaking this function, the Chair will be assisted by the Executive Officer;
- Summarising outcomes for each agenda item at the end of the discussion for each item and at the end of the meeting. This will assist in the reporting of the outcomes after each meeting;
- Ensuring that meeting minutes, letters and other correspondence to the PZJA Chair (in the case of a MAC, RAG or SAC) or a MAC Chair (in the case of a WG) clearly and accurately describe MAC, SAC, WG or RAG recommendations and alternative options when an agreed position has not been reached; and
- Ensuring that minutes and other material arising from meeting deliberations clearly and accurately describe MAC, SAC, WG or RAG recommendations, including dissenting views where they are expressed.

Chairs are not to allow members who are absent from meetings to have separate notes or views attached to minutes. Absentee members may convey views in writing to the MAC, SAC, WG or RAG prior to the meeting.

10.1.2 Selection/Appointment Procedure

Whenever there is a vacancy in the office of MAC, SAC, WG or RAG Chair, whether created by the resignation of an existing Chair or the expiration of the term of appointment of an existing Chair, a shortlist of nominees considered to have the necessary attributes to fill the vacant position may be drawn from applications for the position or from a *Register of Interest maintained by AFMA*. A selection panel including representatives from the PZJA Agencies will review the nominee's relevant skills and experience and may interview nominees before candidates are submitted to the PZJA or delegate for consideration and approval.

On behalf of the PZJA, AFMA maintains a *Register of Interest* of suitably qualified persons interested in being appointed to the position of Chair of a MAC, SAC, WG or RAG. From time to time AFMA may advertise nationally for nominations to this Register.

10.1.3 Acting Chair

The PZJA or delegate may appoint a person to act as the Chair of a MAC, SAC, WG or RAG during:
- a vacancy in the office of Chair (whether or not an appointment has previously been made to the office); or
- any period, when the Chair is absent from duty or from Australia or is, for any other reason, unable to perform the duties of the office.

A person appointed to act during a vacancy must not continue to do so for more than 12 months.

10.2 Protected Zone Joint Authority (PZJA) Agency Members

10.2.1 Roles
The role of an AFMA and QDPI&F member of a MAC, SAC, WG or RAG is to:
- participate in general discussion;
- contribute fisheries management expertise to deliberations;
- provide advice on relevant Government policy and the process required for policy development and change;
- ensure that the MAC, SAC, WG or RAG is aware of, and fully understands, PZJA policy and obligations under its governing legislation; and
- seek and provide additional information on Government policy as necessary.

The views expressed and the policies advocated by AFMA and QDPI&F members are to be considered those of their relevant organisations.

The role of the TSRA member of a MAC, SAC, WG or RAG is to:
- assist and support the traditional inhabitant members and provide fisheries expertise.

10.2.2 Selection/Appointment Procedure
AFMA, QDPI&F and TSRA will nominate officers to a MAC, SAC, RAG and WG at the organisations' discretion.

10.3 Industry Members

10.3.1 Role
The role of an industry member of a MAC, SAC, WG or RAG is to:
- contribute knowledge and experience relevant to the particular fishery and the fishing industry generally;
- contribute fisheries expertise to achieve the best management of the fishery; and
- regularly report to and liaise with other operators in the fishery on the MAC, SAC, WG or RAG activities, including the issues being dealt with and the possible solutions being considered.

10.3.2 Selection/Appointment Procedure
The PZJA considers the selection of the industry members to a MAC, SAC, WG or RAG to be critical to the success of the Committee/Group. These individuals must have

the capacity to put views clearly and concisely and be prepared to negotiate to achieve acceptable compromises when necessary. Industry members should not have commercial interests in the same company as another member/s of the same committee or group. Above all, they must have credibility within the industry and the ability to address issues with the best interests of the fisheries in mind.

Industry members will normally be appointed through the following process:

- all operators in the fishery will be invited to nominate for consideration for appointment as a MAC, SAC, WG or RAG industry member. Relevant industry organisations will also be informed to allow them to canvass within their membership for nominations;
- interested operators will be required to complete a nomination form which is included with the invitation to nominate. This form sets out the nominee's personal details and provides space for nominees to outline the particular skills and expertise they can bring to the MAC, SAC, WG or RAG. Industry organisations can provide statements of support to individuals who nominate themselves; and
- an Assessment and Ranking Panel (the Panel) will be formed to consider nominations and make recommendations to the PZJA or delegate. The Panel will usually comprise the MAC, SAC, WG or RAG Chair, PZJA agency representatives and an industry member of standing in the fishery. The Executive Officer of the MAC, SAC, WG or RAG will act as secretariat to the Panel.

To facilitate the short listing process, the Panel may interview potential appointees, either in person or by telephone. Where candidates are well known to agencies and in the interests of cost-effectiveness, the requirement to conduct interviews may be waived.

The PZJA or delegate will determine industry member appointments on the advice of the Panel.

In considering each nomination, the Panel assesses whether the applicant is a fit and proper person for the purposes of MAC, SAC, WG or RAG membership. If the Panel identifies any issue that is likely to adversely effect:

- the applicant's ability to perform his/her role as an industry member;
- the PZJAs credibility; or
- the applicant's credibility with industry or other stakeholders.

The Panel may advise the PZJA or delegate that the applicant is unsuitable for appointment to the MAC, SAC, WG or RAG. The Panel may also consider that an applicant is not a fit and proper person if the applicant has been convicted of a fisheries offence and if the Panel believes that the conviction may compromise either the PZJA, or the applicant's credibility, or the applicant's ability to perform his/her duties as a member of a MAC, SAC, WG or RAG.

While the PZJA or delegate may consult with industry organisations in the selection of industry members, once appointed, industry members are required to act in accordance with the duties and obligations of MAC, SAC, WG and RAG members as set out in this paper. This means their contribution must be in the best interests of the fishery, rather than as an advocate of the industry sector that nominated them. Industry members are not representatives of particular sectors or interest groups.

10.4 Scientific Member

10.4.1 Role

A Scientific member of a MAC, SAC, WG or RAG should be independent of commercial interests in the fishery. The role of the scientific member is to:

- contribute impartial scientific and/or economic expertise to MAC, SAC, WG or RAG deliberations; and
- provide advice to the MAC, SAC, WG or RAG on the latest scientific or economic developments of relevance to the fishery.

10.4.2 Selection/Appointment Procedure

The scientific member will be appointed on the basis of his/her scientific or economic qualifications, experience and expertise, knowledge of the fishery and the species being managed and therefore must:

- be a person of seniority and standing in the scientific community;
- have experience in liaising with the major Commonwealth and State fisheries research organisations at the highest level; and
- not have, or be employed by an entity with or representing entities with, commercial interests in the fishery.

Scientific members will normally be appointed through the following process:

- relevant research agencies will be invited to submit nominations for membership on a MAC, SAC, WG or RAG. Nominations may also be sought from appropriate individuals; or
- Calls for applications for the position as scientific members on the TSSAC will be advertise nationally by AFMA.

A selection panel that may include the MAC or Working Group Chair will review and may interview applicants from a shortlist of candidates prior to submission of a preferred candidate to the PZJA Board for consideration and approval.
The PZJA or delegate will determine scientific member appointments after considering nominations and any other information sought or obtained in relation to the nomination.

10.5 Traditional Inhabitant Members

10.5.1 Role

The role of the Traditional Inhabitant Members and traditional fishing representatives is to:

- contribute knowledge of fisheries and communities to a MAC, SAC, WG or RAG;
- contribute fisheries expertise to achieve the best management of the fishery;
- regularly report to and liaise with other traditional inhabitants in the community on MAC, SAC, WG or RAG activities, including the issues being dealt with and the possible solutions being considered; and
- consult with members of community through local associations and meetings as necessary.

10.5.2 Selection/Appointment Procedure

The TSRA runs an open process to seek members for their community fishers group. Accordingly nomination traditional inhabitant members and the TSRA support member will be sought from the TSRA. AFMA as the agency administering the MACs, SACs, WGs and RAGs appointment process will liaise with the TSRA when member appointments are required.

10.6 Conservation Member - Optional

The PZJA or delegate may appoint a conservation member to a MAC, SAC, WG or RAG if appropriate.

10.6.1 Role
The role of the conservation member is to:

- Contribute ecological knowledge and expertise to MAC, SAC, WG or RAG deliberations;
- Advise the MAC, SAC, WG or RAG on environmental or conservation developments of relevance to the particular fishery; and
- Advise on any implications that MAC, SAC, WG or RAG deliberations and recommendations may have in relation to ecological considerations.

10.6.2 Selection/Appointment procedure
Appointment of conservation members will be done by the PZJA or delegate. Conservation members will be selected on the basis of their ability to fulfill the role outlined above.

Conservation members are not appointed as representatives of a particular sector/s or interest group/s and, once appointed, must act in the best interest of the fishery.

10.7 Other Members

According to the changing needs of the Torres Strait Fisheries, the PZJA or delegate may appoint other persons to a MAC, SAC, WG or RAG as a member, including persons from the general community. On appointment, these members will have the same rights, and be subject to the same obligations and responsibilities, as other members as set out in this FMP.

11. Termination or resignation – Chair and Members

11.1 Termination of appointment

The PZJA or delegate may terminate the appointment of the Chair or any other MAC, SAC, WG or RAG member for:

- misbehaviour or physical or mental incapacity;
- misconduct or non-performance; or
- inefficiency or incompetence.

Misconduct includes, non-observance of confidentiality (e.g. disclosure of data, results or other materials prior to an agreement to circulate, conflict of interest, misleading or misinforming, and making fraudulent travel or expense claims).

Non-performance includes excessive unexplained absences from meetings, repeated non-performance of assigned tasks or failure to participate in discussions in an objective, impartial and constructive manner.

The PZJA has determined that any action by a Chair or member that demonstrates unwillingness or inability to comply with their obligations and responsibilities may constitute misbehaviour and/or inefficiency. As such, non-compliance with the obligations and responsibilities as outlined in this FMP are grounds for termination of appointment.

In addition, any action by a member which results in his/her conviction for a fisheries or related offence during the term of his/her appointment may be considered as misbehaviour and could constitute grounds for termination of appointment.

Appointment may also be terminated if:
- the Chair or member becomes bankrupt, applies to take the benefit of any law for the relief of bankrupt or insolvent debtors, compounds with his/her creditors of makes an assignment of his or her remuneration for their benefit; or
- the Chair or member has a direct or indirect pecuniary interest in a matter being considered, or about to be considered, and the interest could conflict with the proper performance of the member's duties in relation to consideration of the matter, and he/she fails to disclose the nature of the interest at a meeting of a MAC SAC, WG or RAG; or
- the Chair is absent, except with the leave of the PZJA, from two consecutive meetings of a MAC, SAC, WG or RAG; or
- a Member is absent, except with the leave of the Chair, from two consecutive meetings of a MAC, SAC, WG or RAG.

Termination of appointment under this section will take effect when:
- the member has been warned by the MAC, SAC, WG or RAG Chair, or the PZJA Chair in a case of MAC, SAC, WG or RAG Chair non-compliance, that:
  - they have not complied with one or more of their obligations or responsibilities, and
  - the non-compliance is unacceptable, and
- the PZJA Chair or delegate is satisfied the member has a case to answer of non-compliance with their obligations or responsibilities warranting termination of appointment; and
- the PZJA Chair or delegate has asked the member in writing to show cause why their appointment should not be terminated; and
- after at least 14 days have elapsed, the PZJA or delegate has considered the matter, including any response by the member, and made a decision on the member's continuation in their position.

Cancellation of membership may be appealed. The PZJA or delegate will consider any appeals. These appeals must be addressed to the PZJA Chair and lodged, in writing, within 21 days after receiving notice to stand down.

11.2 Resignation

11.2.1 Chair
A Chair may resign from a MAC, SAC, WG or RAG before the term of his/her appointment has expired by forwarding a signed notice of resignation to the PZJA Chair or delegate with a copy to the relevant Executive Officer (EO).

11.2.2 Members
A member may resign from the MAC, SAC, WG or RAG before the term of his/her appointment has expired by forwarding a signed notice of resignation to the MAC, SAC, WG or RAG Chair with a copy to the relevant EO.

12. Other participants

12.1 Permanent Observers

The PZJA or delegate may also appoint other persons who can be expected to make a meaningful contribution to a MAC, SAC, WG or RAG as a permanent observer. Permanent observers are required to participate in discussions in accordance with the obligations and responsibilities set out under this FMP.

Appointment of permanent observers is generally viewed as a transitionary phase which might be prompted by a requirement for additional expertise and balance which cannot be accommodated within the existing MAC, SAC, WG or RAG due to limitations on the number of members. Accordingly, the PZJAs preferred approach is that there be a general move towards appointing permanent observers as full members where appropriate.

As with members, the contribution of permanent observers to the MAC, SAC, WG or RAG discussions and deliberations will be recorded in the minutes of the meeting. While permanent observer contributions will be recorded in the minutes, in the unlikely event that consensus in the MAC, SAC, WG or RAG cannot be reached, only members' views will be included in recommendations put before the PZJA.

The appointment processes for permanent observers will generally mirror those undertaken for MAC, SAC, WG or RAG members – nominations will be sought in the same way as for members and proposed permanent observers will be required to complete a declaration form before being appointed to the MAC, SAC, WG or RAG. There is nothing to prevent the appointment of a permanent observer covering an area of interest for which a member has been appointed.

As for MAC, SAC, WG and RAG members, a permanent observer may resign from the MAC, SAC, WG or RAG before the term of his/her appointment has expired. A resigning permanent observer must give signed notice of resignation to the PZJA Chair or delegate with a copy to the MAC, SAC, WG or RAG Chair. The appointment of a permanent observer may be terminated on the same grounds as any other member.

12.2 Casual Observers

Casual observers are generally welcome to attend MAC, SAC, WG and RAG meetings. Individuals should seek the agreement of the MAC, SAC, WG or RAG Chair to attend a meeting as a casual observer for a particular agenda item or items – either to provide additional advice and expertise which may be required for that meeting or to observe the proceedings of the MAC, SAC, WG or RAG. This is done via contacting the MAC, SAC, WG or RAG Executive Officer.

Attendance by casual observers is to be on the basis that the presence of the casual observer does not inhibit or disrupt formal members from freely contributing to discussions and decisions. Casual observers must follow any directions made by the MAC, SAC, WG or RAG Chair.

Casual Observers are not formally appointed to a MAC, SAC, WG or RAG and do not participate in the decision-making processes.

Papua New Guinea representatives may be granted observer status on any Torres Strait MAC, SAC, WG or RAG. This is an important opportunity to engage PNG in the management of these stocks.

13. Executive Officers (EO)

13.1 Role of Executive Officers

The role of the Executive Officer (EO) is to provide all the necessary secretariat services to ensure smooth operation of a MAC, SAC, WG or RAG. In performing this role, the EO liaises with, and reports to the MAC, SAC, WG or RAG Chair.

13.2 Duties of Executive Officers

While there may be some variation in the duties undertaken by external and internal Executive Officers (EO), in consultation with the Chair they are generally responsible for:

- making arrangements (including booking venues and catering) for meetings of the MAC, SAC, WG or RAG;
- preparing and circulating meeting notices, agendas and agenda papers to members, ensuring a final agenda and papers are provided to the Chair and members at least **10 working days** prior to all meetings of the MAC, SAC, WG or RAG;
- ensuring a Chair's Summary of the MAC, SAC, WG or RAG meeting is prepared and cleared within **five working days** following the meeting;
- ensuring the Chair's Summary is made available to all operators and others with an interest in Torres Strait fisheries (or in the case of a WG or RAG the relevant individual Torres Strait fishery) as soon as practicable following the MAC, SAC, WG or RAG meeting but no later than **10 working days** after the meeting;
- preparing the draft minutes and action sheets from each meeting and submitting them to the Chair for comment and approval within **14 working days** and distributing them to members within **21 working days** after the meeting;
- maintaining files, correspondence lists and follow-up action arising lists relating to the MAC, SAC, WG or RAG business; and
- ensuring that there is positive two way communication between the MAC, SAC, WG or RAG and the participants in the fishery/fisheries and that decisions or recommendations made by the MAC, SAC, WG or RAG and the reasons for them, are well publicised.

In addition, the EO is available to the MAC, SAC, WG or RAG as a resource to conduct research and investigations into matters affecting Torres Strait fisheries. These may, or may not, be directly related to the management of the fisheries. The EO may also be required to undertake surveys of operators in the fishery so that the MAC, SAC, WG or RAG has a better understanding of industry views on major issues under consideration.

The duties of the EO will be determined in consultation with the MAC, SAC, WG or RAG Chair and in the case of an external EO, will be specified in the relevant employment contract or letter or appointment.

13.3 Selection/Appointment Procedure

The Executive Officer (EO) is appointed by AFMA on behalf of the PZJA, not by the MAC, SAC, WG or RAG. An EO may be either internal or external to the PZJA Agencies.

An EO will generally be a person who is involved in the management of the particular fishery and who will undertake the EO role as part of his/her normal duties as a PZJA Agency employee.

14. Meetings

The procedures to be followed for MAC, SAC, WG and RAG meetings are set out in Attachment C.

15. Communication

15.1 General Communication and Liaison Issues

The Chair and members of a MAC, SAC, WG or RAG are expected to develop effective two way communication with the PZJA and any individuals or organisations that have an interest or are engaged in Torres Strait Fisheries, including PZJA Agencies.

The MAC, SAC, WG and RAG Chair and EO carry the major responsibility for communicating with industry and ensuring the flow of information between industry and the PZJA. However the PZJA and Agencies also have a role to play in the communication process.

15.2 Publication and distribution of MAC, SAC, WG and RAG papers

All MAC, SAC, WG and RAG papers are considered to be public documents unless they contain items of specific commercial confidentiality. As such, the PZJA has agreed that MAC, SAC, WG and RAG agendas, agenda papers (other than commercial-in-confidence) and Chair's Summaries should be made available to all stakeholders to facilitate the flow of information between the PZJA, MACs, SACs, WGs and RAGs and those with an interest in Torres Strait Fisheries.

The preferred means for making such information available is via the PZJA website, rather than providing printed copies of papers to individual fishing concession holders or other stakeholders. In accordance with the Government's Online Strategy, it is the PZJAs intention to publish MAC, SAC, WG and RAG papers on the website at the same time they are printed and made available in hard copy. This will mean that papers will be available on the website before they are considered at the MAC, SAC, WG or RAG meeting.

15.3 Reporting

All MAC, SAC, WG and RAG members are responsible for regularly reporting to their stakeholders on MAC, SAC, WG and RAG activities, the issues and possible solutions under consideration. The MAC, SAC, WG and RAG Chair's Summary report of meetings is available to assist in this process.

The PZJA expects the MACs, SACs and RAGs to keep it informed about what is happening in Torres Strait fisheries, to develop views on issues affecting the fishery and to recommend changes to make management of the fishery more effective. In making recommendations directly to the PZJA, multiple recommendations from MACs, RAGs and SACs are acceptable for particular issues if considered necessary.

In turn, MACs, RAGs and SACs can expect the PZJA to communicate its decisions and the reasons for them to a MAC, RAG or SAC through the PZJA and MAC, RAG and SAC Chairs.

It is expected that each consultative committee or group report discussions through meeting reports, technical working papers and/or fishery assessment reports. The reporting process should not become onerous and should attempt to balance the reporting costs with the benefits achieved through the process.

i. Meeting reports are minutes or the record of a meeting;
ii. Technical working papers are reports tabled and considered during meetings. These are important resources that underpin an overall assessment of the fishery. Technical working papers may not become public documents, but do need to be retained and archived. These documents should be series numbered identifying the Committee or Assessment Group involved, the year produced and the meeting when they were considered. Copies must be provided to the relevant Committee Secretariat for lodgement in the AFMA research library; and
iii. Assessment reports are PZJA publications that are produced annually or periodically, and provide an assessment of the fishery. These assessment reports should generally adopt a standard reporting format for fishery assessment reports. The reports should carry an AFMA and PZJA logo, be series numbered and be made available for public circulation to stakeholders. Copies must be provided to the relevant Committee Secretariat for lodgement in the AFMA research library.

15.3.1 Chair's summary

The PZJA expects the Chair's of a MAC, RAG and SAC to provide it with a formal report (MAC, RAG or SAC Chair's Summary) after each MAC, RAG and SAC meeting. The Chairs of WGs are required to submit a similar report to the relevant MAC Chair.

It is important that the Chair summarises outcomes for each agenda item after the discussion on that item has concluded and at the end of the meeting to aid in reporting outcomes after meetings. The Chair is to be diligent in ensuring that meeting minutes, letters and other correspondence to the PZJA, MAC, RAG or SAC Chair, clearly and accurately describe MAC, SAC, WG or RAG recommendations and alternative options when an agreed position has not been reached.

15.3.2 Self Assessment

All MACs, SACs, WGs and RAGs are to conduct a self-assessment of their performance at least once a year against the following performance indicators set by the PZJA, reporting the outcome to the PZJA:

1. The performance of the MAC, SAC, WG or RAG as a forum for the discussion of matters relevant to the management of the fishery;

2. Ability of the MAC, SAC, WG or RAG to provide advice and make recommendations to the PZJA (or MAC) as appropriate with respect to the management of the fishery;
3. Ability of the MAC, SAC, WG or RAG to provide advice and make recommendations to the PZJA (or MAC) as appropriate on research priorities and projects for Torres Strait fisheries;
4. Standard of liaison by MACs, RAGs or SACs with the PZJA, or by WGs with MACs to ensure that the range of management issues is given the proper attention;
5. Quality of meeting papers;
6. Quality of Chair's performance;
7. Quality of Executive Officer's support services;
8. Quality of PZJA Agency Members' performance;
9. Level of confidence that the MACs, RAGs or SACs views and recommendations are conveyed effectively to the PZJA, or that WGs views are conveyed to MACs; and
10. Rating the dynamics of the MAC, SAC, WG or RAG when in session over the last year.

16. Financial Management

16.1 Fishery Budgets

All MACs and WGs will be asked to provide comment on the draft annual budget for the fishery for consideration by the PZJA.

The draft budget will show the cost of managing Torres Strait fisheries, including surveillance, logbook collection and processing and general administration costs. It will also include the cost of MAC meetings and other specific activities or projects that have been commissioned by MACs.

Comments received from MACs and WGs will be considered by the PZJA Agencies. Once approved by the Agencies, the budget will be used by the PZJA as the basis for determining levies payable by those in the fisheries.

16.2 Annual work planning and budget preparation for RAGs

RAG members may be required to assist in developing an annual, costed work plan for the RAG. The relevant WG and MAC should be consulted and provide comment on whether the budgeted work plan best meets the assessment needs for the fishery. The PZJA may be required to approve the annual work plans and accompanying budgets. The Chair of a RAG may obtain advice on this from the relevant line agency members and if required obtain an application proforma from AFMAs research administrator.

It is the responsibility of a RAG chair to ensure that annual work plans are developed and that applications for funding, where required, are submitted in an accurate and timely fashion.

16.3 Travel Expenses of Members

The policy concerning the travel allowances to MAC and SAC meetings for members and other participants, and to WG and RAG meetings for members is contained in Attachment D.

16.4 Remuneration for inter-sessional work

It is expected that a significant amount of MAC, SAC, WG or RAG work will be conducted between formal meetings. The PZJA will consider claims for reimbursement of such inter-sessional work where it can be demonstrated that a member's contribution to MAC, SAC, WG or RAG inter-sessional work is outside the normal business of the member's agency providing the services. This is a matter for consideration by the PZJA when determining budgets. Remuneration provision for inter-sessional work will be specified in member contracts at the time of appointment where appropriate.

Claims for inter-sessional work benefiting a MAC, SAC, WG or RAG should be budgeted, and reasonable. Remuneration can be claimed by lodgment of a tax invoice with AFMA and should be supported by a documentary record of the actual staff time inputs to MAC, SAC, WG or RAG work. AFMA, on behalf of the PZJA, reserves the right to inspect such records, before approving payment of claims for inter-sessional work.

16.5 Remuneration for Chairs and SAC/RAG Scientific Members

The PZJA accepts that the duties of Chairs and SAC/RAG scientific members require high-level skills and carry obligation and responsibility. In order to attract and retain suitable people, remuneration for these duties may be considered. The level of remuneration is not fixed, but may be negotiated between AFMA and the chairperson/scientific members. Approved Chair/scientific member remuneration will be specified in the relevant contract at the time of appointment.

16.6 Consultancies

In order to accomplish work plans MACs, SACs, WGs or RAGs may, from time to time, require the specialist skills or services of people not already members of the MAC, SAC, WG or RAG. In these instances and for specific defined tasks, the chairperson may engage consultants. Work plans must anticipate these needs and budgets need to provide for any consultancy fees to be paid.

Consultants should be engaged under an AFMA contract. Preparation of such a contract is the responsibility of the AFMA Research Manager in consultation with the MAC, SAC, WG or RAG chairperson. (For further information on contracts refer to the AFMA Research Manager).

17. Consultative Committees

The PZJA may establish committees, other than a MAC, SAC, WG or RAG to assist it in the performance of its functions.

ATTACHMENT A

Legislative Objectives and Functions

Governing and guiding the PZJAs fisheries related activities are the legislative objectives contained under the provisions of sections 8 and 34 of the *Torres Strait Fisheries Act 1984*.

8 Objectives to be pursued

In the administration of this Act, regard shall be had to the rights and obligations conferred on Australia by the Torres Strait Treaty and in particular to 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.

34 Functions of Joint Authority under this Act

Where there is in force an arrangement under this Part under which the Protected Zone Joint Authority has the management of a fishery and the fishery is to be managed in accordance with the law of the Commonwealth, the Protected Zone Joint Authority has the functions of:

(a) keeping constantly under consideration the condition of the fishery;

(b) formulating policies and plans for the good management of the fishery; and

(c) for the purposes of the management of the fishery:

(i) exercising the powers conferred on it by this Part; and

(ii) co-operating and consulting with other authorities (including Joint Authorities established under the *Fisheries Act 1952* or the *Fisheries Management Act 1991*) in matters of common concern.

ATTACHMENT B

EXAMPLE ONLY – NOT FOR USE

Chair
Protected Zone Joint Authority
C/- Communications and Planning Section
Australian Fisheries Management Authority
PO Box 7051
Canberra Business Centre ACT 2610

Dear Chair

I refer to my proposed appointment as the ………….. ……………. Member/Permanent Observer on the ……………………….MAC/SAC/WG/RAG.

In compliance with the PZJAs requirements prior to appointment to this position, I advise that:

(i) I have read, and understand, PZJAs Fisheries Management Paper covering MACs, SAC, WGs and RAGs; and
(ii) I understand that, if my appointment is confirmed, I must disclose any relevant conflict of interest during the course of all MAC/SAC/WG/RAG meetings at which I am present.

I also give my assurance that I will endeavour to participate in discussion in an objective and impartial manner and that I will serve the best interests of the above mentioned MAC/SAC/WG/RAG and of the fisheries, and hold up the PZJAs legislative objective.

Yours sincerely

Signature ………………………………………………………………

Name (please print) ………………………………………………………………

Mailing Address ……………………………………………………………....

Daytime Telephone No.………………………………………………………………

Mobile Telephone No. ………………………………………………………………

Daytime Fax No. ………………………………………………………………

Email Address ………………………………………………………………

Date ………………………………………………………………

ATTACHMENT C

Procedural Matters

The Torres Strait MACs, SACs, WGs and RAGs will operate in accordance with the following procedures:

1. Notice of a meeting

Except in exceptional circumstances, notice of a meeting shall be forwarded by the Executive Officer to all members no less than **20 working days** prior to a meeting being held. The notice shall call for agenda items and stipulate:

- the date of the meeting
- the time the meeting will commence
- the venue for the meeting
- the proposed business to be dealt.

The notice shall be sent to every member of the MAC, SAC, WG or RAG whether they are able to attend the meeting or not. The issue of a notice of the meeting to all members before the meeting is held is necessary for the meeting to be correctly constituted.

Full use of the PZJA web page should be made to assist in the communication of papers and other relevant information concerning the MAC, SAC, WG or RAG.

2. Quorum

A quorum is the minimum number of persons who need to be present to constitute a valid meeting. If a meeting is not properly constituted, it cannot conduct business in a valid manner. For resolutions of a meeting to be valid the number of Members necessary to form the quorum must be present throughout the meeting.

A sensible size for a quorum is a sufficient number of members to conduct business with an adequate spread of responsibility, experience and representation. In the case of MACs, SACs, WGs and RAGs, the number shall be two-thirds of the members.

3. Agenda

An agenda is more than a list of items or a guide to matters to be dealt with at a meeting. It provides a program to aid consideration of each item and allow the business of the MAC, SAC, WG or RAG to proceed in a logical, orderly and timely manner. It also provides a basis on which to write the minutes of the meeting.

Members are encouraged to provide input to the development of the draft agenda. Where significant business is proposed by a member, the agenda item supporting papers must be submitted to the EO by the member no less than **15 working days** before the meeting and be accompanied by a brief explanatory note setting out the main points to be considered. Otherwise, special items can only be submitted with the concurrence of the Chair.

All MAC, SAC, WG and RAG papers are to be considered public documents unless they contain items of specific commercial confidentiality.

Irrespective of the time frames specified in this section, it is the responsibility of the MAC, SAC, WG or RAG Chair to ensure the timely availability of agenda and other papers to all members prior to meetings.

The EO shall prepare the agenda in consultation with the Chair which is to be sent out to MAC, SAC, WG or RAG members, with papers and other information **10 working days** prior to the meeting. Papers are also to be sent to the AFMA Web Administrator (webadmin@afma.gov.au) at least 10 working days prior to the meeting to allow posting on the PZJA website.

The agenda should have items listed in the following order:

- **Chair's Opening Remarks**

  Provides the Chair with an opportunity to make any opening remarks to set the tone of the meeting, welcome any visitors etc.

- **Review and adoption of the agenda**

  Provides an opportunity for members to review the agenda and either confirm its adoption or make any necessary adjustments.

- **Declaration of Interests**

  This gives members an opportunity to declare any interest/s they may have in relation to the matters being considered by the MAC, SAC, WG or RAG. Interests may be declared in relation to a specific agenda item or items or be of a standing nature.

- **Apologies**

- **Minutes of the Previous Meeting on (date)**

  This gives those present the opportunity to be satisfied about the correctness of those minutes as a record of the proceedings of that meeting. It also serves as a reminder of decisions made by, and progress reported at, the last meeting and thus of matters which remain pending, decisions still to be made and developments about which reports should be forthcoming.

- **Outcomes of the meeting of the PZJA on (date)**

  The outcomes of the most recent meeting of the PZJA will be reported.

- **Business Arising from the Minutes**

  While the immediate consideration of any business that arises from the minutes of the previous meeting is normal, it may be appropriate for some issues to be dealt with as individual items later in the agenda.

- **Routine Items**

  Regular business which comes before the MAC, SAC, WG or RAG (such as correspondence etc.) should be dealt with at an early stage in the meeting to enable such items to be dealt with expeditiously, but without undue haste. Reports of the SACs, WGs and RAGs and of each individual fishery will be discussed at this point during a MAC meeting.

- **Business Items to be Dealt With**

  The order in which business is dealt with at a meeting needs to take account of business items arising from the previous meeting and the possible effects on later agenda items. Business items should be structured logically and the sequence of items should not be changed unless to achieve some worthwhile benefit and then only after adequate consideration.

- **Other Business**

  This item provides for the consideration, if only in a preliminary way, of any unexpected or fresh and important business; it also enables up-to-date information on matters of passing interest to be reported and noted at the time rather than wait for the next meeting. As a general rule, items under this agenda heading should not go beyond the scope of the notice for the meeting. At this point the date of the next meeting is discussed.

4. Attendance of Casual Observers

Casual observers are welcome to attend MAC, SAC, WG and RAG meetings. Casual observers may participate at the discretion of the Chair where he or she deems it consistent with the efficient and effective operations of the MAC, SAC, WG or RAG. Casual observers must respect the need for orderly management of the business before the MAC/SAC/WG/RAG and the rights of others in the meeting. Casual observers must follow any directions made by the Chair.

5. Rules of Debate

Rules of debate have no legal authority and it is not necessary to apply such rules at a meeting. However, adherence to conventional rules of debate provides a Chair and others with confidence that a meeting will be conducted in an orderly fashion, with good manners and common decency.

In the case of MAC, SAC, WG and RAG meetings, it is unlikely that the rules of debate will need to be enforced. Rather, issues should be discussed in a co-operative, informal and consultative manner with resolutions being normally arrived at through consensus. At the same time, it is important for members to appreciate that the business of a meeting will be expedited by their personal observance of the general rules of debate and their support for the maintenance of order.

6. The Minutes

Once a MAC, SAC, WG or RAG meeting is completed, the Chair is responsible for formally communicating the outcomes of the meeting, including recommendations and matters for information, to the PZJA Chair (in the case of a MAC or SAC) or to the MAC Chair (in the case of WGs or RAGs) for consideration and to the industry for information. It is a function of the EO to assist the Chair in preparing the minutes of the meeting as well as the Chair's Summary.

Minutes may be defined as the official, permanent, written record of the business transacted at a meeting. They should be accurate, concise and articulate, being free from ambiguity or uncertainty. Where there is, by necessity, substantial and significant detail covered in the MAC, SAC, WG or RAG meeting, the minutes need to reflect this level of detail.

As a general rule, minutes should be expressed in words, phrases and sentences which are free from errors of grammar and syntax. They should preferably be without clichés, jargon, fashionable words or unnecessary detail.

The minutes need to include:

- day and date of meeting
- place of meeting
- names of those present
- apologies
- reference to the minutes of the previous meeting and the signing of them as a correct record of the proceedings of that meeting by the Chair
- record of agenda items discussed, including agreements reached, action required, and the MACs, SACs, WGs or RAGs decision/s in regard to any declared conflict/s of interest
- date and time for the next meeting
- time the meeting closed

Draft minutes are to be written up and submitted to the Chair for comment and approval within **14 working days**, and distributed to members within **21 working days** after the meeting. Minutes are also to be sent electronically to the AFMA Web Administrator (webadmin@afma.gov.au) for posting on the PZJA website.

MAC, SAC, WG or RAG Chairs must not allow members who are absent from meetings to have separate notes or views attached to minutes, however absentee members may convey views in writing to the MAC, SAC, WG or RAG prior to the meeting.

ATTACHMENT D

TRAVEL EXPENSES

Members of travelling on MAC, SAC, WG or RAG business will be paid travel expenses reasonably incurred in connection with RAG business. Normally, this is reimbursement of airfares at the economy class rate, reimbursement of receipted expenditure for accommodation costs, meals and incidental expenses in accordance with AFMAs (as a PZJA Agency) staff travel policy.

To claim reimbursement for expenses incurred while on MAC, SAC, WG or RAG business, members must provide AFMA with a tax invoice with any relevant supporting documentation such as airline tickets, receipts for accommodation, meals, taxis and parking vouchers etc.

No allowance is payable if there is not an overnight stay. However, members may claim reimbursement of any meal expenses incurred by them during the day of a MAC, SAC, WG or RAG meeting not involving an overnight stay. Claims for reimbursement must be accompanied by a valid receipt or tax invoice and approval is at the discretion of PZJA Agency staff.

If a Member would like payment of travel costs to be made to their employer or business, then they must either submit a tax invoice from their employer or business or enter into a signed Recipient Created Tax Invoice (RCTI) agreement with AFMA. An RCTI agreement form can be obtained from AFMAs Finance Manager.

All flights to MAC, SAC, WG and RAG meetings should be booked through AFMAs travel provider. The cost of the flight will be charged directly to AFMA.

Members of a MAC, SAC, WG or RAG who are employed by a Commonwealth or State organisation that has their own discounted travel arrangements, may book flights through their own system. AFMA will reimburse their employer on submission of a valid tax invoice.

The claim form for travel expenses is attached.

Australian Government
Australian Fisheries Management Authority

CLAIM FOR EXPENSES AND ALLOWANCES FOR OFFICIAL ATTENDANCE AT A COMMITTEE (MAC, SAC) OR GROUP (WG or RAG) MEETING

DETAILS OF MEMBER

Name…………………………………………… ABN*……………………….……. Phone No…………….….

Address………………………………………………….…………………….……. Fax No………………….

DETAILS OF MEETING

Name of Committee/Group……………………….………………	Meeting place……………………………………..….
Meeting date……………………………..…….…..………	Meeting time……………………………...……….

DETAILS OF TRAVEL

Start: Place…………….……………. Time………... Date…..……

End: Place……………….…………… Time………... Date…..……

Was this travel by the most direct route? Yes ☐ No ☐

If no, please provide comments ...………………………………….

…………………………………………………………………………………

Method of travel: ☐ Plane (go to section A)
☐ Vehicle (go to section B)

Section A - DETAILS OF FLIGHT (attach tax invoice*)

Outward: Date…………….. Depart……………. Arrive……….…….
Return: Date…………….. Depart……………. Arrive……….…….

Are you claiming reimbursement for total cost of the airline ticket?

Yes ☐ No ☐ Comments ………………………………………. .

…………………………………………………………………………

Section B - DETAILS OF VEHICLE

Distance travelled by direct route ……….…….km Engine size………..cc

Section C - DETAILS OF EXPENSES (attach tax invoices*)

Taxi $……………..……..Parking $………..………Other $..…………

SIGNED ……..…………….……INVOICE DATE……………..

ATTENDANCE VERIFIED ………………………………………

(AFMA use only)

	No.	$
Complete days		
Less meals provided		
Travel allowance payable (6410)		
		$
Cost of ticket *		
Deductions		
Net cost (6420)		
Rate……….c/km (6430)		$
Expenses * $		
TOTAL PAYABLE $		

THE TOTAL PAYABLE INCLUDES GST

COST CENTRE ……………………………...….TOTAL PAYABLE APPROVED BY…………………………….

*Official MAC/WG/RAG/SAC members do not need to provide an ABN. Costs should be entered including GST, where applicable. AFMA can recover GST on reimbursements where an original tax invoice is attached. If the member's business is paid then the member must provide the business' ABN. AFMA can recover the GST from payments to those members only if they have signed an RCTI agreement or provide their own tax invoice

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
PRELIMINARIES **Action items from previous meetings**	**Agenda Item 1.4** **For Decision**

RECOMMENDATIONS

1. That the RAG:
   a. **ADOPT** the final meeting record for TRLRAG 25 held on 11-12 December 2018 (**Attachments 1.4a and 1.4b**).
   b. **NOTE** the progress against actions arising from previous meetings (**Attachment 1.4c**).

BACKGROUND

Meeting record

2. The draft meeting record for TRLRAG 25 held on 11-12 December 2018 was provided out of session for comment on 11 January 2019. Minor comments were received from the TSRA. Additional changes were made by the Executive Officer to correct Attachment A and appropriately reference sources for Attachments D and E. A track-change version of the draft meeting record, showing the comments received is provided at **Attachment 1.4a** for information.
3. The final meeting record is provided at **Attachment 1.4b**.

Actions arising

4. Updates are provided on the status of actions arising from previous TRLRAG meetings and relevant TRLWG meetings at **Attachment 1.4c**.

Torres Strait Tropical Rock Lobster Resource Assessment Group Meeting 25

Meeting Record

11-12 December 2018

Thursday Island

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

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 afma.gov.au

Contents

Meeting participants

Members

Name	Position	Declaration of interest
Ian Knuckey	Chair	Chair/Director of Fishwell Consulting Pty Ltd and Olrac Australia (electronic logbooks). Chair/member of other RAGs and MACs. Conducts various AFMA and FRDC funded research projects including FRDC Indigenous Capacity Building project. Nil interests in TRL Fishery and no research projects in the Torres Strait. Full declaration of interests provided at **Attachment A**.
Georgia Langdon	AFMA Executive Officer	Nil.
Natalie Couchman	AFMA member	Nil.
Mark Anderson#	TSRA member	Nil. TSRA holds multiple TVH TRL fishing licences on behalf of Torres Strait Communities but does not benefit from them. They will not be leased in the 2018/19 fishing season.
Danielle Stewart	Queensland Department of Agriculture and Fisheries (QDAF) member	Nil. Harvest Fisheries Manager, QDAF.
Andrew Penney	Scientific member	Research consultant (Pisces Australis), member of other AFMA RAGs (SPFRAG and SESSFRAG). Nil pecuniary or research interests in the Torres Strait.
Éva Plagányi	Scientific member	Lead scientist for PZJA funded TRL research projects conducted by CSIRO.
Aaron Tom	Industry member	Traditional Inhabitant Gudumalulgal and TIB licence holder.
Les Pitt	Industry member	Traditional Inhabitant Kemer Kemer Meriam and TIB licence holder.
Phillip Ketchell*	Industry member	Traditional Inhabitant Kaiwalagal, Traditional Owner and fisher.
Terrence Whap	Industry member	Traditional Inhabitant Maluialgal and Traditional

Name	Position	Declaration of interest
		Owner. Does not hold a TIB licence.
Daniel Takai+	Industry member	Pearl Island Seafoods, Tanala Seafoods, TIB licence holder and lessee of TSRA TVH licence in 2017/18 fishing season.
Brett Arlidge	Industry member	General Manager MG Kailis Pty Ltd. MG Kailis Pty Ltd is a holder of 5 TVH licences.

Observers

Name	Position	Declaration of interest
Joseph Posu	PNG National Fisheries Authority (NFA)	Nil.
Mark Tonks	Scientific observer	Project staff for AFMA funded TRL research projects
Jerry Stephen	TSRA Deputy Chair, TSRA Member for Ugar and TSRA Portfolio Member for Fisheries	TIB licence holder and Native Title holder.
Trent Butcher	Industry observer	TVH licence holder.
Suzannah Salam^	Industry observer	Torres Straits Seafood Pty Ltd, TIB licence holder and lessee of TSRA TVH licence in 2017/18 fishing season.
Nathan Binjuda	Industry observer	Traditional inhabitant crew on TVH operated vessel
Allison Runck	TSRA observer	Nil.
Medina David	TSRA observer	Nil.

Notes:

Departed the meeting at 3.30pm on Tuesday 11 December
* Arrived after morning tea ~ 11am on Tuesday 11 Dec and left again at 3.30pm to attend the Fisheries Stakeholder meeting with Assistant Minister Colbeck. Did not attend on Wednesday 12 December.

^ Attended the full day on Tuesday 11 December. Arrived at 9.40am on Wednesday 12 December.

+ Departed the meeting between 2-3pm on Tuesday 11 December

1 Preliminaries

1.1 Apologies

1. The meeting was opened in prayer at 9 am on Tuesday 11 December 2018.
2. The Chair welcomed attendees to the 25th meeting of the Torres Strait Tropical Rock Lobster Resource Assessment Group (TRLRAG 25). The Chair acknowledged the Traditional Owners of the land on which the meeting was held and paid respect to Elders past and present.
3. Attendees at the RAG are detailed in the meeting participant tables at the start of this meeting record.
4. Apologies were received from Mark David (Industry Member and Traditional Inhabitant Kulkalgal), Dr Ray Moore (Industry Member).

1.2 Adoption of agenda

5. The draft agenda was adopted (**Attachment B**).

1.3 Declaration of interests

6. The Chair stated that as outlined in PZJA Fisheries Management Paper No. 1 (FMP1), all members of the RAG must declare all real or potential conflicts of interest in Torres Strait TRL Fishery at the commencement of the meeting. Declarations of interests were provided by each meeting participant. These are detailed in the meeting participant tables at the start of this meeting record.

1.4 Action items from previous meetings

7. The RAG noted the status of actions arising from previous TRLRAG, and where relevant, TRL Working Group (TRLWG) meetings (**Attachment C**).
8. The RAG noted that the final meeting record for TRLRAG 24 held on 18-19 October 2018 was finalised out of session.

1.5 Out-of-session correspondence

9. The RAG noted out of session correspondence on RAG matters since the previous meeting.

2 Updates from members

2.1 Industry and scientific

10. The RAG noted updates provided by industry and scientific members, and observers on the performance of the TRL Fishery during 2017/18 and at the very start of the 2018/19 season (only two weeks in) and raised the following:
    a) A Transferable Vessel Holder (TVH) industry member advised that since the start of the 2018/19 season prices have been good due to the low supply of lobsters in the previous season. The start of the 2019 season was so far showing lots of small size lobsters, and not a lot of larger lobsters. Similar results are also being seen with smaller tails from Papua New Guinea (PNG).
    b) Local catch rates (around Thursday Island) are down, however anecdotal reports indicate that Warrior Reef and the central islands are doing well.
    c) A Traditional Inhabitant member advised that during the first week of the season, free divers were surprised by the abundance of 0+ and 1+ lobsters in the east which are not normally observed in Kemer Kemer Meriam waters.
    d) Other TI members advised that more 1+ lobsters are being observed around home reefs in the western and top western islands, compared to last season where fishers were

working further afield. It is usually around 1 January when the larger lobsters come back in to the fishing grounds.

e) A TVH industry observer also reported lots of small lobsters are around. He added that although the lobster stocks is looking strong, warmer water temperatures are having an impact on captured lobsters in cages.

f) An industry buyer advised that the ratio of 1+ lobsters, to larger sizes (2+) is about 60/40 with lots of positive reports from fishers that the lobsters are around. Prices are looking good with no oversupply, and it is expected to remain that way until February when hookah diving commences. Due to an earlier than usual Chinese New Year, the hookah divers will miss out on the higher Chinese New Year prices.

g) Another TVH industry member also advised that frozen whole lobsters will often get a better return for fishers than tails, however the frozen whole market is limited and has been flooded before. Currently there is not a huge demand for whole frozen lobsters unlike 4-5 years ago, however prices are slightly higher. An industry buyer added that the market prefers smaller whole frozen lobsters. It was also noted that there is currently no field on the TRL daily fishing logs to record whole frozen lobsters.

11. The RAG noted that no additional scientific updates were required as all relevant topics were to be covered under other agenda items.

2.2 Government

12. The RAG noted an update provided by the AFMA member regarding management initiatives relevant to the TRL Fishery:

TRL Management Plan and Sectoral Split

a) On 26 November 2018, having considered outcomes of consultation, the Protected Zone Joint Authority (PZJA) decided to determine the *Torres Strait Fisheries (Quotas for Tropical Rock Lobster (Kaiar)) Management Plan 2018* (the Management Plan) and to amend the *Torres Strait Fisheries (Tropical Rock Lobster) Management Instrument 2018* (the Instrument).

b) The Management Plan and amendments to the Instrument came into force for the 2018/19 fishing season starting on 1 December 2018.

c) Unless delayed by legal appeals, a quota management system will be fully operational in the TRL Fishery for the 2019/20 fishing season. A review of existing PZJA licencing policies and management arrangements, including input controls, will be conducted periodically after the quota management system is operational.

d) During 2018/19, separate total allowable catch (TAC) shares will be implemented on an interim basis; 66.17 per cent under an Olympic TAC for the TIB sector and 33.83 per cent share under provisional quota allocations for the TVH sector.

Interim and final TACs

a) In order to give effect to the sectoral split, the PZJA further agreed to open the 2018/19 fishing season with an interim TAC of 200 tonnes. This decision is based on advice received from the TRL Resource Assessment Group and TRL Working Group that an interim TAC derived from the maximum annual catch amount over the years 2005-2018 for the period 1 December and end of February should be implemented.

b) AFMA will be working closely with PNG NFA over the coming months to finalise negotiations on how the Recommended Biological Catch (RBC) is shared between Australia and PNG in line with obligations under the *Torres Strait Treaty*.

Moon-tide Hookah Closures

a) The PZJA also reaffirmed existing management controls currently applied to the TRL Fishery, to be implemented under the Instrument and licence conditions. This includes periodic closures to the use of hookah gear for three days either side of the full or new moon each month based on the largest difference between high and low tide levels.

b) AFMA will be looking to review the current input controls in the TRL fishery to better understand if they are still required as management tools in the fishery once it is fully transitioned to a quota management system.

13. The RAG discussed:
    a) Whether tidal flows and currents have been considered when calculating moon-tide closures as current flow rates (as distinct from tidal height differences) have a significant impact on the ability to dive for TRL. Noting the variability in tides across the Torres Strait region, the AFMA member advised that the moon-tide hookah closures are calculated using the Bureau of Meteorology tide charts from Thursday Island. The RAG advised that the Thursday Island charts should be continued to be used.
    b) An industry member advised that the TIB sector will continue to advocate for moon-tide hookah closures to remain in place and agreed that strong currents are an important factor influencing TIB fishing effort.
    c) In considering the RAGs advice to the TRL Working Group about who will discuss any changes to input controls, a scientific member advised that any changes to input controls will have an impact on Catch per Unit Effort (CPUE) index used in both the assessment and empirical harvest control rule (eHCR). If moon-tide hookah closures, or other input controls, are removed the RAG will need to consider the impacts on CPUE and how these impacts will be adjusted for in future analyses. If the closures are to change, it was suggested that a staggered or transitional approach would be beneficial to try and understand any potential impacts on fishery trends over time.
    d) The CSIRO scientific member agreed and advised caution when considering any management arrangements that will impact abundance indices in the fishery noting that fishery data trends will also be impacted by the wholesale change to a quota system. Economic implications should also be considered for the fishery, as well as those for the data and stock assessment.

14. **The RAG agreed that the potential removal of any input controls should be addressed with caution. Given the immediate changes that will apply as the fishery moves to a quota management system, the RAG recommended that all current input controls remain in place for the 2018/19 season before a review (or change) of input controls takes place.**

15. The RAG also discussed:
    a) A concern raised regarding the carriage of hookah apparatus on board during a hookah closure. Some industry members queried if at the end of a moon-tide hookah closure, where an operator still has capacity to fish the remainder of their quota using free dive only, if they must still return to port to unload their hookah gear. Some industry members feel this creates an economic disadvantage for their operations. The AFMA member advised that the AFMA compliance team are looking at ways to effectively enforce this rule without being completely unpractical and economically disadvantageous for operators. They stressed that at under present rules, the requirement is for hookah apparatus to be removed during moon-tide hookah closures if an operator is to continue fishing;
    b) Concerns with how catches will be tracked against the quota system during 2018/19 if the catch reporting system is not implemented in real time. The AFMA member advised that the primary responsibility lies with TVH operators to keep track of and report what they have caught against the allowable weight provided as a condition on each licence. AFMA will use Catch Disposal Records (CDRs) to verify catches against each TVH operator's allocation. This will be a manual process initially. It is expected that the fishery will move to the Commonwealth system known as GoFish which allows operators to log in online and view their quota balance for the season.
16. The AFMA member also advised that AFMA (through the Australian Institute of Marine Science – AIMS) is monitoring increased water temperatures and the potential impact on TRL stocks. Industry operators were advised to consider their stocking densities of TRL in cages as a precaution during periods of warmer water temperatures. Overstocking may lead to unacceptable quality or mortality rates in conditions during periods of raised water temperatures.

17. The RAG noted an update provided by the QDAF member regarding the East Coast TRL fishery:
    a) QDAF have held a series of TRL Fishery Working Group meetings since the last RAG to progress the development of a TRL Harvest Strategy.
    b) A similar logbook issue was raised in Queensland with regards to whole frozen lobster. QDAF are looking to address this with the rollout of electronic logbooks next year as the data is not being effectively captured on paper logs.
18. The RAG discussed the following key points:
    a) The RAG data subcommittee should learn more about the QDAF e-logs program, to ensure Torres Strait and Queensland TRL datasets remain compatible.
    b) Electronic logbook reporting is being rolled out in the Commonwealth, however changes need to be made to *Torres Strait Fisheries Act 1984* (the Act) before it can be considered in the Torres Strait TRL fishery.
    c) Concerns around data confidentiality in the Fish Receiver System (FRS) when reporting on areas fished. The AFMA member advised that the *Torres Strait Fisheries Act (1984)* currently constrains how spatial data can be collected and so the provision of such data is only voluntary on CDRs. These constraints are also being addressed through legislative amendments to the Act. Any legislative amendments (including mandatory TIB logbook reporting or electronic logs) will take a number of years to achieve as the amendment process is lengthy.
19. The RAG agreed that although legislative changes are a lengthy process, the RAG data subcommittee should start considering the data needs of the fishery moving forward.

20. The RAG noted an update provided by the TSRA member regarding TSRA activities relevant to the management of the TRL Fishery:
    a) New Traditional Inhabitant members were elected at the 2018 Fisheries Summit, with three new members joining the TRL RAG, and three members outgoing.
    b) The TSRA member thanked the outgoing Traditional Inhabitant Members Mr Terrence Whap, Mr Mark David and Mr Phil Ketchell for their contributions to the RAG over the past three years.
    c) The TSRA will be holding an induction program for all incoming and ongoing PZJA forum members in early 2019.

Action
The TRL RAG Chair to provide the TSRA with a copy of expected behaviours of RAG members to assist with the induction program for incoming PZJA forum members.

21. The RAG also noted and discussed the following:
    a) The TSRA is progressing the development of an independent entity that will hold fisheries assets on behalf of traditional inhabitants. The TSRA member advised that a shortlist of model options will be considered.
    b) Based on extensive community consultation advice, the TSRA will not be considering the leasing of any further TVH licences leasing during 2019. The TSRA member advised that the lease arrangements for the 2017/18 season were made before advice was received of a low RBC. Industry expressed the belief that fishing effort had increased through the TSRA's leasing of licences, however the licences were leased by TIB operators already active in the fishery.

2.3 PNG NFA

22. The RAG noted an update from the PNG NFA member regarding management of the PNG TRL Fishery:
    a) The PNG fishery remains closed to hookah diving and is scheduled to re-open in April 2019. The fishery was closed with resistance from the artisanal sector.
    b) Management are looking to implement other appropriate management measures as the early fishery closure was not anticipated.
    c) PNG is hoping for a higher RBC in 2019 to meet market demand.
23. In response to a question from CSIRO about the size of lobsters observed in the fishery, the PNG NFA member advised that this is a key area the NFA is trying to address through the

collection of length frequency data. Both CSIRO and the PNG NFA member agreed to continue discussions on data PNG may be able to provide to feed into the current TRL stock assessment.

2.4 Native Title

24. No updated was provided as a Malu Lamar representative was not in attendance.

3 Preliminary Results of the November 2018 Pre-Season Survey

25. The RAG considered a presentation provided by Dr Mark Tonks, CSIRO Scientific observer detailing the preliminary results of the November 2018 pre-season survey:
    a) Dive surveys were conducted between 11-22 November 2018 aboard the *"Wild Blue"* and CSIRO dive tender. The surveys were undertaken by four divers, Mark Tonks, Nicole Murphy, Kinam Salee and Steve Edgar with the experience of 23 TRL surveys combined.
    b) Dive surveys were conducted at 82 sites consisting of 77 repeat pre-season sites and 5 additional sites in the northwest. Photo transects were also completed at 7 sites to monitor coral bleaching.
    c) The pre-season TRL surveys provide indices of abundance for recruiting age lobsters (age 1+) and recently-settled lobsters (age 0+), abundance indices by stratum (region) and length-frequency and sex ratios. Most older lobsters (age 2+) have migrated and those that remain are mostly male.

    1+ pre-season index

    d) The 2018 1+ pre-season index is above average and approximately 3 times the 2017 survey index. The pre-season 1+ counts per site indicated good recruitment throughout the fishery, but higher counts along the western side. This differs from the 2017 pre-season site counts, which were higher in the south-east and low in most other regions.
    e) The survey also indicated good recruitment across all strata particularly in the northwest region (Mabuiag and Buru). Buru had a high standard error due to high count variability between sites. In 2018, Mabuiag and Buru recorded their highest indices over the last 9 surveys.

    0+ pre-season index

    f) Although less well estimated, the 2018 0+ index was three times the 2017 0+ index however this was not significantly different from the 2006, 2007, 2015 and 2016 indices.
    g) 0+ age counts were indicative of typical settlement mostly on the western side of the survey area. 2018 0+ counts were not dissimilar to 2016, but there was fewer 0+ in the south west, and more in the north west. All 2018 0+ counts were significantly better than in 2017.
    h) Abundance indices by stratum showed Mabuiag significantly higher than the other stratum. The 2018 0+ indices showed similar regional recruitment trends compared to previous surveys.

    2018 pre-season size and sex ratio

    i) The modal size of age 1+ has increased compared to recent years.
    j) 2018 length frequency trends were similar to 2005 and the sampled sex ratio was almost 1:1, which is as expected.
26. The RAG discussed:
    a) The key stratum in the survey are not mapped or selected based specifically on where commercial catches are made. They stem from the original benchmark survey that collected habitat data across the Torres Strait. Survey sites were then randomly selected from areas of habitat known to support lobster populations. The RAG also noted that the strata used in the survey, differ from those collected through the TRL04 logbook and TDB02 CDR. The CSIRO scientific member advised that these strata can be better cross-

mapped as improvements are made to the collection of spatial data (lats and longs) through logbooks and CDRs.

b) The Chair noted an issue with the presentation of industry-provided length frequency data analysis which indicated a consistent peak over the years at a certain length. The RAG considered that this was likely due to how a conversion factor is applied to catch weight data to convert it to length.

Action
CSIRO to investigate the reasons for the consistent peak in the length frequency distribution and determine if it is related to conversion factors from the catch weight data provided by MG Kailis.

c) An industry observer expressed concern as to why there are more dive sites around Warrior Reef compared to others where greater lobster production is observed. The CSIRO scientific member reiterated that the original benchmark survey contained hundreds of sites. Following this, the first pre-season survey had 140 sites which were selected from the original benchmark survey. The sites have since been reduced to just 77 but ensuring they remain representative. Other sites were removed due to logistical constraints. For example, some deep sites were removed due to more stringent CSIRO diving requirements. In reducing the number of sites in the survey, some trade-offs around precision were considered by the RAG.

d) The CSIRO Scientific member advised that the survey has been scaled down over recent years in order to reduce costs however this was done with consideration of the potential loss of precision. The original sites were based on habitat, and were reduced in a way to ensure the survey would still give a reliable estimate of recruiting biomass.

27. The RAG was asked to consider whether to include the additional 5 sites from the 2018 surveys in the calculation of the abundance indices:

a) The RAG noted that the additional 5 sites were added to the 2018 surveys to answer specific questions around the distribution of the stock in that particular year. Such ad-hoc modifications, if they are ongoing, may undermine the representativeness of surveys over time.

b) The independent scientific member noted that should the re-inclusion of sites (back to 140) be proposed, this must be undertaken the same way they were removed, in a statistical and planned method. With no additional resources available to increase the number of survey sites, continuity in the data into the future must be considered.

Action
CSIRO to calculate the cost of increasing the number of pre-season survey sites from the current 77 sites back to 140 for RAG industry members to consider.

c) **The RAG agreed that the additional 5 sites from the 2018 surveys should not be included in the calculation of the survey indices.**

28. The RAG noted that analyses pertaining to the catch and effort data from the 2017/18 season, including the standardised CPUE indices, were presented at TRLRAG 24 held on 18-19 October 2018. No further analysis has been undertaken since that time.

4 Stock Assessment Update and RBC

29. The RAG considered a presentation provided by Dr Eva Plaganyi, CSIRO Scientific member detailing the preliminary results of the 2018 stock assessment update:

a) <u>Summary of life cycle and assessment</u> – The pre-season survey provides a rough indication of how many 0+ lobsters have settled in the region. It also provides a good estimate of how many 1+ recruits will be available to be fished in the coming season (next year). The 2+ lobsters are fished before females migrate out of the Torres Strait to breed between August and September each year. The fishery-dependent CPUE data provides an index of 2+ abundance.

b) Assessment basics – The number of 0+ settled lobsters is compared with the spawning biomass to inform the stock recruitment relationship. This relationship is highly variable but a low spawning biomass has a higher probability of poor recruitment. The pre-season survey is then used to estimate how many lobsters will be available to be caught in the coming season. The stock assessment model calculates how many of these lobsters can be caught while ensuring the spawning biomass is kept close to the target level (0.65_{SB}). The model applies a fixed target proportion of 0.15 unless the spawning biomass is lower than the reference point.

c) Summary of model – the stock assessment uses an Age Structured Production Model (ASPM) which corresponds to a Statistical Catch-at-Age Analysis (SCAA) as the data fitted includes catch-at-age information. This is a widely used approach for providing TAC advice. The output of the assessment is a Recommended Biological Catch (RBC) with confidence intervals each year. It is an integrated assessment that takes into account all available sources of information. This includes:
   - Pre-season survey data (9 years with a gap in the time series);
   - Mid-year survey data 1989-2014; 2018;
   - Catch statistics from all sectors in the Torres Strait;
   - Length frequency data (Australia and PNG);
   - CPUE data from TVH sector;
   - CPUE data from TIB sector; and,
   - Historical information.

30. The PNG NFA member noted that some PNG catches from recent months are still outstanding and that there had not been any trawling effort in the Gulf of Papua in the past season. Noting that the PNG season does not normally close until 1 December, the RAG agreed that the timelines for assessment need to be considered if data concerning catches from the PNG sector are delayed.

Action

Considering assessment timelines, PNG NFA to provide CSIRO with a best estimate of PNG catches by mid-November. CSIRO to liaise closely with PNG regarding reporting timeframes and provision of catch data. In parallel, the RAG data sub-group to examine ways to adjust the stock assessment model to account for delayed catch data from PNG.

d) TVH CPUE – the model incorporates six different standardised CPUE series. There is little difference between these series. The RAG requested the data sub-group have further discussions as to the best series to use. The reference case CPUE series currently used in the assessment is ‘Int-1’.

Action

That the TRL RAG data subcommittee discuss which TVH CPUE series are the best to use within the model.

e) TIB CPUE – 4 different standardised CPUE series are used for the TIB sector. The RAG agreed to use the ‘Seller’ series as the reference case as the remaining three standardisations are impacted by the issue of area caught vs area landed. This issue is to be discussed further by the RAG data sub-group.

f) Model ‘Reference Case’ Specifications –
   - Fixed steepness h=0.7
   - Fixed hyperstability parameters for each CPUE series (TVH 0.75; TIB 0.5)

- Mid-year survey index – after applying mixture model to separate age classes
- Pre-season survey index – use as Reference MYO (mid-year only) series and same series as in November 2017 without the additional 5 sites added
- CPUE TVH – Int-1 standardised series (and Int-3)
- CPUE TIB – Seller standardised series

g) Key sensitivities –

- fix steepness h=0.6 and try to estimate h
- fix CPUE hyperstability parameters (TVH 1; CPUE TIB 1); try to estimate hyperstability parameters
- pre-season survey index – use the additional 5 sites added; test other series particularly excluding Buru which provides a lower standard error for 1+ index; downweight pre-season 0+ (2017)
- CPUE TVH – Int-3 standardised series; nominal
- CPUE TIB – Seller&A standardised series; nominal

31. The RAG noted that each CPUE series has an associated variance to which the model weights each accordingly. The 1+ index is the most reliable indicator of biomass and the key input to the model with the greatest weight, however the model considers all corroborating information.
32. In the current assessment update, a significant data conflict exists between the November 2017 0+ index (which was very low relative to historical) and the 2018 1+ index (which was closer to average). Given the good confidence in the survey observations of 1+ lobsters, CSIRO explored the impacts of the anomalous 2017 0+ index on the model. The stock assessment model is sensitive to the inclusion or exclusion (or down-weighting) of the 2017 0+ index. To inform the discussion on how the anomalous 0+ index should be treated, CSIRO presented some alternative hypotheses to explain the data conflict (**Attachment D**, Table 1).
33. The RAG agreed that Hypotheses 4 was the most plausible explanation. It is known that lobster settlement changes from year to year however if it were to change radically, this is unlikely to be detected in the survey. The 0+ counts will always be more uncertain than the 1+ counts, given the cryptic nature of 0+ lobsters; even if there is a variable distribution of 1+ lobsters, the survey can still capture this, however if for example, all 0+ settled up in the north west or somewhere outside the survey sites this may not be captured in the fishery-wide survey counts.
34. Previously, the RAG has agreed that the 0+ index contains valuable information and is a key input in to stock assessment. With the exception of 2017, the 0+ index has generally been consistent with the following year's 1+ index. The independent scientific member agreed that anecdotal industry reports reaffirm that perhaps the survey did not accurately capture the 0+ lobster counts due a change in distribution or some other factors. Industry observers provided anecdotal reports of significant numbers 0+ lobsters observed in the fishery last season. The CSIRO scientific member agreed that, given the sound evidence of a reasonable 2018 1+ index, there must have been 2017 0+ lobsters in the fishery that were not evident in the survey index.
35. When examining the model versus observed pre-season index, there is a conflict between the 2017 0+ and 2018 1+ indices. To demonstrate the impact this conflict can have on the assessment, CSIRO undertook a comparison of the stock assessment model fit to the pre-season survey index when; (A) fitting to the 2017 0+ index, versus (B) excluding the 2017 0+ index. Under scenario (A), the model fits to the lower end of the confidence intervals and greatly overestimates the 0+ index relative to the observed. Under scenario (B), the model allows the 0+ index in 2017 to be freely estimated which produces a much higher predication as needed to improve the fit to the higher 1+ numbers observed in 2018 (**Attachment E**, Figure 1).
36. Similarly, when comparing the mid-year survey index of abundance (**Attachment E**, Figure 2) and the model versus observed survey catch-at-age proportions (**Attachment E**, Figure 3) the assessment achieves a much better fit when the 2017 0+ is excluded.
37. Results of the Reference Case –
    a) The reference case model fits well to both previous benchmark surveys, and the 1+ and 2+ relative abundances from mid-year surveys.
    b) Stock recruitment residuals are average, however the results are higher when the 2017 0+ is down-weighted.

c) Spawning biomass has declined in recent years but the RBC for the 2018/19 season will enable the spawning stock biomass to increase back towards the target.

d) Fishing mortality estimates also indicate that the spawning stock biomass was low and supports the 2018 decision to limit catches.

e) Hyperstability parameters are fixed within the reference case model. The TIB CPUE series has a far more hyperstable index than the TVH CPUE series. This is largely due to the TVH fleet being more mobile and therefore more efficient at maintaining higher catch rates. When estimating the hyperstability parameters the model CPUE index is lower than the model observed.

38. In considering how to treat the anomalous 2017 0+ index in the assessment, the RAG considered and discussed the following key points:

    a) Given that the model fits the 0+ index reasonably well throughout the time series, except for 2017, it provides support to down-weight but not exclude the single 2017 0+ data point;

    b) The mid-year survey validates down-weighting or excluding the 0+ index and supports the results of the 2018 pre-season survey;

    c) The 2017 0+ index falls outside of the normal distribution which is statistically possible, although rare;

    d) Caution should be exercised around selecting a down-weighting value on the 0+ index simply because it provides a more favourable 1+ index;

    e) The 2017 0+ index is a result of the 2016 spawning stock biomass which experienced an anomalous year in terms of poor environmental conditions including high water temperatures. Oceanographic modelling will improve our understanding of such conditions on the abundance of the stock;

    f) Excluding the 0+ index entirely would impact the eHCR as the harvest control rule incorporates the 0+ index. However, with a stock assessment scheduled every three years under the draft Harvest Strategy, continuing with one anomalous data point should not impact the overall function of the eHCR.

39. **There is evidence to suggest the 2017 0+ index may be anomalous. The RAG agreed that the 0+ series should be down-weighted appropriately rather than be excluded entirely. The down-weighting should be undertaken using an appropriate statistical methodology and not be applied arbitrarily. CSIRO undertook to complete this work prior to the next meeting.**

40. <u>Recommended Biological Catch</u> – although the RAG agreed on how to treat the 2017 0+ index, the CSRIO scientific member presented a range of RBC values depending on how the 2017 0+ index may be treated (e.g. excluded or down-weighted by doubling the variance).

    a) When the 2017 0+ index is included, the reference case model provides an RBC value of 533 tonnes.

    b) When the 2017 0+ variance is doubled as a means of down-weighting this point, the reference case model provides an RBC value of 637 tonnes.

41. **Given the RAG advice to apply a statistically calculated down-weighting to the 2017 0+ index, the RAG noted that the final RBC would likely lie somewhere between 533 and 637 tonnes. A final RBC value will not be available until the February 2019 TRL RAG meeting.**

42. The RAG also noted advice from the AFMA member that once a final RBC value is available, Australia and PNG will need to have discussions as to how the RBC is shared between the two countries under the *Torres Strait Treaty*. The initial split is 85 per cent to Australia, and 15 per cent to PNG, based on the agreed distribution of the stock. Each country then has a right to access 25% of the other country's share in that country's waters through cross-endorsement. Discussions on this arrangement are scheduled to commence in January 2019.

43. Environmental Correlates – Although not formally included in the current reference case model, the RAG considered some preliminary results on how environmental correlates may impact the stock assessment:
    a) The predictions are for temperature increases under the current emission scenario for Australia. Although not expected for several decades, once temperatures in Torres Strait consistently exceed 30 degrees Celsius, the impacts on the TRL fishy may be significant. Most marine animals including TRL have thermal tolerances with optimal conditions, however once conditions are above the thermal tolerance, negative impacts on the population increase markedly.
    b) The climate-linked model indicates that spawning biomass is trending downwards more significantly than the non-climate linked model which also changes the historic depletion statistics.
    c) Under the climate-linked model, some additional growth variability can be explained. When understanding historical trends, some can be explained by sea surface temperatures (SST).
44. The RAG acknowledged that under a climate-linked model, if a significant impact is detected, this can have implications for reference points and how that impacts the stock assessments that underpin the Harvest Strategy and eHCR. Other reference points such as fished versus unfished biomass may need to be considered in future.

45. **Noting that understanding climate effects is a high research priority for the TRL fishery, the RAG agreed that further consideration of the impacts of SST on the fishery is important and that CSIRO should continue to explore this.**

5 Revision of Draft Harvest Strategy and Control Rules

Empirical Harvest Control Rule (eHCR)

46. The RAG considered a presentation provided by Dr Eva Plaganyi, CSIRO Scientific member detailing the results of testing of alternative empirical harvest control rules for the Torres Strait TRL fishery.
47. At the last RAG meeting held on 18-19 October 2018, members recommended that in light of the 2017/18 season, the number of years to be averaged in the eHCR index and decision rule triggers be revisited at the next meeting of the RAG prior to finalising the Harvest Strategy. The eHCR is designed to adjust the RBC relative to a recent average, based predominantly on the logarithm of the slopes of recent trends of four key indicators; the pre-season recruiting lobster (1+) weighted at 70%, with lower weighting accorded to trends in recently-settled lobster (0+) and CPUEs from the TIB and TVH fishing sectors (each 10%).
48. Key performance statistics also previously considered by the RAG included spawning biomass level, and levels relative to target reference levels, average annual catch (over 20 years), and average annual variability in catch as well as risk to the fishery and risk of closure of the fishery. Other eHCR candidates have previously been considered in terms of how well each rule performed with regard to the fishery objectives, however the RAG agreed the eHCR that performed the best also dampened inter-annual variability when applied based on trends from the past 5 years.
49. For comparative purposes, the CSIRO scientific member provided the results from re-testing the rule using the alternative 3-year slope average, as well as a 3-year slope average in combination with catch averaged over 3 years, rather than 5.
50. The RAG noted the following results of key statistics performance under each alternative eHCR (compared to the status quo) (**Attachment F**, Figure 4):
    a) Under each eHCR, there is no risk to the spawning biomass falling below the limit reference point (Bsp<0.32K);

b) the risk of the spawning biomass falling below the precautionary limit reference point of 0.48K across each eHCR however the range of variance for both the 3-year alternative eHCR is considerably higher;

c) when considering average annual variability (AAV), the status quo 5-year eHCR performs best, with the lowest median AAV; and

d) when considering average catch, the median catch under the status quo 5-year eHCR is higher compared to the alternative 3-year candidates.

e) The use of a 3-year slope in combination with a 3-year catch average did not perform satisfactorily as biomass declines over time, however the alternative 3-year rule with 5-year average catch performed reasonably.

f) When comparing RBC outputs using available data in 2018, the 5-year slope eHCR yields an RBC of 500 tonnes, and the 3-year slope eHCR yields an RBC of 693 tonnes.

51. The RAG acknowledged that the key trade-off using an alternative 3-year eHCR results in much greater catch variability between years, i.e. the RBC may be much higher, or lower in any year. However, under the status quo 5-year eHCR, this variability is dampened to a greater extent.

52. **In consideration of the comparative results presented, the RAG agreed to not change the current eHCR and continue the use of the 5-year slope rule. Given this advice, the RAG also agreed that additional sensitivity analyses on the alternative eHCRs were no longer required.**

Harvest Strategy Decision Rules

53. The RAG considered the decision rule triggers under the draft Harvest Strategy. At the last RAG meeting, members discussed that given the experience during the 2017/18 season, the mid-year survey trigger may not align with the current expectations or management of the fishery.

54. The RAG noted the following key points:

a) If in any year the pre-season survey 1+ index is less than or equal to 1.25, a stock assessment is triggered;

b) If the eHCR limit reference point is triggered in the first year, a stock assessment update must be conducted in March;

c) If after the first year the stock is assessed below the biomass limit reference point, it is optional to conduct a mid-year survey noting that the pre-season survey must continue annually.

d) If the stock assessment determines the stock to be below the biomass limit reference point in two successive years, the TRL fishery will be closed to commercial fishing. Although unlikely, this circumstance could also result from other variables such as increased water temperatures, not just fishing mortality.

e) The current 1.25 trigger limit is based on historical lows in the 1+ index and although never breached, the 2017/18 1+ index was the lowest it had been within the series.

55. The CPUE index is a proxy measure for spawning biomass and so understanding trends in this index, particularly downward trends is important in planning management actions.

56. The CSIRO scientific member noted the importance of having pre-agreed actions in place if the trigger limit is breached which must also be considered with regard to resourcing availability for subsequent action. A more conservative trigger limit would provide an earlier indication that abundance may be in decline and to better understand what might be happening to the stock.

57. The RAG discussed that industry's reaction to the low RBC in the 2017/18 season and management changes to control catch that season, may suggest a more precautionary trigger is required. In light of this, the RAG considered two options for setting a higher trigger limit: 1) a biological trigger limit related to a biomass index; or 2) a TAC-based trigger limit. The RAG noted that using a TAC-based trigger limit may trigger a stock assessment more frequently which can have cost implications. It would also be affected by mechanisms (averaging) that dampened TAC changes, thereby masking underlying changes in biomass. The RAG also discussed concerns about modifying the trigger simply to satisfy economic objectives.

58. It was noted however, that with the determination of the TRL Management Plan the concerns expressed by industry the previous season under a low RBC would be less of an issue now that sectoral catch shares are in place. These concerns may also be addressed once variability in TACs is dampened under the 5-year eHCR.
59. It was also noted that the trigger and the Harvest Strategy can always be reviewed if considered to not be working effectively.

60. **Noting the sectoral catch shares in the fishery which may now alleviate previous concerns relating to the availability of TRL in a low TAC scenario; and the need to monitor the stock spawning biomass to inform RBCs, the RAG agreed to maintain the 1.25 trigger limit as a biological indicator to trigger an extraordinary stock assessment rather than an economics based trigger (e.g. TAC-based limit).**

6 Other Business

61. In response to an action item arising from the RAG, the CSIRO scientific member presented the preliminary key findings of the National Environmental Science Program (NESP) project assessing the influence of the Fly River runoff in the Torres Strait region. The RAG noted the following key points:
    a) The area of the Fly River influence is largely limited to the northern Torres Strait
    b) Habitats located north of Masig Island, as far east as Bramble Cay and at least as far west as Boigu Island are located in higher potential risk areas of exposure to brackish and turbid waters and associated contaminants from or derived from the Fly River.
    c) The assessment of trace metals in sediment and water across the region identified relatively low concentrations overall, with comparatively higher concentrations in the norther Torres Strait, and around Saibai and Boigu Islands in particular.
    d) The environmental and public health implications of this influence are still not well understood. While the impacts on TRL in particular are assumed to be low, the bioaccumulation risk for species such as turtles and dugong is much higher.
    e) While this movement of water from the Fly River is a historic pattern, the estimated 40 per cent 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.
    f) Under certain flow conditions, water can travel as far as the Torres Strait. Flow patters can be variable depending on currents and trade winds. Further, increased turbidity will still be seen in the Torres Strait during monsoon seasons due to the resuspension of sediments in the water column.
    g) It is unclear how the high concentrations of dissolved copper in benthic sediments around Saibai Island are impacting the area relative to deemed safe levels.
62. The RAG expressed a strong interest in further understanding the impacts on Torres Strait fisheries, particularly on larval production and survivability through testing tissue samples from TRL, mud crabs and sea cucumbers. A TVH industry member from MG Kailis offered to provide testing of frozen TRL tails for trace metal analysis.

Action
MG Kailis to submit tissue samples from frozen TRL tails for trace metal analysis to better understand the impacts of dissolved contaminants from the Fly River run off on important fisheries species in the Torres Strait.

63. While the results of the study are preliminary, the CSIRO scientific member agreed to circulate the full report to members when it becomes available.

Action

CSIRO to circulate the final report from the Fly River study to all RAG members once available.

7 Date and venue for next meeting

64. The next TRL RAG meeting is tentatively scheduled for the week beginning 4 February 2019, with exact dates to be confirmed out of session.
65. The Chair thanked Mr Terence Whap, Mr Mark David and Mr Phil Ketchell as all outgoing RAG members for their time and contributions to the RAG over the past three years. Their input to the fisheries management process was constructive and highly valued.
66. The meeting was closed in prayer at 10:50am on Wednesday 12 December 2018.

Declaration of interests
Dr Ian Knuckey – October 2018

Positions:

Director –	Fishwell Consulting Pty Ltd
Director –	Olrac Australia (Electronic logbooks)
Deputy Chair –	Victorian Marine and Coastal Council
Chair / Director –	Australian Seafood Co-products & ASCo Fertilisers (seafood waste)
Chair –	Northern Prawn Fishery Resource Assessment Group
Chair –	Tropical Rock Lobster Resource Assessment Group
Chair –	Victorian Rock Lobster and Giant Crab Assessment Group
Scientific Member –	Northern Prawn Management Advisory Committee
Scientific Member –	SESSF Shark Resource Assessment Group
Scientific Member –	Great Australian Bight Resource Assessment Group
Scientific Member –	Gulf of St Vincents Prawn Fishery Management Advisory Committee
Scientific participant –	SEMAC, SERAG

Current projects:

AFMA 2018/08	Bass Strait Scallop Fishery Survey – 2018 and 2019
FRDC 2017/069	Indigenous Capacity Building
FRDC 2017/122	Review of fishery resource access and allocation arrangements
FRDC 2016/146	Understanding declining indicators in the SESSF
FRDC 2016/116	5-year RD&E Plan for NT fisheries and aquaculture
AFMA 2017/0807	Great Australian Bight Trawl Survey – 2018
Traffic Project	Shark Product Traceability
FRDC 2018/077	Implementation Workshop re declining indicators in the SESSF
FRDC 2018/021	Development and evaluation of SESSF multi-species harvest strategies
AFMA 2017/0803	Analysis of Shark Fishery E-Monitoring data
AFMA 2016/0809	Improved targeting of arrow squid

25th MEETING OF THE PZJA TORRES STRAIT TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG 25)

Tuesday 11 December 2018 (9:00 AM – 5:00 PM)

Wednesday 12 December 2018 (8:30 AM – 11:00 AM)

TSRA Boardroom

Level 1 Torres Strait Haus

46 Victoria Parade, Thursday Island

ADOPTED AGENDA

1 PRELIMINARIES

1.1 Welcome and apologies

The Chair will welcome members and observers to the 25th meeting of the RAG.

1.2 Adoption of agenda

The RAG will be invited to adopt the draft agenda.

1.3 Declaration of interests

Members and observers will be invited to declare any real or potential conflicts of interest 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 RAG will be invited to note the status of action items arising from previous meetings.

1.5 Out-of-session correspondence

The RAG will be invited to note out of session correspondence on RAG matters since the previous meeting.

2 UPDATES FROM MEMBERS

2.1 Industry members

Industry members and observers will be invited to provide an update on matters concerning the Torres Strait TRL Fishery.

2.2 Scientific members

Scientific members and observers will be invited to provide an update on matters concerning the Torres Strait TRL Fishery.

2.3 Government agencies

The RAG will be invited to note updates from AFMA, TSRA and QDAF on matters concerning the Torres Strait TRL Fishery. AFMA will provide a summary of management arrangements for the 2018/19 fishing season.

2.4 PNG National Fisheries Authority

The RAG will be invited to note an update from the PNG National Fisheries Authority.

2.5 Native Title

The RAG will be invited to note an update from Malu Lamar (Torres Strait Islander) Corporation RNTBC.

3 PRELIMINARY RESULTS OF THE NOVEMBER 2018 PRE-SEASON SURVEY

The RAG will be invited to consider the preliminary results of the November 2018 pre-season survey.

4 STOCK ASSESSMENT UPDATE AND RBC

The RAG will be invited to consider the preliminary results of the integrated stock assessment. Preliminary estimates of the 2019/20 RBC will be provided based on the integrated stock assessment. Preliminary estimates of the 2019/20 RBC will also be provided based on the current empirical harvest control rule (eHCR), but will for noting as the Harvest Strategy has not been agreed by the PZJA.

5 REVISION OF DRAFT HARVEST STRATEGY AND CONTROL RULES

At their last meeting, the RAG recommended that some of the conditions and decision rule triggers in the harvest strategy be revisited prior to finalising the Harvest Strategy. This included consideration of the number of years to be averaged across in the eHCR index.

6 OTHER BUSINESS

The RAG will be invited to raise other business for consideration.

7 DATE AND VENUE FOR NEXT MEETING

The next RAG meeting is proposed for February 2019.

Action items from previous TRLRAG meetings

#	Action Item	Meeting	Responsible Agency/ies	Due Date	Status
1.	AFMA to review the effectiveness of certain TIB licensing arrangements (in its 2016 licencing review) including: • TIB licenses should share a common expiry date • licences to last for longer than the current 12 month period.	TRLRAG14 (25-26 August 2015)	AFMA	2017	**Ongoing** AFMA has begun undertaking a review of licensing of Torres Strait Fisheries, this issue will be considered as part of this review. At present however, AFMA resources are focused on progressing the proposed legislative amendments as a matter of priority. Further work on this item will be progressed in the 2019/20 financial year. • Administrative arrangements can be made to provide for licences held by the same person to expire on the same day. This change can be progressed when resources allow. • The *Torres Strait Fisheries Regulations 1985* currently provide for TIB and TVH licences to be issued for up to 5 years. Administrative arrangements can be progressed when resources allow.
2.	AFMA and CSIRO prepare a timeline of key events that have occurred in the Torres Strait Tropical Rock Lobster Fishery (e.g. licence buy backs, weather events and regulation changes) and provide a paper to TRLRAG.	TRLRAG14 (25-26 August 2015)	AFMA CSIRO	TRLRAG17 (31 March 2016)	**Ongoing** AFMA to complete further work. This has been difficult to action ahead of other priorities for the TRL Fishery.
3.	AFMA to liaise with Mr Pitt and Malu Lamar to provide agreed traditional names for the area around Erub.	TRLRAG23 (15 May 2018)	AFMA		**Ongoing** Further discussions needed to finalise this action. A map developed by the TSRA's Land and Sea Management Unit in consultation with PBCs, has recently been developed. A copy of this map has been provided to CSIRO and is provided at **Attachment 1.4c** for information.
4.	South Fly River studies to be provided for consideration at the next TRL and Finfish RAG meetings.	TRLRAG23 (15 May 2018)	AFMA	TRLRAG24 (18-19 October 2018)	**Ongoing**

#	Action Item	Meeting	Responsible Agency/ies	Due Date	Status
					A report detailing the findings of these studies is currently being finalised and will be provided once available, expected just prior to TRLRAG25.
5.	With regards to future TIB catch and effort analyses, CSIRO to explore the use of boat marks to improve location fished data extracted from the TDB02 CDR.	TRLRAG24 (18-19 October 2018)	CSIRO	2019	**Ongoing** To be examined when the next analyses are undertaken.
6.	Circulate copies of the Dao et al 2015 and Rothlisberg et al 1994 papers to the RAG for information.	TRLRAG24 (18-19 October 2018)	AFMA	TRLRAG25	**Completed** Papers provided at **Attachments 1.4d-e** for information.
7.	CSIRO to provide information on a recent review of the survey design to the RAG for information.	TRLRAG24 (18-19 October 2018)	CSIRO	TRLRAG25	**Ongoing** A review of the Torres Strait TRL Fishery survey design by the U.S. National Park Service is not yet finalised for distribution. A copy will be provided to the RAG once finalised. Provided at **Attachments 1.4f-i** for information are published peer-reviewed papers relating to the Torres Strait TRL Fishery survey design.
8.	RAG members to provide comments on the CSIRO TRL age class poster. CSIRO to include a better image of the 2+ lobster on the poster	TRLRAG24 (18-19 October 2018)	RAG CSIRO	2019	**Ongoing** Comments to be provided out-of-session and poster to be finalised in 2019.
9.	AFMA to prepare some explanatory material and a diagram explaining the start of season catch limit.	TRLRAG24 (18-19 October 2018)	AFMA	TRLRAG25	**Completed** Diagram provided at **Attachment 1.4j** developed and distributed to interested stakeholders. Further explanation was provided to all TRL Fishery licence holders prior to the start of the 2018/19 fishing season.

Table 1. Consideration of alternative hypotheses to explain the low 2017 0+ survey index compared with the 2018 1+ survey index. ***Source: TRLRAG25 Agenda paper 4a – Plagányi E et al. (2018) Preliminary summary regarding 2018 assessment of Torres Strait tropical lobster TRL stock. Summary Report for TRLRAG Dec 2018.***

	Alternative Hypotheses	Does it explain low 0+ in Nov 2017?	Does it explain 1+ size distrib^n in June 2018?	Notes and evidence	Plausibility
1	The 2017 0+ index was negatively biased due to observational error	No	no	There was some concern that as 2017 was the first year without a "gold standard" (GS) diver participating in the survey with considerable experience detecting the small 0+ age class, this may have biased the index negatively. However a statistical comparison of historical performance between GS and Other teams showed that whereas the GS teams generally found slightly more 0+, there was no significant difference between the results, and evidence of rapid learning. Even if the maximum likely bias is applied to the 0+ index, it does not increase it sufficiently to explain the 2018 1+ abundance.	low
2	The 2017 0+ index was low because of the timing of settlement	maybe	maybe	As lobsters spawn over a period of a few months, there is also approximately 3 months variability in terms of when they settle. In addition, the anomalous environmental conditions in 2016 (influencing the spawners producing the 2017 0+ cohort) could easily have influenced the timing of spawning and successful transport and settlement of pueruli. If settlement occurred earlier than usual, then this could explain relatively larger 1+ observed during 2018, but it means the 0+ would have been easier to observe during the 2017 survey. On the other hand, if settlement occurred later, then this explains the reduced numbers during the survey, but not the larger sizes of 1+ during 2018 (but it's possible that this was a result of a combination of timing of settlement and change in growth rate as below).	medium
3	Faster growth due to higher temperatures in 2017-2018 and/or reduced density dependence	no	yes	TRL growth is known to increase with increasing SST (Skewes et al. 1997) and there is evidence to suggest that the 2016 high temperatures had an influence on the stock, but there is less	high
4	The 2017 0+ index was low because the distribution of settling recruits changed substantially	yes	yes	The recent anomalous environmental conditions would have had an influence on local Torres Strait currents, as well as sand and habitat distribution and quality which could have influenced the spatial pattern of puerulus settlement. There is some evidence from the 2017 preseason survey 0+ spatial distribution data that the pattern differed to that observed in previous years e.g. lower than usual density in TI_Bridge stratum. The highest densities of 0+ were in the South-East and Mabuiag strata, so it's possible that relatively more settlement may have occurred to the north-west to the extent that the index wasn't as comparable as in previous years. Previous research (Skewes et al. 1997) showed that there are differences in growth rate	very high

Alternative Hypotheses	Does it explain low 0+ in Nov 2017?	Does it explain 1+ size distrib^n in June 2018?	Notes and evidence	Plausibility
			between the four zones (NW, SW, Central, SE), with lobsters being larger in the NW, and this may have contributed to the larger average size of this 1+ cohort (see Tonks et al. 2018).	

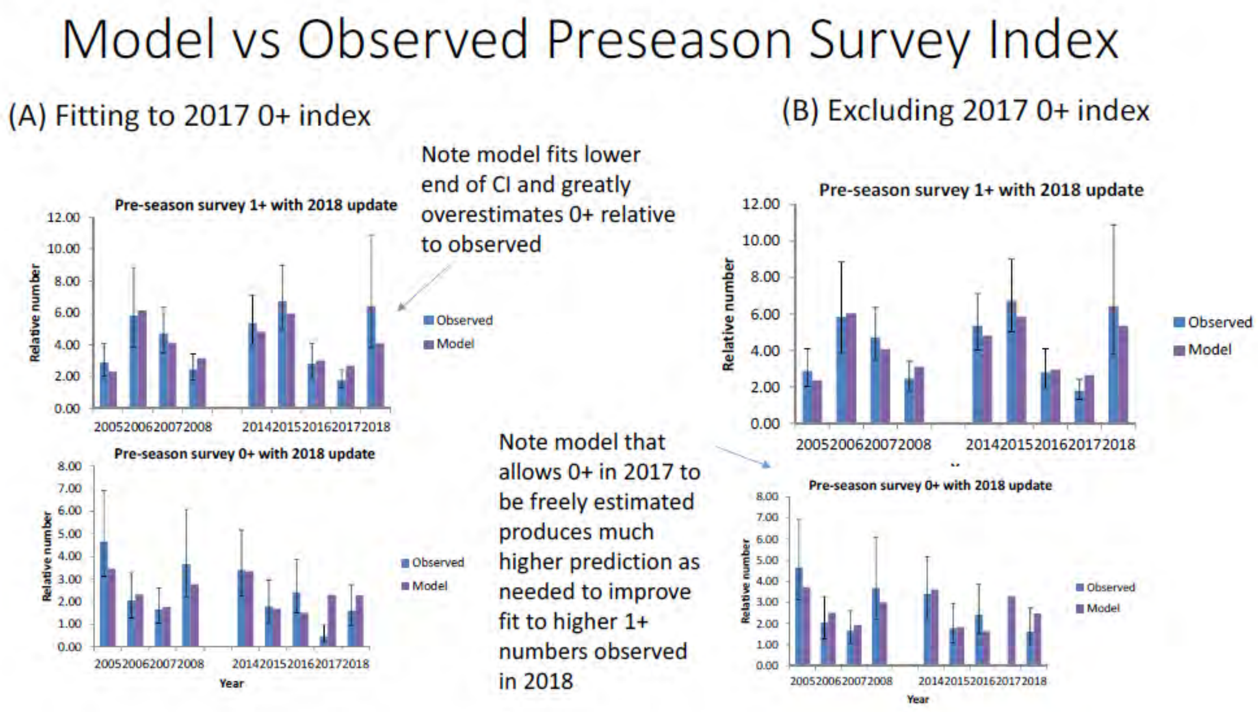

Figure 1. Comparison of stock assessment model fit to pre-season survey index when (A) including versus (B) excluding (for illustrative purposes) the 2017 0+ index.

Source: TRLRAG25 Agenda paper 4a – Plagányi E et al. (2018) Preliminary summary regarding 2018 assessment of Torres Strait tropical lobster TRL stock. Summary Report for TRLRAG Dec 2018.

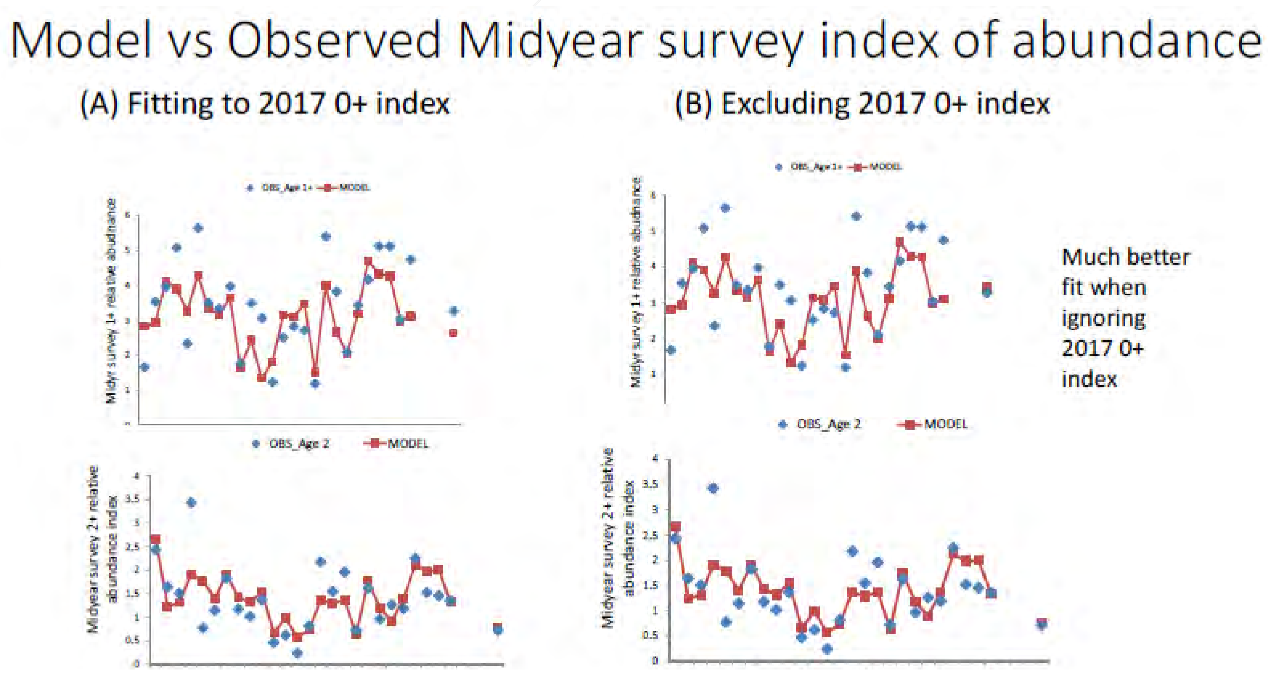

Figure 2. Comparison of stock assessment model fit to Midyear survey index when (A) included versus (B) excluding (for illustrative purposes) the 2017 0+ index.

Source: TRLRAG25 Agenda paper 4a – Plagányi E et al. (2018) Preliminary summary regarding 2018 assessment of Torres Strait tropical lobster TRL stock. Summary Report for TRLRAG Dec 2018.

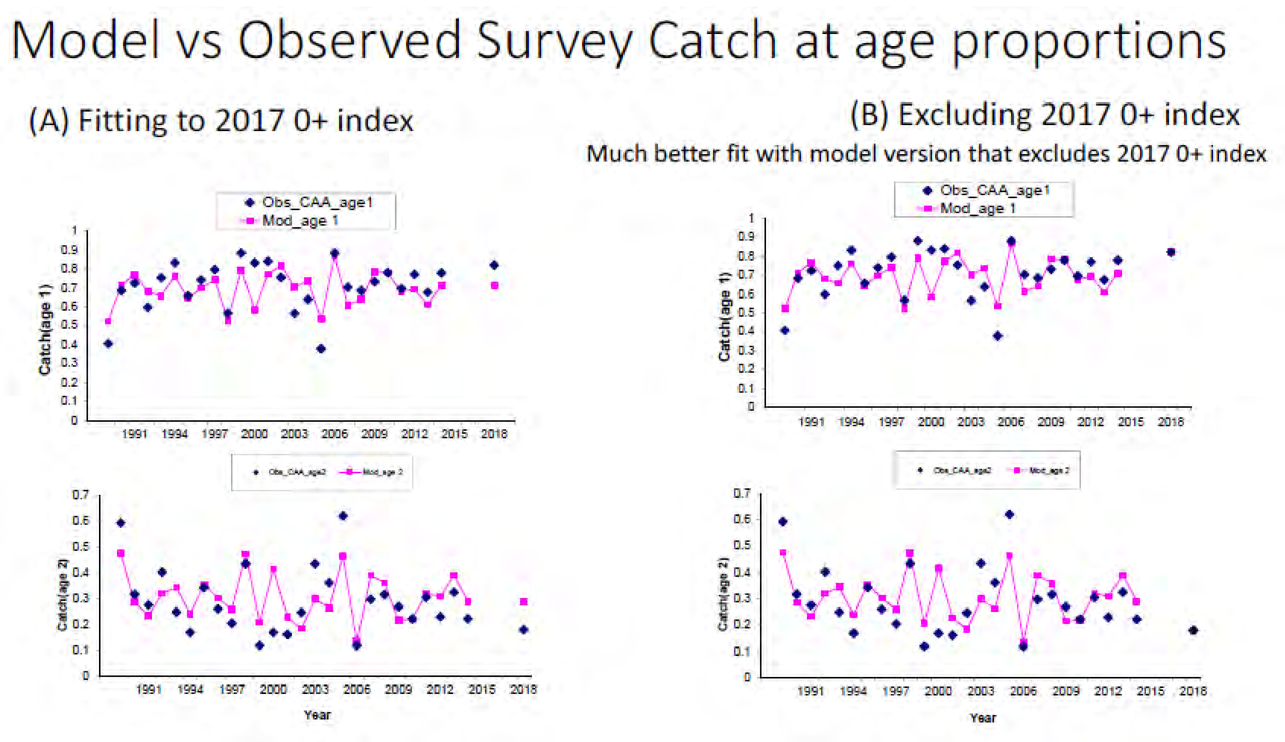

Figure 3. Comparison of stock assessment model fit to Survey Catch-at-Age information when (A) including versus (B) excluding (for illustrative purposes) the 2017 0+ index.

Source: TRLRAG25 Agenda paper 4a – Plagányi E et al. (2018) Preliminary summary regarding 2018 assessment of Torres Strait tropical lobster TRL stock. Summary Report for TRLRAG Dec 2018.

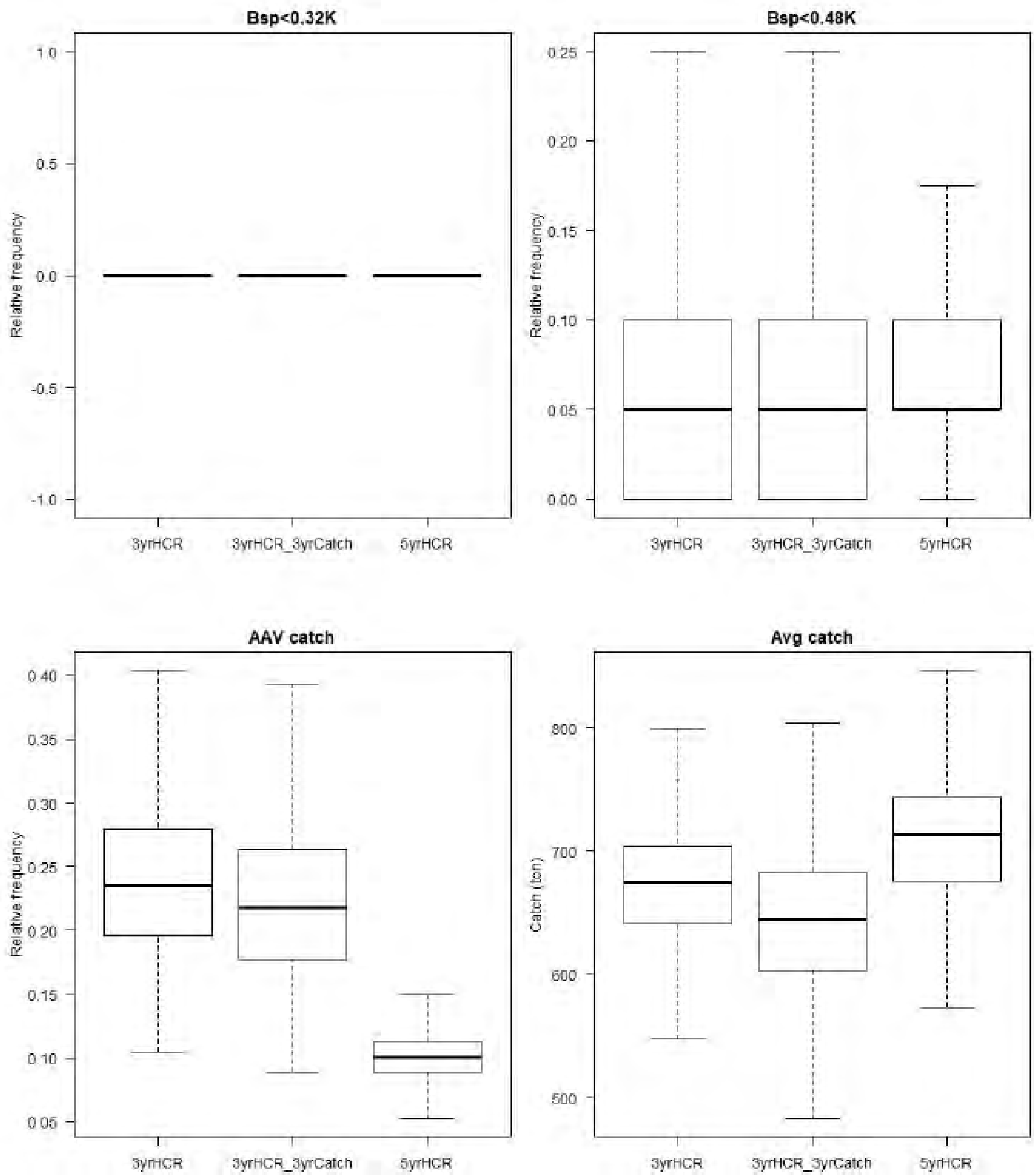

Figure 4. Comparison of some key performance statistics for final set of eHCRs. Plots show probability of depletion below each of two reference levels, B_{LIM} = 0.32K and precautionary level 0.48K limit reference point, together the Average Annual Variability (AAC) of catch, and ottal annual catch (t). The central lines shows the median, the box the 75th and 25th percentiles and the whiskers represent the full range of porojected values exlcluding outliers.

Source: TRLRAG25 Agenda paper 5c – Plagányi E et al. (2018) Testing an alternative empirical harvest control rule for the Torres Strait Panulirus ornatus tropical rock lobster fishery..

Torres Strait Tropical Rock Lobster Resource Assessment Group Meeting 25

Meeting Record

11-12 December 2018

Thursday Island

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

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 afma.gov.au

Contents

Meeting participants

Members

Name	Position	Declaration of interest
Ian Knuckey	Chair	Chair/Director of Fishwell Consulting Pty Ltd and Olrac Australia (electronic logbooks). Chair/member of other RAGs and MACs. Conducts various AFMA and FRDC funded research projects including FRDC Indigenous Capacity Building project. Nil interests in TRL Fishery and no research projects in the Torres Strait. Full declaration of interests provided at **Attachment A**.
Georgia Langdon	AFMA Executive Officer	Nil.
Natalie Couchman	AFMA member	Nil.
Mark Anderson#	TSRA member	Nil. TSRA holds multiple TVH TRL fishing licences on behalf of Torres Strait Communities but does not benefit from them. They will not be leased in the 2018/19 fishing season.
Danielle Stewart	Queensland Department of Agriculture and Fisheries (QDAF) member	Nil. Harvest Fisheries Manager, QDAF.
Andrew Penney	Scientific member	Research consultant (Pisces Australis), member of other AFMA RAGs (SPFRAG and SESSFRAG). Nil pecuniary or research interests in the Torres Strait.
Éva Plagányi	Scientific member	Lead scientist for PZJA funded TRL research projects conducted by CSIRO.
Aaron Tom	Industry member	Traditional Inhabitant Gudumalulgal and TIB licence holder.
Les Pitt	Industry member	Traditional Inhabitant Kemer Kemer Meriam and TIB licence holder.
Phillip Ketchell*	Industry member	Traditional Inhabitant Kaiwalagal, Traditional Owner and fisher.
Terrence Whap	Industry member	Traditional Inhabitant Maluialgal and Traditional

Name	Position	Declaration of interest
		Owner. Does not hold a TIB licence.
Daniel Takai+	Industry member	Pearl Island Seafoods, Tanala Seafoods, TIB licence holder and lessee of TSRA TVH licence in 2017/18 fishing season.
Brett Arlidge	Industry member	General Manager MG Kailis Pty Ltd. MG Kailis Pty Ltd is a holder of 5 TVH licences.

Observers

Name	Position	Declaration of interest
Joseph Posu	PNG National Fisheries Authority (NFA)	Nil.
Mark Tonks	Scientific observer	Project staff for AFMA funded TRL research projects
Jerry Stephen	TSRA Deputy Chair, TSRA Member for Ugar and TSRA Portfolio Member for Fisheries	TIB licence holder and Native Title holder.
Trent Butcher	Industry observer	TVH licence holder.
Suzannah Salam^	Industry observer	Torres Straits Seafood Pty Ltd, TIB licence holder and lessee of TSRA TVH licence in 2017/18 fishing season.
Nathan Binjuda	Industry observer	Traditional inhabitant crew on TVH operated vessel
Allison Runck	TSRA observer	Nil.
Medina David	TSRA observer	Nil.

Notes:

Departed the meeting at 3.30pm on Tuesday 11 December

* Arrived after morning tea ~ 11am on Tuesday 11 Dec and left again at 3.30pm to attend the Fisheries Stakeholder meeting with Assistant Minister Colbeck. Did not attend on Wednesday 12 December.

^ Attended the full day on Tuesday 11 December. Arrived at 9.40am on Wednesday 12 December.

+ Departed the meeting between 2-3pm on Tuesday 11 December

1 Preliminaries

1.1 Apologies

1. The meeting was opened in prayer at 9 am on Tuesday 11 December 2018.
2. The Chair welcomed attendees to the 25th meeting of the Torres Strait Tropical Rock Lobster Resource Assessment Group (TRLRAG 25). The Chair acknowledged the Traditional Owners of the land on which the meeting was held and paid respect to Elders past and present.
3. Attendees at the RAG are detailed in the meeting participant tables at the start of this meeting record.
4. Apologies were received from Mark David (Industry Member and Traditional Inhabitant Kulkalgal), Dr Ray Moore (Industry Member).

1.2 Adoption of agenda

5. The draft agenda was adopted (**Attachment B**).

1.3 Declaration of interests

6. The Chair stated that as outlined in PZJA Fisheries Management Paper No. 1 (FMP1), all members of the RAG must declare all real or potential conflicts of interest in Torres Strait TRL Fishery at the commencement of the meeting. Declarations of interests were provided by each meeting participant. These are detailed in the meeting participant tables at the start of this meeting record.

1.4 Action items from previous meetings

7. The RAG noted the status of actions arising from previous TRLRAG, and where relevant, TRL Working Group (TRLWG) meetings (**Attachment C**).
8. The RAG noted that the final meeting record for TRLRAG 24 held on 18-19 October 2018 was finalised out of session.

1.5 Out-of-session correspondence

9. The RAG noted out of session correspondence on RAG matters since the previous meeting.

2 Updates from members

2.1 Industry and scientific

10. The RAG noted updates provided by industry and scientific members, and observers on the performance of the TRL Fishery during 2017/18 and at the very start of the 2018/19 season (only two weeks in) and raised the following:
    a) A Transferable Vessel Holder (TVH) industry member advised that since the start of the 2018/19 season prices have been good due to the low supply of lobsters in the previous season. The start of the 2019 season was so far showing lots of small size lobsters, and not a lot of larger lobsters. Similar results are also being seen with smaller tails from Papua New Guinea (PNG).
    b) Local catch rates (around Thursday Island) are down, however anecdotal reports indicate that Warrior Reef and the central islands are doing well.

c) A Traditional Inhabitant member advised that during the first week of the season, free divers were surprised by the abundance of 0+ and 1+ lobsters in the east which are not normally observed in Kemer Kemer Meriam waters.

d) Other TI members advised that more 1+ lobsters are being observed around home reefs in the western and top western islands, compared to last season where fishers were working further afield. It is usually around 1 January when the larger lobsters come back in to the fishing grounds.

e) A TVH industry observer also reported lots of small lobsters are around. He added that although the lobster stocks is looking strong, warmer water temperatures are having an impact on captured lobsters in cages.

f) An industry buyer advised that the ratio of 1+ lobsters, to larger sizes (2+) is about 60/40 with lots of positive reports from fishers that the lobsters are around. Prices are looking good with no oversupply, and it is expected to remain that way until February when hookah diving commences. Due to an earlier than usual Chinese New Year, the hookah divers will miss out on the higher Chinese New Year prices.

g) Another TVH industry member also advised that frozen whole lobsters will often get a better return for fishers than tails, however the frozen whole market is limited and has been flooded before. Currently there is not a huge demand for whole frozen lobsters unlike 4-5 years ago, however prices are slightly higher. An industry buyer added that the market prefers smaller whole frozen lobsters. It was also noted that there is currently no field on the TRL daily fishing logs to record whole frozen lobsters.

11. The RAG noted that no additional scientific updates were required as all relevant topics were to be covered under other agenda items.

2.2 Government

12. The RAG noted an update provided by the AFMA member regarding management initiatives relevant to the TRL Fishery:

TRL Management Plan and Sectoral Split

a) On 26 November 2018, having considered outcomes of consultation, the Protected Zone Joint Authority (PZJA) decided to determine the *Torres Strait Fisheries (Quotas for Tropical Rock Lobster (Kaiar)) Management Plan 2018* (the Management Plan) and to amend the *Torres Strait Fisheries (Tropical Rock Lobster) Management Instrument 2018* (the Instrument).

b) The Management Plan and amendments to the Instrument came into force for the 2018/19 fishing season starting on 1 December 2018.

c) Unless delayed by legal appeals, a quota management system will be fully operational in the TRL Fishery for the 2019/20 fishing season. A review of existing PZJA licencing policies and management arrangements, including input controls, will be conducted periodically after the quota management system is operational.

d) During 2018/19, separate total allowable catch (TAC) shares will be implemented on an interim basis; 66.17 per cent under an Olympic TAC for the TIB sector and 33.83 per cent share under provisional quota allocations for the TVH sector.

Interim and final TACs

e) In order to give effect to the sectoral split, the PZJA further agreed to open the 2018/19 fishing season with an interim TAC of 200 tonnes. This decision is based on advice received from the TRL Resource Assessment Group and TRL Working Group that an interim TAC derived from the maximum annual catch amount over the years 2005-2018 for the period 1 December and end of February should be implemented.

f) AFMA will be working closely with PNG NFA over the coming months to finalise negotiations on how the Recommended Biological Catch (RBC) is shared between Australia and PNG in line with obligations under the *Torres Strait Treaty*.

Moon-tide Hookah Closures

g) The PZJA also reaffirmed existing management controls currently applied to the TRL Fishery, to be implemented under the Instrument and licence conditions. This includes periodic closures to the use of hookah gear for three days either side of the full or new moon each month based on the largest difference between high and low tide levels.

h) AFMA will be looking to review the current input controls in the TRL fishery to better understand if they are still required as management tools in the fishery once it is fully transitioned to a quota management system.

13. The RAG discussed:

a) Whether tidal flows and currents have been considered when calculating moon-tide closures as current flow rates (as distinct from tidal height differences) have a significant impact on the ability to dive for TRL. Noting the variability in tides across the Torres Strait region, the AFMA member advised that the moon-tide hookah closures are calculated using the Bureau of Meteorology tide charts from Thursday Island. The RAG advised that the Thursday Island charts should be continued to be used.

b) An industry member advised that the TIB sector will continue to advocate for moon-tide hookah closures to remain in place and agreed that strong currents are an important factor influencing TIB fishing effort.

c) In considering the RAGs advice to the TRL Working Group about who will discuss any changes to input controls, a scientific member advised that any changes to input controls will have an impact on Catch per Unit Effort (CPUE) index used in both the assessment and empirical harvest control rule (eHCR). If moon-tide hookah closures, or other input controls, are removed the RAG will need to consider the impacts on CPUE and how these impacts will be adjusted for in future analyses. If the closures are to change, it was suggested that a staggered or transitional approach would be beneficial to try and understand any potential impacts on fishery trends over time.

d) The CSIRO scientific member agreed and advised caution when considering any management arrangements that will impact abundance indices in the fishery noting that fishery data trends will also be impacted by the wholesale change to a quota system. Economic implications should also be considered for the fishery, as well as those for the data and stock assessment.

14. **The RAG agreed that the potential removal of any input controls should be addressed with caution. Given the immediate changes that will apply as the fishery moves to a quota management system, the RAG recommended that all current input controls remain in place for the 2018/19 season before a review (or change) of input controls takes place.**

15. The RAG also discussed:

a) A concern raised regarding the carriage of hookah apparatus on board during a hookah closure. Some industry members queried if at the end of a moon-tide hookah closure, where an operator still has capacity to fish the remainder of their quota using free dive only, if they must still return to port to unload their hookah gear. Some industry members feel this creates an economic disadvantage for their operations. The AFMA member advised that the AFMA compliance team are looking at ways to effectively enforce this rule without being completely unpractical and economically disadvantageous for operators. They stressed that at under present rules, the requirement is for hookah apparatus to be removed during moon-tide hookah closures if an operator is to continue fishing;

b) Concerns with how catches will be tracked against the quota system during 2018/19 if the catch reporting system is not implemented in real time. The AFMA member advised that the primary responsibility lies with TVH operators to keep track of and report what they have caught against the allowable weight provided as a condition on each licence. AFMA will use Catch Disposal Records (CDRs) to verify catches against each TVH operator's allocation. This will be a manual process initially. It is expected that the fishery will move to the Commonwealth system known as GoFish which allows operators to log in online and view their quota balance for the season.

16. The AFMA member also advised that AFMA (through the Australian Institute of Marine Science – AIMS) is monitoring increased water temperatures and the potential impact on TRL stocks. Industry operators were advised to consider their stocking densities of TRL in cages as a precaution during periods of warmer water temperatures. Overstocking may lead to unacceptable quality or mortality rates in conditions during periods of raised water temperatures.

17. The RAG noted an update provided by the QDAF member regarding the East Coast TRL fishery:

    a) QDAF have held a series of TRL Fishery Working Group meetings since the last RAG to progress the development of a TRL Harvest Strategy.

    b) A similar logbook issue was raised in Queensland with regards to whole frozen lobster. QDAF are looking to address this with the rollout of electronic logbooks next year as the data is not being effectively captured on paper logs.

18. The RAG discussed the following key points:

    a) The RAG data subcommittee should learn more about the QDAF e-logs program, to ensure Torres Strait and Queensland TRL datasets remain compatible.

    b) Electronic logbook reporting is being rolled out in the Commonwealth, however changes need to be made to *Torres Strait Fisheries Act 1984* (the Act) before it can be considered in the Torres Strait TRL fishery.

    c) Concerns around data confidentiality in the Fish Receiver System (FRS) when reporting on areas fished. The AFMA member advised that the *Torres Strait Fisheries Act (1984)* currently constrains how spatial data can be collected and so the provision of such data is only voluntary on CDRs. These constraints are also being addressed through legislative amendments to the Act. Any legislative amendments (including mandatory TIB logbook reporting or electronic logs) will take a number of years to achieve as the amendment process is lengthy.

19. The RAG agreed that although legislative changes are a lengthy process, the RAG data subcommittee should start considering the data needs of the fishery moving forward.

20. The RAG noted an update provided by the TSRA member regarding TSRA activities relevant to the management of the TRL Fishery:

    a) New Traditional Inhabitant members were elected at the 2018 Fisheries Summit, with three new members joining the TRL RAG, and three members outgoing.

    b) The TSRA member thanked the outgoing Traditional Inhabitant Members Mr Terrence Whap, Mr Mark David and Mr Phil Ketchell for their contributions to the RAG over the past three years.

    c) The TSRA will be holding an induction program for all incoming and ongoing PZJA forum members in early 2019.

Action
The TRL RAG Chair to provide the TSRA with a copy of expected behaviours of RAG members to assist with the induction program for incoming PZJA forum members.

21. The RAG also noted and discussed the following:

   a) The TSRA is progressing the development of an independent entity that will hold fisheries assets on behalf of traditional inhabitants. The TSRA member advised that a shortlist of model options will be considered.

   b) Based on extensive community consultation advice, the TSRA will not be considering the leasing of any further TVH licences leasing during 2019. The TSRA member advised that the lease arrangements for the 2017/18 season were made before advice was received of a low RBC. Industry expressed the belief that fishing effort had increased through the TSRA's leasing of licences, however the licences were leased by TIB operators already active in the fishery.

2.3 PNG NFA

22. The RAG noted an update from the PNG NFA member regarding management of the PNG TRL Fishery:

   a) The PNG fishery remains closed to hookah diving and is scheduled to re-open in April 2019. The fishery was closed with resistance from the artisanal sector.

   b) Management are looking to implement other appropriate management measures as the early fishery closure was not anticipated.

   c) PNG is hoping for a higher RBC in 2019 to meet market demand.

23. In response to a question from CSIRO about the size of lobsters observed in the fishery, the PNG NFA member advised that this is a key area the NFA is trying to address through the collection of length frequency data. Both CSIRO and the PNG NFA member agreed to continue discussions on data PNG may be able to provide to feed into the current TRL stock assessment.

2.4 Native Title

24. No updated was provided as a Malu Lamar representative was not in attendance.

3 Preliminary Results of the November 2018 Pre-Season Survey

25. The RAG considered a presentation provided by Dr Mark Tonks, CSIRO Scientific observer detailing the preliminary results of the November 2018 pre-season survey:

   a) Dive surveys were conducted between 11-22 November 2018 aboard the *"Wild Blue"* and CSIRO dive tender. The surveys were undertaken by four divers, Mark Tonks, Nicole Murphy, Kinam Salee and Steve Edgar with the experience of 23 TRL surveys combined.

   b) Dive surveys were conducted at 82 sites consisting of 77 repeat pre-season sites and 5 additional sites in the northwest. Photo transects were also completed at 7 sites to monitor coral bleaching.

   c) The pre-season TRL surveys provide indices of abundance for recruiting age lobsters (age 1+) and recently-settled lobsters (age 0+), abundance indices by stratum (region) and length-frequency and sex ratios. Most older lobsters (age 2+) have migrated and those that remain are mostly male.

1+ pre-season index

   d) The 2018 1+ pre-season index is above average and approximately 3 times the 2017 survey index. The pre-season 1+ counts per site indicated good recruitment throughout the fishery, but higher counts along the western side. This differs from the 2017 pre-season site counts, which were higher in the south-east and low in most other regions.

e) The survey also indicated good recruitment across all strata particularly in the northwest region (Mabuiag and Buru). Buru had a high standard error due to high count variability between sites. In 2018, Mabuiag and Buru recorded their highest indices over the last 9 surveys.

0+ pre-season index

f) Although less well estimated, the 2018 0+ index was three times the 2017 0+ index however this was not significantly different from the 2006, 2007, 2015 and 2016 indices.

g) 0+ age counts were indicative of typical settlement mostly on the western side of the survey area. 2018 0+ counts were not dissimilar to 2016, but there was fewer 0+ in the south west, and more in the north west. All 2018 0+ counts were significantly better than in 2017.

h) Abundance indices by stratum showed Mabuiag significantly higher than the other stratum. The 2018 0+ indices showed similar regional recruitment trends compared to previous surveys.

2018 pre-season size and sex ratio

i) The modal size of age 1+ has increased compared to recent years.

j) 2018 length frequency trends were similar to 2005 and the sampled sex ratio was almost 1:1, which is as expected.

26. The RAG discussed:

a) The key stratum in the survey are not mapped or selected based specifically on where commercial catches are made. They stem from the original benchmark survey that collected habitat data across the Torres Strait. Survey sites were then randomly selected from areas of habitat known to support lobster populations. The RAG also noted that the strata used in the survey, differ from those collected through the TRL04 logbook and TDB02 CDR. The CSIRO scientific member advised that these strata can be better cross-mapped as improvements are made to the collection of spatial data (lats and longs) through logbooks and CDRs.

b) The Chair noted an issue with the presentation of industry-provided length frequency data analysis which indicated a consistent peak over the years at a certain length. The RAG considered that this was likely due to how a conversion factor is applied to catch weight data to convert it to length.

Action
CSIRO to investigate the reasons for the consistent peak in the length frequency distribution and determine if it is related to conversion factors from the catch weight data provided by MG Kailis.

c) An industry observer expressed concern as to why there are more dive sites around Warrior Reef compared to others where greater lobster production is observed. The CSIRO scientific member reiterated that the original benchmark survey contained hundreds of sites. Following this, the first pre-season survey had 140 sites which were selected from the original benchmark survey. The sites have since been reduced to just 77 but ensuring they remain representative. Other sites were removed due to logistical constraints. For example, some deep sites were removed due to more stringent CSIRO diving requirements. In reducing the number of sites in the survey, some trade-offs around precision were considered by the RAG.

d) The CSIRO Scientific member advised that the survey has been scaled down over recent years in order to reduce costs however this was done with consideration of the potential loss of precision. The original sites were based on habitat, and were reduced in a way to ensure the survey would still give a reliable estimate of recruiting biomass.

27. The RAG was asked to consider whether to include the additional 5 sites from the 2018 surveys in the calculation of the abundance indices:
    a) The RAG noted that the additional 5 sites were added to the 2018 surveys to answer specific questions around the distribution of the stock in that particular year. Such ad-hoc modifications, if they are ongoing, may undermine the representativeness of surveys over time.
    b) The independent scientific member noted that should the re-inclusion of sites (back to 140) be proposed, this must be undertaken the same way they were removed, in a statistical and planned method. With no additional resources available to increase the number of survey sites, continuity in the data into the future must be considered.

Action
CSIRO to calculate the cost of increasing the number of pre-season survey sites from the current 77 sites back to 140 for RAG industry members to consider.

    c) **The RAG agreed that the additional 5 sites from the 2018 surveys should not be included in the calculation of the survey indices.**

28. The RAG noted that analyses pertaining to the catch and effort data from the 2017/18 season, including the standardised CPUE indices, were presented at TRLRAG 24 held on 18-19 October 2018. No further analysis has been undertaken since that time.

4 Stock Assessment Update and RBC

29. The RAG considered a presentation provided by Dr Eva Plaganyi, CSIRO Scientific member detailing the preliminary results of the 2018 stock assessment update:
    a) <u>Summary of life cycle and assessment</u> – The pre-season survey provides a rough indication of how many 0+ lobsters have settled in the region. It also provides a good estimate of how many 1+ recruits will be available to be fished in the coming season (next year). The 2+ lobsters are fished before females migrate out of the Torres Strait to breed between August and September each year. The fishery-dependent CPUE data provides an index of 2+ abundance.
    b) <u>Assessment basics</u> – The number of 0+ settled lobsters is compared with the spawning biomass to inform the stock recruitment relationship. This relationship is highly variable but a low spawning biomass has a higher probability of poor recruitment. The pre-season survey is then used to estimate how many lobsters will be available to be caught in the coming season. The stock assessment model calculates how many of these lobsters can be caught while ensuring the spawning biomass is kept close to the target level (0.65_{SB}). The model applies a fixed target proportion of 0.15 unless the spawning biomass is lower than the reference point.
    c) <u>Summary of model</u> – the stock assessment uses an Age Structured Production Model (ASPM) which corresponds to a Statistical Catch-at-Age Analysis (SCAA) as the data fitted includes catch-at-age information. This is a widely used approach for providing TAC advice. The output of the assessment is a Recommended Biological Catch (RBC) with confidence intervals each year. It is an integrated assessment that takes into account all available sources of information. This includes:
        i. Pre-season survey data (9 years with a gap in the time series);
        ii. Mid-year survey data 1989-2014; 2018;
        iii. Catch statistics from all sectors in the Torres Strait;

iv. Length frequency data (Australia and PNG);
v. CPUE data from TVH sector;
vi. CPUE data from TIB sector; and,
vii. Historical information.

30. The PNG NFA member noted that some PNG catches from recent months are still outstanding and that there had not been any trawling effort in the Gulf of Papua in the past season. Noting that the PNG season does not normally close until 1 December, the RAG agreed that the timelines for assessment need to be considered if data concerning catches from the PNG sector are delayed.

Action
Considering assessment timelines, PNG NFA to provide CSIRO with a best estimate of PNG catches by mid-November. CSIRO to liaise closely with PNG regarding reporting timeframes and provision of catch data. In parallel, the RAG data sub-group to examine ways to adjust the stock assessment model to account for delayed catch data from PNG.

d) TVH CPUE – the model incorporates six different standardised CPUE series. There is little difference between these series. The RAG requested the data sub-group have further discussions as to the best series to use. The reference case CPUE series currently used in the assessment is 'Int-1'.

Action
That the TRL RAG data subcommittee discuss which TVH CPUE series are the best to use within the model.

e) TIB CPUE – 4 different standardised CPUE series are used for the TIB sector. The RAG agreed to use the 'Seller' series as the reference case as the remaining three standardisations are impacted by the issue of area caught vs area landed. This issue is to be discussed further by the RAG data sub-group.

f) Model 'Reference Case' Specifications

i. Fixed steepness h=0.7
ii. Fixed hyperstability parameters for each CPUE series (TVH 0.75; TIB 0.5)
iii. Mid-year survey index – after applying mixture model to separate age classes
iv. Pre-season survey index – use as Reference MYO (mid-year only) series and same series as in November 2017 without the additional 5 sites added
v. CPUE TVH – Int-1 standardised series (and Int-3)
vi. CPUE TIB – Seller standardised series

g) Key sensitivities –

i. fix steepness h=0.6 and try to estimate h
ii. fix CPUE hyperstability parameters (TVH 1; CPUE TIB 1); try to estimate hyperstability parameters
iii. pre-season survey index – use the additional 5 sites added; test other series particularly excluding Buru which provides a lower standard error for 1+ index; downweight pre-season 0+ (2017)
iv. CPUE TVH – Int-3 standardised series; nominal

v. CPUE TIB – Seller&A standardised series; nominal

31. The RAG noted that each CPUE series has an associated variance to which the model weights each accordingly. The 1+ index is the most reliable indicator of biomass and the key input to the model with the greatest weight, however the model considers all corroborating information.

32. In the current assessment update, a significant data conflict exists between the November 2017 0+ index (which was very low relative to historical) and the 2018 1+ index (which was closer to average). Given the good confidence in the survey observations of 1+ lobsters, CSIRO explored the impacts of the anomalous 2017 0+ index on the model. The stock assessment model is sensitive to the inclusion or exclusion (or down-weighting) of the 2017 0+ index. To inform the discussion on how the anomalous 0+ index should be treated, CSIRO presented some alternative hypotheses to explain the data conflict (**Attachment D**, Table 1).

33. The RAG agreed that Hypotheses 4 was the most plausible explanation. It is known that lobster settlement changes from year to year however if it were to change radically, this is unlikely to be detected in the survey. The 0+ counts will always be more uncertain than the 1+ counts, given the cryptic nature of 0+ lobsters; even if there is a variable distribution of 1+ lobsters, the survey can still capture this, however if for example, all 0+ settled up in the north west or somewhere outside the survey sites this may not be captured in the fishery-wide survey counts.

34. Previously, the RAG has agreed that the 0+ index contains valuable information and is a key input in to stock assessment. With the exception of 2017, the 0+ index has generally been consistent with the following year's 1+ index. The independent scientific member agreed that anecdotal industry reports reaffirm that perhaps the survey did not accurately capture the 0+ lobster counts due a change in distribution or some other factors. Industry observers provided anecdotal reports of significant numbers 0+ lobsters observed in the fishery last season. The CSIRO scientific member agreed that, given the sound evidence of a reasonable 2018 1+ index, there must have been 2017 0+ lobsters in the fishery that were not evident in the survey index.

35. When examining the model versus observed pre-season index, there is a conflict between the 2017 0+ and 2018 1+ indices. To demonstrate the impact this conflict can have on the assessment, CSIRO undertook a comparison of the stock assessment model fit to the pre-season survey index when; (A) fitting to the 2017 0+ index, versus (B) excluding the 2017 0+ index. Under scenario (A), the model fits to the lower end of the confidence intervals and greatly overestimates the 0+ index relative to the observed. Under scenario (B), the model allows the 0+ index in 2017 to be freely estimated which produces a much higher predication as needed to improve the fit to the higher 1+ numbers observed in 2018 (**Attachment E**, Figure 1).

36. Similarly, when comparing the mid-year survey index of abundance (**Attachment E**, Figure 2) and the model versus observed survey catch-at-age proportions (**Attachment E**, Figure 3) the assessment achieves a much better fit when the 2017 0+ is excluded.

37. <u>Results of the Reference Case</u>

    a) The reference case model fits well to both previous benchmark surveys, and the 1+ and 2+ relative abundances from mid-year surveys.

    b) Stock recruitment residuals are average, however the results are higher when the 2017 0+ is down-weighted.

    c) Spawning biomass has declined in recent years but the RBC for the 2018/19 season will enable the spawning stock biomass to increase back towards the target.

    d) Fishing mortality estimates also indicate that the spawning stock biomass was low and supports the 2018 decision to limit catches.

    e) Hyperstability parameters are fixed within the reference case model. The TIB CPUE series has a far more hyperstable index than the TVH CPUE series. This is largely due to the TVH fleet being more mobile and therefore more efficient at maintaining higher catch rates. When estimating the hyperstability parameters the model CPUE index is lower than the model observed.

38. In considering how to treat the anomalous 2017 0+ index in the assessment, the RAG considered and discussed the following key points:

a) Given that the model fits the 0+ index reasonably well throughout the time series, except for 2017, it provides support to down-weight but not exclude the single 2017 0+ data point;

b) The mid-year survey validates down-weighting or excluding the 0+ index and supports the results of the 2018 pre-season survey;

c) The 2017 0+ index falls outside of the normal distribution which is statistically possible, although rare;

d) Caution should be exercised around selecting a down-weighting value on the 0+ index simply because it provides a more favourable 1+ index;

e) The 2017 0+ index is a result of the 2016 spawning stock biomass which experienced an anomalous year in terms of poor environmental conditions including high water temperatures. Oceanographic modelling will improve our understanding of such conditions on the abundance of the stock;

f) Excluding the 0+ index entirely would impact the eHCR as the harvest control rule incorporates the 0+ index. However, with a stock assessment scheduled every three years under the draft Harvest Strategy, continuing with one anomalous data point should not impact the overall function of the eHCR.

39. **There is evidence to suggest the 2017 0+ index may be anomalous. The RAG agreed that the 0+ series should be down-weighted appropriately rather than be excluded entirely. The down-weighting should be undertaken using an appropriate statistical methodology and not be applied arbitrarily. CSIRO undertook to complete this work prior to the next meeting.**

40. Recommended Biological Catch – although the RAG agreed on how to treat the 2017 0+ index, the CSRIO scientific member presented a range of RBC values depending on how the 2017 0+ index may be treated (e.g. excluded or down-weighted by doubling the variance).

    a) When the 2017 0+ index is included, the reference case model provides an RBC value of 533 tonnes.

    b) When the 2017 0+ variance is doubled as a means of down-weighting this point, the reference case model provides an RBC value of 637 tonnes.

41. **Given the RAG advice to apply a statistically calculated down-weighting to the 2017 0+ index, the RAG noted that the final RBC would likely lie somewhere between 533 and 637 tonnes. A final RBC value will not be available until the February 2019 TRL RAG meeting.**

42. The RAG also noted advice from the AFMA member that once a final RBC value is available, Australia and PNG will need to have discussions as to how the RBC is shared between the two countries under the *Torres Strait Treaty*. The initial split is 85 per cent to Australia, and 15 per cent to PNG, based on the agreed distribution of the stock. Each country then has a right to access 25% of the other country's share in that country's waters through cross-endorsement. Discussions on this arrangement are scheduled to commence in January 2019.

43. Environmental Correlates – Although not formally included in the current reference case model, the RAG considered some preliminary results on how environmental correlates may impact the stock assessment:

    a) The predictions are for temperature increases under the current emission scenario for Australia. Although not expected for several decades, once temperatures in Torres Strait consistently exceed 30 degrees Celsius, the impacts on the TRL fishy may be significant. Most marine animals including TRL have thermal tolerances with optimal conditions, however once conditions are above the thermal tolerance, negative impacts on the population increase markedly.

b) The climate-linked model indicates that spawning biomass is trending downwards more significantly than the non-climate linked model which also changes the historic depletion statistics.

c) Under the climate-linked model, some additional growth variability can be explained. When understanding historical trends, some can be explained by sea surface temperatures (SST).

44. The RAG acknowledged that under a climate-linked model, if a significant impact is detected, this can have implications for reference points and how that impacts the stock assessments that underpin the Harvest Strategy and eHCR. Other reference points such as fished versus unfished biomass may need to be considered in future.

45. **Noting that understanding climate effects is a high research priority for the TRL fishery, the RAG agreed that further consideration of the impacts of SST on the fishery is important and that CSIRO should continue to explore this.**

5 Revision of Draft Harvest Strategy and Control Rules

Empirical Harvest Control Rule (eHCR)

46. The RAG considered a presentation provided by Dr Eva Plaganyi, CSIRO Scientific member detailing the results of testing of alternative empirical harvest control rules for the Torres Strait TRL fishery.

47. At the last RAG meeting held on 18-19 October 2018, members recommended that in light of the 2017/18 season, the number of years to be averaged in the eHCR index and decision rule triggers be revisited at the next meeting of the RAG prior to finalising the Harvest Strategy. The eHCR is designed to adjust the RBC relative to a recent average, based predominantly on the logarithm of the slopes of recent trends of four key indicators; the pre-season recruiting lobster (1+) weighted at 70%, with lower weighting accorded to trends in recently-settled lobster (0+) and CPUEs from the TIB and TVH fishing sectors (each 10%).

48. Key performance statistics also previously considered by the RAG included spawning biomass level, and levels relative to target reference levels, average annual catch (over 20 years), and average annual variability in catch as well as risk to the fishery and risk of closure of the fishery. Other eHCR candidates have previously been considered in terms of how well each rule performed with regard to the fishery objectives, however the RAG agreed the eHCR that performed the best also dampened inter-annual variability when applied based on trends from the past 5 years.

49. For comparative purposes, the CSIRO scientific member provided the results from re-testing the rule using the alternative 3-year slope average, as well as a 3-year slope average in combination with catch averaged over 3 years, rather than 5.

50. The RAG noted the following results of key statistics performance under each alternative eHCR (compared to the status quo) (**Attachment F**, Figure 4):

a) Under each eHCR, there is no risk to the spawning biomass falling below the limit reference point (Bsp<0.32K);

b) the risk of the spawning biomass falling below the precautionary limit reference point of 0.48K across each eHCR however the range of variance for both the 3-year alternative eHCR is considerably higher;

c) when considering average annual variability (AAV), the status quo 5-year eHCR performs best, with the lowest median AAV; and

d) when considering average catch, the median catch under the status quo 5-year eHCR is higher compared to the alternative 3-year candidates.

e) The use of a 3-year slope in combination with a 3-year catch average did not perform satisfactorily as biomass declines over time, however the alternative 3-year rule with 5-year average catch performed reasonably.

f) When comparing RBC outputs using available data in 2018, the 5-year slope eHCR yields an RBC of 500 tonnes, and the 3-year slope eHCR yields an RBC of 693 tonnes.

51. The RAG acknowledged that the key trade-off using an alternative 3-year eHCR results in much greater catch variability between years, i.e. the RBC may be much higher, or lower in any year. However, under the status quo 5-year eHCR, this variability is dampened to a greater extent.

52. **In consideration of the comparative results presented, the RAG agreed to not change the current eHCR and continue the use of the 5-year slope rule. Given this advice, the RAG also agreed that additional sensitivity analyses on the alternative eHCRs were no longer required.**

Harvest Strategy Decision Rules

53. The RAG considered the decision rule triggers under the draft Harvest Strategy. At the last RAG meeting, members discussed that given the experience during the 2017/18 season, the mid-year survey trigger may not align with the current expectations or management of the fishery.

54. The RAG noted the following key points:

a) If in any year the pre-season survey 1+ index is less than or equal to 1.25, a stock assessment is triggered;

b) If the eHCR limit reference point is triggered in the first year, a stock assessment update must be conducted in March;

c) If after the first year the stock is assessed below the biomass limit reference point, it is optional to conduct a mid-year survey noting that the pre-season survey must continue annually.

d) If the stock assessment determines the stock to be below the biomass limit reference point in two successive years, the TRL fishery will be closed to commercial fishing. Although unlikely, this circumstance could also result from other variables such as increased water temperatures, not just fishing mortality.

e) The current 1.25 trigger limit is based on historical lows in the 1+ index and although never breached, the 2017/18 1+ index was the lowest it had been within the series.

55. The CPUE index is a proxy measure for spawning biomass and so understanding trends in this index, particularly downward trends is important in planning management actions.

56. The CSIRO scientific member noted the importance of having pre-agreed actions in place if the trigger limit is breached which must also be considered with regard to resourcing availability for subsequent action. A more conservative trigger limit would provide an earlier indication that abundance may be in decline and to better understand what might be happening to the stock.

57. The RAG discussed that industry's reaction to the low RBC in the 2017/18 season and management changes to control catch that season, may suggest a more precautionary trigger is required. In light of this, the RAG considered two options for setting a higher trigger limit: 1) a biological trigger limit related to a biomass index; or 2) a TAC-based trigger limit. The RAG noted that using a TAC-based trigger limit may trigger a stock assessment more frequently which can have cost implications. It would also be affected by mechanisms (averaging) that dampened TAC changes, thereby masking underlying changes in biomass. The RAG also discussed concerns about modifying the trigger simply to satisfy economic objectives.

58. It was noted however, that with the determination of the TRL Management Plan the concerns expressed by industry the previous season under a low RBC would be less of an issue now that sectoral catch shares are in place. These concerns may also be addressed once variability in TACs is dampened under the 5-year eHCR.

59. It was also noted that the trigger and the Harvest Strategy can always be reviewed if considered to not be working effectively.

60. **Noting the sectoral catch shares in the fishery which may now alleviate previous concerns relating to the availability of TRL in a low TAC scenario; and the need to monitor the stock spawning biomass to inform RBCs, the RAG agreed to maintain the 1.25 trigger limit as a biological indicator to trigger an extraordinary stock assessment rather than an economics based trigger (e.g. TAC-based limit).**

6 Other Business

61. In response to an action item arising from the RAG, the CSIRO scientific member presented the preliminary key findings of the National Environmental Science Program (NESP) project assessing the influence of the Fly River runoff in the Torres Strait region. The RAG noted the following key points:

    a) The area of the Fly River influence is largely limited to the northern Torres Strait

    b) Habitats located north of Masig Island, as far east as Bramble Cay and at least as far west as Boigu Island are located in higher potential risk areas of exposure to brackish and turbid waters and associated contaminants from or derived from the Fly River.

    c) The assessment of trace metals in sediment and water across the region identified relatively low concentrations overall, with comparatively higher concentrations in the norther Torres Strait, and around Saibai and Boigu Islands in particular.

    d) The environmental and public health implications of this influence are still not well understood. While the impacts on TRL in particular are assumed to be low, the bioaccumulation risk for species such as turtles and dugong is much higher.

    e) While this movement of water from the Fly River is a historic pattern, the estimated 40 per cent 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.

    f) Under certain flow conditions, water can travel as far as the Torres Strait. Flow patters can be variable depending on currents and trade winds. Further, increased turbidity will still be seen in the Torres Strait during monsoon seasons due to the resuspension of sediments in the water column.

    g) It is unclear how the high concentrations of dissolved copper in benthic sediments around Saibai Island are impacting the area relative to deemed safe levels.

62. The RAG expressed a strong interest in further understanding the impacts on Torres Strait fisheries, particularly on larval production and survivability through testing tissue samples from TRL, mud crabs and sea cucumbers. A TVH industry member from MG Kailis offered to provide testing of frozen TRL tails for trace metal analysis.

Action
MG Kailis to submit tissue samples from frozen TRL tails for trace metal analysis to better understand the impacts of dissolved contaminants from the Fly River run off on important fisheries species in the Torres Strait.

63. While the results of the study are preliminary, the CSIRO scientific member agreed to circulate the full report to members when it becomes available.

Action
CSIRO to circulate the final report from the Fly River study to all RAG members once available.

7 Date and venue for next meeting

64. The next TRL RAG meeting is tentatively scheduled for the week beginning 4 February 2019, with exact dates to be confirmed out of session.
65. The Chair thanked Mr Terence Whap, Mr Mark David and Mr Phil Ketchell as all outgoing RAG members for their time and contributions to the RAG over the past three years. Their input to the fisheries management process was constructive and highly valued.
66. The meeting was closed in prayer at 10:50am on Wednesday 12 December 2018.

Declaration of interests

Dr Ian Knuckey – October 2018

Positions:

Director –	Fishwell Consulting Pty Ltd
Director –	Olrac Australia (Electronic logbooks)
Deputy Chair –	Victorian Marine and Coastal Council
Chair / Director –	Australian Seafood Co-products & ASCo Fertilisers (seafood waste)
Chair –	Northern Prawn Fishery Resource Assessment Group
Chair –	Tropical Rock Lobster Resource Assessment Group
Chair –	Victorian Rock Lobster and Giant Crab Assessment Group
Scientific Member –	Northern Prawn Management Advisory Committee
Scientific Member –	SESSF Shark Resource Assessment Group
Scientific Member –	Great Australian Bight Resource Assessment Group
Scientific Member –	Gulf of St Vincents Prawn Fishery Management Advisory Committee
Scientific participant –	SEMAC, SERAG

Current projects:

AFMA 2018/08	Bass Strait Scallop Fishery Survey – 2018 and 2019
FRDC 2017/069	Indigenous Capacity Building
FRDC 2017/122	Review of fishery resource access and allocation arrangements
FRDC 2016/146	Understanding declining indicators in the SESSF
FRDC 2016/116	5-year RD&E Plan for NT fisheries and aquaculture
AFMA 2017/0807	Great Australian Bight Trawl Survey – 2018
Traffic Project	Shark Product Traceability
FRDC 2018/077	Implementation Workshop re declining indicators in the SESSF
FRDC 2018/021	Development and evaluation of SESSF multi-species harvest strategies
AFMA 2017/0803	Analysis of Shark Fishery E-Monitoring data
AFMA 2016/0809	Improved targeting of arrow squid

25th MEETING OF THE PZJA TORRES STRAIT TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG 25)

Tuesday 11 December 2018 (9:00 AM – 5:00 PM)

Wednesday 12 December 2018 (8:30 AM – 11:00 AM)

TSRA Boardroom

Level 1 Torres Strait Haus

46 Victoria Parade, Thursday Island

ADOPTED AGENDA

1 PRELIMINARIES

1.1 Welcome and apologies

The Chair will welcome members and observers to the 25th meeting of the RAG.

1.2 Adoption of agenda

The RAG will be invited to adopt the draft agenda.

1.3 Declaration of interests

Members and observers will be invited to declare any real or potential conflicts of interest 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 RAG will be invited to note the status of action items arising from previous meetings.

1.5 Out-of-session correspondence

The RAG will be invited to note out of session correspondence on RAG matters since the previous meeting.

2 UPDATES FROM MEMBERS

2.1 Industry members

Industry members and observers will be invited to provide an update on matters concerning the Torres Strait TRL Fishery.

2.2 Scientific members

Scientific members and observers will be invited to provide an update on matters concerning the Torres Strait TRL Fishery.

2.3 Government agencies

The RAG will be invited to note updates from AFMA, TSRA and QDAF on matters concerning the Torres Strait TRL Fishery. AFMA will provide a summary of management arrangements for the 2018/19 fishing season.

2.4 PNG National Fisheries Authority

The RAG will be invited to note an update from the PNG National Fisheries Authority.

2.5 Native Title

The RAG will be invited to note an update from Malu Lamar (Torres Strait Islander) Corporation RNTBC.

3 PRELIMINARY RESULTS OF THE NOVEMBER 2018 PRE-SEASON SURVEY

The RAG will be invited to consider the preliminary results of the November 2018 pre-season survey.

4 STOCK ASSESSMENT UPDATE AND RBC

The RAG will be invited to consider the preliminary results of the integrated stock assessment. Preliminary estimates of the 2019/20 RBC will be provided based on the integrated stock assessment. Preliminary estimates of the 2019/20 RBC will also be provided based on the current empirical harvest control rule (eHCR), but will for noting as the Harvest Strategy has not been agreed by the PZJA.

5 REVISION OF DRAFT HARVEST STRATEGY AND CONTROL RULES

At their last meeting, the RAG recommended that some of the conditions and decision rule triggers in the harvest strategy be revisited prior to finalising the Harvest Strategy. This included consideration of the number of years to be averaged across in the eHCR index.

6 OTHER BUSINESS

The RAG will be invited to raise other business for consideration.

7 DATE AND VENUE FOR NEXT MEETING

The next RAG meeting is proposed for February 2019.

Action items from previous TRLRAG meetings

#	Action Item	Meeting	Responsible Agency/ies	Due Date	Status
1.	AFMA to review the effectiveness of certain TIB licensing arrangements (in its 2016 licencing review) including: • TIB licenses should share a common expiry date • licences to last for longer than the current 12 month period.	TRLRAG14 (25-26 August 2015)	AFMA	2017	**Ongoing** AFMA has begun undertaking a review of licensing of Torres Strait Fisheries, this issue will be considered as part of this review. At present however, AFMA resources are focused on progressing the proposed legislative amendments as a matter of priority. Further work on this item will be progressed in the 2019/20 financial year. • Administrative arrangements can be made to provide for licences held by the same person to expire on the same day. This change can be progressed when resources allow. • The *Torres Strait Fisheries Regulations 1985* currently provide for TIB and TVH licences to be issued for up to 5 years. Administrative arrangements can be progressed when resources allow.
2.	AFMA and CSIRO prepare a timeline of key events that have occurred in the Torres Strait Tropical Rock Lobster Fishery (e.g. licence buy backs, weather events and regulation changes) and provide a paper to TRLRAG.	TRLRAG14 (25-26 August 2015)	AFMA CSIRO	TRLRAG17 (31 March 2016)	**Ongoing** AFMA to complete further work. This has been difficult to action ahead of other priorities for the TRL Fishery.
3.	AFMA to liaise with Mr Pitt and Malu Lamar to provide agreed traditional names for the area around Erub.	TRLRAG23 (15 May 2018)	AFMA		**Ongoing** Further discussions needed to finalise this action. A map developed by the TSRA's Land and Sea Management Unit in consultation with PBCs, has recently been developed. A copy of this map has been provided to CSIRO and is provided at **Attachment 1.4c** for information.
4.	South Fly River studies to be provided for consideration at the next TRL and Finfish RAG meetings.	TRLRAG23 (15 May 2018)	AFMA	TRLRAG24 (18-19 October 2018)	**Ongoing**

#	Action Item	Meeting	Responsible Agency/ies	Due Date	Status
					A report detailing the findings of these studies is currently being finalised and will be provided once available, expected just prior to TRLRAG25.
5.	With regards to future TIB catch and effort analyses, CSIRO to explore the use of boat marks to improve location fished data extracted from the TDB02 CDR.	TRLRAG24 (18-19 October 2018)	CSIRO	2019	**Ongoing** To be examined when the next analyses are undertaken.
6.	Circulate copies of the Dao et al 2015 and Rothlisberg et al 1994 papers to the RAG for information.	TRLRAG24 (18-19 October 2018)	AFMA	TRLRAG25	**Completed** Papers provided at **Attachments 1.4d-e** for information.
7.	CSIRO to provide information on a recent review of the survey design to the RAG for information.	TRLRAG24 (18-19 October 2018)	CSIRO	TRLRAG25	**Ongoing** A review of the Torres Strait TRL Fishery survey design by the U.S. National Park Service is not yet finalised for distribution. A copy will be provided to the RAG once finalised. Provided at **Attachments 1.4f-i** for information are published peer-reviewed papers relating to the Torres Strait TRL Fishery survey design.
8.	RAG members to provide comments on the CSIRO TRL age class poster. CSIRO to include a better image of the 2+ lobster on the poster	TRLRAG24 (18-19 October 2018)	RAG CSIRO	2019	**Ongoing** Comments to be provided out-of-session and poster to be finalised in 2019.
9.	AFMA to prepare some explanatory material and a diagram explaining the start of season catch limit.	TRLRAG24 (18-19 October 2018)	AFMA	TRLRAG25	**Completed** Diagram provided at **Attachment 1.4j** developed and distributed to interested stakeholders. Further explanation was provided to all TRL Fishery licence holders prior to the start of the 2018/19 fishing season.

Table 1. Consideration of alternative hypotheses to explain the low 2017 0+ survey index compared with the 2018 1+ survey index. ***Source: TRLRAG25 Agenda paper 4a – Plagányi E et al. (2018) Preliminary summary regarding 2018 assessment of Torres Strait tropical lobster TRL stock. Summary Report for TRLRAG Dec 2018.***

	Alternative Hypotheses	Does it explain low 0+ in Nov 2017?	Does it explain 1+ size distrib^n in June 2018?	Notes and evidence	Plausibility
1	The 2017 0+ index was negatively biased due to observational error	No	no	There was some concern that as 2017 was the first year without a "gold standard" (GS) diver participating in the survey with considerable experience detecting the small 0+ age class, this may have biased the index negatively. However a statistical comparison of historical performance between GS and Other teams showed that whereas the GS teams generally found slightly more 0+, there was no significant difference between the results, and evidence of rapid learning. Even if the maximum likely bias is applied to the 0+ index, it does not increase it sufficiently to explain the 2018 1+ abundance.	low
2	The 2017 0+ index was low because of the timing of settlement	maybe	maybe	As lobsters spawn over a period of a few months, there is also approximately 3 months variability in terms of when they settle. In addition, the anomalous environmental conditions in 2016 (influencing the spawners producing the 2017 0+ cohort) could easily have influenced the timing of spawning and successful transport and settlement of pueruli. If settlement occurred earlier than usual, then this could explain relatively larger 1+ observed during 2018, but it means the 0+ would have been easier to observe during the 2017 survey. On the other hand, if settlement occurred later, then this explains the reduced numbers during the survey, but not the larger sizes of 1+ during 2018 (but it's possible that this was a result of a combination of timing of settlement and change in growth rate as below).	medium
3	Faster growth due to higher temperatures in 2017-2018 and/or reduced density dependence	no	yes	TRL growth is known to increase with increasing SST (Skewes et al. 1997) and there is evidence to suggest that the 2016 high temperatures had an influence on the stock, but there is less	high
4	The 2017 0+ index was low because the distribution of settling recruits changed substantially	yes	yes	The recent anomalous environmental conditions would have had an influence on local Torres Strait currents, as well as sand and habitat distribution and quality which could have influenced the spatial pattern of puerulus settlement. There is some evidence from the 2017 preseason survey 0+ spatial distribution data that the pattern differed to that observed in previous years e.g. lower than usual density in TI_Bridge stratum. The highest densities of 0+ were in the South-East and Mabuiag strata, so it's possible that relatively more settlement may have occurred to the north-west to the extent that the index wasn't as comparable as in previous years. Previous research (Skewes et al. 1997) showed that there are differences in growth rate	very high

Alternative Hypotheses	Does it explain low 0+ in Nov 2017?	Does it explain 1+ size distrib^n in June 2018?	Notes and evidence	Plausibility
			between the four zones (NW, SW, Central, SE), with lobsters being larger in the NW, and this may have contributed to the larger average size of this 1+ cohort (see Tonks et al. 2018).	

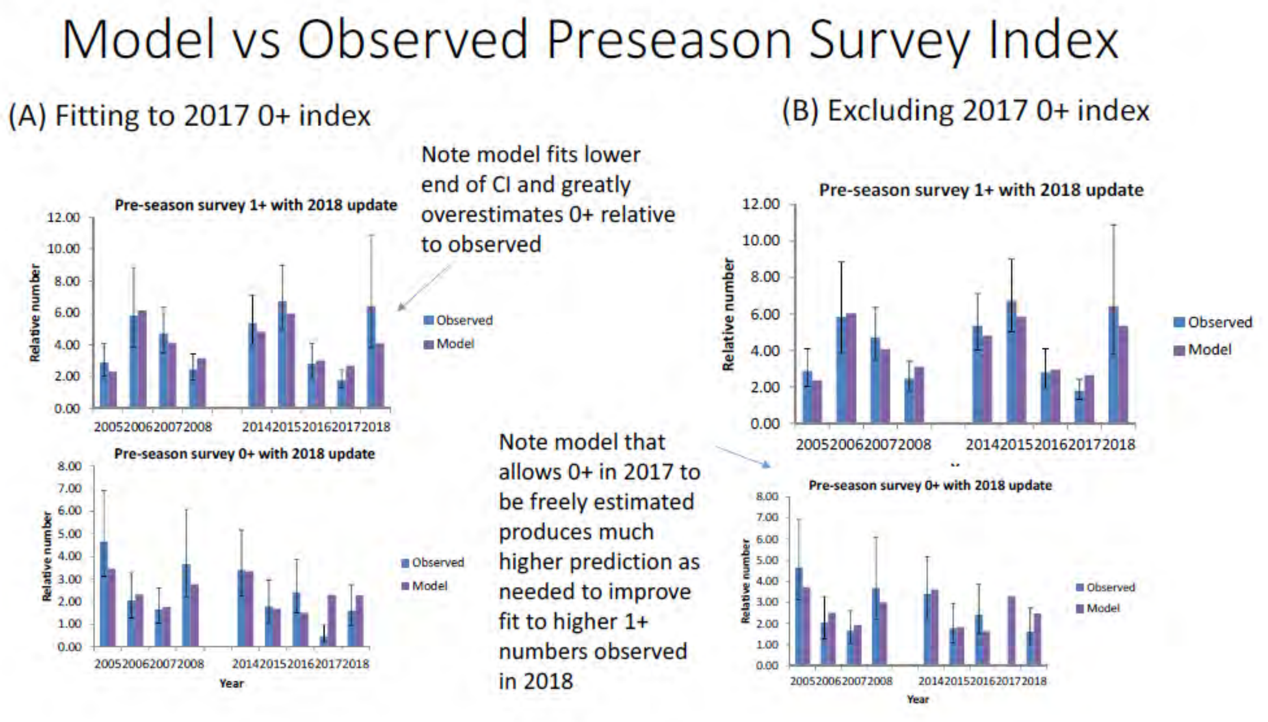

Figure 1. Comparison of stock assessment model fit to pre-season survey index when (A) including versus (B) excluding (for illustrative purposes) the 2017 0+ index.

Source: TRLRAG25 Agenda paper 4a – Plagányi E et al. (2018) Preliminary summary regarding 2018 assessment of Torres Strait tropical lobster TRL stock. Summary Report for TRLRAG Dec 2018.

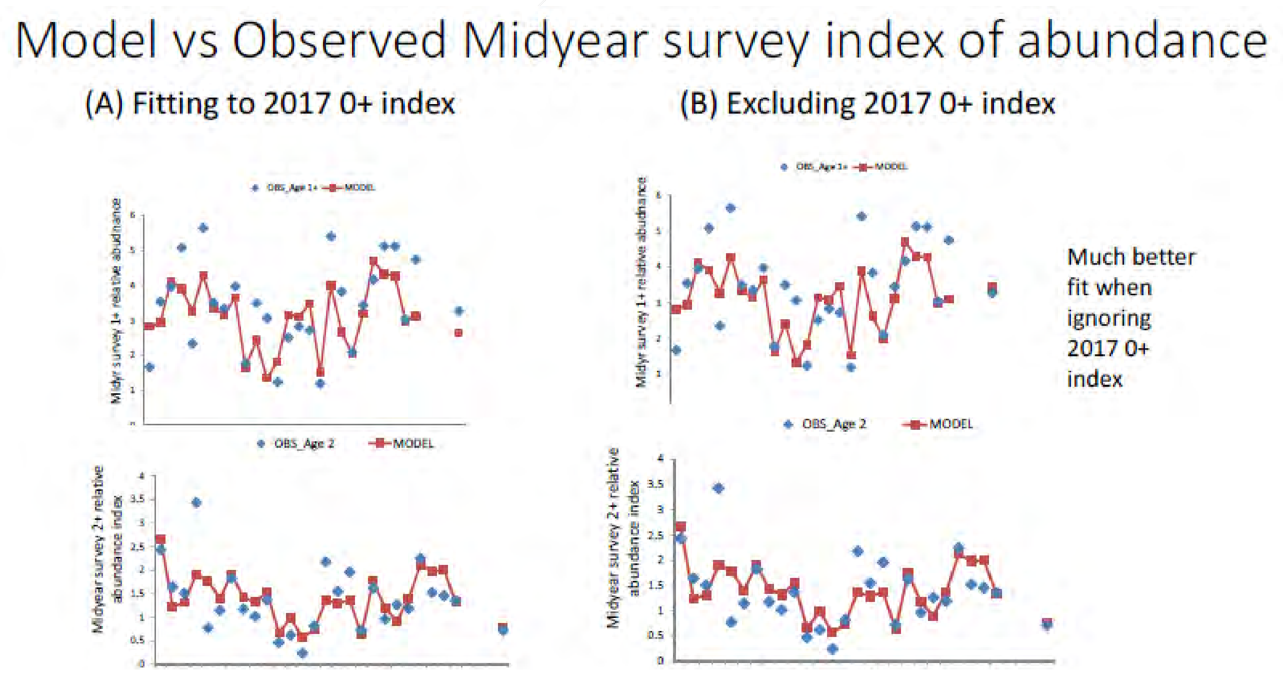

Figure 2. Comparison of stock assessment model fit to Midyear survey index when (A) included versus (B) excluding (for illustrative purposes) the 2017 0+ index.

Source: TRLRAG25 Agenda paper 4a – Plagányi E et al. (2018) Preliminary summary regarding 2018 assessment of Torres Strait tropical lobster TRL stock. Summary Report for TRLRAG Dec 2018.

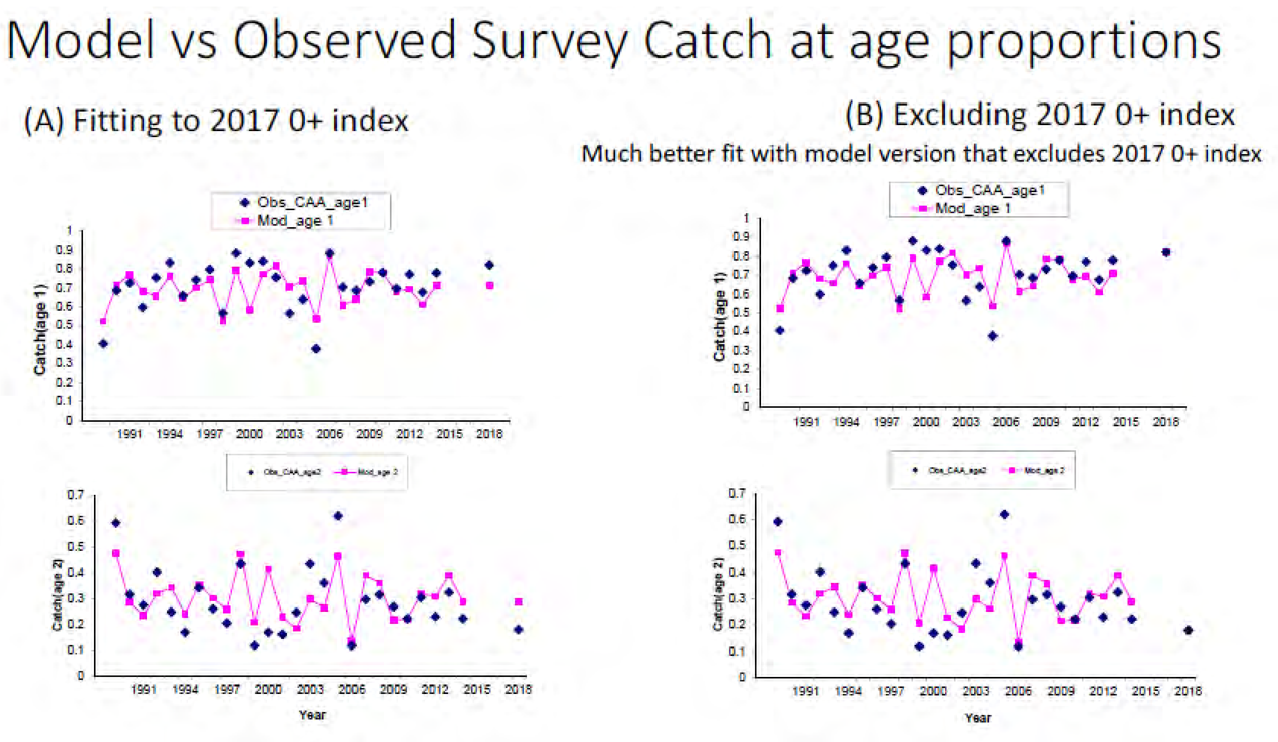

Figure 3. Comparison of stock assessment model fit to Survey Catch-at-Age information when (A) including versus (B) excluding (for illustrative purposes) the 2017 0+ index.

Source: TRLRAG25 Agenda paper 4a – Plagányi E et al. (2018) Preliminary summary regarding 2018 assessment of Torres Strait tropical lobster TRL stock. Summary Report for TRLRAG Dec 2018.

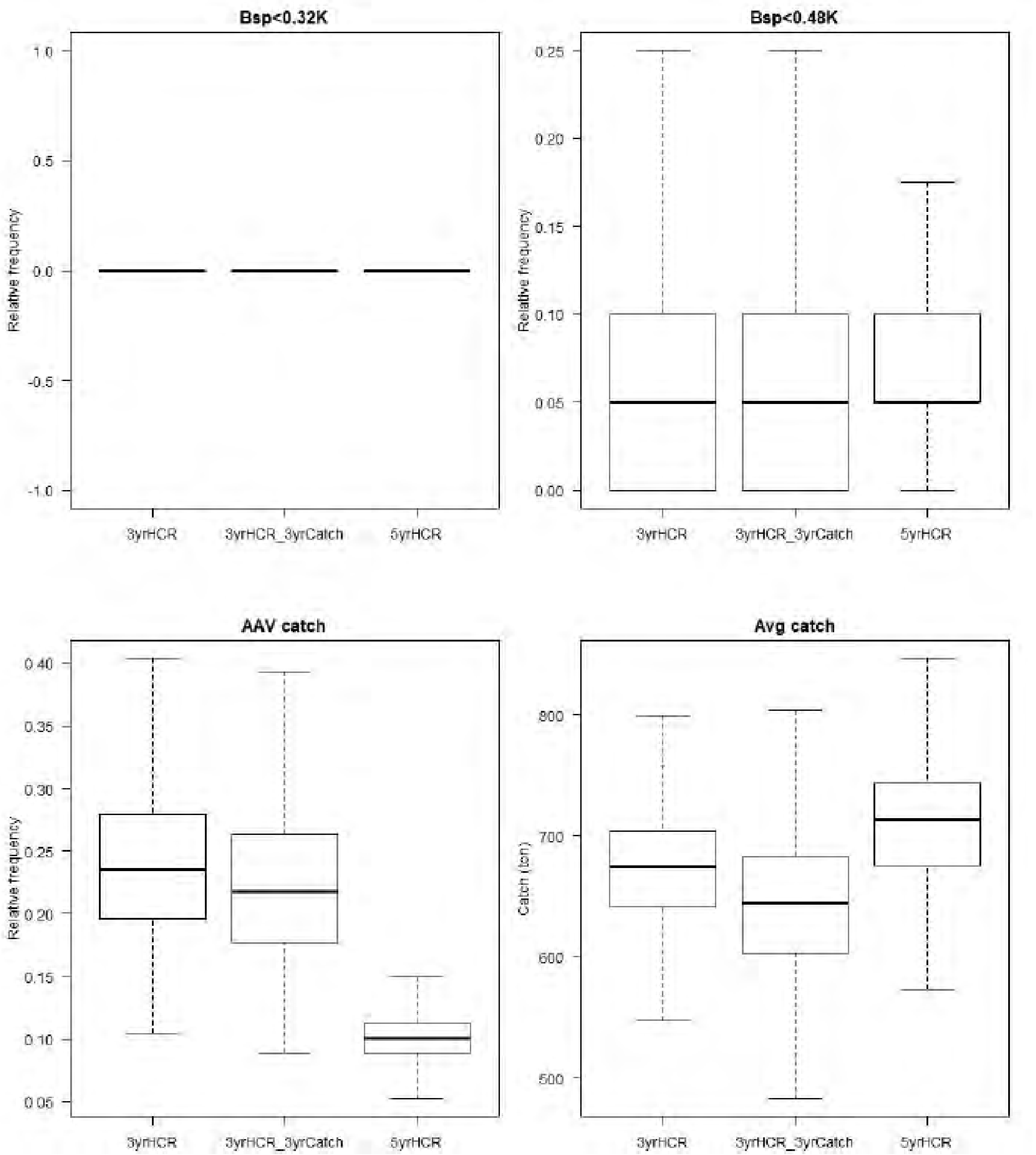

Figure 4. Comparison of some key performance statistics for final set of eHCRs. Plots show probability of depletion below each of two reference levels, B_{LIM} = 0.32K and precautionary level 0.48K limit reference point, together the Average Annual Variability (AAC) of catch, and ottal annual catch (t). The central lines shows the median, the box the 75th and 25th percentiles and the whiskers represent the full range of porojected values exlcluding outliers.

Source: TRLRAG25 Agenda paper 5c – Plagányi E et al. (2018) Testing an alternative empirical harvest control rule for the Torres Strait Panulirus ornatus tropical rock lobster fishery.

Attachment 1.4c

Action items from previous TRLRAG meetings

#	Action Item	Meeting	Responsible Agency/ies	Due Date	Status
1.	AFMA to review the effectiveness of certain TIB licensing arrangements (in its 2016 licencing review) including: • TIB licenses should share a common expiry date • licences to last for longer than the current 12 month period.	TRLRAG14 (25-26 August 2015)	AFMA	2017	**Ongoing** This item will be considered at the next meeting of the TRL Working Group scheduled for 19-20 February 2019, with a view to progressing during 2019. AFMA will provide further updates on this item once it has been considered and prioritised by the TRL Working Group and resourcing has been allocated.
2.	AFMA and CSIRO prepare a timeline of key events that have occurred in the Torres Strait Tropical Rock Lobster Fishery (e.g. licence buy backs, weather events and regulation changes) and provide a paper to TRLRAG.	TRLRAG14 (25-26 August 2015)	AFMA CSIRO	TRLRAG17 (31 March 2016)	**Ongoing** AFMA to complete this action in 2019.
3.	AFMA to liaise with Mr Pitt and Malu Lamar to provide agreed traditional names for the area around Erub.	TRLRAG23 (15 May 2018)	AFMA		**Complete** AFMA has liaised with Mr Pitt regarding this action. A map developed by the TSRA's Land and Sea Management Unit in consultation with PBCs, including Malu Lamar was developed in late 2018. A copy of this map was provided to CSIRO and the RAG at the meeting held on 11-12 December 2019. Further copies can be requested from the RAG Executive Officer as required.

4.	South Fly River studies to be provided for consideration at the next TRL and Finfish RAG meetings.	TRLRAG23 (15 May 2018)	AFMA	TRLRAG24 (18-19 October 2018)	**Ongoing** Preliminary results of these studies was presented to TRLRAG24 held on 11-12 December 2018. A report detailing the findings of these studies is currently being finalised and will be provided to the RAG once available.
5.	With regards to future TIB catch and effort analyses, CSIRO to explore the use of boat marks to improve location fished data extracted from the TDB02 CDR.	TRLRAG24 (18-19 October 2018)	CSIRO	2019	**Ongoing** To be examined when the next analyses are undertaken.
6.	CSIRO to provide information on a recent review of the survey design to the RAG for information.	TRLRAG24 (18-19 October 2018)	CSIRO	TRLRAG25	**Ongoing** A review of the Torres Strait TRL Fishery survey design by the U.S. National Park Service is not yet finalised for distribution. A copy will be provided to the RAG once finalised.
7.	RAG members to provide comments on the CSIRO TRL age class poster. CSIRO to include a better image of the 2+ lobster on the poster.	TRLRAG24 (18-19 October 2018)	RAG CSIRO	2019	**Completed** Copies can be requested from CSIRO or AFMA.
8.	The TRL RAG Chair to provide the TSRA with a copy of expected behaviours of RAG members to assist with the induction program for incoming PZJA forum members.	TRLRAG25 (11-12 December 2018)	RAG Chair	2019	**Completed**
9.	CSIRO to investigate the length frequency conversion factors from the catch weight data provided by MG Kailis.	TRLRAG25 (11-12 December 2018)	CSIRO	2019	**Ongoing** CSIRO to address when resources become available. This is a lower priority as the outcomes of this work will not affect the RBC calculations for the 2018/19 fishing season.

10.	CSIRO to calculate the cost of increasing the number of pre-season survey sites from the current 77 sites back to 140 for RAG industry members to consider.	TRLRAG25 (11-12 December 2018)	CSIRO	2019	**Completed** To be considered under Agenda Item 4.
11.	Considering assessment timelines, PNG NFA to provide CSIRO with a best estimate of PNG catches by mid-November. CSIRO to liaise closely with PNG regarding reporting timeframes and provision of catch data. In parallel, the RAG data sub-group to examine ways to adjust the stock assessment model to account for delayed catch data from PNG.	TRLRAG25 (11-12 December 2018)	PNG NFA CSIRO AFMA RAG Data Sub-Group	2019	**Ongoing** AFMA and CSIRO continue to liaise with PNG NFA with regards to the provision of catch and effort data for the PNG TRL Fishery. RAG data sub-group yet to convene. Arrangements for this meeting to be considered under Agenda Item 5.
12.	That the TRL RAG data subcommittee discuss which TVH CPUE series are the best to use within the model.	TRLRAG25 (11-12 December 2018)	AFMA RAG Data Sub-Group	2019	**Not complete** RAG data sub-group yet to convene. Arrangements for this meeting to be considered under Agenda Item 5.
13.	MG Kailis to submit tissue samples from frozen TRL tails for trace metal analysis to better understand the impacts of dissolved contaminants from the Fly River run off on important fisheries species in the Torres Strait.	TRLRAG25 (11-12 December 2018)	MG Kailis	2019	**Completed** Test results expected February 2019.
14.	CSIRO to circulate the final report from the Fly River study	TRLRAG25 (11-12	CSIRO	2019	**Ongoing** Preliminary results of these studies was presented to TRLRAG24 held on 11-12 December 2018. A report

	to all RAG members once available.	December 2018)			detailing the findings of these studies is currently being finalised and will be provided to the RAG once available.

Relevant action items from previous TRLWG meetings*

#	Action Item	Meeting	Responsible Agency/ies	Due Date	Status
1.	Discard reporting and estimation be considered by the RAG (possibly by the RAG data subgroup)	TRLWG8 (8 November 2018)	AFMA RAG Data Sub-Group	2019	**Not complete** RAG data sub-group yet to convene. Arrangements for this meeting to be considered under Agenda Item 5.
2.	RAG to consider the merit and options for improving the index of 0+ lobster abundance, through logbooks or other means. The Working Group noted that this would may be relevant to the RAG data sub-committee.	TRLWG8 (8 November 2018)	AFMA RAG Data Sub-Group	2019	**Not complete** RAG data sub-group yet to convene. Arrangements for this meeting to be considered under Agenda Item 5.

*TRLWG actions not relevant to TRLRAG have not been included in the above.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
PRELIMINARIES **Out-of-session correspondence**	**Agenda Item 1.5** **For Information**

RECOMMENDATIONS

1. That the RAG **NOTE** the correspondence sent out-of-session since the last TRLRAG meeting held on 11-12 December 2018.

BACKGROUND

2. The following correspondence was circulated out-of-session since the last TRLRAG meeting held on 11-12 December 2018 (TRLRAG 25). Copies of this correspondence can be requested at any time from the TRLRAG Executive Officer.

Date	Item
17 December 2018	AFMA emailed all RAG members seeking availability for the next TRLRAG meeting proposed for 5 February 2019 in Brisbane or Cairns.
7 January 2019	AFMA circulated an email from Ian Cartwright, Torres Strait Scientific Advisory Committee (TSSAC) Chair regarding the annual call for research for 2019/20.
11 January 2019	AFMA circulated the draft meeting record for TRLRAG 25 held on 11-12 December 2019, seeking comment from members.
18 January 2019	AFMA circulated the draft agenda for the TRLRAG 26 meeting to be held on 5 February 2019 in Cairns.
24 January 2019	AFMA emailed all RAG members to confirm arrangements for the TRLRAG 26 meeting to be held on 5 February 2019 in Cairns.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	**MEETING 26** **5 February 2019**
UPDATES FROM MEMBERS **Industry members**	**Agenda Item 2.1** **For Information**

RECOMMENDATIONS

1. That the RAG **NOTE** updates provided by industry members.

BACKGROUND

2. Verbal reports are sought from industry 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 the TRL Fishery. This includes within adjacent jurisdictions. This ensures that where relevant, the RAG is able to have regard for these strategic issues and trends.
4. RAG 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.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
UPDATES FROM MEMBERS **Scientific members**	**Agenda Item 2.2** **For Information**

RECOMMENDATIONS

1. That the RAG **NOTE** updates provided by scientific members.

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 the TRL Fishery. This includes 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 of interest to the Torres Strait in future.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
UPDATES FROM MEMBERS **Government agencies**	**Agenda Item 2.3** **For Information**

RECOMMENDATIONS

1. That the RAG:
   a. **NOTE** the update provided by AFMA below;
   b. **NOTE** a verbal update will be provided by the QDAF and TSRA.

AFMA UPDATE

PNG-Australia catch sharing arrangements

2. The AFMA Chief Executive Officer met with the PNG National Fisheries Authority Managing Director on 17 January 2018 to discuss preliminary catch sharing arrangements, as per the terms of the Torres Strait Treaty, for the 2018/19 fishing season for the Torres Strait Protected Zone TRL Fishery. Both agencies will again meet in late February to agree on final catch sharing arrangements, prior to a decision being sought from the PZJA on a final total allowable catch (TAC) for the 2018/19 fishing season for the Australian TRL Fishery. The Australian TAC equates to Australia's share of the final recommended biological catch (RBC). Further details on timeframes is provided at **Attachment 2.3a**.

TRL Management Plan

3. On 26 November 2018, having considered outcomes of consultation, the Protected Zone Joint Authority (PZJA) decided to determine the *Torres Strait Fisheries (Quotas for Tropical Rock Lobster (Kaiar)) Management Plan 2018* (the Management Plan) and to amend the *Torres Strait Fisheries (Tropical Rock Lobster) Management Instrument 2018* (the Instrument). AFMA wrote to all TRL Fishery licence holders on 28 November providing notification of these decisions and key management arrangements for the 2018/19 fishing season.
4. The Management Plan and amendments to the Instrument came into force for the 2018/19 fishing season starting on 1 December 2018. These decisions mean that, unless delayed by legal appeals, a quota management system will be fully operational in the TRL Fishery for the 2019/20 fishing season. AFMA has commenced the formal allocation process prescribed under the Management Plan and will be in contact with affected licence owners as the process progresses.
5. A review of existing PZJA licencing policies and management arrangements, including input controls, will be conducted periodically after the quota management system is operational. Initial consideration regarding existing management arrangements and priority arrangements for review will occur at the next meeting of the TRL Working Group scheduled for 19-20 February 2019 on Thursday Island.
6. Copies of the Management Plan and amended Instrument along with a supporting guide describing how the Management Plan will work can also be found on the PZJA website at www.pzja.gov.au.

Management arrangements for the 2018/19 fishing season

7. As the TRL Fishery undergoes the transition to a fully operational Management Plan, some key management arrangements that will apply in the 2018/19 season follow.

Sectoral split

8. Separate total allowable catch (TAC) shares will be implemented on an interim basis for the Traditional Inhabitant and Transferable Vessel Holder (TVH) sectors:

   a. Traditional Inhabitant sector – will be able to take a 66.17 per cent share of the TAC. This will be exclusively available to all Traditional Inhabitant Boat (TIB) licence holders. If all of this catch is taken by TIB licence holders before the end of the fishing season, a notice will be issued requiring fishing by this sector to cease.

   b. TVH sector – the remaining 33.83 per cent of the TAC will be individually apportioned to TVH licence holders, via licence conditions, in accordance with individual provisional allocation notices dated 1 October 2007. The TVH licence holders will be able to trade within the sector. Once TVH licence holders have exhausted their individual portion, including any leased quota, they will be required to cease fishing. Each TVH licence holder will receive a letter outlining the licence condition setting their portion of the TAC. This portion may not reflect the allocation of quota under the Management Plan, which will be subject to a catch verification and appeals process.

Interim and final TACs

9. In order to give effect to the sectoral split, the PZJA further agreed to open the 2018/19 fishing season with an interim TAC of 200 tonnes. This decision is based on advice received from the TRL Resource Assessment Group and TRL Working Group, which advised that an interim TAC derived from the maximum annual catch amount over the years 2005-2018 for the period 1 December and end of February should be implemented.

10. This means that, from the opening of the 2018/19 fishing season:

    a. Traditional Inhabitant sector – can take a combined total of 132.34 tonnes of TRL.

    b. TVH sector – can take the amount of TRL specified in their individual licence conditions. The total amount that can be taken by the TVH sector will not be more than 33.83 per cent of the TAC.

11. The interim TAC will apply until a final TAC for the 2018/19 fishing season can be agreed. A final TAC is expected to be decided in early March 2019 and will follow the consideration of the updated stock assessment to be undertaken by CSIRO (including the results of the November 2018 pre-season survey), consultation with the TRL RAG and TRL Working Group and having regard to Australia's obligations under the Torres Strait Treaty.

Moon-Tide Hookah Closures

12. The PZJA also reaffirmed existing management controls currently applied to the TRL Fishery, to be implemented under the Instrument and licence conditions. This includes periodic closures to the use of hookah gear for three days either side of the full or new moon each month based on the largest difference between high and low waters.

13. The use, possession or control, on a boat, of hookah gear to take, process or carry TRL will not be permitted during the 2018/19 fishing season during the moon-tide hookah closure periods shown in the calendar (dated 28 November 2018) provided at **Attachment 2.3b**. The first scheduled moon-tide hookah closure period starts on 17 February 2018.

14. These moon-tide hookah closures are in addition to the hookah closure period from 1 December and 31 January each fishing season. Free-diving, lamp fishing and traditional fishing are permitted during all hookah closure periods.

Sea surface temperatures

15. Sea surface temperatures (SSTs) are currently below the coral bleaching threshold. The Australian Institute of Marine Science (AIMS) monitors sea surface temperatures to identify the risk of bleaching events. Reports can be accessed on the AIMS website at https://www.aims.gov.au/docs/research/climate-change/coral-bleaching/predicting-events.html.

16. Since 1970 the SST in the Coral Sea has consistently been above the long term average (data from 1900 to 2017).
17. The El Nino event from 2015/16 was more intense than previous events in recent history. The impacts to the TRL Fishery include increased mortality of cage-held lobsters and increasing coral mortality that may result in a reduction of suitable habitat. The influences on the larval phases of TRL are poorly understood.
18. SST information is also monitored by some fishers. If there is a spike in temperature the TRL held in cages or tanks will be monitored more closely (2 to 3 times a day) and they will be tailed or frozen whole if they are weak or not a suitable grade for live product.
19. AFMA, through AIMS, will continue to monitor SSTs this season.

Attachment 2.3a

Proposed timeline for determining the recommended biological catch (RBC) and PNG-Australia catch shares for the 2018/19 fishing season for the Tropical Rock Lobster (TRL) Fishery[1]

Steps	Description	Indicative timeline
Pre-season scientific survey	Results are used to update the annual stock assessment. Survey must be conducted in November to provide comparable results overtime and the most accurate estimate of annual lobster recruitment into the fishery.	11-23 November 2018
Stock assessment update	Conducted by CSIRO with preliminary stock assessment results within 4-5 weeks of the pre-season scientific survey.	early December 2018
TRL Resource Assessment Group (TRLRAG) advice[2]	Review the preliminary stock assessment results and Recommended Biological Catch (RBC) advice. Provide advice on finalising the assessment and RBC advice.	11-12 December 2018
PNG-Australia discussions	AFMA CEO and PNG NFA Director General to meet to discuss preliminary RBC advice from the TRLRAG, and cross-endorsement and catch sharing arrangements under the Treaty – a diagram illustrating the catch sharing formula as applied during the 2017/18 fishing season under the Treaty is provided below.	17 January 2019
TRLRAG advice[2]	Review the final stock assessment results and RBC advice. Provide final RBC advice.	5 February 2019
TRL Working Group (TRLWG) advice[2]	Consider TRLRAG advice on the final RBC and provide final RBC advice.	19-20 February 2019

[1] The Australian Tropical Rock Lobster Fishery fishing season runs from 1 December each year to 30 September the following year. Hookah gear is not permitted between December and January.
[2] Officers from PNG National Fisheries Authority (NFA) are invited to attend all PZJA advisory forums.

PNG-Australia discussions	AFMA CEO and PNG NFA Director General to meet to discuss final RBC advice from the TRLRAG and TRLWG, and agree to final cross-endorsement and catch sharing arrangements[3] under the Treaty.	22 February 2019 (proposed)
PZJA or Delegate	Agree to final TAC for the Australian TRL Fishery for the 2018/19 fishing season. A final TAC for the Australia TRL Fishery needs to be determined by 1 March 2019.	25 February 2019 (proposed)
Cross-endorsement arrangements – if agreed between PNG and Australia	Formal letters exchanged between PNG and Australia requesting cross-endorsement. Licence requests processed (approval by PZJA required). Cross-endorsed operators notified that cross-endorsement/fishing can commence.	March 2019

[3] The Australian total allowable catch (TAC) equates to Australia's catch share of the final RBC in Australian waters, as agreed with PNG under the Treaty.

Torres Strait Tropical Rock Lobster Fishery Moon-Tide Hookah Closures for the 2018/19 Fishing Season* (as at 28 November 2018)

Dec-18	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
	1	2	3	4	5	6		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan-19	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu
	1	2	3	4	5		7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Feb-19	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu			
	1	2	3	4		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			
Mar-19	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
	1	2	3	4	5	6		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Apr-19	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	
	1	2	3	4		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
May-19	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri
	1	2	3	4		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jun-19	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	
	1	2		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Jul-19	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed
	1	2		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Aug-19	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29		31
Sep-19	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28		30	
Oct-19	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		29	30	31
Nov-19	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25		27	28	29	30	

* The 2018/19 fishing season runs from 1 December 2018 through to 30 September 2019

KEY

New moon — **Fishery closed**

Full moon — **Hookah closure (use of hookah gear not permitted)**

Moon-tide hookah closure (use of hookah gear not permitted)

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	**MEETING 26** **5 February 2019**
UPDATES FROM MEMBERS **PNG National Fisheries Authority**	**Agenda Item 2.4** **For Information**

RECOMMENDATIONS

1. That the RAG **NOTE** the update to be provided by the PNG National Fisheries Authority (NFA).

BACKGROUND

2. A verbal report will be provided under this item.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
UPDATES FROM MEMBERS **Native Title**	**Agenda Item 2.5** **For Information**

RECOMMENDATIONS

1. That the RAG **NOTE** any updates on Native Title matters from members, including representatives of 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 managing 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.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	**MEETING 26** **5 February 2019**
CATCH SUMMARY FOR THE 2018/19 FISHING SEASON	**Agenda Item 3** **For Information**

RECOMMENDATIONS

1. That the RAG:

    a. **NOTE** the reported landed catch for the Australian Torres Strait TRL Fishery for the 2018/19 fishing season as of 29 January 2019 is 32,553 kg (**Attachment 3a**);

    b. **NOTE** that the PNG TRL Fishery opened 1 December 2018, with the use of hookah gear prohibited until 31 March 2019. AFMA is working closely with PNG to share catch data.

KEY ISSUES

Australian TRL catch

2. As reported through the mandatory fish receiver system, implemented on 1 December 2017, the reported landed catch for the Australian Torres Strait TRL Fishery for the 2018/19 fishing season to date, is 32,553 kg.

3. This equates to 16.28 per cent of the 200 tonne interim Total Allowable Catch (TAC) for the TRL Fishery. This catch data is sourced from the Torres Strait Fisheries Catch Disposal Record (TDB02) and covers the Traditional Inhabitant Boat (TIB) and Transferable Vessel Holder (TVH) sectors.

4. This is the first season that sectoral catch shares have been implemented across the Australian TRL Fishery following the determination of the *Torres Strait Fisheries (Quotas for Tropical Rock Lobster (Kaiar)) Management Plan 2018* (the Management Plan).

5. In order to give effect to the sectoral split, the PZJA agreed to open the 2018/19 fishing season with an interim Total Allowable Catch (TAC) of 200 tonnes. This decision was based on advice received from the TRL RAG and TRL Working Group, which advised that an interim TAC derived from the maximum annual catch amount over the years 2005-2018 for the period 1 December and end of February should be implemented.

6. This means that, from the opening of the 2018/19 fishing season:

    a. Traditional Inhabitant Boat (TIB) sector – can take a combined total of 132.34 tonnes of TRL

    b. Transferable Vessel Holder (TVH) sector can take the amount of TRL specified in their individual licenced conditions. The total amount that can be taken by the TVH sector will not be more than 33.83 per cent of the interim TAC.

7. All reported landed catch to date has been caught by freediving or lamp fishing only.

8. Further details, including final catch totals from the 2017/18 fishing season, are provided at **Attachment 3a**.

PNG TRL catch

9. The PNG TRL Fishery opened 1 December 2018, with the use of hookah gear prohibited in the waters of Western Province and Torres Strait effective until 31 March 2019.

10. To date, AFMA has not received any catch reports on the TRL fishery from PNG NFA.

Table 1. Reported landed catch (kg whole weight) of Tropical Rock Lobster (TRL) for the Australian Torres Strait TRL Fishery by month for the 2018/19 fishing season. Source: Torres Strait Fisheries Catch Disposal Record (TDB02) as at 29 January 2019.

Month	Reported catch (kg) for all licence holders*
Dec-18	25,705.55
Jan-19	6,847.57
Total reported catch (kg)*	**32,553.12**
Reported catch as a per cent (%) of the 200 tonne interim TAC~	**16.28%**
Notes:	
* The reported catch figures are sourced from catch disposal records (TDB02). There may be some outstanding records. The reported catch figures do not include any unreported catch. Under AFMA's Information Disclosure Policy (**Attachment 3b**), information on catch by sector (i.e. TIB and TVH sectors) has not been provided as some of this information is from less than five boats. The Policy does allow more detailed fishing information to be disclosed where the information has or will be used to guide fishery management decisions (for example; research or information supporting the implementation of harvest strategies, Stock Recovery Plans, stock-based management measures). AFMA will provide public monthly catch updates from February 2019, via the AFMA and PZJA websites, to assist industry in monitoring catch against interim sectoral split arrangements for the 2018/19 fishing season.	
~ The interim total allowable catch (TAC) for the Australian Torres Strait TRL Fishery for the 2018/19 fishing season is 200,000 kg until a final TAC can be agreed. Under sectoral catch shares, this equates to 132,340 kg for the Traditional Inhabitant Boat (TIB) sector and 67,660 kg for the Transferable Vessel Holder (TVH) sector, which is allocated to each licence holder as specified in their individual licence conditions.	

Table 2. Reported landed catch (kg whole weight) of TRL for the Australian Torres Strait TRL Fishery by month for the 2017-18 fishing season. Source: Torres Strait Fisheries Catch Disposal Record (TDB02) as at 24 January 2019

Month	Reported catch (kg) for Traditional Inhabitant Boat (TIB) licence holders*	Reported catch (kg) for Transferable Vessel Holder (TVH) licence holders*^	Total reported catch (kg)*
Dec-17	15,077.98	33.72	15,111.70
Jan-18	13,119.23		13,119.23
Feb-18	20,936.83	42,415.36	63,352.19
Mar-18	19,095.97	28,605.83	47,701.79
Apr-18	17,063.75	23,381.14	40,444.88
May-18	10,130.47	3,110.28	13,240.75
Jun-18	10,832.57	2,966.17	13,798.75
Jul-18	20,812.78	33,557.31	54,370.09
Total reported catch (kg)*	**127,069.57**	**134,069.81**	**261,139.38**
Reported catch as a per cent (%) of the TAC~	**50.00%**	**52.75%**	**102.75%**

Reported catch as a per cent (%) of total reported catch	**48.66%**	**51.34%**	**100.00%**

Notes:

* The reported catch figures are sourced from catch disposal records (TDB02). The reported catch figures do not include any unreported catch.

^ The reported catch figures for Transferable Vessel Holder (TVH) licence holders includes catch taken under licences held by the Torres Strait Regional Authority (TSRA).

~ The total allowable catch (TAC) for the Australian Torres Strait TRL Fishery for the 2017-18 fishing season was 254,150kg. The 2017-18 fishing season ran from 1 December 2017 to 30 July 2018.

Australian Government
Australian Fisheries Management Authority

Fisheries management paper 12

INFORMATION DISCLOSURE

MAY 2014

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AFMA Direct 1300 723 621

Document Change History

Revision Date	Version Number	Document Changes
21 May 2014	1.1	Minor changes to make the Policy consistent with changes to the *Privacy Act.* These include changes to Clause 2 relating to the definition of personal information and inserting new clauses for 6.1.2a) and b)

1. Purpose

This document sets out the Australia Fishery Management Authority's (AFMA) policy and procedures for disclosing information it collects.

2. Definitions

For the purposes of this policy ***"personal information"*** has the same meaning as in the *Privacy Act 1988* which is, "*information or an opinion about an identified individual, or an individual who is reasonably identifiable:*
(a) whether the information or opinion is true or not; and
(b) whether the information or opinion is recorded in a material form or not.".

As under the *Privacy Act*, it does not include information that is already (properly) in the public domain.

3. Background

3.1 Need

In performing its functions, AFMA *collects* a range of information. Information collected by AFMA is official information which is held on behalf of the Australian community. This does not mean that all of the information collected by AFMA may be *disclosed*. No information collected by AFMA can be disclosed, unless this would be in accordance with one of AFMA's functions or powers. Further, much of the information collected by AFMA is provided by holders of Commonwealth fishing concessions and can contain both personal information and information that has commercial value.

Therefore in deciding whether to disclose information it has collected, AFMA must ensure that:

- it acts consistently with the *Fisheries Administration Act 1991* (FA Act) and *Fisheries Management Act 1991* (FM Act);
- it acts consistently with the *Privacy Act 1988,* the purpose of which is to protect the privacy of personal information; and
- where personal or commercially valuable information is provided, measures are in place, as appropriate, to protect the information.

This policy establishes a decision making framework to ensure that decisions to disclose information are, consistent, legally sound and that proper account is taken of all relevant considerations.

3.2 AFMA's ability to disclose information it has collected

AFMA's legislation provides AFMA with both broad and specific authority to disclose information in the exercise of its powers and performance of its functions.

A number of AFMA's functions and powers *specifically* authorise the disclosure of information. For example:

FA Act: paragraph 7(1)(g) - AFMA may consult and exchange information with State, Territory and overseas bodies having functions similar to AFMA's functions;

paragraph 7(1)(gb) - AFMA may disclose, *as authorised* under s7(4), information (including personal information) relating to:

(a) possible breaches of laws of Australia or of a foreign country;

(b) the control and protection of Australia's borders;

(c) the administration and management of fisheries or marine environments; or

(d) research or monitoring conducted, or proposed to be conducted, into fisheries or marine environments.

Disclosure under paragraph 7(1)(gb) is authorized if done in accordance with the FA Act, the FM Act, the *Torres Strait Fisheries Act 1984*, or regulations made under one of those Acts.

FM Act: section 167 - AFMA may publish or make available, in any way it thinks fit, statistics compiled from logbooks or other sources.

section 108B - The Minister may disclose (or authorise a prescribed agency to disclose on the Minister's behalf) information relating to fishing activities that may involve a breach of the laws of Australia or a foreign country to the government of a foreign country or the other specified bodies.

section 167B - AFMA may disclose VMS information to Customs.

AFMA may also disclose information in performing its other functions, where disclosure is necessary for the performance of those functions. This broader authority is conferred by FA Act s8, which provides that AFMA "may do all things that are necessary or convenient to be done for, or in connection with, the performance of its functions". For example, a central function of AFMA is to "devise management regimes in relation to Australian fisheries" (FA Act s7(1)(a)). In performing this function, it is necessary to disclose information AFMA has collected to external bodies (such as research providers or Independent Allocation Advisory Panels) to conduct research on AFMA's behalf.

In performing its functions, AFMA is required to pursue its objectives (in FM Act s3, and FA Act s6). Therefore, a decision to disclose information must be consistent with pursuit of those objectives. In addition to the objectives of implementing efficient and cost-effective fisheries management on behalf of the Commonwealth (FA Act paragraph 6(a)) and ensuring that the exploitation of fisheries resources are conducted in a manner consistent with the principles of ESD (FA Act paragraph 6(b)), these objectives include ensuring accountability to the fishing industry and to the Australian community in AFMA's management of fisheries resources (FA Act paragraph 6(d)).

4. Objective

To guide AFMA decisions to disclose information in accordance with its functions and powers, including powers specified in regulations made for the purposes of section 7(4) of the FA Act.

5. Scope

This policy applies to all AFMA decisions to disclose information already collected by AFMA, as well as information to be collected in the future.

6. Policy guidelines and procedures

6.1 Guidelines

6.1.1 AFMA will only disclose information it collects where it is:

a) authorised by a provision of the FA Act or the FM Act that specifically authorises the disclosure of information (e.g. paragraphs 7(1)(g), (ga) and (gb) of the FA Act); or

b) is otherwise required to perform a function where disclosure of information is not specifically authorised (FA Act section 8).

Note: The FA Act and FM Act provide that in performing its functions AFMA must pursue its objectives set out in FA Act s6 and FM Act s3.

6.1.2 In deciding whether to disclose *personal* information, AFMA will ensure the decision to do so is consistent with the *Privacy Act 1988*. This means that AFMA will not disclose personal information to a person, body or agency unless:

a) the individual concerned would reasonably expect that AFMA would disclose the information for a purpose other than the purpose for which it was collected and, if the information is sensitive information, it is directly related to the primary purpose for which the information was collected.; or

b) the individual concerned would reasonably expect that AFMA would disclose the information for a purpose other than the purpose for which it was collected and, if the information is not sensitive information, it is related to the primary purpose for which the information was collected: or

c) the individual concerned has consented to the disclosure; or

d) AFMA believes on reasonable grounds that the disclosure is necessary to prevent or lessen a serious and imminent threat to life or health of the individual concerned or of another person; or

e) the disclosure is required or authorised by or under law; or

f) the disclosure is reasonably necessary for the enforcement of the criminal law or of a law imposing a pecuniary penalty, or for the protection of the public revenue.

6.1.3 To provide accountability to the fishing industry and Australian community in AFMA's management of fisheries resources, AFMA may publicly disclose the following fishing information for all fisheries, so far as it is consistent with Australia's obligations under international law:

a) total fishing season catch and effort statistics for each species[1] aggregated by fishing method, sector and/or fishery;

b) the total area of waters fished within a season by fishery, sector and/or method, reported at a minimum spatial resolution of one degree square. This does not include catch or effort information where the data represents less than five vessels; or

c) any other catch and effort information, including spatial information, where the information represents data from five or more vessels.

[1] Includes: target, byproduct, bycatch and Threatened, Endangered or Protected species

6.1.4 AFMA may publicly disclose more detailed fishing information than that outlined in (6.1.3) where:

a) the information has or will be used to guide fishery management decisions (for example; research or information supporting the implementation of harvest strategies, Stock Recovery Plans, stock-based management measures); or

b) it is used to ensure that Australia meets its obligations under international law (for example, disclosure to Regional Fishery Management Organisations).

6.2 Procedures for disclosing information that is not available in public domain

6.2.1 Where information concerns the activities of individual operators that may have commercial value (in that the disclosure of the information may diminish the value of the information to the person who provided it to AFMA), AFMA will, as far as possible, having regard to the purpose of the disclosure, provide information in a form that will protect information.

a) For example, the information may be provided in an aggregated form.

6.2.2 All decisions to disclose information will be made by officers who have been authorised to do so by the CEO (including, if required, under an instrument of delegation).

6.2.3 Where it has been requested to provide information, AFMA will make inquiries of the requesting person, body or agency, as appropriate, in order to be satisfied that the request correctly identifies the particular information relevant to the purpose of the request, and does not capture information that is not necessary for that purpose. AFMA will also make reasonable enquiries before releasing any information to ensure that sufficient controls exist for managing any information received.

6.2.4 AFMA will enter into a Memorandum of Understanding (MOU), covering the basis on which information will be provided, with agencies to which AFMA provides information on a reoccurring basis. Such MOUs will require that:

a) the confidentiality of any information provided by AFMA will be maintained and the information will be properly protected; and

b) information provided by AFMA will not be disclosed outside the agency without AFMA's prior consent.

6.2.5 Where information is provided to a person or agency with which an MOU governing the provision of the information is not in place, the information will only be provided subject to conditions that protect the information. At a minimum, the conditions will include the following, that the information:

a) will only be used for the purpose for which it is provided;

b) will only be disclosed to those persons and/or agencies with a 'need to know', as part of their duties;

c) will not be disclosed to a third party without AFMA's prior consent.

6.2.6 AFMA will keep a record of the disclosure. The record will include the data that was disclosed, to whom and for what purpose.

6.3 Cost recovery

AFMA will recover costs associated with disclosing information in accordance with the Australian Government's Cost Recovery Policy.

7. Review

This policy will be reviewed at a minimum period of five years, or as required, from its commencement.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
FINAL STOCK ASSESSMENT AND RBC	Agenda Item 4 For Discussion and Advice

RECOMMENDATIONS

1. That the RAG:
    a. **CONSIDER** the intersessional analyses to reduce the conflict between the November 2017 0+ survey index and the 2018 1+ index, to be presented by CSIRO (**Attachments 4a-4d**). Please note, **Attachment 4b** was pending at the time these papers were sent;
    b. **CONSIDER** the final stock assessment for the Torres Strait Tropical Rock Lobster Fishery (TRL Fishery) to be presented by CSIRO (**Attachment 4e**);
    c. **DISCUSS** and **PROVIDE ADVICE** on the final recommended biological catch (RBC) for the 2018/19 fishing season.

KEY ISSUES

Down-weighting of 2017 0+ index

2. At the RAG meeting held on 11-12 December 2018, the RAG discussed evidence suggesting the 2017 0+ index may be anomalous. The RAG agreed that the 2017 0+ index should be down-weighted appropriately rather than be excluded entirely. The down-weighting should be undertaken using an appropriate statistical methodology and not be applied arbitrarily. CSIRO undertook to complete this work prior to the next meeting.
3. In the intersessional period, CSIRO undertook additional analyses to reduce the conflict between the November 2017 0+ survey index (which was very low relative to historical) and the 2018 1+ index (which was closer to average). These analyses will be presented by CSIRO at this meeting. The RAG is being asked to review the analyses and where relevant provide advice on the findings and applied approach:
    a. **Attachment 4a** - Plagányi E *et al* (2019) Accounting for Observation and Process Error in the Torres Strait tropical lobster TRL stock 0+ survey index for input to the stock assessment. Summary Report for TRLRAG Feb 2019, 7pp;
    b. **Attachment 4b** (this paper is pending) - Upston J *et al* (2019) Tropical Rock Lobster abundance surveys – data conflicts and different analysis approaches. TRLRAG document February 2019;
    c. **Attachment 4c** - Campbell R *et al* (2019) Extended Analysis of Pre-Season Survey Data to Calculate the Annual Index for 0+ Lobsters. TRLRAG document February 2019, 8pp;
    d. **Attachment 4d** - Plagányi E *et al* (2018) Environmental drivers of variability and climate projections for Torres Strait tropical lobster *Panulirus ornatus*. CSIRO/AFMA Technical Report, March 2018, 156pp.

Final stock assessment and RBC

4. The 2018/19 RBC is to be calculated using the integrated fishery stock assessment model and interim harvest strategy (see details below).
5. A preliminary stock assessment update was presented by the CSIRO Scientific Member at the RAG meeting held on 11-12 December 2018. The stock assessment update

incorporated catch and effort data for the 2017/18 fishing season, historic catch and effort information and the results of the 2018 mid-year and pre-season surveys.

6. Noting RAG advice to apply a statistically calculated down-weighting to the 2017 0+ index, the RAG noted that the final RBC would likely lie somewhere between 533 and 637 tonnes.
7. A report on the final stock assessment will be presented by the CSIRO Scientific Member at this meeting:
    a. **Attachment 4e** - Plagányi E *et al* (2019) Torres Strait rock lobster (TRL) 2018 stock assessment: AFMA Project 2016/0822. February 2019, 56pp.
8. The RAG is being asked to review the final stock assessment and provide advice on the final RBC for the 2018/19 fishing season.
9. The draft Harvest Strategy, including the empirical harvest control rule (eHCR), have not been agreed by the PZJA. The final RBC calculated by applying the eHCR was presented at the RAG meeting held on 11-12 December 2018 but was for noting only and will not be used to determine the RBC for the 2018/19 fishing season.

BACKGROUND

Interim TRL Harvest Strategy

10. The interim Harvest Strategy is as follows:
    a. B_0 = varied between 0.65 and 0.80 of unfished biomass
    b. B_{TARG} = 0.65 B_0
    c. B_{THRES} is the RAG agreed threshold biomass level below which more stringent rules for calculating the total allowable catch apply. B_{THRES} = 0.48.
    d. B_{LIM} = 0.4 B_0
    e. F_{TARG} = 0.15 year-1
    f. F_{LIM} = F_{TARG}

Accounting for Observation and Process Error in the Torres Strait tropical lobster TRL stock 0+ survey index for input to the stock assessment

Éva Plagányi, Rob Campbell, Judy Upston, Mark Tonks, Nicole Murphy, Roy Deng

CSIRO Oceans and Atmosphere

Summary Report for TRLRAG Feb 2019

SUMMARY

The Integrated Stock Assessment Model was updated using results from the 2018 TRL Preseason Survey (conducted between the 11th and 23rd November 2018) as well as the Midyear survey conducted during 28th June - 9th July 2018. The preliminary results were presented at the TRLRAG meeting 11-12 December, Thursday Island, 2018, but no final RBC set as there was a conflict identified between different abundance data sets in the model, and more time was needed to decide how best to handle the data conflict. This report summarises additional analyses undertaken to reduce the conflict between the November 2017 0+ survey index (which was very low relative to historical) and the 2018 1+ index (which was closer to average) (Figs 1-2). Given we are reasonably confident in survey observations of 1+ lobsters (for reasons outlined in Plagányi et al. (2018)), the focus is on the anomalous 0+ observations. The stock assessment model is sensitive to the inclusion or exclusion (or downweighting) of the 2017 0+ index, and hence it is important that the TRLRAG consider the basis for including, revising, further downweighting or excluding the index.

The previous investigation identified that the 0+ survey index is less reliable than the 1+ index, mainly due to the cryptic nature of recently-settled lobsters making them more difficult to survey, and that there may be additional biases that influence the reliability of the 0+ index, including diver experience in sampling 0+ lobsters. In addition, it was acknowledged that there were major environmental anomalies over the recent period which may have influenced the distribution and timing of settlement, and hence the representativeness of the 2017 0+ index (noting that these animals were spawned in late 2016/early 2017 during a period of the hottest recorded sea surface temperatures). Hence there are three aspects that merit investigation:

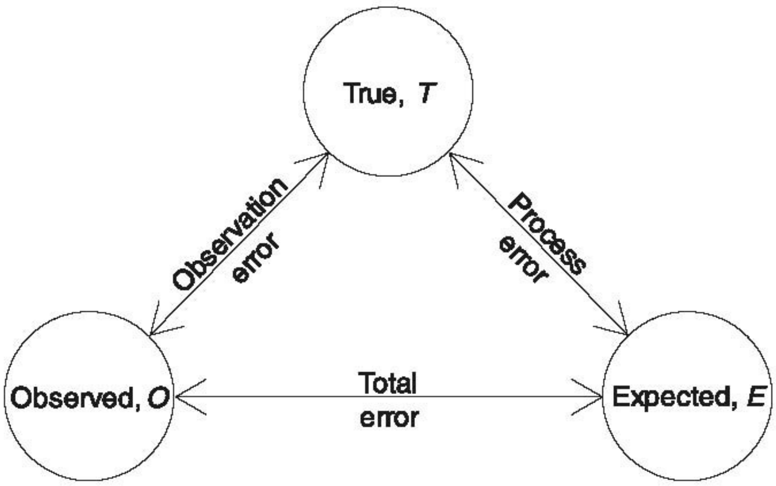
(1) Reviewing the relative weighting assigned to the 2017 0+ index (Upston et al. 2019);
(2) Analysing and standardizing the 0+ index to take into account additional factors that may have influenced it, for example, using a General Linear Model approach (see Campbell et al. 2019);
(3) Quantifying and accounting for environmental influences (see Table 1 summary and also (Plagányi et al. 2018a))

(1) Reviewing the relative weighting assigned to the 2017 0+ index

Integrated fisheries stock assessments that simultaneously utilize multiple types of data in a likelihood framework need to consider data weighting, i.e. the relative influence of each data type (Francis 2011, 2017). The contribution to the total likelihood of each survey abundance datum is defined by the associated observed survey C.V. (coefficient of variation), and a lognormal distribution of the error associated with the survey data is assumed.

Dealing with apparent data conflict among data sets in fisheries stock assessments is not straight forward; this is an evolving field of study and there are many different approaches (Maunder et al 2017). Two key guiding principles proposed in the seminal paper by Francis (2011) were adhered to in the preliminary stock assessment: (i) don't let other data stop the model from fitting abundance data well; and (ii) don't downweight abundance data because they may be unrepresentative. An example of an unrepresentative data set could be a CPUE series that does not reliably index the stock abundance, and this is one of the reasons considerable care is taken in the TRL assessment to standardise the CPUE series so that it might, as far as possible, provide an index of true underlying stock abundance. The gold standard being a research survey abundance index. Francis (2011) cites as an example of an unrepresentative survey one which covers different fractions of a population each year. Rather than downweighting data sets, he recommends that alternative assessments be considered in which possibly unrepresentative data sets are excluded, and this uncertainty be communicated to fishery managers, as was done at the previous TRLRAG.

It is important to recognize that the total error that exists between an Observed and Expected (by stock assessment model) quantity depends on both observation error (i.e. the sampling error) and process error (process variation and model misspecification (Maunder et al. 2017), i.e. how well the model represents the 'real world'), as illustrated in the schematic below from Francis (2011):



The survey c.v. represents the observation error and the c.v. associated with the 0+ survey is larger than that for the 1+ survey, with a range of 0.2 to 0.37. Process error is sometimes computed external to a stock assessment and then added to the total error, with most examples finding process and observation error to be approximately equal in variance (Francis 2011). Examples of factors that may contribute to process error include variable spatial distribution of 0+ lobsters and timing of the survey relative to spawning activity. Future work could consider methods for trying to quantify process error outside the stock assessment model. One method for accounting for process error within a stock assessment model is to estimate a single or series of additional variance parameters. The first approach assumes that the process error is roughly constant from year to year, whereas the latter assumes it is year-dependent, which is more closely aligned with the current hypotheses.

For TRL it is possible to estimate the additional variance for all years except the most recent survey 0+ datum because 1+ surveys have been conducted in all previous years, enabling validation of the earlier 0+ estimates. This approach was considered preferable to a less internally consistent option of only singling out the current anomalous year and estimating an associated additional variance. It also has the advantage that it can then be applied consistently in future analyses, and would again be helpful in future should another anomalous year occur. The fact that the additional variance can't be estimated for the last survey datum isn't a major problem because the 0+ only forecast the future fished age class 2 years ahead. Hence the proposed approach used here used the average of all previous additional variance parameters as the process error for the current survey 0+ datum, and then this is re-estimated in each subsequent assessment once the following year 1+ survey data become available.

Standard model selection criteria can be used to decide whether the estimation of further model parameters (i.e. the additional variance parameters for all survey years except the last year) is justified and also the Hessian-based standard errors associated with each parameter estimate indicate the reliability with which each parameter is estimated.

(2) Standardising the 0+ index using a GLM

The methods and results are presented in Campbell et al. (2019). Alternative model results are presented for model version that use the standardized GLM 0+ series rather than the unstandardized series.

(3) Quantifying and accounting for environmental influences

Substantial research has already been conducted to try and explain the large inter-annual variability in TRL recruitment strength but with limited success thus far (Plagányi et al. 2018a). This is by no means unusual as is the case in almost all fisheries globally, despite intensive research since Hjort's (1914)[1] influential work to understand the relationships between spawners, recruits and environmental variability. However ongoing research in this

[1] In June 2019 ICES are celebrating the 150-year anniversary of Johan Hjort at the Hjort symposium: Challenging the scientific legacy of Johan Hjort: time for a new paradigm in marine research?

area may improve the ability to quantify the role of environmental factors, and this would in turn reduce process error in the model.

The different analysis approaches considered to resolve the current data conflict are outlined in more detail in an accompanying document (Upston et al. 2019). Similarly, some preliminary results of alternative analyses used to calculate the 0+ index of abundance are detailed in (Campbell et al. 2019). Finally, based on the analyses in these accompanying documents and the summary as outlined in this document, the stock assessment model was revised and the results are summarised in (Plaganyi et al. 2019).

Finally note that the TRLRAG also agreed that the statistical downweighting of the 0+ survey index as described here was for application to the stock assessment model only, and not the empirical harvest control rule (eHCR). The eHCR is deliberately tuned to reduce inter-annual variation in the TAC, and uses the logarithm of the slope of the past 5 years' survey and CPUE data, with a 10% weighting accorded to the preseason 0+ index (Plagányi et al. 2018b).

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Table 1. Consideration of alternative hypotheses to explain the low 2017 0+ survey index compared with the 2018 1+ survey index.

	Alternative Hypotheses	**Does it explain low 0+ in Nov 2017?**	**Does it explain 1+ size distribution in June 2018?**	**Notes and evidence**	**PLAUSIBILITY**
1	The 2017 0+ index was negatively biased due to observational error	No (see Appendix 1)	no	There was some concern that as 2017 was the first year without a "gold standard" (GS) diver participating in the survey with considerable experience detecting the small 0+ age class, this may have biased the index negatively. However a statistical comparison of historical performance between GS and Other teams showed that whereas the GS teams generally found slightly more 0+, there was no significant difference between the results, and evidence of rapid learning. Even if the maximum likely bias is applied to the 0+ index, it does not increase it sufficiently to explain the 2018 1+ abundance.	low
2	The 2017 0+ index was low because of the timing of settlement	maybe	maybe	As lobsters spawn over a period of a few months, there is also approximately 3 months variability in terms of when they settle. In addition, the anomalous environmental conditions in 2016 (influencing the spawners producing the 2017 0+ cohort) could easily have influenced the timing of spawning and successful transport and settlement of pueruli. If settlement occurred earlier than usual, then this could explain relatively larger 1+ observed during 2018, but it means the 0+ would have been easier to observe during the 2017 survey. On the other hand, if settlement occurred later, then this explains the reduced numbers during the survey, but not the larger sizes of 1+ during 2018 (but it's possible that this was a result of a combination of timing of settlement and change in growth rate as below).	medium
3	Faster growth due to higher temperatures in 2017-2018 and/or reduced density dependence	no	yes	TRL growth is known to increase with increasing SST (Skewes et al. 1997) and there is evidence to suggest that the 2016 high temperatures had an influence on the stock, but there is less	high

				evidence of high temperatures over December 2017-June 2018 (Fig. 9) potentially influencing growth of the recruiting cohort. Differences in growth due to SST will be more substantial for younger animals as the von Bertalanffy growth curve predicts that growth converges as animals approach maturity. Density dependence is also thought to influence growth rates (Skewes et al. 1997), and the relatively low average density of 2+ lobsters during 2018 means the 1+ lobsters would have had access to more favourable habitat and food supplies and this may also have influenced growth rate. The broad spread in size distribution of this cohort suggests these dynamics may have been spatially patchy (and hence that density dependence may have played a role rather than just temperature) and the relatively large sizes of some individuals lends further support to this hypothesis.	
4	The 2017 0+ index was low because the distribution of settling recruits changed substantially	yes	yes	The recent anomalous environmental conditions would have had an influence on local Torres Strait currents, as well as sand and habitat distribution and quality which could have influenced the spatial pattern of puerulus settlement. There is some evidence from the 2017 preseason survey 0+ spatial distribution data that the pattern differed to that observed in previous years eg lower than usual density in TI_Bridge stratum. The highest densities of 0+ were in the South-East and Mabuiag strata, so its possible that relatively more settlement may have occurred to the north-west to the extent that the index wasn't as comparable as in previous years. Previous research (Skewes et al. 1997) showed that there are differences in growth rate between the four zones (NW,SW,Central, SE), with lobsters being larger in the NW, and this may have contributed to the larger average size of this 1+ cohort (see Tonks et al. 2018). Commercial catch data from 2018 PNG commercial catches also suggested there was good recruitment up north which lends further support to this hypothesis.	very high

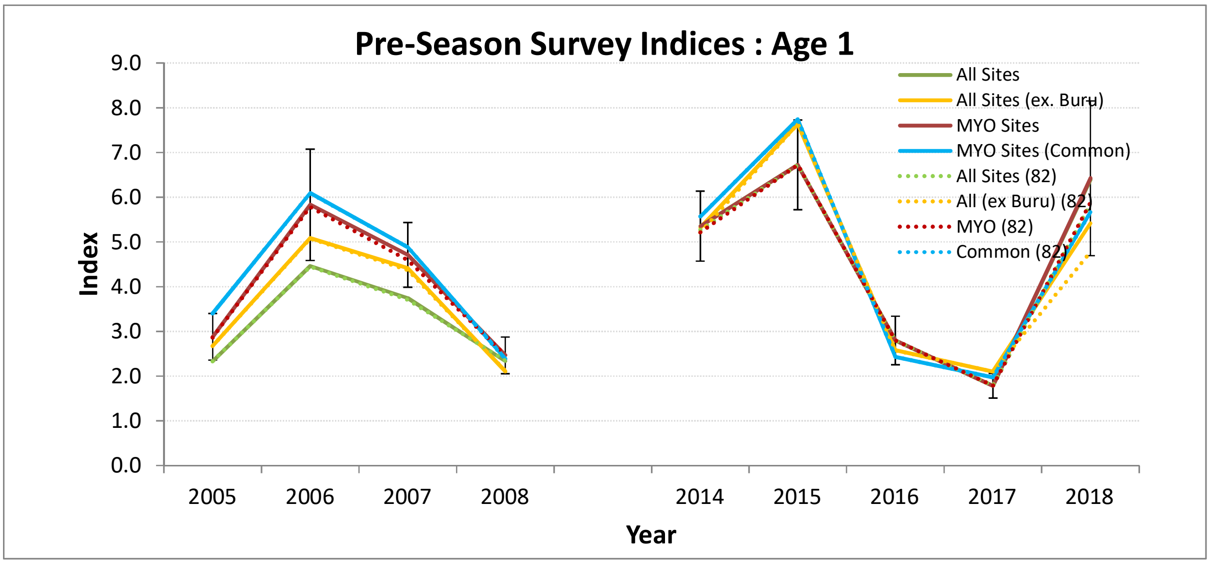

Figure 1. Comparative indices of abundance of recruiting (1+) ornate rock lobsters (*Panulirus ornatus*) recorded during pre-season surveys in Torres Strait between 2005 and 2018 (note surveys were not done during 2009-2013) shown for all sites as well as reduced series including Midyear-Only Sites (MYO). Error bars of MYO indices represent standard errors

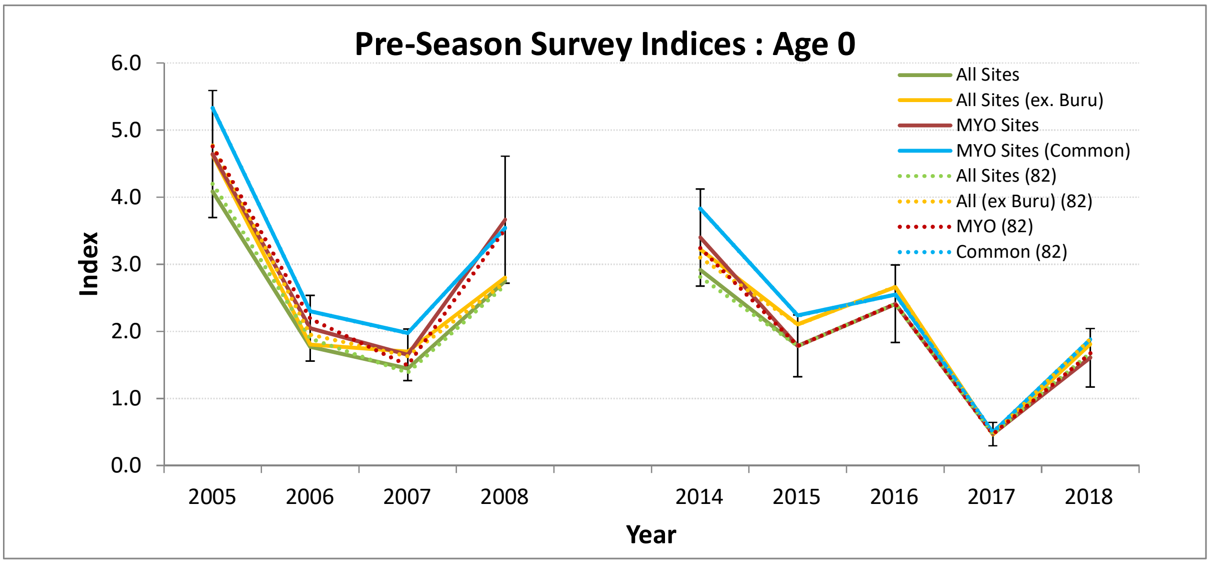

Figure 2. Comparative indices of abundance of newly settled (0+) ornate rock lobsters (*Panulirus ornatus*) recorded during pre-season surveys in Torres Strait between 2005 and 2018 (note surveys were not done during 2009-2013) shown for all sites as well as reduced series including Midyear-Only Sites (MYO). Error bars of MYO indices represent standard errors

Extended Analysis of Pre-Season Survey Data to Calculate the Annual Index for 0+ Lobsters

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CSIRO Oceans & Atmosphere

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Introduction

The assessment model used to assess the status of Torres Strait rock lobsters is unable to satisfactorily fit the 2017 0+ index because it is too low to explain the 1+ numbers observed during both the mid-year and pre-season surveys conducted in 2018. However the 0+ index has some weight in the model (likelihood contribution depends on the variance) as apart from the 1+ indices it is the only direct prediction of 2018 1+ numbers, and unfortunately the 2018 pre-season 1+ index has relatively high variance also due to the spatial variability (mainly Buru). That means the model doesn't fit the 1+ index satisfactorily.

The TRLRAG agreed that the 2017 0+ index is anomalous and not a true reflection of the abundance possibly because (as outlined in the hypotheses table) of an environmentally-mediated change in distribution over that period. Note that although less reliable than the 1+ index, the 0+ index is fitted reasonably well in all previous years. Hence the RAG agreed that it should be down-weighted in the model in order to adequately fit the 1+ index. We agreed not to discard it entirely and are wanting an objective justifiable method for down-weighting it. For example it can be shown that if we double the associated variance for that year, the model is able to adequately fit the 1+ index (a minimum criterion given it is the key information that determines the TAC). But we don't want to adjust the variance in an ad hoc manner, especially as it makes a big difference to the RBC.

Given this situation, this paper investigates an alternative analysis of the pre-season survey data using General Linear Models (GLMs). In comparison to the present method used to calculate the annual index of 0+ lobsters based on the pre-assessment survey conducted each year, the use of GLMs allows for additional factors which may influence the number of lobsters observed and counted during any survey transect to be taken into account. Factors which may influence the number of observed lobsters include the depth of the survey transect, current speed and water visibility, each of which have been coded for when each transect was undertaken. An outline of the data and models used to undertake these alternative analyses is first described in the next two sections before the results are presented.

Data

The surveys analysed in this paper are limited to the pre-season surveys conducted during the nine years 2005-2008 and 2014-2018 and the 82 distinct sampling sites commensurate with those sampled during the mid-year surveys together with the five additional sites sampled in 2018. In total this gave a total of 678 survey transects (c.f. Figure 1). During each survey, together with the number of 0+ lobsters observed, the following additional information was also collected: i) length of transect, ii) width of transect, iii) water depth, iv) current speed, and v) visibility. While the transect width was 4 meters for all sampled sites, the length of the

Figure 1. Number of sampling sites visited during each of the annual pre-season surveys,

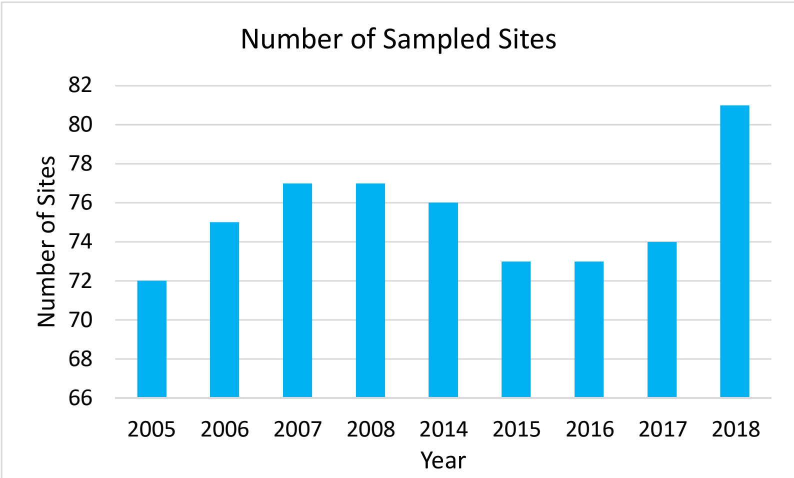
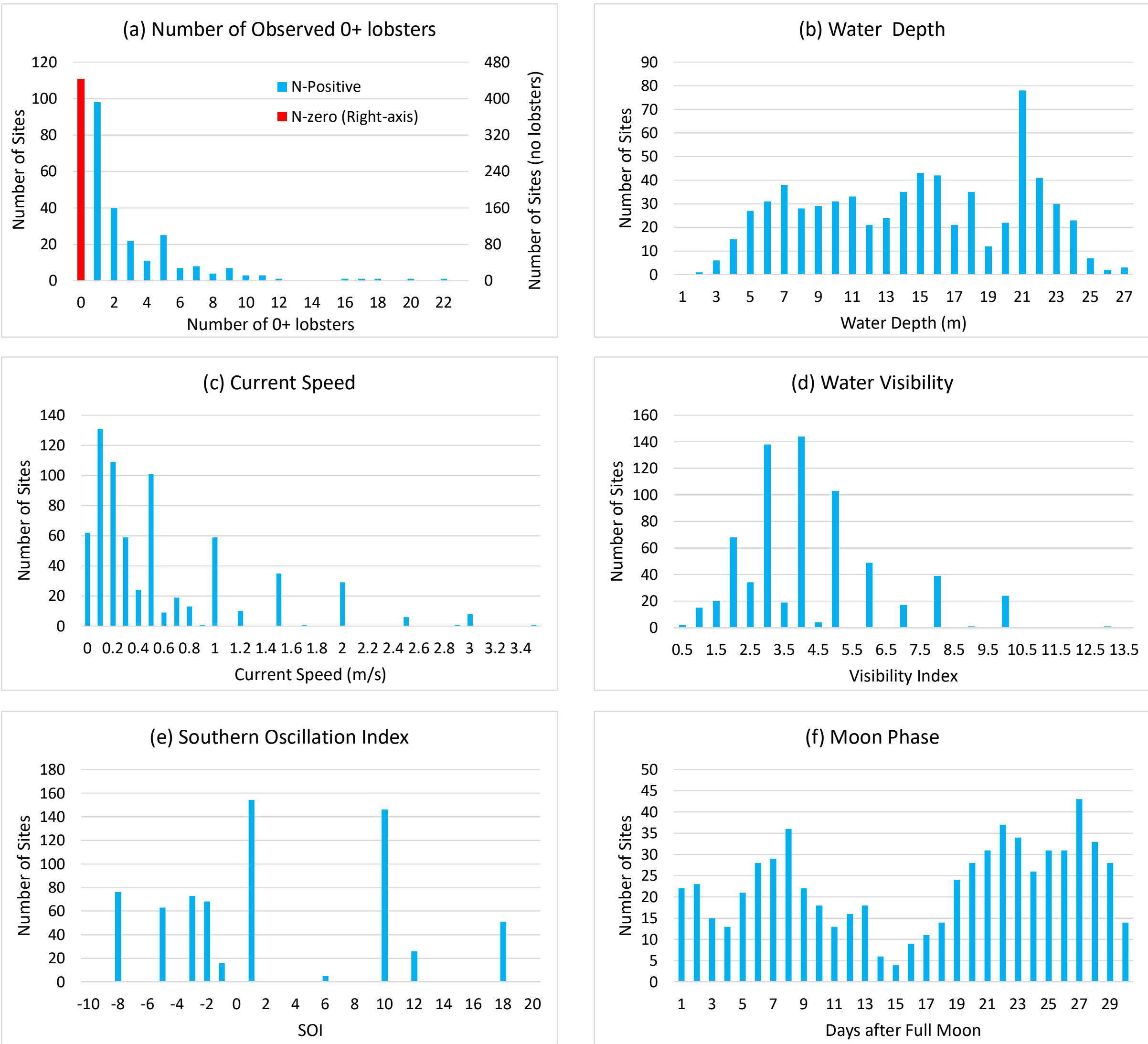


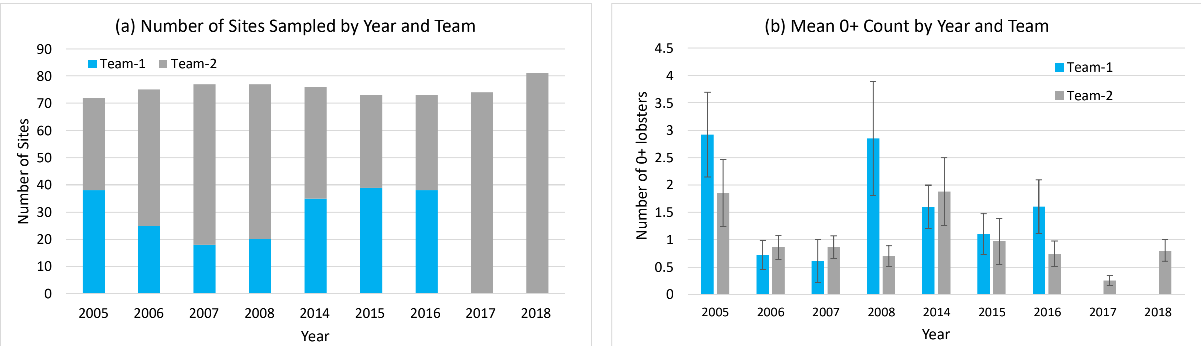
Figure 2. Data summary. Histograms of (a) number of 0+ lobsters observed, (b) water depth, (c) current speed, (d) water visibility, € southern oscillation index, and (f) moon-phase at each of the 678 sampled sites.



transect varied between 216 and 500 meters (being 500m for 625 sites, or 92.2% of all sites). For those sampled sites where the transect length was less than 500m the number of lobsters observed was scaled (or standardised) to represent the number within a 2000 m^2 area. This scaling assumes that mean density of lobsters along the entire 500m is similar to that along the surveyed transect. Histograms of the distribution of raw (i.e. unstandardized) number of 0+ lobsters observed at each sample site is shown in Figure 2a, while histograms of the distribution of water depth, current speed and visibility recorded for all sampled sites is shown in Figures 2b-d. For each sample site the associated value of the Southern Oscillation Index and phase of the moon (coded as the number of days after a full moon) corresponding to the date each site was sampled were also obtained and the histograms of the distributions of these values are shown in Figures 2e-f.

Finally, as a long term member of the diving team left the project after 2016, a question has been raised as to whether the absence of this experienced diver during the past two years may have influenced the number of 0+ lobsters observed. While there has been sixteen divers listed as participating in the 678 sites sampled above, where a two person diver team surveys each site, a simple analysis was conducted where these dive teams were divided into the following two groups: Team-1 included all two-person teams which included the experienced diver mentioned above while Team-2 included all teams which did not include this diver. Across the 678 sites, Team-1 surveyed 213 sites while Team-2 surveyed 465 sites. The number of sites surveyed by each team in each year is shown in Figure 3a while a comparison of the mean number of 0+ lobsters counted by each team within each year is shown in Figure 3b.

Figure 3. (a) Number of sites surveyed and (b) the mean number of 0+ lobsters counted by each team within each year (with standard errors also shown).



Method

Due to the high number of zero observations of 0+ lobsters across all sampled sites (444 of the 678 sampled sites, or 65%) it was considered best practice to standardise the number of observed 0+ lobsters as a two stage process: one stage being concerned with the pattern of occurrence of positive observations, and the other stage with the mean size of the positive counts. We also assume that both the probability of a positive catch and the size of a positive catch rate can be modelled as linear combinations of the factors described in the previous section. Once this is done, we can combine the means from the two distributions to give an overall mean standardised index of lobster counts.

A small example helps illustrate this approach. Consider a survey season for which there are n sampled sites with an observed number of 0+ lobsters, C_i, recorded against each site. The average number of 0+ lobsters across all sites can be expressed as follows:

$$\mu = \frac{1}{n}\sum_{i=1}^{n} C_i = \frac{1}{n_S + n_F}\sum_{i=1}^{n_s} C_i = \frac{n_S}{n_S + n_F}\frac{1}{n_S}\sum_{i=1}^{n_s} C_i = p_S \mu_S$$

where n_S is the number of positive count sites obtained (C_i>0), n_F is the number of counts (C_i =0), p_S is the proportion of positive count sites and μ_S is the average of the positive counts. This result shows that the overall mean catch rate can be expressed as the combination of the parameters from the distributions used to model the probability of a successful catch and that used to model the non-zero counts. A similar approach was used in the estimation of egg production based on plankton surveys (Pennington 1983, Pennington and Berrien 1984) and for estimating indices of fish abundance based on aerial spotter surveys (Lo et al 1992).

Stage 1: Prob(positive count)

The Binominal distribution is used to model the probability of a non-zero lobster count where we model each observation as either a success (C_i >0) of a failure (C_i =0), with the probability of either expressed as follows:

$$\Pr(C_i > 0) = p_S \qquad \text{and} \qquad \Pr(C_i = 0) = 1 - p_S$$

Associated with each observation is a vector of covariates or explanatory variables X_j thought likely to influence the probability of a positive catch. Furthermore, we assume that the dependence of p_S occurs through a linear combination $\eta = \sum \beta_j X_j$ of the explanatory variables. In order to ensure that $0 \le p_S \le 1$ we use the logit link function which takes the following form:

$$\eta = \log\left(\frac{p_S}{1 - p_S}\right)$$

The inverse of this relation gives the probability of a positive sighting as a function of the explanatory variables:

$$p_S = \frac{e^{\eta}}{1 + e^{\eta}} = \frac{\exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots)}{1 + \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots)}$$

The following model was then fitted to the data using the SAS GENMOD procedure (SAS, 2008):

MODEL p_S = *Intercept* +*Year***Strata* +*Team*
+*Water-Depth* + *Current-Speed* + *Visibility* + *SOI* + *Moon-Phase*
/ dist=binomial link=logit

where *Year* refers to the sampling year, *Strata* refers to the seven regions used to stratify the sampled sites (Buru, Kircaldi, Mabuiag, Reef-Edge, South-East, TI-Bridge and Warraber) and * represents an interaction between these two variables. After fitting the above model to the data the standardised probability for a positive catch, p_S, was then calculated for each spatio-temporal strata (year, strata) against a standard set of model factors.

Stage 2: Mean Size of Positive Catch Rate

Having fitted the above model to the probability of obtaining a positive catch, a separate model was fitted to the distribution of positive catch rates, μ_S. For this purpose a log-Gamma model was adopted, such that the μs was assumed to have a gamma distribution with a log link to the vector of covariates or explanatory variables X_j. The data fitted to the model were limited to those observations having a positive catch.

As before, the following model was then fitted to the data using the SAS GENMOD procedure:

MODEL μs = *Intercept* + *Year*Strata* + *Team*
+ *Water-Depth* + *Current-Speed* + *Visibility* + *SOI* + *Moon-Phase*
/ dist=gamma link=log

A standardised mean positive catch rate, μs, was then calculated for each spatio-temporal strata (year, quarter and area) against a standard set of model factors.

Note: the continuous gamma distribution is used here as the fitted count may no longer be an integer after being scaled to represent the number of lobsters observed over a 2000 m^2 area.

In each of the two models described above, the explanatory variables Water-Depth, Current-Speed, Visibility and SOI were fitted as linear covariates (each standardized to have a mean of zero over all data) while Team and Moon-phase were fitted as a categorical variables, with the latter having ten equally spaced levels between 1 and 30. After fitting each model, the explanatory variables with the largest Type-III chi-square probability greater than 0.05 was removed. This process was repeated until no explanatory variables remained with a Type-III chi-square probability greater than 0.05.

Abundance index

The above two models were fitted to the data-sets defined below for each species and the results used to calculate the standardized index, *I*, in each year and stratum:

$$I(year,y;\ stratum,s) = ps(y,s) * \mu s(y,s)$$

An annual index of abundance, *Index(year)*, was then determined by calculating the area-weighted sum of the standardized index across all *NA* strata as follows:

$$Index(year, y) = \sum_{s=1}^{NA} Size_s * ps(y,s) * \mu s(y,s)$$

where $Size_s$ is the spatial size of the individual stratum. The annual index for all years was scaled so that the mean of the annual index over the entire time-series was equal to 1. Associated standard errors were also calculated using the method described in Campbell (2015).

Finally, the standardised index was compared with the nominal CPUE defined as follows:

$$Nominal\ Index(year, y) = \sum_{s=1}^{NA} Size_s * \left[\frac{\sum_{i=1}^{n_{y,s}} C_{y,s,i}}{n_{y,s}}\right]$$

where $C_{y,s,i}$ refers to the number of lobsters observed in the i^{th} site sampled in Stratum s and Year y and $n_{y,s}$ is the number of sites sampled in Stratum s and Year y. Again, the index was scaled so that the mean over the entire time-series was equal to 1.

Results

After fitting both models described above, apart from the highly significant *Year*Strata* interaction term, only the *Team* effect (0.0285) was found to be significant at the 5% level in

Table 1. Type-1 analysis for both the Binomial and the Gamma GLM analyses.

(a) Binominal Analysis

Source	Deviance	DF	Chi-Square	Pr > ChiSq
Intercept	873.781			
YEAR*STRATA	704.834	62	168.95	<.0001
TEAM	700.036	1	4.8	0.0285

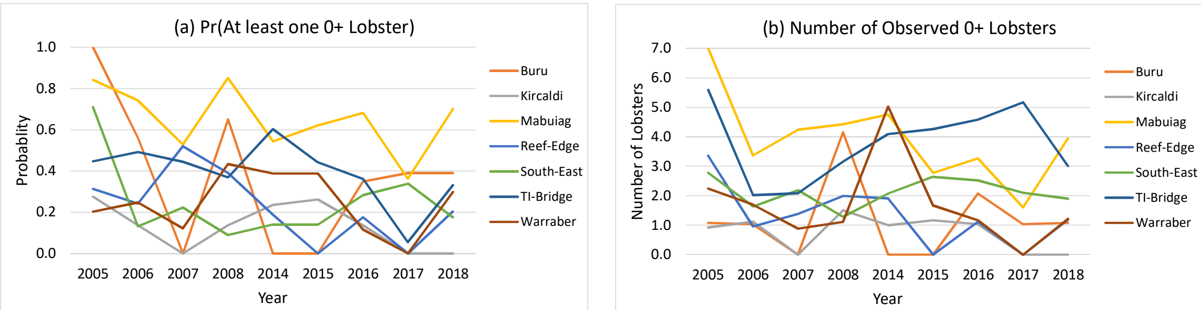
(b) Gamma Analysis

Source	2*LogLikelihood	DF	Chi-Square	Pr > ChiSq
Intercept	-1020.7998			
YEAR*STRATA	-912.2869	53	108.51	<.0001
VISIB	-906.0102	1	6.28	0.0122

the Binomial model and only the *Visibility* effect (0.0122) was found to be significant in the Gamma model. The Type-1 analyses for both the Binomial and the Gamma models are shown in Table 1.

The results of the GLM analysis for (a) the mean probability of observing at least one 0+ lobster, and (b) the mean number of 0+ lobsters observed per transect surveyed in each strata and year are shown in Figure 4. Across all nine years, the strata having the highest average probability (0.65) of observing at least one 0+ lobster is Mabuiag while the strata having the lowest probability (0.13) is Kircaldi. This spatial pattern is also found for the average number of 0+ lobsters observed within each strata across all years, with Mabuiag and Kircaldi having the highest (3.93) and lowest (0.75) mean number of lobsters respectively.

Figure 4. Results of GLM analysis: (a) the mean probability of observing at least one 0+ lobster, and (b) the mean number of 0+ lobsters observed per transect surveyed in each strata and year.



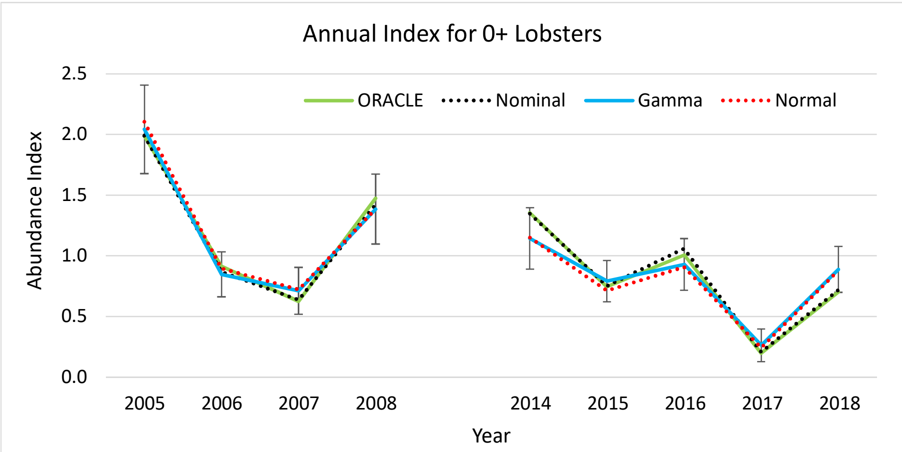
Finally, the annual index (and associated standard error) of 0+ lobster abundance across the nine survey years is listed in Table 2 and displayed in Figure 5 (known as the GLM analysis). Also shown is the annual index based on the method which has been used in recent years for analysing the survey data (known as the ORACLE analysis). Also shown is the Nominal annual index based on the method described in the previous section together with the results of an alternative GLM analysis which used a log-Normal distribution instead of a log-Gamma distribution in the Stage-2 model described previously.

As expected, the Nominal and ORACLE based indices are very similar (and provides a useful check) as the two associated methods are both similar. The two GLM-based indices are also similar indicating that the result is not sensitive to the type of distribution assumed for the analysis. The Gamma distribution is recommended as it assumes a more general variance structure. A comparison of the GLM and ORACLE based indices is shown in Table 2 and indicates that the two indices have the greatest relative difference in the last two years, where the former GLM index is around 34% and 27% higher respectively. The standard error associated with the 2017 GLM-based index is also appreciably higher (84%) than that associated with the ORACLE-based index and this result may help overcome the issue of the anomalously low variance associated with the 2017 index described in the Introduction.

Table 2. Annual index (and standard error, SE) for the abundance of 0+ lobsters based on various analysis of the pre-season survey data.

	GLM Analysis		ORACLE Analysis		GLM vs ORACLE Analysis		Nominal Analysis	GLM Normal
Year	Index	SE	Index	SE	Index	SE	Index	Index
2005	2.044	0.365	1.987	0.376	2.84%	-3.03%	1.991	2.106
2006	0.846	0.185	0.914	0.200	-7.40%	-7.13%	0.869	0.896
2007	0.711	0.193	0.624	0.149	13.94%	29.68%	0.636	0.721
2008	1.385	0.289	1.473	0.375	-5.96%	-23.03%	1.424	1.388
2014	1.144	0.253	1.355	0.293	-15.57%	-13.52%	1.347	1.151
2015	0.791	0.171	0.745	0.192	6.25%	-11.04%	0.750	0.712
2016	0.928	0.214	1.007	0.242	-7.80%	-11.42%	1.060	0.906
2017	0.262	0.134	0.195	0.073	33.86%	84.45%	0.206	0.241
2018	0.888	0.189	0.700	0.168	26.94%	12.41%	0.717	0.878
Mean	1.00		1.00				1.00	1.00

Figure 5.Annual index for the abundance of 0+ lobsters based on various analysis of the pre-season survey data. The standard error is shown for the GLM-Gamma index.



Discussion

The approach outlined in this paper describes an alternative approach to analysing the data associated with the annual surveys conducted for the Torres Strait rock lobster and used to construct an annual abundance index for use in the associated stock assessments and harvest strategies. While this approach has only been used here to construct an annual index for 0+ lobsters based on the pre-season surveys, there is no reason why this method could not also be used to construct annual indices for the other age classes using both the mid-year and pre-season surveys. The results presented here should nevertheless be seen as preliminary as the approach used to assess the *Team* effect is rather simple and further investigations should be undertaken to assess the possible influence of other divers. For example, we have not addressed the issue of counts by teams for each transect being paired (counts are not independent), which can influence estimation of errors and conclusions about differences between teams Furthermore, for the purpose of this preliminary analysis we have assumed that the *Team* effect does not vary between years and this should be tested in future analyses. Also, there has been no investigation of the residuals associated with the analyses presented above to assess the suitability of the assumed Gamma distribution. Finally, it would also be useful to add further explanatory variables to account for changes in the in-situ environment (e.g. water temperature) and, in particular, the habitat data which has been routinely collected during the surveying of each sampled site.

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Environmental drivers of variability and climate projections for Torres Strait tropical lobster *Panulirus ornatus*

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March 2018

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Tables

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The work described here forms part of an AFMA/CSIRO Project No. 2017/0816 entitled Environmental influences on Torres Strait lobster recruitment. We thank Richard Matear and Xuebin Zhang (CSIRO) for climate data. Thanks to the following colleagues for helpful discussions and inputs: Roy Deng, Trevor Hutton, Leo Dutra, Nicole Murphy, Mibu Fischer.

Executive summary

The Torres Strait tropical rock lobster (TRL) *Panulirus ornatus* fishery is a culturally and economically important fishery, and hence it is important to consider the potential influence of changing climate on the future fishery and the flow-on effects on stakeholders. The TRLRAG and fishery stakeholders have been requesting additional information on three related aspects: (1) scientific basis to further assess the interaction of recent Papua New Guineau (PNG) trawl fishing with the TRL spawning migration; (2) the need to better understand environmental drivers of TRL survival and recruitment variability, and in particular the impact of El Niño years; (3) the need to advance understanding of medium and long-term impacts of climate change on Torres Strait fisheries and communities. Larval circulation plots were proposed to improve understanding of connectivity of the Torres Strait lobster stock with that of the East Coast and PNG.

The larval advection modelling in this study illustrated the highly variable nature of the paths of particles given strong inter-annual differences in the Coral Sea Gyre and associated currents. For particles released from Yule Island, during some years there is considerable spread to the east whereas during others the distribution is more focused within the Coral Sea Gyre, with some leakage to the north of PNG. In contrast, the paths of particles released from Princess Charlotte Bay are far more restricted. During some years particles pass through a narrow band north along the Queensland coast; sometimes not even reaching the Torres Strait.

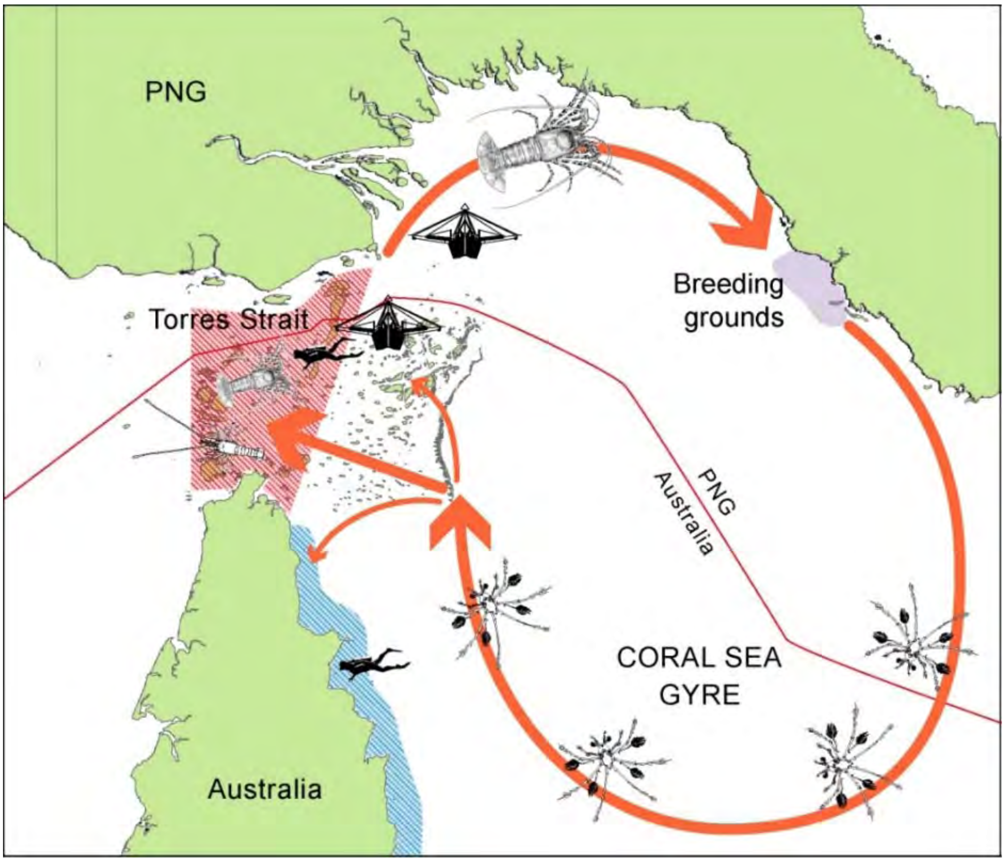
Preliminary analyses have found no sufficiently rigorous relationships between the larval advection model predictions and the actual observed recruitment levels in Torres Strait. Hence preliminary analyses did not provide a basis for updating the stock assessment model to improve prediction of recruitment based on oceanic currents influencing advection and settlement rates.

Overall, the CONNIE model results confirm the shared nature of the Torres Strait *P. ornatus* stock between Australia and Papua New Guineau, and complements current understanding that large lobsters migrate from Torres Strait to breed in the eastern Gulf of Papua, with some of the larvae released off locations such as Yule Island then advected back to reseed Torres Strait. This underscores the need to protect lobsters on the spawning migration from trawling (particularly given the lobsters are aggregated during the migration and hence more susceptible to overfishing) in order to achieve long-term sustainability of the fishery for the shared benefit of both Australia and PNG. An inter-annually variable proportion of the larvae are likely also advected to the east of PNG as well as along Australia’s Great Barrier Reef. The study also confirmed that larvae spawned in northern Great Barrier Reef locations such as Princess Charlotte Bay (considered part of the Queensland East Coast fishery) may also be advected to Torres Strait but the extent to which the East Coast stock may be contributing to Torres Strait recruitment is difficult to quantify, and there are some indications that this transport pathway doesn’t operate in all years.

Model simulations were conducted with the stock assessment model to assess the impact on model estimates and predictions arising from using an assumption that the Torres Strait lobster fishery is a closed population compared with assuming that recruitment is supplemented by contributions from the East Coast fishery. Model results suggested that this would bias estimates of the stock-recruit steepness parameter h and carrying capacity parameter K (and hence depletion estimates) but that model predictions remain robust because of the availability of direct survey data on recruiting lobsters measured as part of annual Pre-season surveys.

The CONNIE simulations confirm that there is substantial inter-annual variability in environmental factors that could be driving changes in recruitment to Torres Strait. In some years of bad recruitment, there are indications that the clockwise Coral Sea Gyre circulation pattern is more diffuse and many particles are lost to the system by being transported to the east. On the other hand, there are some indications that good lobster recruitment years may be partially explained by the Coral Sea currents operating in a more contained clockwise fashion. Nonetheless, the huge variability further confounds detection of underlying relationships, and the final particle plots are not easily distinguishable in good and bad years either. Ongoing work may shed further light on the complex system dynamics.

This document also presents TRL projections to 2050 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 methods draw on earlier studies, and the preliminary projection scenario presented is based on the most up to date understanding of the impacts of key climate variables on the resource growth, productivity and survival. The March 2017 TRL stock assessment model is 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 Sea Surface Temperature (SST). The parameters of the latter functional form are 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. However ongoing work will continue to refine these projections and the results presented here should thus be considered as preliminary only.


PNG
Breeding
grounds
Torres Strait
PNG
Australia
CORAL SEA
GYRE
Australia

1 Part I Climate

1.1 Data Sources

Modelled climate data were provided by Richard Matear and Xuebin Zhang (CSIRO) starting in 1992 and climate change (rcp8p5) and control projections up to 2099. The data consists of monthly surface data of temperature (SST; °C), salinity (SSS), phosphate (SPO4; mmol m^{-3}), phytoplankton (SPHYL; mmol N m^{-3}) and primary productivity (PP; mmol C m^{-2} day^{-1}).

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

Another set of outputs were obtained for the same area with an exclusion zone representing the subset of the initial area lying within the GBRMP, as defined:

A. Exclusion zone top left coordinates: 10° 41’ 17” S / 142° 31’ 55.82”E

B. Exclusion zone bottom right coordinates: 11° 10’ 0.00” S / 144° 28’ 0.00”E (Figure 1-1)

Plots of the monthly mean values for each variable are provided in Appendix A

Remotely sensed Sea Surface Temperature data for the Torres Strait area as defined above (without exclusion zone) was obtained from the global Multi-scale Ultra-high Resolution (MUR) SST dataset (https://podaac.jpl.nasa.gov/dataset/MUR-JPL-L4-GLOB-v4.1) from the ERDDAP (Environmental Research Division Data Access Program) server at the NOAA/SWFSC Environmental Research Division in Santa Cruz, California using the R package xtractomatic.

Daily (from 12-05-1998 to 13-09-13) temperature data recorded by the Australian Institute of Marine Science at a depth of 2m from Thursday Island was downloaded from: http://data.aims.gov.au/aimsrtds/datatool.xhtml?from=1980-01-01&thru=2017-11-23&qc=LEVEL2&period=DAY&aggregations=AVG,STDDEV&channels=1978.

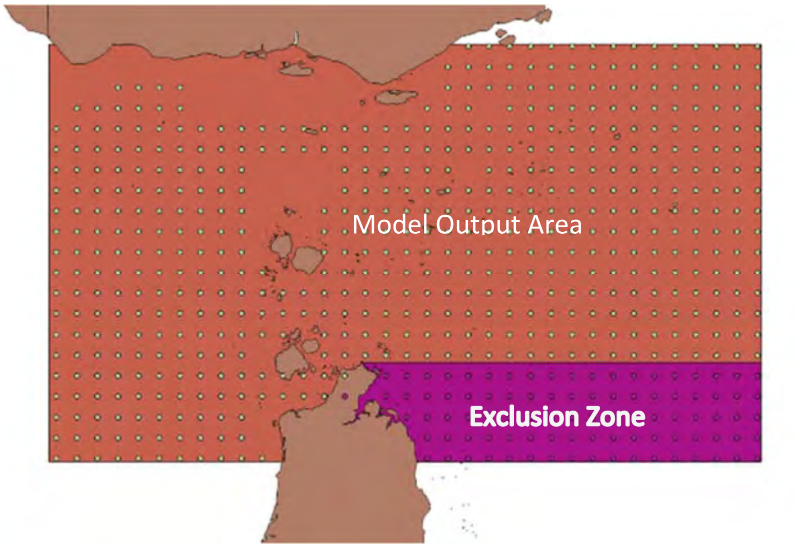


Figure 1-1. Map of Torres Strait showing the Model Output Area (MOA) and the GBRMP exclusion zone.

1.2 Temperature

In order to determine how closely the datasets corresponded to each other, the period during which data was available for all sources (2003-01-01 – 2010-03-01) was extracted and Pearson correlation co-efficients were calculated (Figure 1-2).

For the period 2003 – 2010 the data was all highly correlated with all correlation co-efficients being highly significant and ≥0.98 (Figure 1-2). However, examination of the full time series showed that (apart from 2016) for all the modelled scenarios, the modelled SST exceeded the maximum recorded temperature at Thursday Island and the MODIS remotely sensed SST each year (Figure 1-3). In addition, the minimum temperatures each year matched very closely for all data sources under the control scenarios (Figure 1-3A, B), but the RCP8.5 scenarios overestimated the minimum temperatures each year (Figure 1-3C, D).

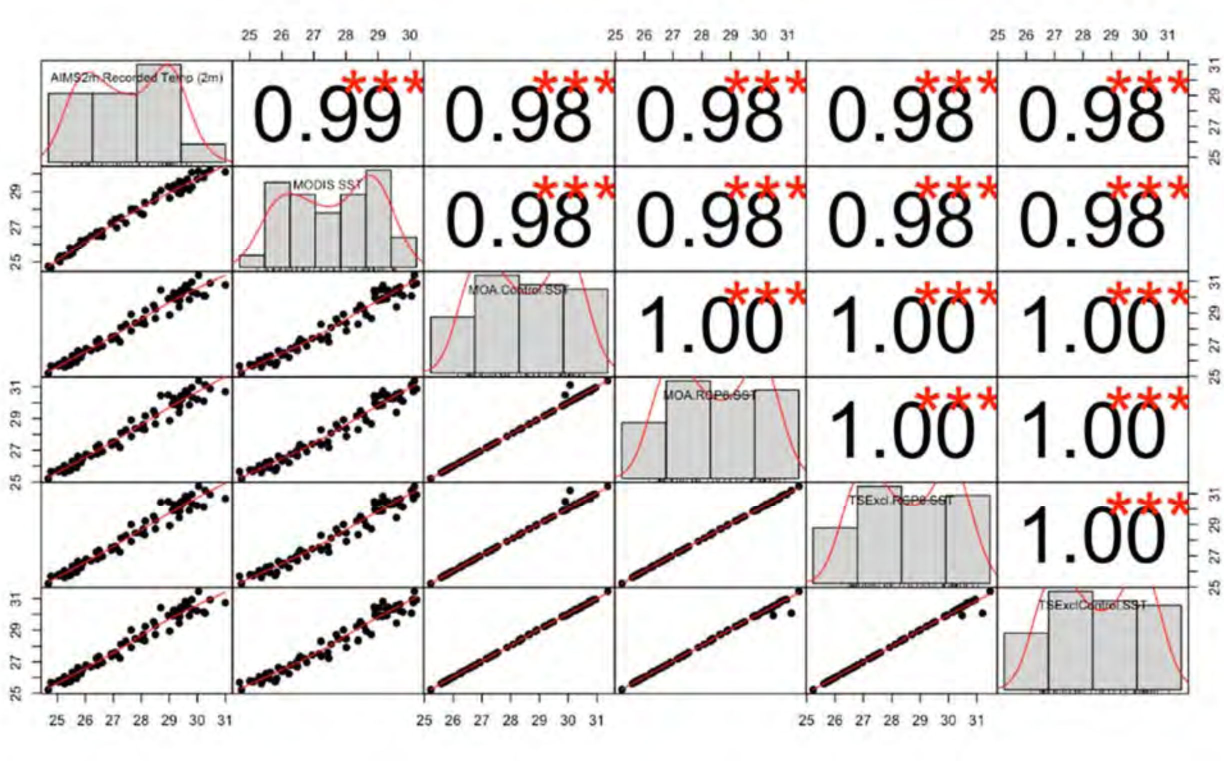


Figure 1-2. Pearson correlation co-efficients of the temperature recorded at 2 m depth at Thursday Island, remotely sensed MODIS SST and modelled SST within the Torres Strait with and without the overlapping area zoned within the GBRMP.

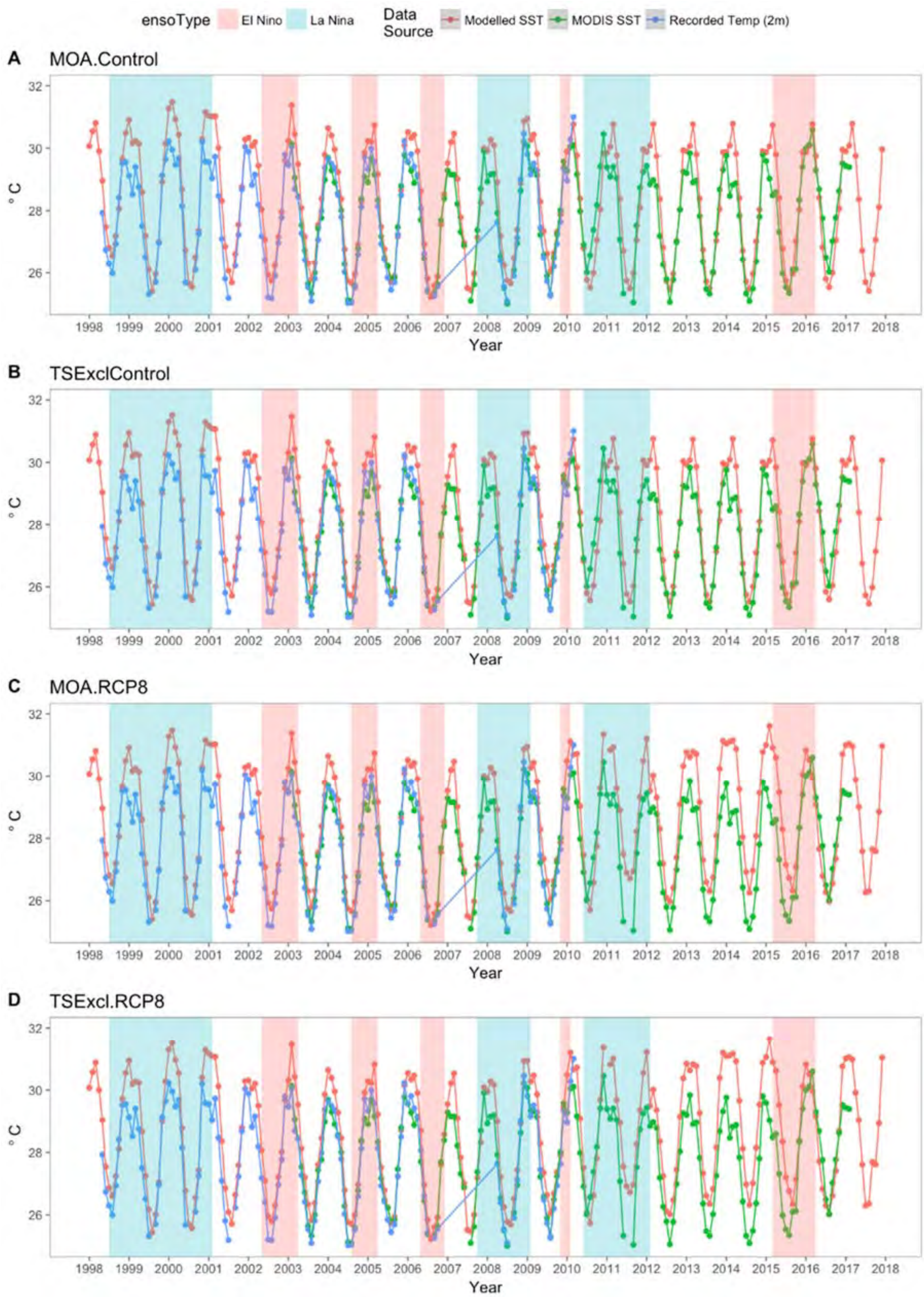


Figure 1-3. Plots of water temperature (modelled SST, remotely sensed (MODIS) SST and actual water temperature at 2 m depth at Thursday Island). The modelled SST is shown for the Torres Strait model output area (MOA) and the MOA minus the exclusion zone (TSExcl) under two future climate scenarios: no change (Control) and RCP8.5 (RCP8). Major ENSO events are overlaid.

2 Part 2 Habitat

2.1 Data sources

During the annual lobster surveys conducted throughout the western Torres Strait divers swim 500 x 4 m transects at each site collecting and counting lobsters and also recording various habitat-related information such as the numbers of pearl oyster (*Pinctada maxima*), crown-of-thorns starfish and holothurian species observed, and visually estimating the percent cover of standard substratum and biota (including seagrass and algae species) categories.

We used this habitat information to try and identify any relationships between the abundance of 1+ and 2+ lobsters in the Torres Strait fishery.

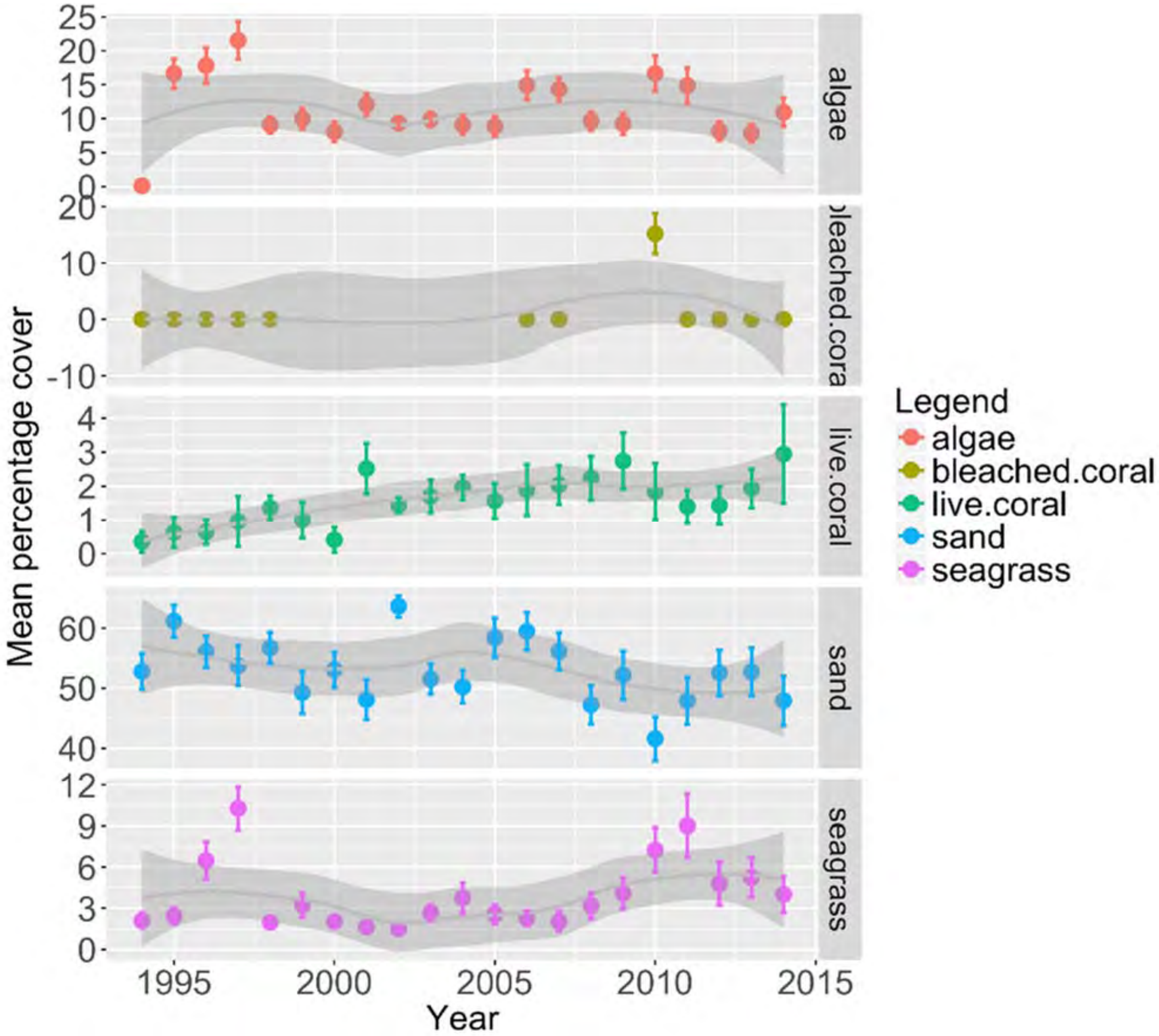


Figure 2-1. Mean (±1 SE) percentage cover of the main habitat variables recorded by lobster survey divers during the mid-season surveys (1994 – 2014). Between 53 and 483 sites were surveyed each year.

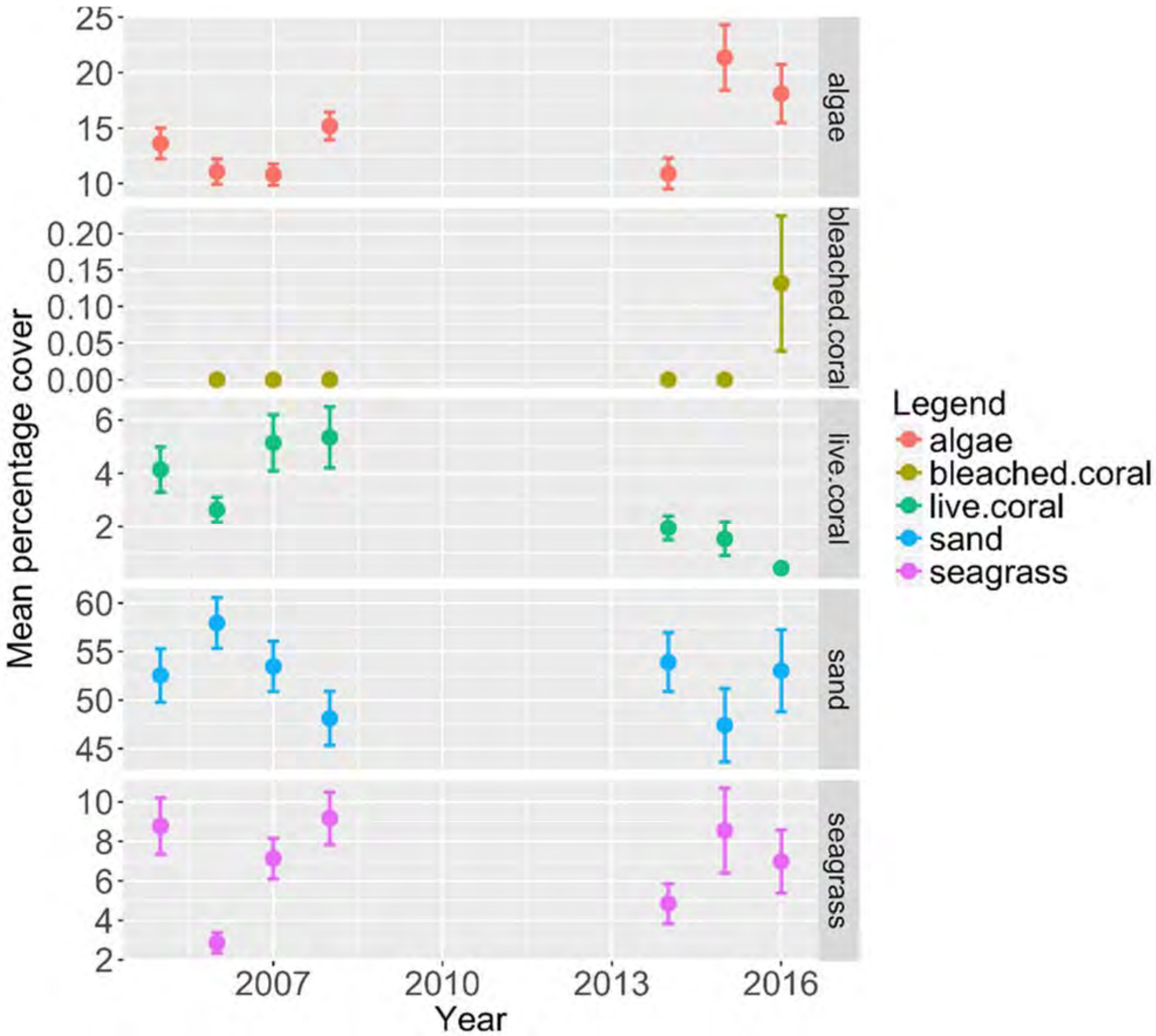


Figure 2-2. Mean (±1 SE) percentage cover of the main habitat variables recorded by lobster survey divers during the pre-season surveys (2005 – 2016). Between 76 and 188 sites were surveyed each year.

The habitat data for all mid and pre-season surveys is summarised in Figure 2-1 and Figure 2-2. Live coral cover has always been relatively low, mainly because most sites are not on coral reefs, however there was a significant decrease in live coral cover in 2016 accompanied by an increase in bleached coral resulting from the thermal anomaly that occurred during that year. The cover of macroalgae appears to be increasing over recent years, being ~20% in 2015 and 2016 compared to 10 to 15% for most of the period between 1998 to 2014.

2.2 Tree models for the whole of Torres Strait

The habitat data were analysed using univariate regression trees which are a form of constrained or supervised clustering which permits the recursive partitioning of quantitative variables (mean count of lobsters per transect) under the control of a set of quantitative or categorical explanatory variables (e.g. percentage cover of mud, sand etc.). The output from this analysis is a tree whose "leaves" are composed of groups of sites chosen to minimize the within-group sums of squares, but where each successive partition is defined by a threshold value or a state of one of the explanatory variables.

Regression trees are a powerful method that can handle a wide range of data, are not influenced by missing values, can deal with non-linear relationships between the response and explanatory variables and high order interactions among the variables {Borcard:2011tq}.

The data used were the Torres Strait lobster winter surveys i.e. the pre-season surveys (conducted in spring) were excluded. The two response variables were the average catch (from paired divers) of 1+ and 2+ lobsters. The explanatory variables were the percentage cover of a number of substrate and epibenthic organisms observed by the divers whilst surveying each transect (Table 2-1).

Table 2-1. Explanatory variables used in the tree models. All are visual percentage cover estimates made by the divers whilst surveying each transect for lobsters.

Explanatory variable
mud
sand
rubble
boulders
consolidated rubble
pavement
bommies
live hard coral
bleached hard coral
seagrass
algae
hard coral foliose
whips
tubes

Explanatory variable
soft coral
ascidians
hydroids
crinoids
Xestospongiae
Solenocolon
Ianthella
Cymbastella
gorgonians
Ircinians

For some analyses the site stratum (= area within Torres Strait) was also included. All data were analysed using the mvpart library in the R software package.

Figure 2-3. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 during mid-year surveys from 2001 -2012.

For 1+ lobsters, the percentage cover of consolidated rubble appears to be important in distinguishing transects having relatively high versus low catches of lobsters. The critical value in determining this first split is at 8.5% cover of consolidated rubble (Figure 2-3). At levels of consolidated rubble greater then 8.5% two further groups were distinguished based on the stratum in which the transect was located, suggesting that further investigation into the importance of habitat on lobster abundance might be better spent by looking at the strata separately. Overall, the model only explained 12.6% of the variation in

1+ lobster catch rates, with the majority of this been accounted for by the first split as a result of the percentage cover of consolidated rubble (8.8%).

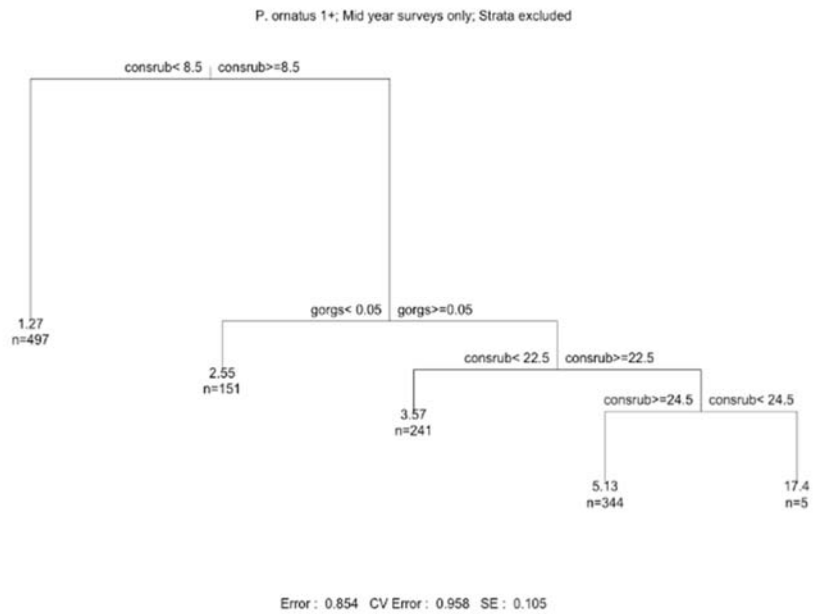


Figure 2-4. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 during mid-year surveys from 2001 -2012. The 'strata' variable was excluded from this model.

When stratum is excluded from the model, other environmental characteristics are identified as important in explaining the variation in the 1+ lobster catch rates, although once again the total amount of variation accounted for by the model is quite low (15%; Figure 2-4). The second split is determined by the percentage cover of gorgonians with higher catches of 1+ lobsters being taken at transect having a gorgonian cover of greater than 5%. The catches are further discriminated by two levels of the cover of consolidated rubble with the highest catches (mean=17.4) being taken at sites with a cover of consolidated rubble between 22.5-24.5%. However, given that the amount of extra variance explained by these last couple of splits is relatively small and remembering that the estimates of percentage cover of the various habitat variables were visual estimates made by a variety of divers (during the period 2001-2012) integrating over a 500 m long transect it is likely that by extending this tree to this level is probably over-fitting the model.

2.3 Tree models by stratum

Maubiag

For the Maubiag region the percentage cover of consolidated rubble was the only covariate to explain the abundance of 1+ *Panulirus ornatus*, (14% of variance explained) with higher abundance being found in areas having ≥ 13.5% cover of consolidated rubble (Figure 2-5).

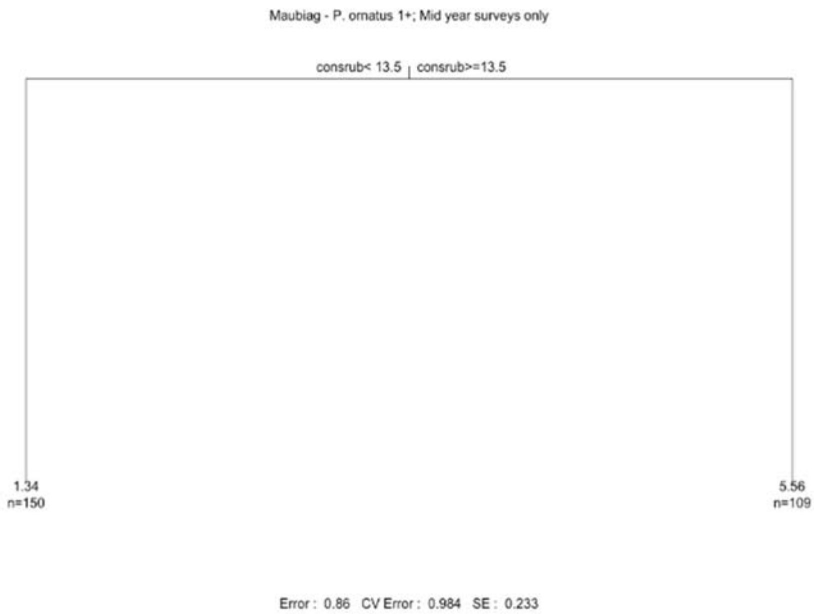


Figure 2-5. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 from the Maubiag stratum during mid-year surveys from 2001 -2012.

Kircaldie rubble

Similarly, for the Kircaldie rubble region the percentage cover of consolidated rubble was also the only covariate to explain the abundance of 1+ *Panulirus ornatus* (23% of variance explained), with higher abundance being found in areas having ≥ 22.5% cover of consolidated rubble (Figure 2-6).

Figure 2-6. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 from the Kircaldie rubble stratum during mid-year surveys from 2001 -2012.

T.I. Bridge

For the T.I. Bridge region none of the variables recorded were able to explain much of the variability of the catch of 1+ *Panulirus ornatus.* Only the percentage cover of seagrass was statistically significant and only explained 5% of the variance. A higher abundance of 1+ *Panulirus ornatus* was found in areas having ≥ 17.5% cover of seagrass (Figure 2-7).

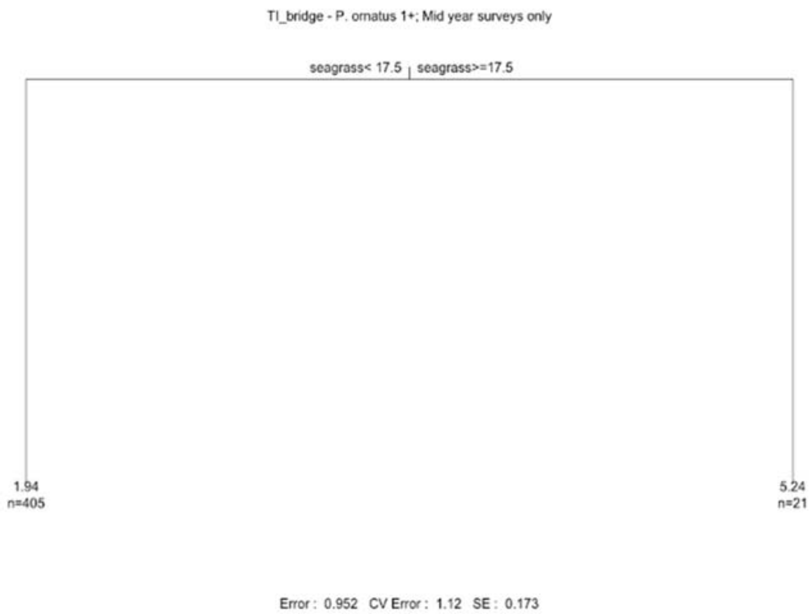


Figure 2-7. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 from the T.I. Bridge stratum during mid-year surveys from 2001 -2012.

South-east

In the South-east region the percentage cover of consolidated rubble was also the only covariate to explain the abundance of 1+ *Panulirus ornatus* (15% of variance explained), with higher abundance being found in areas having ≥ 8.5% cover of consolidated rubble (Figure 2-8).

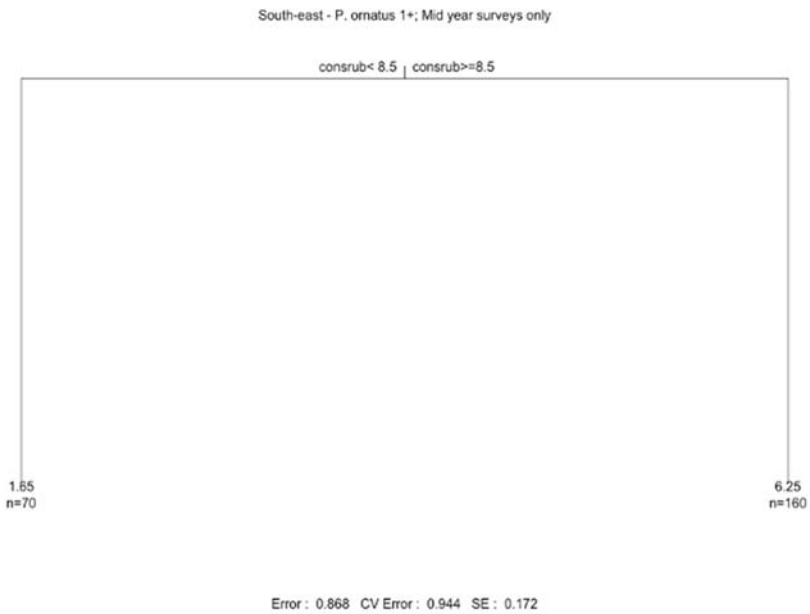


Figure 2-8. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 from the South-east stratum during mid-year surveys from 2001 -2012.

Warraber bridge

The distribution of 1+ *Panulirus ornatus* in the Warraber bridge stratum was explained the percentage cover of Solenocolon and whips (31% variance explained). The initial split was at a cover of 2.5% of Solenocolon, with the group having the higher cover of Solenocolon being further split at a cover of whips of 0.55% (Figure 2-9).

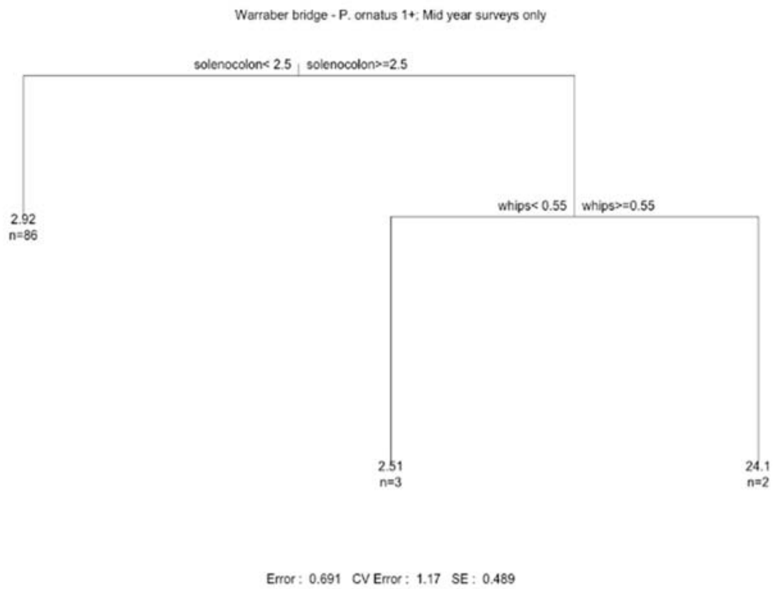


Figure 2-9. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 from the Warraber bridge stratum during mid-year surveys from 2001 -2012.

Buru

In the Buru region consolidated rubble was the only variable to explain the distribution of 1+ *Panullirus ornatus*, (27% variance explained) with two approximately equal sized groups of transects being separated at a cover of 2.5% of consolidated rubble (Figure 2-10).

Figure 2-10. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 from the Buru stratum during mid-year surveys from 2001 -2012.

Reef edge

The distribution of 1+ lobsters from reef edge stratum were explained (30% of variance) by the percentage cover of consolidated rubble and live coral. The lower densities of lobsters were found at covers of consolidated rubble <27.5% whereas at higher cover of consolidated rubble two groups were further identified at a split of 45% live coral; higher densities of lobsters were found at a higher cover of live coral (Figure 2-11).

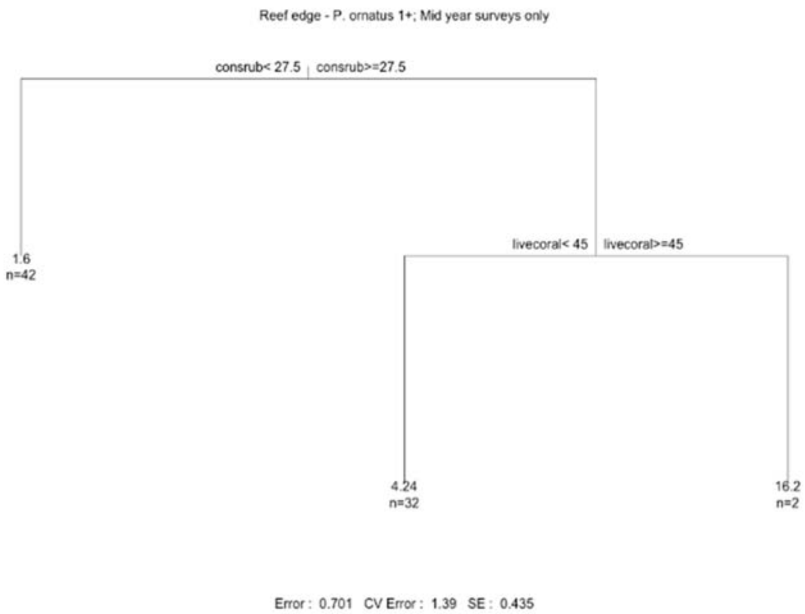


Figure 2-11. Univariate regression tree of the mean catch of 1+ *Panulirus ornatus* with the environmental variables listed in Table 2-1 from the reef edge stratum during mid-year surveys from 2001 -2012.

Warrior back

There was only a single transect in the dataset characterised as "Warrior-back" and so no analysis was possible.

3 Part 3 Larval Advection

3.1 Introduction

In order to better understand the potential impacts of climate change related influences on the recruitment of TRL to Torres Strait, improve our assessment of the impacts of trawling migrating lobsters within PNG waters and understand the connectivity between east coat and Torres Strait rock lobster populations, we conducted a series of larval advection runs using the CONNIE 3 particle tracking engine. The CONNIE 3 particle tracking engine uses 0.1 degree daily data from the global Bluelink Re ANalysis (BRAN) 2016 model (http://www.cmar.csiro.au/staff/oke/BRAN.htm). Note the BRAN model is a global model with a daily time resolution so it does not adequately capture the complex dynamics of the tides in the Torres Strait. Any particles close to the shelf are likely to get flushed through the Torres Strait by the tides and this is not captured in the results.

3.2 Methods

CONNIE 3 uses archived currents from oceanographic models and particle tracking techniques to estimate connectivity statistics from user-specified source regions (or to user-specified sink regions). A range of physical and biological behaviors can be specified including vertical migration, horizontal propulsion or swimming (user-specified random or constant velocity).

For the rock lobster larval advection runs we released particles (larvae) from 21 November – 25 February each year from 1994 to 2016. To examine connectivity between east coast and Torres Strait populations, larvae were released from two locations: Yule Island, PNG and Princess Charlotte Bay (Figure 3-1). A total of 9600 particles were uniformly released over the 96 day period each year with 100 particles released each day.

Larval rock lobsters are known to undergo diel vertical migrations through the water column and so the particles were assigned different depths during the day and night as follows:

Phase 1

Dispersal length: 120 days

Vertical distribution: 2.5 m at night; 23 m during daytime

Phase 2

Dispersal length: 30 days

Vertical distribution: 2.5 m at night; 95 m during daytime

Four sets of plots were generated as outputs from the larval advection runs:

Final Plots:

These plots show the final locations of all particles at the end of the simulation. The values plotted are the number of particles that lie within each grid cell at the end of the simulation, divided by the number of particles in the simulation (9600). The scale of the colour bar is altered to show some variation between the values and a consistent scale is used over all plots to allow for comparisons.

Proportion of particles reaching Torres Strait:

These plots show the proportion of the total numbers of particles released from each of the two release areas that were within the Torres Strait Rock Lobster fishery at the end of the simulations.

Proportion of particles reaching Torres Strait with 1+ distribution:

These plots show the proportion of the total numbers of particles released from each of the two release areas that were within the Torres Strait Rock Lobster fishery at the end of the simulations. The catch of 1+ TRL for the survey of the following year are overlaid.

Cumulative Statistics Plots:

The 'All Phases' plots show the probabilities of distinct particles passing through a cell. The values plotted are the values in the number of particles that pass through each grid cell divided by the number of particles in the simulation (9600).

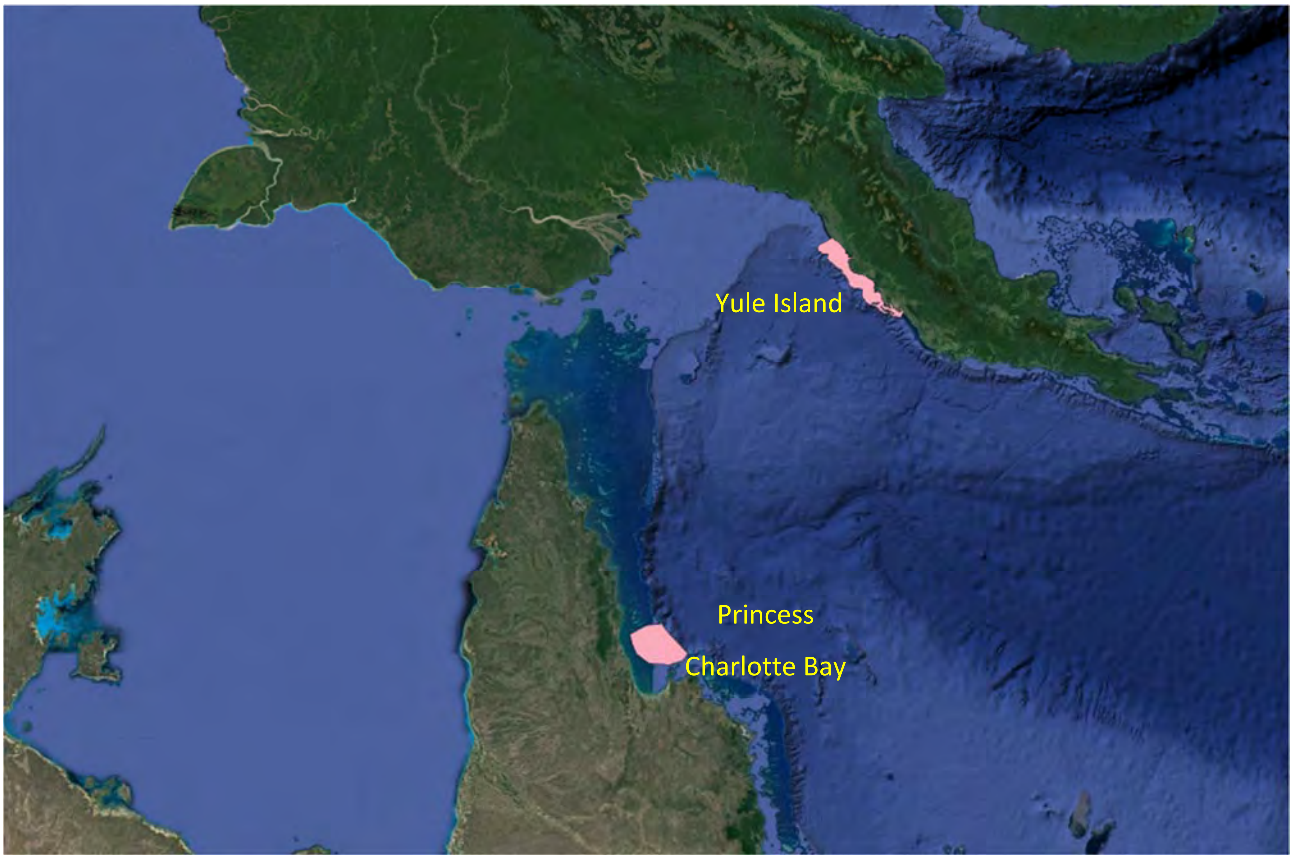


Figure 3-1. Map of NE Australia and PNG showing the particle release sites at Princess Charlotte Bay and Yule Island

3.3 Results

3.3.1 Final particle destination

The final particle positions for particles released from Yule Island were quite variable each year, sometimes extending well to the east into the Coral Sea and well into the southern parts of Torres Strait and to the south of West Papua (Figure 3-2; plots of all years (1994–2015) are provided in Appendix B).

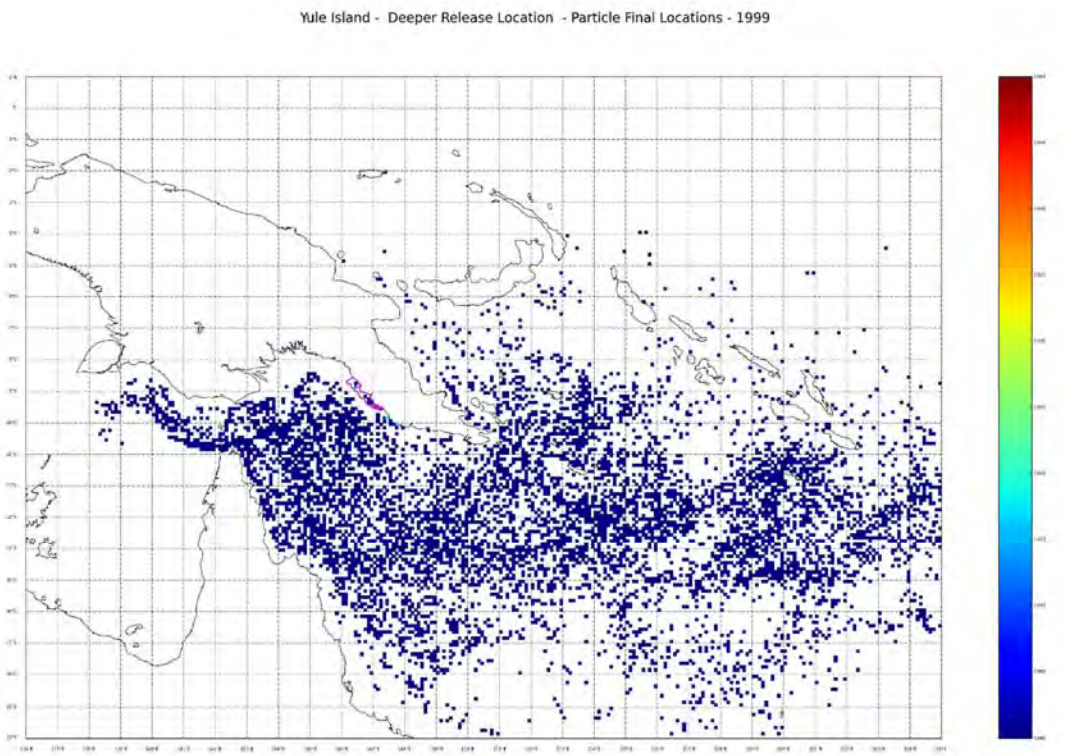


Figure 3-2. Final particle positions for particles released from Yule Island during the period Nov 1999 – Feb 2000.

During other years, particles extended along the northern coastline of PNG, into Torres Strait and down the eastern coastline of northern Queensland (Figure 3-3).

Yule Island - Deeper Release Location - Particle Final Locations - 2001

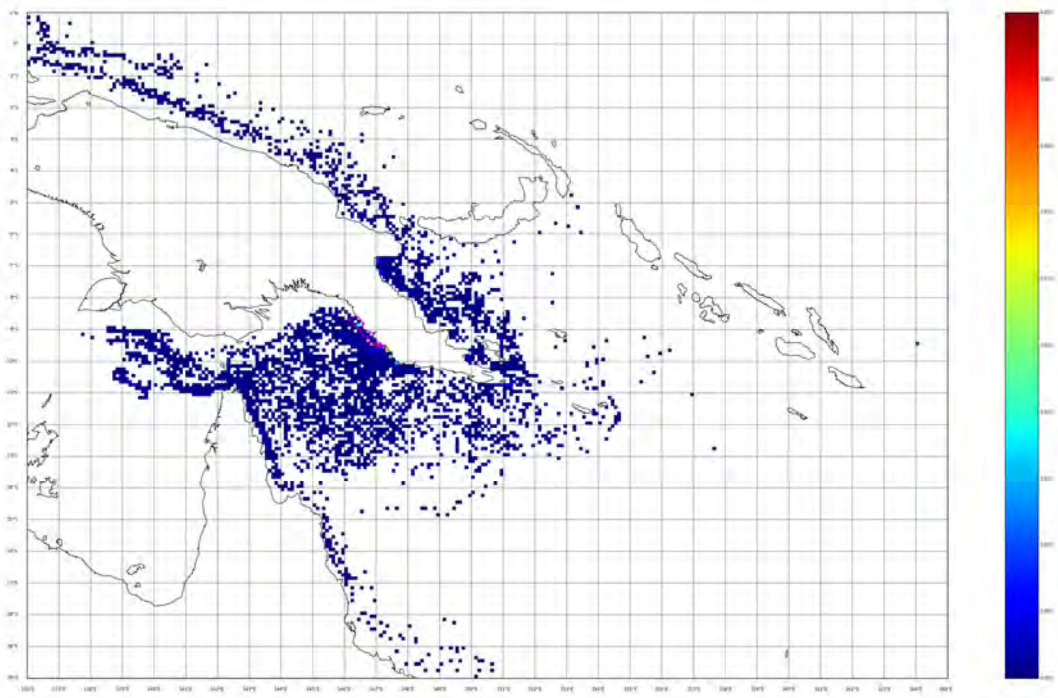


Figure 3-3. Final particle positions for particles released from Yule Island during the period Nov 2001 – Feb 2002.

The distribution of particles released from Princess Charlotte Bay (PCB) was not quite as widespread. During all years particles were distributed close to the Queensland coastline to the north of PCB and into Torres Strait (

Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2001

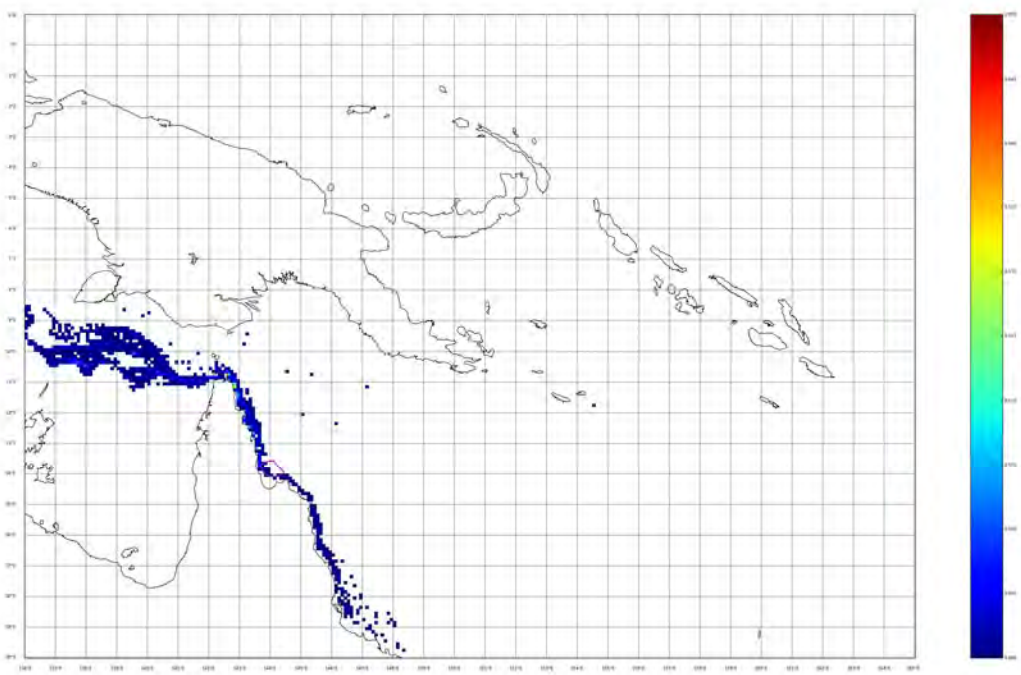


Figure 3-4. Final particle positions for particles released from Princess Charlotte Bay during the period Nov 2001 – Feb 2002.

; plots of all years (1994–2015) are provided in Appendix B); occasionally particles also travelled south along the Queensland coastline (Figure 3-5).

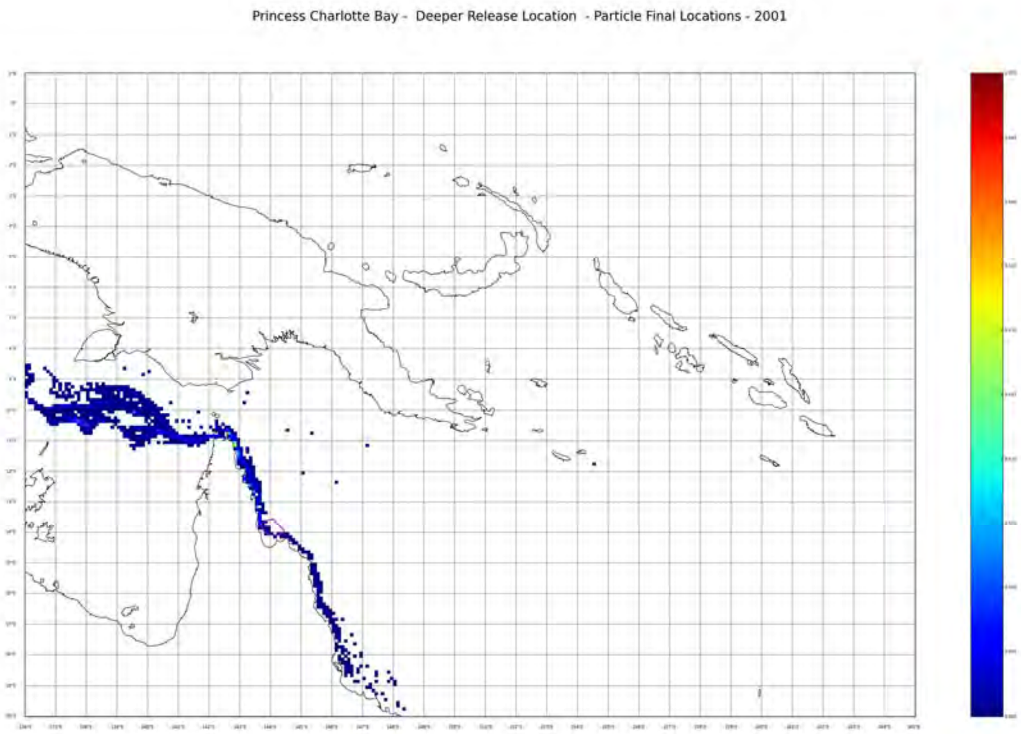


Figure 3-4. Final particle positions for particles released from Princess Charlotte Bay during the period Nov 2001 – Feb 2002.

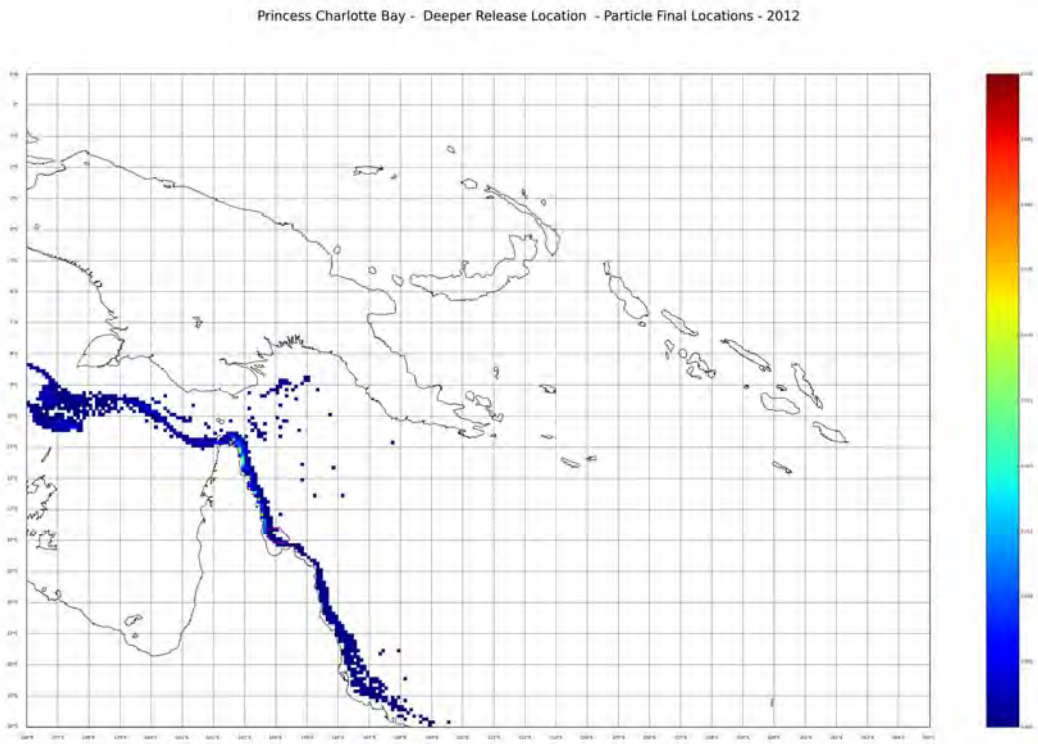


Figure 3-5. Final particle positions for particles released from Princess Charlotte Bay during the period Nov 2012 – Feb 2013.

Proportion of particles reaching Torres Strait

In order to determine the relative importance of the two release areas to lobster recruitment in the Torres Strait, we calculated the proportion released particles that were within the Torres Strait fishing grounds on settlement (Figure 3-6; Table 3-1; Figure 3-7; Figure 3-8. Plots of all years are presented in Appendix B). Between 0 and 2% of particles released from Yule Island and 1 and 9 % of particles released from Princess Charlotte Bay respectively settled with the Torres Strait Fishery zone during the period 1994–2015 (Table 3-1).

a)
b)

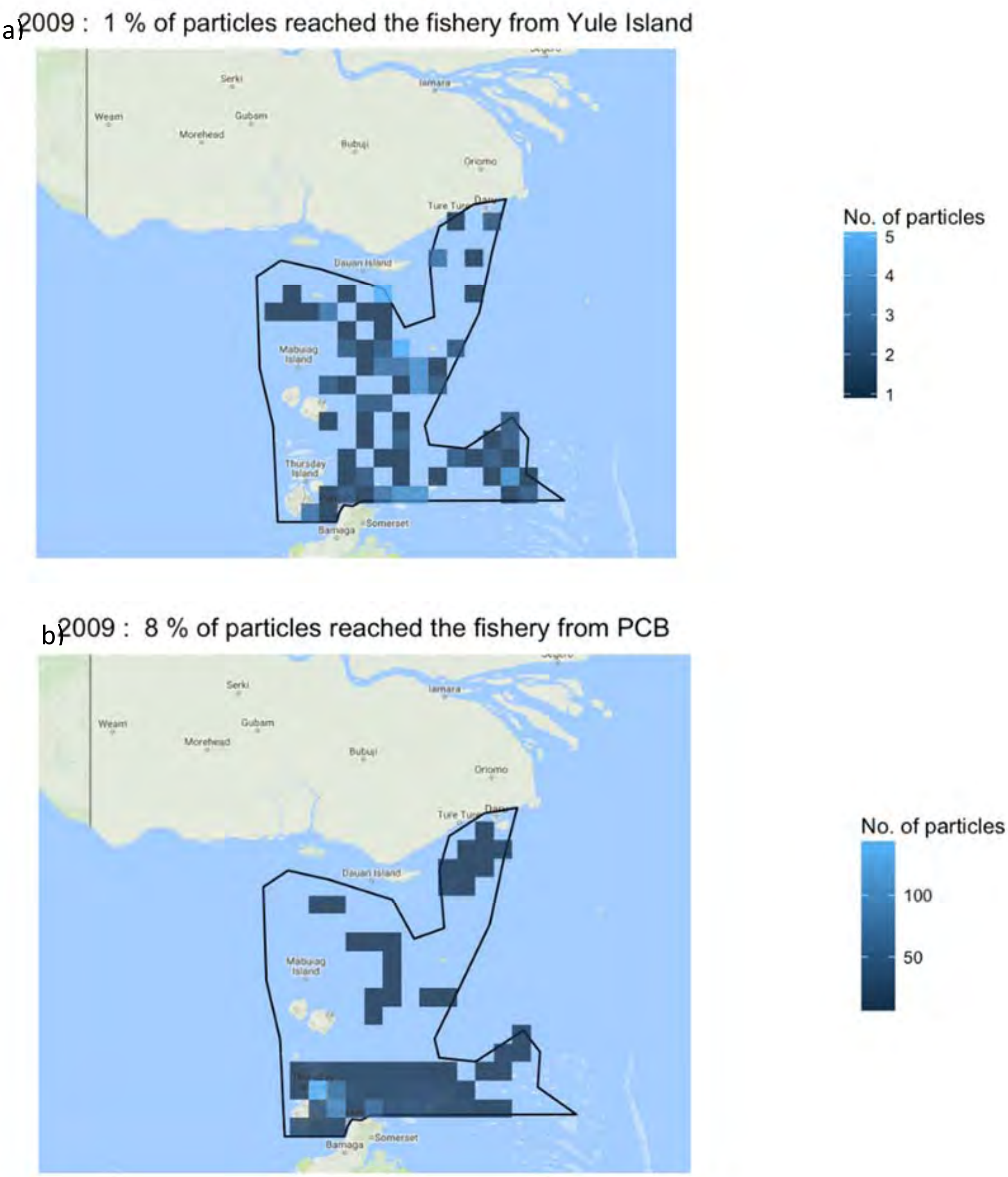


Figure 3-6. 2009: Percentage of particles released from a) Yule Island and b) Princess Charlotte Bay that settled within the Torres Strait fishing zone 6 months following release.

Table 3-1. The percentage of particles released from Yule Island and Princess Charlotte Bay during the tropical rock lobster spawning season (21 November to 25 February) each year that settle within the Torres Strait fishery zone 6 months following release.

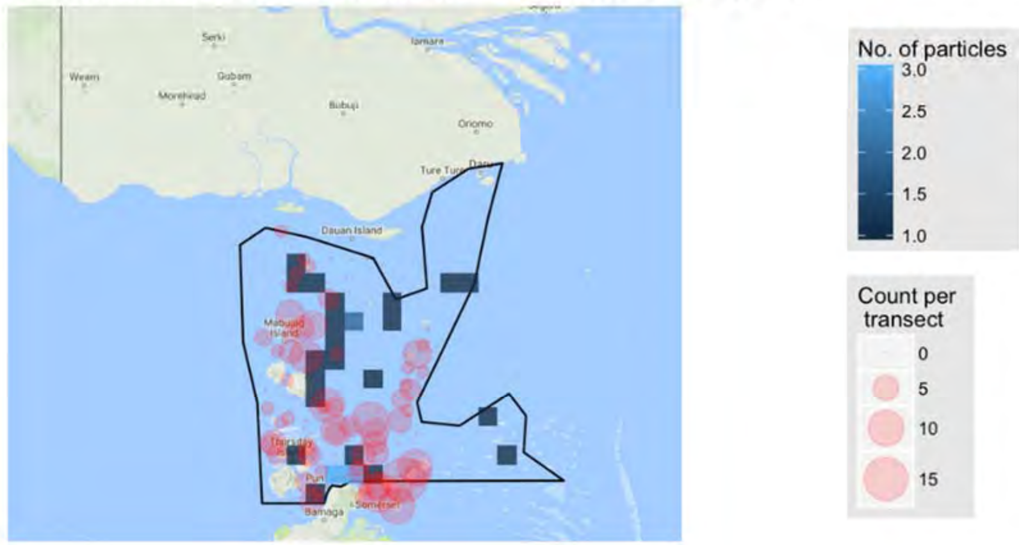
	Percentage of released particles	
Year	Yule Island	Princess Charlotte Bay
1994	1	3
1995	1	4
1996	1	7
1997	1	1
1998	0	5
1999	1	9
2000	1	4
2001	2	2
2002	2	3
2003	0	4
2004	1	1
2005	0	8
2006	1	2
2007	1	5
2008	2	3
2009	1	8
2010	0	4
2011	2	3
2012	1	3
2013	1	4
2014	0	4
2015	1	5

3.3.2 Proportion of particles reaching Torres Strait with subsequent 1+ lobster survey counts

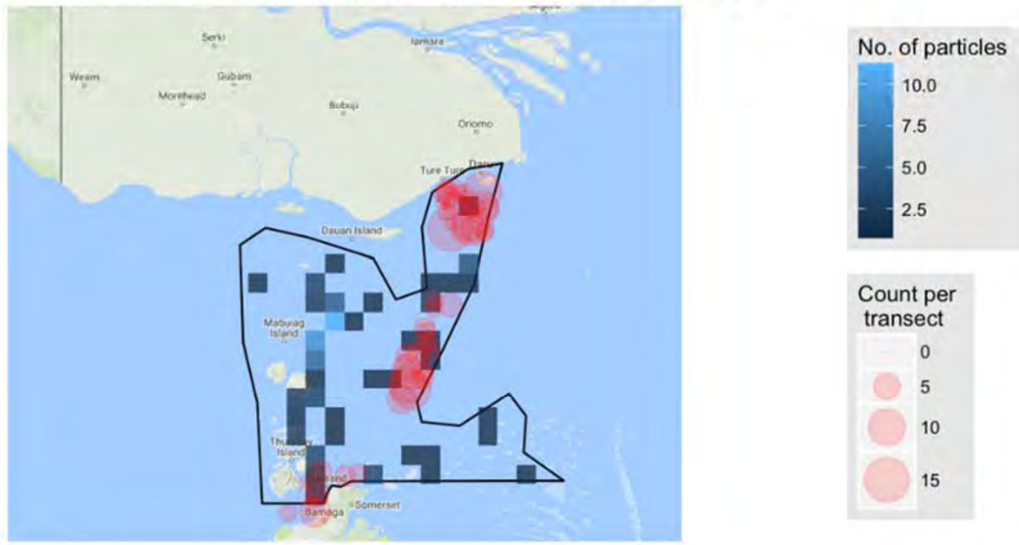
In order to examine the relationship between the predicted particle final destinations within Torres Strait and the distribution of 1+ lobsters two years following the particle release we overlaid the spatial distribution of 1+ lobsters from the preseason survey for each year that data was available (2005, 2006, 2007, 2008, 2015 & 2016). It can be seen that from the following plots there is very little spatial correlation with the predicted settlement locations of the particles and the 1+ lobsters surveyed two years following the particle release (Figure

3-7; Figure 3-8).

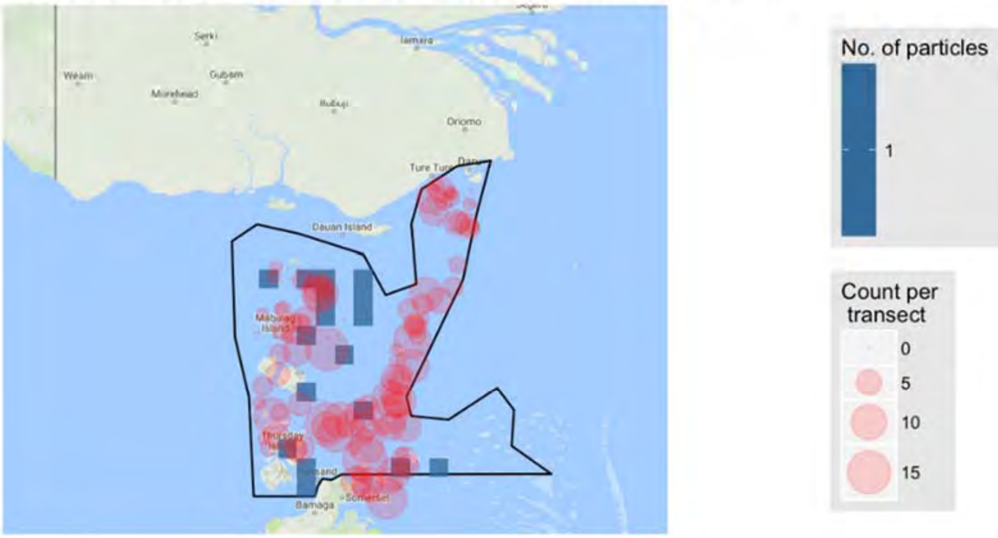
2003 : 0 % of particles reached the fishery from Yule Island



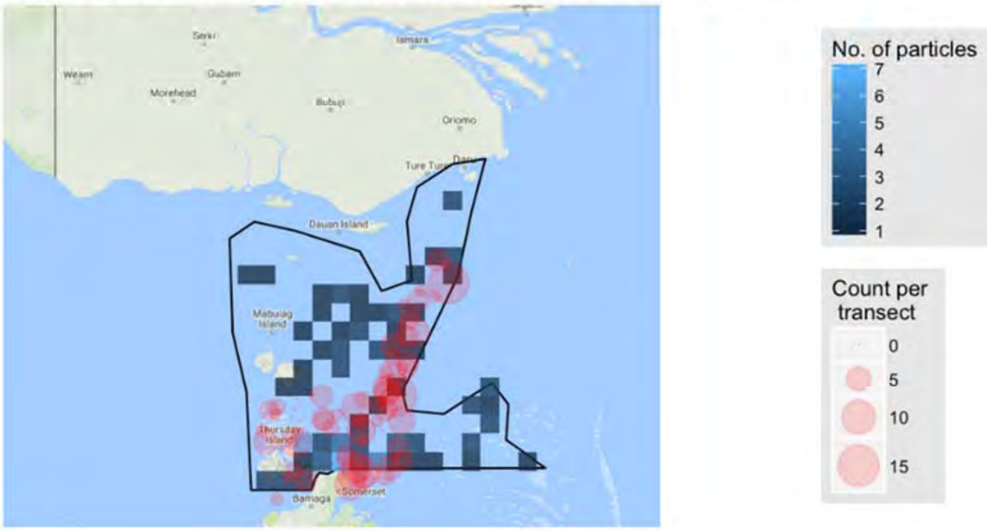
2004 : 1 % of particles reached the fishery from Yule Island

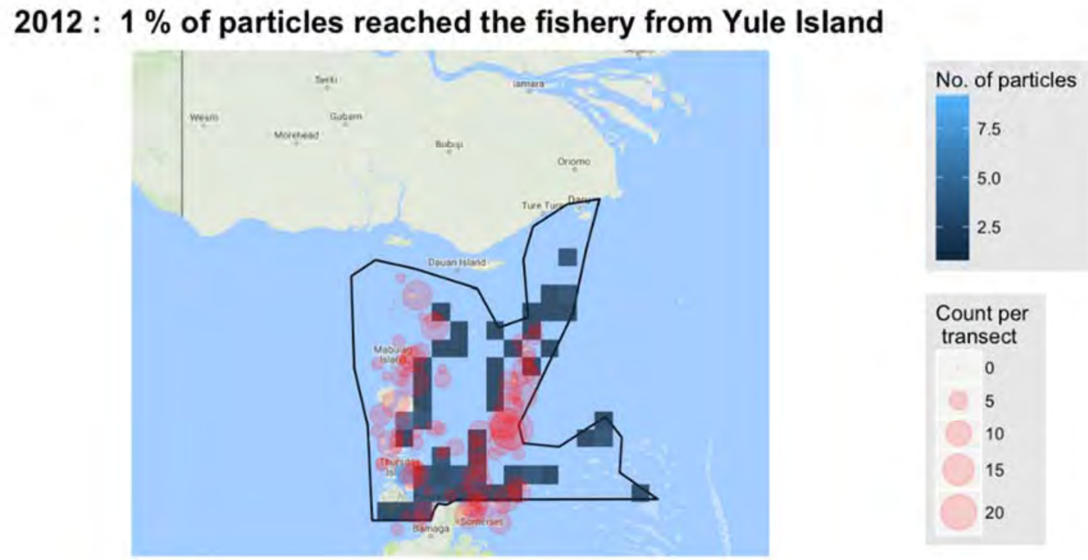


2005 : 0 % of particles reached the fishery from Yule Island



2006 : 1 % of particles reached the fishery from Yule Island





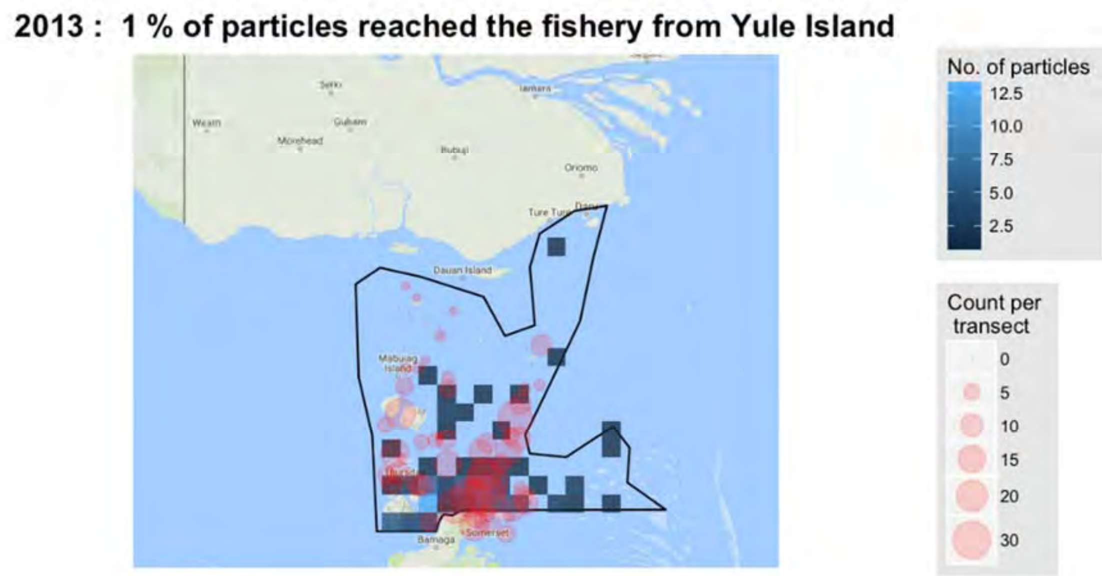
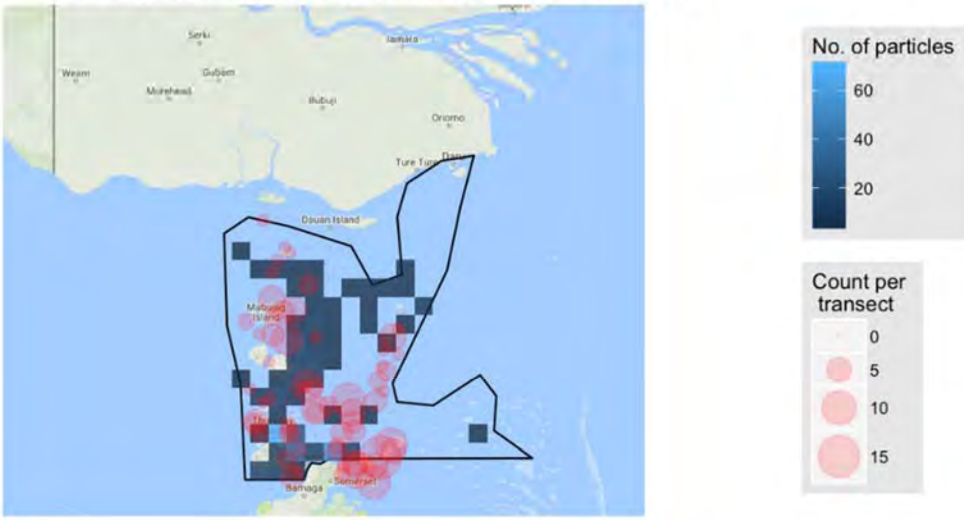
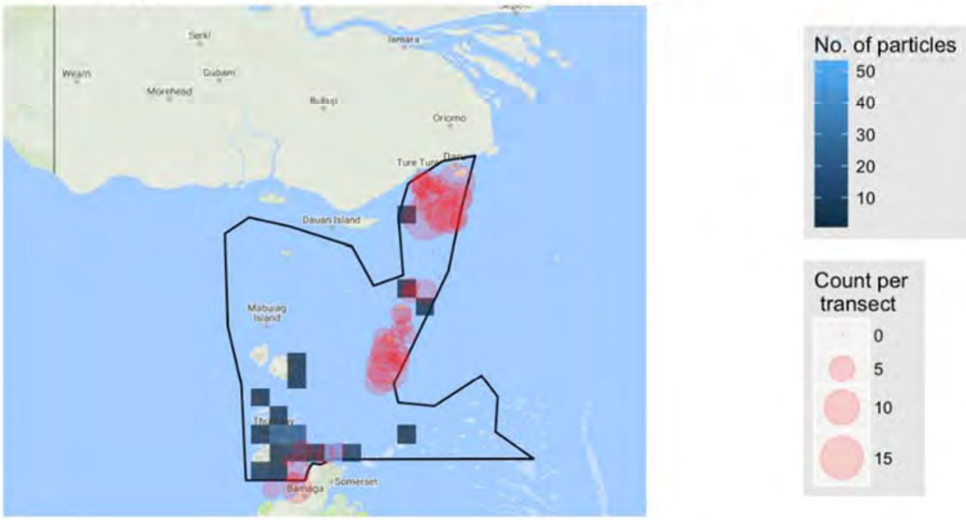


Figure 3-7. Percentage of particles released from Yule Island that settled with the Torres Strait fishing zone overlaid with the distribution of 1+ lobsters surveyed two years following the particle release.

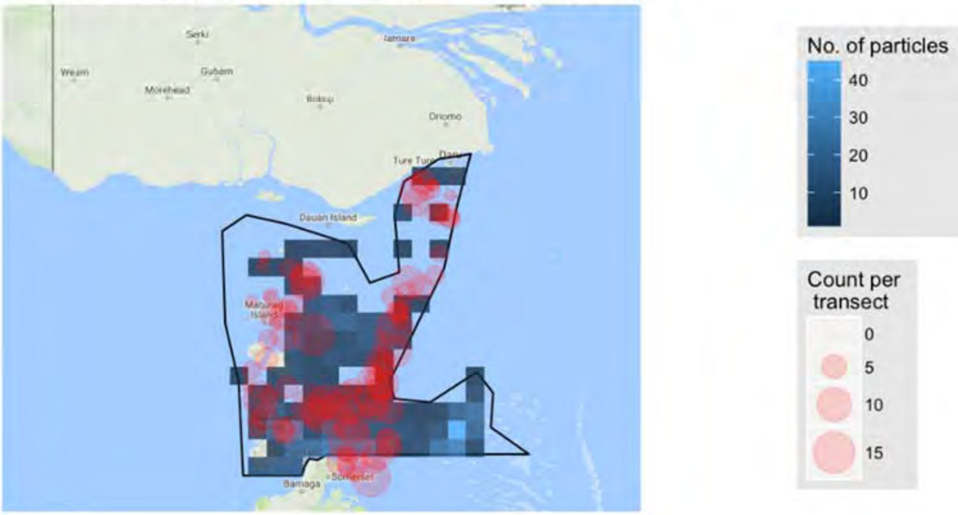
2003 : 4 % of particles reached the fishery from PCB



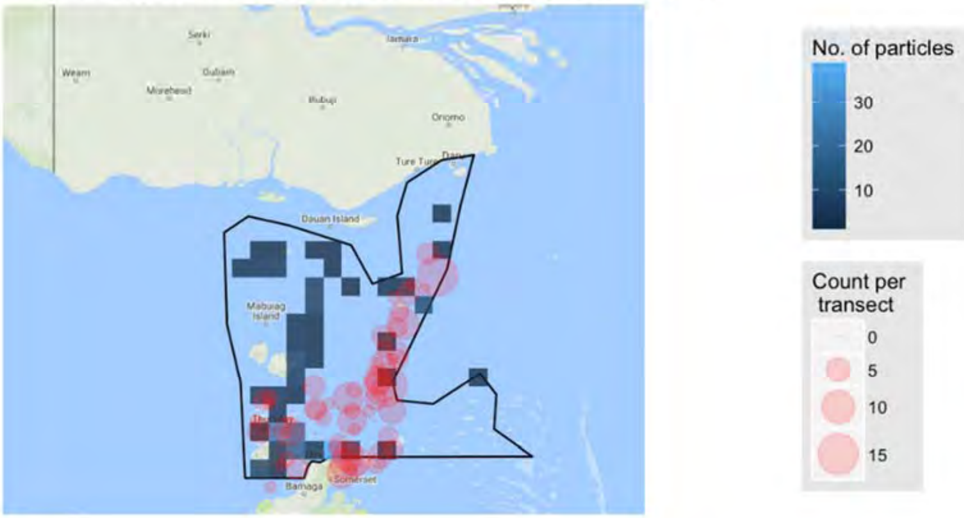
2004 : 1 % of particles reached the fishery from PCB



2005 : 8 % of particles reached the fishery from PCB



2006 : 2 % of particles reached the fishery from PCB



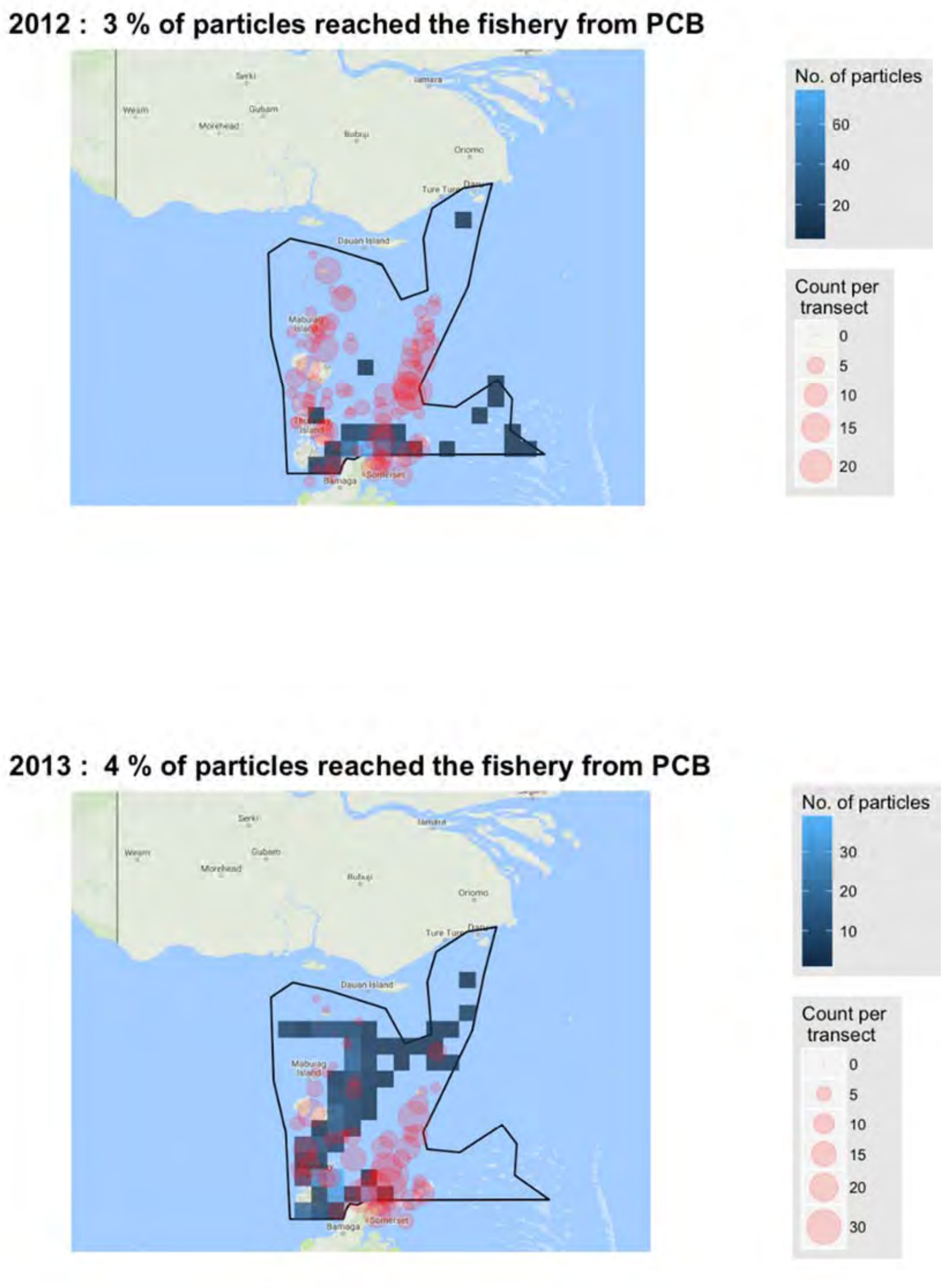
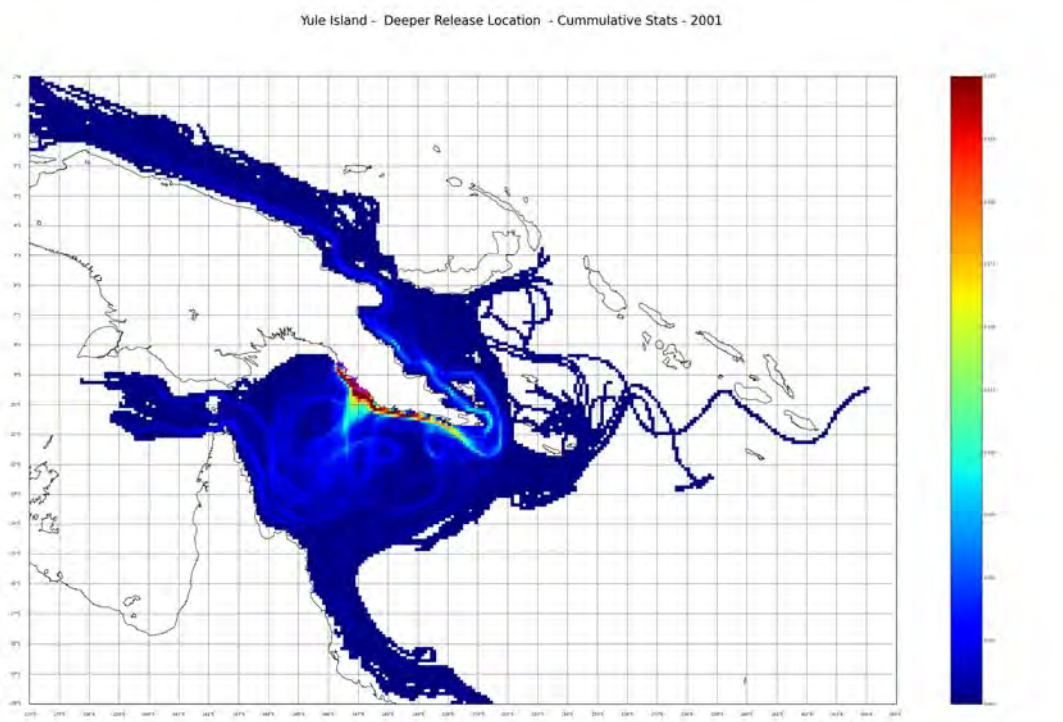


Figure 3-8. Percentage of particles released from Princess Charlotte Bay that settled with the Torres Strait fishing zone overlaid with the distribution of 1+ lobsters surveyed two years following the particle release.

3.3.3 Cumulative statistics plots

The ‘All Phases’ plots show the probabilities of distinct particles passing through a cell. The values plotted are the values in the number of particles that pass through each grid cell divided by the number of particles in the simulation (9600).

These plots show the highly variable nature of the paths of particles. For particles released from Yule Island, during some years there is considerable spread to the east (Figure 3-9); during others the distribution is more focused within the Coral Sea Gyre, with some leakage to the north of PNG (Figure 3-10; Plots of all years are presented in Appendix B).Figure 3-9. The probability of a particle passing through each grid cell for particles released from Yule Island during the period Nov 1999 – Feb 2000.



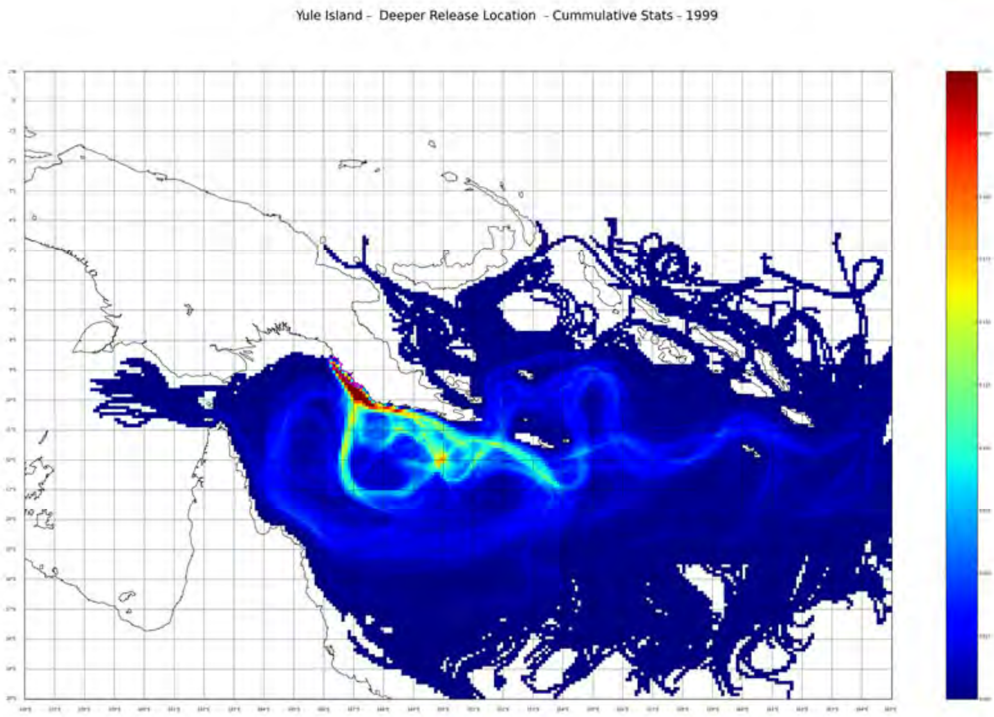


Figure 3-9. The probability of a particle passing through each grid cell for particles released from Yule Island during the period Nov 1999 – Feb 2000.

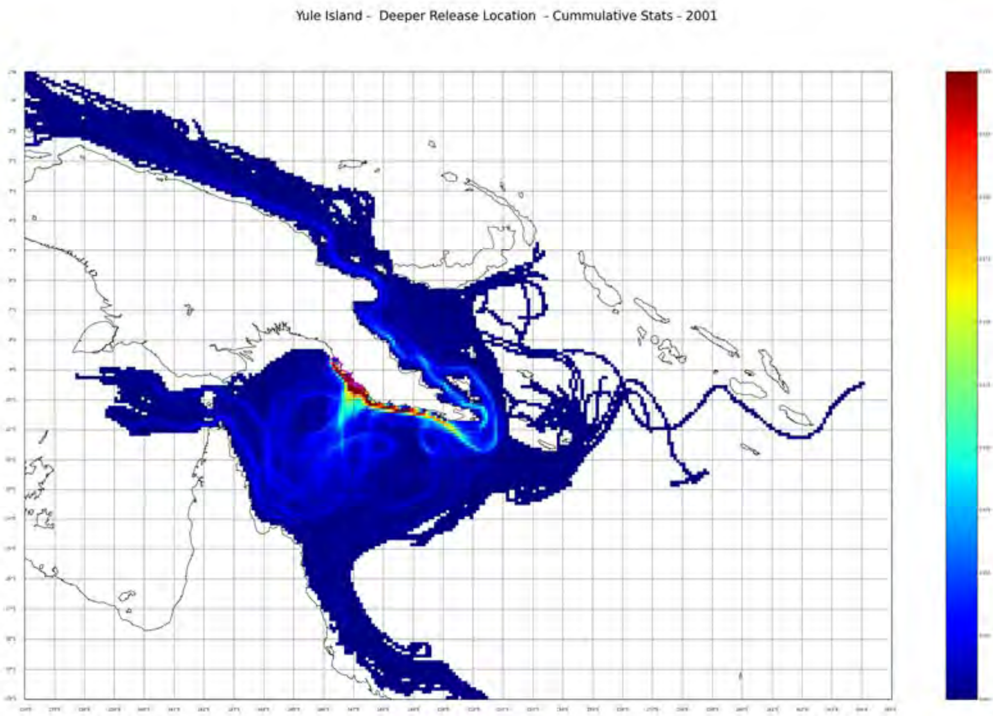


Figure 3-10. Final particle positions for particles released from Yule Island during the period Nov 2001 – Feb 2002.

In contrast, the paths of particles released from Princess Charlotte Bay are far more restricted. During some years particles pass through a narrow band north along the Queensland coast; sometimes not even reaching the Torres Strait (Figure 3-11; Figure 3-12).

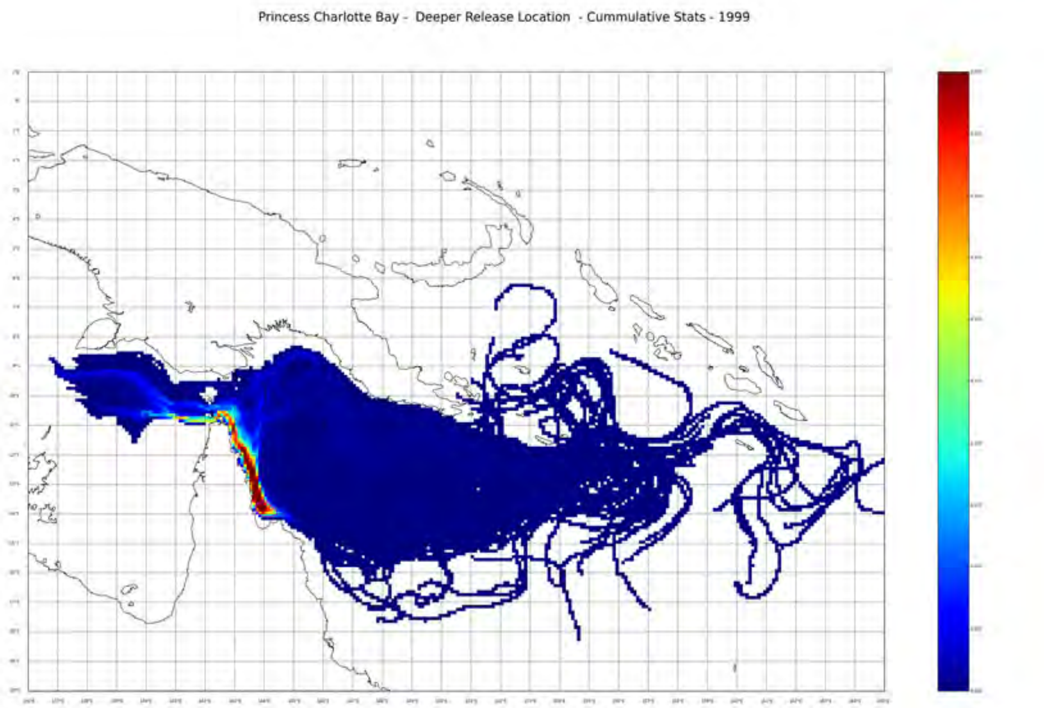


Figure 3-11. The probability of a particle passing through each grid cell for particles released from Princess Charlotte Bay during the period Nov 1999 – Feb 2000.

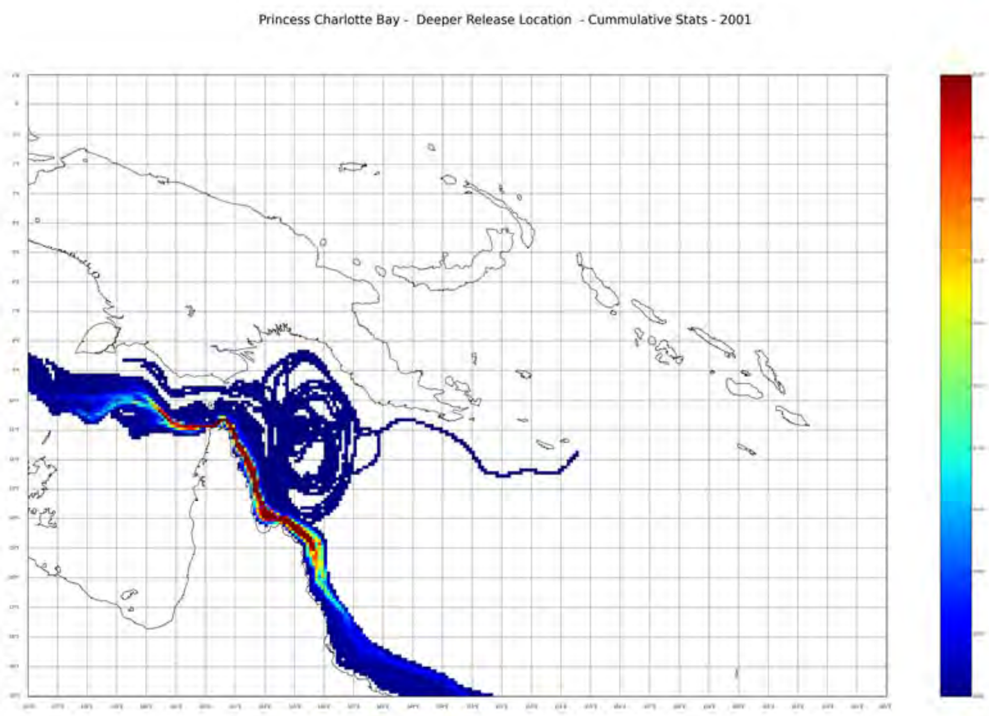


Figure 3-12. The probability of a particle passing through each grid cell for particles released from Princess Charlotte Bay during the period Nov 2001 – Feb 2002.

3.3.4 Relationships with observed lobster recruitment

The quantified inter-annual differences in larval dispersal presented above were compared with survey observations of recruitment of TRL in Torres Strait, as well as with the stock-recruitment residuals estimated in the stock assessment model because the latter also account for differences in spawning biomass. The 1+ recruitment numbers are a function of both how many are advected to Torres Strait and the survival rate. The analyses were conducted both at the scale of the entire Torres Strait region covered by the stock assessment model, which corresponds to the scale of surveys as shown in Figure 3-13. Note that survey and habitat data are available for every year since 1989, but there have been changes in the number of survey sites, time of the survey (mid-year (May-June) or pre-season (November)), and the mid-year survey provides estimates of 1+ and 2+ lobsters whereas the more recent pre-season survey provides estimates of relative abundance of 0+ and 1+ lobsters.

The CONNIE model predicted percentage of particles that reached the Torres Strait fishery from Yule Island and Princess Charlotte Bay release sites were compared with the fishery-independent dive survey 1+ relative index of abundance lagged by one year (as the settlement corresponds to 0+ lobsters which are aged 1+ in the following year and therefore observed as 1+ lobsters in the following year’s survey) (Figure 3-14). As evident also from Figure 3-15, there was no statistical significant relationship (n=22; p>0.05) between observed recruitment and the CONNIE model-estimated percentages. Similarly there was very little spatial correlation with the predicted settlement locations compared with the spatial distribution of 1+ lobsters from the preseason survey for each year that data were available. The inability to detect a clear relationship may be because other factors are more important, or because the circulation model doesn't adequately model tides which are an important component.

Preliminary analyses have found no sufficiently rigorous relationships, and hence the stock assessment model could not be updated to improve prediction of recruitment based on oceanic currents influencing advection and settlement rates. No clear relationship was evident in El Niño years either. However in combination the CONNIE model results confirm the shared nature of the Torres Strait *P. ornatus* stock between Australia and Papua New Guineau, as well as linked recruitment with Australia's East Coast, although the extent to which the East Coast stock contributes to Torres Strait recruitment is difficult to quantify. Moreover, the circulation simulations confirm that there is substantial inter-annual variability in environmental factors that could be driving changes in recruitment to Torres Strait. In some years of bad recruitment, there are indications from the cumulative statistics plots that the clockwise Coral Sea Gyre circulation pattern is more diffuse and many particles are lost to the system by being transported to the east (see Figure 3-16 and Figure 3-17). Similarly, there are some indications that good lobster recruitment years may be partially explained by the Coral Sea currents operating in a more contained clockwise fashion (Figure 3-16). Nonetheless, the huge variability further confounds detection of underlying relationships, and the final particle plots are not easily distinguishable in good and bad years either. Ongoing work and review by the forthcoming TRLRAG may shed further light on the complex system dynamics.

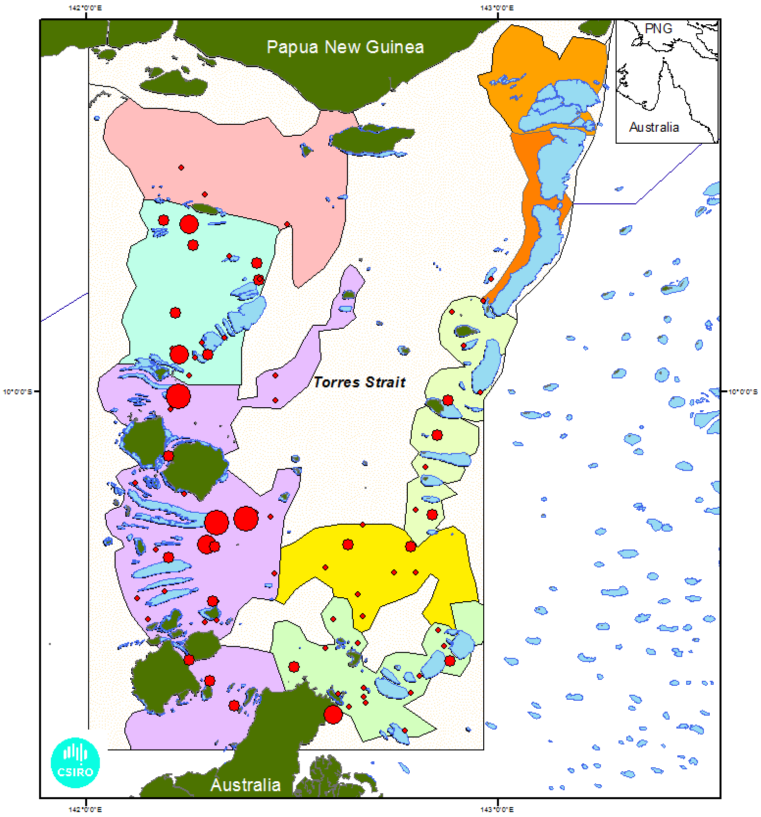


Figure 3-13. Map showing areas (coloured sections) surveyed for lobster abundance since 1989. This example is for 0+ lobsters during the 2015 pre-season population survey, with the size of the red bubbles indicating relative abundance and showing the 0+ lobsters occur predominantly along the western margin of the fishery.

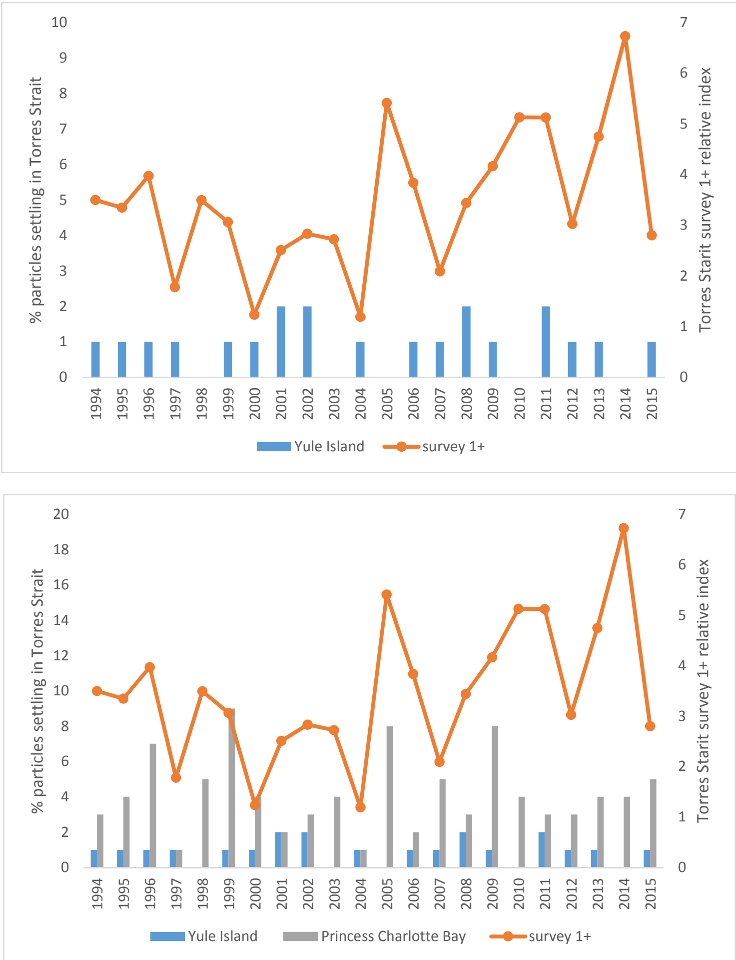


Figure 3-14. Comparison of CONNIE model predicted percentage of particles that reached the Torres Strait fishery from Yule Island release site (top figure) and Yule Island and Princess Charlotte Bay release sites (bottom figure) plotted with the fishery-independent dive survey 1+ relative index of abundance lagged by one year.

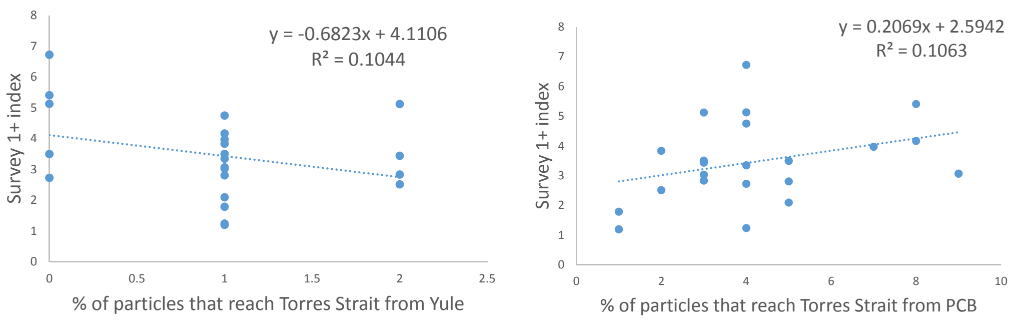


Figure 3-15. Regression analysis of survey 1+ index as a function of percentage of particles predicted to reach Torres Strait originating from Yule Island (left panel) and Princess Charlotte Bay (PCB) (right panel).

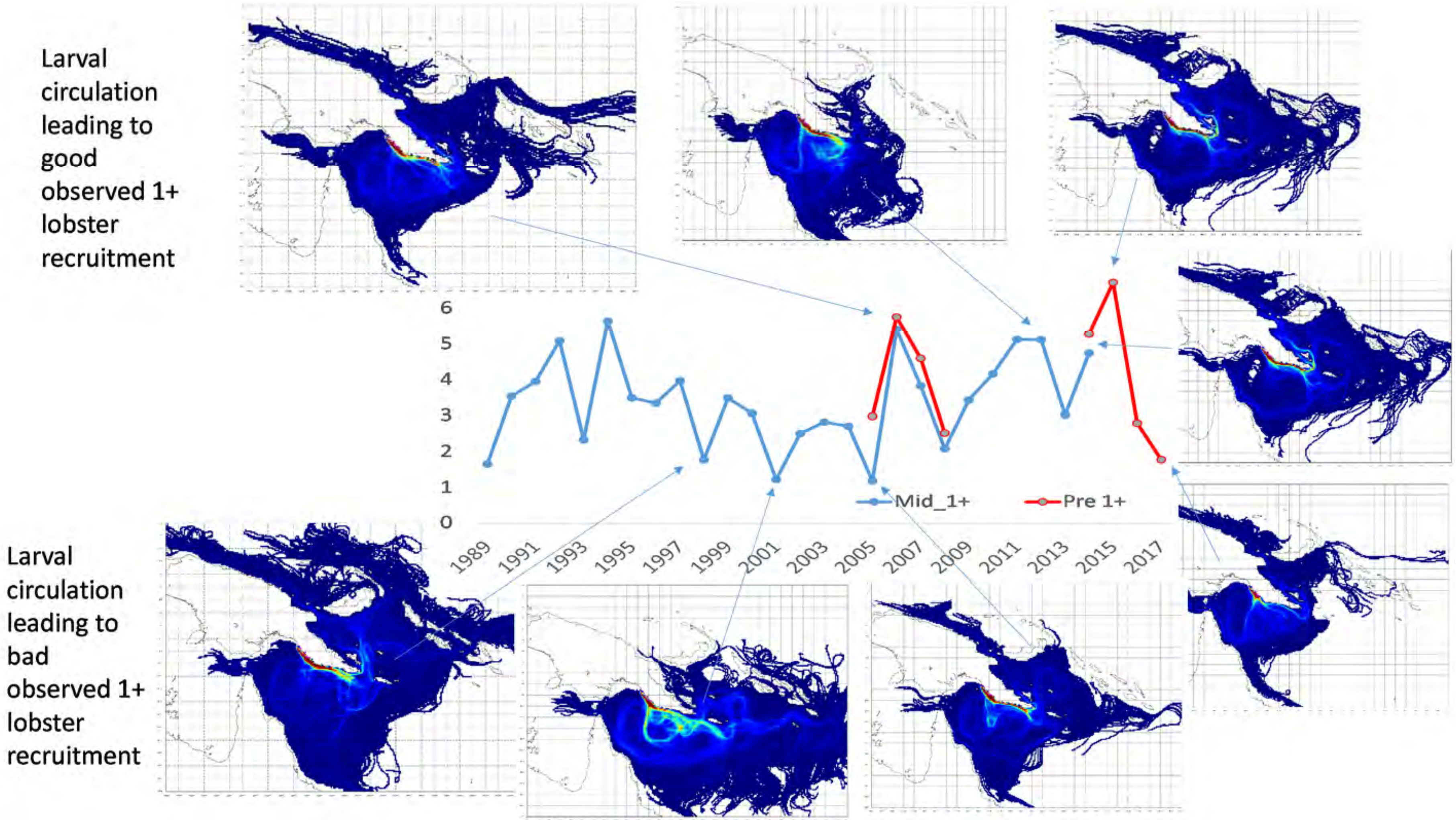


Figure 3-16. Schematic showing larval circulation trajectories based on cumulative statistics corresponding to observed Torres Strait lobster 1+ recruitment for selected good years (top panels) and poor years (lower panels).

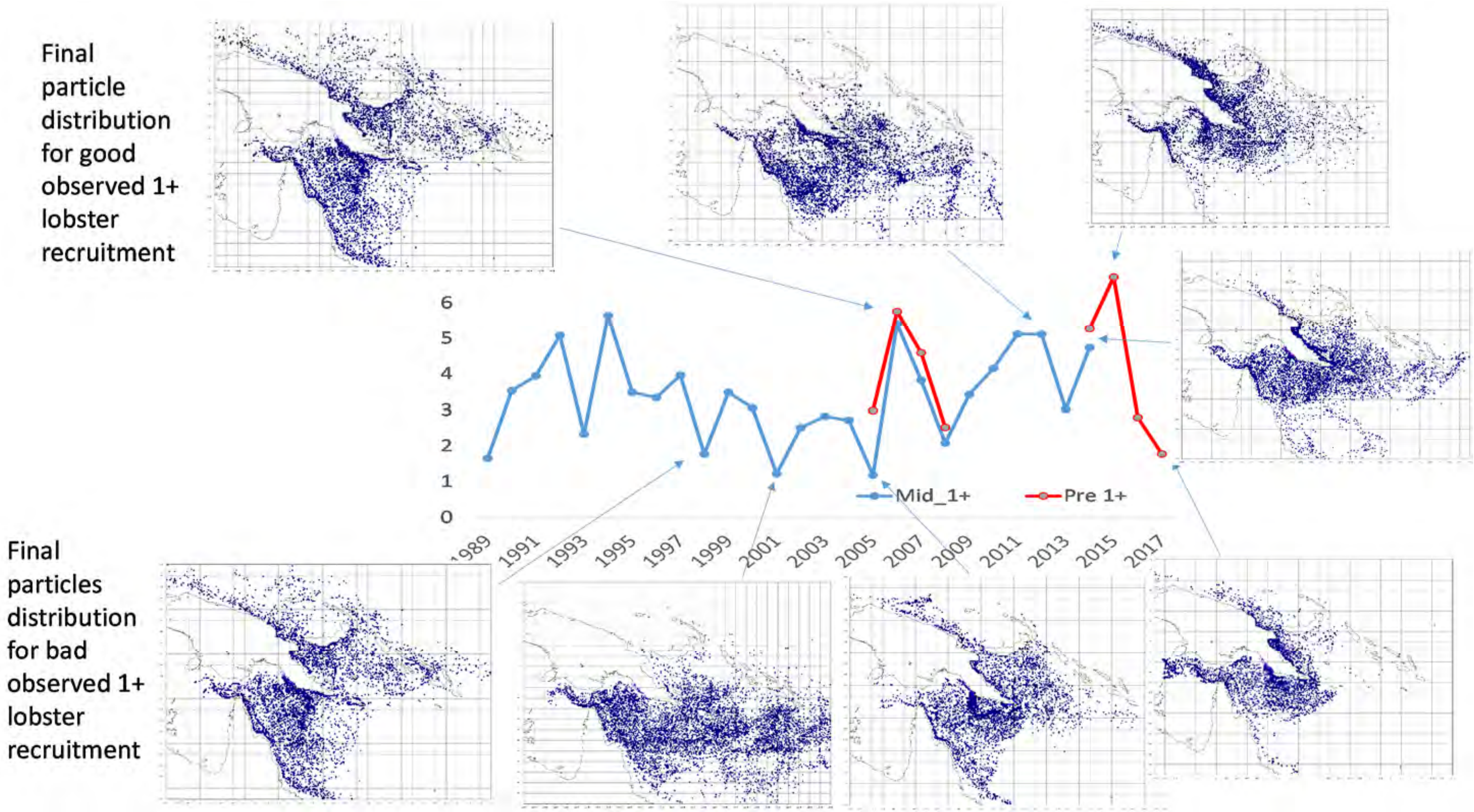


Figure 3-17. CONNIE model-predicted final particle distributions (from Yule Island release site) corresponding to observed Torres Strait lobster 1+ recruitment for selected good years (top panels) and poor years (lower panels)

3.4 Discussion

Complex and variable larval dispersion is a feature of many palinurid lobsters. For example, puerulus settlement of the western rock lobster (*Panulirus cygnus*) fishery is markedly influenced by environmental factors such as the Leeuwin Current (influenced by the El Niño – Southern Oscillation cycle) and westerly winds in late winter – spring (Caputi 2008, Caputi et al. 2010). Elsewhere in the world, *P. argus* populations off Florida for example are sustained by larval transport in the Caribbean Current transporting postlarvae from Caribbean populations (Acosta et al. 1997, Yeung & Lee 2002).

As with other palinurid lobsters, *P. ornatus* undertakes a spawning migration in order to release larvae close to oceanic currents (Figure 3-18). Moore and McFarlane (1984) noted that if larvae were released in Torres Strait, the predominant south-east trade winds would advect them to unsuitable settlement sites on the Papua New Guinea mainland further to the west. However, if mature lobsters spawn at the eastern extremity of the Gulf of Papua, early research suggested that ocean currents would carry these larvae to the eastern coast of Australia (particularly Princess Charlotte Bay) and Torres Strait (MacFarlane 1980). Surveys also showed that breeding also occurs on the far northern Great Barrier Reef during summer (Prescott & Pitcher 1991), with settlement peaks into Torres Strait around June each year suggesting a larval duration of 4 to 7 months (Dennis et al. 1997).

In the north-west Coral Sea, oceanic transport is largely influenced by the influx of warm equatorial water flowing westward in the South Equatorial Current (SEC) that enters between the Solomon Islands and Vanuatu (Figure 3-19) (Church 1987). In the Great Barrier Reef, the SEC bifurcates between 14 and 18°S, and feeds south into the East Australian Current (EAC) and north along the GBR into the Gulf of Papua (Andrews & Clegg 1989). The northern flow of the SEC then forms a western boundary current, which circulates clockwise around the Gulf of Papua, following the Queensland and PNG continental slopes. This closed gyre is termed the Coral Sea Gyre.

Dennis et al. (2001) undertook an extensive plankton survey in the Coral Sea to research the distribution and transport pathways of *P. ornatus* and other lobster larvae. Their study confirmed the hypothesis that phyllosomas are transported from the Gulf of Papua breeding grounds by the Hiri boundary current into the Coral Sea Gyre and then by surface onshore currents onto the Queensland coast and into Torres Strait (Figure 3-19).

The larval advection modelling in this study illustrated the highly variable nature of the paths of particles given strong inter-annual differences in the Coral Sea Gyre and associated currents. For particles released from Yule Island, during some years there is considerable spread to the east whereas during others the distribution is more focused within the Coral Sea Gyre, with some leakage to the north of PNG. In contrast, the paths of particles released from Princess Charlotte Bay are far more restricted. During some years particles pass through a narrow band north along the Queensland coast; sometimes not even reaching the Torres Strait.

The results presented assume the same total number of larvae released each year and from each location, but it should be noted that the spawning biomass per location and time period will also influence the magnitude of recruitment. The model also highlights that only a very small percentage of the original larvae released are likely to end up at the final Torres Strait destination, a result which is not unexpected but further underscores the low probability of success and challenges of predicting recruitment success. The small final destination percentages also mean that there is perhaps too low contrast to distinguish between alternative scenarios. The model estimates of the proportion of larvae that reach nearshore Torres Strait settlement habitats also ignores predation impacts, including potentially different predation rates on larvae and pueruli circulating in open ocean currents compared with the nearshore Great Barrier Reef region. Palinurid postlarvae settlement fluxes are known to be associated with lunar phases such as those linked to stronger flooding tides during new-moon periods, as well as utilising the dark moon phase of the new moon, possibly as a protective mechanism from visual predators (Acosta et al. 1997). As noted, the oceanographic model underlying CONNIE 3 does not resolve the complex tides in Torres Strait and hence may underestimate retention and entrainment into the settlement areas.

The spatial distribution of 1+ lobsters from the preseason survey were overlaid on the spatial predictions of larval settlement from the advection model to see how well they matched, but there was very little spatial correlation with the predicted settlement locations. However, given that Torres Strait tidal processes are not represented in the underlying oceanographic models, the modelled settlement distributions within Torres Strait are not very meaningful, and hence it is not surprising that there is a lack of spatial correlation with observed recruitment inside Torres Strait.

Preliminary analyses have found no sufficiently rigorous relationships, and hence the stock assessment model could not be updated to improve prediction of recruitment based on oceanic currents influencing advection and settlement rates. No clear relationship was evident in El Niño years either. However in combination the CONNIE model results confirm the shared nature of the Torres Strait *P. ornatus* stock between Australia and Papua New Guinea, as well as linked recruitment with Australia's East Coast, although the extent to which the East Coast stock contributes to Torres Strait recruitment is difficult to quantify. Moreover, the circulation simulations confirm that there is substantial inter-annual variability in environmental factors that could be driving changes in recruitment to Torres Strait. In some years of bad recruitment, there are indications from the cumulative statistics plots that the clockwise Coral Sea Gyre circulation pattern is more diffuse and many particles are lost to the system by being transported to the east (see Figure 3-16 and Figure 3-17). Similarly, there are some indications that good lobster recruitment years may be partially explained by the Coral Sea currents operating in a more contained clockwise fashion (Figure 3-16). Nonetheless, the huge variability further confounds detection of underlying relationships, and the final particle plots are not easily distinguishable in good and bad years either. Ongoing work may shed further light on the complex system dynamics.

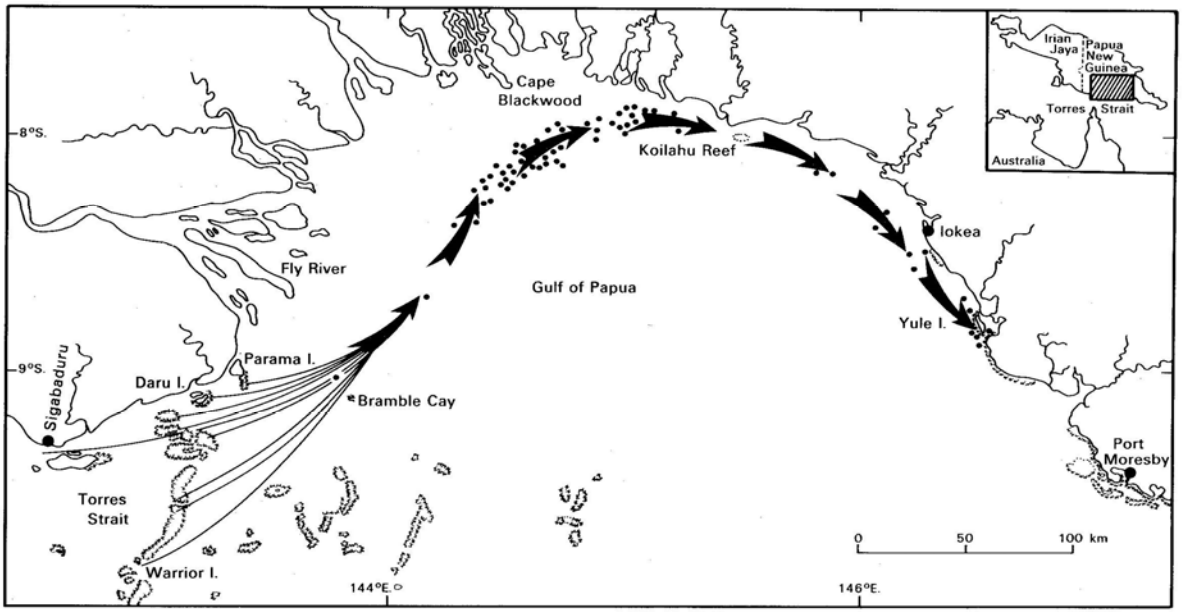


Figure 3-18. Summary of long-range movements of *P. ornatus* from Torres Strait to breeding grounds, based on tagging data (source: (Moore & MacFarlane 1984a)

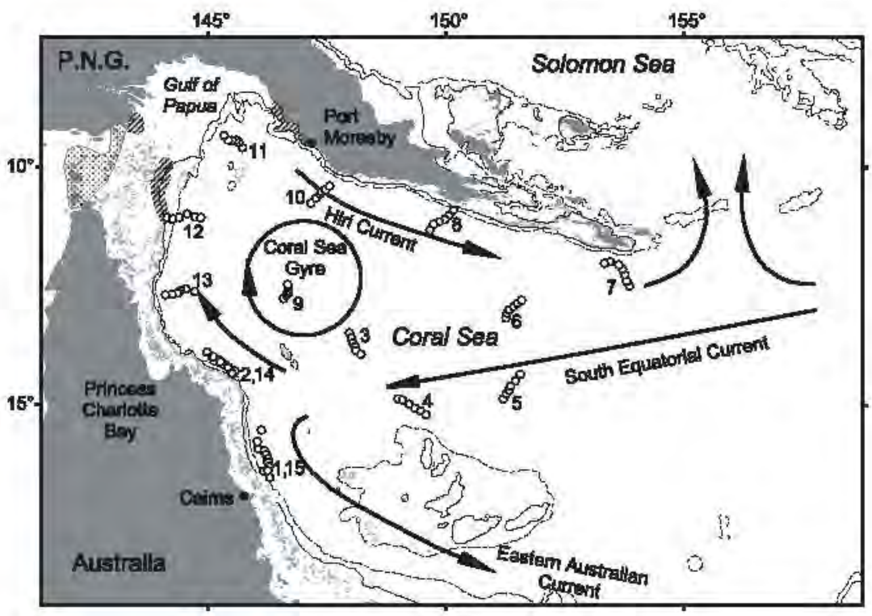


Figure 3-19. Schematic of the north-west Coral Sea showing near-surface ocean currents, *P. ornatus* breeding grounds (hatched area) and Torres Strait settlement area, together with 13 sampling locations surveyed during May 1997. The solid and dashed lines represent the 200m and 100m isobaths respectively. (Source: (Dennis et al. 2001)

4 Part 4 Model projections of medium- and long-term climate impacts on TRL

Preliminary climate projections for the Torres Strait *Panulirus ornatus* tropical rock lobster

Abstract

The Torres Strait tropical rock lobster (TRL) *Panulirus ornatus* fishery is a culturally and economically important fishery, and hence it is important to consider the potential influence of changing climate on the future fishery the flow-on effects on stakeholders. The TRLRAG and fishery stakeholders have been requesting additional information to advance understanding of medium and long-term impacts of climate change on Torres Strait fisheries and communities. This chapter summarises progress made in generating TRL projections to 2050 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 methods draw on earlier studies, and the prelininary projection scenario presented is based on the most up to date understanding of the impacts of key climate variables on the resource growth, productivity and survival. The March 2017 TRL stock assessment model is refitted by linking with climate data available from 1992, and model results suggest strong support the hypotheses that growth and survival of lobsters are affected by changes in SST. The parameters of the latter functional form are 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. However ongoing work will continue to refine these projections and the results presented here should thus be considered as preliminary only.

4.1 Introduction

The Torres Strait tropical rock lobster (TRL) *Panulirus ornatus* fishery is a culturally and economically important fishery and concern has been expressed regarding the impacts of climate change on the resource and fishery. Management of the fishery is complicated by the high natural recruitment variability and diving surveys have been used for the past 28 years to monitor changes in the size of the recruiting population (Plagányi et al. 2017).

As part of a previous TRLMSE project, the impact and likelihood of a range of climate change impacts on TRL life history parameters was evaluated and integrated into the stock assessment model to provide projections under future climate change scenarios (Norman-Lopez et al. 2013). These runs can be updated with the latest information and 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 CSIRO model is a global high-resolution (0.1o) ocean general circulation model (OGCM) used to dynamically downscale climate changes in the 21st century derived from Coupled Model Intercomparison Project Phase 5 (CMIP5) climate models (see Chapter 1). The global OGCM is integrated over the historical period (1979-2014) then projected from 2006 to 2101 under a high emission scenario (RCP8.5). Model results provide downscaled climate change projections for all common ocean state variables including sea level, temperature and currents. This provides a basis for planning for anticipated climate change impacts on the major fisheries in the region. Currently projections are being done as part of a AFMA/FRDC proposal for a number of fisheries around Australia and hence rerunning the lobster projections with the new scenario will facilitate inclusion of Torres Strait in this bigger project.

The previous studies (Plaganyi et al. 2011, Norman-Lopez et al. 2013) investigated the possible biological and socio-economic effects of climate change to the Torres Strait tropical rock lobster fishery. Hypothesized responses of lobster growth, mortality, distribution, and migration in each fishing sector were gathered from the literature, unpublished experimental studies, and expert consultation (Dennis et al. 1997, Skewes et al. 1997, Dennis et al. 2001). Impacts were projected at three different life stages (larvae, juvenile defined as pre-maturation moult and adult) under climate change scenarios (Appendix A). Responses were assessed in an impact-likelihood framework to identify the overall risk to the lobster population. The hypothesized high risk (>5% change in a lobster production parameter) (Scenario I) and high plus moderate risk (Scenario II) effects under emission A1B (IPCC 2007), were implemented through modifications to the lobster stock assessment model.

Here we describe updated preliminary projections to 2050 for lobster, using more recent climate projections.

4.2 Methods

Climate Data

Climate data were provided by Richard Matear and Xuebin Zhang (CSIRO) starting in 1992 and climate change (rcp8p5) and control projections up to 2050, as described in Chapter 1. The data consists of monthly surface data of temperature (SST; °C), salinity (SSS), phosphate (SPO4; mmol m^{-3}), phytoplankton (SPHYL; mmol N m^{-3}) and primary productivity (PP; mmol C m^{-2} day^{-1}).

Model

The analysis used the March 2017 version of the TRL stock assessment model, with model equations as summarised in Appendix C . Apx Table C-1 summarises information on potential climate impacts on TRL. This study aimed to update an earlier analysis. Below follows a brief summary of the methods used to link dynamically with the climate variables and specifically SST.

Somatic growth:

For each year, an annual climate multiplier was computed as the product of the monthly SST values relative to the historical (1992-2015) average value. This provides an average temperature residual multiplier function SST_mult for each year such that historical multipliers are approximately 1 whereas with future increasing SST the value will increase.

The model uses the Phillips et al. (1992) von Bertalanffy growth relationship and a morphometric relationship as follows:

$$L_m = 165.957 * (1 - \exp(-0.0012 \times 30 \times m))$$

$$w_m = 0.00258 \times \left(L_m\right)^{2.76} / 1e6$$

where L_m is the carapace length (mm) and w_m the mass (tons) for individual aged m months.

A recent study (Leland & Bucher 2017) on ageing in Australian lobsters found similar growth parameters for *P. ornatus* to those used in this study (Figure 4-1). The Leland and Butcher (2017) study used lobsters from the Southeast Zone and hence the resultant growth curve was most similar to the Skewes et al. (1997) model which was applied to the same zone and found a slightly reduced growth rate parameter estimate *k*. Skewes et al. (1997) note that the lower growth rate is likely due to a combination of food availability and quality, as well as temperature as the SE zone has been observed to have lower temperatures than the NW zone, with lower temperatures resulting in lower growth rates. The Leland and Butcher (2017) study also confirmed the presence of four distinct age classes.

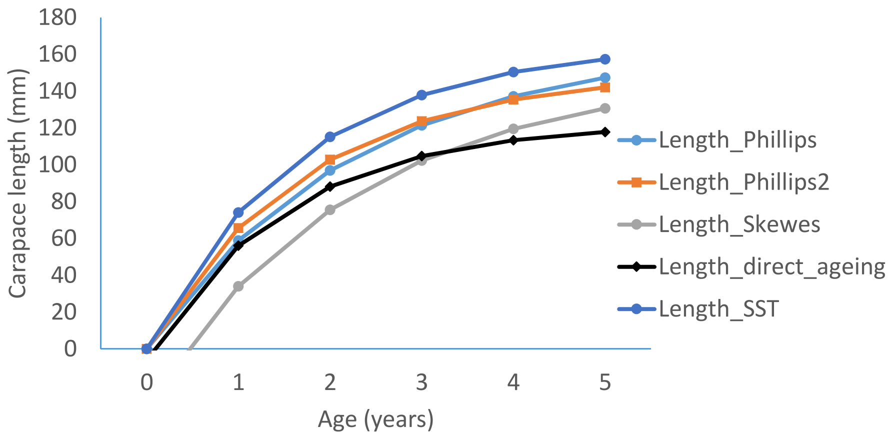


Figure 4-1. Comparison of growth curves from the Leland and Butcher (2017) direct ageing study, the Skewes et al. (1997) study (also SE Zone), and the Phillips et al. (1992) curves based on Fabens (as used in the stock assessment model) and Palmer methods. The length_SST curve illustrates modification of the growth curve at 32°C.

The climate multiplier is applied to the von Bertalanffy equation to estimate time-variant growth dependent on SST:

$$L_{y,m} = 165.957 * (1 - \exp(-(SST\_mult(y,m) * 0.0012 \times 30 \times m)))$$

$$w_{y,m} = 0.00258 \times \left(L_{y,m}\right)^{2.76} / 1e6$$

Where $L_{y,m}$ is the carapace length (mm) and $w_{y,m}$ the mass (tons) for individual aged *m* months in year *y*.

Natural mortality:

The exact relationship between temperature and survival of lobsters is uncertain (Appendix A). However, crustaceans are sensitive to temperature as they are poikilothermic and hence their body temperature follows that of the environment. Moreover, the preferred temperature for many crustaceans is shifted to higher values for animals (such as TRL) acclimated to higher temperatures (Lagerspetz & Vainio 2006). Several studies have found that for *P. ornatus* growth is significantly affected by temperature and that there is a temperature band over which growth is optimal - Jones (2009) found maximal growth occurred at 25-31°C. This is similar to findings for other *Panulirus* lobsters – for example the temperature preference for *P. argus* is 29-30°C and for *P. interruptus* around 28°C (Jones 2009). However, as 31°C was the highest temperature used in the Jones (2009) experiments, the response of *P. ornatus* to temperatures greater than this is unknown.

Based on the historical SST data over 1992-2015, the minimum SST (during the winter months) is around 25°C and the maximum SST is 32°C, although is more usually 29-31°C during the summer months. There is some evidence that higher temperatures will affect lobster physiology (Lagerspetz and Vainio 2006), and that this will have an increasingly negative effect as temperatures increase.

For most marine animals, high critical temperatures are associated with a drastic rise in oxygen demand (Pörtner 2001). Temperature preferences are species- and location-specific, and the width of a temperature preference band can be different, with the low and high threshold temperatures termed pejus temperatures (where pejus means turning worse) and key physiological responses such as haemolymph PO_2, ventilation and heart rate decreasing outside the optimum range, often with a steeper rate of decrease at higher temperatures (Pörtner 2001). Hence in the model developed here, we assume an optimal temperature for *P. ornatus* of 29°C (and test sensitivity to 30°C also) and assume a non-symmetric pejus type relationship between lobster survival (assumed to be the net outcome of a number of physiological responses to changes in temperature) and SST. We parameterise this as two separate quadratic functions that intersect at the optimum SST, such that the slope of the response to decreasing versus increasing SST can be different i.e. the impacts of temperatures greater than the optimum are more severe than those of temperatures less than the optimum (Figure 4-2a, b). Hence the functional forms assumed for the mortality multiplier functions (*SST_multiplier*) are:

$$SST\_multiplier_t = 1 + \tau_1 \left(SST_t - T_O \right)^2 \quad SST_t \le T_0$$
$$SST\_multiplier_t = 1 + \tau_2 \left(SST_t - T_O \right)^2 \quad SST_t > T_0$$

Where T_0 is the optimum SST and SST_t is the monthly average Sea Surface Temperature (°C) at time *t*, with the annual composite SST multiplier (SST_M_y) for year *y* computed as the average of the multipliers for the 12 months of each year. The two slope parameters τ_1, τ_2 can be fixed (at the same or different values) or estimated by fitting to historical data (as has been done here). In the model, for all years since 1992 (start of the SST input series), the fixed annual natural mortality *M* is therefore adjusted using the average annual SST-dependent multiplier:

$$M_y^{SST} = M \times SST\_M_y$$

Conversely, the average survival proportion S_y for each year *y* is computed simply as:

$$S_y = e^{-M_y}$$

And an example of the SST-S relationship is shown in Figure 4-2b.

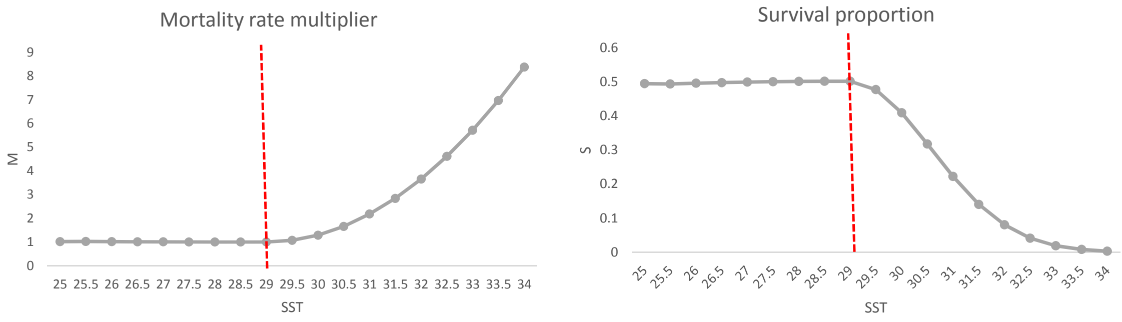


Figure 4-2. (a) Natural mortality multiplier shown as a function of SST, with relatively large increases in M as SST increases above the optimal SST, but small changes only down to lower limit of 25°C. (b) Survival proportion S shown as a function of SST.

Impacts of future climate change on recruitment including consideration of larval advection

This aspect is highly uncertain and as per the preceding chapters, no clear relationship could be established, hence this is not included in the reference case results presented here.

Other climate variables

The impact of changes in 2 other climate variables, namely salinity and primary productivity, on lobster survival, growth and/or recruitment is highly uncertain, and the results presented here assume no impacts.

4.3 Results

The model was run in the first instance assuming no impact of future changes in climate variables. This was compared with a run projecting the model to 2050 under the assumption that the lobsters are influenced by changing climate variables as described above. The model estimated the 2 slope parameters of the SST-mortality relationship by fitting to all available data, with climate data available since 1992. The fitted parameter values were then used in projecting the model forwards under changing SST. When refitting the model, the annual average mortality rate was fixed at the Reference Case level (because otherwise it would be confounded with the multiplier functions being estimated) and the selectivity parameters were also held at their Reference Case values, but the pre-exploitation spawning biomass parameter $B^{sp}(1973)$ was estimated, together with the two SST slope parameters and the 32 recruitment residuals (Table 1). The model converged and successfully estimated the two SST slope parameters. The model fit was significantly better (c.f. AIC values in Table 1) when including the climate relationships. The left-hand slope parameter describing the impact of decreasing temperature was estimated imprecisely but suggested that there is almost no discernible impact on natural mortality over the SST range 25-29°C. However the model yielded a relatively precise estimate of the right-hand slope parameter (0.29 with Hessian-based SE 0.09) describing the response to increasing temperature. The model implies there is a relatively rapid increase in natural mortality as SST increases above the optimum SST of 29°C (Figure 4-2a). This result is conditioned on historical data which has an overall monthly maximum of 32.04°C, whereas the maximum monthly averages in the SST-projections to 2050 and 2100 respectively are 33.06°C and 34.24°C. Hence there is some confidence in the model projections in the near-term, but less confidence in longer-term model projections when SST is predicted to increase beyond the bounds observed in the historical data.

Table 4-1. Model estimates shown together with Hessian-based confidence intervals

	(a) Climate projection			(b) No-climate Reference Case		
Parameter	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**
B(1973) ^{sp} *(tons)*	6959	4645	9274	4947	3499	6396
M	fixed 0.69			0.69	0.56	0.82
h	fixed 0.7			fixed 0.7		
Sel (age 1+) 1973-1988	fixed			0.44	0.24	0.63
Sel (age 1+) 1989-2001	fixed			0.16	0.14	0.19
Sel (age 1+) post2002	fixed			0.02	0.00	0.03
SST-M par1	0.0019	0.00	0.04			
SST-M par2	0.2949	0.14	0.45			
Recruitment residuals (1985-2016)		32 parameters			**32 parameters**	
B(2016) ^{sp} *(tons)*	4830	3056	6603	5872	3668	8077
No. parameters estimated	39			37		
'-lnL:overall	**-194.704**			-189.056		
AIC	**-311.408**			-304.112		
Likelihood contributions		**Sigma**	**q**		Sigma	q
'-lnL:CAA	-62.61	0.04		-60.38	0.05	
'-lnL:CAAsurv	-19.13	input from data		-19.17	input from data	
-lnL:CAA historic	-21.39	0.14		-21.77	0.13	
-lnL:Survey Index 1+	-25.60	input from data	3.140E-07	-24.31	input from data	3.780E-07
-lnL:Survey Index 2+	-15.95	input from data	3.814E-07	-13.04	input from data	3.953E-07
-lnL:Survey benchmark	-2.79	input from data		-3.14	input from data	
'-lnL:PRESEASON	-8.28	input from data	6.643E-07	-8.22	input from data	7.305E-07
-lnL:PRESEASON 0+	-5.68	input from data	6.459E-08	-5.82	input from data	8.504E-08
-lnL:CPUE (TVH)	**-26.02**	0.20	1996.0000	-26.02	0.20	1996.0000
-lnL:CPUE (TIB)	**-13.31**	0.20	2006.0000	-13.31	0.20	2006.0000
'-lnL:RecRes	6.05	0.50	(input sigma 0.5)	6.13	0.50	(input sigma 0.5)

The SST-growth relationship acts to increase biomass over the short to medium term, but as average annual SST continues to rise, this is countered by the negative influence of SST on survival (Figure 4-3). The average changes per decade are shown in Figure 4-4.

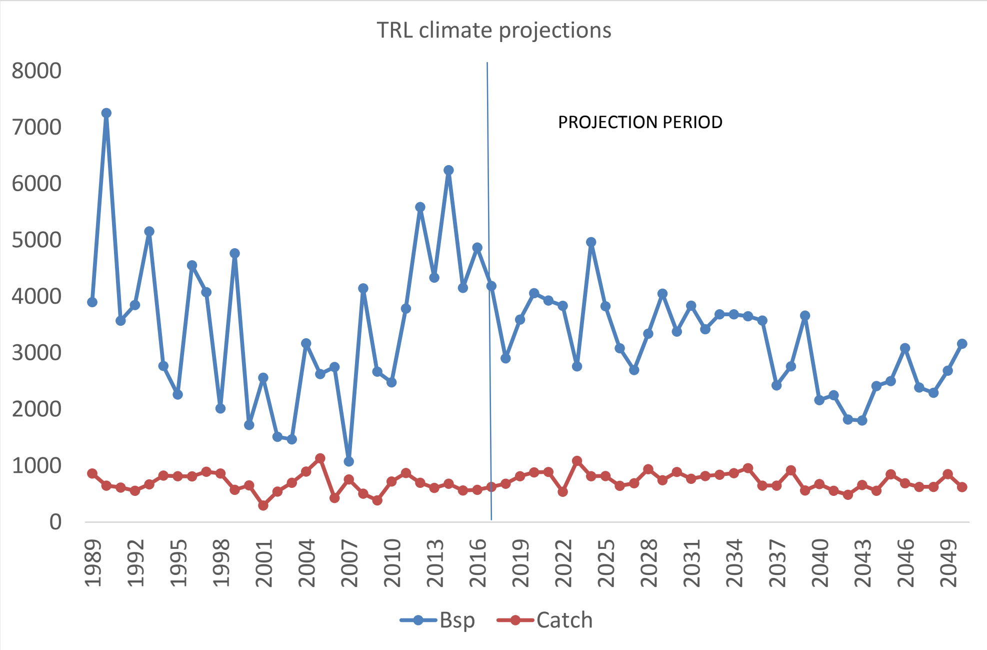


Figure 4-3. Plot of the model-estimated spawning biomass (Bsp) trajectory when linked to climate data over the historical period to 2016 and projected to 2050. The plot also shows the observed historical catch to 2016 and model-estimated catch (Catch; when fixing target F=0.15) to 2050.

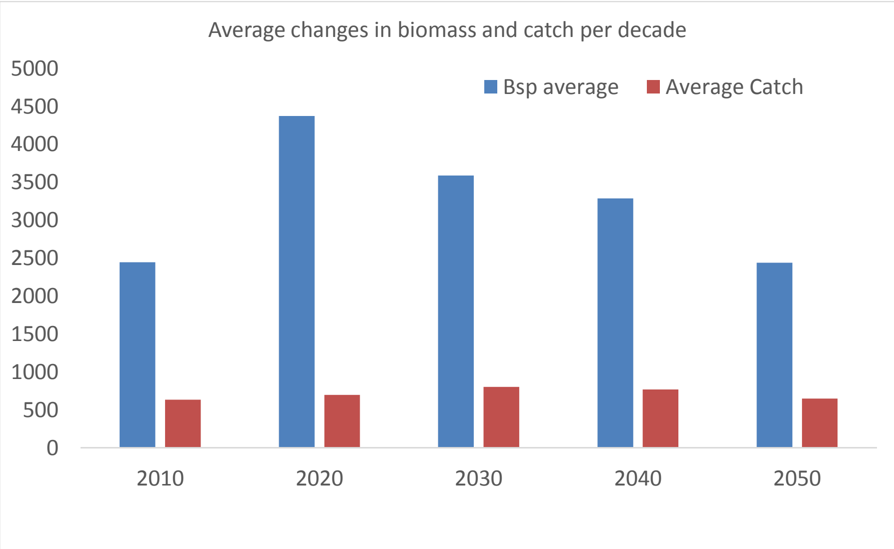


Figure 4-4. Summary of changes in average biomass and catch per decade as shown.

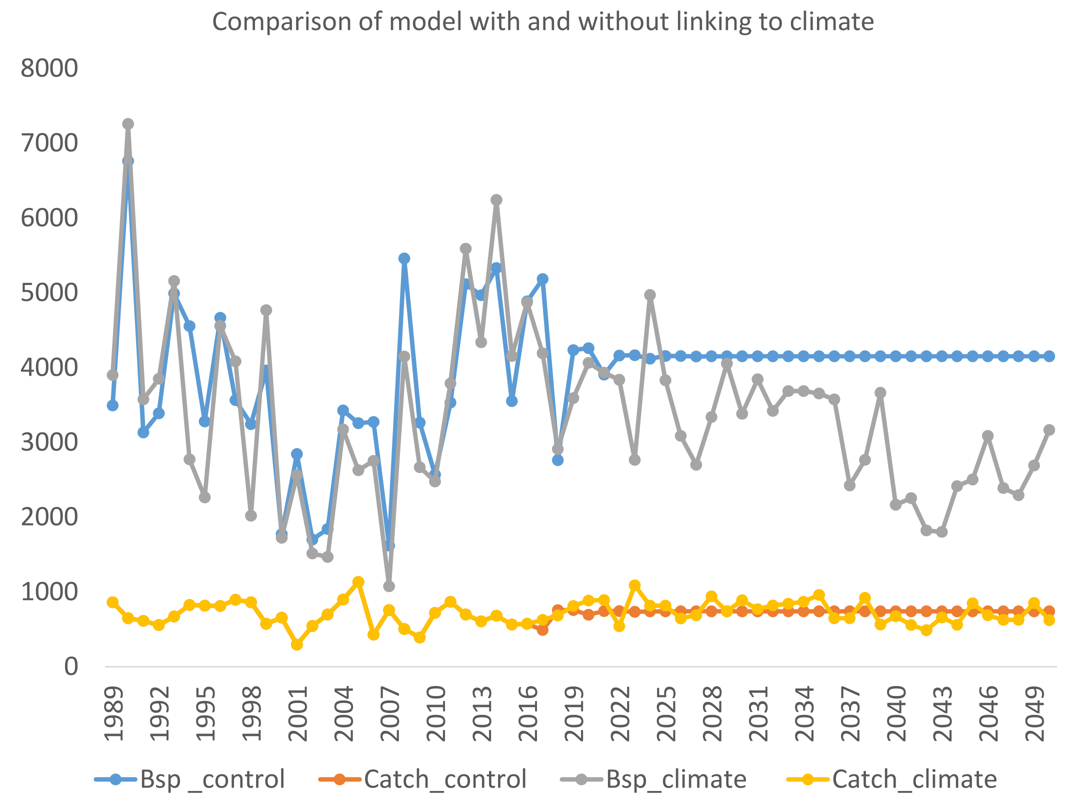


Figure 4-5. Comparison of model projections (and historical fit) with (Bsp_climate & Catch_climate) and without (Bsp_control & Catch_control) linking to climate variables.

A comparison of model historical estimates and projections of spawning biomass under a no-climate control and linked climate model are shown in Figure 4-5. Comparing the historical model spawning biomass trajectories illustrates the extent to which some of the historical fluctuations can be explained by SST (Figure 4-6). This is illustrated further by overlaying the model – estimated spawning biomass trajectory with the SST annual averages, with a one year lag to account for the influence of SST on lobster growth and survival during the preceding year (Figure 4-7). This highlights that SST is able to explain some of the variability, particularly during recent years, whereas the mismatch during some of the earlier years suggests that other factors were more influential on stock dynamics – in this case there was heavy fishing preceding a decline in stock abundance, which resulted in a change to the minimum size limit and subsequent stock recovery.

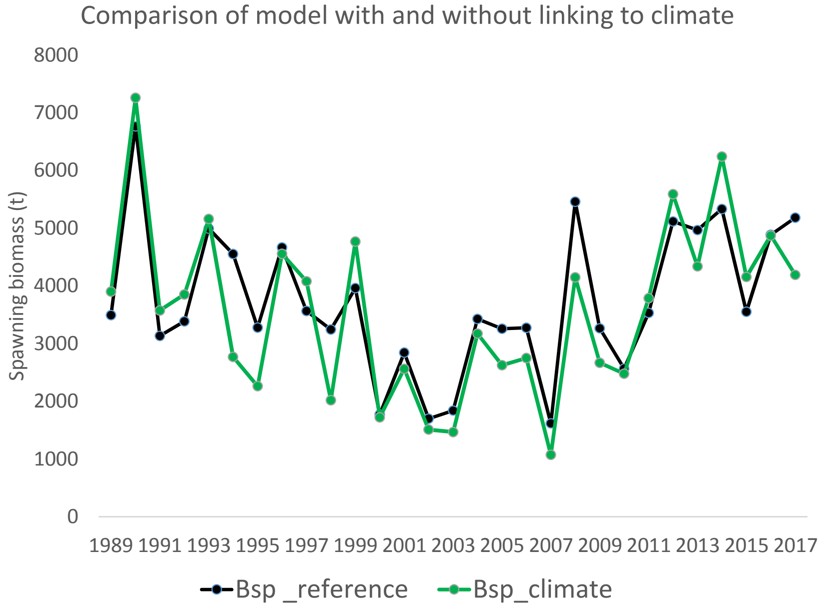


Figure 4-6. Comparison of historical spawning biomass trajectory with and without linked climate driver.

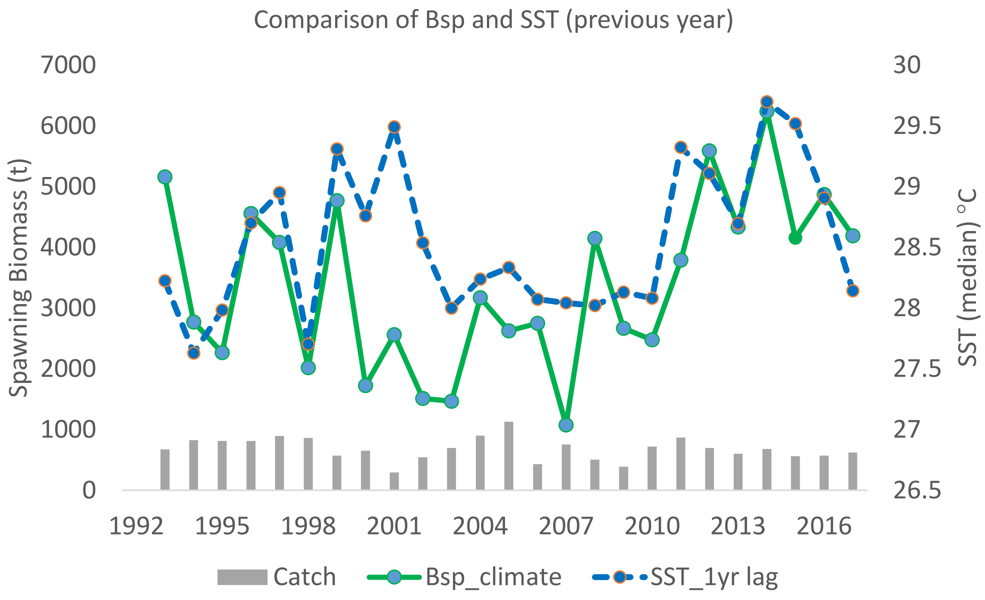


Figure 4-7. Comparison of model spawning biomass trajectory and SST (lagged one year)

4.4 Discussion of Model Projections

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 period, 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).

Comparing the historical model spawning biomass trajectories with the SST annual averages, with a one year lag to account for the influence of SST on lobster growth and survival during the preceding year, highlighted that SST is able to explain some of the variability, particularly during recent years, whereas the mismatch during some of the earlier years suggests that other factors were more influential on stock dynamics – in this case there was heavy fishing preceding a decline in stock abundance, which resulted in a change to the minimum size limit and subsequent stock recovery. As the incorporation of SST explains some of the observed variability, this suggests that consideration should be given to adjusting or re-estimating the model standard deviation that is input to control the extent of fluctuations in the stock-recruit residual estimates.

Overall, the TRL spawning biomass is predicted to remain roughly at current levels, with large inter-annual fluctuations as observed in the past, during the short to medium-term, but a decrease is predicted in the longer term (Figure 4-5). However ongoing work will continue to refine these projections and the results presented here should thus be considered as preliminary only.

5 Modelling the consequences of not accounting for potential contributions to Torres Strait lobster recruitment from the neighbouring East Coast region

Abstract

The stock assessment model assumes that the Torres Strait lobster population is a closed population, with the numbers of annual recruits (defined as 1+ lobsters) assumed to have originated solely from the Torres Strait spawning stock biomass. However as described in this report, larval circulation models suggest that dependent 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. The stock assessment model accounts for the former of these effects through estimation of large annual deviations about the average recruitment level that would be deterministically predicted based on the Torres Strait spawning biomass level. But the model ignores the second effect, which can most simplistically be thought of as a "bonus" contribution of recruits from an external unknown spawning biomass. Model results suggested that this would bias estimates of the stock-recruit steepness parameter *h* and carrying capacity parameter *K* (and hence depletion estimates) but that model predictions remain robust because of the availability of direct survey data on recruiting lobsters measured as part of annual Pre-season surveys.

5.1 Introduction

The *P. ornatus* stock is naturally highly variable and the fishery focuses on essentially a single 2+ age-class only. This is because these lobsters have a complex life-history comprising a 6 month larval life and a breeding migration of ~ 550 km. Extensive tagging studies (~20000 tags) were conducted in Torres Strait and Queensland waters and recaptures showed the 500 km Autumn (Aug/Sept) breeding migration 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 & Macfarlane 1984b, Skewes et al. 1997, Dennis et al. 2001). The stock assessment model assumes that the Torres Strait lobster population is a closed population, with the numbers of annual recruits (defined as 1+ lobsters) assumed to have originated solely from the Torres Strait spawning stock biomass. However as described in this report, larval circulation models suggest that dependent 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 Straits due to the predominant northerly direction of the current. The stock assessment model accounts for the former of these effects through estimation of large annual deviations about the average recruitment level that would be deterministically predicted based on the Torres Strait spawning biomass level (see Appendix C). But the model ignores the second effect, which can most simplistically be thought of as a “bonus” contribution of recruits from an external unknown spawning biomass.

In this Chapter, model simulations are used to explore the consequences of a range of assumptions as to how the neighboring stock might be supplementing and influencing recruitment.

5.2 Methods

As there are fewer data and no surveys available for the East Coast fishery, the precise biomass of this component is not reliably estimated. But for current purposes, it isn’t necessary to explicitly model the East Coast population – rather model simulations are used to explore the consequences of a range of assumptions as to how the neighboring stock might be supplementing and influencing recruitment. The scenarios considered are:

A. Constant annual contribution - considered the most likely scenario because catch levels are set at a low constant value for the East Coast fishery, and a large proportion of the broader fished area is designated as green (no-fishing) zones;
B. Increasing linear trend – as might be expected for a fishery if catches are reduced or some other management measure introduced in a neighbouring region;
C. Decreasing linear trend – as might be expected if a gradual decline is observed in a neighbouring stock;
D. Variable scenario which assumes that the trend is proportional to the catch history from the east Coast fishery – this scenario more explicitly explores what the impact might be of inter-annual changes in catches from the neighbouring fishery.

5.3 Results

Under the constant annual contribution scenarios, there was an inverse relationship between the external contribution percentage and the model estimates of the spawning stock-recruit parameter *h* (Table 5-1). This is consistent with discussions at previous TRLRAG meetings noting that model estimates of steepness may be biased low if the spawning biomass is larger than predicted in the model because of a shared effect with the East Coast region if it is assumed that the East Coast region has relatively stable stock abundance.

Changes in model estimates of *h* also result in changes in estimates of stock depletion relative to the pre-exploitation spawning biomass in 1973 (B1973) (Table 5-1, Figure 5-1). Assuming a linearly increasing or decreasing trend in recruits contributed from an adjacent area had a relatively small effect on estimates of steepness, but a large effect on the depletion estimates. To further explore this last effect, a model run under the decreasing trend scenario and that fixed steepness at the reference case level of 0.7 yielded a higher depletion estimate (Table 5-1).

Table 5-1. Summary of model estimates of stock-recruit steepness parameter *h* and spawning biomass depletion level (B(2017)/B(1973) assuming annual recruitment is supplemented by an adjacent area under a range of scenarios as shown

	Fixed external recruitment contribution							
	0	10%	33%	66%	variable	increasing	decreasing	decreasing &fixh
h	0.59	0.56	0.52	0.46	0.65	0.6	0.55	0.7 (fix)
B(2017)/B(1973)	0.61	0.69	0.92	1.32	0.69	0.90	0.72	0.74

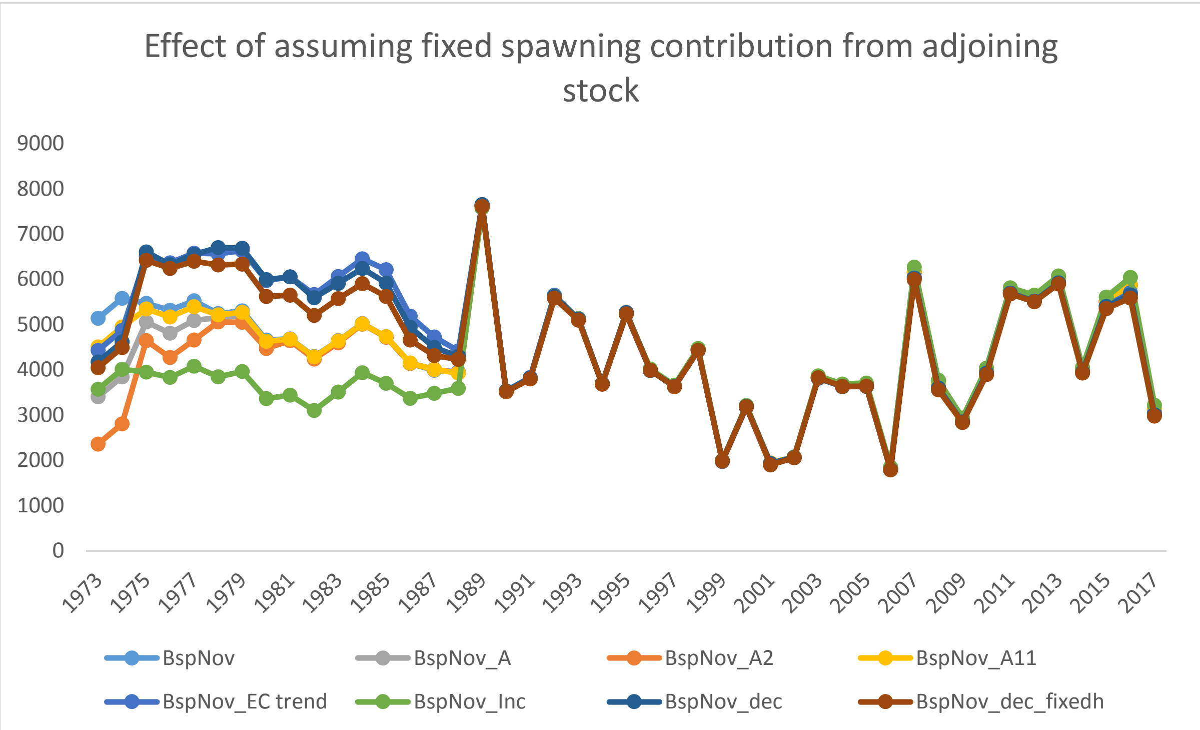


Figure 5-1. Comparison of model-estimated spawning biomass trajectories under alternative assumptions of a spawning contribution from an adjoining area.

5.4 Discussion

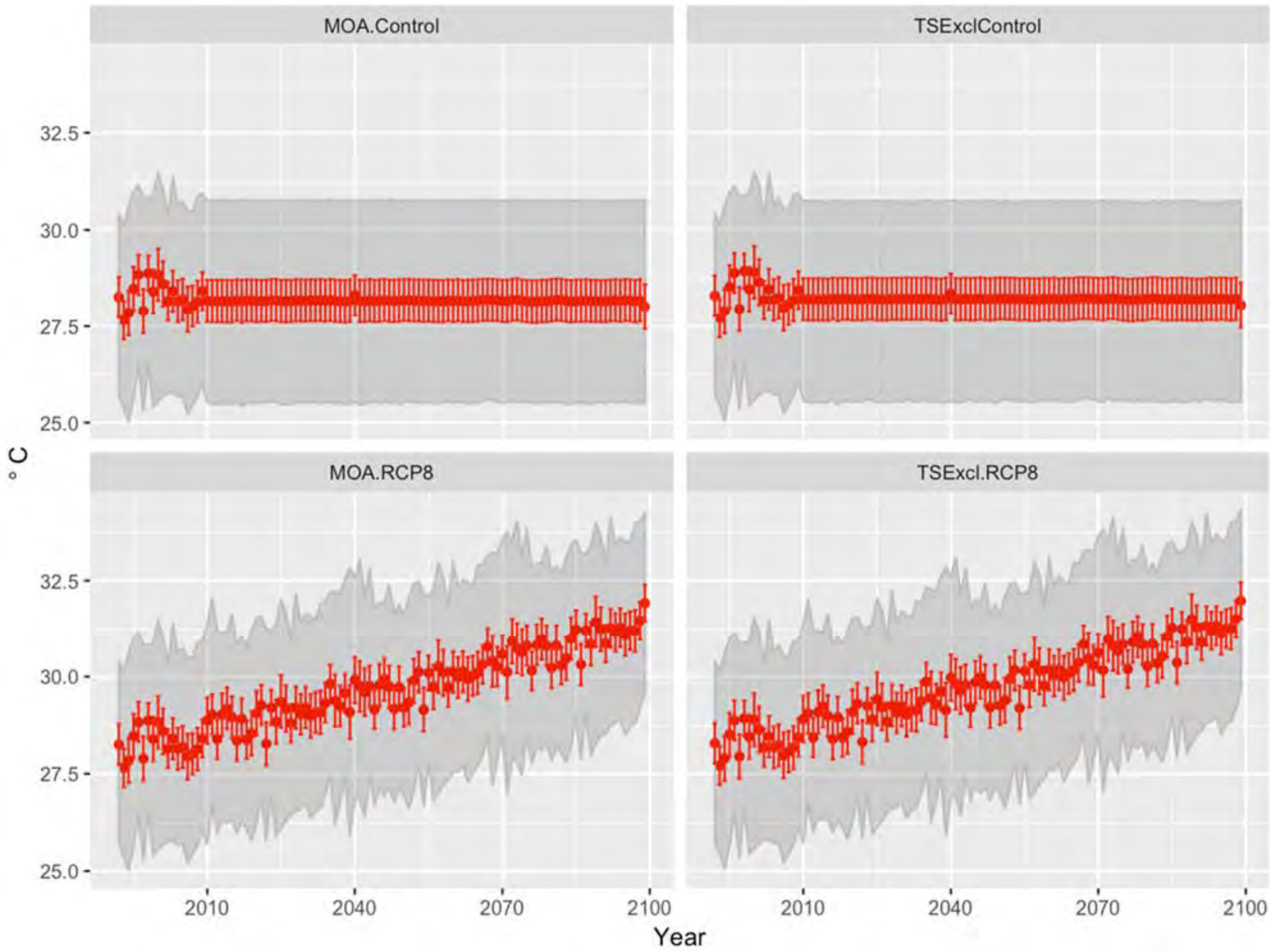
Estimates of stock depletion are important for management because they are used to assess stock status as a basis for determining whether a stock is overfished or not, as well as often for setting target reference points. But model estimates of depletion level are sensitive to model estimates of steepness *h* and natural mortality *M*, because these parameters determine stock productivity –for example *M* and carrying capacity *K* are usually inversely related because observations on a stock can usually be explained by either a high abundance and relatively low productivity or lower abundance with high productivity (and additional data sources, preferably with contrast in the data, are used to distinguish between these alternatives). The steepness parameter is based on a stock-recruitment curve that assumes that a “known” spawning biomass yields the observed recruitment. However, as demonstrated in this example, sometimes the true spawning biomass that contributes to recruitment can be larger (or smaller) than that represented in a model. This is because as with many fisheries models, an assumption is made for practical purposes, that the stock boundaries are closed. The purpose of this analysis was to assess what the implications for the stock assessment and associated management recommendations are. This also has relevance under a climate change context, as if there are future climate-driven changes in oceanic currents (particularly the Coral Sea Gyre) that influence the contribution of larval recruits from seed areas, then the implications for the stock assessment model also need to be understood.

Importantly, changes in model estimates of *h* also result in changes in estimates of stock depletion relative to the pre-exploitation spawning biomass in 1973 (B1973). Over the more recent period where there are data to inform on the model fit, the model self-adjusts and there are minimal differences between model-estimated trajectories with and without the assumption of an adjacent area contributing recruits. However, prior to 1985, there were catch data only and hence no basis for estimating recruit residuals, and the model estimate of carrying capacity K varies under the scenarios tested, with consequent impacts on depletion level estimates. This has important implications for management as the depletion level is often used to assess stock status, and can also be used to set reference points such as the target spawning biomass level that management should aim to achieve.

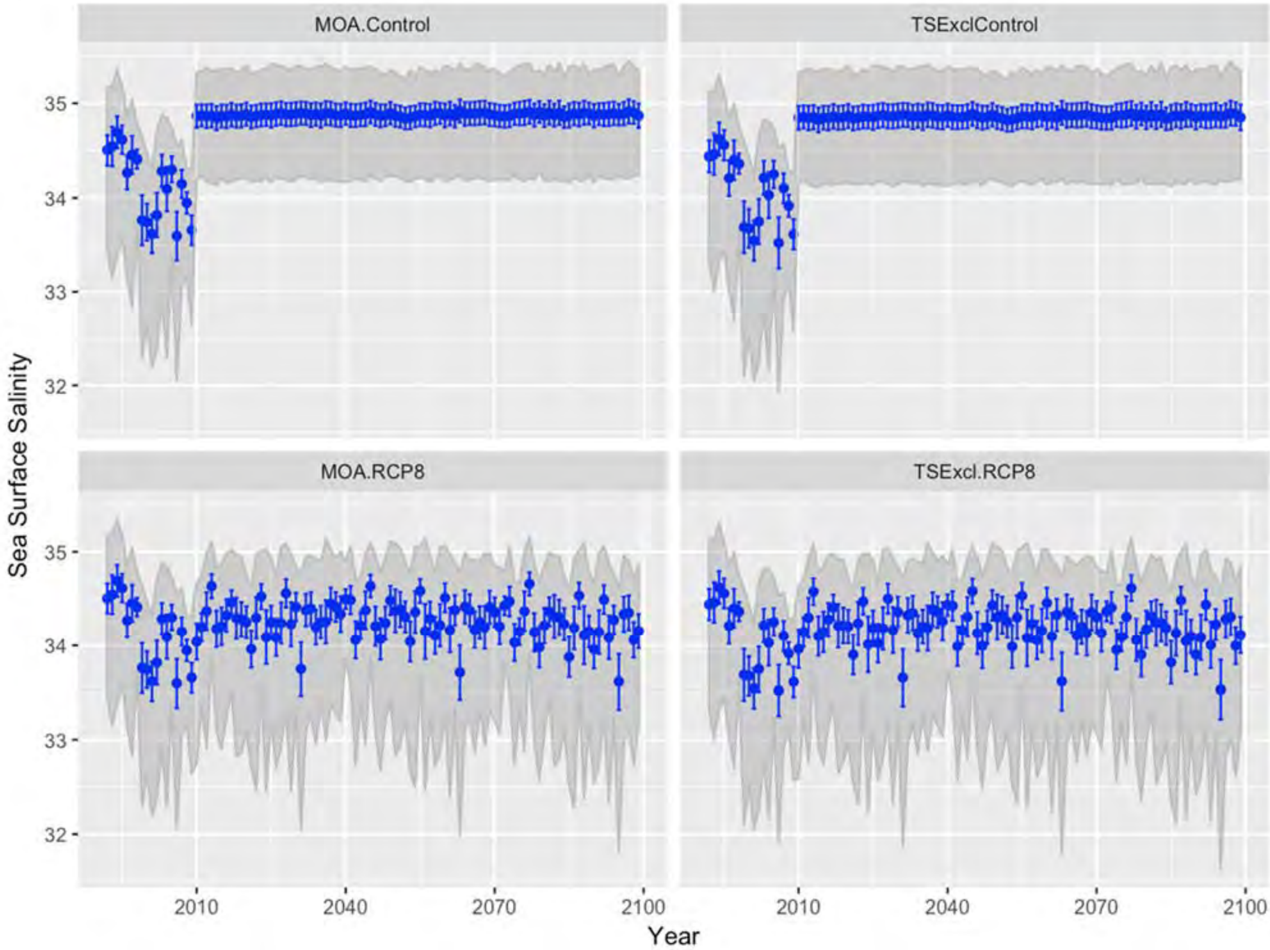
In summary, estimation of *K* and *h* are sensitive to whether an adjacent stock is influencing total recruitment. However, the assessment is dominated by inter-annual recruitment variability which can be estimated from survey data hence the sustainable catch forecast is still robust. In addition, for TRL a target reference level is used that is independent of the estimate of *K*. In addition, the fishery is developing an empirical harvest control rule (HCR) that uses survey and fishery CPUE (catch-per-unit-effort) data directly as inputs. The HCR has also been tested across a range of alternative steepness *h* values as well as testing robustness to scenarios assuming future disruptions in recruitment and increases in natural mortality.

An alternative approach would be to model TRL as a single stock, but this potentially causes more problems than it solves, including different data availability, and cross-jurisdictional as well as cross-border management complications.

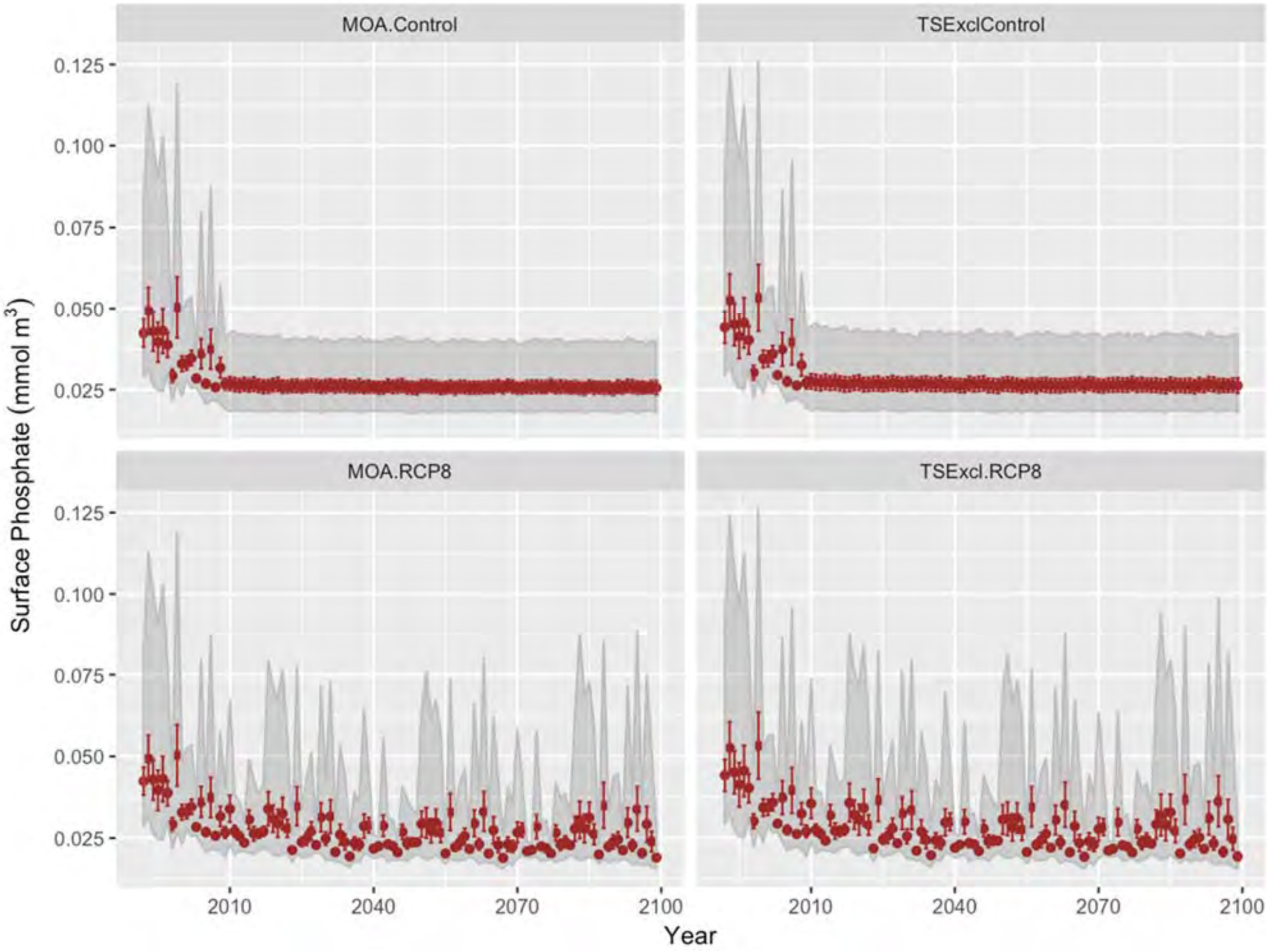
Appendix A Modelled climate variables



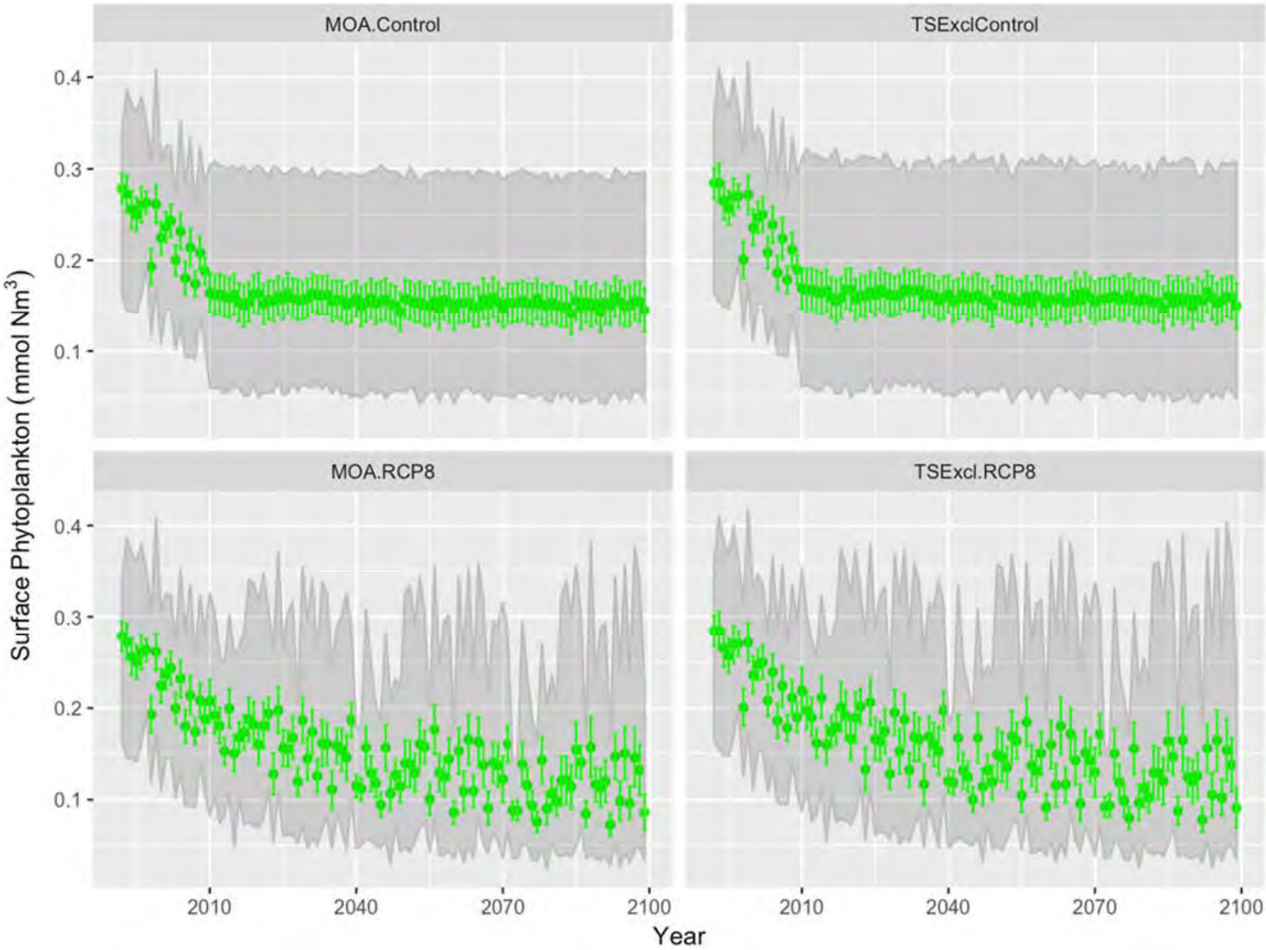
Apx Figure A-1. Modelled mean monthly Sea Surface Temperature (SST; ±1 SE) for the Torres Strait model output area (MOA) and the MOA minus the exclusion zone (TSExcl) under two future climate scenarios: no change (Control) and RCP8.5 (RCP8). The grey ribbon shows the minimums and maximums.



Apx Figure A-2. Modelled mean monthly Sea Surface Salinity (SSS; ±1 SE) 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). The grey ribbon shows the minimums and maximums.



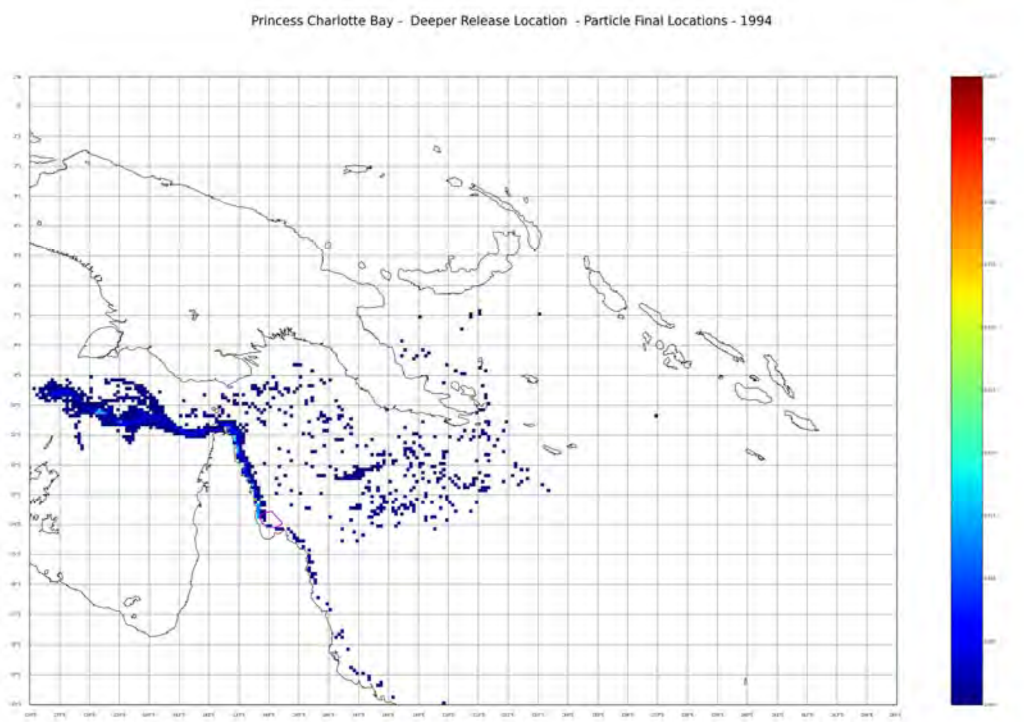
Apx Figure A-3. Modelled mean monthly Sea Surface Phosphate (±1 SE) for the Torres Strait model output area (MOA) and the MOA minus the exclusion zone (TSExcl) under two future climate scenarios: no change (Control) and RCP8.5 (RCP8). The grey ribbon shows the minimums and maximums.



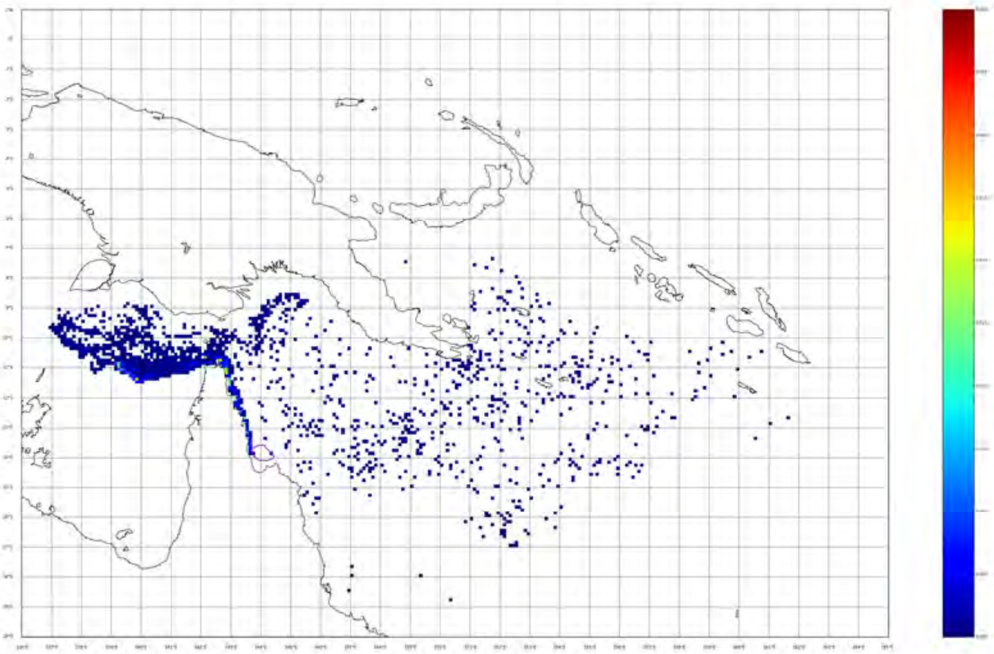
Apx Figure A-4. Modelled mean monthly Sea Surface Phytoplankton (±1 SE) for the Torres Strait model output area (MOA) and the MOA minus the exclusion zone (TSExcl) under two future climate scenarios: no change (Control) and RCP8.5 (RCP8). The grey ribbon shows the minimums and maximums.

Appendix B Larval advection plots

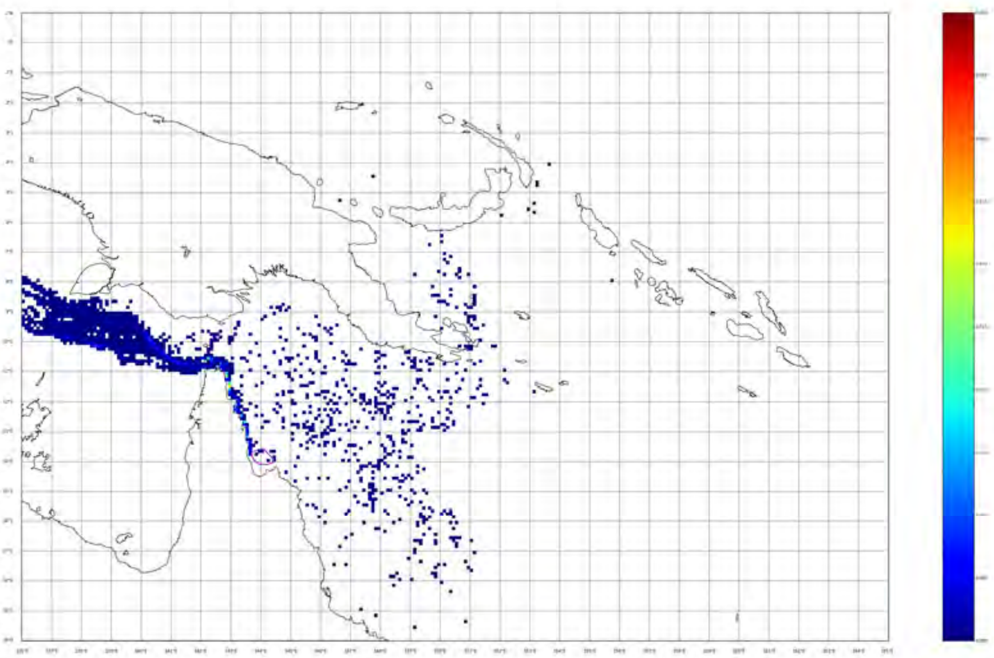
B.1 Final particle positions for particles released from Princess Charlotte Bay (1994 – 2015).



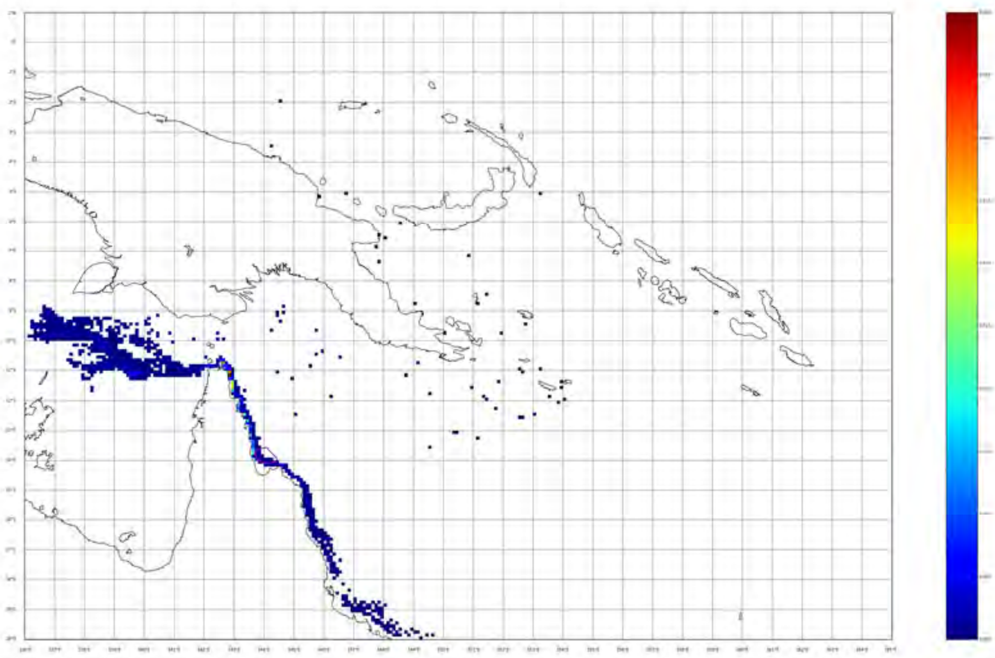
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 1995



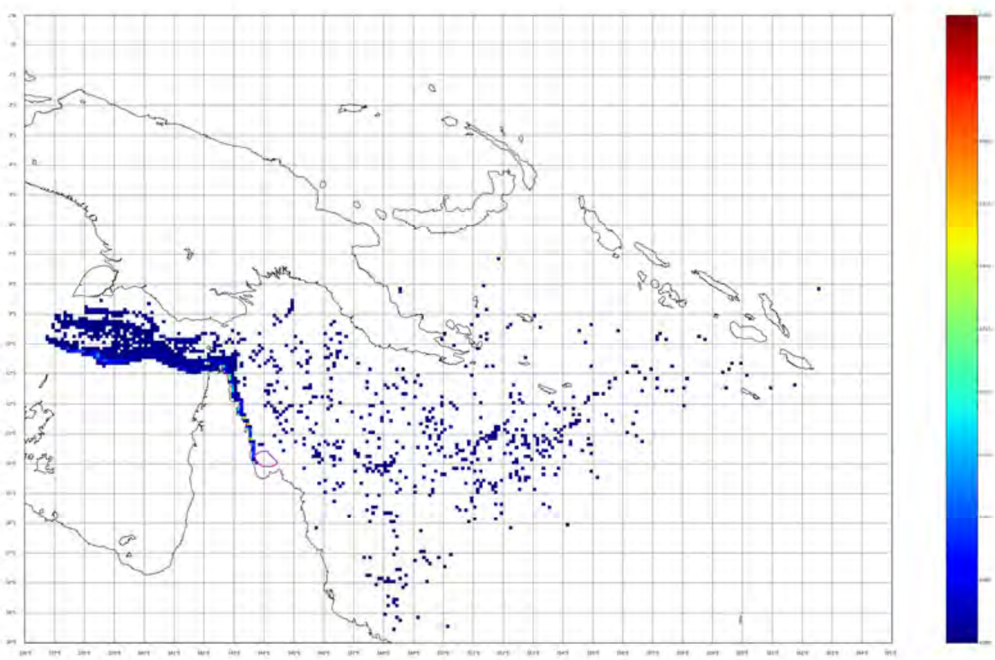
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 1996



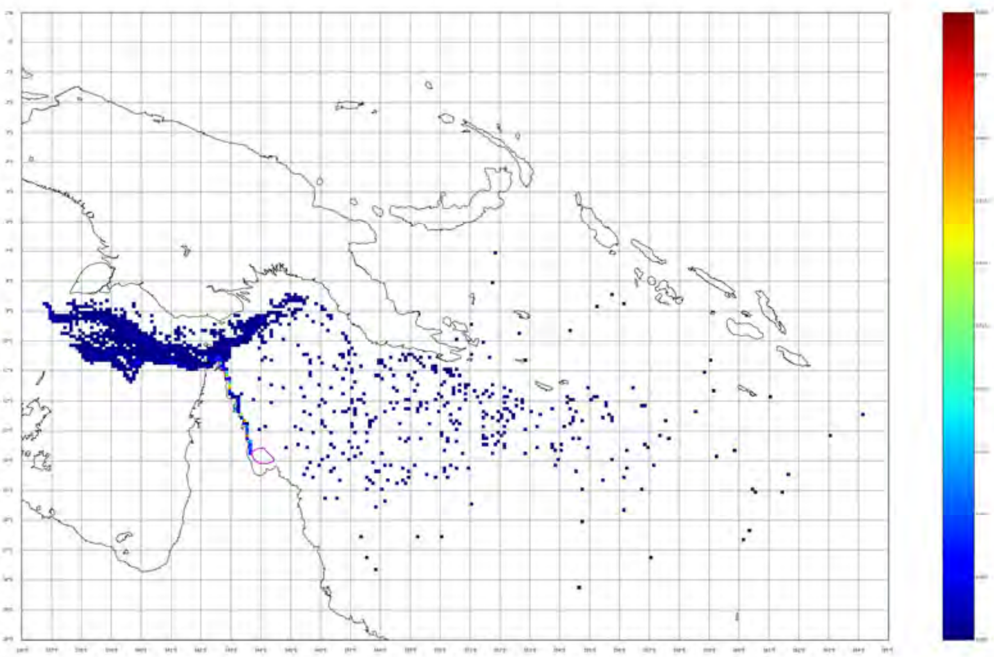
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 1997



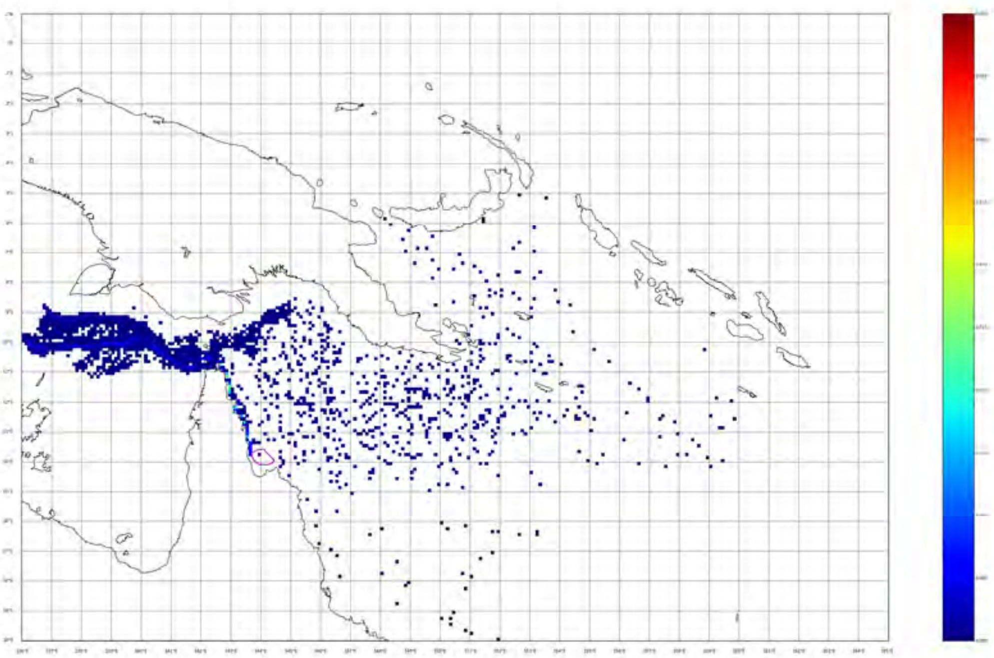
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 1998



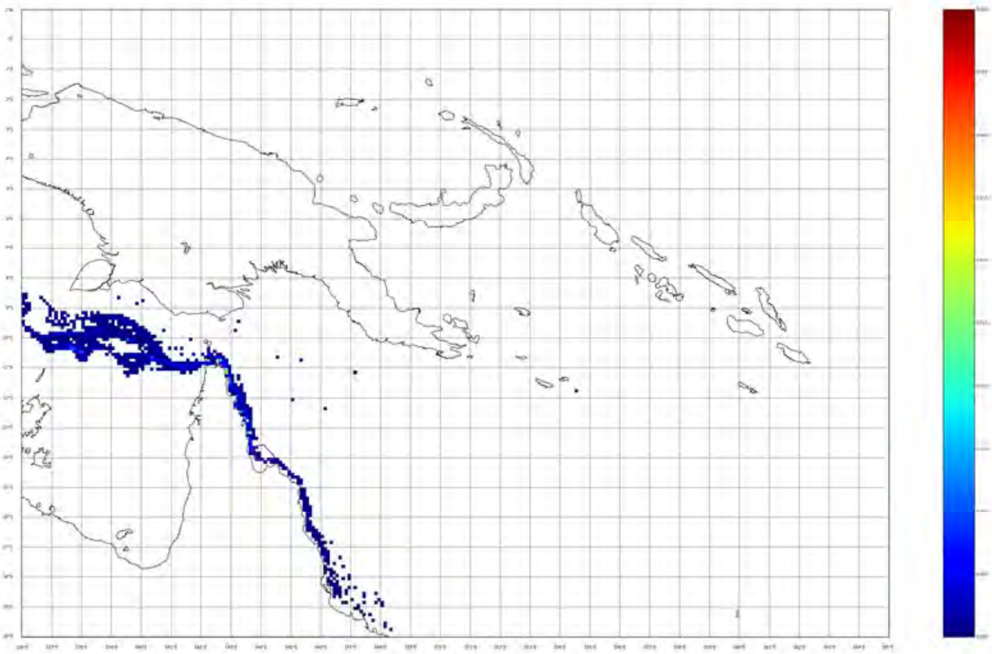
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 1999



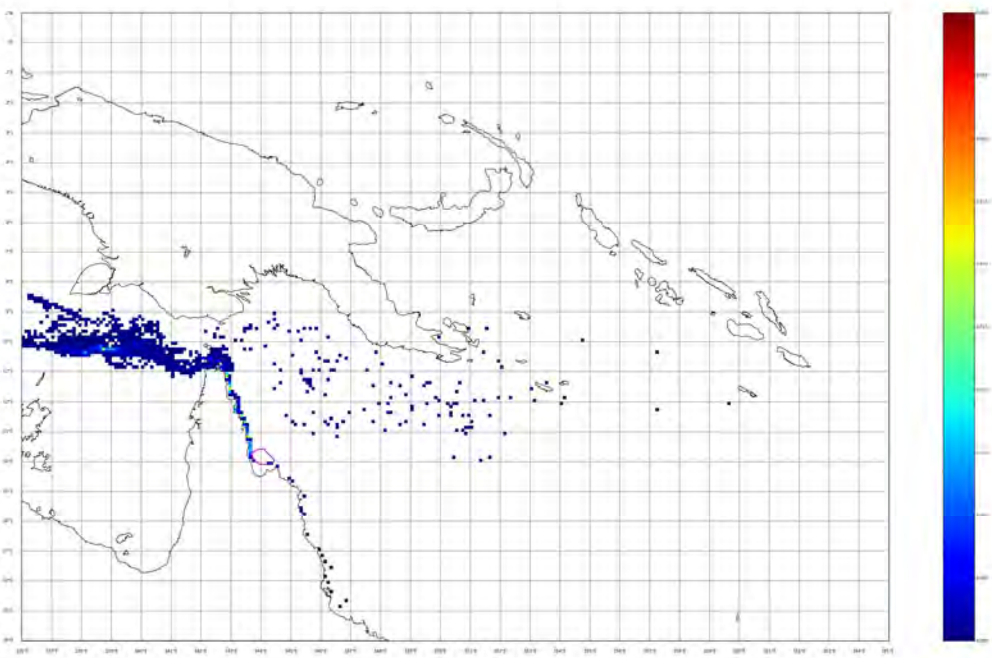
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2000



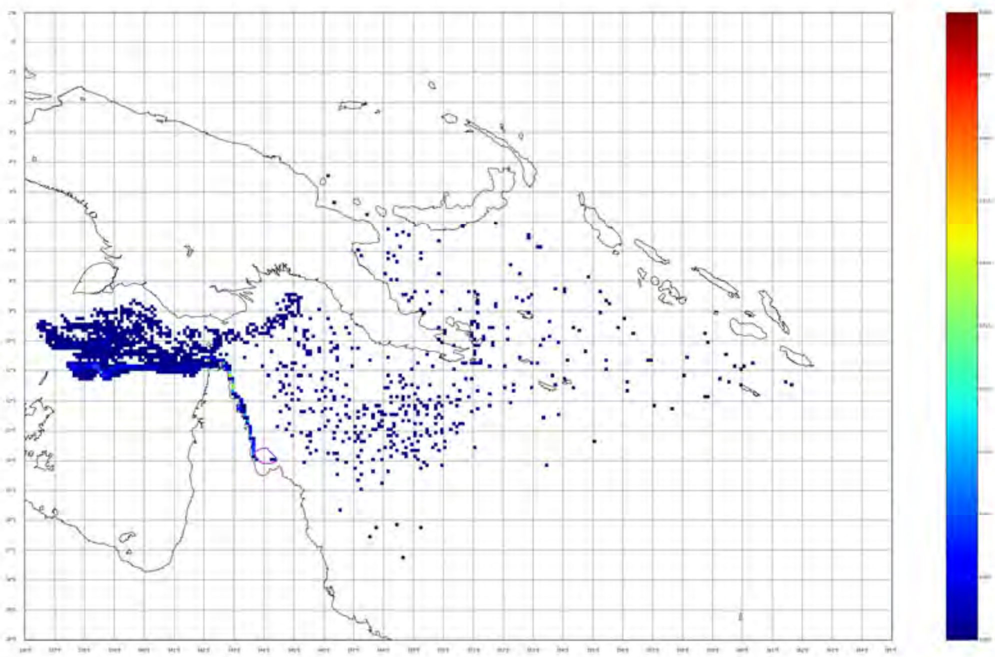
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2001



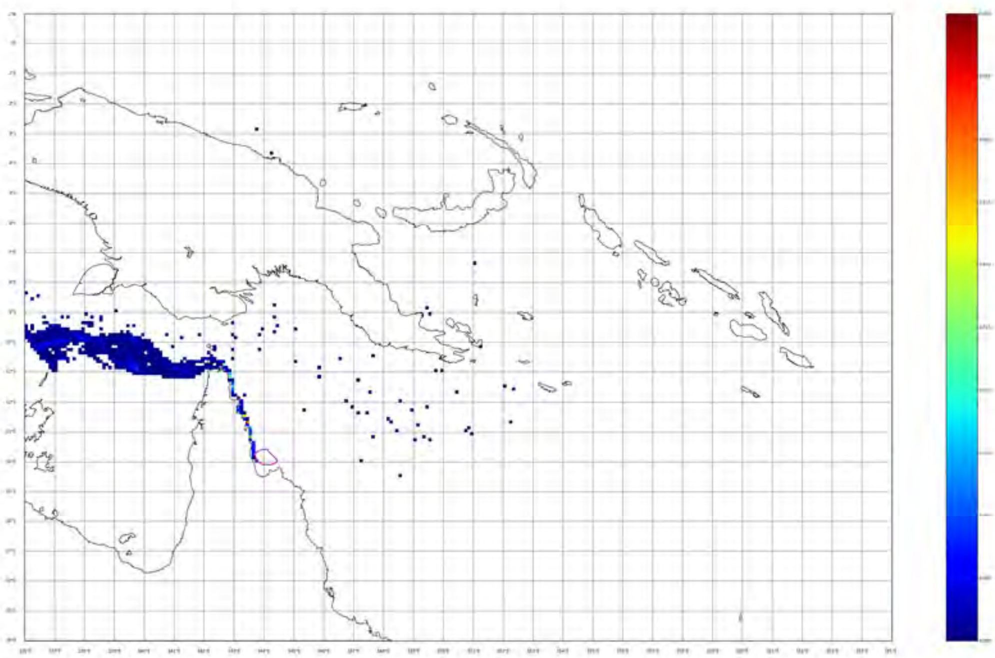
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2002

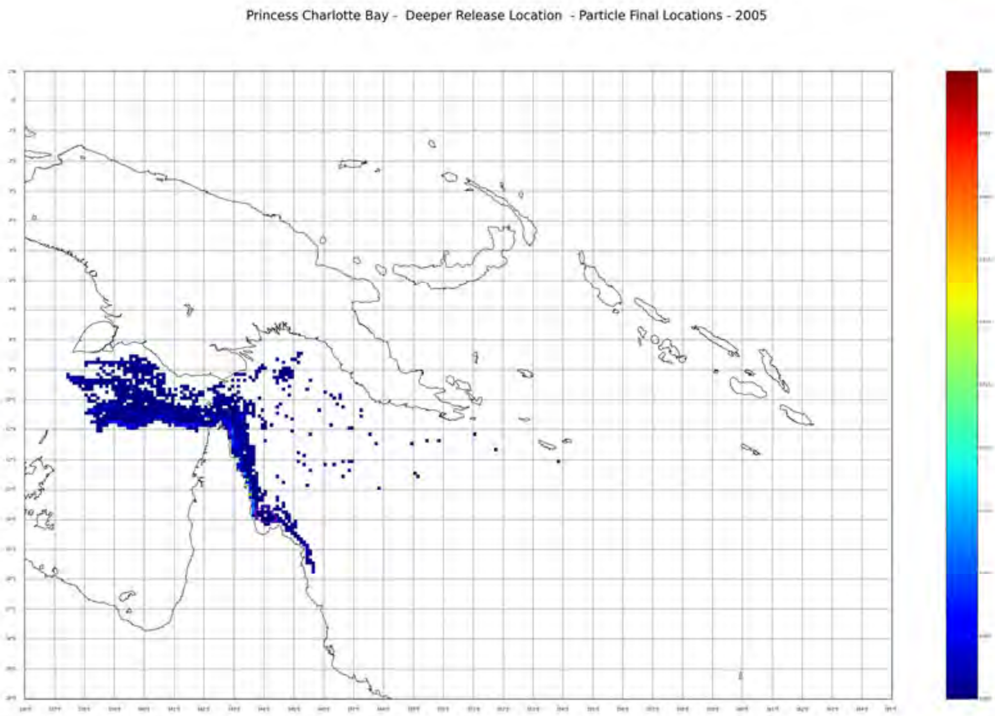


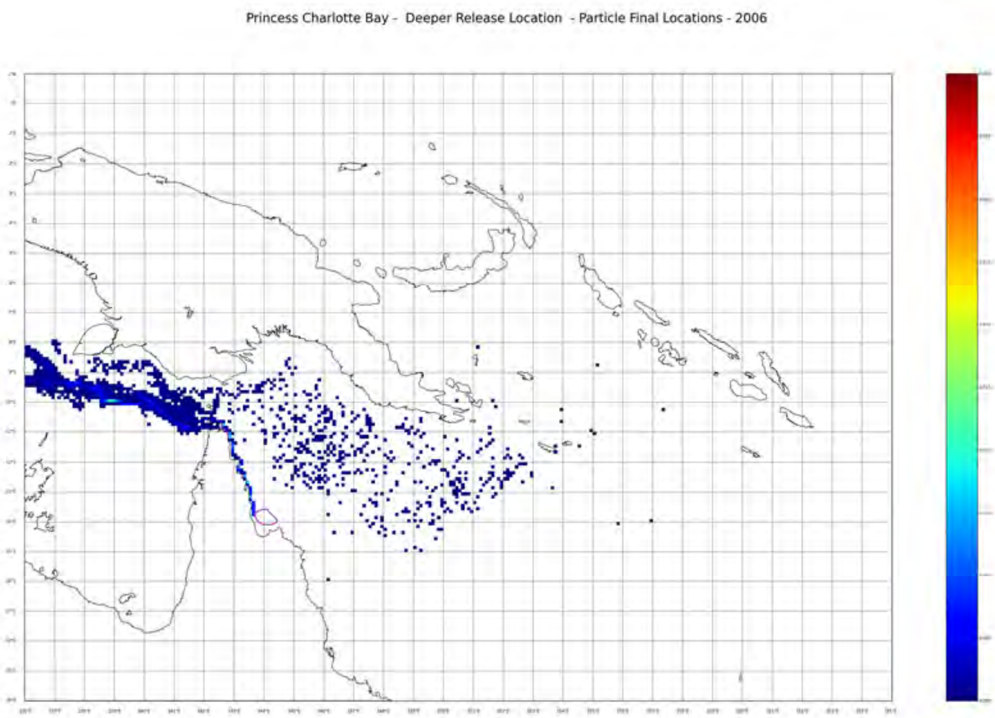
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2003



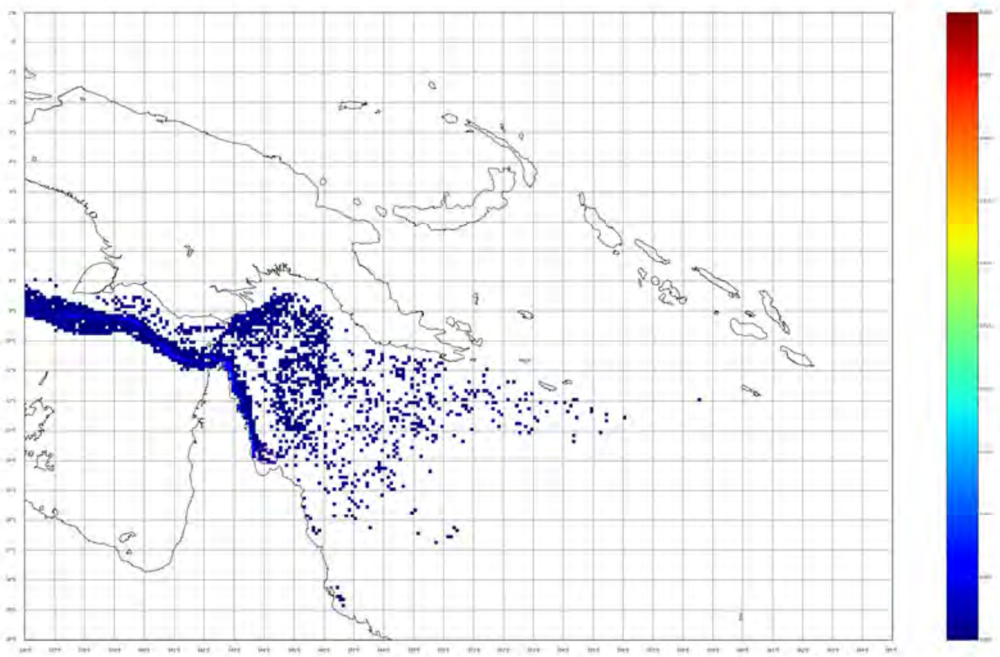
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2004



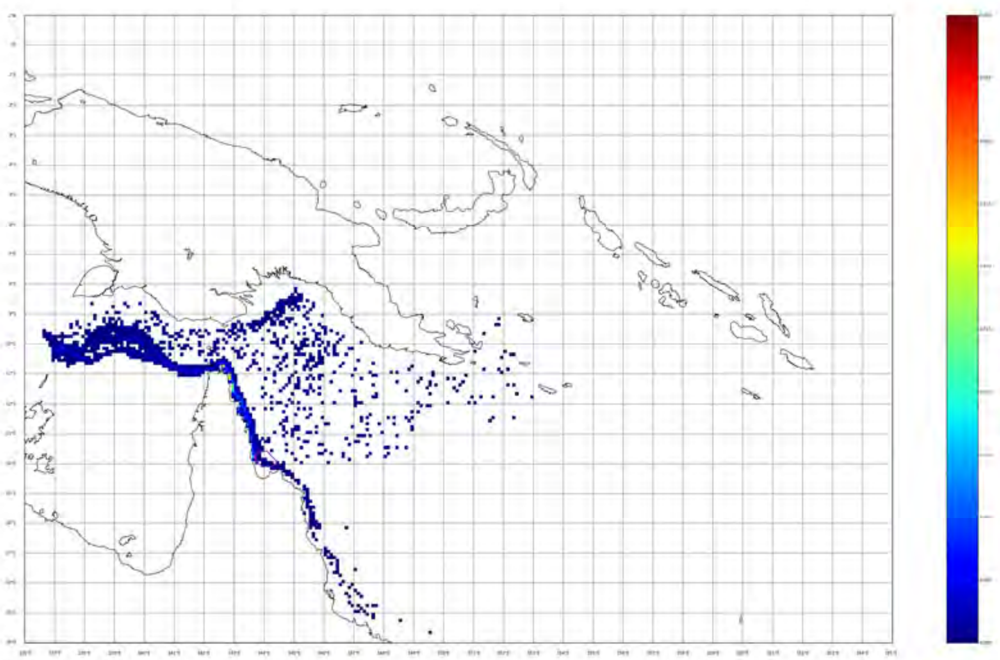

Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2005


Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2006

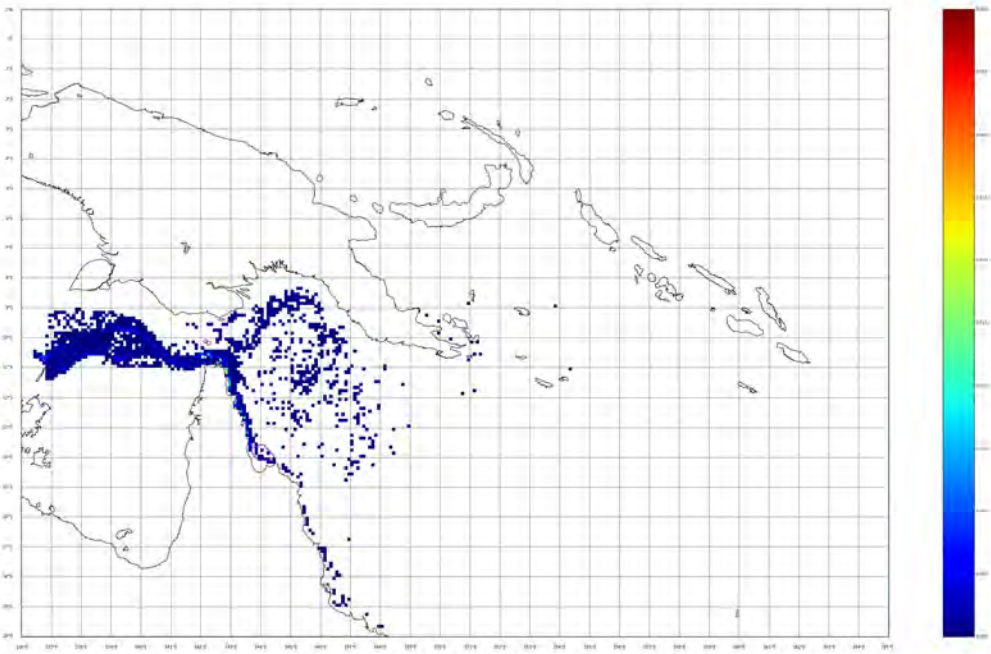
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2007



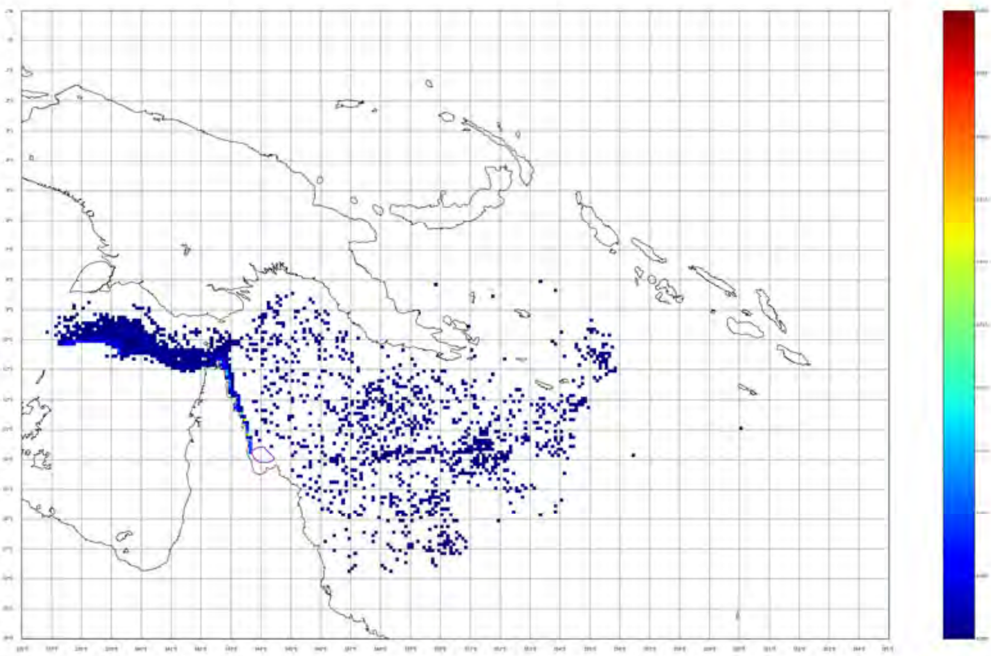
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2008



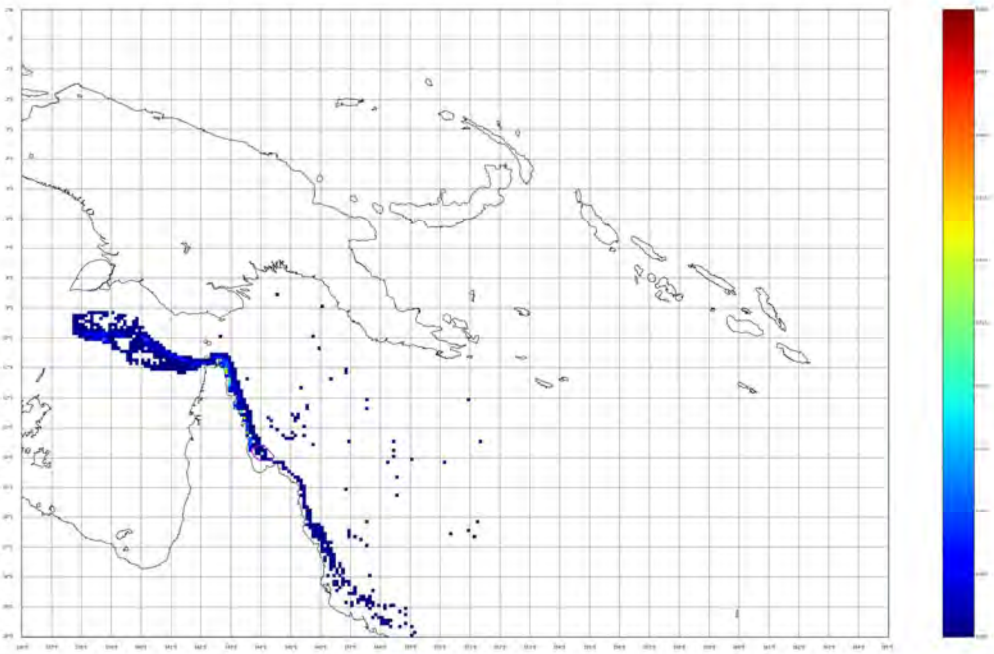
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2009



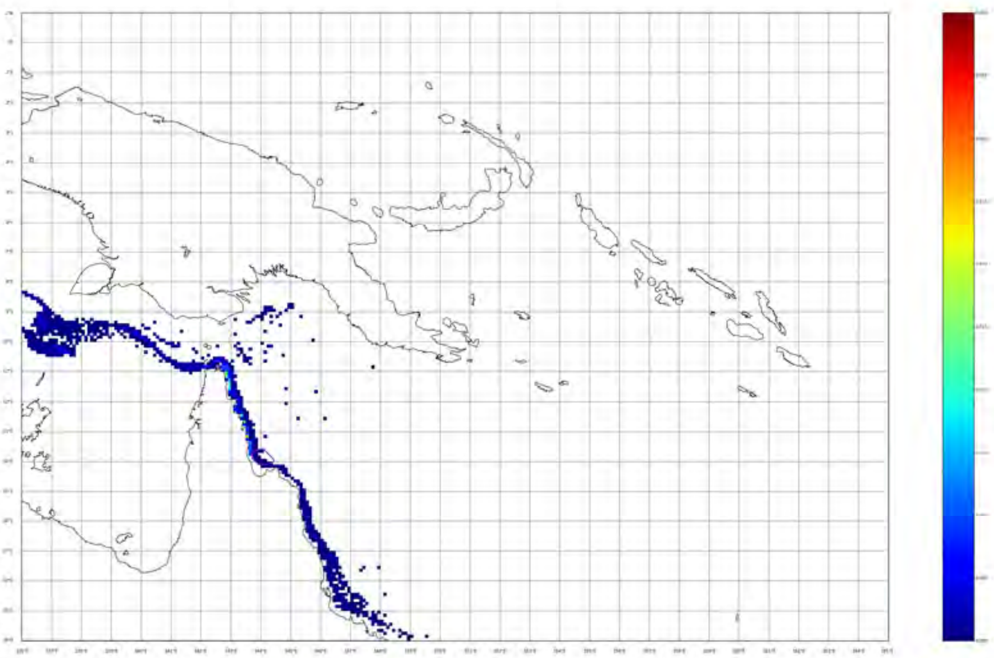
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2010



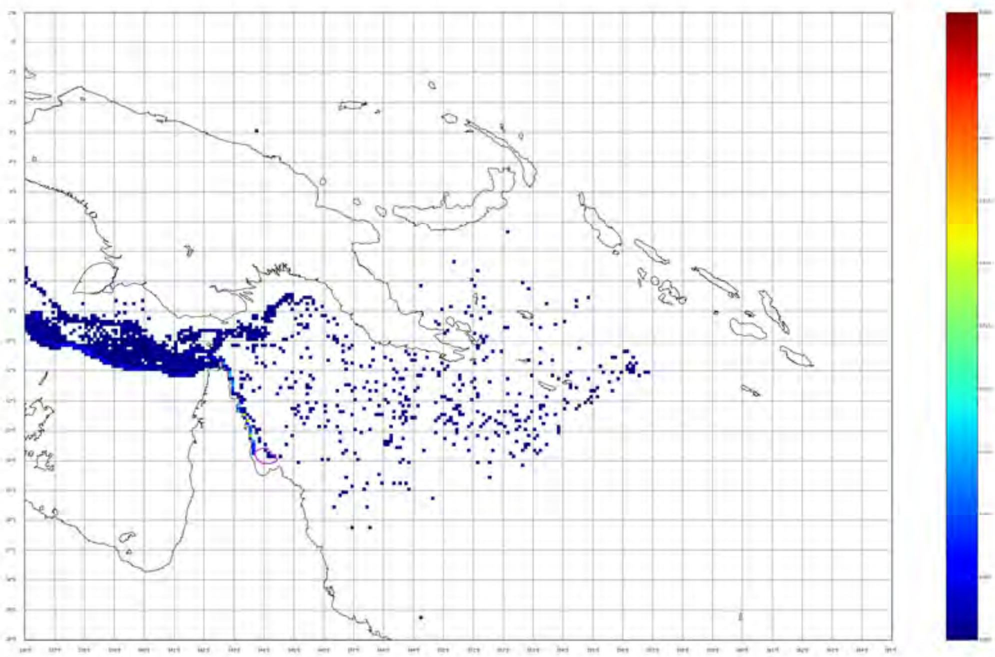
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2011



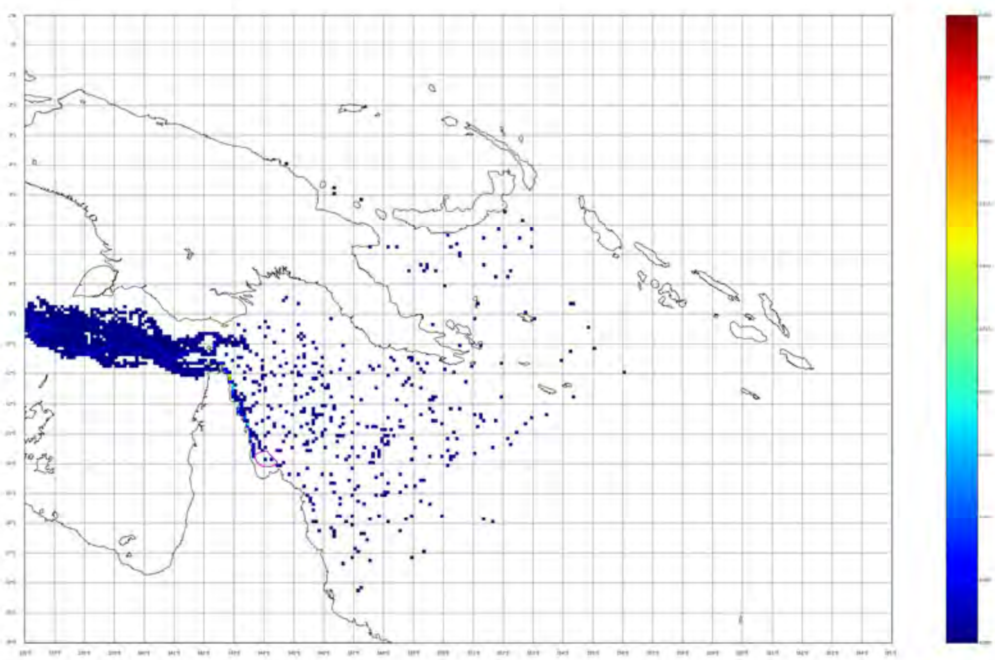
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2012



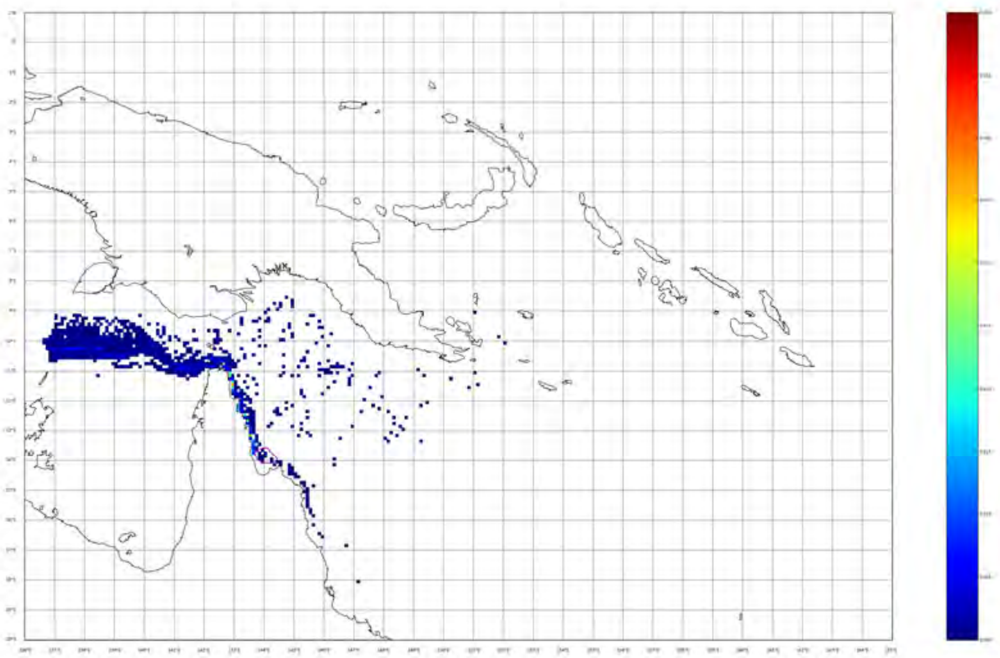
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2013



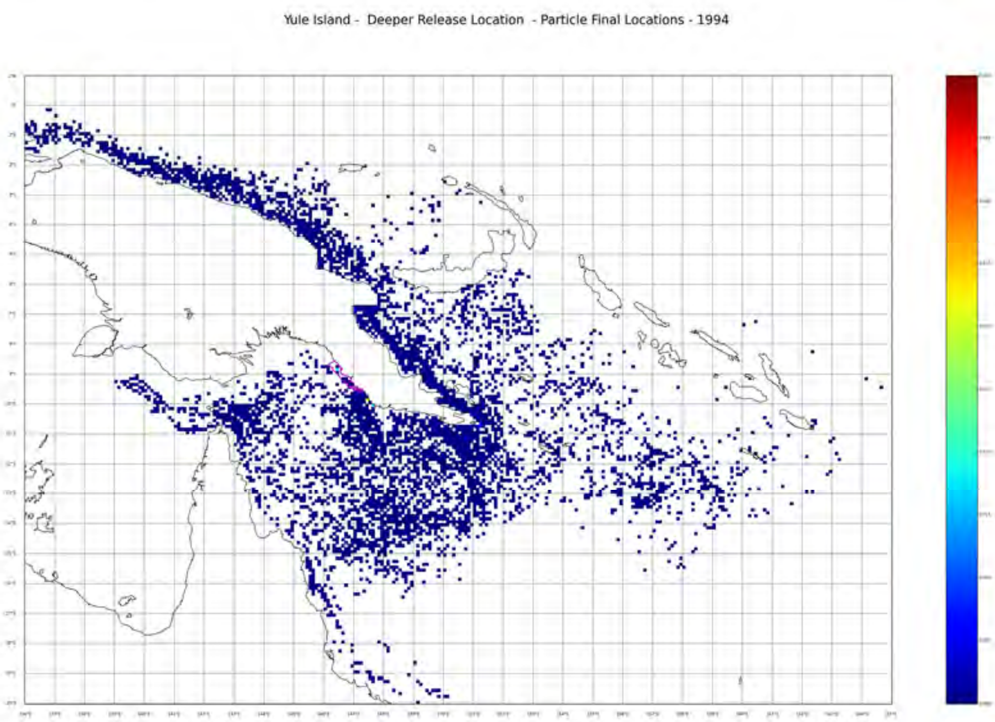
Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2014

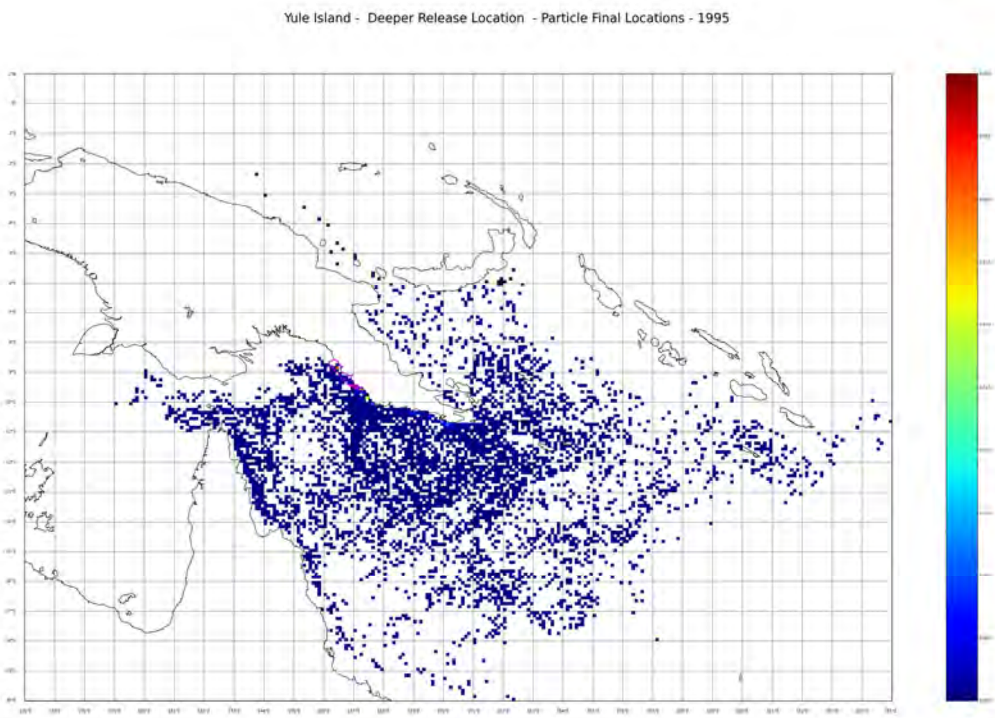


Princess Charlotte Bay - Deeper Release Location - Particle Final Locations - 2015

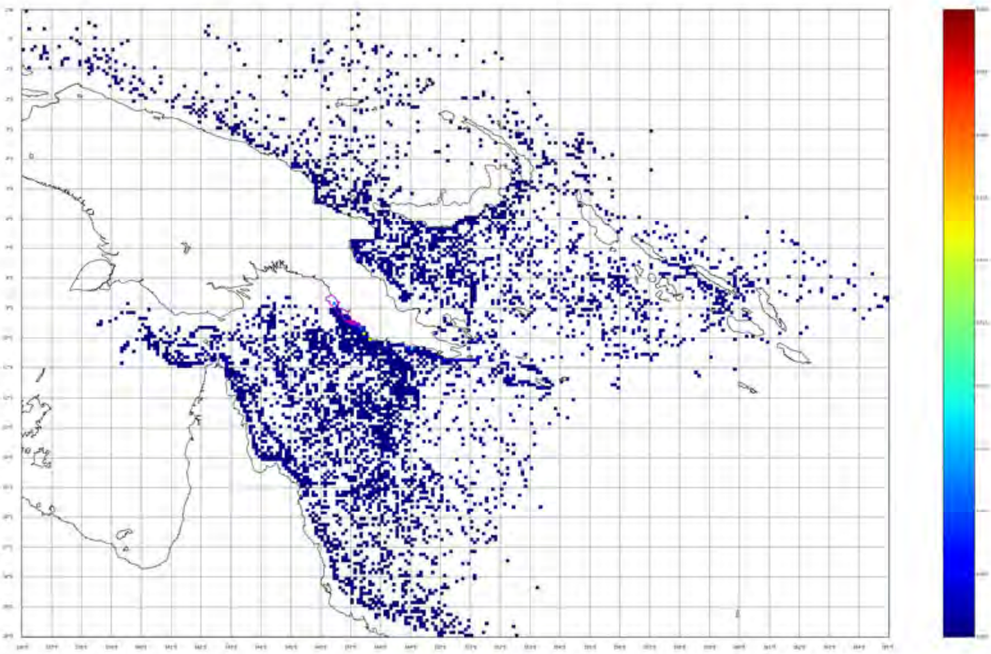


B.2 Final particle positions for particles released from Yule Island (1994 – 2015).

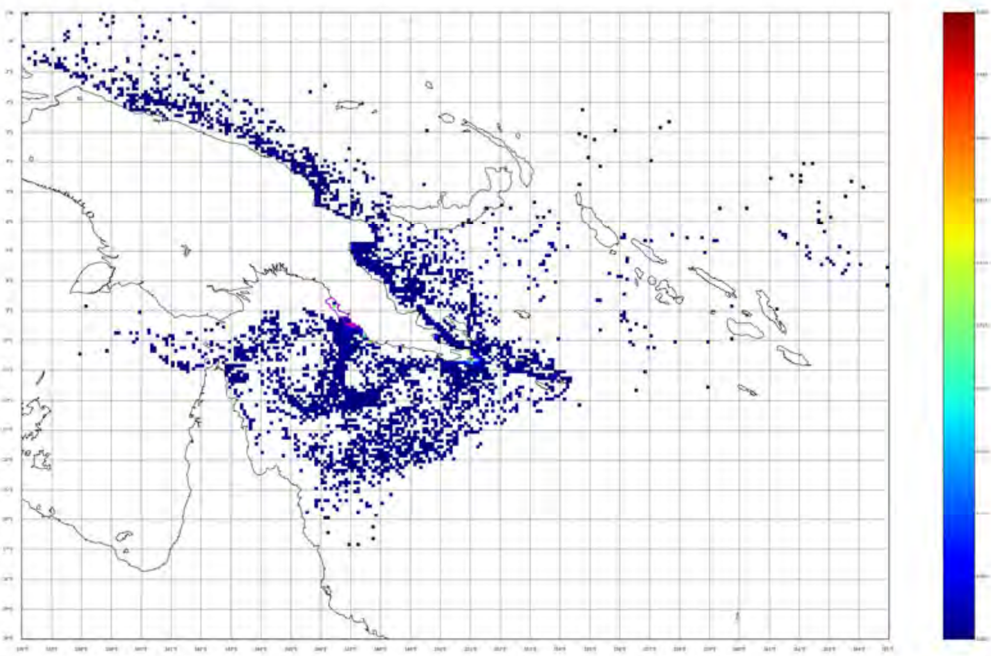




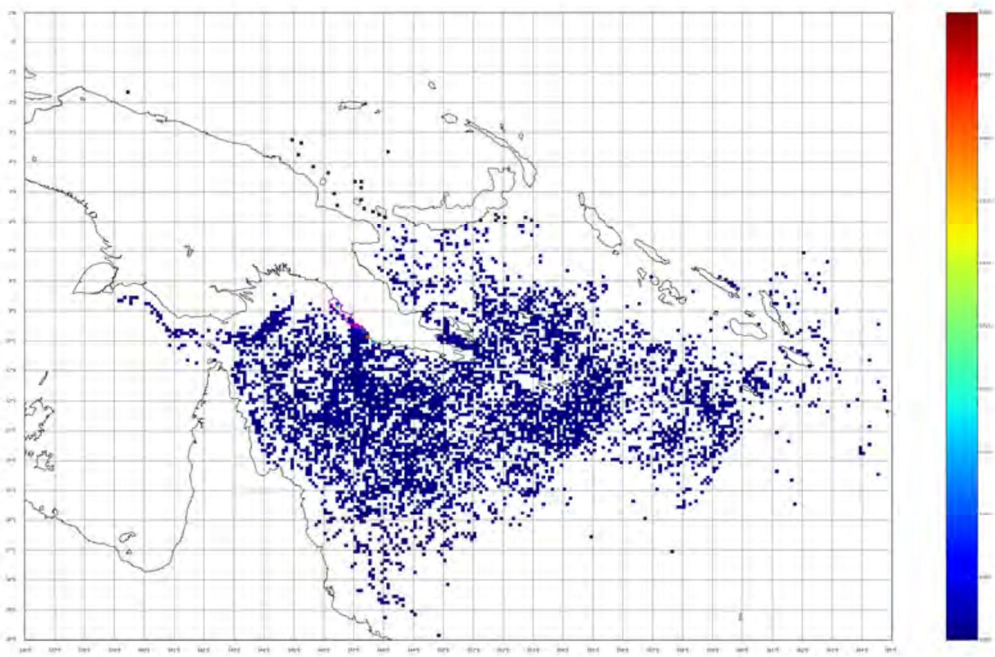
Yule Island - Deeper Release Location - Particle Final Locations - 1996



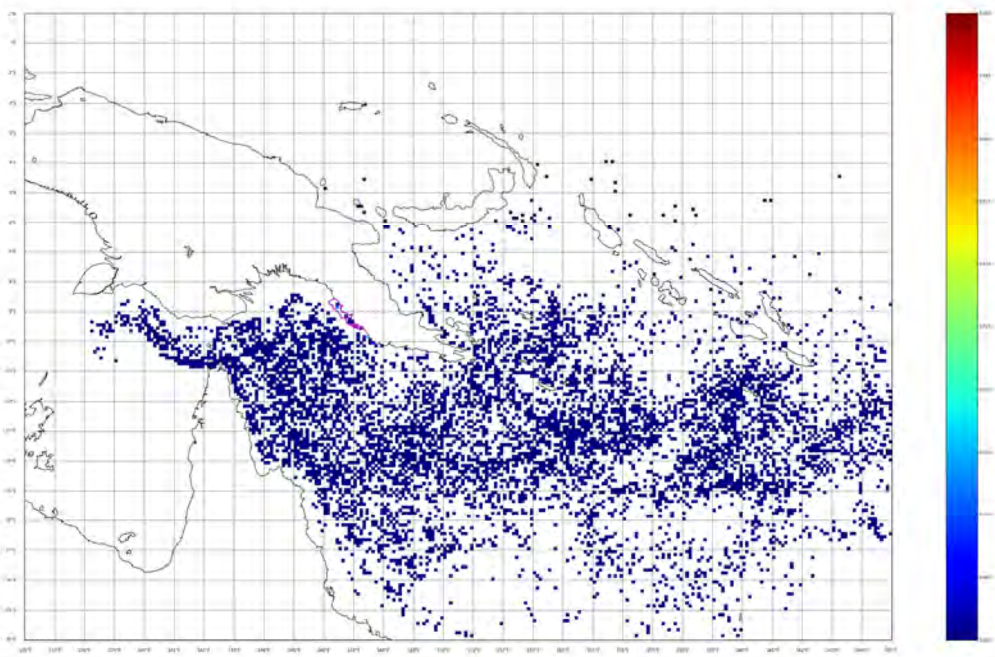
Yule Island - Deeper Release Location - Particle Final Locations - 1997

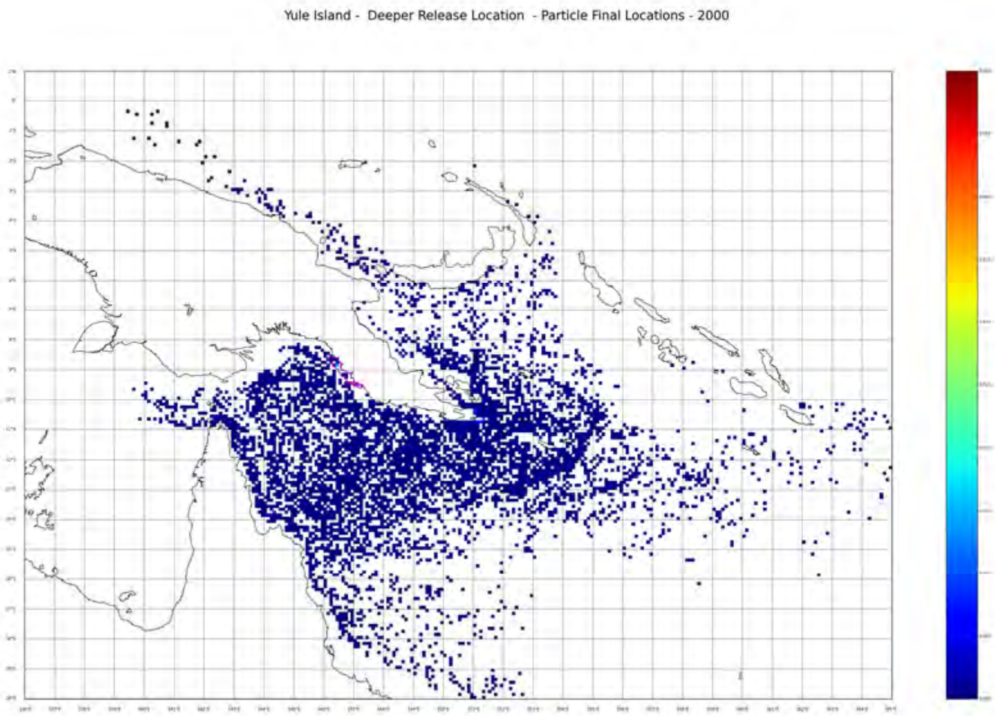


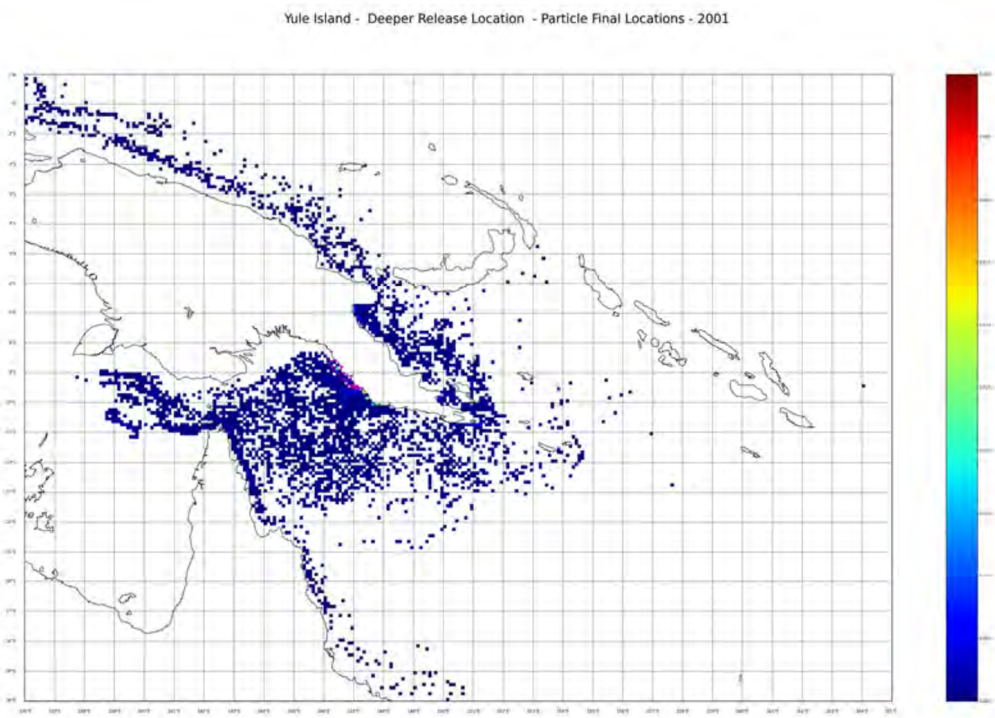
Yule Island - Deeper Release Location - Particle Final Locations - 1998



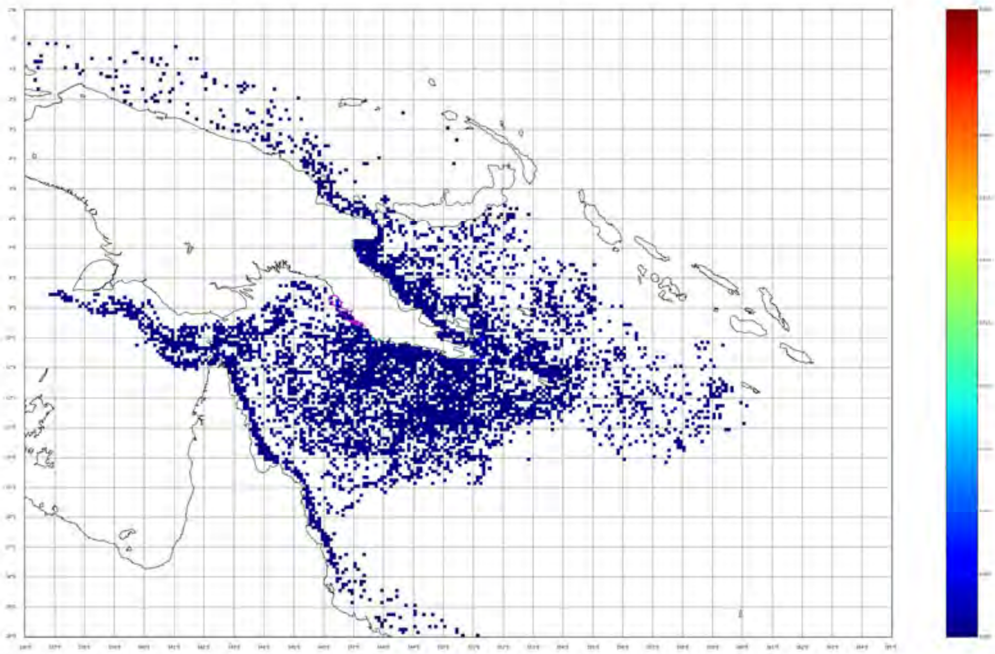
Yule Island - Deeper Release Location - Particle Final Locations - 1999



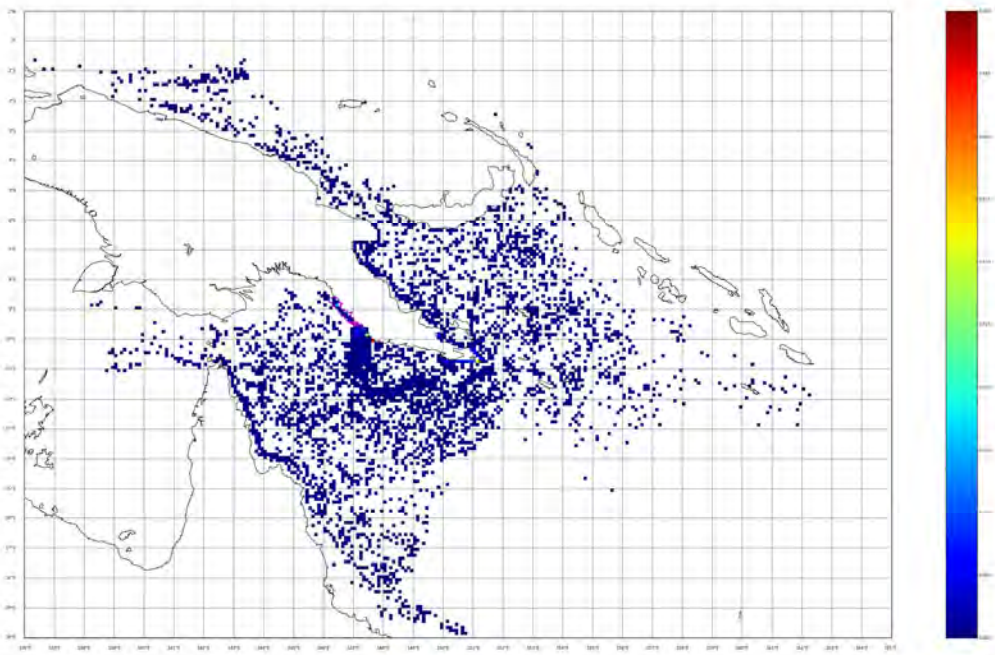

Yule Island - Deeper Release Location - Particle Final Locations - 2000


Yule Island - Deeper Release Location - Particle Final Locations - 2001

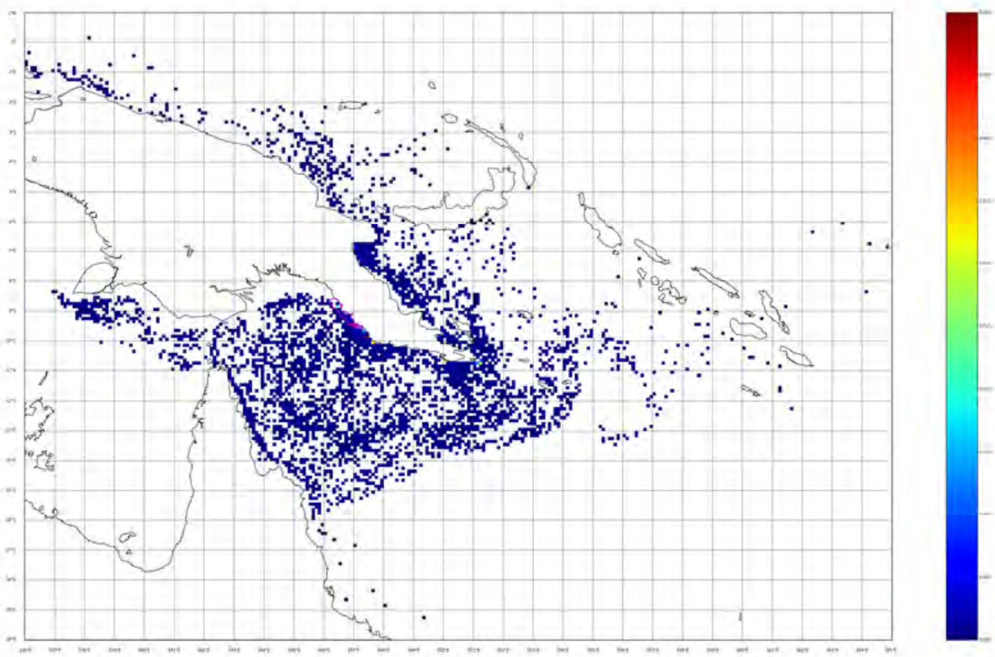
Yule Island - Deeper Release Location - Particle Final Locations - 2002



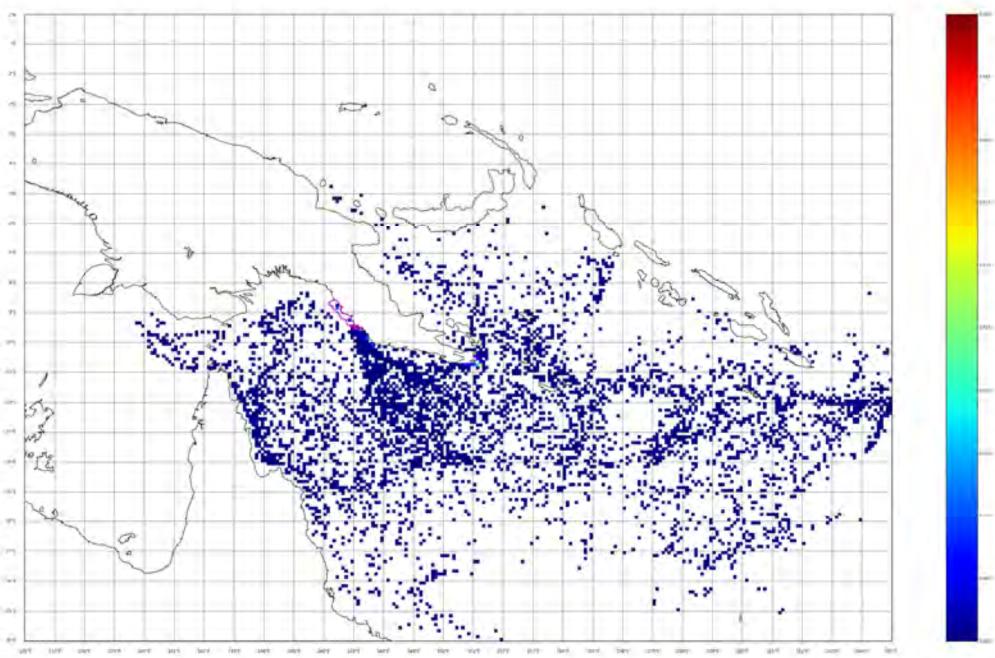
Yule Island - Deeper Release Location - Particle Final Locations - 2003



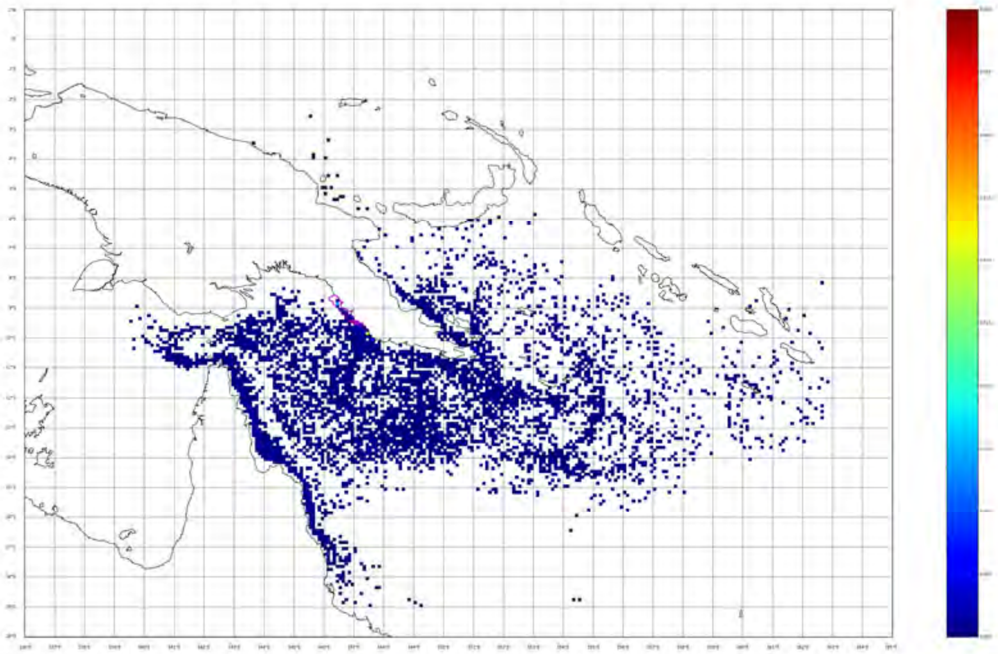
Yule Island - Deeper Release Location - Particle Final Locations - 2004



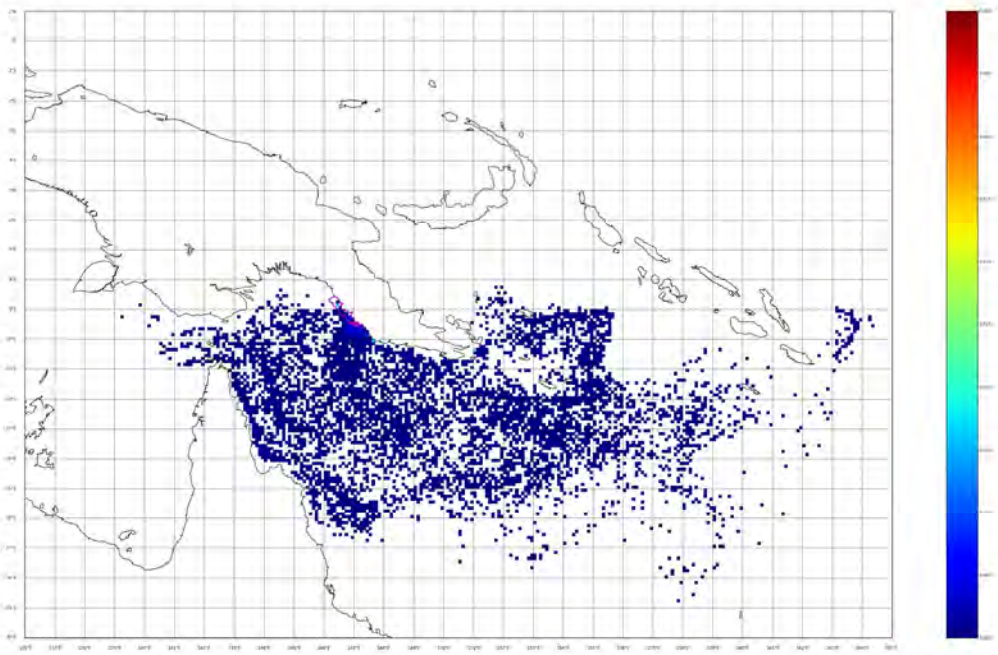
Yule Island - Deeper Release Location - Particle Final Locations - 2005



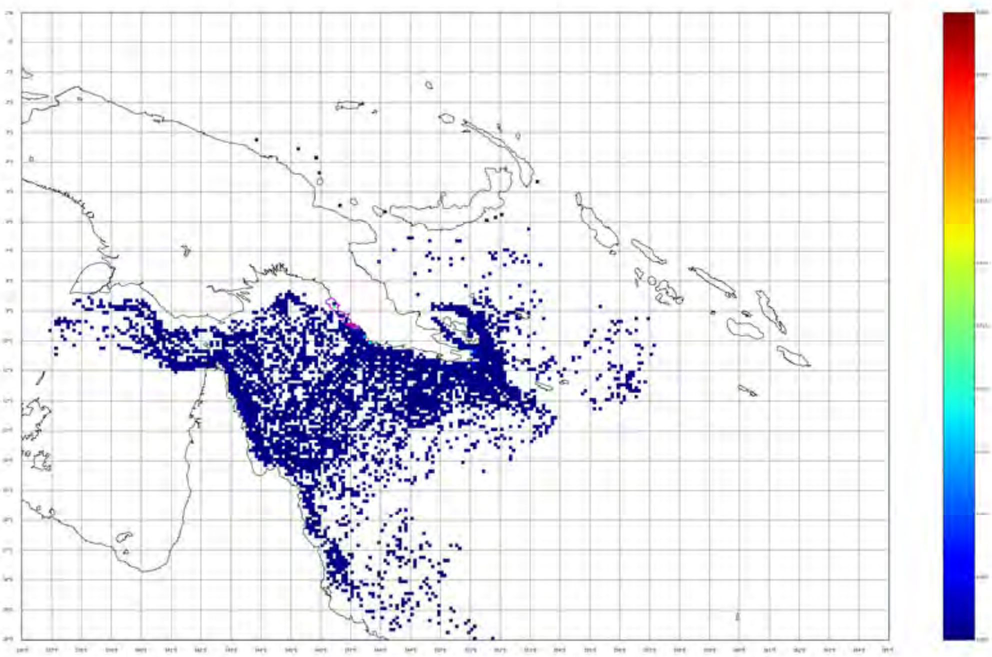
Yule Island - Deeper Release Location - Particle Final Locations - 2006



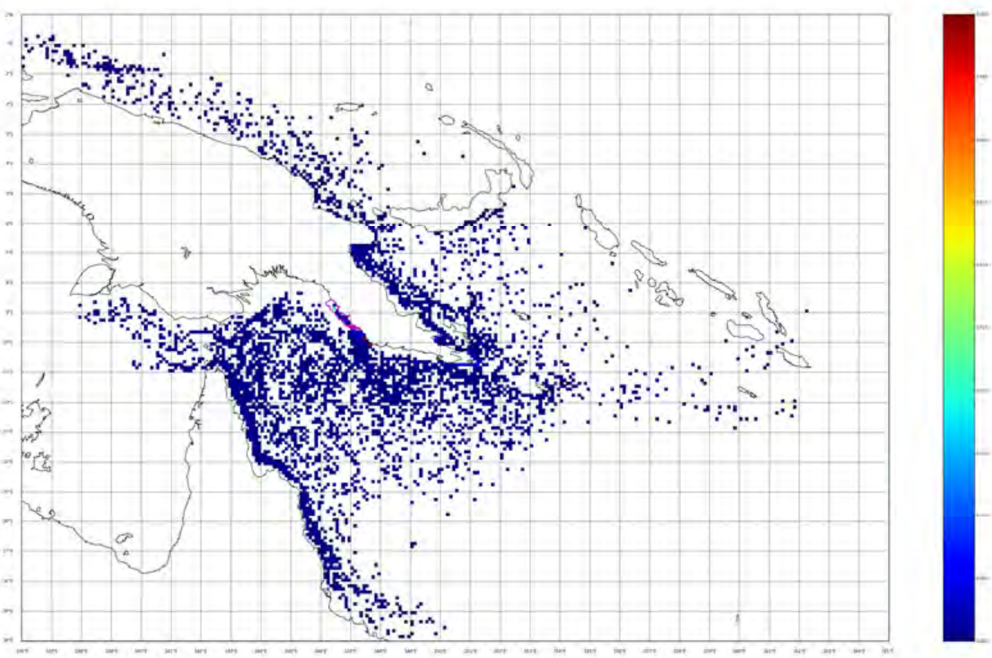
Yule Island - Deeper Release Location - Particle Final Locations - 2007



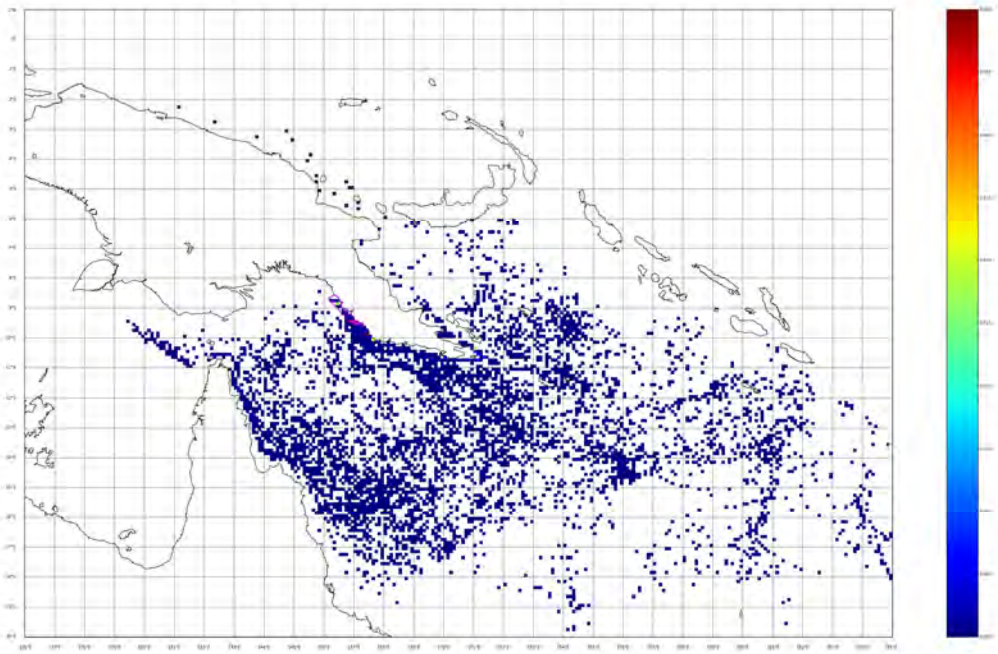
Yule Island - Deeper Release Location - Particle Final Locations - 2008



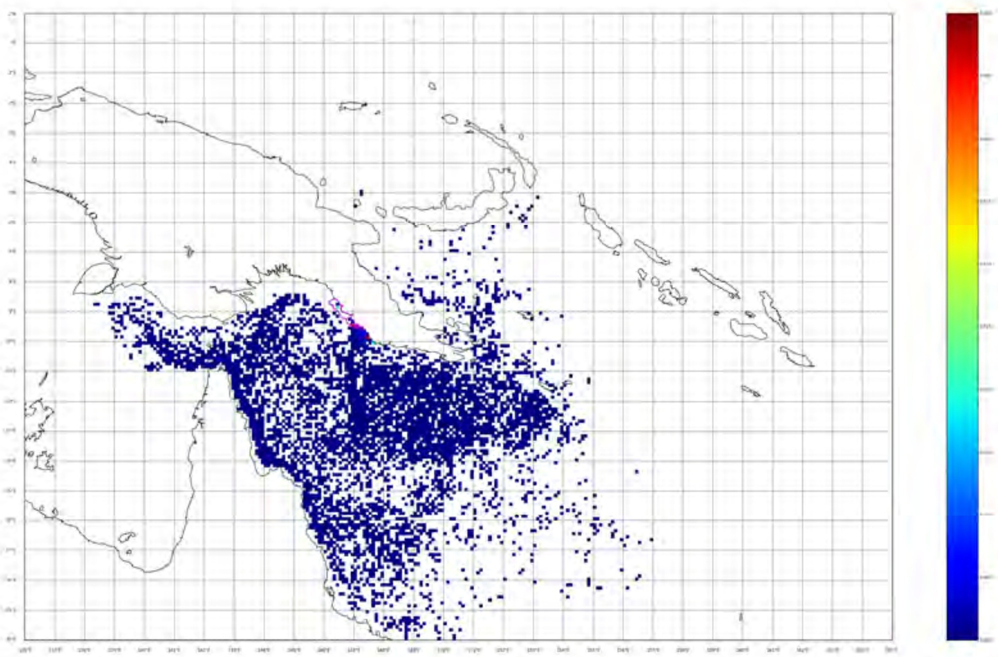
Yule Island - Deeper Release Location - Particle Final Locations - 2009



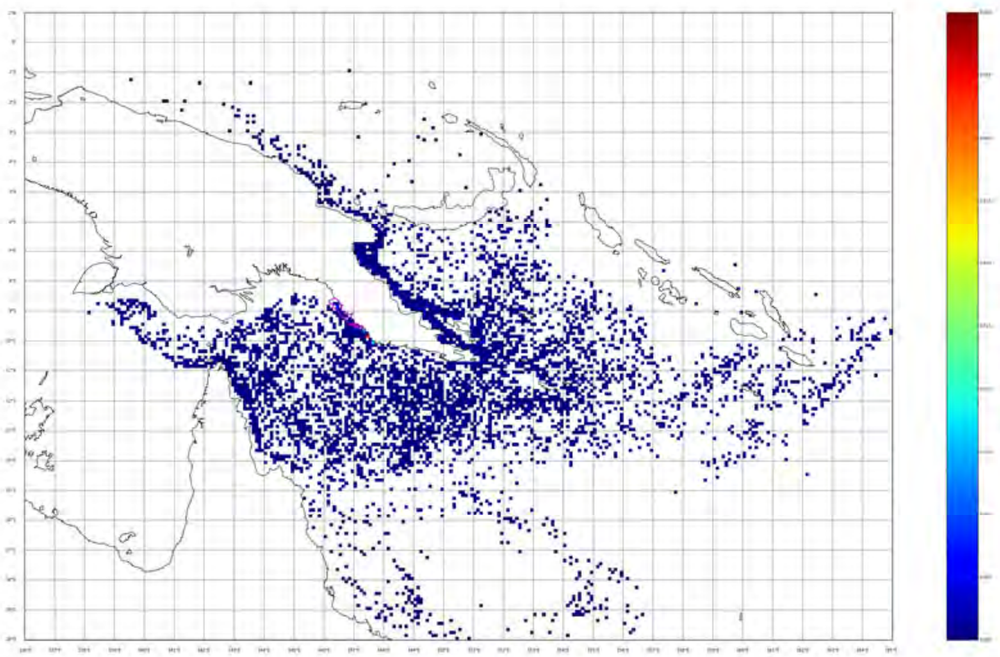
Yule Island - Deeper Release Location - Particle Final Locations - 2010



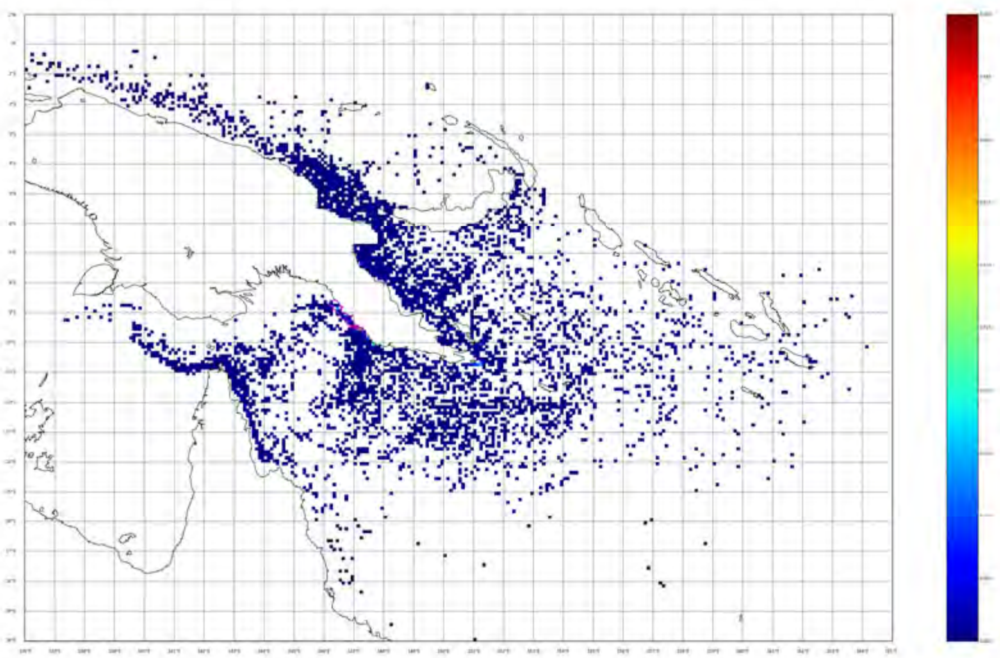
Yule Island - Deeper Release Location - Particle Final Locations - 2011



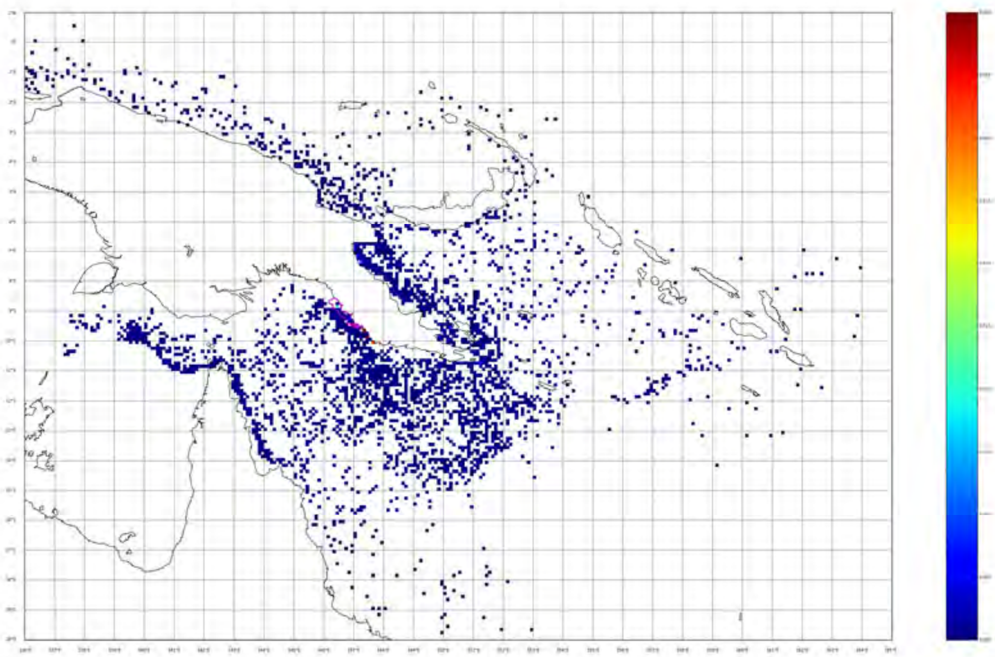
Yule Island - Deeper Release Location - Particle Final Locations - 2012



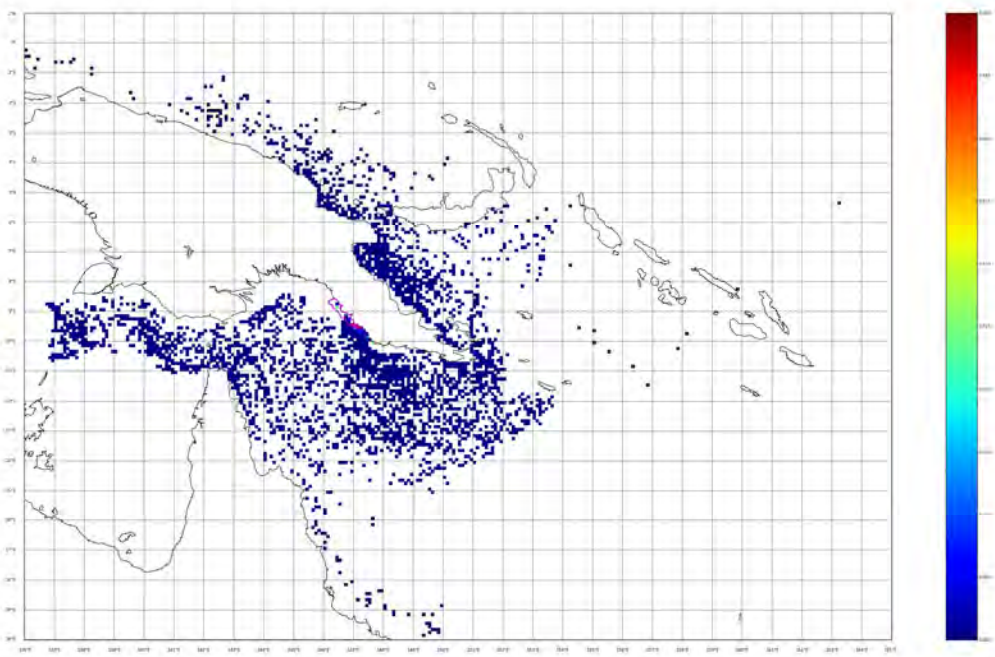
Yule Island - Deeper Release Location - Particle Final Locations - 2013



Yule Island - Deeper Release Location - Particle Final Locations - 2014



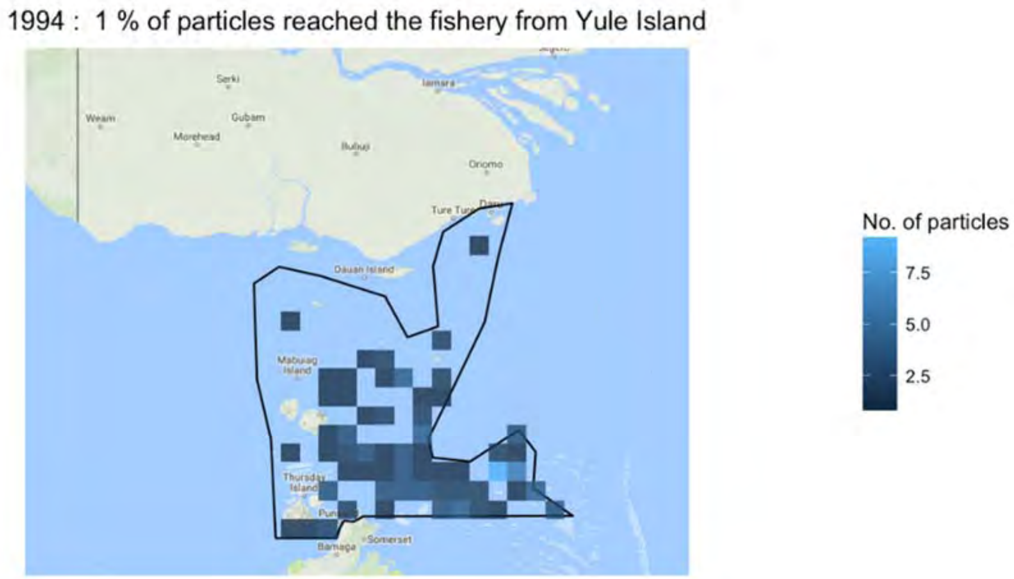
Yule Island - Deeper Release Location - Particle Final Locations - 2015



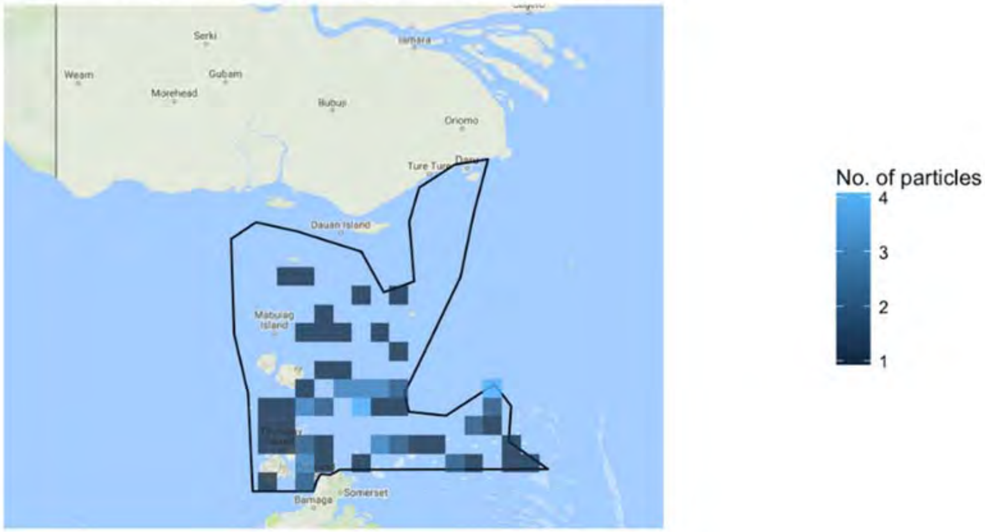
B.3 Percentage of particles settling within the Torres Strait fishing zone

These plots show the percentage of the total number of particles released (9600) at each of two release sites (Yule Island and Princess Charlotte Bay) that settled within the Torres Strait fishing zone following 6 months in the plankton.

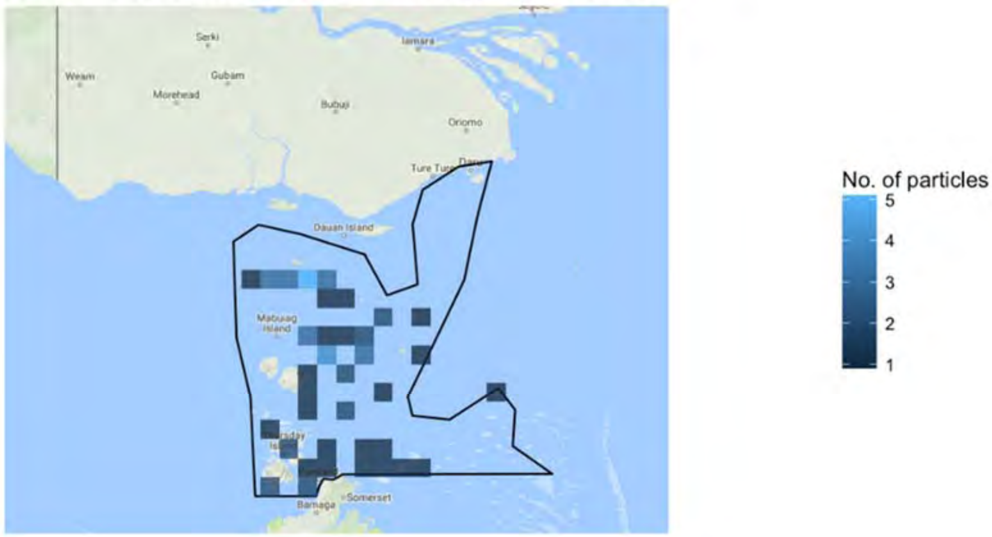
Release area: Yule Island



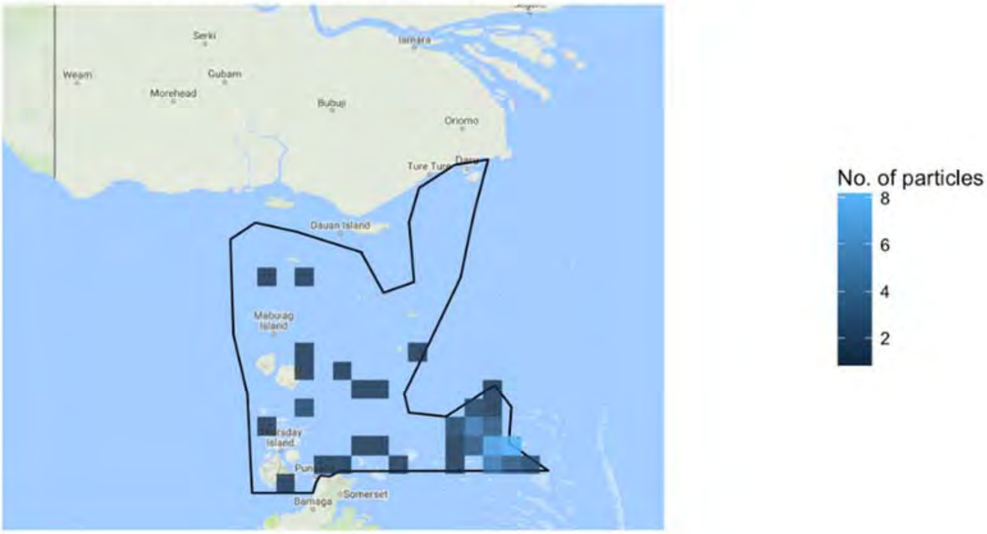
1995 : 1 % of particles reached the fishery from Yule Island



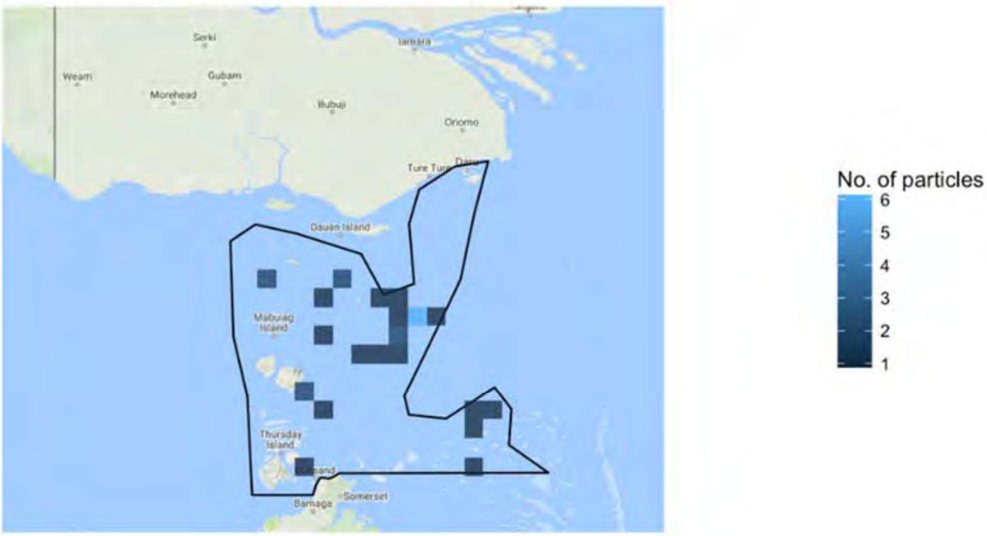
1996 : 1 % of particles reached the fishery from Yule Island



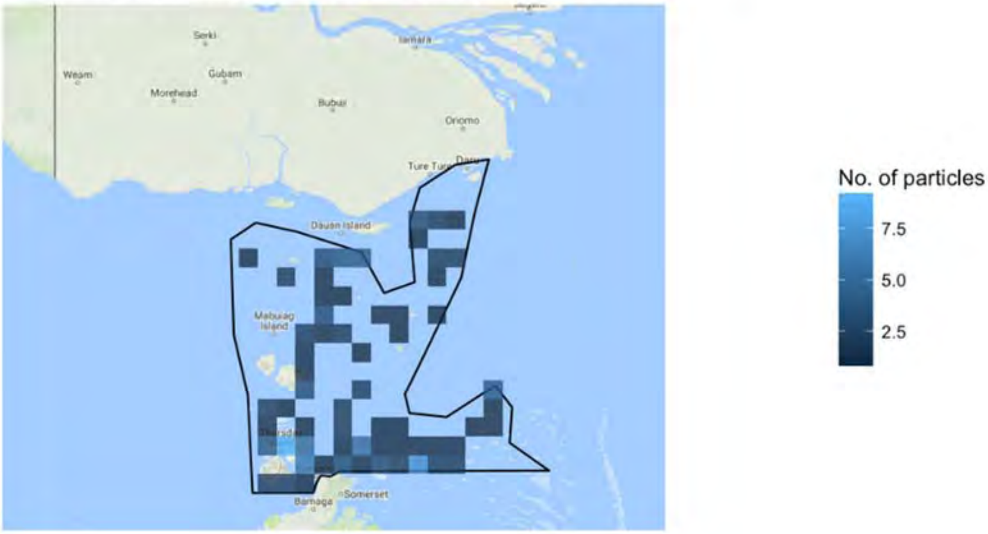
1997 : 1 % of particles reached the fishery from Yule Island



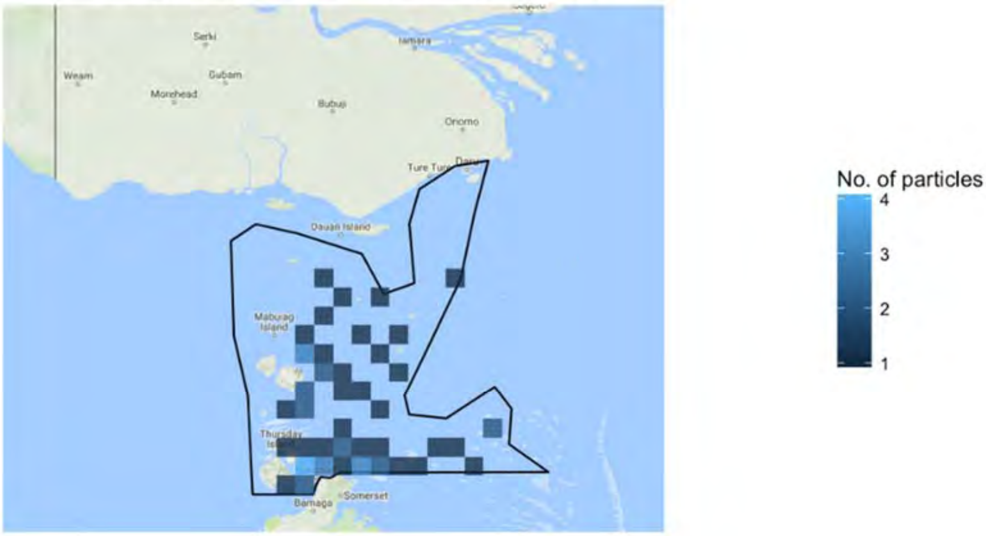
1998 : 0 % of particles reached the fishery from Yule Island



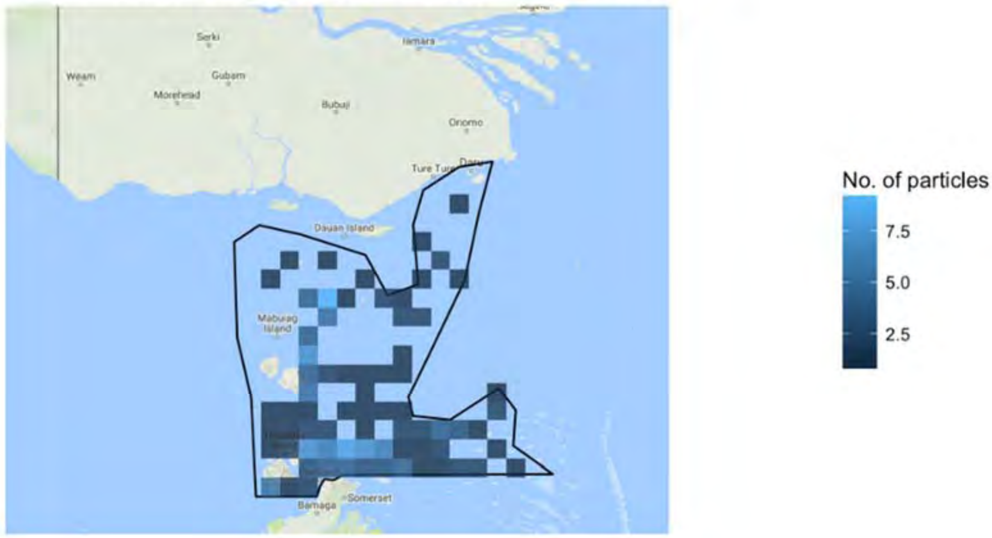
1999 : 1 % of particles reached the fishery from Yule Island



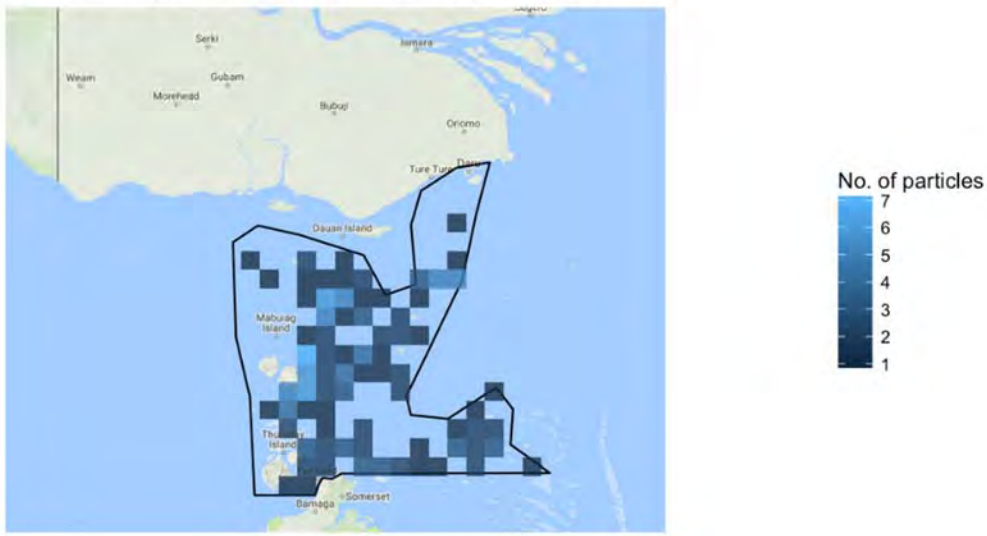
2000 : 1 % of particles reached the fishery from Yule Island



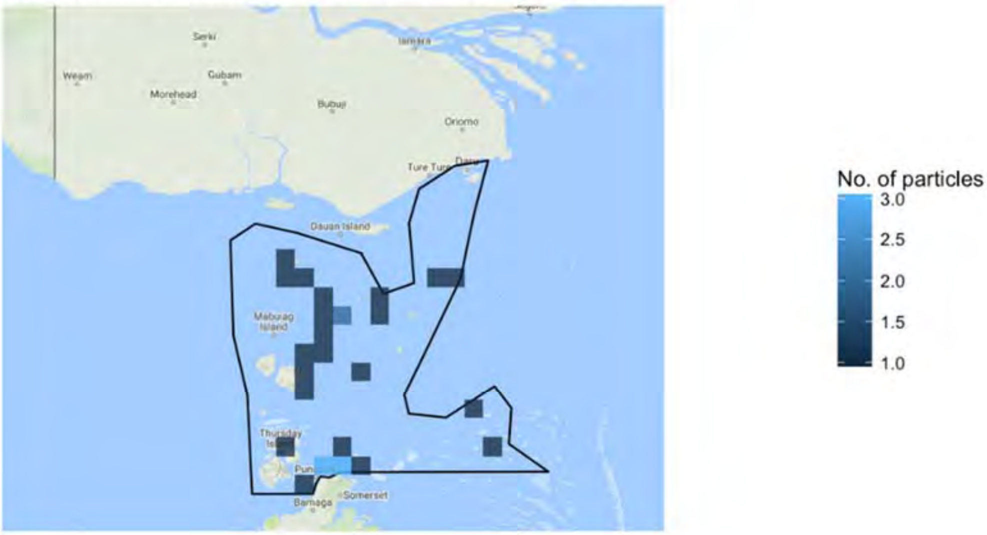
2001 : 2 % of particles reached the fishery from Yule Island



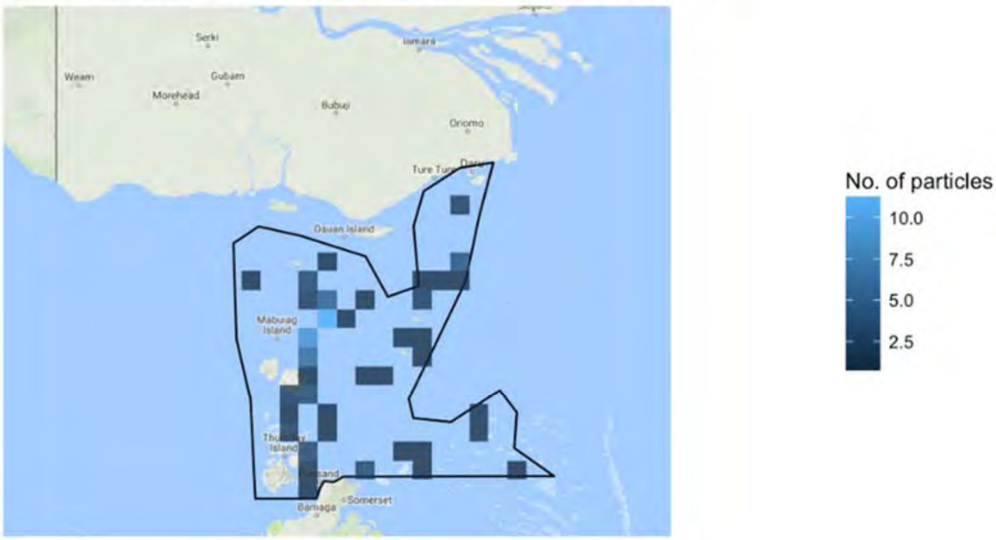
2002 : 2 % of particles reached the fishery from Yule Island



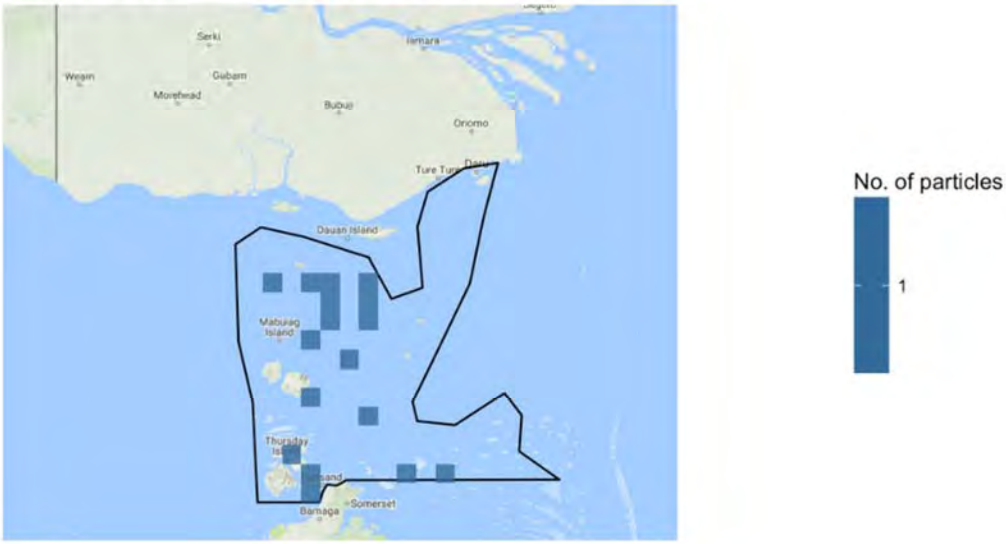
2003 : 0 % of particles reached the fishery from Yule Island



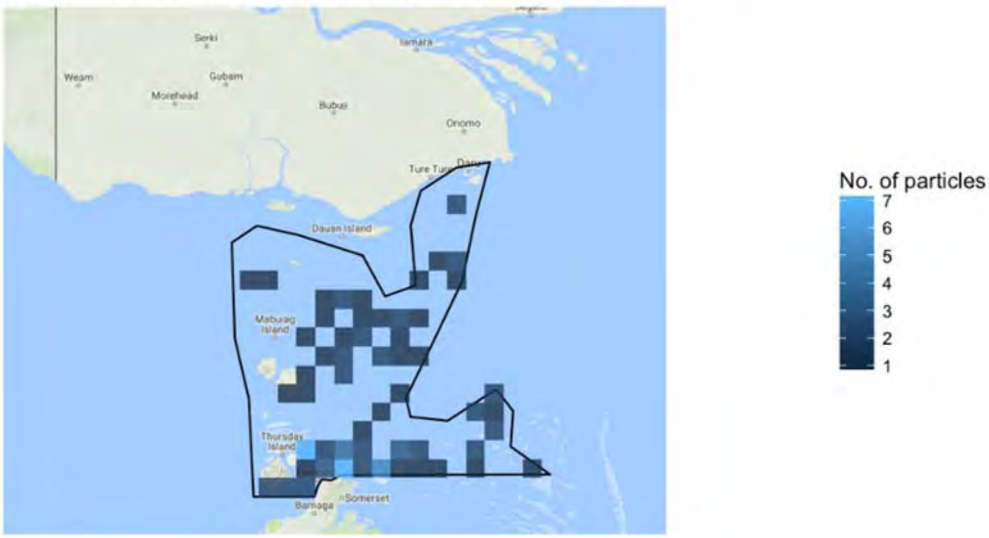
2004 : 1 % of particles reached the fishery from Yule Island



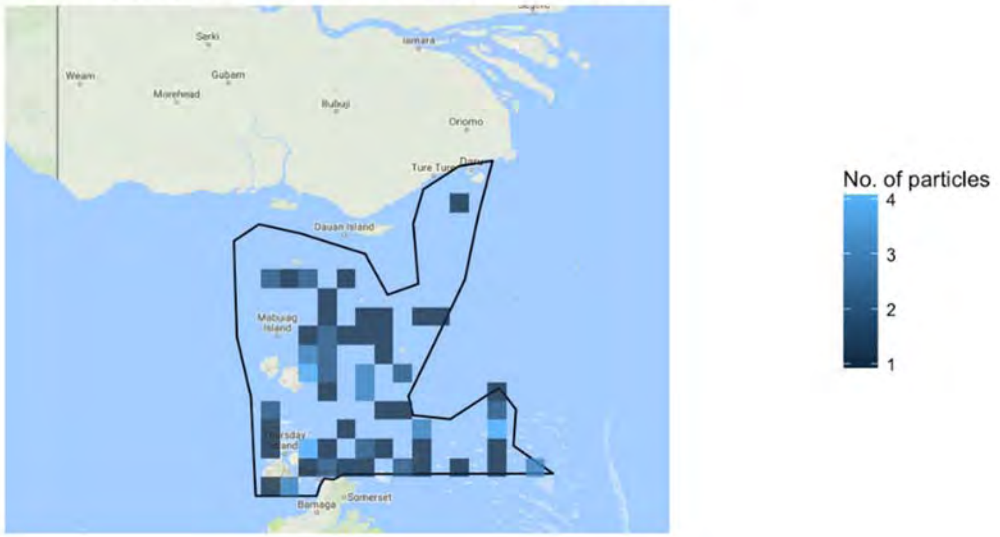
2005 : 0 % of particles reached the fishery from Yule Island



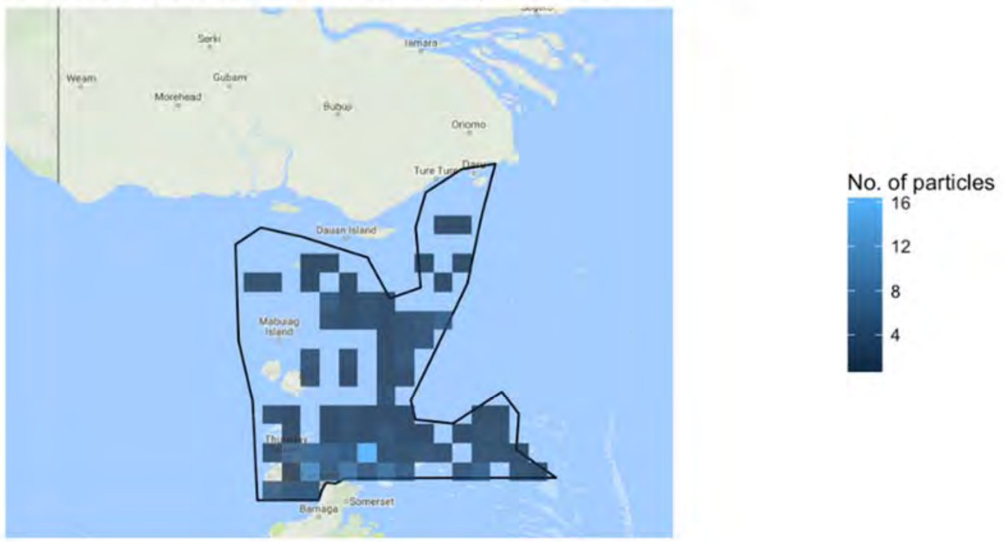
2006 : 1 % of particles reached the fishery from Yule Island



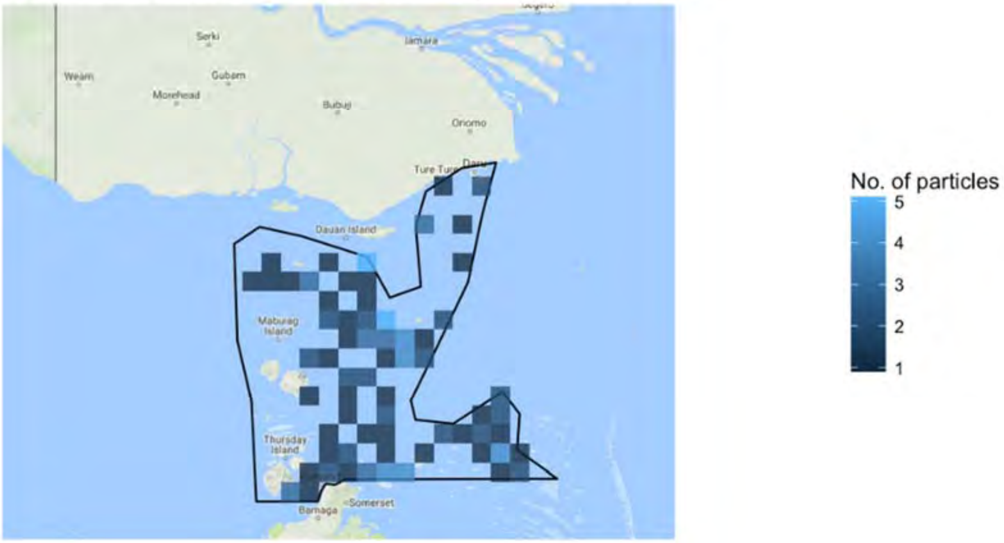
2007 : 1 % of particles reached the fishery from Yule Island



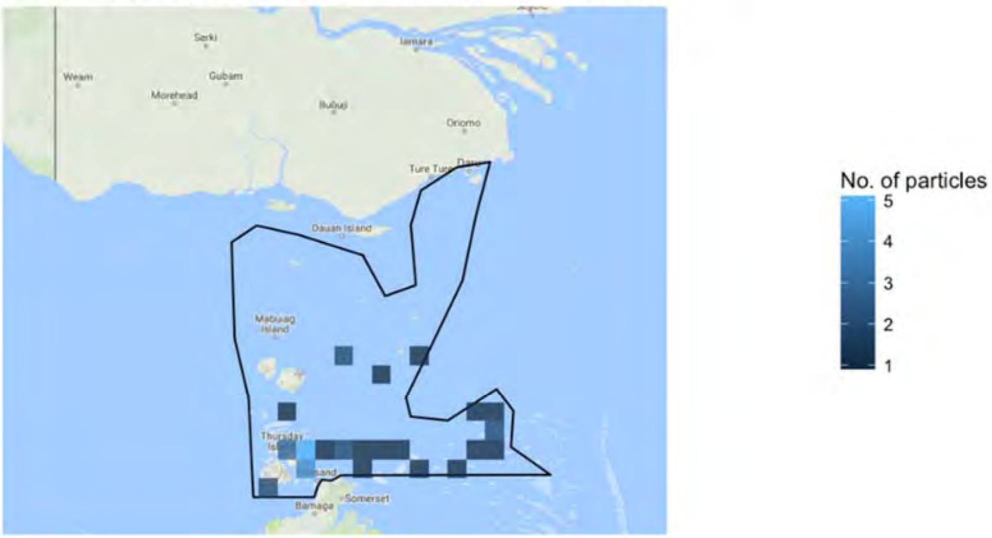
2008 : 2 % of particles reached the fishery from Yule Island



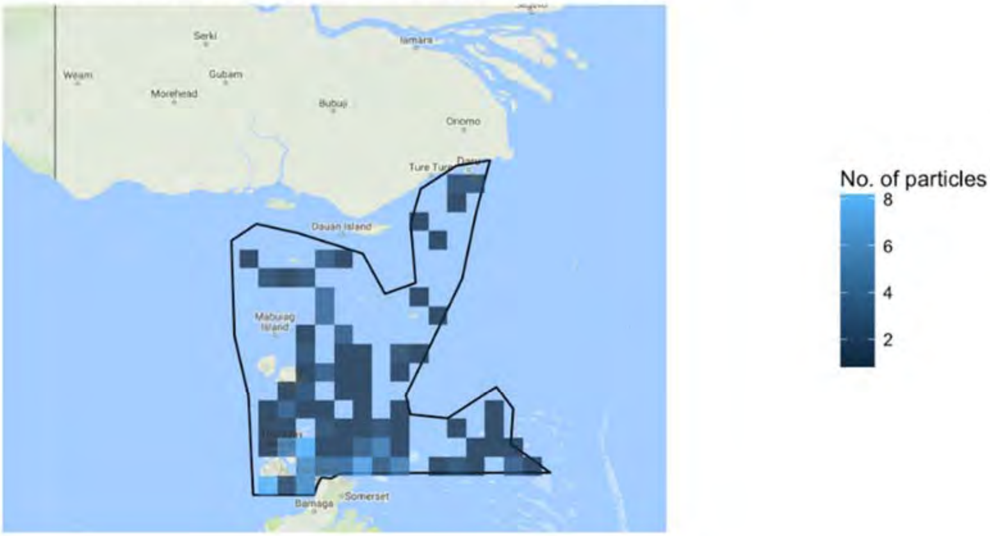
2009 : 1 % of particles reached the fishery from Yule Island



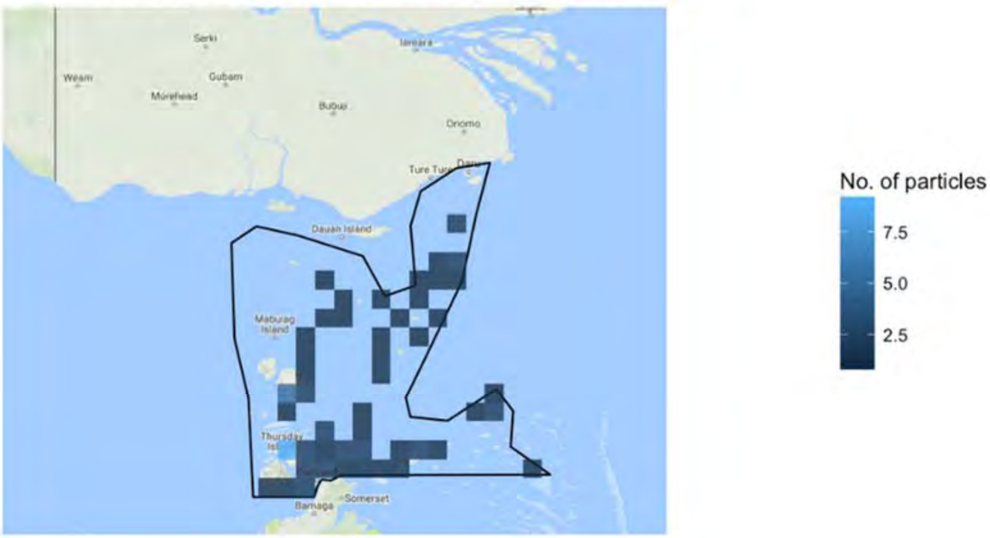
2010 : 0 % of particles reached the fishery from Yule Island



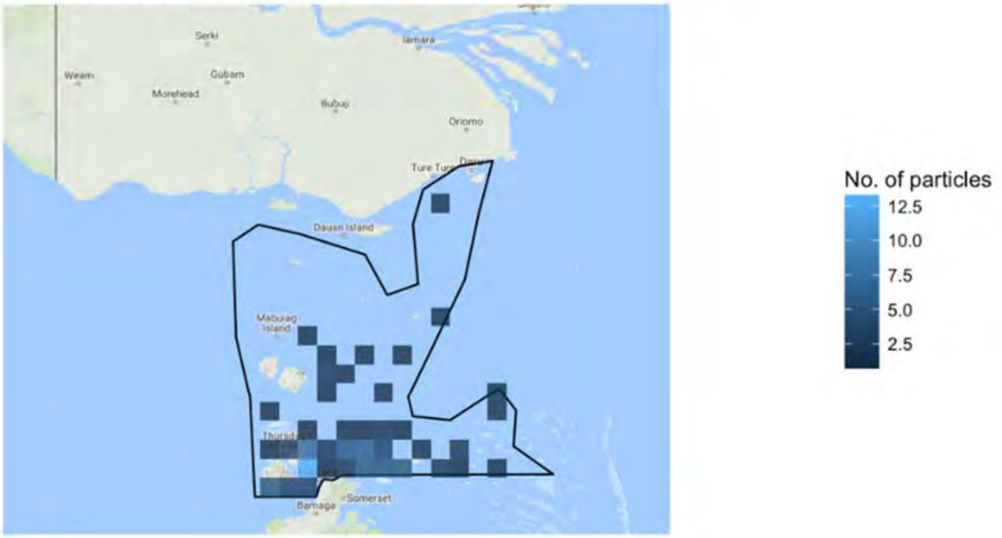
2011 : 2 % of particles reached the fishery from Yule Island



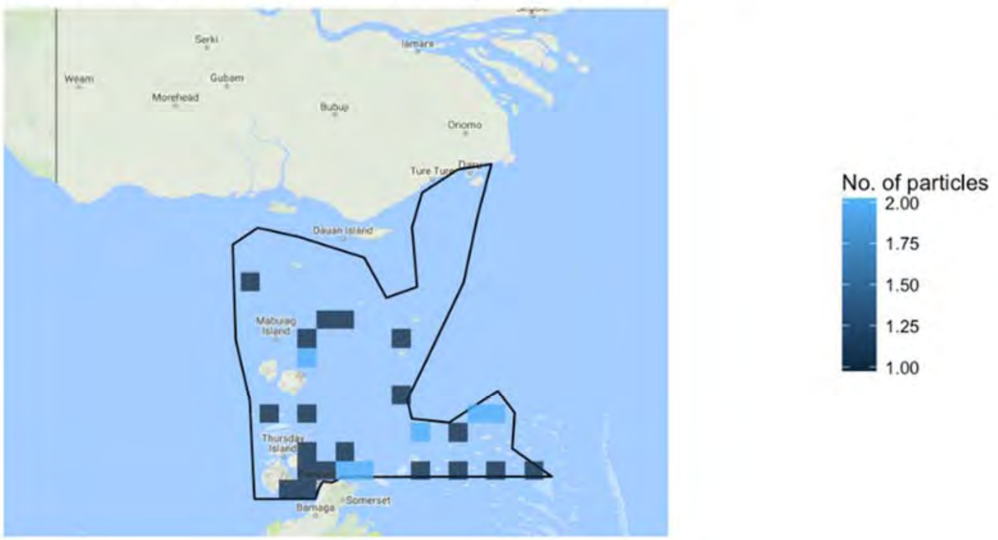
2012 : 1 % of particles reached the fishery from Yule Island



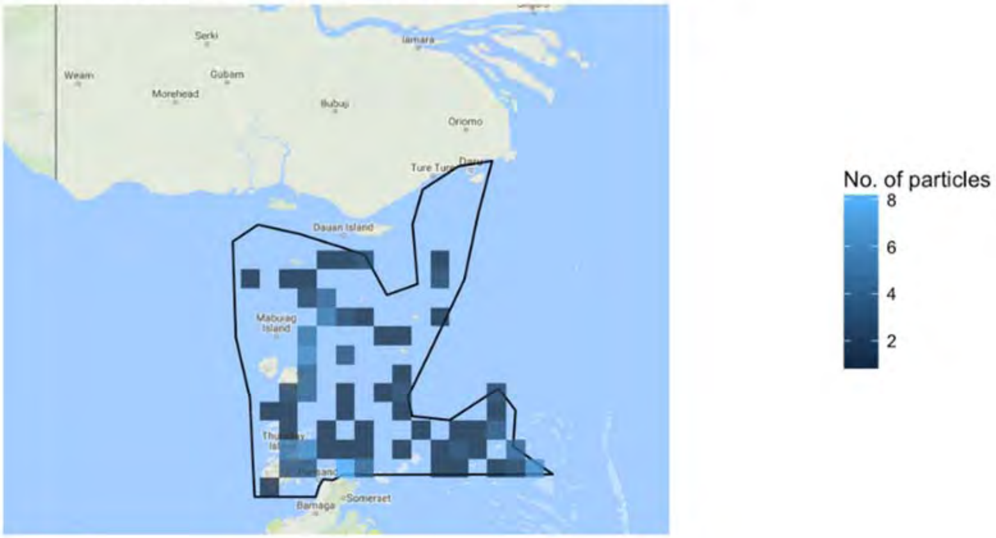
2013 : 1 % of particles reached the fishery from Yule Island



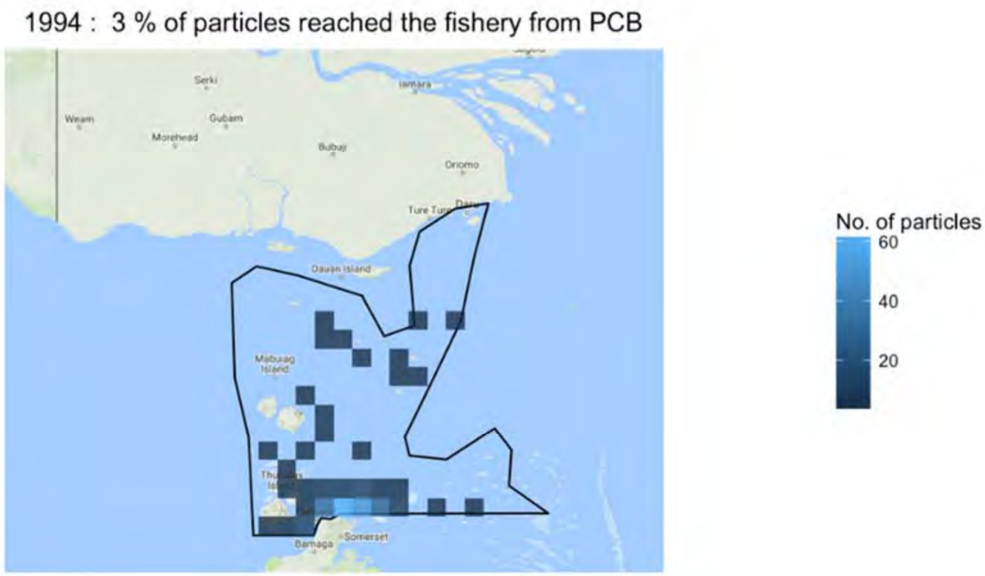
2014 : 0 % of particles reached the fishery from Yule Island

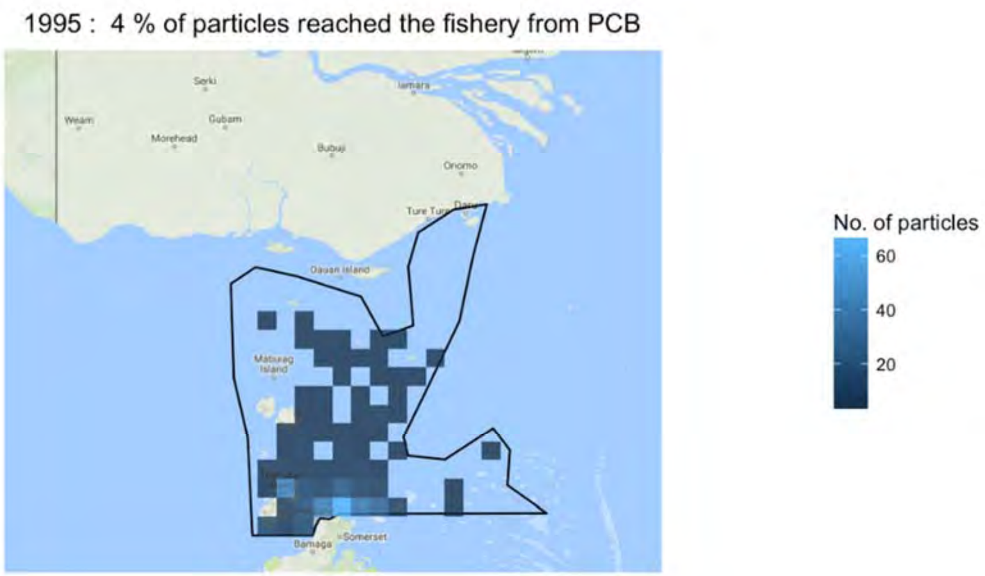


2015 : 1 % of particles reached the fishery from Yule Island

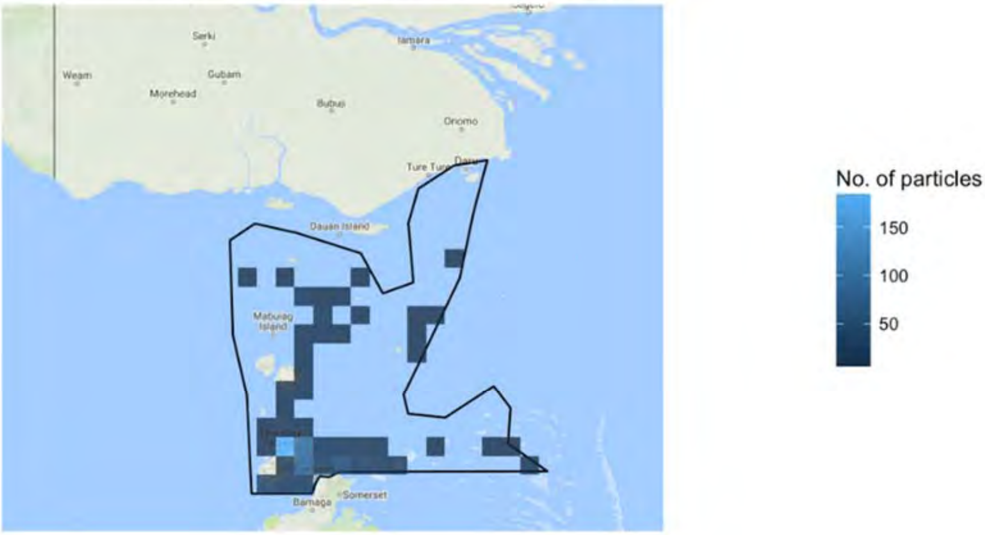


Release area: Princess Charlotte Bay

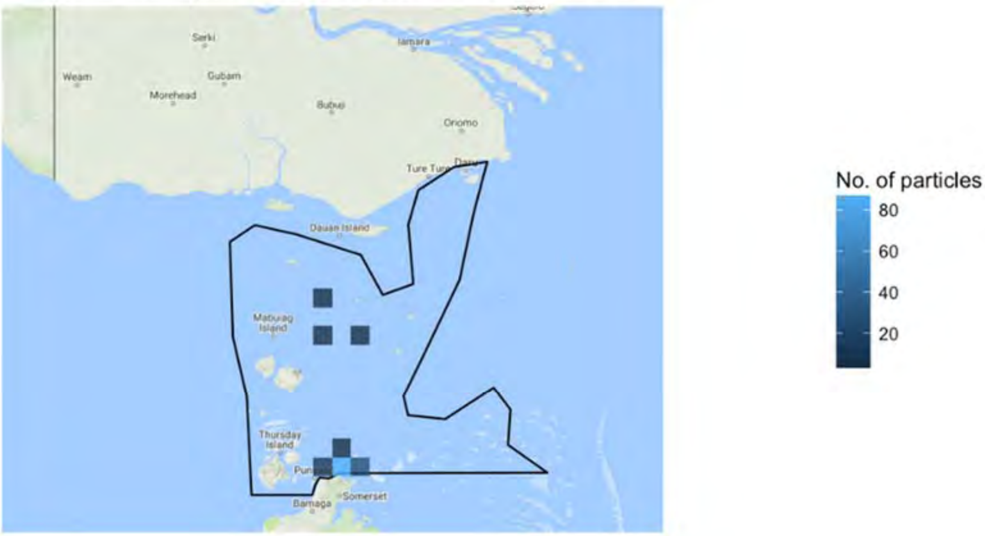




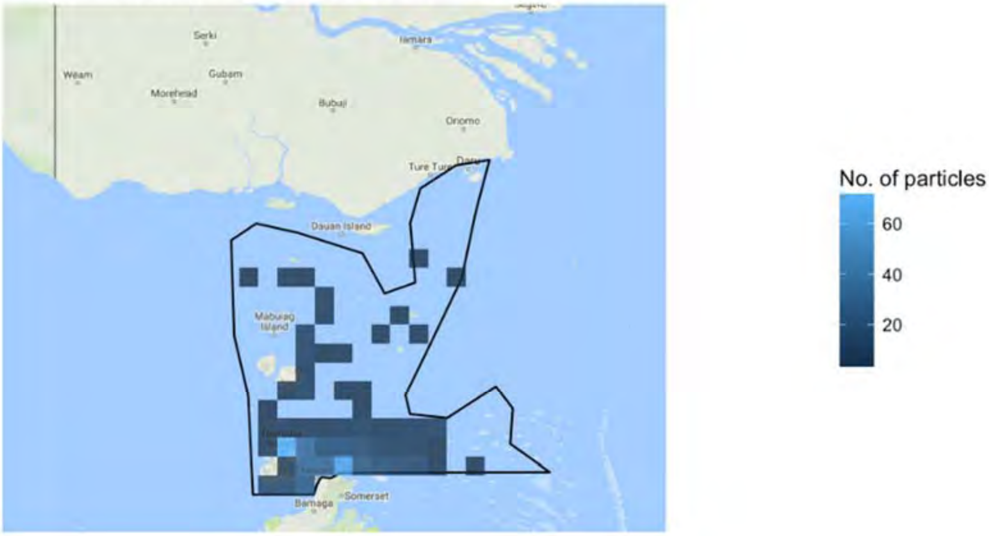
1996 : 7 % of particles reached the fishery from PCB



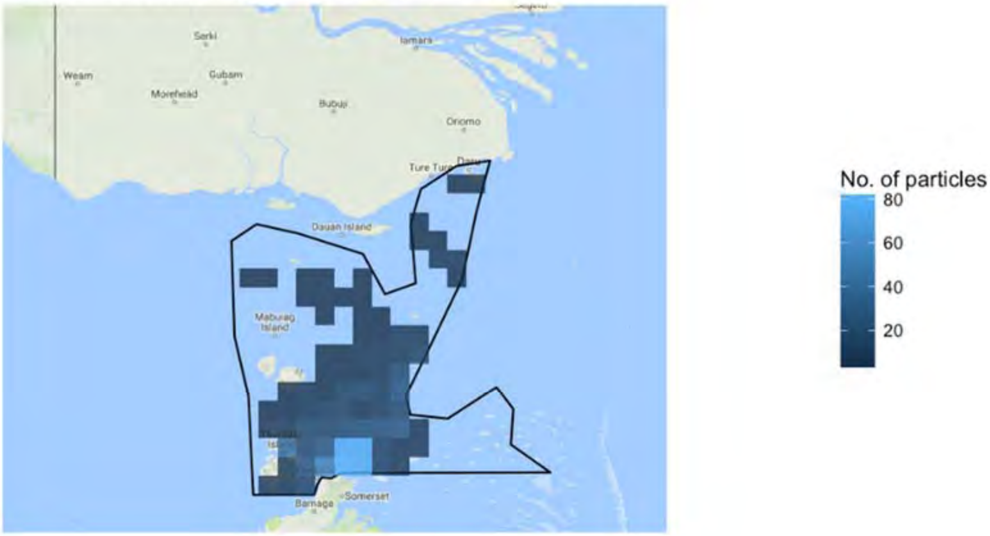
1997 : 1 % of particles reached the fishery from PCB



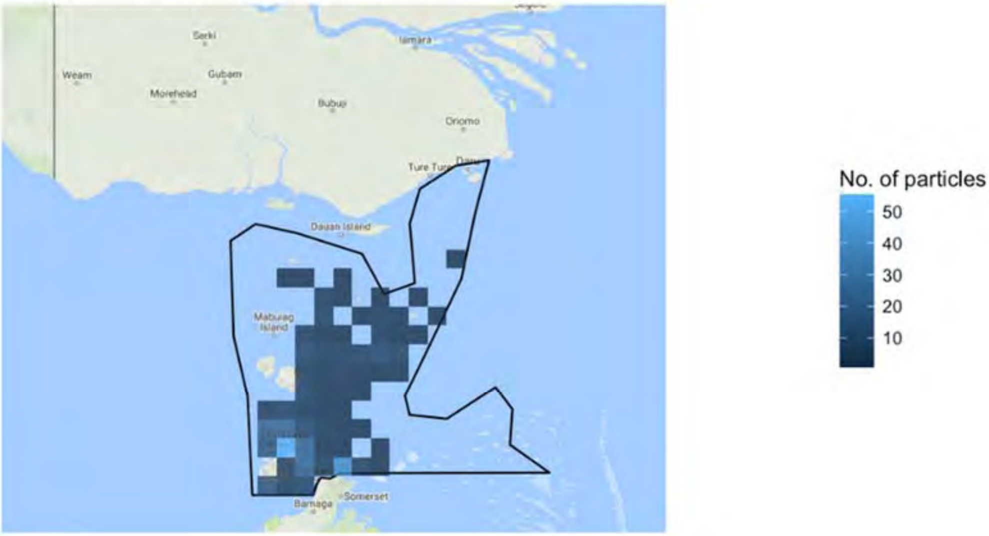
1998 : 5 % of particles reached the fishery from PCB



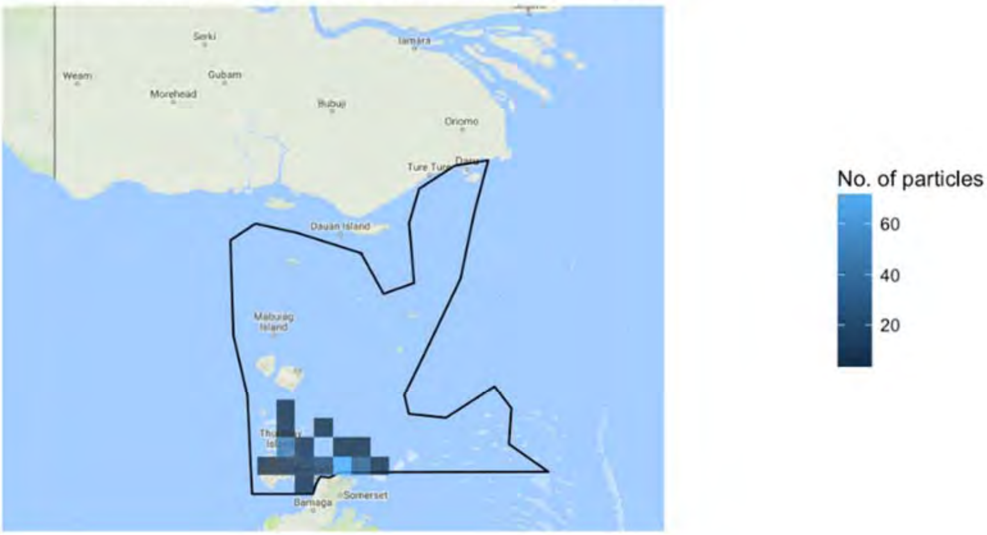
1999 : 9 % of particles reached the fishery from PCB



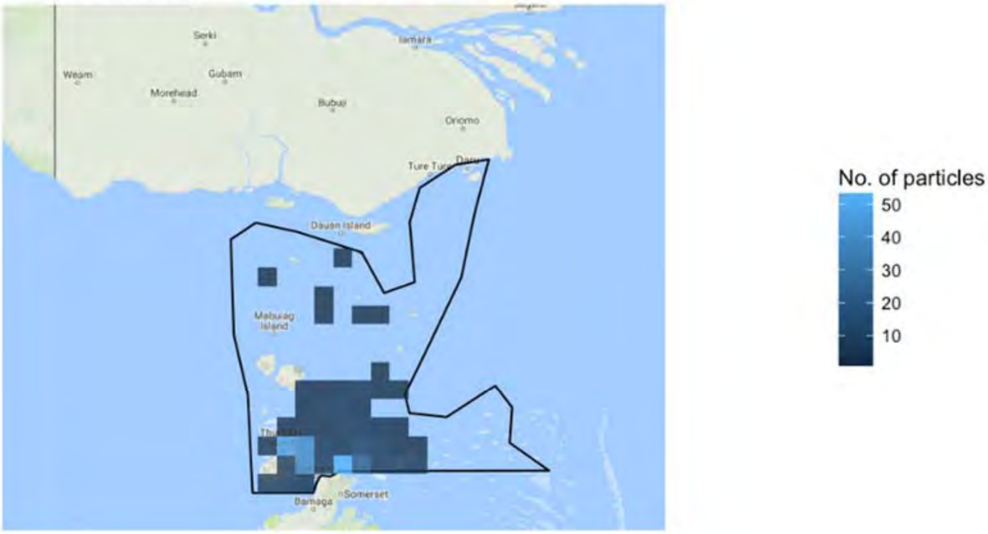
2000 : 4 % of particles reached the fishery from PCB



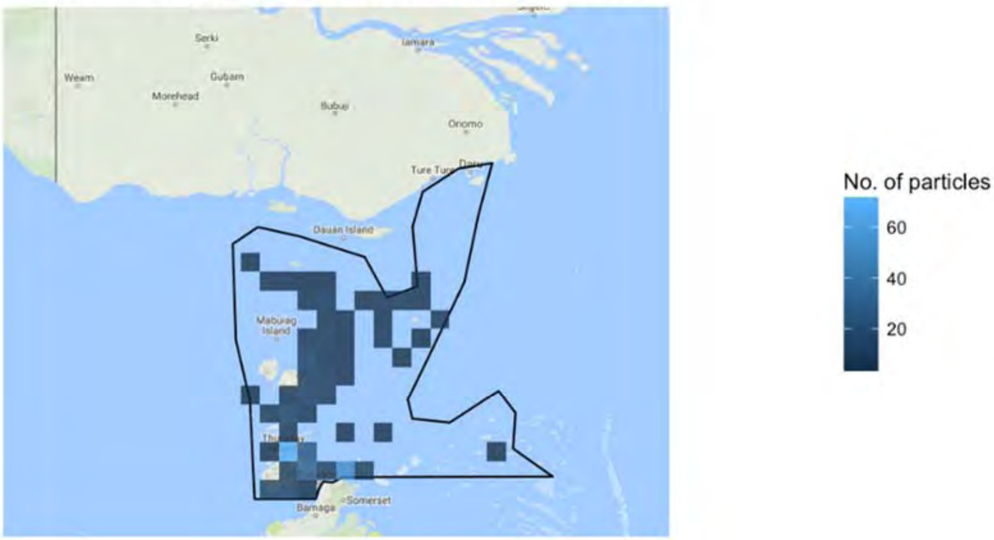
2001 : 2 % of particles reached the fishery from PCB



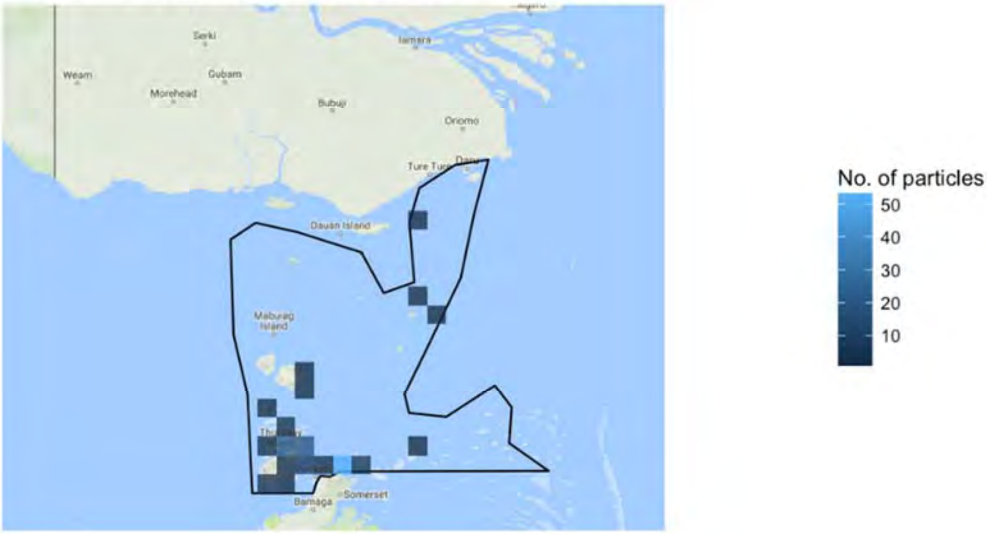
2002 : 3 % of particles reached the fishery from PCB



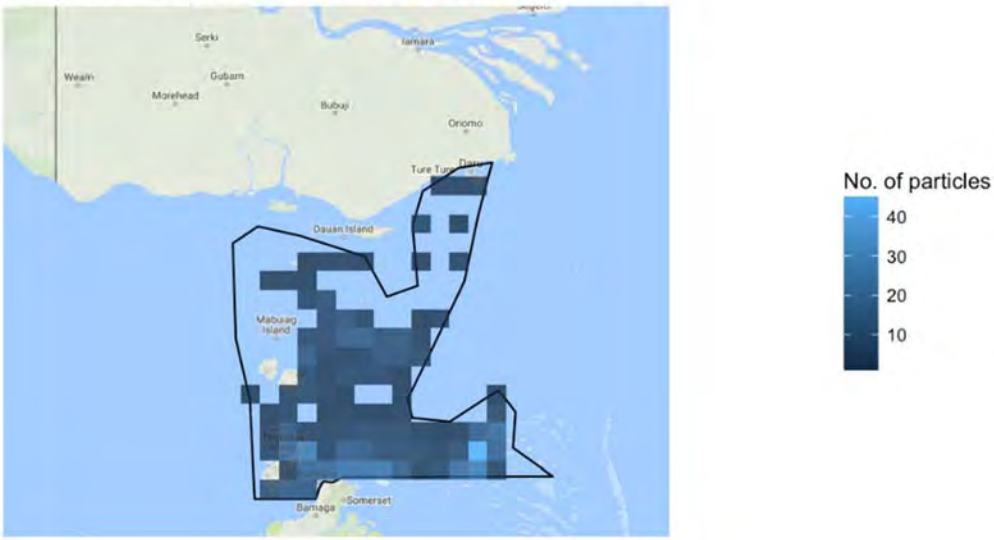
2003 : 4 % of particles reached the fishery from PCB



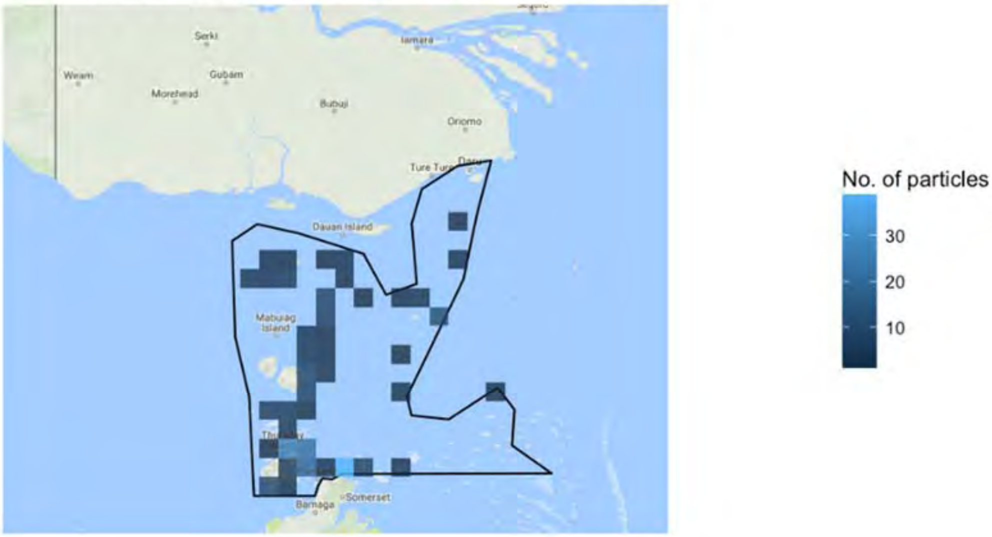
2004 : 1 % of particles reached the fishery from PCB



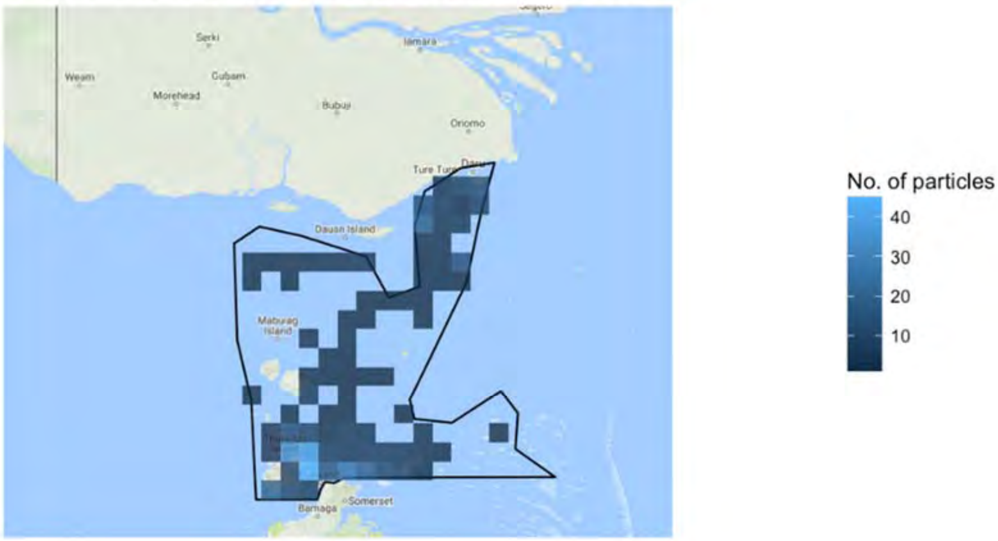
2005 : 8 % of particles reached the fishery from PCB



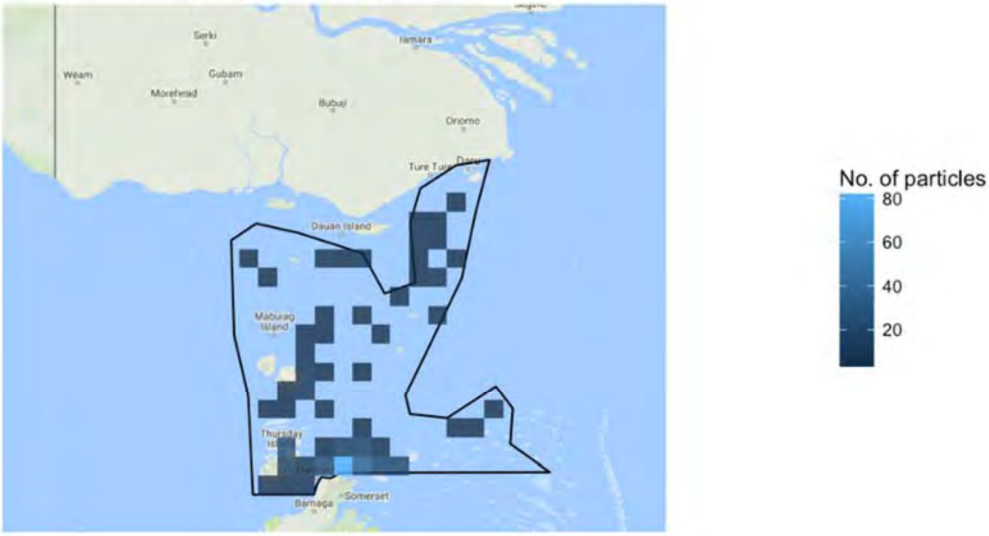
2006 : 2 % of particles reached the fishery from PCB



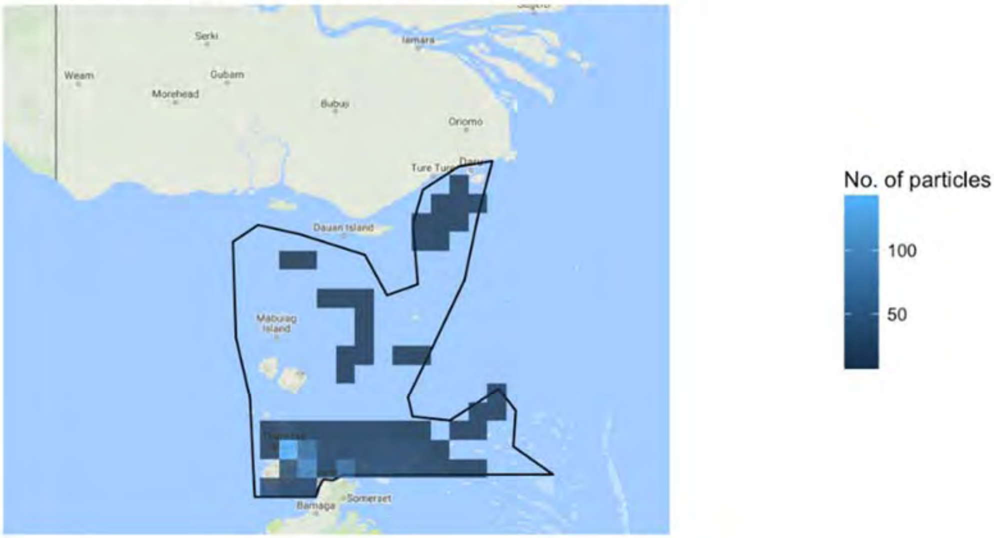
2007 : 5 % of particles reached the fishery from PCB



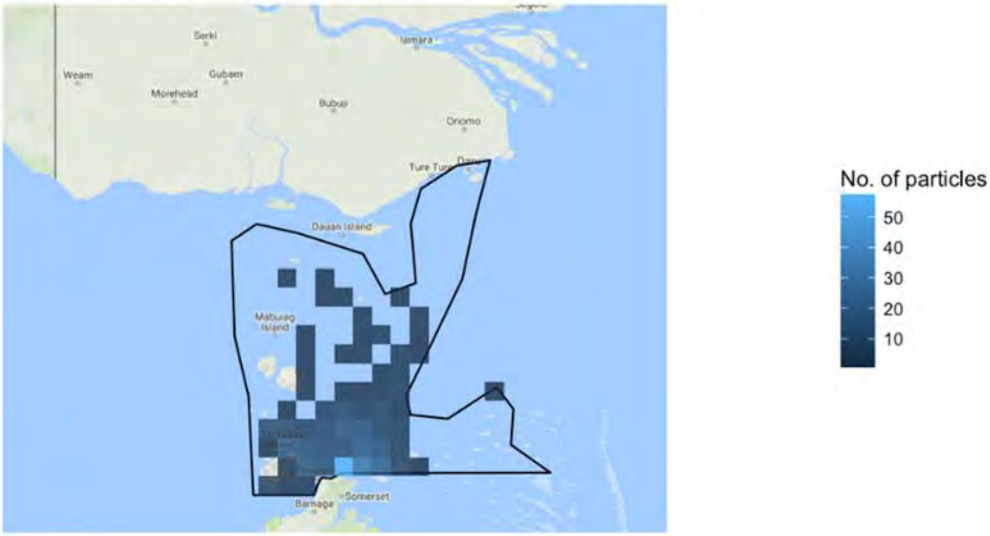
2008 : 3 % of particles reached the fishery from PCB



2009 : 8 % of particles reached the fishery from PCB

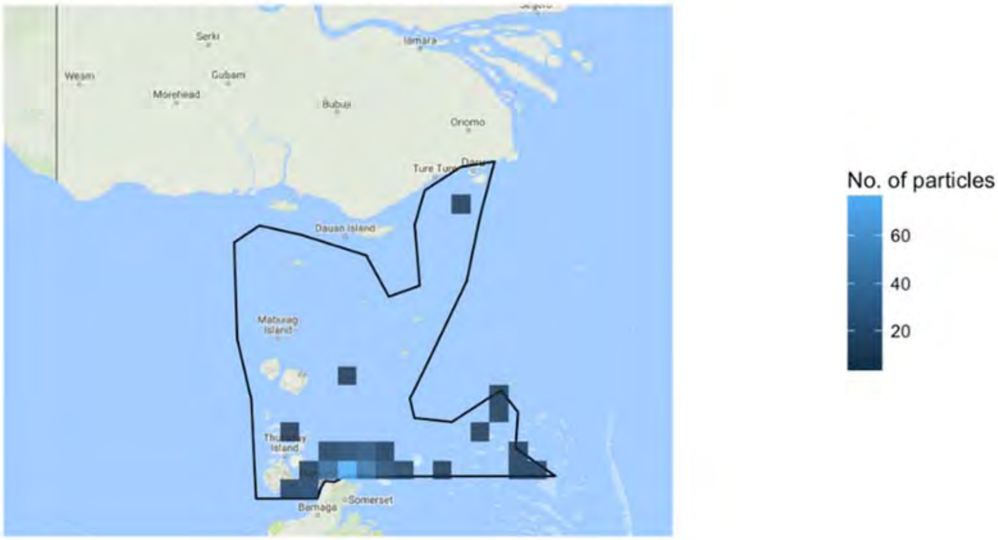


2010 : 4 % of particles reached the fishery from PCB

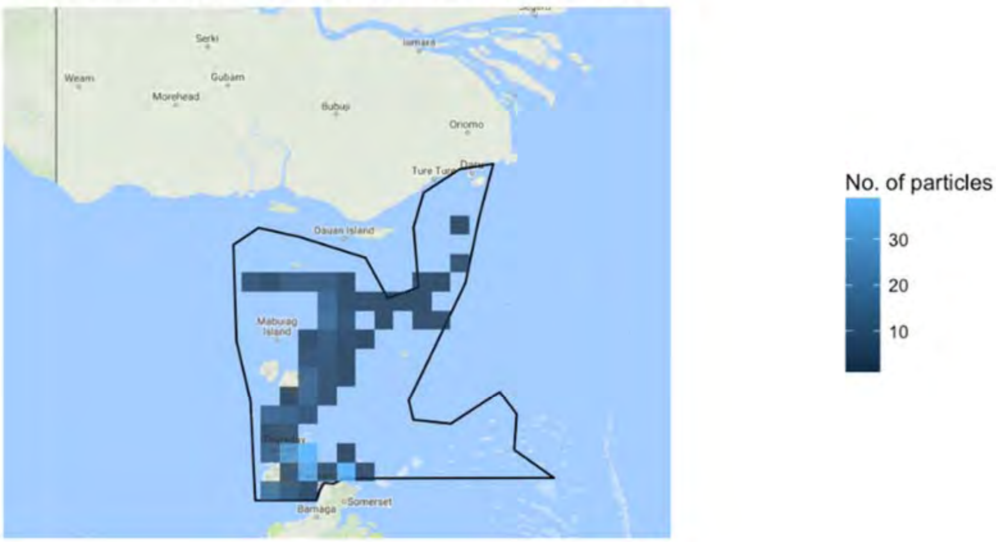


2011 : 3 % of particles reached the fishery from PCB

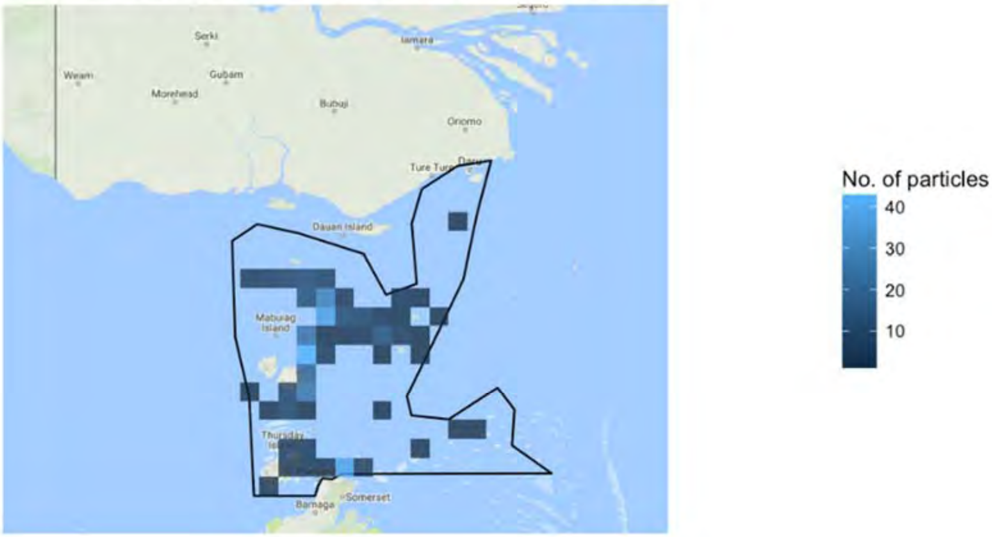
2012 : 3 % of particles reached the fishery from PCB



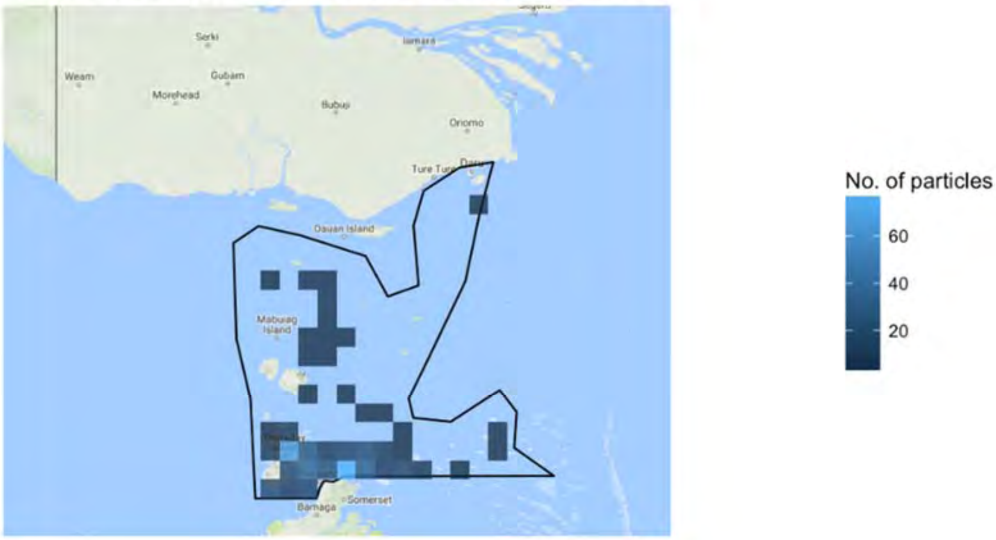
2013 : 4 % of particles reached the fishery from PCB



2014 : 4 % of particles reached the fishery from PCB



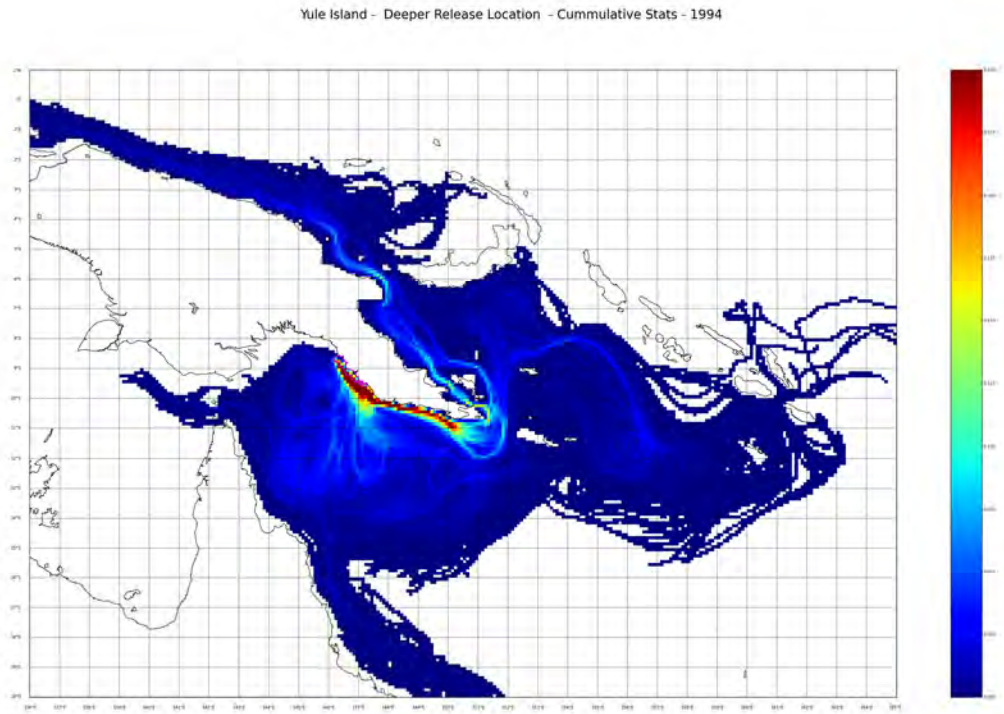
2015 : 5 % of particles reached the fishery from PCB



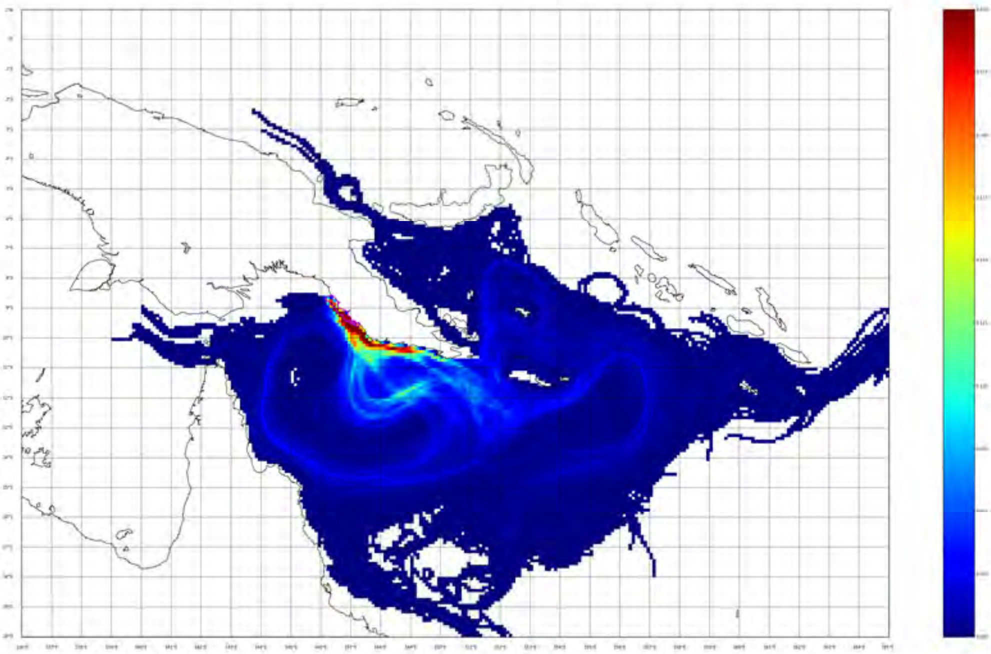
B.4 Cumulative statistics plots

The ‘All Phases’ plots show the probabilities of distinct particles passing through a cell. The values plotted are the values in the number of particles that pass through each grid cell divided by the number of particles in the simulation (9600).

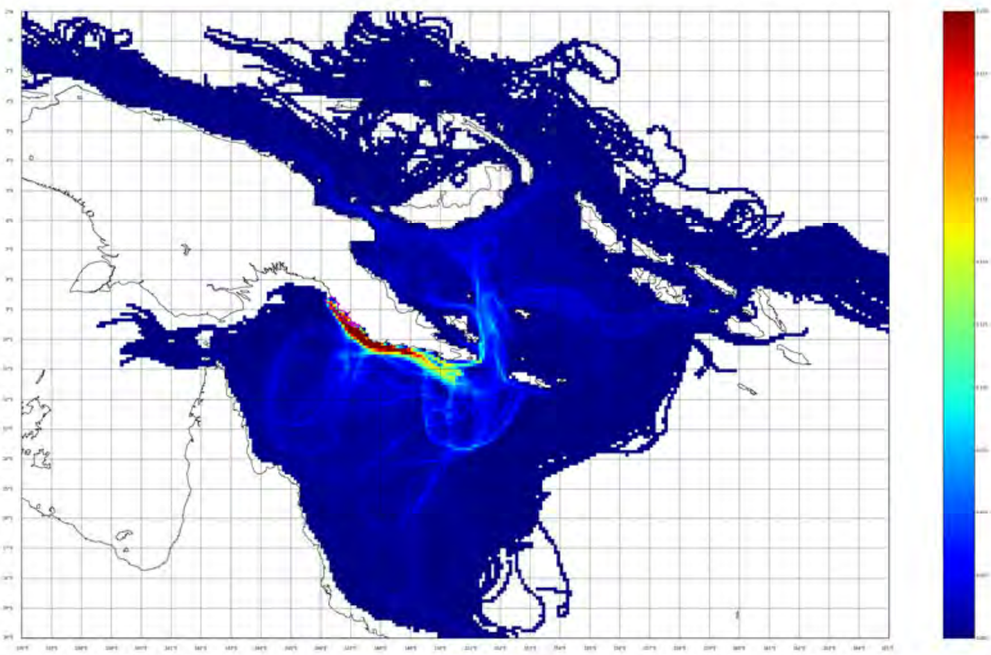
Release site: Yule Island



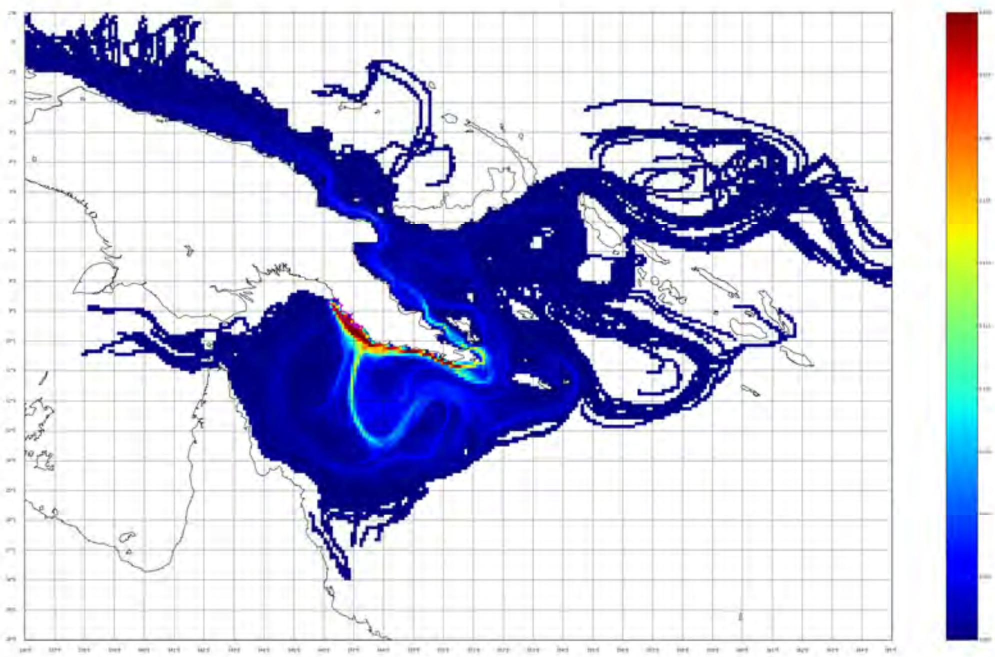
Yule Island - Deeper Release Location - Cummulative Stats - 1995



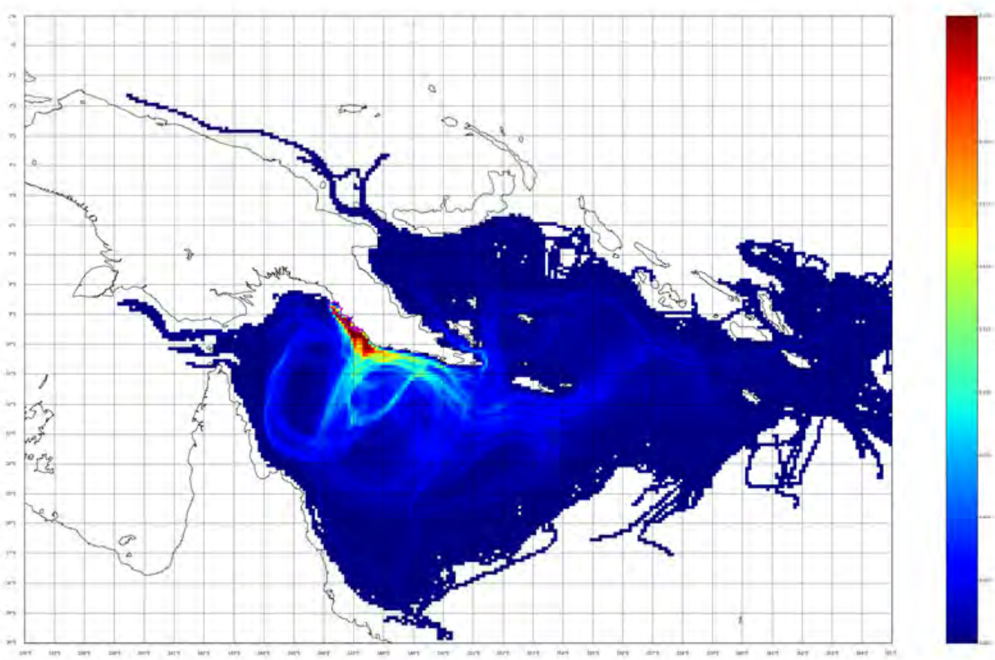
Yule Island - Deeper Release Location - Cummulative Stats - 1996



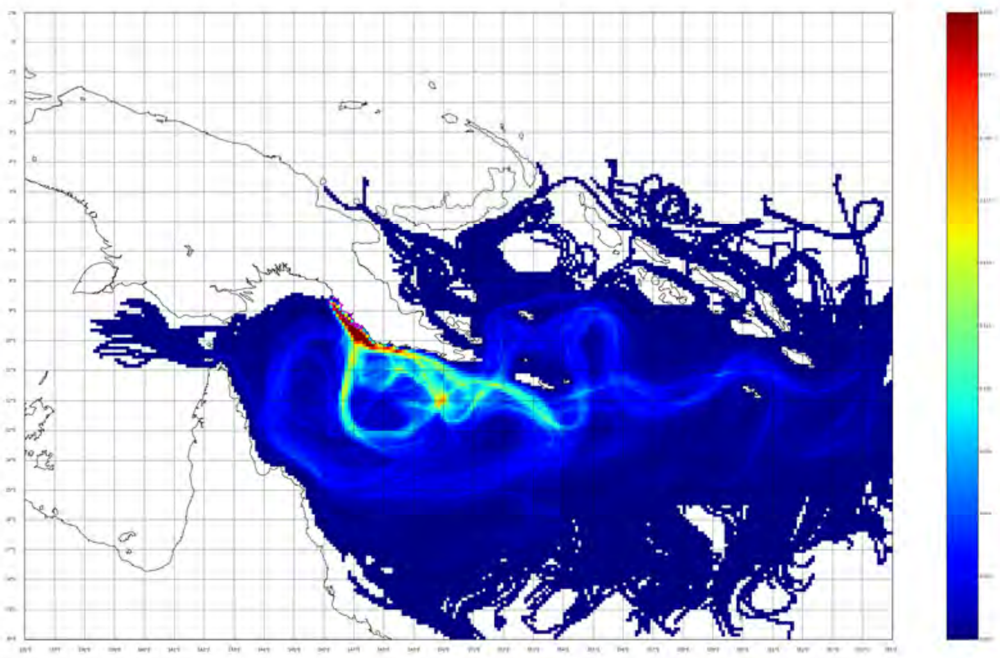
Yule Island - Deeper Release Location - Cummulative Stats - 1997



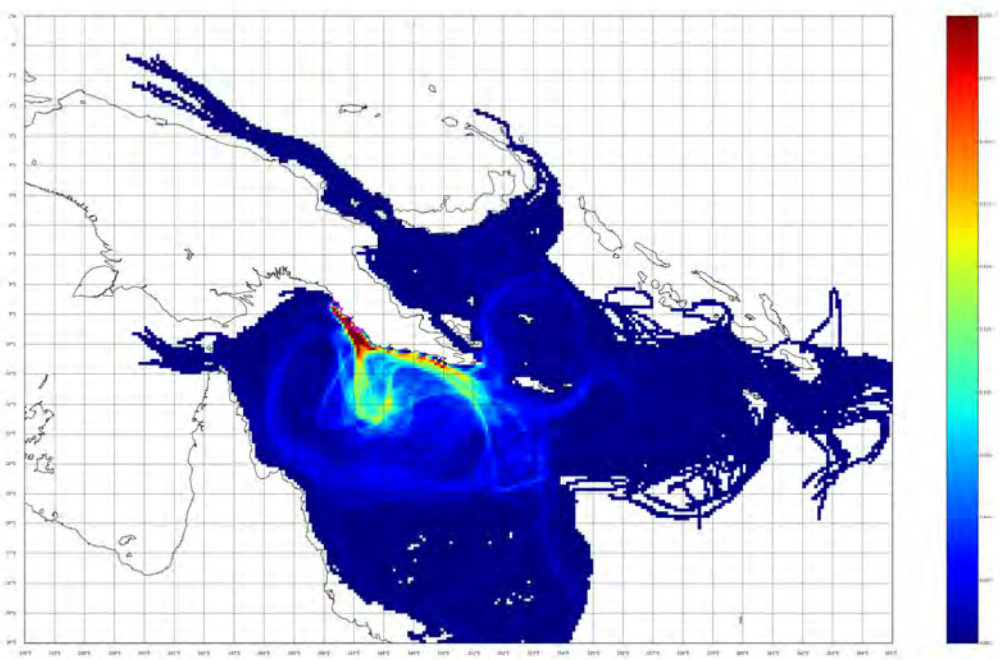
Yule Island - Deeper Release Location - Cummulative Stats - 1998

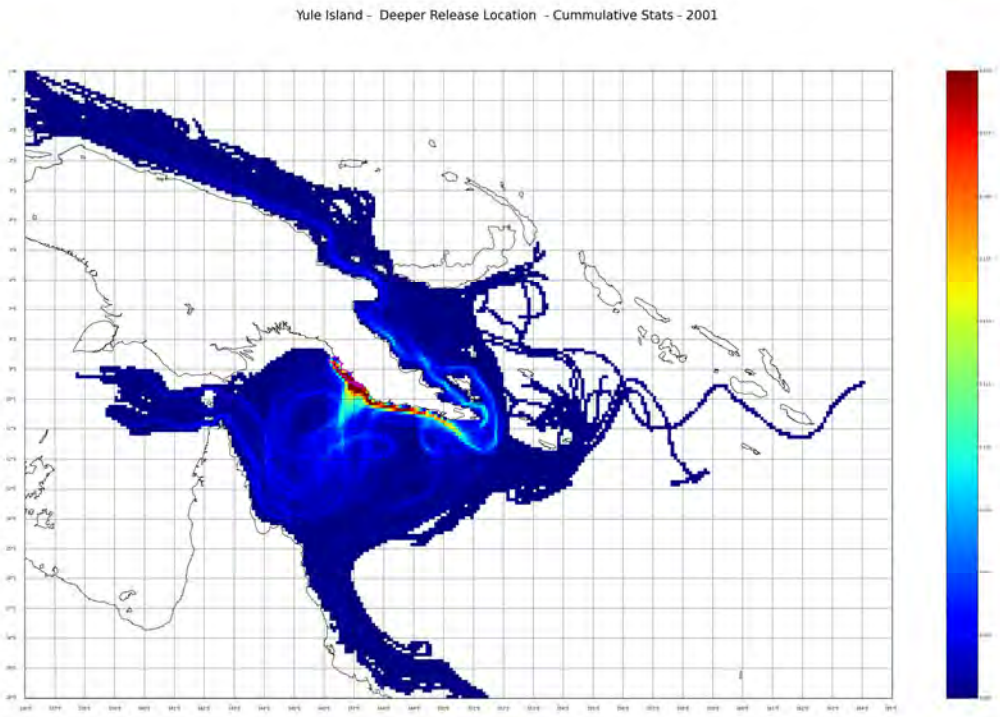


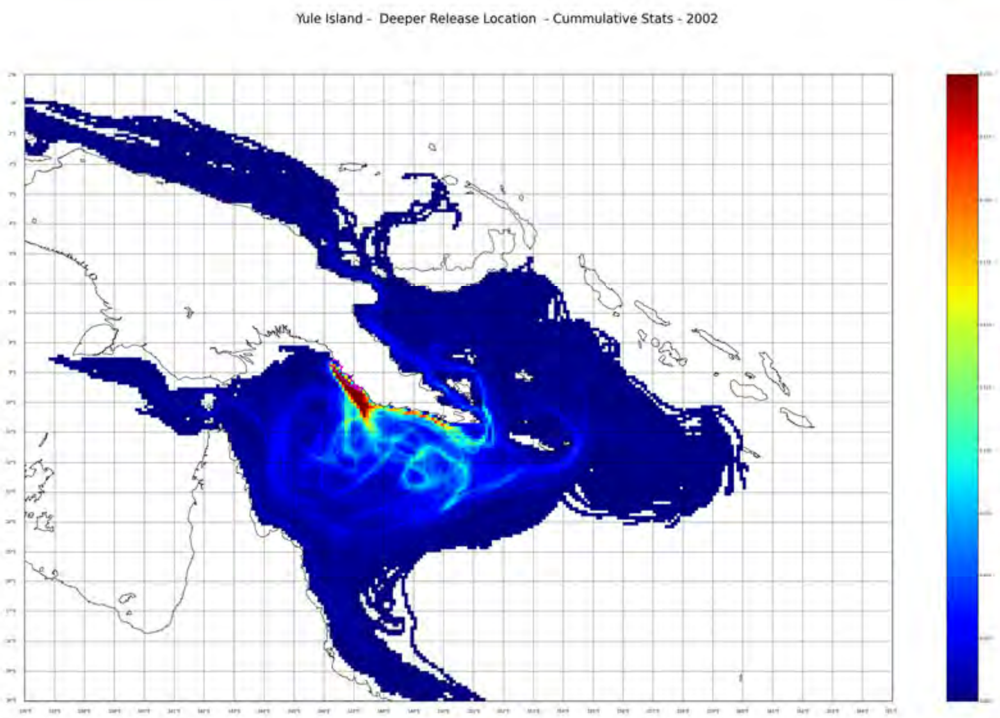
Yule Island - Deeper Release Location - Cummulative Stats - 1999



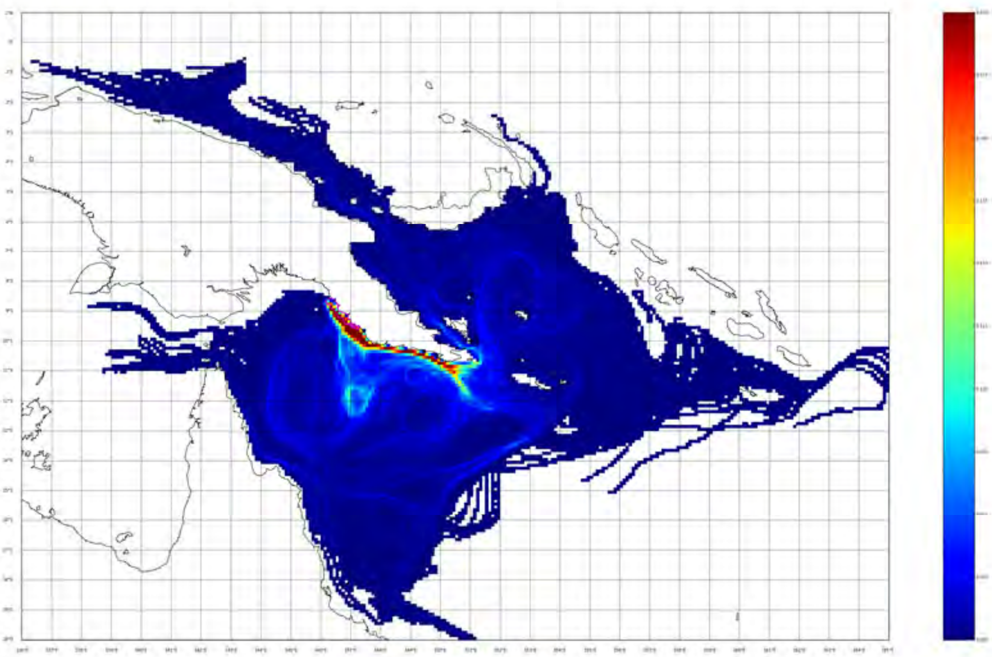
Yule Island - Deeper Release Location - Cummulative Stats - 2000



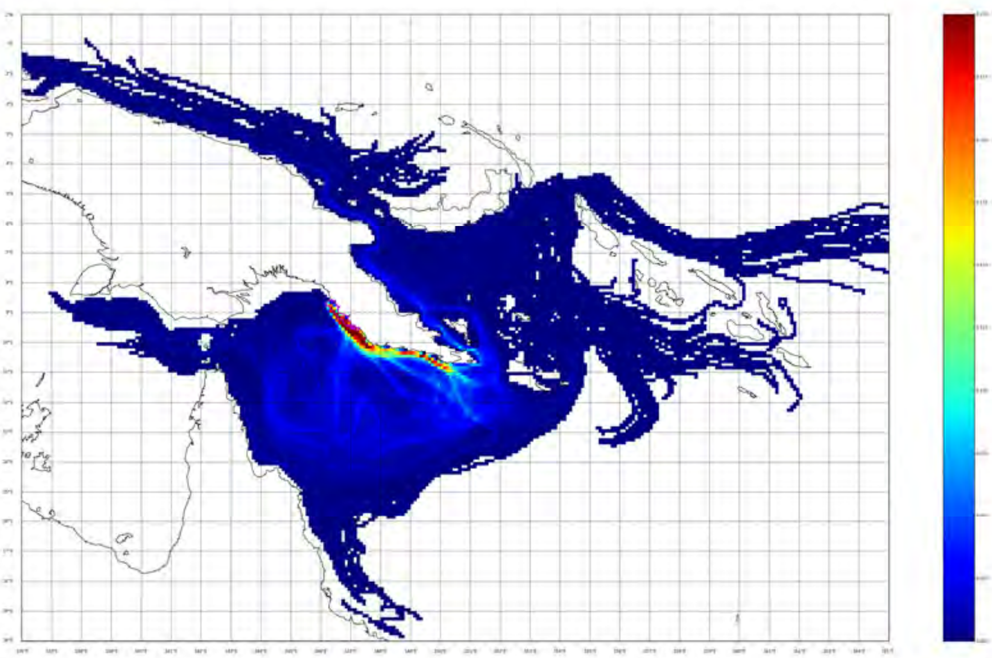

Yule Island - Deeper Release Location - Cummulative Stats - 2001


Yule Island - Deeper Release Location - Cummulative Stats - 2002

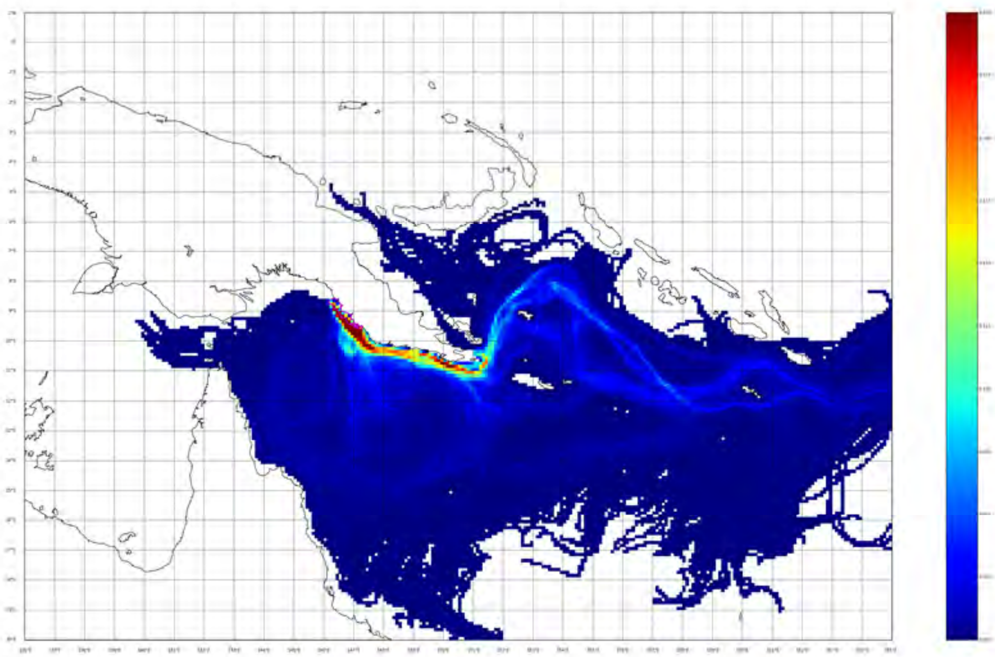
Yule Island - Deeper Release Location - Cummulative Stats - 2003



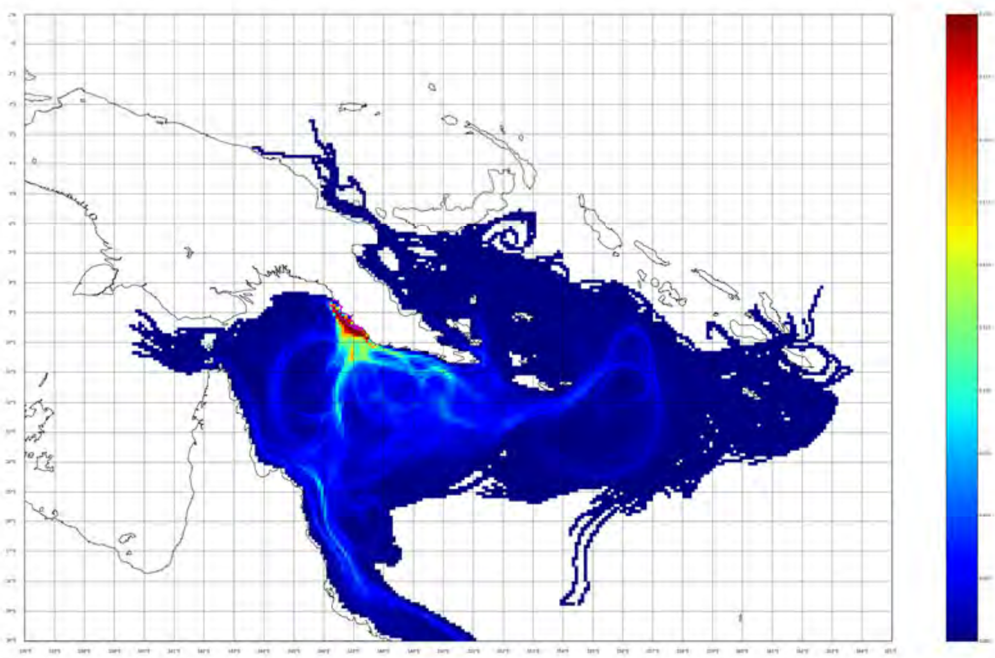
Yule Island - Deeper Release Location - Cummulative Stats - 2004



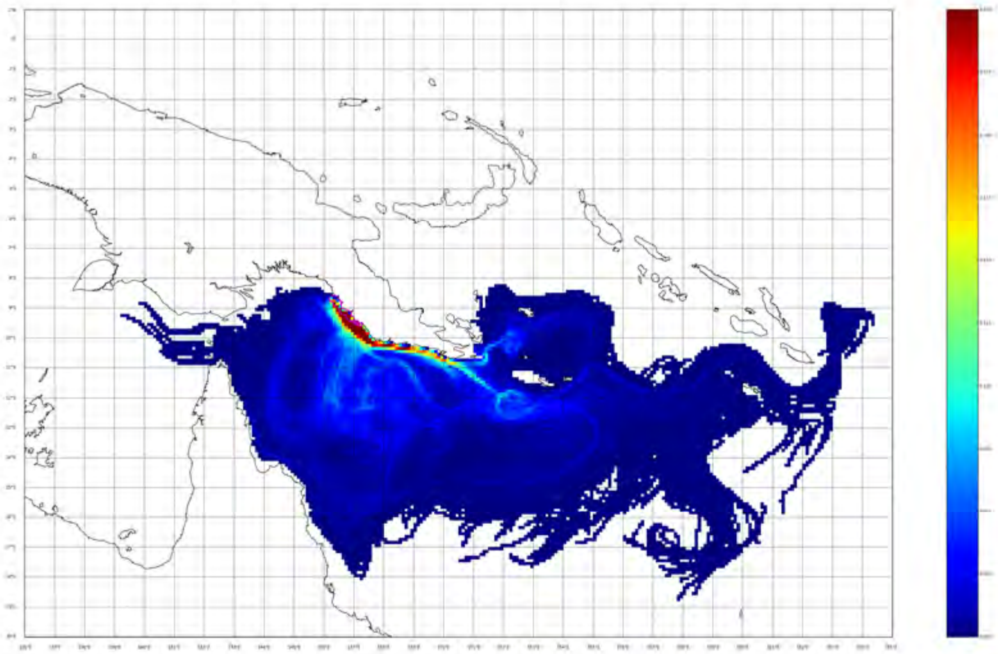
Yule Island - Deeper Release Location - Cummulative Stats - 2005



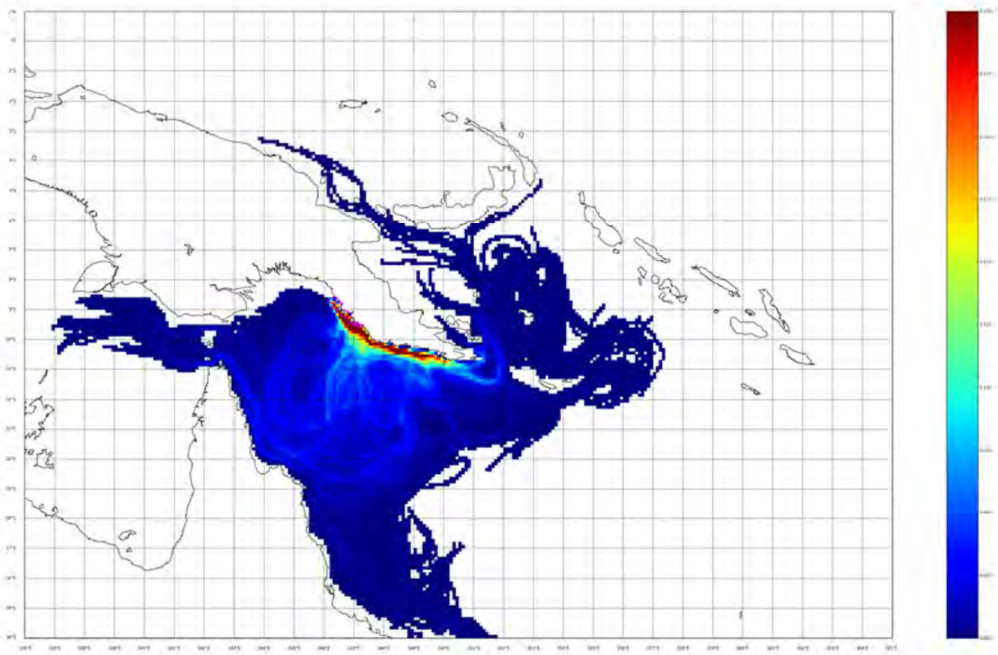
Yule Island - Deeper Release Location - Cummulative Stats - 2006



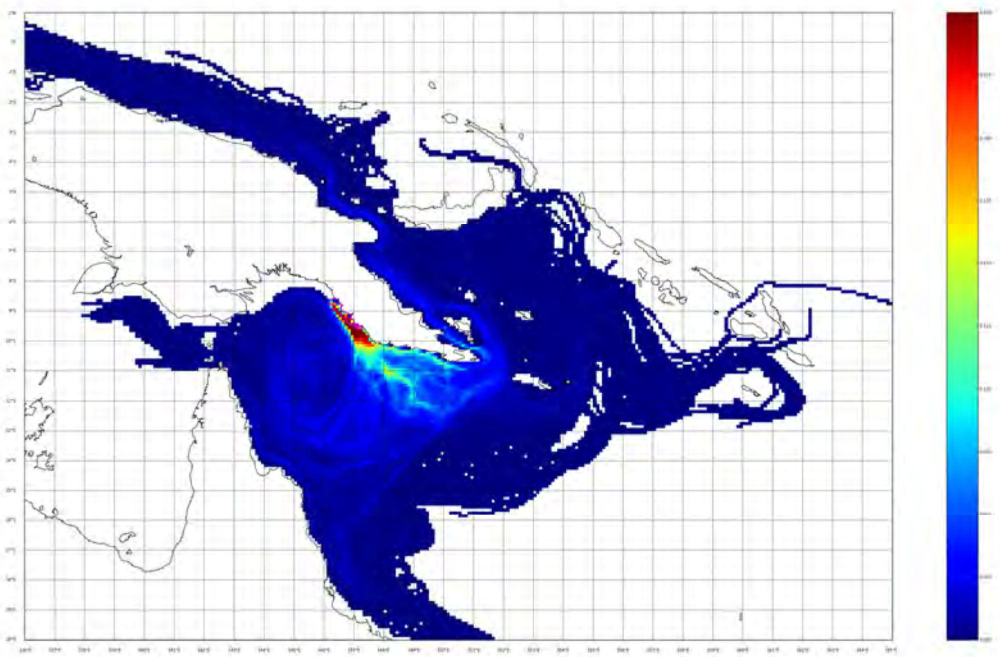
Yule Island - Deeper Release Location - Cummulative Stats - 2007



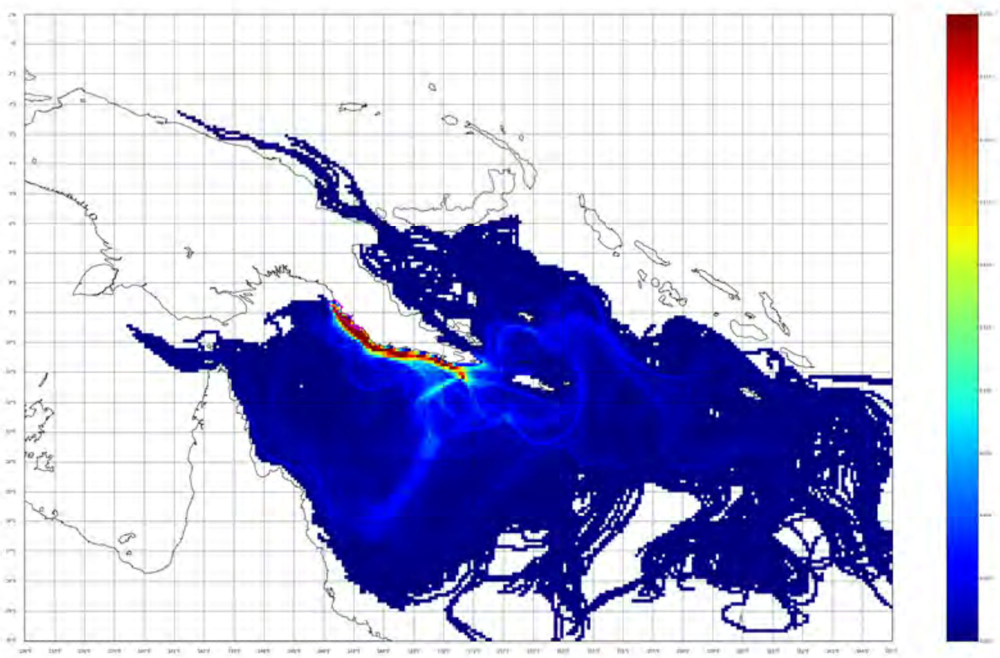
Yule Island - Deeper Release Location - Cummulative Stats - 2008



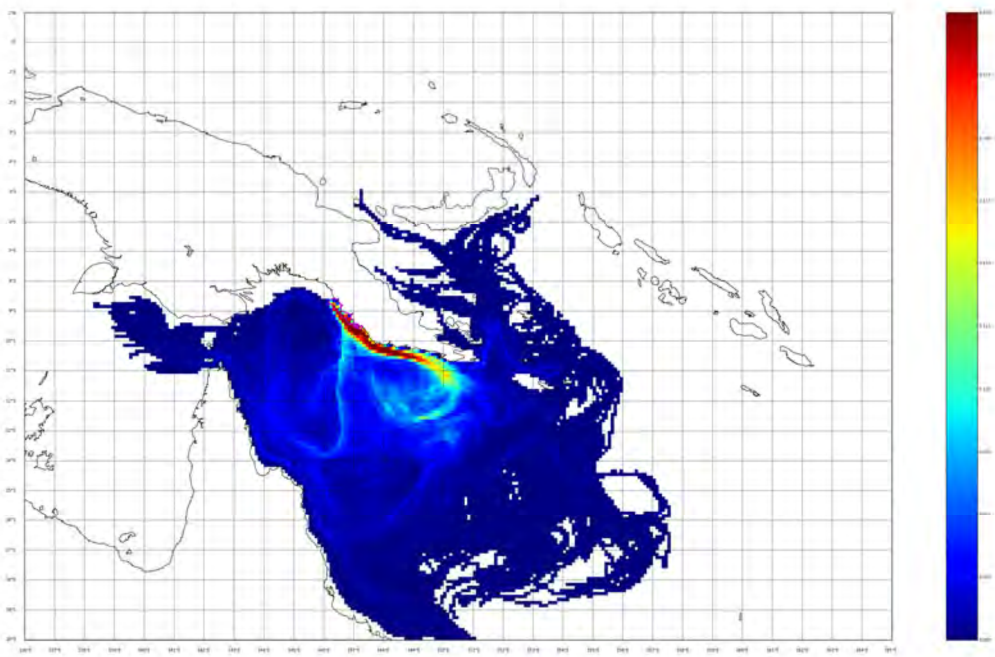
Yule Island - Deeper Release Location - Cummulative Stats - 2009



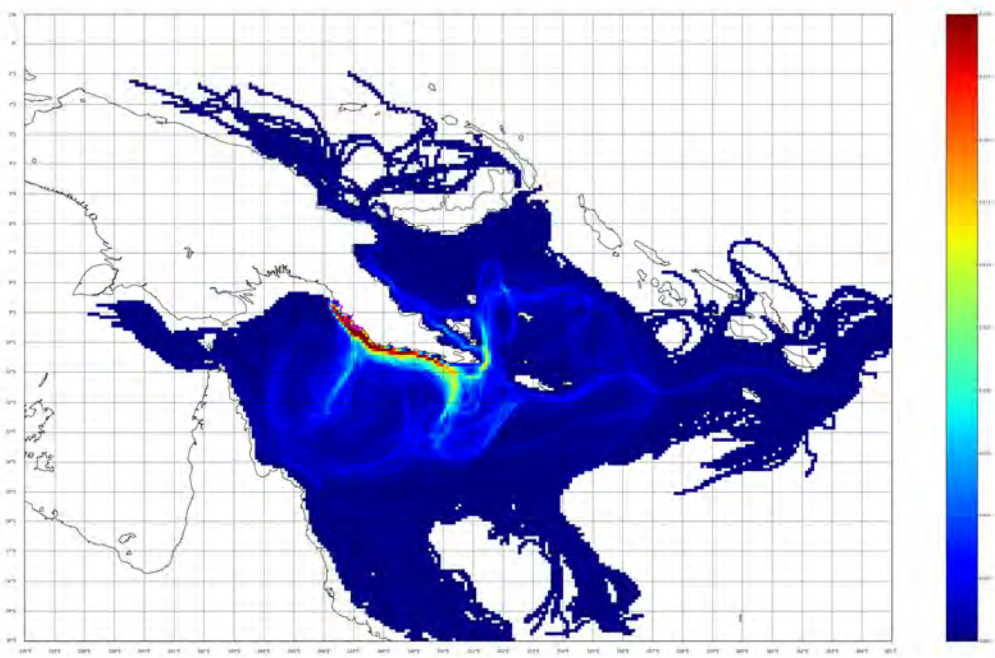
Yule Island - Deeper Release Location - Cummulative Stats - 2010



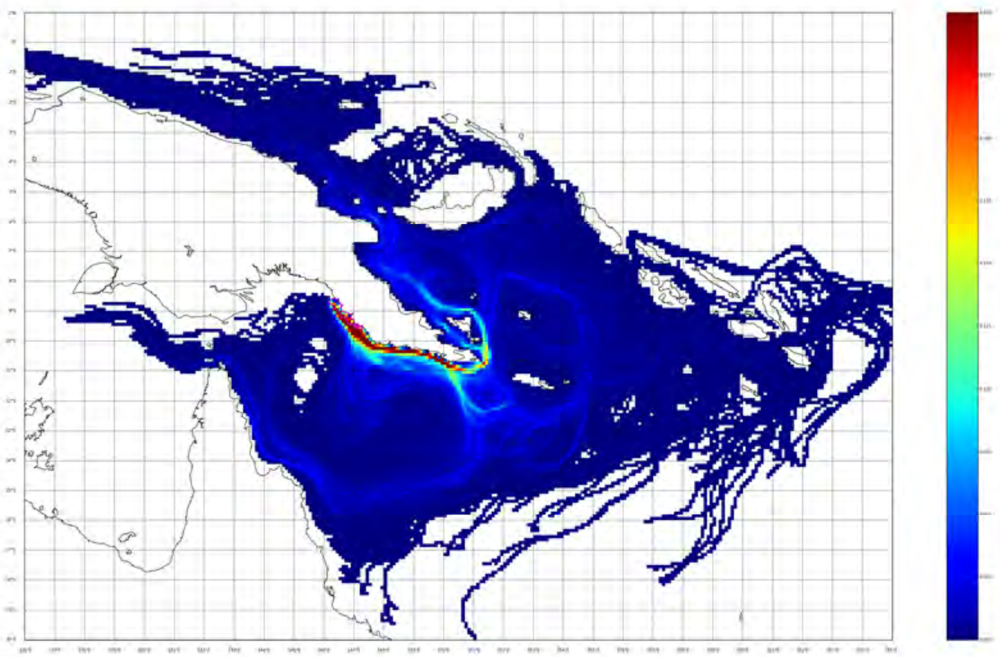
Yule Island - Deeper Release Location - Cummulative Stats - 2011



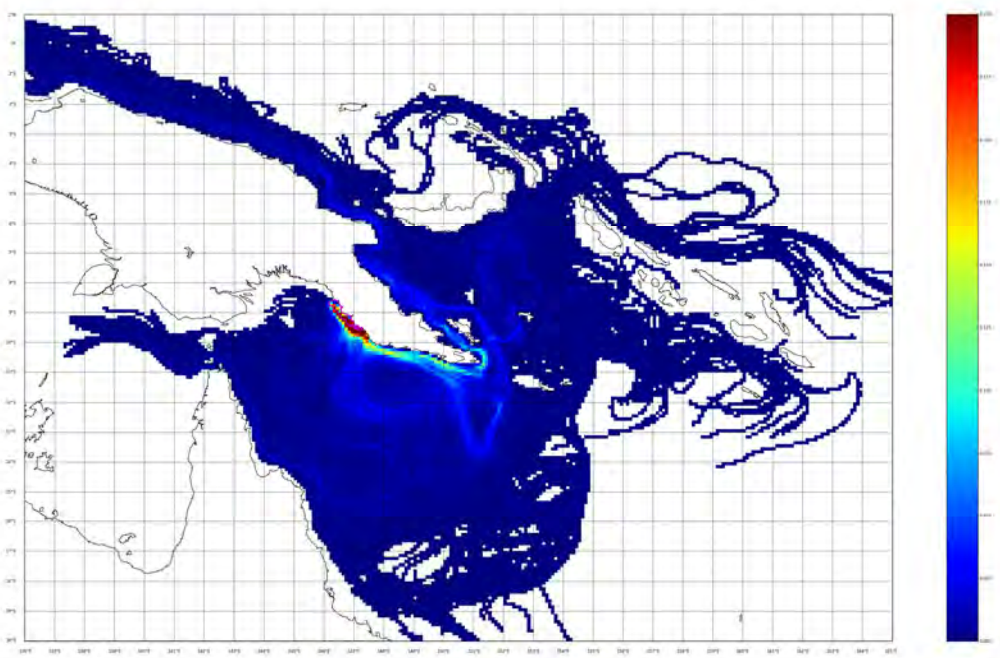
Yule Island - Deeper Release Location - Cummulative Stats - 2012

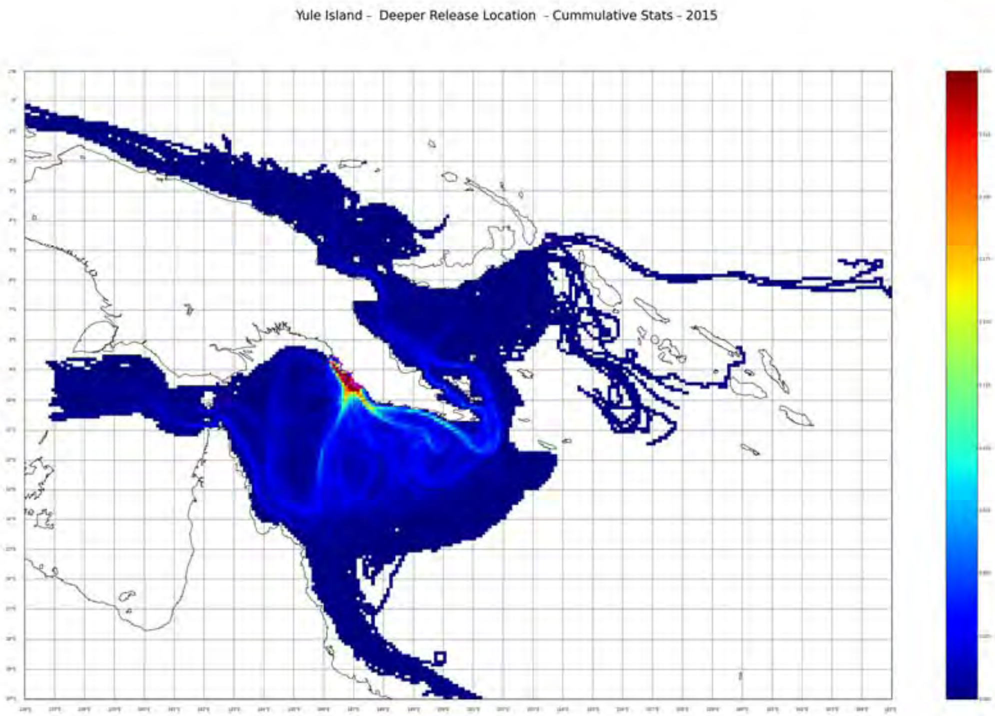


Yule Island - Deeper Release Location - Cummulative Stats - 2013

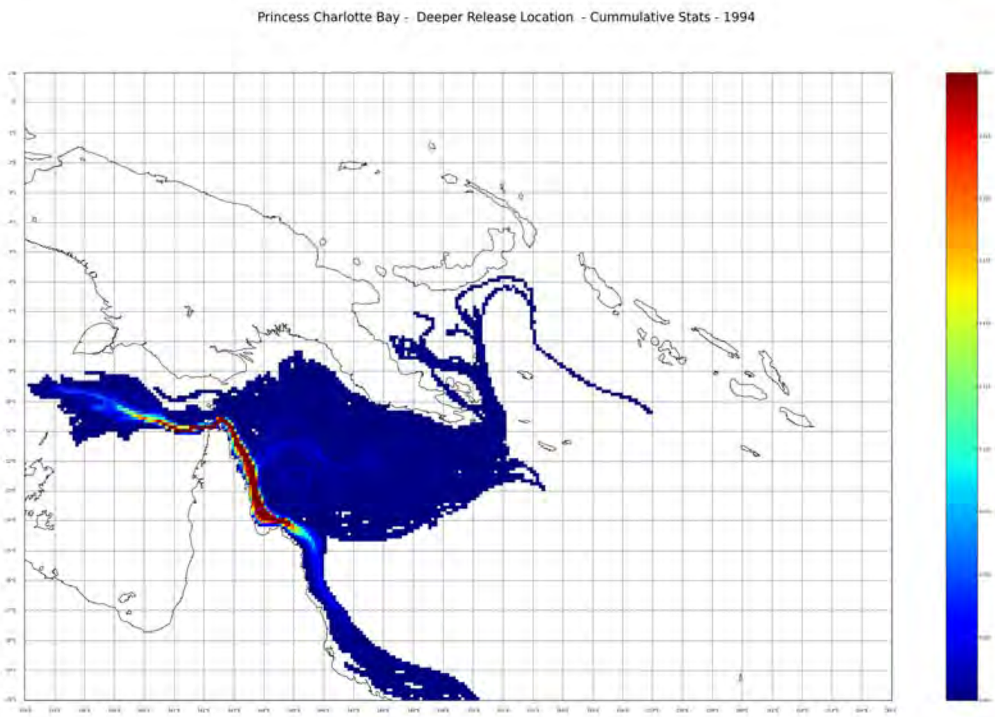


Yule Island - Deeper Release Location - Cummulative Stats - 2014

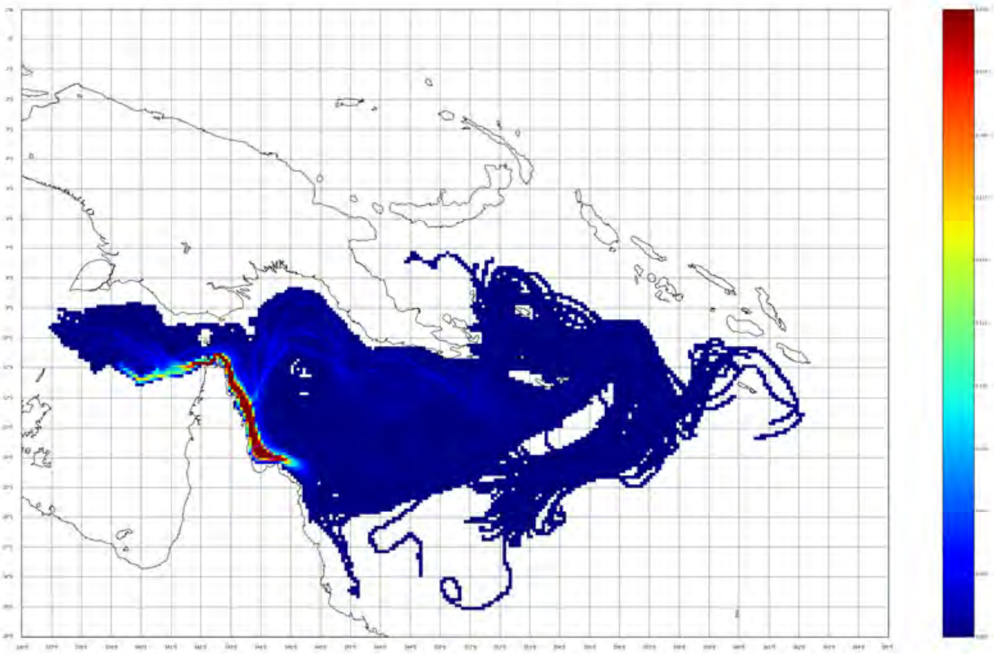




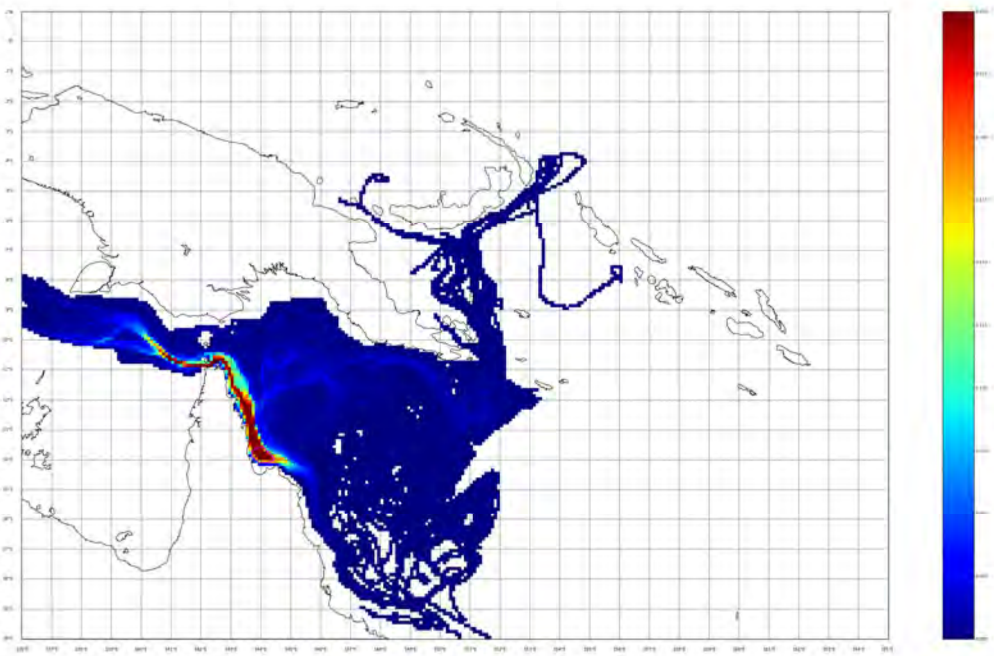
Release site: Princess Charlotte Bay



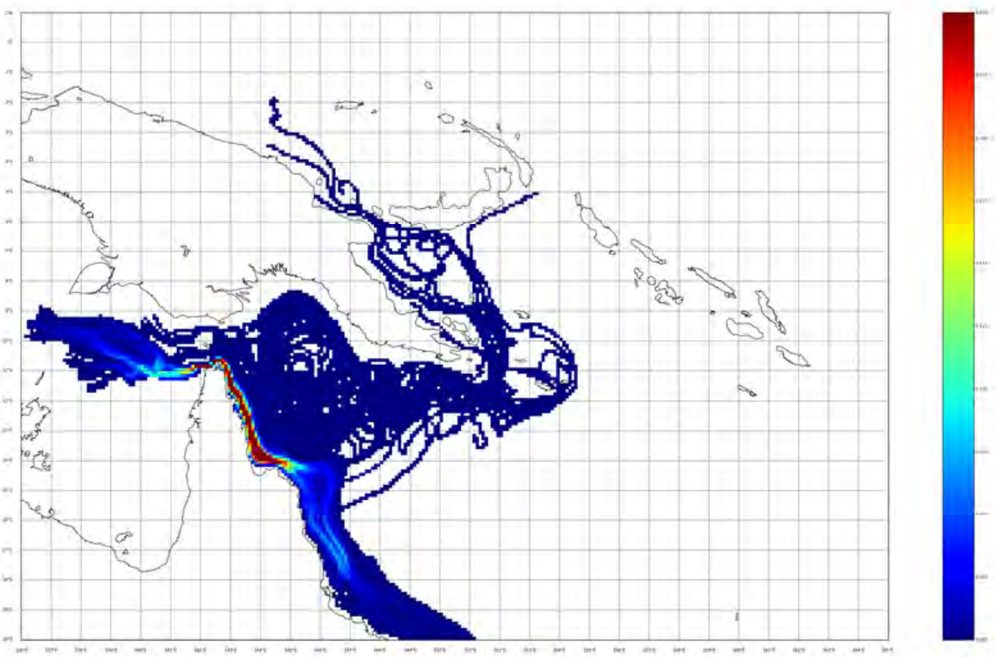
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 1995



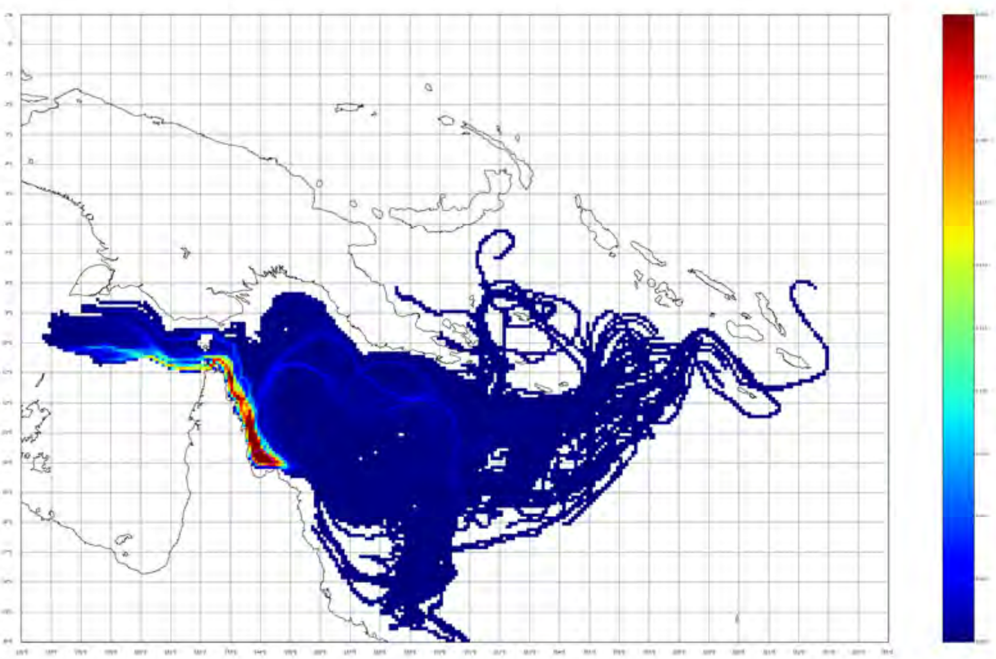
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 1996



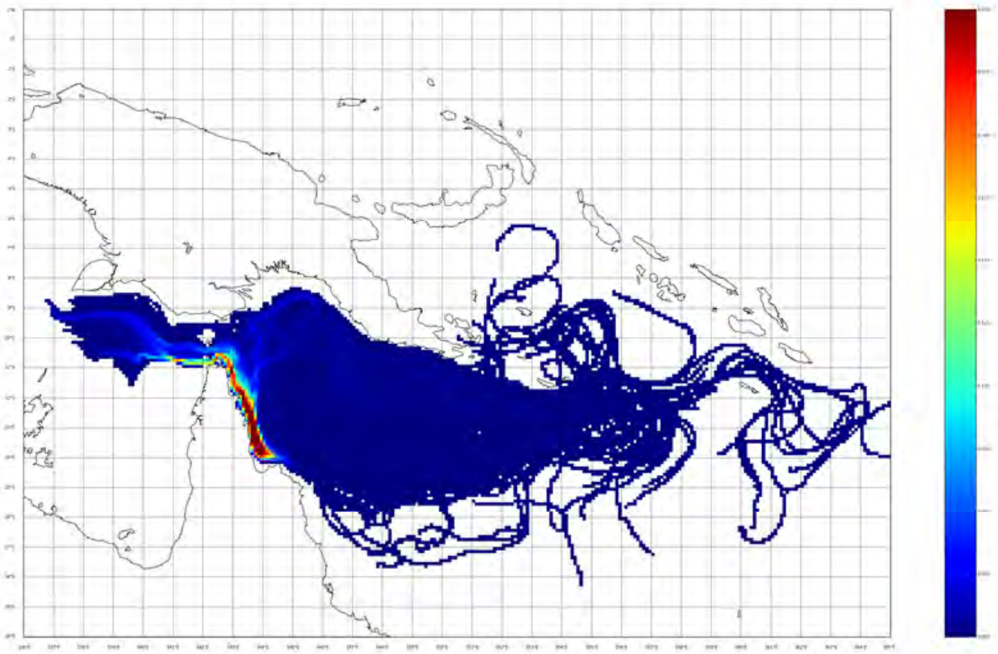
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 1997



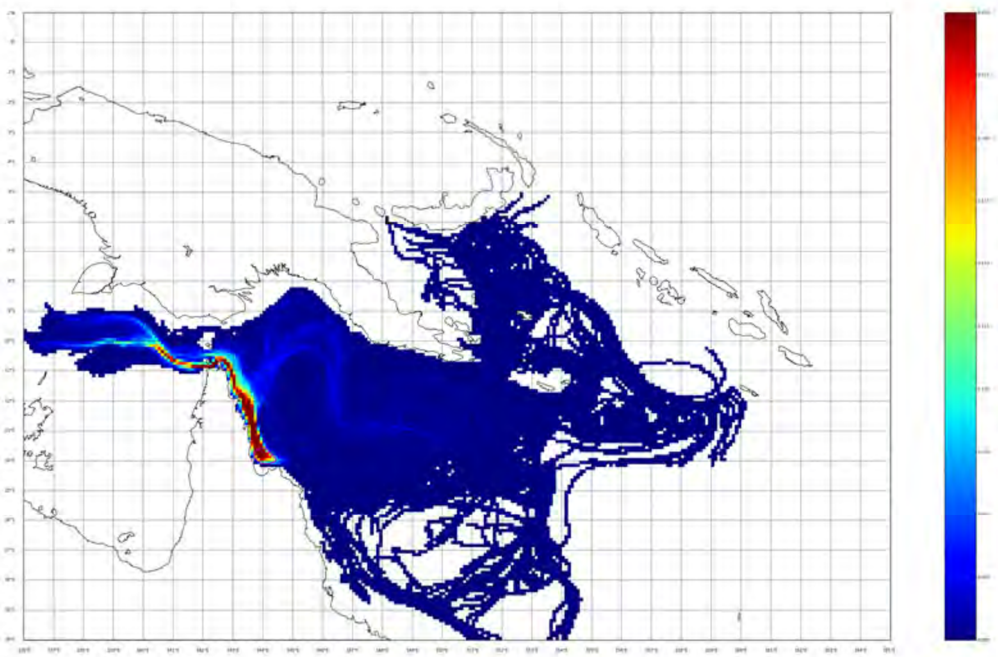
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 1998



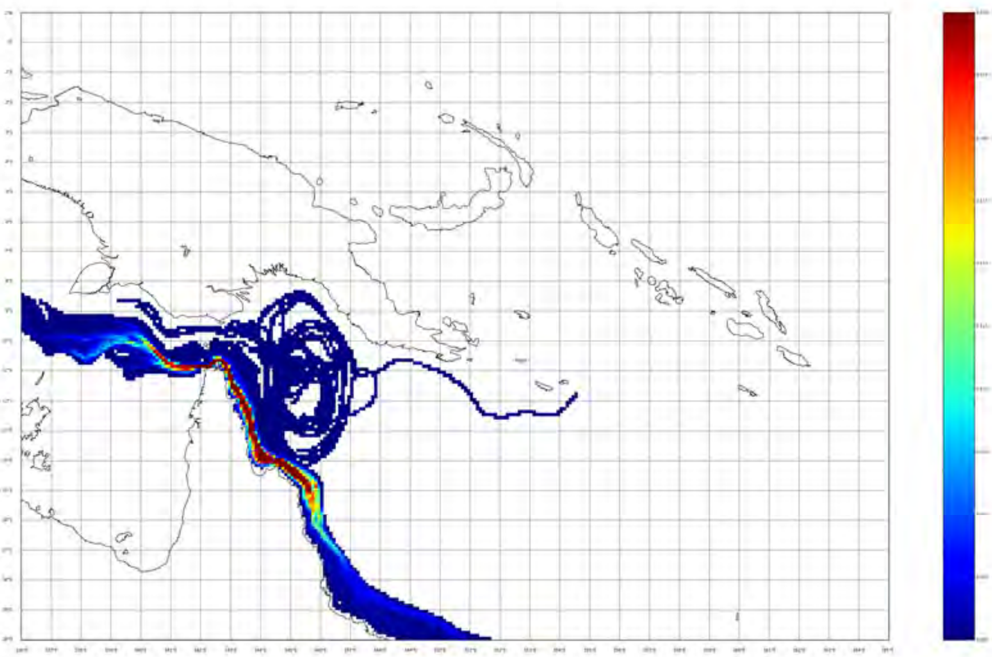
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 1999



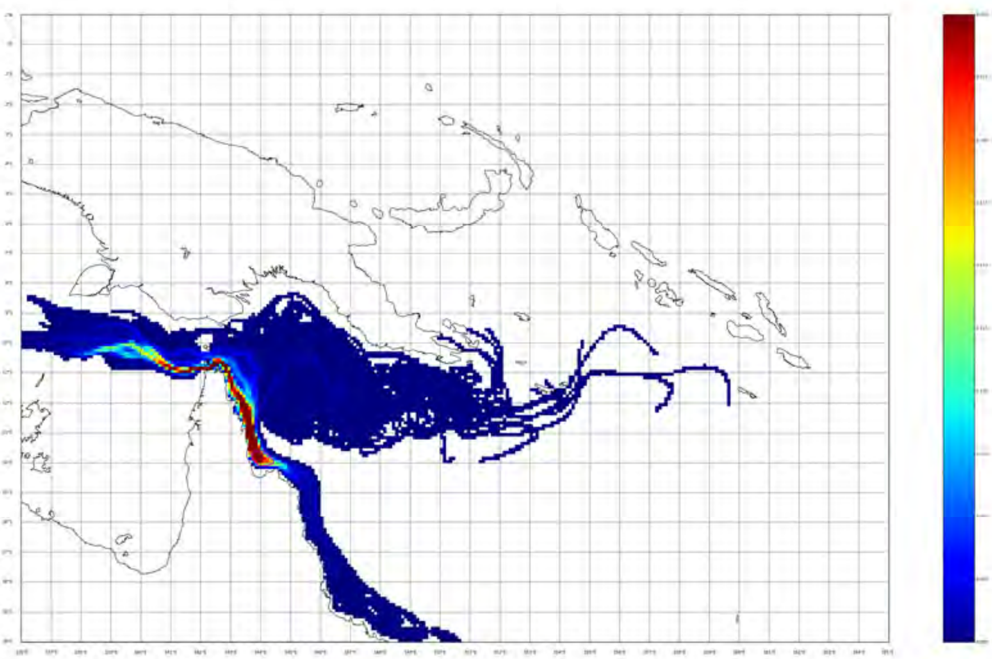
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2000



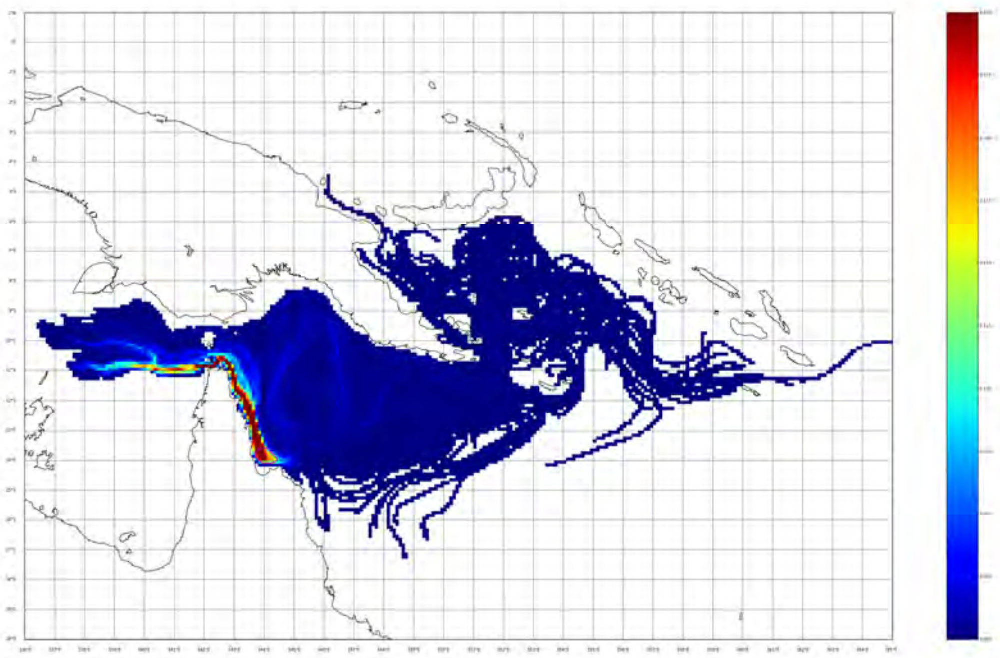
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2001



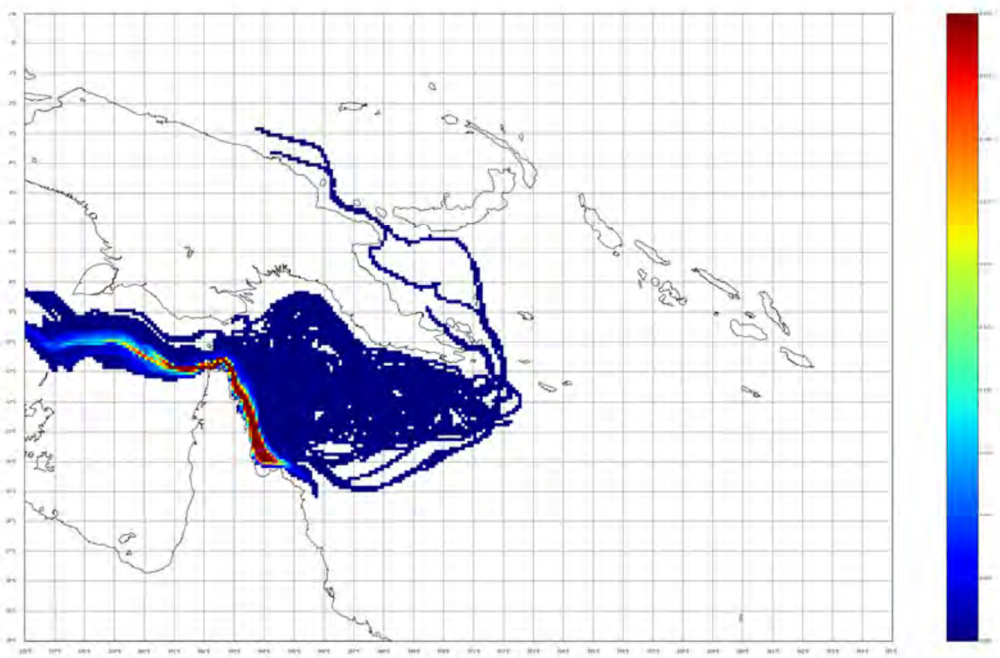
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2002



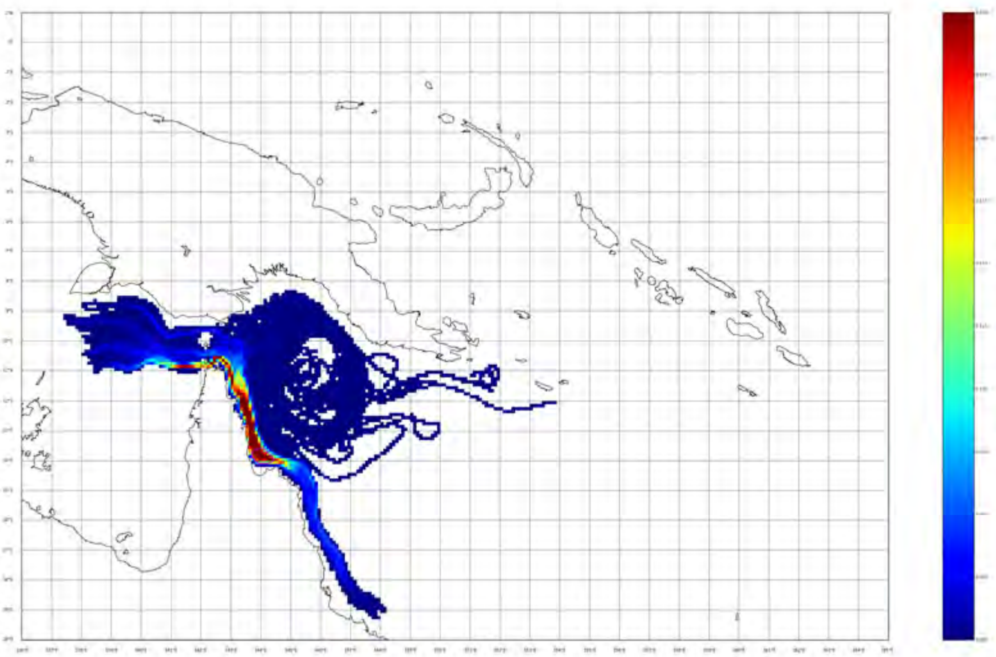
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2003



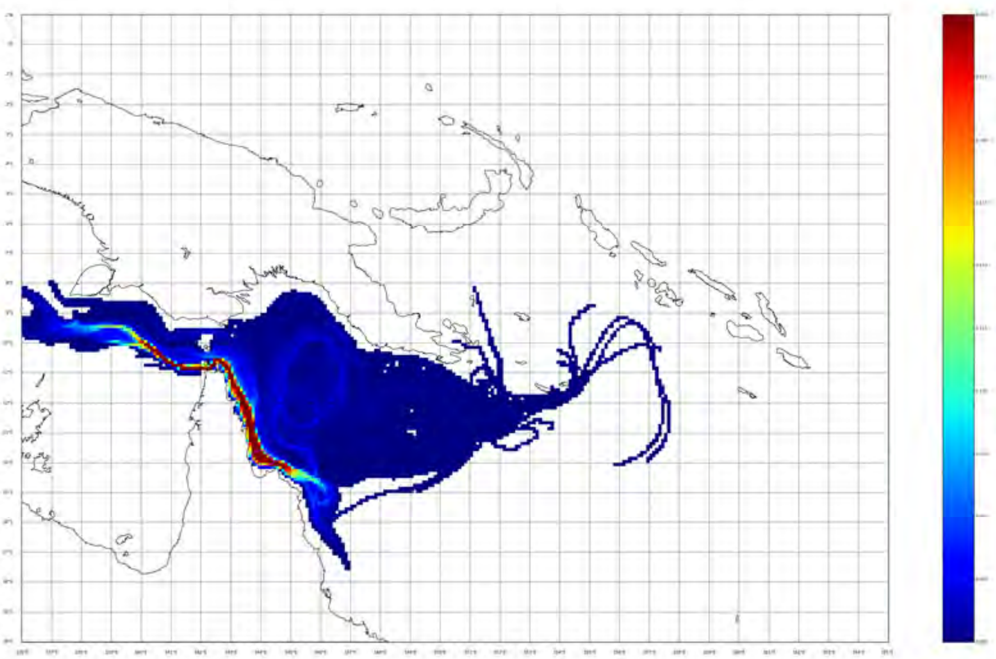
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2004



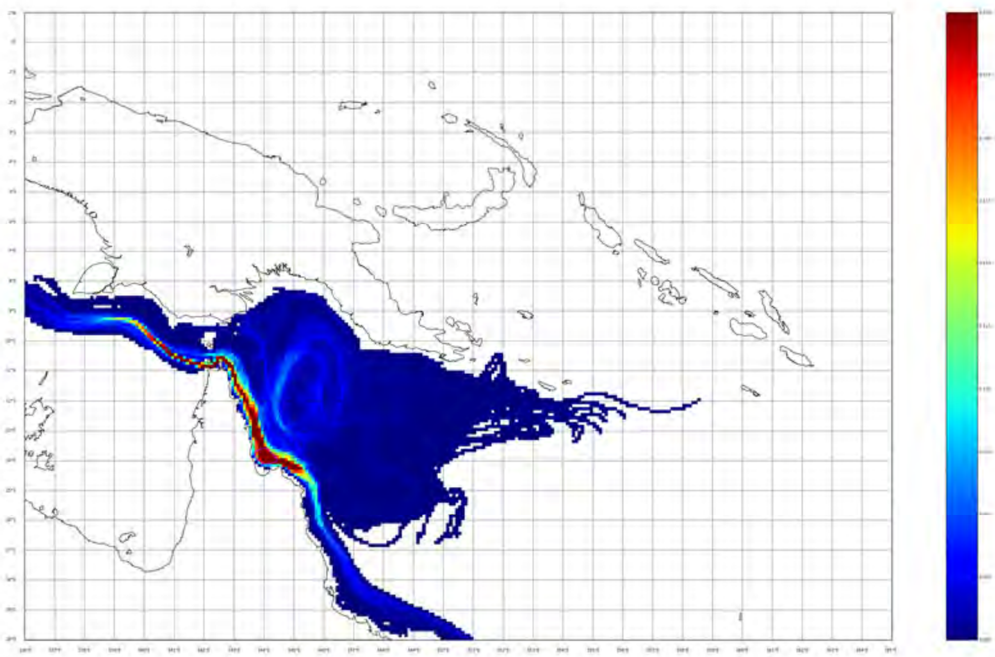
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2005



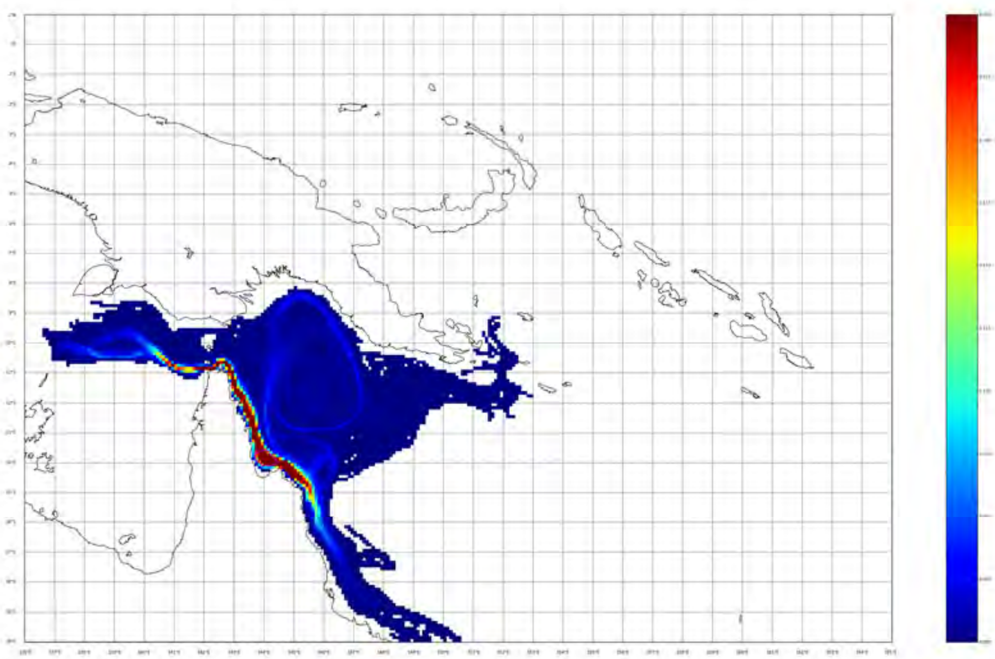
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2006



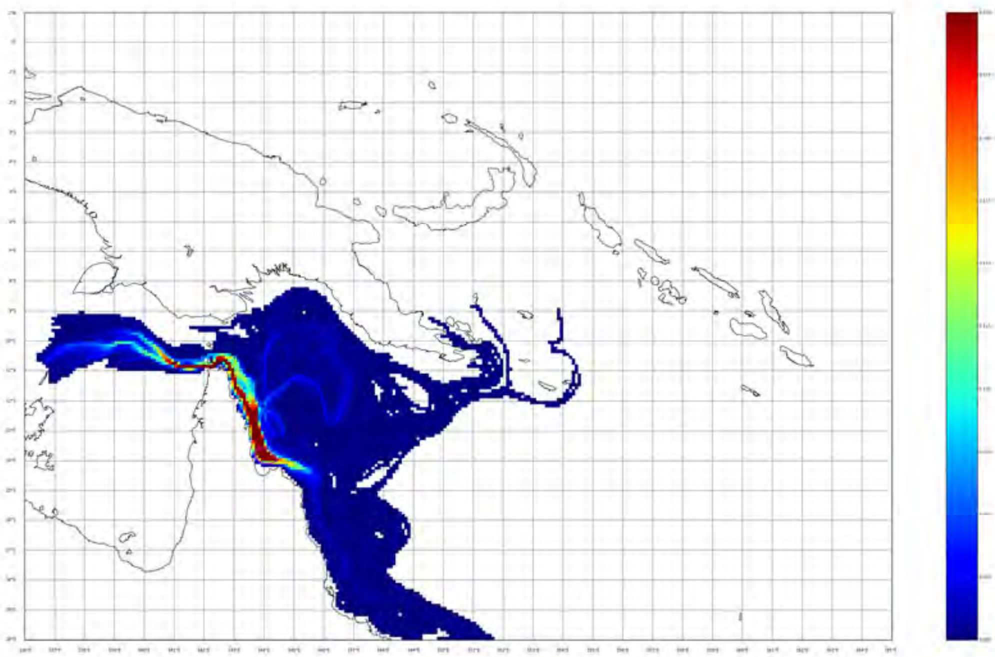
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2007



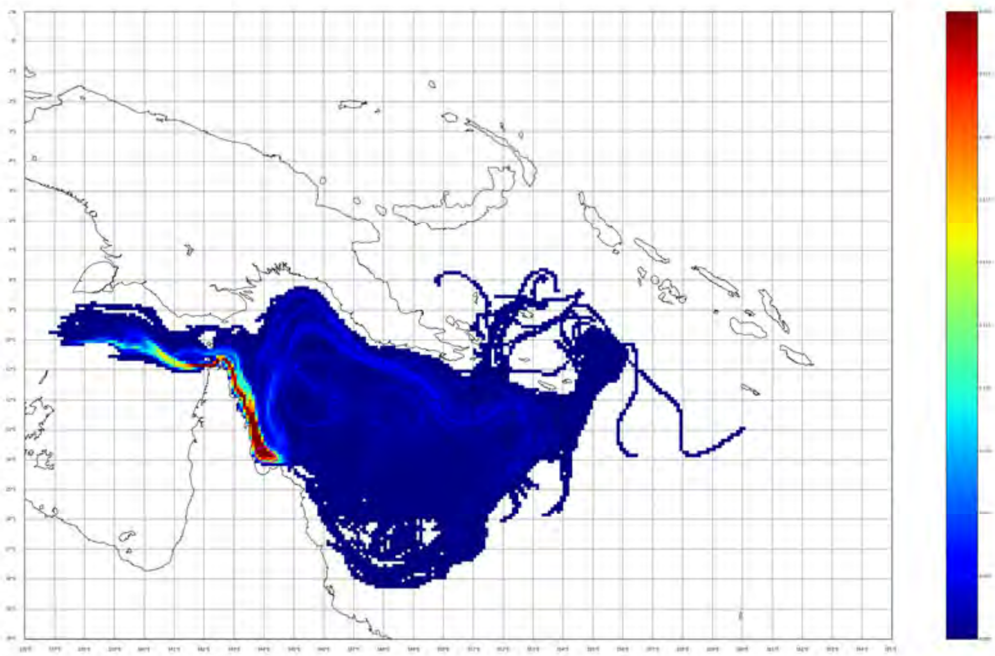
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2008

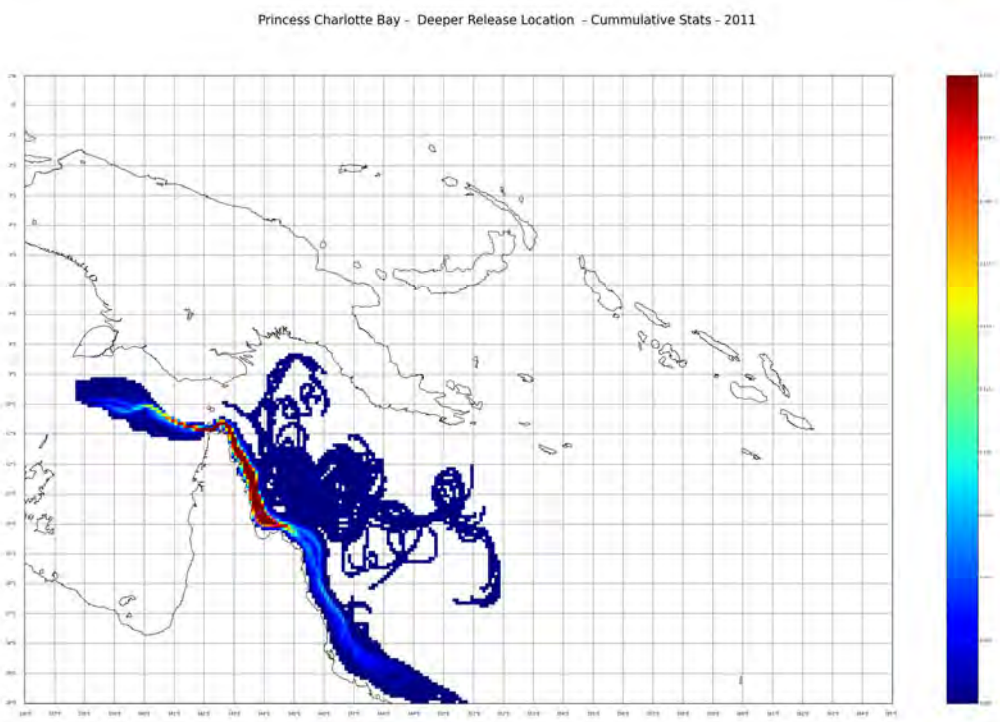


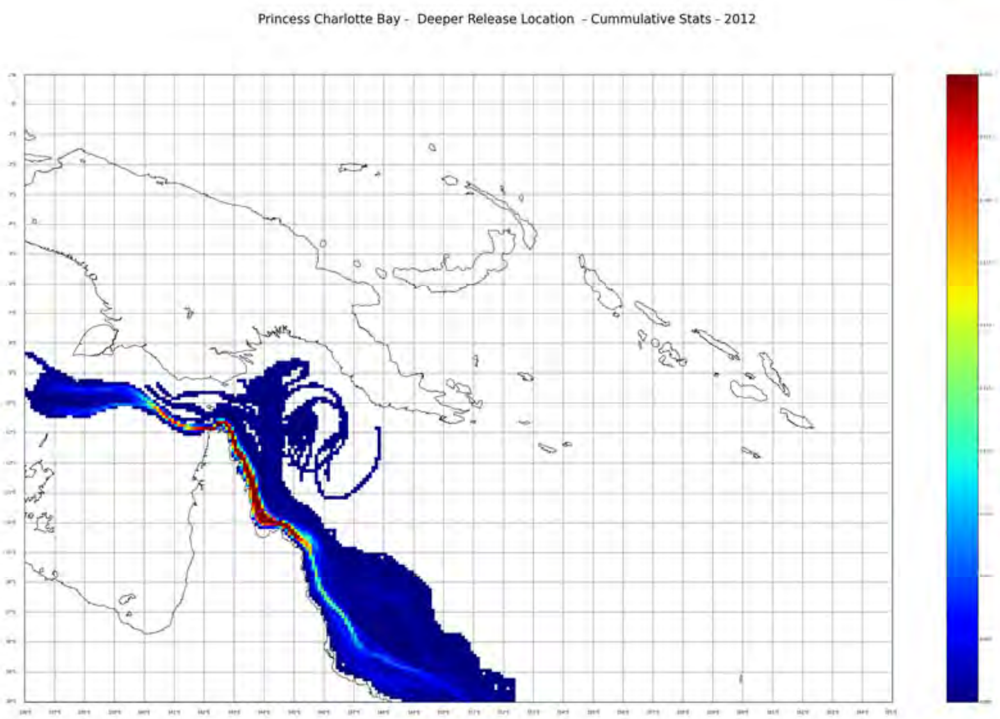
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2009



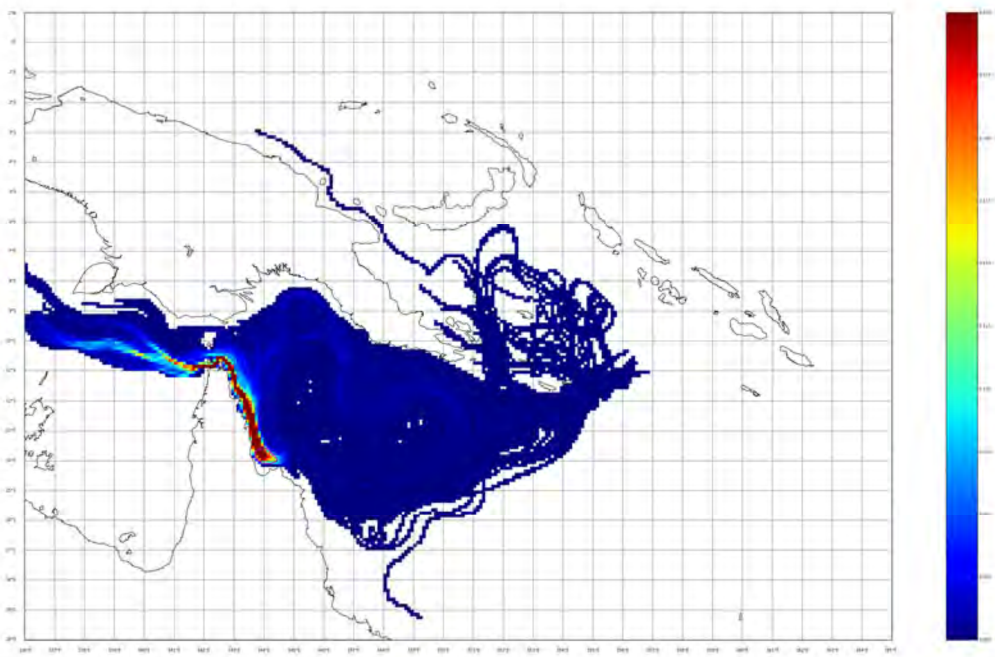
Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2010



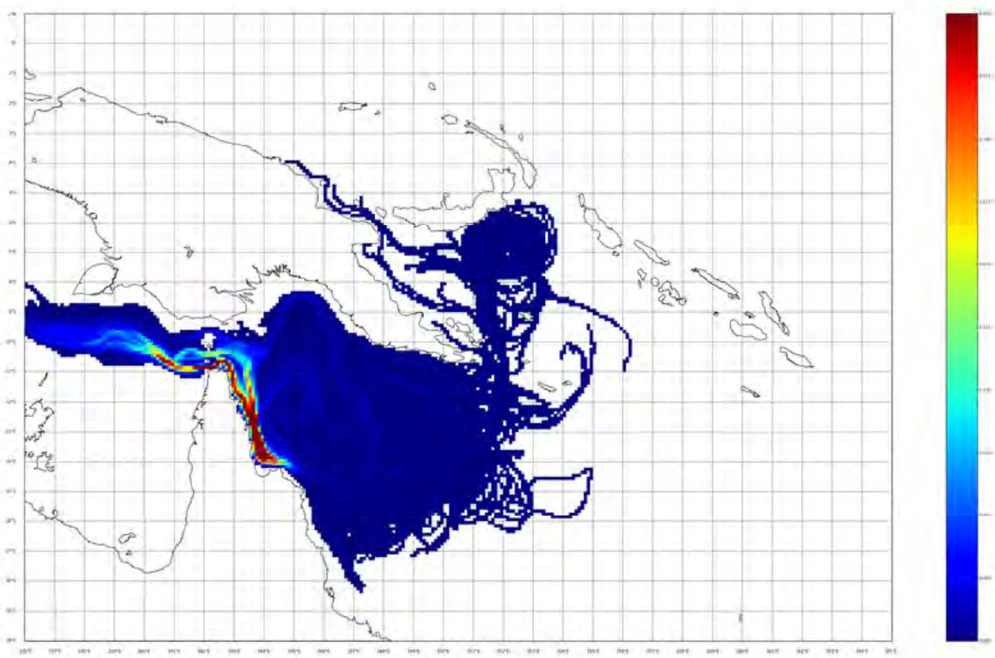

Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2011

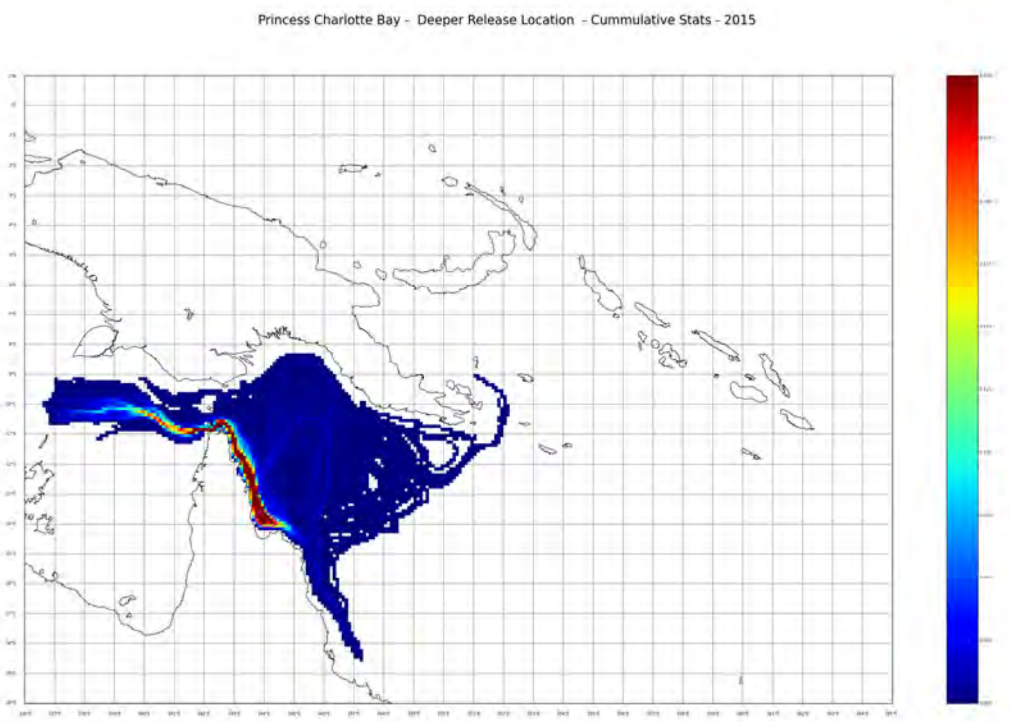

Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2012

Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2013



Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2014




Princess Charlotte Bay - Deeper Release Location - Cummulative Stats - 2015

Appendix C EQUATIONS

C.1 INTRODUCTION

Torres Strait rock lobsters emigrate in spring and breed during the subsequent summer (November-February) (Moore & Macfarlane 1984b). Therefore, the number of age 2+ lobsters at the middle of the breeding season (December) is assumed to represent the size of the spawning stock. The model assumes catches, migration and spawning occur at discrete times, with quarterly updates to the dynamics of each age class. Catches of 2+ individuals are assumed as being taken as a pulse at midyear, with individuals migrating out of the Torres Straits at the end of the third quarter, and a spawning biomass being computed at the end of the year. Catches of 1+ lobsters are assumed taken at the end of the third quarter, when a proportion of this age class have grown large enough to be available to fishers.

The model uses the Phillips et al. (1992) von Bertalanffy growth relationship and a morphometric relationship as follows:

$$L_m = 165.957 * (1 - \exp(-0.0012 \times 30 \times m))$$

$$w_m = 0.00258 \times \left(L_m\right)^{2.76} / 1e6$$

Where L_m is the carapace length (mm) and w_m the mass (tons) for individual aged m months.

An age-structured model of the Torres Rock Lobster population dynamics is fitted to the available abundance indices by maximising the likelihood function, based on the age-structured production model approach as described in (Rademeyer et al. 2008, Plagányi & Butterworth 2010). The model equations and the general specifications of the model are described below, followed by details of the contributions to the log-likelihood function from the different sources of data available. Quasi-Newton minimization is used to minimize the total negative log-likelihood function (the package AD Model Builder^{TM} (Fournier et al. 2012) is used for this purpose.

C.2 Lobster population dynamics

Numbers-at-age

The resource dynamics are modelled by the following set of population dynamics equations:

$$N_{y+1,1} = R_{y+1} \qquad 1$$

$$N_{y+1,a+1} = \left(N_{y,a}\, e^{-3M_a/4} - C_{y,a}\right)e^{-M_a/4} \qquad \text{for } a=1 \qquad 2$$

$$N_{y+1,a+1} = \left(N_{y,a}\, e^{-M_a/2} - C_{y,a}\right)e^{-M_a/2} \qquad \text{for } a=2 \qquad 3$$

where

$N_{y,a}$ is the number of lobsters of age *a* at the start of year *y* (which refers to a calendar year),

R_y is the recruitment (number of 1-year-old lobsters) at the start of year *y*,

M_a denotes the natural mortality rate on lobsters of age *a*,

$C_{y,a}$ is the predicted number of lobsters of age *a* caught in year *y*, and

m is the maximum age considered (taken to be 3).

These equations simply state that for a closed population, with no immigration and emigration, the only sources of loss are natural mortality (predation, disease, etc.) and fishing mortality (catch). They reflect Pope's form of the catch equation (Pope 1972) (the catches are assumed to be taken as a pulse at midyear for the 2+ class and at the start of the third quarter for the 1+ class) rather than the more customary Baranov form (Baranov 1918) (for which catches are incorporated under the assumption of steady continuous fishing mortality). Pope's form has been used in order to simplify computations.

Recruitment

The number of recruits (i.e. new 1-year old lobsters – it is simpler to work with 1- rather than 0-year old lobsters as recruits) at the start of year *y* is assumed to be related to the spawning stock size (i.e. the biomass of mature lobsters) by a modified Beverton-Holt stock-recruitment relationship (Beverton & Holt 1957), allowing for annual fluctuation about the deterministic relationship:

$$R_y = \frac{\alpha B^{sp}_{y-1}}{\beta + B^{sp}_{y-1}} e^{(\varsigma_y - (\sigma_R)^2/2)} \qquad 4$$

where

α, β are spawning biomass-recruitment relationship parameters,

ς_y reflects fluctuation about the expected recruitment for year *y*, which is assumed to be normally distributed with standard deviation σ_R (which is input in the applications considered here); these residuals are treated as estimable parameters in the model fitting process. Estimating the stock-recruitment residuals is made possible by the availability of catch-at-age data, which give some indication of the age-structure of the population.

B_y^{sp} is the spawning biomass at the start of year *y*, computed as:

$$B_y^{sp} = w_3^{st} \cdot N_{y,3} \qquad 5$$

where

w_3^{st} is the mass of lobsters of age 3 (i.e. in December during the spawning season).

In order to work with estimable parameters that are more meaningful biologically, the stock-recruitment relationship is re-parameterised in terms of the pre-exploitation equilibrium spawning biomass, K^{sp}, and the “steepness”, *h*, of the stock-recruitment relationship, which is the proportion of the virgin recruitment that is realized at a spawning biomass level of 20% of the virgin spawning biomass:

$$\beta = \frac{\left(K^{sp}\right)\left(1-5h0.2\right)}{5h-1} \qquad 6$$

and

$$\alpha = \frac{\beta + \left(K^{sp}\right)}{SPR_{virg}} \qquad 7$$

where

$$SPR_{virg} = w_3^{st} N_3^{virg} \qquad 8$$

with

$$N_1^{virg} = 1 \qquad 9$$

$$N_a^{virg} = N_{a-1}^{virg} e^{-M_{a-1}} \qquad \text{for } 2 < a \le m \qquad 10$$

Total catch and catches-at-age

The catch by mass in year *y* is given by:

$$C_y = w_1^{land} N_{y,1} e^{-3M_a/4} S_{y,1} F_y^{1+} + w_2^{mid} N_{y,2} e^{-M_a/2} S_{y,2} F_y^{2+} \qquad 11$$

Where

w_a^{land} denotes the mass of lobsters of age *a* that are landed at the end of the third quarter,

w_a^{mid} denotes the mid-year mass of lobsters of age *a*,

$S_{y,a}$ is the commercial selectivity (i.e. vulnerability to fishing gear) at age *a* for year *y*; and

F_y is the fished proportion (of the 1+ and 2+ classes) of a fully selected age class.

The model estimate of the exploitable ("available") component of biomass is calculated by converting the numbers-at-age into mass-at-age (using the individual weights of the 1+ lobsters assumed landed at the end of the third quarter, and the 2+ lobsters assumed landed at midyear):

$$B_y^{ex,1+} = w_1^{land} S_{y,1} N_{y,1} e^{-3M_a/4} \quad (12)$$

$$B_y^{ex,2+} = w_2^{mid} S_{y,2} N_{y,2} e^{-M_a/2} \quad (13)$$

and hence:

$$B_y^{ex} = B_y^{ex,1+} + B_y^{ex,2+} \quad (14)$$

The catch by mass for the trawling sector is calculated separately as is assumed to target 2+ lobsters only. The exploitable component of biomass for this sector is thus based on Equation (13) only and assumes full selectivity of the 2+ age group.

The model estimates of the midyear numbers of lobsters are:

$$N_y^{mid} = N_{y,1} e^{-M_1/2} + \left(N_{y,2}\, e^{-M_2/2} - C_{y,2}\right) \quad (15)$$

i.e.

$$N_{y,1}^{mid} = N_{y,1} e^{-M_1/2} \quad (16)$$

$$N_{y,2}^{mid} = N_{y,2}\, e^{-M_2/2} - C_{y,2} \quad (17)$$

Similarly, the model estimate of numbers for comparison with the Pre-Season November survey are as follows:

$$N_{y,1}^{pre} = \left(N_{y,1} e^{-3M_1/4} - C_{y,1}\right) e^{-M_1/6} \quad (18)$$

$$N_{y,2}^{pre} = N^{mid}{}_{y,2}\, e^{-5M_2/12}$$ 19

The proportion of the 1+ and 2+ age classes harvested each year (F_y^{1+}) are given respectively by:

$$F_y^{1+} = C_y^{1+} \;/\, B_y^{exp,1+}$$ 20

$$F_y^{2+} = C_y^{2+} \;/\, B_y^{exp,2+}$$ 21

where C_y^{1+} and C_y^{2+} are the catch by mass in year *y* for age classes 1 and 2, such that:

$$C_y^{1+} = p_{y,1+} C_y$$ 22

and

$$C_y^{2+} = \left(1 - p_{y,1+}\right) C_y$$ 23

with $p_{y,1+}$ representing the 1+ proportion of the total catch.

Given different fishing proportions for the two age classes, the numbers-at-age removed each year from each age class can be computed from:

$$C_{y,1} = S_{y,1} F_y^{1+} N_{y,1} e^{-3M_a/4}$$ for $a = 1$, and 24

$$C_{y,2} = S_{y,2} F_y^{2+} N_{y,2} e^{-M_a/2}$$ for $a = 2$ 25

The fully selected fishing proportion (*F*) is related to the annual fishing mortality rate (*F**) as follows:

$$1 - F = e^{-F^*}$$ 26

Initial conditions

Although some exploitation occurred before the first year for which data are available for the lobster stock, this is considered relatively minor and hence the stock is assumed to be at its pre-exploitation biomass level in the starting year and hence the fraction (θ) is fixed at one in the analysis described here:

$$B_{y_0}^{sp} = \theta \cdot K^{sp}$$ 27

with the starting age structure:

$$N_{y_0,a} = R_{start} N_{start,a}$$ for $1 \le a \le m$ 28

where

$$N_{start,1} = 1$$ 29

$$N_{start,a} = N_{start,a-1} e^{-M_{a-1}} \qquad \text{for } 2 \le a \le m-1 \qquad 30$$

C.3 The (penalised) likelihood function

Model parameters are estimated by fitting to survey abundance indices, commercial and survey catch-at-age data as well as standardised CPUE data (Campbell et al. 2015). A penalty function is included to permit estimation of residuals about the stock-recruitment function. Contributions by each of these to the negative of the log-likelihood (- ℓnL) are as follows.

Survey abundance data

The same methodology is applied for the midyear and pre-season surveys, except that for the former there are indices for both the total 1+ and 2+ numbers, whereas for the pre-season the model is fitted to 0+ and 1+ numbers but not the 2+ lobsters as most of the older lobsters will have migrated out of the region by November. The likelihood is calculated assuming that the observed midyear (and pre-season) survey abundance index is log-normally distributed about its expected value:

$$I_y^i = \hat{I}_y^i \exp\left(\varepsilon_y^i\right) \quad \text{or} \quad \varepsilon_y^i = \ell n\left(I_y^i\right) - \ell n\left(\hat{I}_y^i\right) \qquad 31$$

where

I_y^i is the scaled survey abundance index for year *y* and series *i*,

$\hat{I}_y^i = \hat{q}_s \hat{N}_y^{survey}$ is the corresponding model estimate, where $\hat{N}_y^{survey}$ is the model estimate of midyear numbers, given by equation 16 and 17 for the midyear survey, and for the pre-season survey it is given by equation 18.

$\hat{q}_s$ is the constant of proportionality (catchability) for the survey, and

ε_y^i from $N\left(0, \left(\sigma_y^i\right)^2\right)$.

The contribution of the survey data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-\ell n\, L^{Surv} = \sum_i \sum_y \left[\ell n\left(\sigma_y^i\right) + \left(\varepsilon_y^i\right)^2 / 2\left(\sigma_y^i\right)^2\right] \qquad 32$$

where $\left(\sigma_y^i\right)^2 = \ln\left(1 + \left(CV_y\right)^2\right)$ and the coefficient of variation (CV_y) of the resource abundance estimate for year *y* is input.

The survey catchability coefficient $\hat{q}_s$ is estimated by its maximum likelihood value:

$$\ell n\, \hat{q}_s = 1/n_i \sum_y \left(\ln I_y^i - \ln N_y^{ex}\right) \quad 33$$

CPUE abundance series – variance estimated

In this case the standard deviation of the residuals for the logarithms of abundance series *i* is assumed to be independent of *y*, and is estimated in the fitting procedure by its maximum likelihood value:

$$\hat{\sigma}^i = \sqrt{1/n_i \sum_y \left(\ln I_y^i - \ln \hat{I}_y^i\right)^2} \quad 34$$

where n_i is the number of data points for the abundance series corresponding to sector *i*.

The catchability coefficient q^f for fleet *f*'s abundance index is estimated by its maximum likelihood value:

$$\ell n\, \hat{q}^f = 1/n_i \sum_y \left(\ln I_y^i - \ln \hat{B}_y^{ex}\right) \quad 35$$

Commercial catches-at-age

The contribution of the catch-at-age data to the negative of the log-likelihood function under the assumption of an "adjusted" lognormal error distribution is given by:

$$-\ell n\, L^{CAA} = \sum_y \sum_a \left[\ell n\left(\sigma_{com} / \sqrt{p_{y,a}}\right) + p_{y,a}\left(\ell n\, p_{y,a} - \ell n\, \hat{p}_{y,a}\right)^2 / 2\left(\sigma_{com}\right)^2 \right] \quad 36$$

where

$p_{y,a} = C_{y,a} / \sum_{a'} C_{y,a'}$ is the observed proportion of lobsters caught in year *y* that are of age *a*,

$\hat{p}_{y,a} = \hat{C}_{y,a} / \sum_{a'} \hat{C}_{y,a'}$ is the model-predicted proportion of lobsters caught in year *y* that are of age *a*, where

$$\hat{C}_{y,1} = N_{y,1}\, e^{-3M_a/4}\, S_{y,1}\, F_y^{1+} \quad 37$$

$$\hat{C}_{y,2} = N_{y,2}\, e^{-M_a/2}\, S_{y,2}\, F_y^{2+} \quad 38$$

and

σ_{com} is the standard deviation associated with the catch-at-age data, which is estimated in the fitting procedure by:

$$\hat{\sigma}_{com} = \sqrt{\sum_y \sum_a \left(\ell n\, p_{y,a} - \ell n\, \hat{p}_{y,a}\right)^2 / \sum_y \sum_a 1} \qquad 39$$

The same approach is applied when fitting to the historic catch proportion data.

Survey catches-at-age

The survey catches-at-age are incorporated into the negative of the log-likelihood in an analogous manner to the commercial catches-at-age, assuming an adjusted log-normal error distribution (equation 25) where:

$p_{y,a} = C^{surv}_{y,a} / \sum_{a'} C^{surv}_{y,a'}$ is the observed proportion of lobsters of age *a* in year *y*,

$\hat{p}_{y,a}$ is the expected proportion of lobsters of age *a* in year *y* in the survey, given by:

$$\hat{p}_{y,a} = N_{y,a} \Big/ \sum_{a'=1}^{2} N_{y,a} \qquad 40$$

Benchmark Survey Estimates of Absolute Abundance

The absolute abundance of lobsters is estimated by fitting to data from two benchmark midyear surveys. The total 2002 population estimate, together with 95% confidence interval, was T_{89} = 9.0 (±1.9) million lobsters, and for 1989, T_{89} = 14.0 (±2.9) million lobsters (Pitcher et al. 1992). The 2+ year class was estimated at 1.77 (±0.38) million in 2002, and the 1+ year-class was at 5.2 (±1.5) million.

The approach is similar to that described above for the survey relative abundance index. The contribution of the survey data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-\ell n\, L^{Bench} = \ell n\left(\sigma_{89}\right) + \left(\varepsilon_{89}\right)^2 / 2\left(\sigma_{89}\right)^2 + \ell n\left(\sigma_{02}\right) + \left(\varepsilon_{02}\right)^2 / 2\left(\sigma_{02}\right)^2 \qquad 41$$

where $\varepsilon_{89} = \ell n\left(T_{89}\right) - \ell n\left(\hat{N}^{mid}_{1989,1} + \hat{N}^{mid}_{1989,2}\right)$;

$\varepsilon_{02} = \ell n\left(T_{02}\right) - \ell n\left(\hat{N}^{mid}_{2002,1} + \hat{N}^{mid}_{2002,2}\right)$; and

$\left(\sigma_y\right)^2 = \ln\left(1 + \left(CV_y\right)^2\right)$ and the two coefficients of variation (CV_{89} and CV_{02}) are input.

Stock-recruitment function residuals

The stock-recruitment residuals are assumed to be log-normally distributed and serially correlated. Thus, the contribution of the recruitment residuals to the negative of the (now penalised) log-likelihood function is given by:

$$-\ell nL^{pen} = \sum_{y=y1+1}^{y2}\left[\left(\frac{\lambda_y - \rho\lambda_{y-1}}{\sqrt{1-\rho^2}}\right)^2 \Big/ 2\sigma_R^2\right] \qquad 42$$

where

$\lambda_y = \rho\lambda_{y-1} + \sqrt{1-\rho^2}\,\varepsilon_y$ is the recruitment residual for year *y*, which is estimated for year *y*1 to *y*2 (see equation 4),

ε_y from $N\left(0,(\sigma_R)^2\right)$,

σ_R is the standard deviation of the log-residuals, which is input, and

ρ is the serial correlation coefficient, which is input.

Base-case assumes $\rho = 0$.

C.4 Model parameters

A summary of fixed inputs and model-estimated parameters and management quantities are provided in Apx Table C-1. Natural mortality (M_a) is generally taken to be age independent and is estimated in the model fitting process. The commercial fishing selectivity is taken to differ over the 1973-2002 and 2002+ periods. Full selectivity of the 2+ class is assumed, with a separate selectivity parameter being estimated for each period for the 1+ class.

Apx Table C-11. Summary of lobster climate impacts (from Norman-Lopez et al., 2013).

		Colours = Risk: High, Red; Med, Yellow; Low, Green; None, Grey.	Global trajectory available. Could use latest BlueLink product, 2060s only. Is there more? Downscaling from GCMs could also be done. See what Suppiah Ramsamy is producing for TSRA. [2030: +1 deg C; 2100: +3 deg C]	Global trajectory available. Downscaled info available from Mataer - reservations about coastal component. High variability in coastal zone. Still will decline. Important to look at coastal influence. Fly river run-off in northern TS will lessen buffering effect. [2030: very small; 2100: -0.25 pH];	Increase on a fairly predictable basis. TS and NEC show no deviation from global predictions. 5-15 cm by 2030 and 18-82 cm by 2100. [2030: +10 cm; 2100: +40 cm]
		Likelihood/Probability ->	2030: 80%	2030: 50%	2030: 80%
		Fishery Jurisdictions - differentiation ->	PNG: High; Aust: High; NEC: Mod	PNG: Mod; Aust: Mod; NEC: Low	No differentiation
Life stage	**Lobster Component**	**Description and available Information**	**SST**	**Acidification**	**SL**
Juvenile (pre-maturation moult). Includes all lobsters in Torres Strait, and inshore lobsters on the NEC	**Growth**	Growth for lobster in TS has been established from tag-recapture data and size frequencies. Lobsters have rapid growth, entering the fishery at 1 .2 years old and migrating out of TS at about 2.5 y.o. Lobsters in NW TS appear to grow more quickly than SE TS - can we quantify this difference.	Warmer temperatures mean faster growth - up to a point where physiological tolerance is reached. May be some info in literature. In TS, growth was lower in the SE than the NW, k=0.44 and 0.573 resp, and SST=25.7 and 27.1 resp. Assume K changes and not Linf? and change is proportional = 0.095k/1 deg C. Check literature for upper range of growth response. [2030: k(new) = 1.095 k(current); MLS (90 mm CL) reached 3-4 months earlier, 2+ lobsters in May 5-10% larger (CL). 2100: k(new) = 1.285 k(current) (if no physiological threshhold reached); MLS reached 4-7 months earlier; 2+ lobsters in May 10-20% larger (CL)]	Assume some physiological stress - higher energy/metabolic cost to calcification and maybe some other metabolic stress. This would decrease growth. Check literature. In shrimp, growth uneffected at 1000 ppm, but morphology (2nd antennae shorter) effected (Kurihara 2008). [2030: very small effect; 2100: small effect]	None
	Mortality	Known from stock assessment model. No spatial or temperature variabilty data available? Model mortality = 0.82	Uncertain. 1. General relationship between temperature and mortality rate. Higher SST means higher mortality. 2 Predation pressure reduced due to faster growth would lower mortality rate 3. Physiological threshold could result in higher mortality rate. 4. Disease and parasites could be more prevelent in higher temp, and with additional stress from other factors. [2030: probably small increase (5%); 2100: Could be significant increase depending on physiological thresholds]. PNG>Aust>NEC	Some evidence that morphological changes at 1000 ppm that could effect survivorship. [2030: little effect; 2100: potentially higher M)	None
	Movement and Distribution.	Related to migration behaviour and growth and changes to habitats. Generally there is an inshore to offshore movements, though in Torres Strait this is more complicated. Happens on the east coast at about 1 yo.	Could mean earlier migration of juveniles from settlement reefs. This could mean increase in deeper water populations of juveniles (see WA lobster paper). This could increase fishing pressure on younger lobsters. Strong migration pattern on the NEC, but has lowest SST change, so dificult to rank regions - presume no differentiation.	Could be some impact through sensory organ disruption. Probably little impacton lobsters as water temp and day length and size main controling factors.	Shallow reef tops may become more available for lobster habitat, however, only represents small proportion of habitat.
	Habitat: coral	Coral reefs provide some habitat for rock lobsters in Torres Strait, though mostly they live in intereefal areas. What is the proportions here. 1 y.o. lobsters generally live in inshore reefs and 2 y.o. lobsters live in offshore reefs.	Widescale coral bleaching. Greatest impact on lobsters will be related to loss of structure, which will happen with bleaching. Shallow reefs more vulnerable. Most lobsters in deeper water therefore small overall impact. [2030: small increase in habiat related mortality (lack of shelter) Mortality increased <5% overall ; 2100: widespread coral reef degredation, mortality increased 5-10%] PNG>Aust.>NEC	Less coral, other ecosystem changes, potentially less molluscs and crustaceans, but other food maybe more available. Uncertain. Possible small impacts, lobsters have a wide habitat tolerance. [2030: very small ; 2100: moderate impact - bleaching will get croal first] PNG>Aust.>NEC	Reef tops flooded. Unlikely to impact on lobster living on coral reefs
	Habitat: seagrass	Important settlement habitat for juveniles	Shallow seagrass especially probably negatively impacted by increased SST. Settling lobsters rely more on subtidal seagrass for habitat. [2030: small impact on settling juveniles - recruitment decreased by 5-10%; 2100: significant impact on shallow, but low impact on settling lobsters] PNG>Aust.>NEC	Positive impact. Seagrass more productive. May have small positive flowon impact on juvenile lobsters. PNG>Aust.>NEC	Some shift in distribution driven by light and species niches. More habitat on shallow reefs and banks. Small impact on lobsters as most settle on deeper intertidal seagrass.
	Habitat: benthos	Very important habitat for most lobsters in Torres Strait			
Adult. In TS, short life history stage between maturation moult and breeding mortality. On the NEC may last several years after maturation moult.	**Growth**	Only applies to lobsters on the NEC. Not much known about growth of adult lobsters. Probably slow growing but some "jumbo" lobsters make up NEC fishery.	Warmer temperatures mean faster growth - up to a point where physiological tolerance is reached. [2030: Adult lobsters 5-10% larger on NEC; 2100: 10-20% larger (if no physiological threshhold reached)] NEC>>>Aust., PNG	Probably not a problem for larger, deeper adults.	N\A
	Mortality	Lobsters from Torres Strait have very high mortality with most dieing after breeding. NEC lobsters survivie longer but little known.	Will not impact either mortality type. TS lobsters very high mortality in any case, and NEC lobsters deep and lower SST changes.	Little impact on adult lobster.	N\A
	Movement: breeding migration	Generally all females and most females migrate in August-September each year. In Torres Strait, this migration includes very long migrations into the GoP. On the NEC, probably involves movement to offshore reefs to spawn and some movement back to midshelf reefs after spawning.	Threshold temperature for migration stimulus. Generally after winter minimum. Could be absolute or rate change. Some data available. Model future temperature for 2060 to compare with current. Could mean earlier migration; longer migration period. May miss migration stimulus if minimum SST threshhold required.	Little impact on adult lobster.	N\A
	Reproduction	Mating and spawning take splace over summer. Females may reproduce up to three times. Older females are highly fecund.	Faster growth, bigger lobsters = increased fecundity. Spawning stimulus: earlier timing; longer reproductive season. [2030: small increase in egg production (10%); 2100: larger increase in egg production (20%)] No diff.	Can effect egg viability. Eggs very sensitive to acidification. Reduction in larval production. [2030: small change; 2100: moderat change] No diff.	N\A
Larvae (Coral Sea) Larval stage 6 months, feeding, several stages. Coral Sea gyre returns larvae to settling gorounds in 6 month interval. No differentiation between regions - same gyre system.	**Growth**	Several stages phylosoma, and terminal peurulus. Feed on small zooplankton.	Higher temps mean faster growth, depending on physiological tolerences. Development timing faster (not bigger).	Probably no great changes to growth up to high changes in pH. [2030: small impact; 2100: small impact]	N\A
	Mortality	Very few reach peurulus stage.	Higer temps mean higher mortality (generally), though interactions with other factors (ie higher phytoplankton). Some data from aquaculture studies suggests physiological thresholds. Reduce larval survival by 5%	Decrease in larval fitness with modeerate to high changes in pH. [2030: small impact; 2100: large impact]	N\A
	Trajectory	Coral Sea gyre with 6 month rotation.	N\A	N\A	N\A

		Within Torres Strait, largely driven by phase differences between Coral Sea and Arafura Sea, and wind fields during monsoons. Large internal tidal currents and westerly set during winter and easterly set during summer. Pattern appears to be stable form BlueLink predictions.	SEC forms Coral Sea gyre and start of EAC. EAC predicted to strengthen by 20% by 2100 driven by latitudinal shift in the westerly wind fields. Check BlueLink simulation. Wayne could produce seasonal average vector diagrams. [2030: +5%; 2100: +20%]	Uncertain. Increasing intensity but probably not frequency. No evidence of latitudal shifts in cyclones. [2030: small; 2100: high]	Mataer. Simulations for productivity. Coming from a low base, up to 100% increased productivity in the Coral Sea by 2050. [2030: 50%-100%; 2100: 100%-150%]	Uncertain. Changes in rainfall will affect runoff and salinity. Maybe 50% decrease by 2100 CHECK. Some studies have shown little freshwater incursion into southern TS. Linked to ENSO. [2030: ?; 2100: -50%]	
			2030: 10%	2030: 20%	2030: 40%	2030: 20%	
		No differentiation	N\A	PNG: Low; Aust: Low; NEC: Mod	No differentiation	PNG: High deline; Aust: Low; NEC Low	
Life stage	**Lobster Component**	**Currents, Torres Strait**	**Currents, oceananic**	**Storms and Cyclones**	**Phytoplankton productivity**	**Rainfall**	**Total impact**
Juvenile (pre-maturation moult). Includes all lobsters in Torres Strait, and inshore lobsters on the NEC	**Growth**	None	N/A	None	Could cause increases in benthic productivity in juvenile habitat, which would lead to faster growth.	None	Probably increased growth as SST effect only significant impact. However threshold values need considering. [2030: MLS (90 mm CL) reached 3-4 months earlier; 2100: MLS reached 4-7 months earlier (if no physiological threshhold reached)] [2030: 2+ lobsters in May 5-10% larger (CL); 2100: 2+ lobsters in May 10-20% larger (CL) (if no physiological threshhold reached)] (Overall impact PNG>Aust.>NEC)
	Mortality	None	N/A	Potentially through juvenile habitat impacts, particularly on the NEC.	Probably nothing	Probably little impact. Any current impacts will lessen. If changes occur, slight decrease in mortality in PNG mostly. CHECK LITERATURE	[2030: probably small increase; 2100: Could be significant increase depending on physiological thresholds to temperature, acidity, and habitat destruction on the NEC. Less stressful low salinity in PNG]. PNG>Aust, NEC
	Movement and Distribution.	None	N/A	Potential habitat destruction particularly for juvenile habitat (seagrass, inshore reefs). NEC>>Aust, PNG	Probably little impact	Little impact	Changed migration patterns with increase in deeper water populations of juveniles. This could increase fishing pressure on younger lobsters. NEC>Aust., PNG
	Habitat: coral	No change	N/A	More descructive events on NEC in particular. Greatest impact on inshore juvenile reefs. [2030: small; 2100: high] NEC>Aust., PNG	little impact	Lower turbidity on inshore reefs. May ameliorate bleaching impact in high turbidity zones.	Reefs will change siugnificantly due to bleaching and acidification. Less habitat for juveniules in inshore reefs. [2030: Little change; 2100: Significant impacts through coral less in shallow reefs]. PNG>Aust.> NEC
	Habitat: seagrass	No change	N/A	More descructive events on NEC in particular. Greatest impact on inshore juvenile seagrass beds [2030: small; 2100: high] NEC>Aust., PNG	N\a	Potentially benefit seagrass. Dieback events common, partic in PNG. This has a positive impact on PNG lobster habitat. PNG>>Aust.,NEC	PNG: Negative shallow seagrass (temp), positive deeper waters (acid, rainfall). > NEC: Negative shallow seagrass (cyclones), positive deeper waters (acid). > Aust.: shallow negative (temp), positive deeper (acid). Overall positive effect on lobsters, with largest change positive impact on depper water PNG seagrass beds.
	Habitat: benthos		N/A				
Adult. In TS, short life history stage between maturation moult and breeding mortality. On the NEC may last several years after maturation moult.	**Growth**	N\A	N\A	Deeper, protected from storm events.	N\A	N\A	Potently larger, faster growth on NEC only.
	Mortality	N\A	N\A	Deeper, protected from storm events.	N\A	N\A	Little impact
	Movement: breeding migration	N\A	N\A	N\A	N\A	N\A	Potentially changes in timing and strength of migration stimulus. Difficult to assesss impact without knowledge of individual stimulus thresholds.
	Reproduction	N\A	N\A	N\A	N\A	N\A	Balance between positive SST effect and negative Acid. Effect [2030: Slight benefit (SST); 2100: Possible negative (Acid).
Larvae (Coral Sea) Larval stage 6 months, feeding, several stages. Coral Sea gyre returns larvae to settling gorounds in 6 month interval. No differentiation between regions - same gyre system.	**Growth**	N\A	N\A	N\A	Generally will mean more small zooplankton and therefore, faster growth. Faster development through larval stages. [2030: moderate imact; 2100: larger impact]	N\A	Positive impact from higher SST and productivity, given small acidity impact, especially by 2030, but with acidity negative impact maybe kicking in by 2100. [2030: moderate increase; 2100: small increase (balance food v acid)]
	Mortality	N\A	Shorter duration gyre rotation may decease overall mortality. [2030: small impact; 2100: potentially moderate impact]	Some probability of higher mortality due to large cyclones in Coral Sea, but only small effect.	Reduced mortality with more food, but higher predation from more predators (fish). Bigger size, faster development reduced mortality. All factors probably maintain status quo [2030: small	N\A	On balance, small positive impact from productivity by 2030, balanced by SST and acidity (uncertain) related mortality by 2100. [2030: small positve impact; 2100: status quo with acidification impact negating futher productiviy increases]
	Trajectory	N\A	No change in delivery trajectory	Maybe some changes in trajectory due to cyclones in Coral Sea, but change very small.	N\A	N\A	No change

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Torres Strait rock lobster (TRL) 2018 stock assessment

AFMA Project 2016/0822

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DRAFT REPORT FOR TRLRAG, FEBRUARY 2019

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Acknowledgments

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Non-technical summary

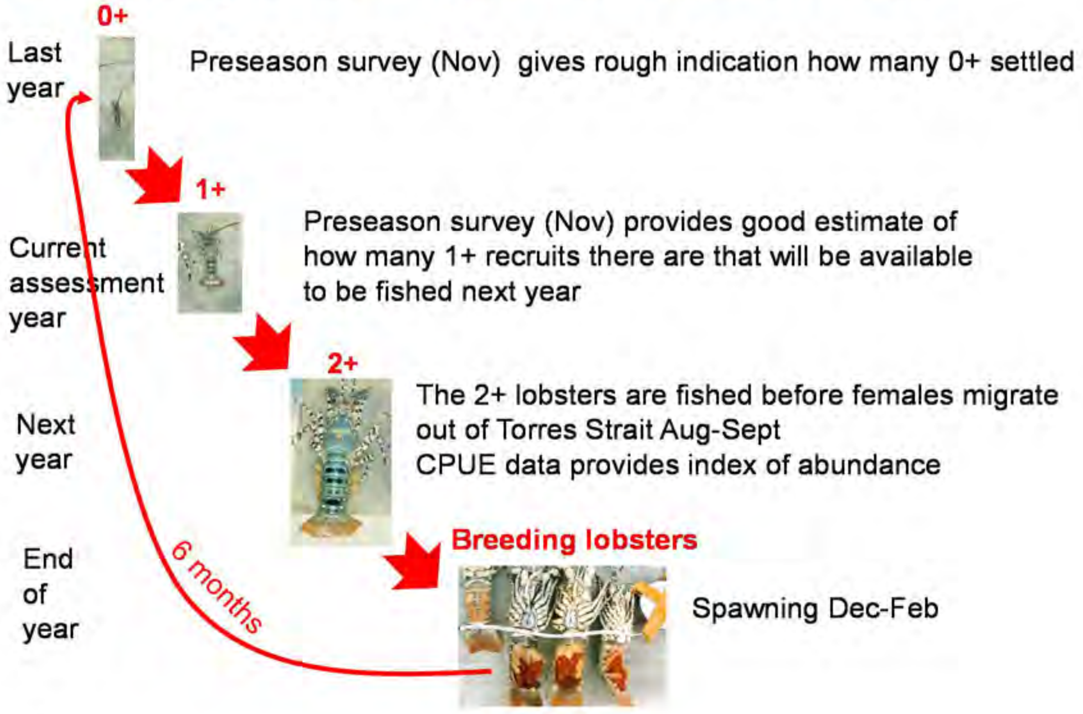
The TRL integrated stock assessment model was again used to inform an RBC for the 2019 fishing season. The TRLRAG agreed that if the fishery transitions to using an empirical Harvest Control Rule (eHCR) (see Plaganyi et al. 2018) to inform the Recommended Biological Catch (RBC), then the stock assessment would only need to be conducted every three years. However until such time as this is formally adopted, the stock assessment model is being used to inform the RBC.

The full details of the stock assessment model are provided in this report. A schematic summary of the model and inputs used to inform on trends in the abundance of the different age classes is given at the end of this summary. The data updates include the latest (Nov 2018) pre-season survey results, the catch total for 2018, and revisions and updates to the commercial CPUE (TVH & TIB) data series. The Reference case model presented here is fitted to the TVH CPUE Main Effects Int1 option and the standardised Seller CPUE TIB series.

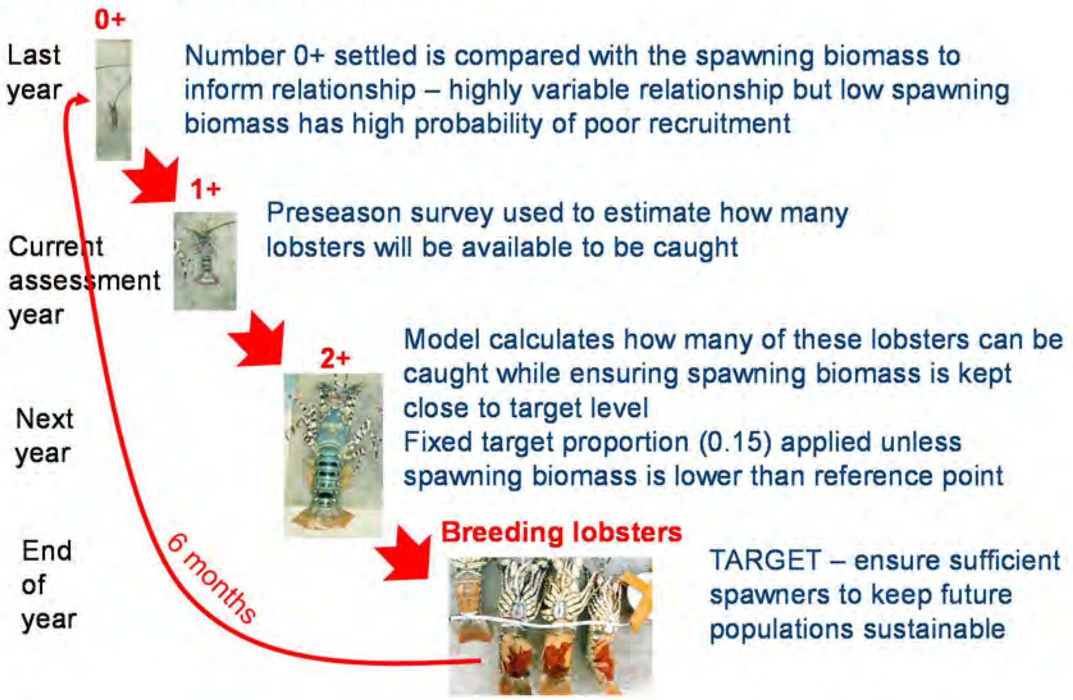
The model predictions for the 2019 fishing season are considerably more optimistic than was the case for the 2018 fishing season because the 2018 preseason survey 1+ index, was slightly above the average level. At the December 2018 meeting it was noted that there was a conflict among the input abundance data in the model, the 2017 0+ survey observation which was notably less than the average and the corresponding 2018 1+ index (i.e. the numbers of 0+ animals that survived the year), and that the survey was not fitting the 1+ index satisfactorily. Whilst we cannot rule out variation in 2017 0+ pre-season survey observations due to fewer sample sites in recent years (77 c.f. > 150 historically), comparable 0+ counts for 2014 and 2015 (yet fewer sites surveyed in 2015) suggest that other processes are also contributing to changes of the magnitude seen in 2017. The model was fitted to the preseason survey index based on midyear sites only. There was agreement that the 2017 0+ observation was likely due to process error for reasons outlined in an earlier document. This means that in addition to the estimated input survey CVs (error in the survey observations), there is additional unmodelled variation in the observation process, such as changes in catchability over time (for a survey this is equivalent to how “observable” the animals are), or environmental changes influencing recruitment of 0+ lobsters (e.g. where and when they settle). Additional work was therefore done to determine the most defensible approach for resolving the conflict in the model, with these analyses outlined in detail in accompanying papers. Based on the updated analyses, the stock assessment model was updated and this report summarises the updated results as a basis for informing management.

Note that some updates to the catch data for 2018 were also made and this has been included in the updated assessment, noting that it is likely that only a small quantity of the Australian total catch records for 2018 are still outstanding. There may also be a small under-estimate of total catches from PNG but this should not have a major effect on the current model outputs.

Summary of Life Cycle and Assessment



Assessment Basics



1. Updated Assessment of the Tropical Rock Lobster (*Panulirus ornatus*) Fishery in Torres Strait following November 2018 Preseason survey

1.1 Summary

This document summarises the post-Nov 2018 preseason survey update of the integrated stock assessment model presented at the December 2018 TRLRAG, with subsequent updated conducted for the February 2019 TRLRAG. The TRLRAG agreed that if the fishery transitions to using an empirical Harvest Control Rule (eHCR) to inform the Recommended Biological Catch (RBC), then the stock assessment would only need to be conducted every three years. However until such time as this is formally adopted, the stock assessment model is being used to inform the RBC for the tropical rock lobster *Panulirus ornatus*.

The data updates include the latest (Nov 2018) pre-season survey results, the catch total for 2018 including revisions which became available since the December 2018 RAG meeting and revisions and updates to the commercial CPUE (TVH & TIB) data series. The full details of the stock assessment model are provided in this report.

The model predictions for 2019 are much more optimistic than the previous season because they are based mostly on the preseason survey 1+ index, which is appreciably higher than the previous year when it was the lowest of the series to date. Note that the model results presented here are fitted to the preseason survey index based on midyear sites only. A number of alternative sensitivity tests were presented at the December 2018 RAG meeting and are not repeated here.

The model fit to the 2018 1+ Preseason survey data was not considered satisfactory, largely due to a conflict with the 0+ index for 2017. However the TRLRAG agreed that the 0+ index is likely to have been subject to substantial process error and thus not strictly comparable with other values because of anomalous changes that year in environmental factors in turn changing population processes such as where and when juveniles settle. Additional work was therefore done to determine the most defensible approach for resolving the conflict in the model, with these analyses outlined in detail in accompanying papers. Additional analyses were also done to test for the effect of other factors (such as dive team composition and current strength) that may have influenced the index and these analyses are also described in accompanying papers. Based on the updated analyses, the stock assessment model was updated and this report summarises the updated results as a basis for informing management.

The model reasonably fits the recent CPUE series for both sectors, although the observed 2018 CPUE for both sector is slightly higher than the expected values, even after accounting for hyperstability. This is not surprising given the detailed analyses as described in papers discussed by the TRLRAG in 2018 (when fishing was capped for the first time at a low TAC amount of 299t) and the TRLRAG has recommended that a data meeting be held to further assess any changes in the fishing patterns and technological methods (fishing power) used. Results presented at the December 2018 RAG also suggested the model fit could be improved by estimating rather than fixing the CPUE hyperstability parameters in the model. As before, the model is unable to satisfactorily fit the 2015 CPUE data for TIB and TVH sectors. The potential reasons for this are discussed in more detail in Plagányi et al. (2015a,b). It is highly plausible that anomalous environmental changes have caused a change in catchability in 2015, but there is also likely to have been an impact of changes in lobster habitat on their survival and productivity, but there are no data available to assist in separating the effect of changes in catchability and survival on the overall catches for 2015 (noting that the total catch was higher than initially expected due to trawling catches). The model assumes constant annual natural mortality, and hence cannot straightforwardly model the change in catchability and/or survival without additional information, and hence the Reference Case model has not included any *ad hoc* adjustments, but these have been further investigated via sensitivity analyses (not presented in detail in this document).

The Reference case model presented here is fitted to the TVH CPUE Main Effects Int1 option and the standardised Seller CPUE TIB series. There isn't much difference between the alternative CPUE standardisations except for recent differences between the Main and Seller series for TIB.

The December 2018 RAG advice was " to apply a statistically calculated down-weighting to the 2017 0+ index, the RAG noted that the final RBC would likely lie somewhere between 533 and 637 tonnes. A final RBC value will not be available until the February 2019 TRL RAG meeting" and a revised Reference case to be developed "using an appropriate statistical methodology" (TRLRAG25 Meeting Minutes). This document has therefore selected a revised Reference Case that includes estimation of Additional Variance for all 0+ survey observations. This document presents full results for this illustrative case as well as summary results for other variants, with the final choice of model version to be used to inform the RBC to be finalised at the forthcoming TRLRAG meeting, and hence note that the final RBC may differ from the revised reference case value presented here.

The revised reference case model suggests a RBC (2019) of 641t [90% CI 426-857t]. Using the revised reference case, the stock is currently estimated to be at 46% of the pristine (1973) spawning biomass level (K). Previous analyses forewarned that the 2018 spawning biomass may be lower than average and provides support for the management decisions taken in 2018 to limit catches so that sufficient lobsters would remain for spawning purposes and subsequent recruitment to the fishery in 3 years' time. Fortunately the good 1+ numbers observed in the most recent survey means that the model spawning biomass projection for the following year is once again much more positive. The very large inter-annual variability in the stock has long been recognised. Hence it is entirely plausible that the current lobster stock have been boosted by good recruitment, however we suggest ongoing monitoring of 2019 catch and the next survey observations will be prudent.

1.2 Introduction

A new stock assessment model (termed the "Integrated Model") (Plagányi *et al.* 2009) was developed in 2009 for the following reasons:

- the new model facilitates the move to a quota management system, in that it integrates all available information into a single framework to output a RBC;
- the new model addresses all of the concerns highlighted in a review of the previous stock assessment approach (Bentley 2006, Ye et al. 2006, 2007);
- the new model incorporates the Pre-Season survey data as well as CPUE data available from the TVH sector;
- the growth relationships used in the model were revised;
- the new model is of a form that could be used as an Operating Model in a Management Strategy Evaluation (MSE) framework, given that the need for a MSE to support the management of the TRL fishery was identified by the TRL RAG.

In addition, in response to review comments in 2012, the following changes are also implemented:

- there is no lower limit on the sigma parameter associated with fitting to the catch at age information;
- the fitting to the commercial catch-at-age information ignores the years when there are no true data;
- given there are catch-at-age data for the pre-1989 period, recruitment residuals are estimated for all years from 1985.

The model outputs a single RBC (with Confidence Interval) for each year, which is an integrated estimate that takes into account all available sources of information. The Integrated Model is a widely used approach for providing TAC advice with associated uncertainties. More formally, it is a Statistical Catch-at-Age Analysis (SCAA) (e.g. Fournier and Archibald 1982). This paper summarises the revised 2018 model assessment using the 2018 pre-season survey data.

The revised Reference Case includes the following specifications (see Plagányi et al. 2010):

- fitting to the CPUE data assuming a hyperstable relationship (with hyperstability parameter 0.75), and setting a lower bound of 0.15 (value selected by TRLRAG in 2013) to the variance associated with the CPUE data because it is less reliable than the survey data;
- increasing the stock recruit variance parameter from 0.3 to 0.5 to capture larger fluctuations in recruitment;
- estimating a different selectivity for the 1973-1988 period;
- using as the new Reference spawning biomass level the annual biomass of mature lobsters on 1 November each year i.e. at the start of the annual migration period;
- estimating the 2018 recruitment residual;
- the use of historic information to permit estimation of a large recruitment event that is known to have occurred in 1988, the year before the long-term surveys commenced. This is an important development as if this good recruitment is not accounted for in the model, the model tries to reconcile the subsequent dynamics by over-estimating the pristine stock size.

At the December 2018 TRLRAG meeting, there was agreement to use the following specifications in the Reference Case model.

a) Fixed steepness h=0.7

b) Fixed hyperstability parameters for each CPUE series (TVH 0.75; TIB 0.5)
c) Mid-year survey index – after applying mixture model to separate age classes
d) Pre-season survey index – use as Reference MYO (mid-year only) series and same series as in November 2017 without the additional 5 sites added
e) CPUE TVH – Int-1 standardised series (and Int-3)
f) CPUE TIB – Seller standardised series

The model fit to the 2018 1+ Preseason survey data was not considered satisfactory, largely due to a conflict with the 0+ index for 2017. However the TRLRAG agreed that the 0+ index is likely to have been subject to substantial process error and thus not strictly comparable with other values because of anomalous changes that year in environmental factors in turn changing population processes such as where and when juveniles settle. Additional work was therefore done to determine the most defensible approach for resolving the conflict in the model, with these analyses outlined in detail in accompanying papers. Additional analyses were also done to test for the effect of other factors (such as dive team composition and current strength) that may have influenced the index and these analyses are also described in accompanying papers. Based on the updated analyses, the stock assessment model was updated and this report summarises the updated results as a basis for informing management.

1.3 Objectives

This document describes an update of the TRL stock assessment model using the results of the preseason survey conducted in November 2018 and applying an objective statistically-justifiable approach for resolving the conflict between the 2017 0+ and 2018 1+ survey observations.

1.4 Methods

The model details are given in Appendix A of this document. A summary of the input catch data is shown in Table 1-1. Lobster catches (tonnes whole weight) landed in different jurisdictions from 1973 to 2018. Catches comprised of both whole animals and tails have been converted into units of whole mass using the conversion ratio of 1kg tail=2.677 kg live. The historical mid-year survey data are shown in Table 1-2. The latest November 2018 Pre-season survey (Fig. 1-3) is included in the model. The commercial catch-at-age data have been updated and the revised series is shown in Table 1-4.

The model uses the latest revised historical catch estimates. As previously, the trawl catch has been separated from the other catches because of differences in the selectivity / targeting of the trawling sector which was focused predominantly on migrating 2+ lobsters. This is important because in the early years the trawling catch comprised 35 – 90% of the total TRL catch (Table 1-1). If recent trawling catches continue, then the model will need to similarly account for these separately to the total catch.

The TVH CPUE data input series have been revised and updated for the period 1989-2018 and TIB for 2004-2018 (Campbell *et al.* 2018a,b).

The model is fitted to additional historical information as described in Plagányi et al. (2010). An adjustment has been made to the model to allow use of a separate selectivity function to be applied to the period 1973 to 1988, prior to the introduction of a MLS of 100mm TL in July 1988. The model already accounts for the subsequent size limit change to 115mm in 2002. Background information on the above specifications is given in Plagányi et al. (2010) and this document.

The relationship between stock abundance and CPUE was explored, and found to be better represented by a hyperstable relationship, than the assumption that CPUE is proportional to stock abundance (see e.g. Harley *et al.* 2001). Based on additional sensitivity tests that were conducted, the Reference case model therefore uses a power curve with a hyperstability shape parameter of 0.75. This suggests that CPUE remains high while stock abundance declines. This is consistent also with results from considering an ecometric production function approach (Pascoe et al. 2013). In addition, the MSE and production function analyses (Pascoe et al. 2013, Plagányi et al. 2012, 2013) suggested that the TIB CPUE relationship was characterized by a greater degree of hyperstability, and hence the Reference case model uses a power curve with a hyperstability shape parameter of 0.5, and sensitivity to alternative choices of this value were tested but don't have a large effect on model outputs.

Table 1-1. Lobster catches (tonnes whole weight) landed in different jurisdictions from 1973 to 2018. Catches comprised of both whole animals and tails have been converted into units of whole mass using the conversion ratio of 1kg tail=2.677 kg live.

SEASON	TIB	TVH	AUS_DIVERS	AUS_TRAWL	AUS-TOTAL	PNG_DIVERS	YULE_DIVERS	PNG-DIVERS TOTAL	PNG_TRAWL	PNG-TOTAL	TS_TOTAL
1973			0	0	0	54	19	73	562.2	635.2	635.2
1974			0	0	0	75	83	158	107.1	265.1	265.1
1975			0	0	0	62	13	75	214.2	289.2	289.2
1976			0	0	0	48	0	48	262.3	310.3	310.3
1977			0	0	0	72	35	107	131.2	238.2	238.2
1978			296.1	0	296.1	43	3	46	187.4	233.4	529.5
1979			308.5	0	308.5	56	13	69	0	69	377.5
1980			328.4	21	349.4	94	3	97	588.9	685.9	1035.3
1981			495.1	131	626.1	96	3	99	262.3	361.3	987.4
1982			669.2	201	870.2	102	3	105	398.9	503.9	1374.1
1983			432.9	139	571.9	86	0	86	112.4	198.4	770.3
1984			330.9	8	338.9	86	0	86	29.4	115.4	454.3
1985			537.4	24	561.4	187	16	203	0	203	764.4
1986			890.6	21	911.6	198	62	260	0	260	1171.6
1987			622	0	622	128	54	182	0	182	804.0
1988			537.4	0	537.4	150.0	5	155.0	0.0	155.0	692.4
1989			651.0	0	651.0	211.0	24	235.0	0.0	235.0	886.0
1990			490.1	0	490.1	158.0	0	158.0	0.0	158.0	648.1
1991			444.100	0	444.100	168.0	0	168.0	0.0	168.0	612.1
1992			423.200	0	423.200	134.0	0	134.0	0.0	134.0	557.2
1993			505.700	0	505.700	166.0	0	166.0	0.0	166.0	671.7
1994		120.061	577.800	0	577.800	247.0	0	247.0	0.0	247.0	824.8
1995		87.022	556.900	0	556.900	257.0	0	257.0	0.0	257.0	813.9
1996		210.872	584.100	0	584.100	228.0	0	228.0	0.0	228.0	812.1
1997		271.449	653.100	0	653.100	241.0	0	241.0	0.0	241.0	894.1
1998		351.396	661.400	0	661.400	201.0	0	201.0	0.0	201.0	862.4
1999		93.563	409.600	0	409.600	163.0	0	163.0	0.0	163.0	572.6
2000		132.374	418.000	0	418.000	235.0	0	235.0	0.0	235.0	653.0
2001	52.000	79.968	131.968	0	131.968	173.0	0	173.0	5.4	178.4	310.4
2002	68.000	147.178	215.178	0	215.178	327.0	0	327.0	42.8	369.8	585.0
2003	123.000	358.799	481.799	0	481.799	211.0	0	211.0	5.4	216.4	698.2
2004	210.381	481.082	691.463	0	691.463	182.0	0	182.0	0.0	182.0	873.5
2005	367.615	549.935	917.550	0	917.550	228.0	0	228.0	0.0	228.0	1145.6
2006	140.451	135.473	275.924	0	275.924	142.0	0	142.0	0.0	142.0	417.9
2007	268.688	268.596	537.284	0	537.284	228.0	0	228.0	0.0	228.0	765.3
2008	185.666	100.437	286.103	0	286.103	221.0	0	221.0	0.0	221.0	507.1
2009	147.813	91.060	238.873	0	238.873	161.4	0	161.4	0.0	161.4	400.3
2010	140.039	282.614	422.653	0	422.653	292.8	0	292.8	0.0	292.8	715.5
2011	199.060	503.534	702.594	0	702.594	165.0	0	165.0	0.0	165.0	867.6
2012	142.380	370.483	512.863	0	512.863	173.7	0	173.7	0.0	173.7	686.6
2013	138.439	361.661	500.100	0	500.100	108.3	0	108.3	0.0	108.3	608.4
2014	196.827	273.214	470.041	0	470.041	151.4	0	151.4	109.8	261.2	731.2
2015	204.659	152.710	357.369	0	357.369	235.7	0	235.7	0.0	235.7	593.1
2016	264.725	243.010	507.735	0	507.735	248.0	0	248.0	0.0	248.0	755.8
2017	117.891	149.738	267.629	0	267.629	113.0	0	113.0	0.0	113.0	380.7
2018	127.010	134.100	261.110	0	261.110	66.6	0	66.6	0.0	66.6	327.7

Table 1-2. Mid-year survey data summary for the period 1989-2014 and 2018. Indices reflect abundance.

Year	Annual	Transects	Age0	SE0	Age1	SE1	Age2	SE2
89	1989	40			1.663	0.243	2.427	0.305
90	1990	40			3.543	0.787	1.643	0.279
91	1991	40			3.953	0.542	1.502	0.343
92	1992	40			5.083	0.765	3.430	0.670
93	1993	37			2.343	0.490	0.774	0.328
94	1994	40			5.644	1.624	1.143	0.304
95	1995	40			3.497	0.591	1.825	0.944
96	1996	40			3.346	0.560	1.175	0.387
97	1997	40			3.970	0.673	1.018	0.248
98	1998	40			1.780	0.431	1.366	0.359
99	1999	40			3.493	0.894	0.467	0.242
00	2000	40			3.063	1.188	0.619	0.224
01	2001	40			1.235	0.246	0.236	0.093
02	2002	73			2.511	0.352	0.819	0.310
03	2003	43			2.829	0.521	2.175	0.640
04	2004	72			2.720	0.411	1.542	0.429
05	2005	71			1.194	0.181	1.957	0.686
06	2006	73	0.231	0.144	5.406	0.933	0.720	0.336
07	2007	70	0.011	0.008	3.833	1.100	1.621	0.536
08	2008	72	0.069	0.048	2.090	0.281	0.964	0.353
09	2009	68	0.034	0.025	3.438	0.523	1.263	0.373
10	2010	67	0.000	0.000	4.165	0.610	1.183	0.300
11	2011	65	0.000	0.000	5.124	0.812	2.243	0.466
12	2012	70	0.000	0.000	5.120	0.907	1.521	0.378
13	2013	66	0.000	0.000	3.024	0.556	1.455	0.454
14	2014	67	0.000	0.000	4.744	0.950	1.351	0.320
15								
16								
17								
18	2018	68	0.094	0.041	3.267	0.666	0.715	0.130

Table 1-3. Pre-season survey index (Midyear-Only (MYO) Sites – see Campbell et al. 2018) for the period 2005-2008 and 2014-2018. Indices reflect relative abundance.

							All-82			All-82			All-82	
Annual	Region	N-Stratum	Area	Fraction	Transects	Age0	Age0	SE0	Age1	Age1	SE1	Age2	Age2	SE2
2005	Total	7	5571500	1.000	71	4.644	4.758	0.946	2.877	2.863	0.519	0.263	0.260	0.097
2006	Total	7	5571500	1.000	74	2.045	2.188	0.49	5.831	5.783	1.243	0.031	0.031	0.024
2007	Total	7	5571500	1.000	75	1.65	1.495	0.384	4.711	4.592	0.723	0.182	0.178	0.095
2008	Total	7	5571500	1.000	76	3.666	3.527	0.947	2.463	2.473	0.409	0.034	0.034	0.020
2014	Total	7	5571500	1.000	75	3.399	3.243	0.725	5.354	5.215	0.782	0.090	0.090	0.031
2015	Total	7	5571500	1.000	73	1.783	1.783	0.46	6.724	6.724	1.005	0.242	0.242	0.092
2016	Total	7	5571500	1.000	73	2.411	2.411	0.579	2.798	2.798	0.542	0.194	0.194	0.072
2017	Total	7	5571500	1.000	74	0.468	0.468	0.174	1.784	1.784	0.277	0.049	0.049	0.028
2018	Total	7	5571500	1.000	76	1.607	1.675	0.437	6.425	5.884	1.729	0.070	0.098	0.038
					Mean	2.408	2.394	0.571	4.330	4.235	0.803	0.128	0.131	0.055

Table 1-4. Summary of commercial catch at age information from 1989 to 2018.

Year	Percentage 1+	Percentage of 2+
1989	5.98	94.02
1990	11.33	88.67
1991	25.39	74.61
1992	25.16	74.84
1993	21.29	78.71
1994	26.38	73.62
1995	23.92	76.08
1996	26.47	73.53
1997	28.63	71.37
1998	16.15	83.85
1999	31.25	68.75
2000	10.79	89.21
2001	1.21	98.79
2002	2.93	97.07
2003	3.13	96.87
2004	2.54	97.46
2005	1.19	98.81
2006	6.79	93.21
2007	1.48	98.52
2008	5.37	94.63
2009	0.71	99.29
2010	6.75	93.25
2011	0.90	99.10
2012	7.20	92.80
2013	5.88	94.12
2014	1.96	98.04
2015	1.72	98.28
2016	1.53	98.47
2017	1.41	98.59
2018	1.25	98.75

1.5 Results

Observation and Process Error in the Torres Strait tropical lobster TRL stock 0+ survey index

Initial model runs were problematic as very low additional variance was estimated for some years but not others, and this also resulted in large associated C.V.s due to the small parameter estimates. A lower bound of 0.05 was set for estimation of the additional variance to improve model estimation. The model estimated 8 additional variance parameters resulting in an 8.44 improvement in the log likelihood, which is statistically significant ($p<0.05$) using log-likelihood ratio test for which the corresponding critical chi-square value is 7.75 (Table 1-5).

The model additional variance parameters could not be reliably estimated for 2005, 2008 and 2016, and the estimates for years 2006 – 2015 hit the lower bound so were not well estimated either (Table 1-5). However the model estimated a large additional variance (0.43) for the 2017 survey 0+ observation with very high precision (C.V. = 0.005). This is consistent with the a priori expectation that the 2017 0+ survey would have the greatest amount of process error (see Table 1 in Plaganyi et al. 2018). For similar reasons, it was also hypothesized that the 2016 0+ survey would have large associated process error.

The 2017 additional variance estimate was considerably larger than the survey variance of 0.08. These results were very similar to the additional variance estimates obtained using the model version with the GLM-standardized 0+ series and associated standard errors instead (Table 1-5). It is not surprising that the 2008 0+ estimate has a high associated C.V. because there was no preseason survey conducted in 2009, and hence no directly comparable 1+ preseason index, but the model is also fitted to a 2009 midyear survey 1+ observation.

Table 1-5. Summary of model-estimated additional variance parameters.

	(b) Model version with AV but not GLM0					(d) Model with AV and GLM0				
	parameter	S.E.	C.V.	90% CI		parameter	S.E.	C.V.	90% CI	
2005	0.112	2.283	20.344	0.000	0.534	0.105	0.220	2.098	0.000	0.468
2006	0.050	0.025	0.503	0.048	0.052	0.050	0.000	0.003	0.050	0.050
2007	0.050	0.004	0.076	0.050	0.050	0.050	0.000	0.007	0.049	0.051
2008	0.051	0.621	12.285	0.000	0.102	0.050	0.000	0.006	0.050	0.050
2014	0.050	0.050	0.999	0.046	0.054	0.050	0.001	0.011	0.049	0.051
2015	0.050	0.016	0.313	0.049	0.051	0.050	0.000	0.004	0.050	0.050
2016	0.256	1.779	6.958	0.000	1.004	0.123	0.272	2.205	0.000	0.571
2017	0.430	0.002	0.005	0.429	0.431	0.430	0.002	0.004	0.427	0.433

Previously the model fit to the 0+ survey index was not satisfactory and estimation of additional variance parameters significantly improved the fit to both the 0+ and 1+ preseason survey indices. This resulted in a much more satisfactory fit to 1+ 2018 observation which was considered important as it is the key predictor of the following year's fished biomass.

Given the problems in trying to estimate all 8 additional variance (A.V.) parameters, two illustrative models runs are also shown in Table 1-6 with first scenario (scenario e in Table 1-7b) a single common 0+ survey additional variance parameter estimated for all years (except 2018) and second (scenario f in Table 1-7b) an additional variance parameter only estimated for 2017. The former scenario is not recommended as an approach though because there are a priori reasons provided as to why process error can be expected to vary inter-annually. The second scenario is also not ideal as it singles out a single year rather than applying an approach consistently, but is useful for comparison purposes. Neither of these two scenarios were preferred compared with the Model version 1 when using the AIC model selection criterion.

Table 1-6. Summary of model-estimated additional variance parameter when estimating a single value only.

	parameter	S.E.	C.V.	90% C.I	
Single common A.V.	0.357	0.250	0.698	-0.053	0.768
A.V. for 2017 only	3.444	5.011	1.455	-4.799	11.686

Given the issues with the estimated A.V. parameters hitting the lower bound, the lower bound was decreased to a very small number and the model refitted as shown in Table 1-7b scenario (g). Using the AIC model; selection criterion, scenario (g) is the preferred model. The A.V. parameter estimates and associated C.V.s are shown in Table 1-7. Once again the largest process error is estimated for the 2017 0+ observation with a very small associated standard error. The model fit to both the 0+ and 1+ index is highly significantly better than the base model version 1 (Table 1-8).

Table 1-7. Summary of model-estimated additional variance parameters for final model versions, including Revised Reference Case and version with GLM0.

Base model with Add Var estimated with no bounds					
	parameter	S.E.	C.V.	90% C.I	
2005	0.118	0.250	2.124	-0.326	0.584
2006	0.001	0.003	3.227	0.000	0.000
2007	0.001	0.001	0.982	0.000	0.000
2008	0.020	0.157	8.003	-0.257	0.316
2014	0.001	0.008	5.807	-0.001	0.001
2015	0.001	0.001	0.641	0.000	0.000
2016	0.258	0.432	1.672	-0.628	1.237
2017	0.450	0.009	0.019	-4.119	10.190
GLM0 with Add Var estimated with no bounds					
	parameter	S.E.	C.V.	90% C.I	
2005	0.11	0.217	1.913	-0.243	0.470
2006	0.00	0.000	0.279	0.001	0.001
2007	0.00	0.000	0.284	0.001	0.001
2008	0.00	0.000	0.286	0.001	0.001
2014	0.00	0.000	0.060	0.001	0.001
2015	0.00	0.000	0.038	0.001	0.001
2016	0.13	0.265	2.042	-0.306	0.565
2017	0.45	0.001	0.002	0.448	0.452

The Final set of runs used the GLM standardized 0+ index as described in Campbell et al. (2019). The analysis of Campbell et al. (2019) accounts for a range of factors which may influence the survey index, and as some of these factors are environmental variables, the standardized series implicitly accounts for part of the process error. For this reason, the base GLM0 scenario (scenario (c) in Table 1-7a) does not also include estimation of additional variance. Although this scenario is not directly comparable using AIC to the Model version 1 scenario because they use different data inputs, the use of the GLM0 series is seen to substantially improve the fit to the 0+ and 1+ preseason survey indices. This is partly because the GLM0 series estimates a substantially larger C.V. associated with the 2017 0+ observation. When the GLM0 scenario was run in conjunction with estimation of 8 additional variance parameters, these scenarios (d and h) were not preferred (using AIC) relative to the base GLM0 scenario. The base GLM0 (c) is therefore the preferred model using the GLM0 index. Overall the results are fairly similar to the non-GLM with A.V. estimated preferred scenario (g) which provides further confidence in terms of using model (g) as the basis for developing management advice.

Model fits

The fits of the Model to all available data sources are shown in Figure 1-1 to Figure 1-9. The results are shown primarily for the TRLRAG Revised Reference Case, with additional results presented at the previous TRLRAG and to be presented at the forthcoming TRLRAG. The starting number of lobsters is estimated and Figure 1-1 compares the benchmark survey (Ye et al. 2004) observed total lobster abundances in 1989 and 2002 with the corresponding model estimates. The Integrated model is fitted to the survey midyear index of abundance (in terms of total numbers of 1+ and 2+ lobsters) (Figure 1-2.). The poor fit for the year (2014) of the series was because of a conflict with the more reliable and lower estimate that same year based on the Preseason survey. The observed and model-predicted proportions in each age class are compared in Fig. 1-3.

The model fits to the catch at age data are adequate (Figure 6-4). The variability in the lobster age groups is well captured and the model reflects the post-2001 (increased size limit) decrease in the relative proportion of 1+ lobsters that are caught.

There were nine data points available from the Pre-season survey for the TRLRAG Revised Reference Case, and the model was fitted to data on both 0+ and 1+ abundance, with a close fit evident for the 1+ (Figure 1-5). The fit is better for the 1+ age group than the 0+ age group, but incorporation of the latter assists in strengthening prediction of future lobster abundance, even given the fairly large uncertainty associated with these estimates. The model doesn't fit the 2017 0+ index as the variability associated with this value is high and the model likelihood contribution is weighted by the inverse of the variance (see Appendix A). The Revised Reference Case incorporates a large additional variance associated with the 2017 0+ observation which allows the model to fit the 2018 1+ index reasonably.

Comparisons between CPUE data from the TVH sector (in kg per tender-day from 1994 to 2018) and corresponding model-predicted estimates are shown in Figure 1-6a (when fixing the lower bound of sigma at 0.15). Similarly, Figure 1-6b shows the fit to the standardised CPUE TIB data as described in Chapter 4. The Reference Case assumes a hyperstable relationship between biomass and CPUE (TVH) as follows:

$$\left(\frac{C}{E}\right)_y^{TVH} = q_{TVH}\left(B_y^{ex}\right)^{0.75}$$

And similarly for the TIB CPUE data:

$$\left(\frac{C}{E}\right)_y^{TIB} = q_{TIB}\left(B_y^{ex}\right)^{0.5}$$

Comparison between historic data and model estimates of the proportions of 1+ and 2+ lobsters in the catch is shown in Figure 1-7. The fit in the early years is reasonably good, with the later deviations in the fit partly a result of a slight conflict between these data and the catch at age data.

The fitted stock-recruit relationship from the Reference-case model version is shown in Figure 1-8, and the stock-recruit residuals are shown in Figure 1-9., from which it is clear that recruitment has been high over the recent period but has declined substantially during the past two years. There is considerable variation about the stock-recruit curve (as is expected), but nonetheless there is some support for an underlying stock-recruit relationship.

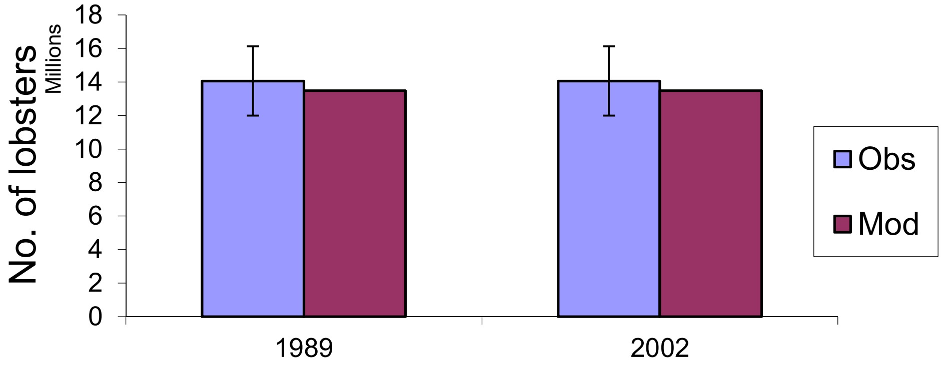
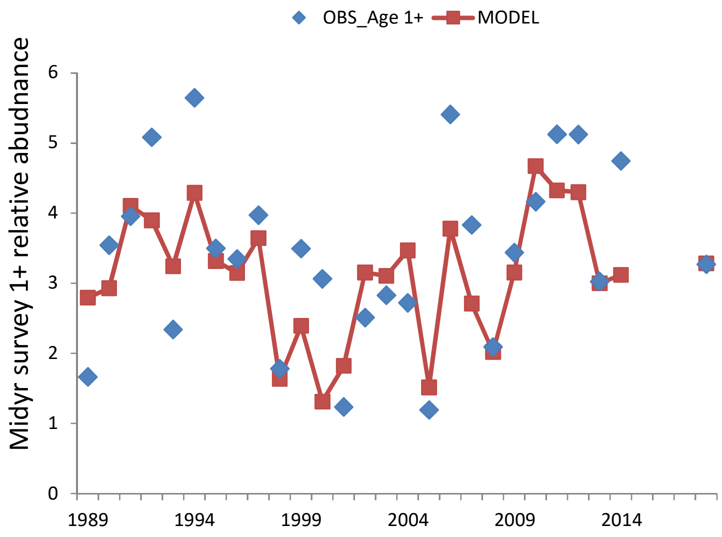
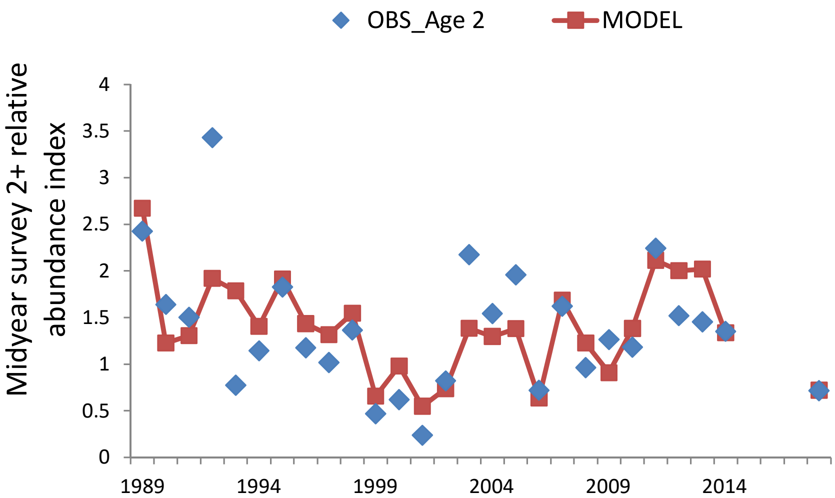


Figure 1-1. Comparison of benchmark survey observed lobster total abundance (with standard errors) and corresponding Revised Reference Case model-estimates of abundance.





Fit shown when combining total numbers from survey

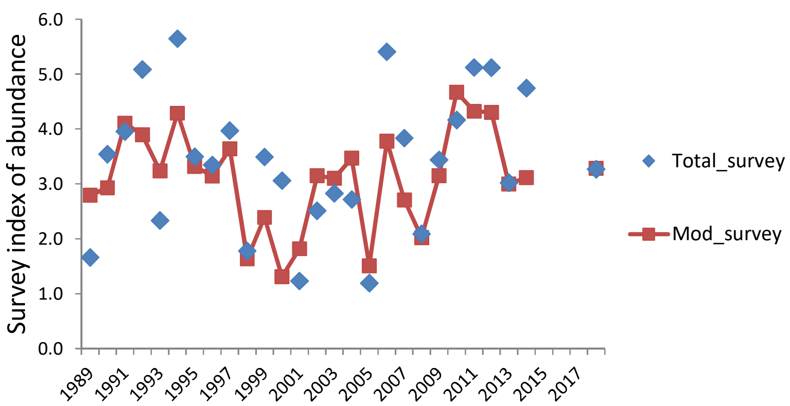
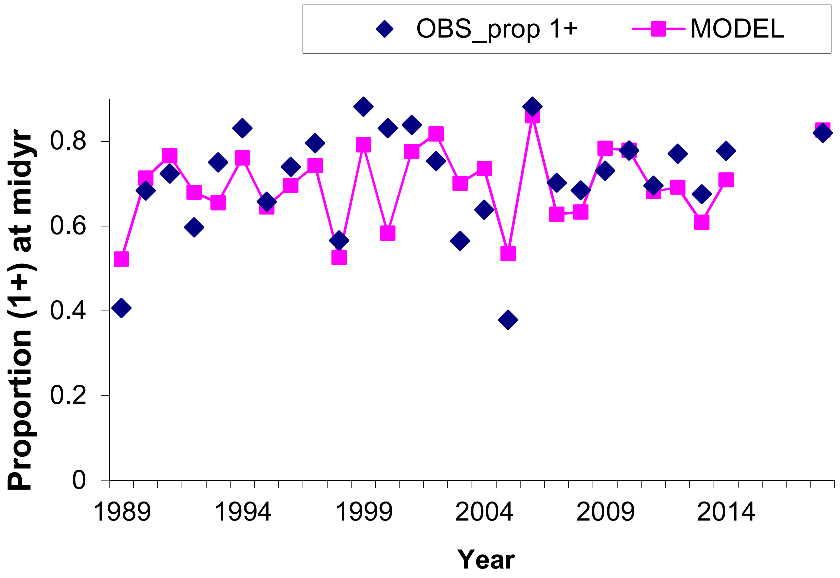


Figure 1-2. Comparison between survey midyear index of abundance (in terms of total numbers of 1+ and 2+ lobsters) compared with the corresponding model-estimated values for TRLRAG Revised Reference Case.



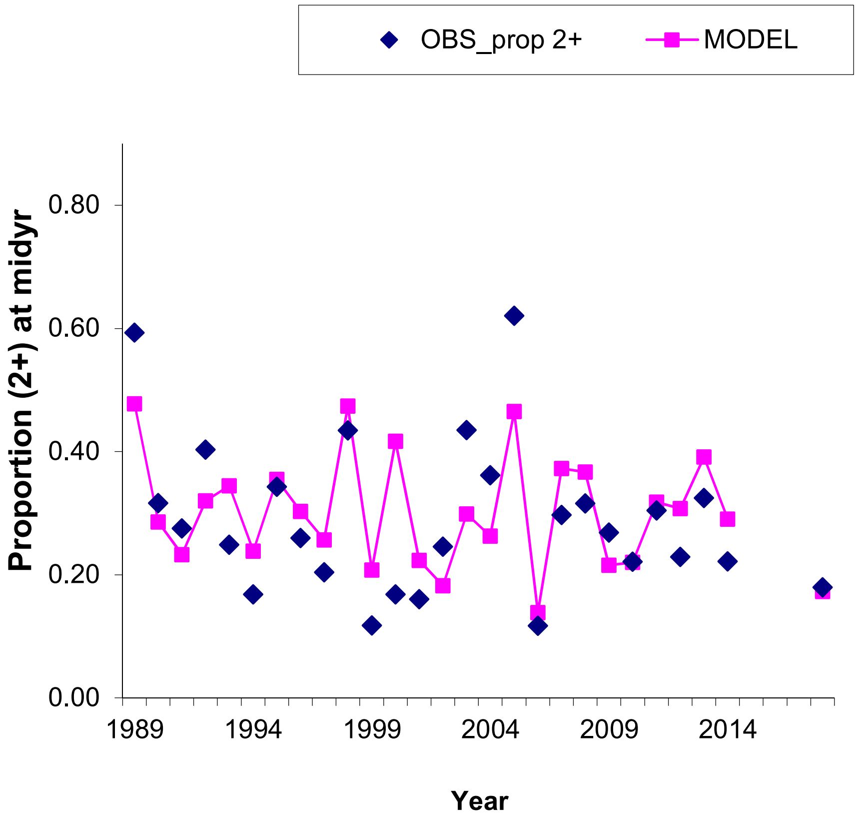
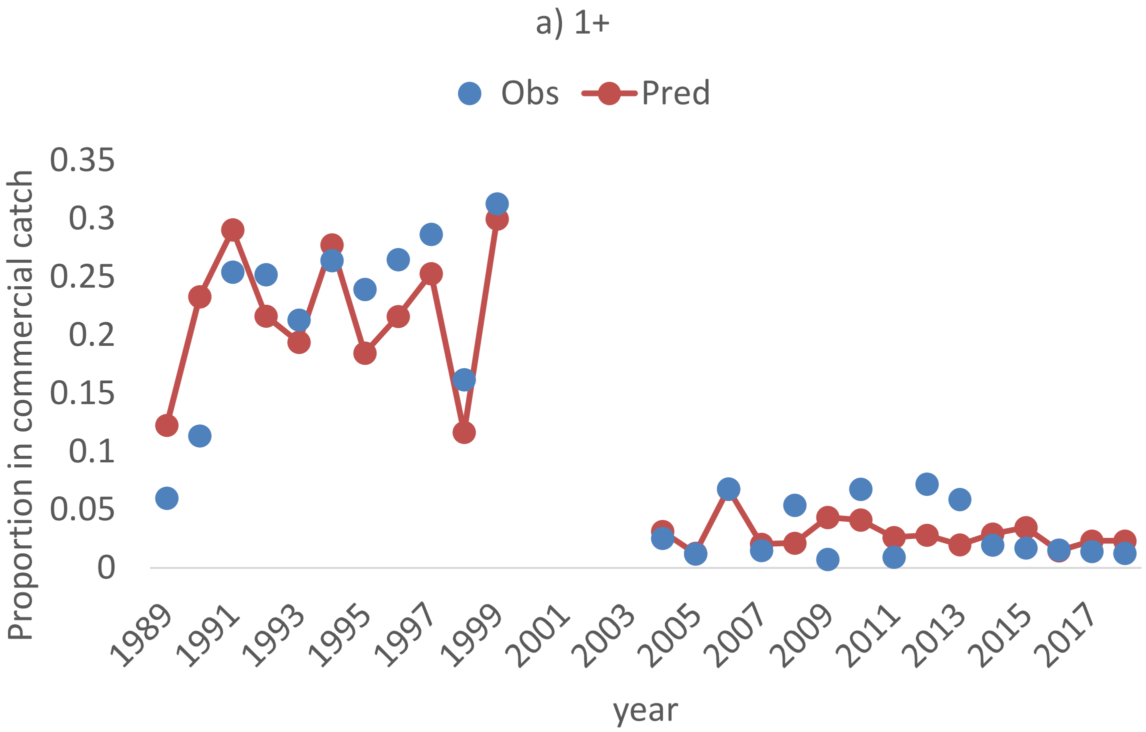


Figure 1-3. Comparison between observed and model-predicted proportions of 1+ and 2+ lobsters in the midyear survey.



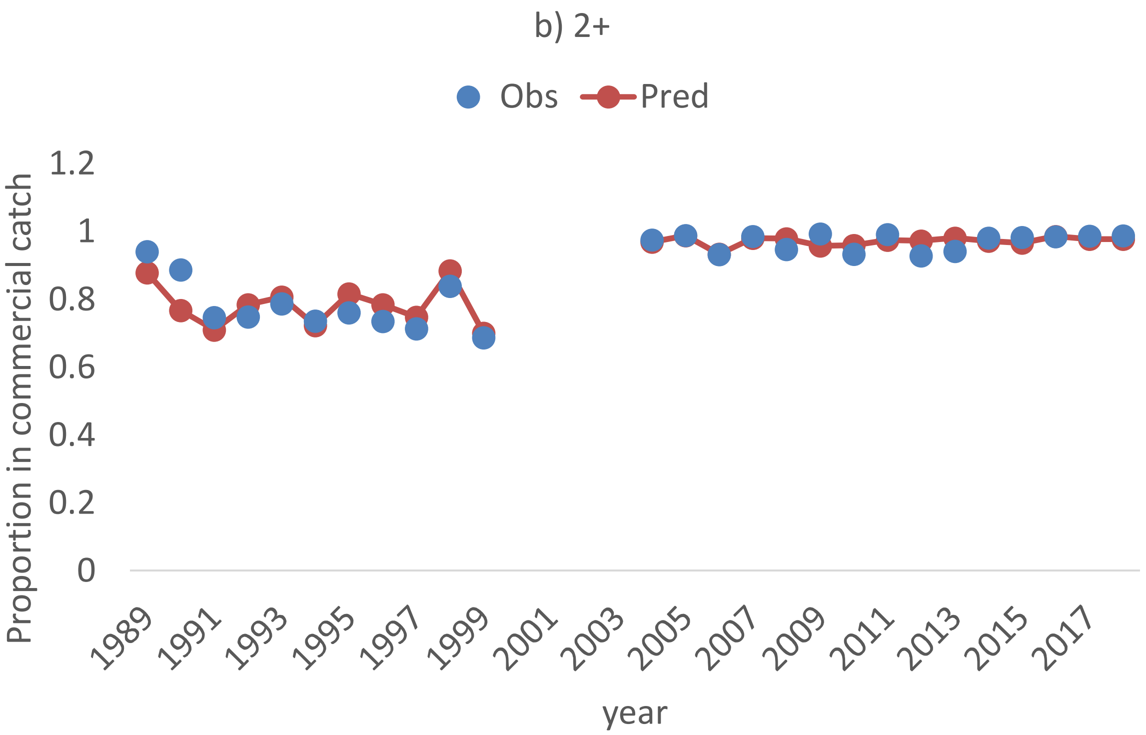
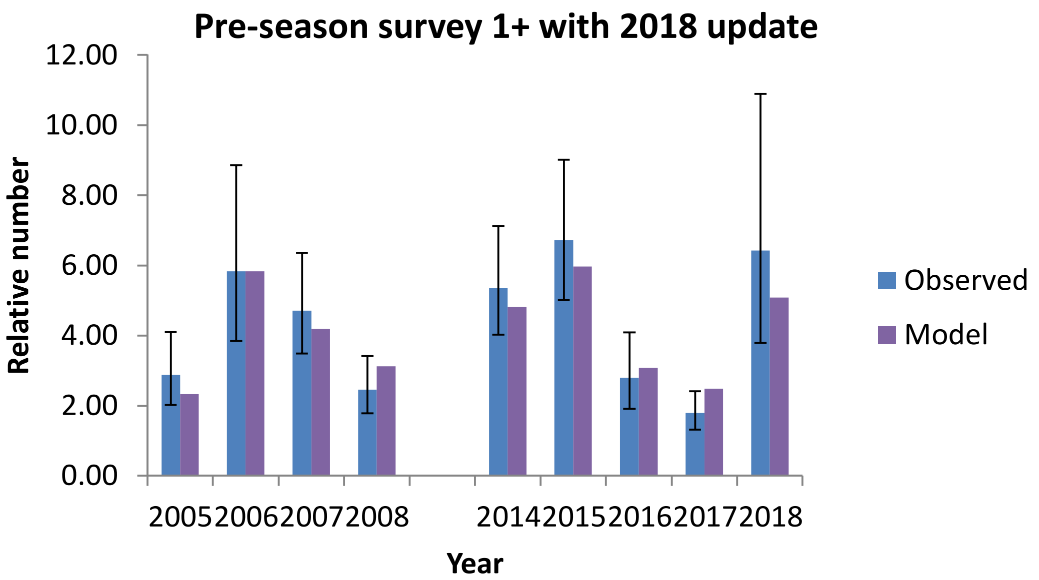


Figure 1-4. Comparison between available commercial catch-at-age data and corresponding model-predicted estimates.

(A)



(B)

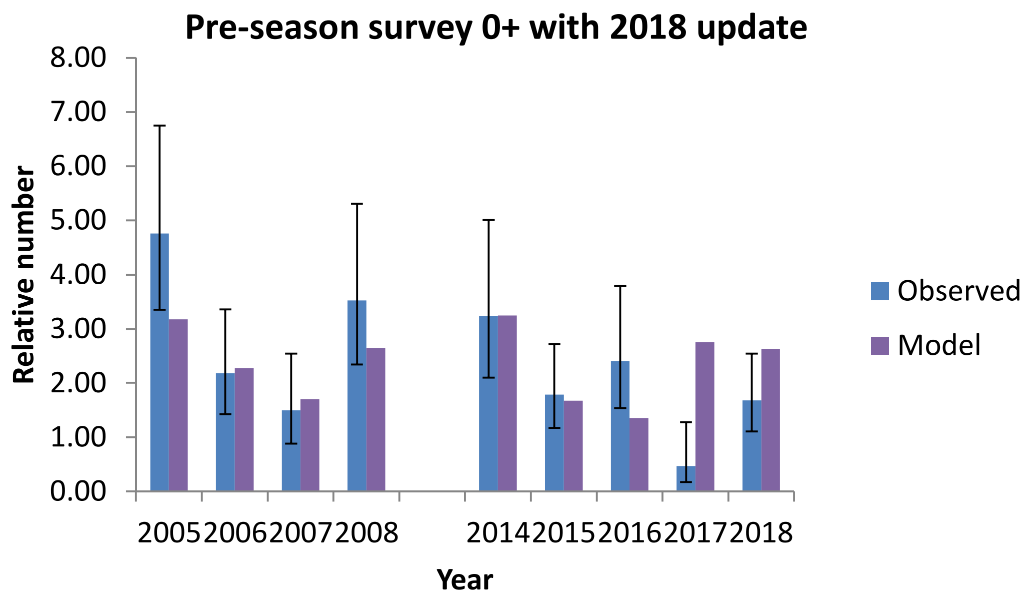
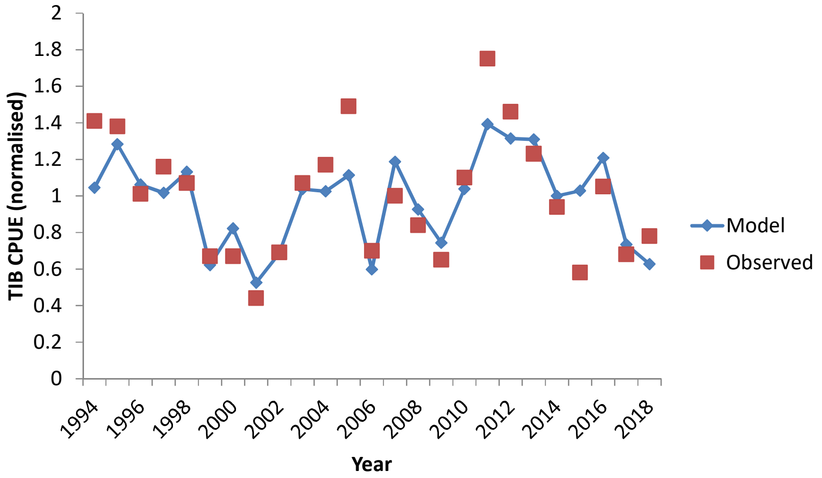


Figure 1-5. Comparison between observed Pre-season survey data (expressed in terms of number * 104) and corresponding (A) 1+ and (B) 0+ model-predicted estimates for TRLRAG Revised Reference Case which incorporates estimation of Additional Variance associated with each of the 0+ observations.

a) FIT TO TVH CPUE (sigma lower bound = 0.15); MAIN EFFECTS Int1 MODEL



b) FIT TO TIB CPUE (sigma lower bound = 0.15); TIB Seller Model

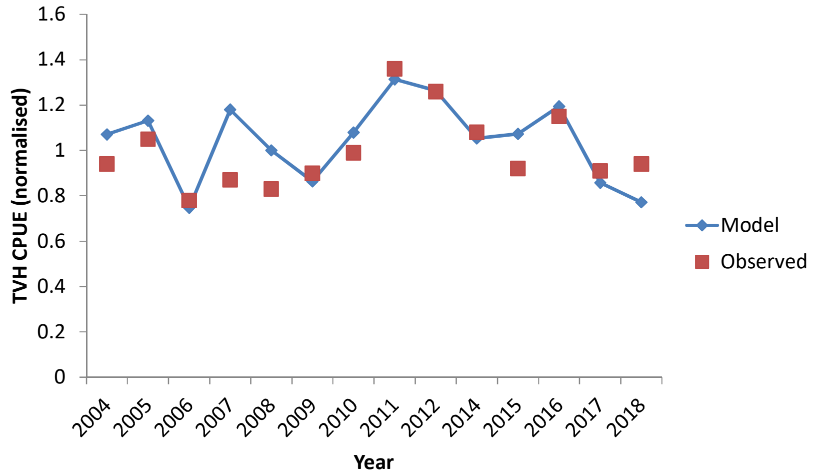


Figure 1-6. Comparison between CPUE data and corresponding model-predicted estimates. The plots are respectively a) Revised reference-Case fit to CPUE standardised estimates from the TVH sector with lower bound for sigma set at 0.15, b) fit to TIB CPUE standardized estimates available from 2004-2018. A hyperstable relationship is assumed (with power shape parameter 0.75 and 0.5 respectively) between CPUE and exploitable biomass for the TVH and TIB sectors.

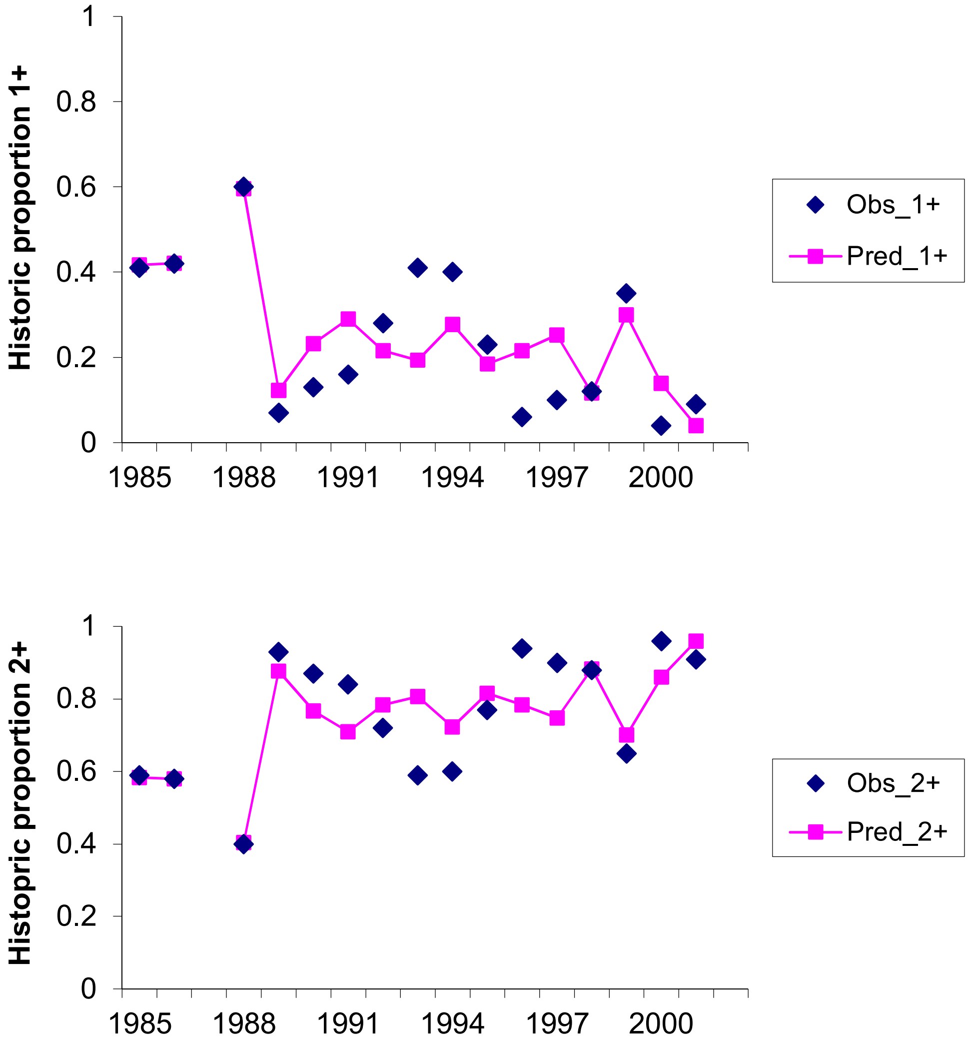


Figure 1-7. Comparison between historic data and model estimates of the proportions of 1+ and 2+ lobsters in the catch.

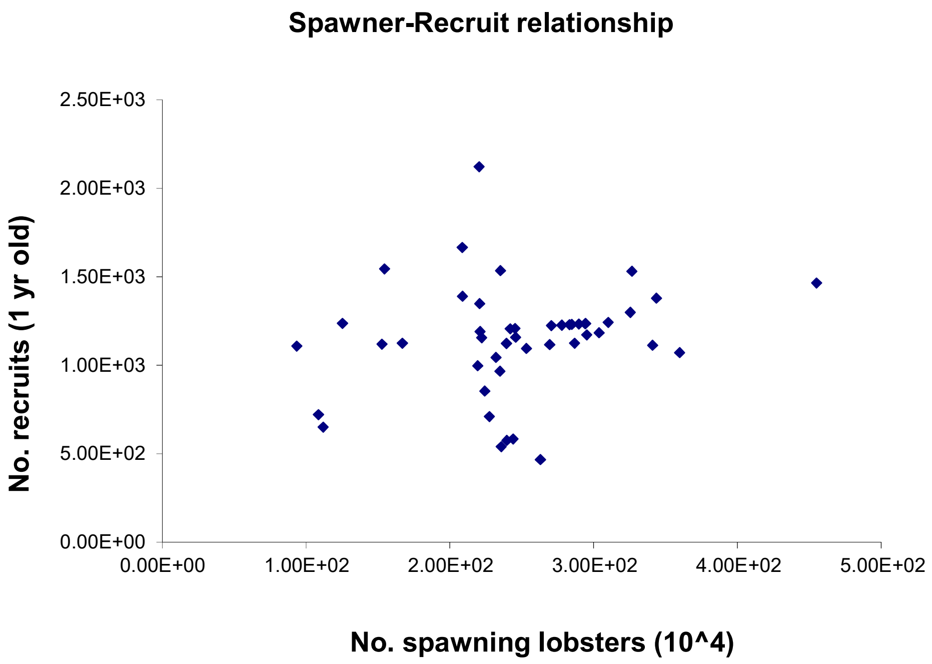


Figure 1-8. Integrated model stock recruitment relationship showing relative number of recruits R as a function of the spawning biomass Bsp for Revised Reference Case.

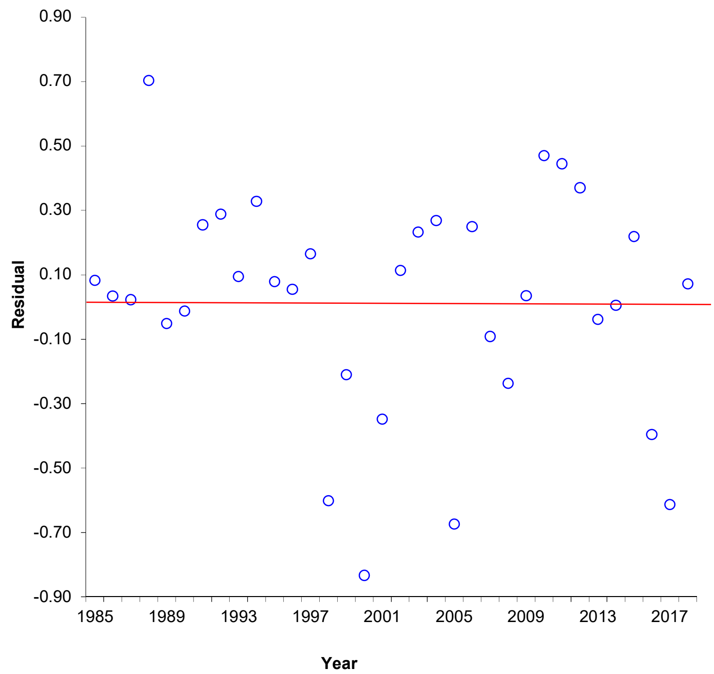


Figure 1-9. Plot of stock-recruit residuals, where recruits are defined as 1+ lobsters. Note the low 2017 residual compared with the roughly average 2018 residual

Estimates of model parameters

A full set of model parameter estimates, depletion statistics and likelihood contributions for the TRLRAG Revised Reference Case including 2018 Pre-season survey and a range of alternative model versions is shown in Table 1-8. In all cases the 90% Hessian-based Confidence Intervals (CI) are given alongside. The Revised Reference model estimates a total of 47 parameters, namely the starting biomass $B(1973)^{sp}$, natural mortality *M*, 1+ selectivity for the 1973-1988, 1989-2001 and post-2002 periods, 34 stock-recruit residuals and 8 additional variance parameters. The steepness parameter *h* could not be precisely estimated as the confidence interval associated with the previous estimate is very wide hence steepness *h* is fixed in the Reference Case at 0.7, based on the median of a fisheries database (Myers et al. 1995). However sensitivities to this are also tested given previous assessments suggesting *h* may be lower. The natural mortality estimate of 0.69 [90% C.I. 0.57 – 0.82] year^{-1} is reasonably estimated.

Full selectivity of the 2+ age class is assumed given they are the target of the fishery and are assumed caught before the end of September, before they migrate out the Torres Straits. Selectivity of 1+ lobsters is substantially less because they are usually only susceptible to fishing after September and not all individuals will have attained the minimum legal size by that time. The selectivity coefficient for age 1+ lobsters was 0.42 for 1973-1988, 0.17 for the period of 1989-2001 and 0.02 for the remaining years. As expected, the decrease in selectivity during the recent time period is a consequence of a change in management measures having been introduced in 2002, which included an increase in the minimum legal size (to 115 mm tail length), a 4-month extension of the hookah ban (October to January) and a 2-month fishing closure (October-November) (Ye et al. 2006).

Following from the above, the level of fishing mortality on age 1+ lobsters is expected to be substantially less than that on age 2+ lobsters (Figure 1-10.), with a decreasing trend evident following the implementation of the new management measures in 2002. The fishing mortality rate for age 2+ lobsters ranged from 0.09 year^{-1} to 0.27 year^{-1} (Figure 1-10.), with a historic average (from 1989) of 0.15 year^{-1}. The target fishing mortality rate is 0.15 year^{-1}. The 2018 catch of 299t was assessed to have been at the target fishing mortality rate (0.15) which suggests that the management decision to limit catches at this low level in 2018 was appropriate.

The fishing mortality estimates above refer to the combined estimate when lumping all TRL catches in the Torres Straits, except the trawling sector (Australian and PNG combined) catches. The latter are assumed to target 2+ lobsters only and were substantial in the early years (1973 – 1984) Figure 1-11., with small catches taken during the period (2001-2003) and zero values for all other years, except for some recent reports that are under discussion by the TRLRAG.

A summary of previous RBC and TACs is shown in Table 1-10.

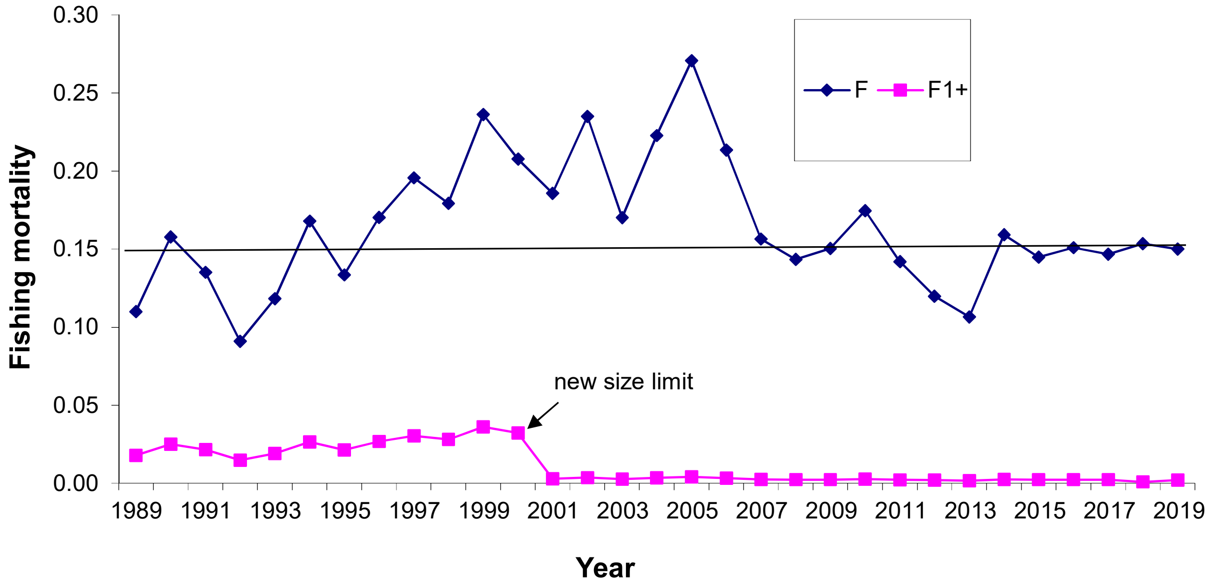


Figure 1-10. Model-estimated fishing mortality trends for 1+ (F 1+star) and 2+ (F 2+ star) lobsters. The 2002 change in size limit is highlighted and the 2019 fishing mortality set equal to the target value of 0.15.

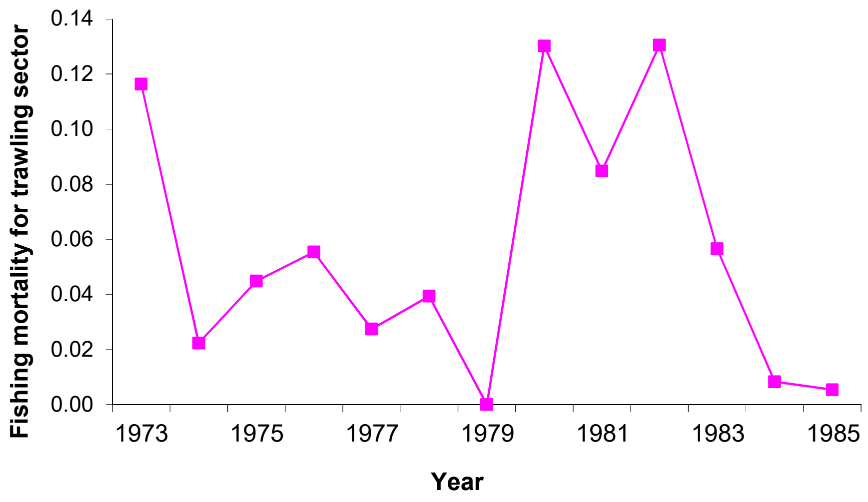


Figure 1-11. Model-estimated trawling sector fishing mortality trends for the early period of the fishery from 1973 - 1985.

Table 1-8. Summary of model parameter estimates for the Revised Reference Case and model variants as described in the text.

	(a) Model version 1			(2) Model not fitting Preseason 0+ index			(b) Additonal Variance (AV) Pars estimated			(c) Model with GLM0		
Parameter	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**
$B(1973)^{sp}$ (tons)	4326	3095	5556	4551	3243	5859	4459	3182	5735	4332	3108	5557
M	0.69	0.57	0.82	0.69	0.57	0.82	0.69	0.57	0.82	0.69	0.57	0.82
h	fixed 0.7			fixed 0.7			fixed 0.7			fixed 0.7		
Sel (age 1+) 1973-1988	0.42	0.23	0.60	0.42	0.23	0.61	0.42	0.23	0.61	0.42	0.23	0.60
Sel (age 1+) 1989-2001	0.17	0.15	0.19	0.17	0.15	0.19	0.17	0.15	0.19	0.17	0.15	0.19
Sel (age 1+) post2002	0.02	0.01	0.03	0.02	0.01	0.03	0.02	0.01	0.03	0.02	0.01	0.03
Recruitment residuals (1985-2018)		34 parameters			34 parameters			34 parameters			34 parameters	
Model estimates and depletion statistics												
$B(2018)^{sp}$ (tons)	2204	1451	2958	1953	1251	2654	1994	1275	2713	2140	1408	2873
RBC(2019) model	533	359	708	691	457	925	645	429	862	601	402	801
RBCforecast(2020) model	600	435	765	625	451	799	614	444	785	600	436	764
Current Depletion (Nov)												
$B(2018)^{sp}$ / B(1973)sp	0.52	0.38	0.66	0.44	0.31	0.56	0.46	0.32	0.59	0.51	1407.71	2872.69
Bexp(2018) (tons)	2518	1782	3255	2295	1604	2986	2329	1623	3035	2465	1747	3182
No. parameters estimated	39			39			47			39		
'-lnL:overall	**-182.113**			-187.39			-190.550			-189.807		
AIC	**-286.226**			-296.780			-287.100			-301.614		
Likelihood contributions		**Sigma**	**q**		Sigma	q		Sigma	q		Sigma	q
'-lnL:CAA	-65.87	0.05		-65.93	0.05		-65.92	0.05		-65.90	0.05	
'-lnL:CAAsurv	-20.35	input from data		-20.64	input from data		-20.53	input from data		-20.33	input from data	
-lnL:CAA historic	-21.99	0.13		-21.97	0.13		-21.97	0.13		-21.97	0.13	
-lnL:Survey Index 1+	-19.56	input from data	3.937E-07	-19.13	input from data	3.931E-07	-19.53	input from data	3.940E-07	-19.85	input from data	3.928E-07
-lnL:Survey Index 2+	-15.38	input from data	4.089E-07	-15.66	input from data	4.125E-07	-15.57	input from data	4.126E-07	-15.58	input from data	4.101E-07
-lnL:Survey benchmark	-3.13	input from data		-3.13	input from data		-3.13	input from data		-3.13	input from data	
'-lnL:PRESEASON	-7.97	input from data	8.033E-07	-10.54	input from data	8.101E-07	-10.14	input from data	8.113E-07	-8.43	input from data	8.121E-07
-lnL:PRESEASON 0+	2.68	input from data	2.214E-07	1.62	input from data	2.036E-07	-3.37	input from data	2.221E-07	-3.86	input from data	9.896E-08
-lnL:CPUE (TVH)	-21.48	0.26	0.0019	-21.12	0.27	0.0019	-21.22	0.26	0.0019	-21.61	0.26	0.0019
-lnL:CPUE (TIB)	-16.71	0.18	0.0162	-16.92	0.18	0.0163	-16.78	0.18	0.0163	-16.79	0.18	0.0162
'-lnL:RecRes	7.63	0.50	(input sigma 0.5)	7.64	0.50	input sigma 0.5	7.61	0.50	input sigma 0.5	7.64	0.50	(input sigma 0.5

Table 1-8 (b) continued

	(a) Model version 1			(d) Model with Add Var estimated & GLM0			(e) Single Preseas0 AV estimate			(f) Single Preseas0 AV for 2017 only		
Parameter	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**
B(1973)^{sp} (tons)	4326	3095	5556	4482	3200	5763	4687	3332	6043	4558	3243	5872
M	0.69	0.57	0.82	0.69	0.57	0.82	0.69	0.57	0.81	0.69	0.56	0.82
h	fixed 0.7			fixed 0.7			fixed 0.7			fixed 0.7		
Sel (age 1+) 1973-1988	0.42	0.23	0.60	0.42	0.23	0.61	0.43	0.24	0.62	0.42	0.23	0.62
Sel (age 1+) 1989-2001	0.17	0.15	0.19	0.17	0.15	0.19	0.17	0.15	0.19	0.17	0.15	0.19
Sel (age 1+) post2002	0.02	0.01	0.03	0.02	0.01	0.03	0.02	0.01	0.03	0.02	0.01	0.03
Recruitment residuals (1985-2018)		34 parameters			34 parameters			34 parameters			34 parameters	
Model estimates and depletion statistics												
B(2018)^{sp} (tons)	2204	1451	2958	2016	1287	2746	1815	1087	2542	2066	1284	2848
RBC(2019) model	533	359	708	656	436	876	676	443	908	712	469	956
RBCforecast(2020) model	600	435	765	618	447	789	628	448	808	610	437	782
Current Depletion (Nov)												
B(2018)^{sp} / B(1973)sp	0.52	0.38	0.66	0.46	0.32	0.59	0.39	0.26	0.52	0.46	0.32	0.60
Bexp(2018) (tons)	2518	1782	3255	2352	1636	3068	2165	1448	2882	2411	1642	3180
No. parameters estimated	39			47			40			40		
'-lnL:overall	**-182.113**			-191.912			-179.980			-183.491		
AIC	**-286.226**			-289.824			-279.960			-286.982		
Likelihood contributions		**Sigma**	**q**		Sigma	q		Sigma	q		Sigma	q
'-lnL:CAA	-65.87	0.05		-65.93	0.05		-66.00	0.04		-65.93	0.05	
'-lnL:CAAsurv	-20.35	input from data		-20.54	input from data		-20.55	input from data		-20.23	nput from data	
-lnL:CAA historic	-21.99	0.13		-21.98	0.13		-21.74	0.13		-21.73	0.13	
-lnL:Survey Index 1+	-19.56	input from data	3.937E-07	-19.35	input from data	3.936E-07	-25.78	input from data	3.789E-07	-25.91	nput from data	3.785E-07
-lnL:Survey Index 2+	-15.38	input from data	4.089E-07	-15.66	input from data	4.122E-07	-13.94	input from data	3.971E-07	-13.90	nput from data	3.961E-07
-lnL:Survey benchmark	-3.13	input from data		-3.13	input from data		-3.14	input from data		-3.14	nput from data	
'-lnL:PRESEASON	-7.97	input from data	8.033E-07	-9.77	input from data	8.137E-07	-11.79	input from data	7.193E-07	-10.85	nput from data	7.243E-07
-lnL:PRESEASON 0+	2.68	input from data	2.214E-07	-4.72	input from data	9.499E-08	-0.19	input from data	1.645E-07	-4.79	nput from data	2.225E-07
-lnL:CPUE (TVH)	-21.48	0.26	0.0019	-21.42	0.26	0.0019	-8.40	0.44	0.4116	-8.42	0.44	0.4117
-lnL:CPUE (TIB)	-16.71	0.18	0.0162	-17.00	0.18	0.0163	-16.31	0.19	0.4329	-16.31	0.19	0.4328
'-lnL:RecRes	7.63	0.50	(input sigma 0.5)	7.57	0.50	(input sigma 0	7.84	0.50	(input sigma 0.5)	7.72	0.50	nput sigma 0.

Table 1-8 (c) continued

	(a) Model version 1			(g) AV Pars estimated no lower bound			(h) GLM0 & AV estimated no lower bou		
Parameter	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**
B(1973) ^{sp} *(tons)*	4326	3095	5556	4439	3168	5710	4472	3194	5750
M	0.69	0.57	0.82	0.69	0.57	0.82	0.69	0.57	0.82
h	fixed 0.7			fixed 0.7			fixed 0.7		
Sel (age 1+) 1973-1988	0.42	0.23	0.60	0.42	0.24	0.61	0.42	0.23	0.61
Sel (age 1+) 1989-2001	0.17	0.15	0.19	0.17	0.15	0.19	0.17	0.15	0.19
Sel (age 1+) post2002	0.02	0.01	0.03	0.02	0.01	0.03	0.02	0.01	0.03
Recruitment residuals (1985-2018)		34 parameters			34 parameters			34 parameters	
Model estimates and depletion statistics									
B(2018) ^{sp} *(tons)*	2204	1451	2958	1969	1260	2678	2013	1286	2740
RBC(2019) model	533	359	708	641	426	857	656	436	876
RBCforecast(2020) model	600	435	765	612	442	781	618	447	788
Current Depletion (Nov)									
B(2018) ^{sp} */ B(1973)sp*	0.52	0.38	0.66	0.45	0.32	0.59	0.46	0.32	0.59
Bexp(2018) (tons)	2518	1782	3255	2304	1607	3000	2349	1635	3062
No. parameters estimated	39			47			47		
'-lnL:overall	**-182.113**			-191.779			-193.558		
AIC	**-286.226**			-289.558			-293.116		
Likelihood contributions		**Sigma**	**q**		Sigma	q		Sigma	q
'-lnL:CAA	-65.87	0.05		-65.79	0.05		-65.91	0.05	
'-lnL:CAAsurv	-20.35	input from data		-20.48	nput from data		-20.48	nput from data	
-lnL:CAA historic	-21.99	0.13		-21.98	0.13		-21.98	0.13	
-lnL:Survey Index 1+	-19.56	input from data	3.937E-07	-19.07	nput from dat	3.964E-07	-19.22	nput from dat	3.936E-07
-lnL:Survey Index 2+	-15.38	input from data	4.089E-07	-15.84	nput from dat	4.153E-07	-15.66	nput from dat	4.120E-07
-lnL:Survey benchmark	-3.13	input from data		-3.12	nput from data		-3.13	nput from data	
'-lnL:PRESEASON	-7.97	input from data	8.033E-07	-10.19	nput from dat	8.200E-07	-9.53	nput from dat	8.190E-07
-lnL:PRESEASON 0+	2.68	input from data	2.214E-07	-4.65	nput from dat	2.223E-07	-6.50	nput from dat	9.579E-08
-lnL:CPUE (TVH)	-21.48	0.26	0.0019	-21.65	0.26	0.0019	-21.62	0.26	0.0019
-lnL:CPUE (TIB)	-16.71	0.18	0.0162	-16.80	0.18	0.0163	-17.11	0.18	0.0163
'-lnL:RecRes	7.63	0.50	(input sigma 0.5)	7.79	0.50	input sigma 0.5	7.58	0.50	nput sigma 0.

Table 1-9. Summary of model parameter estimates for the Revised Reference Case and additional sensitivities (see text for details).

	(g) AV Pars estimated no lower bound			(i) Estimate hyperstability			(j) Change steepness h		
Parameter	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**	**Parameter**	**Value**	**90% CI**
$B(1973)^{sp}$ (tons)	4439	3168	5710	4464	3179	5748	4603	3260	5945
M	0.69	0.57	0.82	0.69	0.57	0.82	0.69	0.57	0.82
h	fixed 0.7			fixed 0.7			**fixed 0.6**		
hyps(TVH)	fixed 0.75			**0.75**	**0.55**	**0.95**	fixed		
hyps(TIB)	fixed 0.5			**0.27**	**0.13**	**0.42**	fixed		
Sel (age 1+) 1973-1988	0.42	0.24	0.61	0.42	0.23	0.61	0.42	0.23	0.60
Sel (age 1+) 1989-2001	0.17	0.15	0.19	0.17	0.15	0.19	0.17	0.15	0.19
Sel (age 1+) post2002	0.02	0.00	0.03	0.02	0.00	0.03	0.02	0.00	0.03
Recruitment residuals (1985-2018)		**34 parameters**			34 parameters			34 parameters	
Model estimates and depletion statistics									
$B(2018)^{sp}$ (tons)	1969	1260	2678	1878	1171	2584	1881	1174	2588
RBC(2019) model	641	426	857	648	430	867	648	430	866
RBCforecast(2020) model	612	442	781	612	441	783	590	423	758
Current Depletion (Nov)									
$B(2018)^{sp}$ / B(1973)sp	0.45	1259.81	2678.39	0.43	0.29	0.56	4533.00	3047.48	6018.52
Bexp(2018) (tons)	2304	1607	3000	2215	1521	2909	2218	1524	2912
No. parameters estimated	47			49			47		
'-lnL:overall	-191.779			-194.582			-194.613		
AIC	-289.558			-291.164			-295.226		
Likelihood contributions		Sigma	q		Sigma	q		Sigma	q
'-lnL:CAA	-65.79	0.05		-65.84	0.05		-65.84	0.05	
'-lnL:CAAsurv	-20.48	input from data		-20.44	input from data		-20.43	input from data	
-lnL:CAA historic	-21.98	0.13		-21.92	0.13		-21.91	0.13	
-lnL:Survey Index 1+	-19.07	input from data	3.964E-07	-20.47	input from data	3.919E-07	-20.57	input from data	3.917E-07
-lnL:Survey Index 2+	-15.84	input from data	4.153E-07	-15.62	input from data	4.105E-07	-15.55	input from data	4.099E-07
-lnL:Survey benchmark	-3.12	input from data		-3.13	input from data		-3.13	input from data	
'-lnL:PRESEASON	-10.19	input from data	8.200E-07	-11.07	input from data	8.101E-07	-11.07	input from data	8.100E-07
-lnL:PRESEASON 0+	-4.65	input from data	2.223E-07	-4.72	input from data	2.199E-07	-4.82	input from data	2.210E-07
-lnL:CPUE (TVH)	-21.65	0.26	0.0019	-20.70	0.27	0.0020	-20.65	0.27	0.0019
-lnL:CPUE (TIB)	-16.80	0.18	0.0163	-18.81	0.16	0.1036	-18.79	0.16	0.1045
'-lnL:RecRes	7.79	0.50	(input sigma 0.5)	8.13	0.50	(input sigma 0.5	8.14	0.50	(input sigma 0.

Table 1-10. Summary of TRLRAG Reference Case RBC.

TAC/Catch (t)	2014	2015	2016	2017	2018	2019
Forecast TAC (90% CI)	767 (518-1016)	751 (556-945)	719 (515-923)	677 (489-866)	758 (546-970)	531 (383-678)
Preliminary TAC (90% CI)	616 (294-938)	894 (571-1217) TIB: 328 t TVH: 251 t PNG: 285 t	704 (510-897) Aug 2015 Dec 2015 update	495 (315-676) TIB: 188 t TVH: 144 t PNG: 163 t	299 (196-401) TIB: 136 t TVH: 64 t PNG: 99 t	[533 – 637t] 641t
Final TAC	616	Mar 2015 (revision with preseason survey = 769t)	796	495t	299t	
Catch	682t	562t	572t	368t	328t	

Model trajectories

The model-predicted numbers of 1+ and 2+ lobsters for the entire model period are shown in Figure 1-12. There is considerable inter-annual variability in stock size, with the extent of the variability consistent with that observed from field studies.

The lobster spawning biomass (t) trajectory is given in Figure 1-13. The stock is currently estimated to be at 46% of the pristine (1973) spawning biomass level but is expected to fluctuate widely about the average target spawning biomass level, and to increase in 2019.

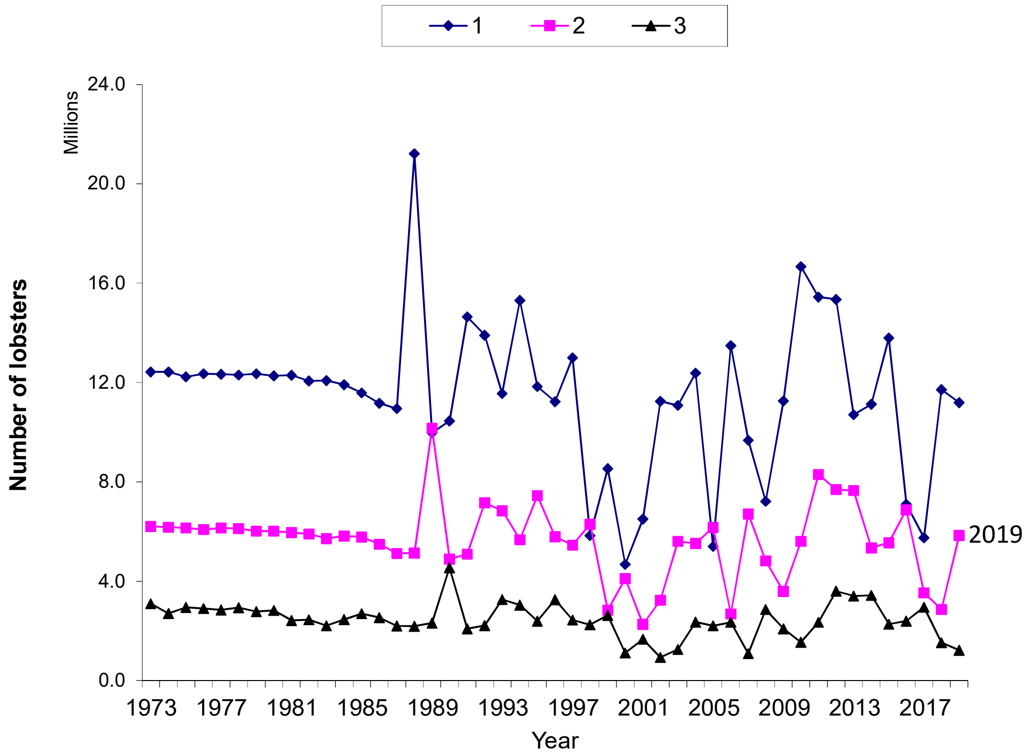


Figure 1-12. Model trajectories of the annual numbers of lobsters in each age class at the start of each of years 1973 to 2016. The increased variability from 1985 onwards is because the model estimates stock recruit residuals for years from 1985 to 2016.

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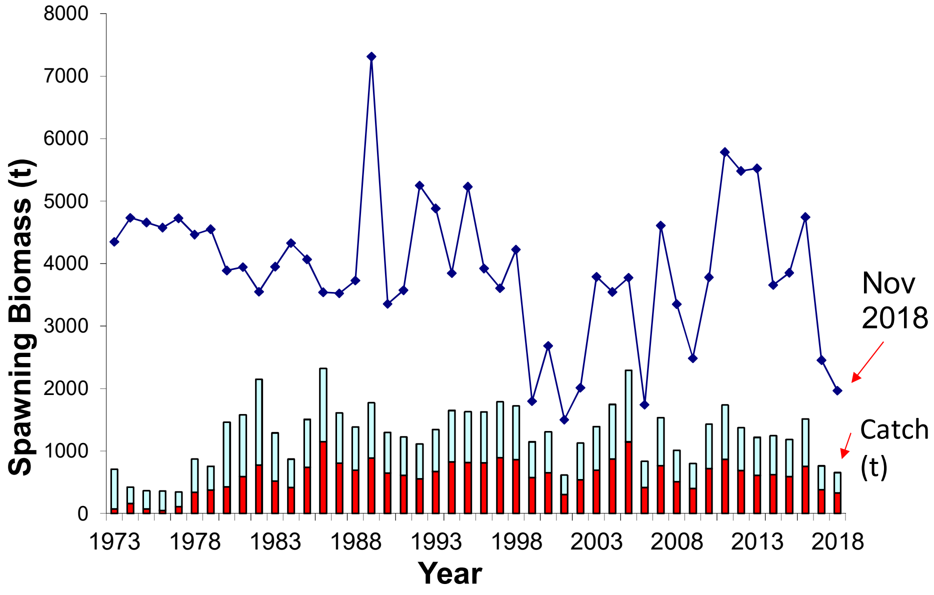


Figure 1-13. Model trajectories of the lobster spawning biomass (t) over the model period shown together with annual catches by the trawling and other sectors combined.

The model-predicted spawning biomass trajectory is shown in Figure 1-14.**Error! Reference source not found.**. The November 2018 spawning biomass for the TRLRAG Revised Reference Case is estimated to be 1969 t [1260; 2678] (Table 1-7). Fig. 1-15 shows the model-predicted commercially available (also termed exploitable) lobster biomass, computed as the sum of all 1+ and 2+ lobsters which are “available” to be caught each year. The current 2018 estimate is 2304t [1607; 3000], but this is predicted to increase in 2019 (Fig. 1-15).

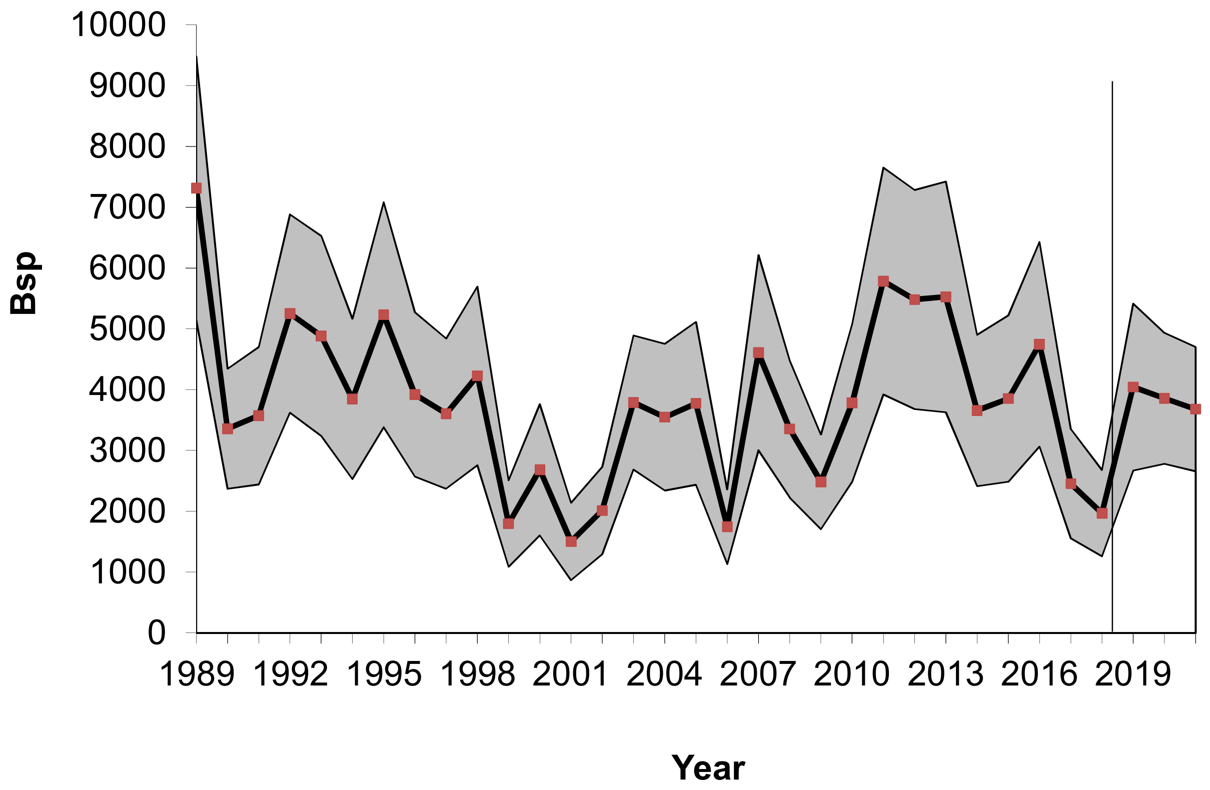


Figure 1-14. Model-predicted lobster November spawning biomass trajectory shown together with Hessian-based 90% confidence intervals for revised Reference Case model. The vertical line indicates the separation between historic and predicted estimates.

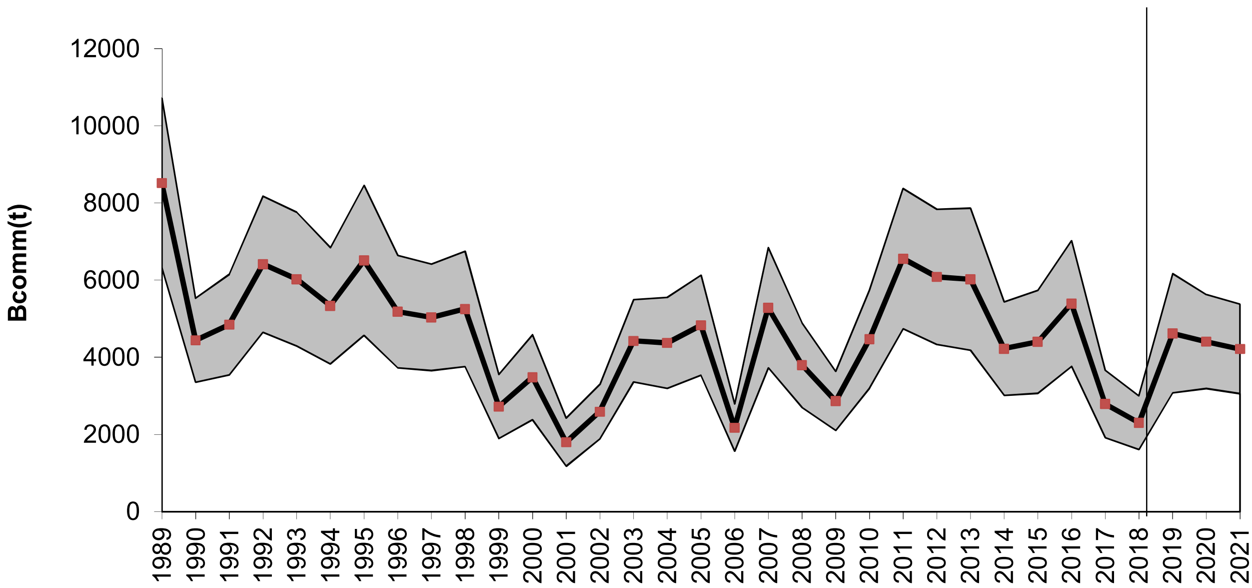


Figure 1-15. Model-predicted commercially available (also termed exploitable) lobster biomass (Bcomm), which is the sum of all 1+ and 2+ lobsters which are "available" to be caught each year. The shaded area shows the Hessian-based 90% confidence intervals. The vertical line indicates the separation between historic and predicted estimates.

Sensitivity Tests

The robustness of model results were tested across a number of important sensitivity tests, including the following which were presented at the TRLRAG December 2018 meeting:

- Fix steepness h=0.6 and try estimate
- Fix hyperstability pars CPUE (TVH 1) (TIB 1); try estimate
- Preseason survey index –
  - use the additional 5 sites added;
  - test other series particularly excluding Buru which gives lower standard error (SE) for 1+ index
  - Downweight Pre0+ (2017)
- CPUE TVH – Int3 standardised series; nominal
- CPUE TIB – Seller&A standardised series ; nominal

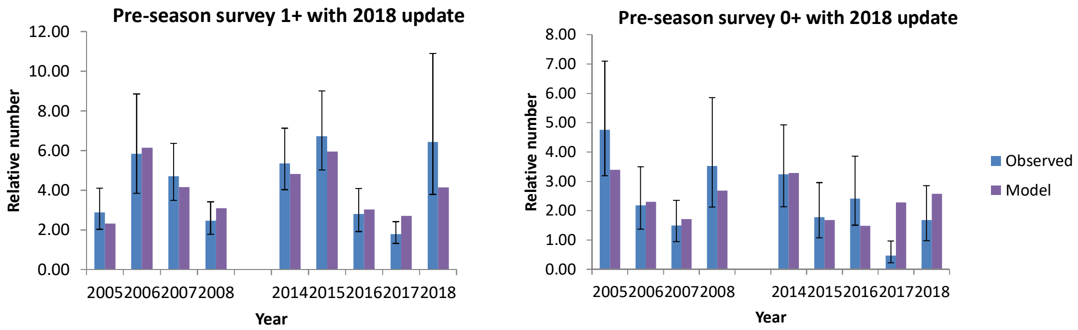
This report focuses on alternative methods tested to account for changes to the survey 0+ observation and process error. Full results are presented in Tables 1-8a-c, and illustrative changes in the fit to the survey data are shown below in Fig. 1-16. As previously, revised model runs are compared with a scenario that uses the 0+ preseason survey index without modification (Model 1 - (a) in Table 1-8) as well as a scenario in which these data are excluded (Model 2 Table 1-8) as a means of bounding the range of plausible alternatives. As expected, the latter model fits the preseason 1+ index very well but the fit to the 0+ data is very poor (note the likelihood contribution from comparing with the 0+ series is shown for illustrative purposes, but is not included in calculation of the total likelihood for this scenario).

The change in the model results was fairly consistent when introducing alternative analyses to address the model conflict. Decreasing the lower bound of the estimated additional variance parameters has a negligible impact on the estimate of RBC(2019) - 645 vs 641 for models (b&g) and no change (656) for models (d&h) - and all four results are relatively similar (within 2%). On the other hand the GLM0 only model has an RBC of 601 which is 6% lower than model (g). All are higher than the base model (a) estimate of 533.

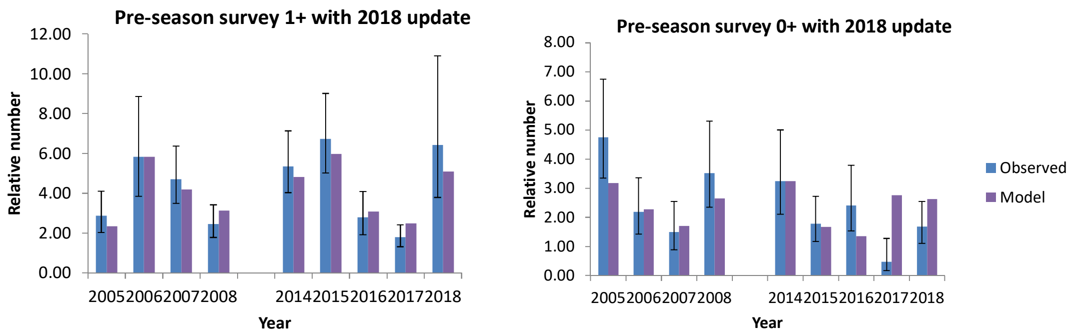
Based on the earlier set of sensitivity analyses, a couple of additional sensitivity analyses were run using the revised Reference Case Model. Estimating (instead of fixing) the hyperstability parameters for the TIB and TVH CPUE series had only a small effect on model results (Table 1-9, Fig. 1-17), although the estimated value for the TIB series was lower than currently used. Both parameters were reasonably estimated in the model and the version with these parameters estimated had an improved AIC but the difference was less than 2. This will therefore be investigated further in future work, and before changes are made it is recommended that the data subgroup first review any recommendations for changing the input CPUE series.

Decreasing the stock-recruitment steepness parameter *h* from 0.7 to 0.6 resulted in a small improvement in the likelihood and AIC values (Table 1-9), and there was some support for a lower steepness value, which is being investigated further in ongoing work.

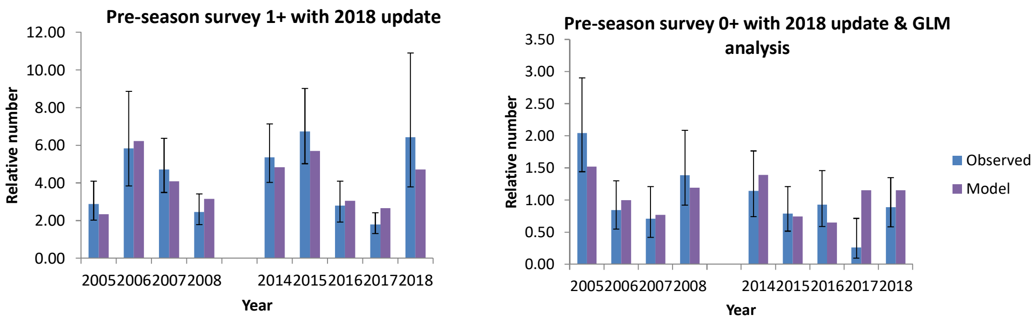
(A) Model (a) without Additional Variance (A.V.) added or GLM0



(B) Model (g) with Additional Variance (A.V.) added



(C) Model (c) with GLM0 but no A.V.



(D) Model (h) with GLM0 and A.V.

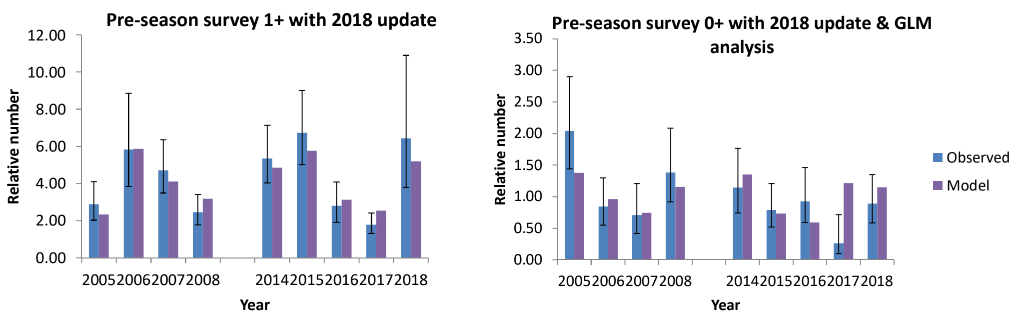
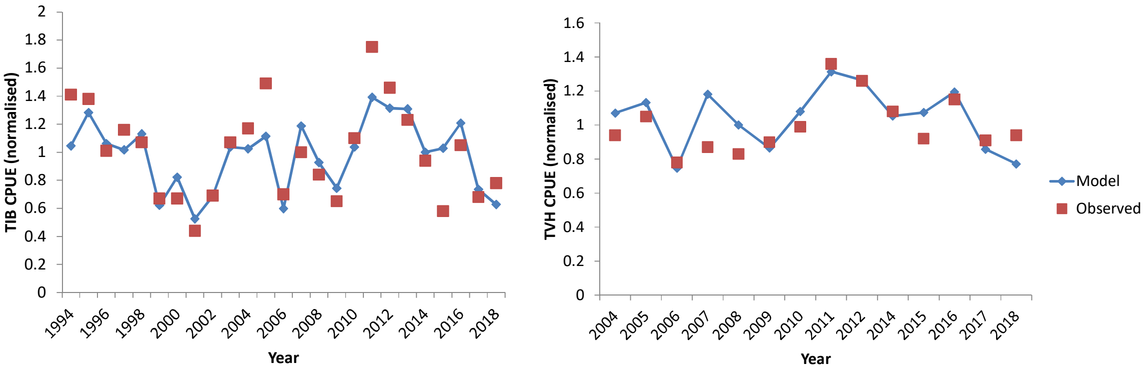


Figure 1-16. Comparison of model fits to preseason survey 0+ and 1+ index using (A) Model version 1 with no Additional Variance (A.V.) estimated versus (B) Revised Reference Case model (g) with A.V. estimated, as well as alternative (C) GLM-standardised 0+ index used and (D) GLM0 and A.V. estimated.

(A) Revised Reference Case (model (g) FIT TO TVH CPUE and TIB CPUE data with fixed hyperstability parameters



(B) Sensitivity analysis when estimating hyperstability parameters

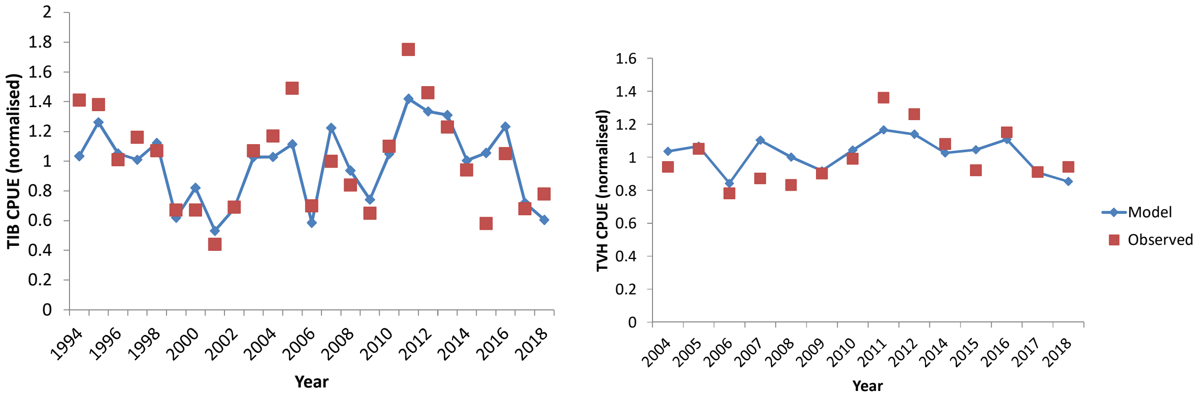


Figure 1-17. Comparison of model fits to CPUE standardised series using (A) Revised Reference Case model (g) and (b) model with hyperstability parameters estimated

1.6 Discussion

The revised and updated model adequately fits the available data and integrates all available information to output a RBC value as required for management. The use of a single model facilitates understanding of the way in which data inputs translate into an assessment of the status and productivity of the resource and hence an associated RBC estimate. Moreover, parameter estimates and resource trajectories are presented together with confidence intervals to illustrate the extent of uncertainty associated with model predictions.

An important assumption of the current and previous assessments is that the Torres Strait rock lobster resource is a closed population, but this is clearly not the case given they migrate eastwards out the Torres Straits (Moore and MacFarlane 1984, Skewes et al. 1994). It is not known to what extent mixing occurs with the eastern component of the stock, and hence whether these two stock components should rather be treated as a single stock in computing a spawning stock biomass. This aspect has been investigated during a related MSE project as well as in ongoing work.

The inherent variability of environmental influences in relatively short-lived highly variable stocks such as TRL confounds both the accuracy and precision of optimal sustainable yield estimates for the following year. As more and better surveys are added, it becomes possible to set less conservative TACs.

The TRLRAG is currently considering adopting a pre-tested harvest control rule that is based on the results of the pre-season survey and other data inputs to set the RBC, rather than annually running the stock assessment (Plaganyi et al. 2018). The advantage of the latter approach is that it can be simulation tested and the harvest control rules agreed beforehand by all stakeholders, so that the TAC updating process is quick and efficient as is necessary given the short time between the pre-season survey completion (plus time for analysis of the data), and the opening of the fishing season.

Following the advice from the December 2018 RAG to apply a statistically calculated down-weighting to the 2017 0+ index, this document has therefore selected a revised Reference Case that includes estimation of Additional Variance for all 0+ survey observations. This document presents full results for this illustrative case as well as summary results for other variants, with the final choice of model version to be used to inform the RBC to be finalised at the forthcoming TRLRAG meeting, and hence note that the final RBC may differ from the revised reference case value presented here.

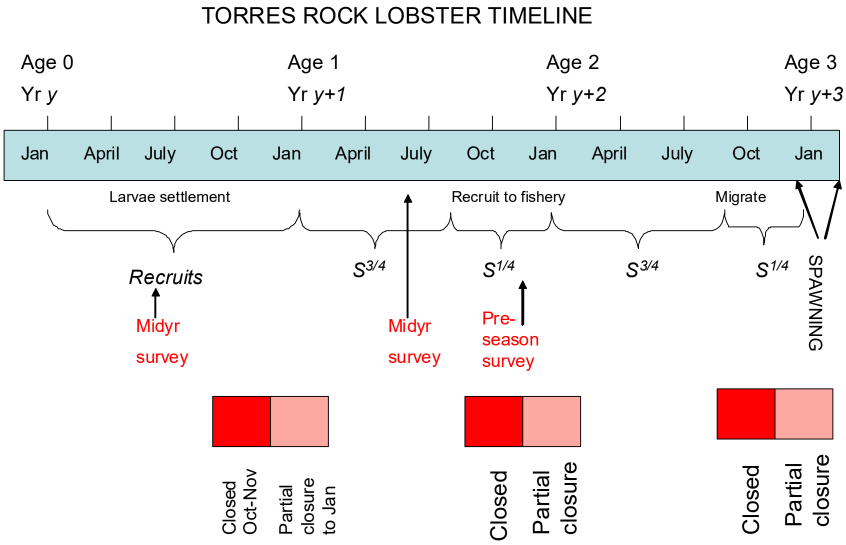
The revised reference case model suggests a RBC (2019) of 641t [90% CI 426-857t]. Using the revised reference case, the stock is currently estimated to be at 46% of the pristine (1973) spawning biomass level (K). Previous analyses forewarned that the 2018 spawning biomass may be lower than average and provides support for the management decisions taken in 2018 to limit catches so that sufficient lobsters would remain for spawning purposes and subsequent recruitment to the fishery in 3 years' time. Fortunately the good 1+ numbers observed in the most recent survey means that the model spawning biomass projection for the following year is once again much more positive. The very large inter-annual variability in the stock has long been recognised. Hence it is entirely plausible that the current lobster stock have been boosted by good recruitment, however we suggest ongoing monitoring of 2019 catch and the next survey observations will be prudent.

Appendix A Stock Assessment Model Equations

A.1 Stock Assessment Equations

Introduction

Torres Strait rock lobsters emigrate in spring and breed during the subsequent summer (November-February) (Moore and MacFarlane, 1984; MacFarlane and Moore, 1986). Therefore, the number of age 2+ lobsters at the middle of the breeding season (December) should represent the size of the spawning stock (Apx Figure A-1). A schematic summary timeline underlying the Integrated model is presented in Apx Figure A-1. To simplify computations, the new model assumes catches, migration and spawning occur at discrete times, with quarterly updates to the dynamics of each age class. Catches of 2+ individuals are assumed taken as a pulse at midyear, with individuals migrating out of the Torres Straits at the end of the third quarter, and a spawning biomass being computed at the end of the year. Catches of 1+ lobsters are assumed taken at the end of the third quarter, when a proportion of this age class have grown large enough to be available to fishers.



Apx Figure A-1. Summary timeline for Torres Strait Rock Lobster model.

P. ornatus is an unusually fast growing lobster and hence analyses are expected to be sensitive to changes in assumption regarding growth rate (length vs age) and mass-at-length. Previous modelling studies used the Trendall et al. (1988) relationship:

$$CL_m = 177\left(1 - e^{-0.386(m/12 - 0.411)}\right)$$

where *CL* is carapace length (mm) and *m* is age in months for aspects of the computations. However, after converting length to mass using the morphometric relationship:

TOTWT=0.00258*(CL^2.76014)

the Trendall et al (1988) relationship translates into average individual masses that are less than the observed average mass of lobsters caught in the fishery. The Integrated model thus uses the Phillips et al. (1992) male growth relationship:

$$CL = L_{\infty}\left(1 - e^{-kt}\right)$$

where $L_{\infty} = 165.957 \quad mm$;

$\kappa = -0.0012$; and

t is age in DAYS.

The integrated model

An age-structured model of the Torres Rock Lobster population dynamics is developed and fitted to the available abundance indices by maximising the likelihood function. The model equations and the general specifications of the model are described below, followed by details of the contributions to the log-likelihood function from the different sources of data available. Quasi-Newton minimization is used to minimize the total negative log-likelihood function (the package AD Model BuilderTM (Fournier et al. 2012) is used for this purpose.

Lobster population dynamics

Numbers-at-age

The resource dynamics are modelled by the following set of population dynamics equations:

$$N_{y+1,1} = R_{y+1} \qquad 1$$

$$N_{y+1,a+1} = \left(N_{y,a}\, e^{-3M_a/4} - C_{y,a}\right) e^{-M_a/4} \qquad \text{for a=1} \qquad 2$$

$$N_{y+1,a+1} = \left(N_{y,a}\, e^{-M_a/2} - C_{y,a}\right) e^{-M_a/2} \qquad \text{for a=2} \qquad 3$$

where

$N_{y,a}$ is the number of lobsters of age a at the start of year y (which refers to a calendar year),

R_y is the recruitment (number of 1-year-old lobsters) at the start of year y,

M_a denotes the natural mortality rate on lobsters of age a, and

$C_{y,a}$ is the predicted number of lobsters of age a caught in year y

These equations simply state that for a closed population, with no immigration and emigration, the only sources of loss are natural mortality (predation, disease, etc.) and fishing mortality (catch). They reflect Pope's form of the catch equation (Pope, 1972) (the catches are assumed to be taken as a pulse at midyear for the 2+ class and at the start of the third quarter for the 1+ class) rather than the more customary Baranov form (Baranov, 1918) (for which catches are incorporated under the assumption of steady continuous fishing mortality). Pope's form has been used in order to simplify computations.

Recruitment

The number of recruits (i.e. new 1-year old lobsters – it is simpler to work with 1- rather than 0-year old lobsters as recruits) at the start of year y is assumed to be related to the spawning stock size (i.e. the biomass of mature lobsters) by a Beverton-Holt stock-recruitment relationship (Beverton and Holt, 1957), allowing for annual fluctuation about the deterministic relationship:

$$R_y = \frac{\alpha B^{sp}_{y-1}}{\beta + \left(B^{sp}_{y-1}\right)^{\gamma}} e^{\left(\varsigma_y - (\sigma_R)^2/2\right)} \qquad 4$$

where

α, β and γ are spawning biomass-recruitment relationship parameters (note that cases with γ > 1 lead to recruitment which reaches a maximum at a certain spawning biomass, and thereafter declines towards zero, and thus have the capability of mimicking a Ricker-type relationship),

ς_y reflects fluctuation about the expected recruitment for year y, which is assumed to be normally distributed with standard deviation σ_R (which is input in the applications considered here); these residuals are treated as estimable parameters in the model fitting process. Estimating the stock-recruitment residuals is made possible by the availability of catch-at-age data, which give some indication of the age-structure of the population.

B^{sp}_y is the spawning biomass at the start of year y, computed as:

$$B^{sp}_y = w^{st}_3 \cdot N_{y,3} \qquad 5$$

where

w^{st}_3 is the mass of lobsters of age 3 (i.e. in December during the spawning season).

In order to work with estimable parameters that are more meaningful biologically, the stock-recruitment relationship is re-parameterised in terms of the pre-exploitation equilibrium spawning biomass, K^{sp}, and the "steepness", h, of the stock-recruitment relationship, which is the proportion of the virgin recruitment that is realized at a spawning biomass level of 20% of the virgin spawning biomass:

$$\beta = \frac{\left(K^{sp}\right)^{\gamma}\left(1 - 5h0.2^{\gamma}\right)}{5h - 1} \qquad 6$$

and

$$\alpha = \frac{\beta + \left(K^{sp}\right)^{\gamma}}{SPR_{virg}} \qquad 7$$

where

$$SPR_{virg} = w^{st}_3 N^{virg}_3 \qquad 8$$

with

$$N_1^{virg} = 1 \qquad 9$$

$$N_a^{virg} = N_{a-1}^{virg} e^{-M_{a-1}} \qquad \text{for } 2 < a \leq m \qquad 10$$

where

m is the maximum age considered (taken to be 3).

Total catch and catches-at-age

The catch by mass in year *y* is given by:

$$C_y = w_1^{land} N_{y,1} e^{-3M_a/4} S_{y,1} F_y^{1+} + w_2^{mid} N_{y,2} e^{-M_a/2} S_{y,2} F_y^{2+} \qquad 11$$

where

w_a^{land} denotes the mass of lobsters of age *a* that are landed at the end of the third quarter,

w_a^{mid} denotes the mid-year mass of lobsters of age *a*,

$S_{y,a}$ is the commercial selectivity (i.e. vulnerability to fishing gear) at age *a* for year *y*; and

F_y is the fished proportion (of the 1+ and 2+ classes) of a fully selected age class.

The model estimate of the exploitable ("available") component of biomass is calculated by converting the numbers-at-age into mass-at-age (using the individual weights of the 1+ lobsters assumed landed at the end of the third quarter, and the 2+ lobsters assumed landed at midyear):

$$B_y^{ex,1+} = w_1^{land} S_{y,1} N_{y,1} e^{-3M_a/4} \qquad 12$$

$$B_y^{ex,2+} = w_2^{mid} S_{y,2} N_{y,2} e^{-M_a/2} \qquad 13$$

and hence:

$$B_y^{ex} = B_y^{ex,1+} + B_y^{ex,2+} \qquad 14$$

The 2010 model version computes the catch by mass separately for the trawling sector, which is assumed to target 2+ lobsters only. The exploitable component of biomass for this sector is thus based on Equation (13) only and assumes full selectivity of the 2+ age group.

The model estimates of the midyear numbers of lobsters are:

$$N_y^{mid} = N_{y,1} e^{-M_1/2} + \left(N_{y,2} e^{-M_2/2} - C_{y,2}\right) \qquad 15$$

i.e.

$$N_{y,1}^{mid} = N_{y,1} e^{-M_1/2} \qquad 16$$

$$N_{y,2}^{mid} = N_{y,2} e^{-M_2/2} - C_{y,2} \qquad 17$$

Similarly, the model estimate of numbers for comparison with the Pre-Season November survey are as follows:

$$N_{y,1}^{pre} = \left(N_{y,1} e^{-3M_1/4} - C_{y,1}\right) e^{-M_1/6} \qquad 18$$

$$N^{pre}_{y,2} = N^{mid}{}_{y,2}\, e^{-5M_2/12} \quad 19$$

The proportion of the 1+ and 2+ age classes harvested each year (F_y^{1+}) are given respectively by:

$$F_y^{1+} = C_y^{1+} \;/ B_y^{exp,1+} \quad 20$$

$$F_y^{2+} = C_y^{2+} \;/ B_y^{exp,2+} \quad 21$$

where C_y^{1+} and C_y^{2+} are the catch by mass in year *y* for age classes 1 and 2, such that:

$$C_y^{1+} = p_{y,1+} C_y \quad 22$$

and

$$C_y^{2+} = \left(1 - p_{y,1+}\right) C_y \quad 23$$

with $p_{y,1+}$ representing the 1+ proportion of the total catch.

Given different fishing proportions for the two age classes, the numbers-at-age removed each year from each age class can be computed from:

$$C_{y,1} = S_{y,1} F_y^{1+} N_{y,1} e^{-3M_a/4} \qquad \text{for } a = 1 \text{, and} \quad 24$$

$$C_{y,2} = S_{y,2} F_y^{2+} N_{y,2} e^{-M_a/2} \qquad \text{for } a = 2 \quad 25$$

The fully selected fishing proportion (*F*) is related to the annual fishing mortality rate (*F**) as follows:

$$1 - F = e^{-F^*} \quad 26$$

Initial conditions

Although some exploitation occurred before the first year for which data are available for the lobster stock, this is considered relatively minor and hence the stock is assumed to be at its pre-exploitation biomass level in the starting year and hence the fraction (θ) is fixed at one in the analysis described here:

$$B^{sp}_{y_0} = \theta \cdot K^{sp} \quad 27$$

with the starting age structure:

$$N_{y_0,a} = R_{start} N_{start,a} \qquad \text{for } 1 \le a \le m \quad 28$$

where

$$N_{start,1} = 1 \quad 29$$

$$N_{start,a} = N_{start,a-1} e^{-M_{a-1}} \qquad \text{for } 2 \le a \le m-1 \quad 30$$

The (penalised) likelihood function

Model parameters are estimated by fitting to survey abundance indices, commercial and survey catch-at-age data as well as standardised CPUE data in some cases. A penalty function is included to permit estimation of residuals about the stock-recruitment function. Contributions by each of these to the negative of the log-likelihood (- $\ell\text{n}L$) are as follows.

Survey abundance data

The same methodology is applied for the midyear and pre-season surveys, except that for the former there are indices for both the total 1+ and 2+ numbers, whereas for the pre-season the fit is only to the 1+ lobsters as most of the older lobsters will have migrated out of the region by November. The likelihood is calculated assuming that the observed midyear (and pre-season) survey abundance index is log-normally distributed about its expected value:

$$I_y^i = \hat{I}_y^i \exp\left(\varepsilon_y^i\right) \quad \text{or} \quad \varepsilon_y^i = \ell\text{n}\left(I_y^i\right) - \ell\text{n}\left(\hat{I}_y^i\right) \qquad 31$$

where

I_y^i is the scaled survey abundance index for year *y* and series *i*,

$\hat{I}_y^i = \hat{q}_s \hat{N}_y^{survey}$ is the corresponding model estimate, where $\hat{N}_y^{survey}$ is the model estimate of midyear numbers, given by equation 16 and 17 for the midyear survey, and for the pre-season survey it is given by equation 18.

$\hat{q}_s$ is the constant of proportionality (catchability) for the survey, and

ε_y^i from $N\left(0, \left(\sigma_y^i\right)^2\right)$.

The contribution of the survey data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-\ell\text{n}\, L^{Surv} = \sum_i \sum_y \left[\ell\text{n}\left(\sigma_y^i\right) + \left(\varepsilon_y^i\right)^2 / 2\left(\sigma_y^i\right)^2\right] \qquad 32$$

where $\left(\sigma_y^s\right)^2 = \ln\left(1 + \left(CV_y\right)^2\right)$ and the coefficient of variation (CV_y) of the resource abundance estimate for year *y* is input.

The survey catchability coefficient $\hat{q}_s$ is estimated by its maximum likelihood value:

$$\ell n\, \hat{q}_s = 1/n_i \sum_y \left(\ln I_y^i - \ln N_y^{ex}\right) \qquad 33$$

Commercial catches-at-age

The contribution of the catch-at-age data to the negative of the log-likelihood function under the assumption of an “adjusted” lognormal error distribution is given by:

$$-\ell\text{n}L^{CAA} = \sum_y \sum_a \left[\ell n\left(\sigma_{com} / \sqrt{p_{y,a}}\right) + p_{y,a}\left(\ell n\, p_{y,a} - \ell n\, \hat{p}_{y,a}\right)^2 / 2\left(\sigma_{com}\right)^2\right] \qquad 34$$

where

$p_{y,a} = C_{y,a} / \sum_{a'} C_{y,a'}$ is the observed proportion of lobsters caught in year y that are of age a,

$\hat{p}_{y,a} = \hat{C}_{y,a} / \sum_{a'} \hat{C}_{y,a'}$ is the model-predicted proportion of lobsters caught in year y that are of age a, where

$$\hat{C}_{y,1} = N_{y,1}\, e^{-3M_a/4}\, S_{y,1}\, F_y^{1+} \qquad 35$$

$$\hat{C}_{y,2} = N_{y,2}\, e^{-M_a/2}\, S_{y,2}\, F_y^{2+} \qquad 36$$

and

σ_{com} is the standard deviation associated with the catch-at-age data, which is estimated in the fitting procedure by:

$$\hat{\sigma}_{com} = \sqrt{\sum_y \sum_a \left(\ell n\, p_{y,a} - \ell n\, \hat{p}_{y,a}\right)^2 / \sum_y \sum_a 1} \qquad 37$$

The same approach is applied when fitting to the historic catch proportion data.

Survey catches-at-age

The survey catches-at-age are incorporated into the negative of the log-likelihood in an analogous manner to the commercial catches-at-age, assuming an adjusted log-normal error distribution (equation 25) where:

$p_{y,a} = C^{surv}_{y,a} / \sum_{a'} C^{surv}_{y,a'}$ is the observed proportion of lobsters of age a in year y,

$\hat{p}_{y,a}$ is the expected proportion of lobsters of age a in year y in the survey, given by:

$$\hat{p}_{y,a} = N_{y,a} \Big/ \sum_{a'=1}^{2} N_{y,a} \qquad 38$$

Benchmark Survey Estimates of Absolute Abundance

The absolute abundance of lobsters is estimated by fitting to data from two benchmark midyear surveys. The total 2002 population estimate, together with 95% confidence interval, was T_{89} = 9.0 (±1.9) million lobsters, and for 1989, T_{89} = 14.0 (±2.9) million lobsters (Pitcher et al. 1992). The 2+ year class was estimated at 1.77 (±0.38) million in 2002, and the 1+ year-class was at 5.2 (±1.5) million.

The approach is similar to that described above for the survey relative abundance index. The contribution of the survey data to the negative of the log-likelihood function (after removal of constants) is then given by:

$$-\ell n L^{Bench} = \ell n(\sigma_{89}) + (\varepsilon_{89})^2 / 2(\sigma_{89})^2 + \ell n(\sigma_{02}) + (\varepsilon_{02})^2 / 2(\sigma_{02})^2 \qquad 39$$

where $\varepsilon_{89} = \ell n(T_{89}) - \ell n\left(\hat{N}^{mid}_{1989,1} + \hat{N}^{mid}_{1989,2}\right)$;

$\varepsilon_{02} = \ell n(T_{02}) - \ell n\left(\hat{N}^{mid}_{2002,1} + \hat{N}^{mid}_{2002,2}\right)$; and

$\left(\sigma_y\right)^2 = \ln\left(1+\left(CV_y\right)^2\right)$ and the two coefficients of variation (CV_{89} and CV_{02}) are input.

Stock-recruitment function residuals

The stock-recruitment residuals are assumed to be log-normally distributed. The contribution of the recruitment residuals to the negative of the (now penalised) log-likelihood function is given by:

$$-\ell nL^{pen} = \sum_{y=y1+1}^{y2} \frac{\left(\lambda_y\right)^2}{2\sigma_R^2} \qquad 40$$

where

$\lambda_y = \varepsilon_y$ is the recruitment residual for year y, which is estimated for year $y1$ to $y2$ (see equation 4),

ε_y from $N\left(0,(\sigma_R)^2\right)$,

σ_R is the standard deviation of the log-residuals, which is input.

Model parameters

Natural mortality:

Natural mortality (M_a) is generally taken to be age independent and is estimated in the model fitting process.

In sensitivity tests where age-dependence is admitted, it is taken to have the form:

$$M_a = \mu_1 + \mu_2 / a \qquad 41$$

Fishing selectivity-at-age:

The commercial selectivity is taken to differ over the 1973-2002 and 2002+ periods. Full selectivity of the 2+ class is assumed, with a separate selectivity parameter being estimated for each period for the 1+ class.

A.2 2018 Revised Reference Case model stock recruitment residual estimates and 90% Hessian-based confidence intervals

	Val	onfidence interval	
1985	0.08	-0.34	0.51
1986	0.03	-0.65	0.72
1987	0.02	-0.50	0.54
1988	0.70	0.46	0.95
1989	-0.05	-0.29	0.19
1990	-0.01	-0.24	0.21
1991	0.25	0.04	0.47
1992	0.29	0.07	0.51
1993	0.09	-0.12	0.31
1994	0.33	0.09	0.56
1995	0.08	-0.14	0.30
1996	0.05	-0.15	0.26
1997	0.16	-0.05	0.38
1998	-0.60	-0.84	-0.36
1999	-0.21	-0.45	0.03
2000	-0.83	-1.12	-0.55
2001	-0.35	-0.59	-0.11
2002	0.11	-0.10	0.33
2003	0.23	0.01	0.45
2004	0.27	0.06	0.48
2005	-0.67	-0.88	-0.47
2006	0.25	0.03	0.47
2007	-0.09	-0.30	0.12
2008	-0.24	-0.42	-0.06
2009	0.03	-0.19	0.26
2010	0.47	0.26	0.68
2011	0.44	0.23	0.66
2012	0.37	0.13	0.61
2013	-0.04	-0.26	0.18
2014	0.01	-0.23	0.24
2015	0.22	-0.01	0.45
2016	-0.40	-0.64	-0.15
2017	-0.61	-0.86	-0.37
2018	0.07	-0.20	0.35

Glossary

AFMA	Australian Fisheries Management Authority
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Agency
eHCR	Empirical Harvest Control Rule
RBC	Recommended Biological Catch
TAC	Total Allowable Catch
TIB	Traditional Inhabitant Boat sector
TRL	Tropical Rock Lobster
TSSAC	Torres Strait Scientific Advisory Committee
TVH	Transferrable Vessel Holder (Licence)
TRL RAG	Tropical Rock Lobster Research Advisory Group
PNG	Papua New Guinea

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TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
RAG DATA SUB-GROUP MEETING	Agenda Item 5 For Discussion and Advice

RECOMMENDATIONS

1. That the RAG:
    a. **DISCUSS** and **PROVIDE ADVICE** on the draft terms of reference for the RAG data sub-group (**Attachment 5a**);
    b. **DISCUSS** and **PROVIDE ADVICE** on the key issues concerning fishery dependent data inputs to the Torres Strait Tropical Rock Lobster Fishery (TRL Fishery) assessment framework that require consideration by the RAG data sub-group meeting and their order of priority (**Table 1**);
    c. **NOTE** administrative arrangements for the upcoming RAG data sub-group meeting (**Attachment 5b**):
        i. the meeting will comprise one day in Brisbane and is tentatively scheduled for between 19-21 March or 17-18 April 2019, depending on attendees' availability.
    d. **FINALISE** membership for the RAG data sub-group:
        i. nominations to form the sub-group were received from the following members: Selina Stoute; Danielle Stewart; Dr Éva Plagányi; Dr Andrew Penney; Mark David; Les Scott; and Joseph Posu. Trent Butcher and Suzannah Salam also offered their nominations as observers.

KEY ISSUES

2. At the RAG meeting held on 18-19 October 2018, the RAG recommended a sub-group of the RAG be established to examine and recommend improvements to be made to the collection and analysis of catch and effort data for the TRL Fishery, including:
    a. TRL04 logbook and TDB02 CDR - improving the accuracy of spatial data (e.g. point of capture as opposed to point of anchoring or landing), finer scale measure of effort (e.g. 'hours actively fishing/in the water' as opposed to 'days fished'), further details on effort (e.g. to include time spent travelling, searching and actively fishing), collection of depth data.
    b. Fishing power (efficiency) - developing a better understanding on changes in fishing behaviour and power over time (e.g. changes to the size of engines, use of GPS, gear, areas fished, time fished, experience of divers), to inform the standardisation of CPUE data.
    c. Use of data collection technology - assessing the use of electronic logbooks in the Fishery.
    d. Use of monitoring technology - assessing the use of VMS on all boats in the Fishery.
3. The RAG further recommended a draft terms of reference be developed for consideration at the first meeting of the sub-group to be convened alongside the next meeting of the RAG. This is provided at **Attachment 5a** for discussion and adoption.
4. It is proposed that the RAG Data Sub-Group be established for an initial term of 18 months, and will focus on issues concerning fishery dependent data inputs to the TRL Fishery

assessment framework. The Sub-Group will meet on an as needs basis, with the first meeting tentatively scheduled for March/April 2019. A report will be provided to the RAG following each meeting. The RAG will be asked to consider each report, provide guidance on further work to be undertaken by the Sub-Group including an assessment of the ongoing need for the Sub-Group.

5. During 2018, the RAG identified a range of issues and questions concerning fishery dependent data inputs to the TRL Fishery assessment framework that require further attention, summarised in **Table 1**. The RAG is asked to provide advice on which of these issues should be examined by the RAG Data Sub-Group and their order of priority. AFMA will provide a further presentation on these issues at the meeting.

6. It is expected, that once the issues identified for examination by the RAG Data Sub-Group have been appropriately addressed, the Sub-Group will be dissolved and the RAG will return to business as usual.

Table 1. Issues and questions concerning fishery dependent data inputs to the TRL Fishery assessment framework raised by the RAG in 2018

Issue	RAG meeting	RAG discussion and advice
Spatial structure	TRLRAG 23 and 24	Industry members advised that catches attributed to the Badu and Thursday Island areas are likely to be overstated, as fishers are reluctant to disclose the areas in which they have fished and may instead nominate the area the lobsters are being landed - catches are more likely coming from the Mabuiag and Northern areas. Dr Campbell agreed that this is a credible conclusion given anecdotal reports do not appear to align spatially with the catch and effort data. With regards to the TVH sector, the TRL04 logbook limits the reporting of catch and effort to a single location. Given this, the location the primary boat is anchored is generally recorded, not the location where tenders are actually fishing (which can range as far as 20 nm from the primary boat). Finer scale (e.g. at the tender level) location data is needed to inform future analysis.
Measure of effort	TRLRAG 23 and 24	Members agreed that the 'days fished' measure used in the TDB02 CDR is a crude measure of effort and may not include travel or searching time nor indicate what portion of the day was spent actively fishing. Industry members advised it is common practice for fishers to round-up to whole days. Further, the 'hours fished' measure used in the TRL04 logbook is being reported inconsistently across fishers (e.g. hours the tender spends away from the boat, hours divers are in the water).
CPUE	TRLRAG 23 and 24	Members agreed that there is a need to better standardise the CPUE data. Standardisation of CPUE data involves making adjustments to the data to take into account factors other than stock abundance that may influence catch rates. An important one of these factors is changes in fishing behaviour and fishing power over time. These changes can otherwise confound results by overestimating CPUE and by inference stock abundance. This "effort creep" includes changes to the size of engines, use of GPS, gear, areas fished, time fished and experience of divers. Current CPUE data may also be confounded by a hyperstability effect, seen when fishers remain on fishing "hotspots" or move from one hotspot to another – thereby maintaining high catch rates that don't represent the

		population size of the entire stock. Industry members and observers acknowledged the best way to understand effort creep is to talk to the fishers themselves. Some issues that need further investigation include: a. increases in fishing power in the Fishery through time and how to account for this in the CPUE standardisation (e.g. is ‘vessel-effect’ a proxy for skill of divers? Increase in boat size - can larger boats search more? Have there been other changes in fishing gears leading to increased CPUE?); b. what factors influence the spatial distribution of lobsters and hotspots, and what influences the spatial distribution of fishing effort; c. how fishing aggregations influence CPUE, and what factors influence aggregation dynamics; d. whether there is hyper-stability in the CPUE (based on factors above); e. the influence of oceanographic conditions (e.g. water temperature, prevailing winds).
Voluntary fields	TRLRAG23	Members noted that given constraints under the *Torres Strait Fisheries Act 1984* (the Act), some data fields on the TDB02 CDR are voluntary and as such often left uncompleted. This creates problems in providing a complete analysis of the data for the TIB sector and it is recommended that all fields be made mandatory. The AFMA member advised that amendments to the Act are being progressed to provide the capacity to require all licence holders to complete logbooks, but that this process is lengthy one and these amendments are a number of years off.
Length frequency	TRLRAG23	Members noted that the length frequency data is currently provided by MG Kailis. The RAG agreed this data is of high value and has been particularly useful this season in informing analyses on the performance of the Fishery. However, there is a longer term need to collect representative length frequency data from across the Fishery.
Depth data	TRLRAG 24	Industry members advised that the depth of water determines the hours that can be fished each day (e.g. at 7m depth a diver can fish as long as there is daylight, but the deeper the dives, the more constrained a diver is).
Survey sites vs. area fished	TRLRAG 24	Are there areas being consistently fished that are not being surveyed (e.g. survey and fishing footprints are not aligned) or has the distribution of the stock changed that these areas are not being surveyed?
Stratum	TRLRAG 24	TRL04 logbook/TDB02 catch disposal record (CDR) and survey stratum should be standardised.
Technology	TRLRAG 24	The RAG agreed that catch and effort data (and the indicators derived from these data e.g. CPUE) are fundamental to understanding the dynamics of the TRL stock and performance of the Fishery and agreed improvements that could be made to its collection and analysis, including:

		a. Use of data collection technology - assessing the use of electronic logbooks in the Fishery. b. Use of monitoring technology - assessing the use of a vessel monitoring system (VMS) on all boats in the Fishery.
PNG catches	TRLRAG 24 and 25	A better understanding is needed of PNG catch and effort inside and outside of the TSPZ including spatial and temporal data. Considering assessment timelines, PNG NFA to provide CSIRO with a best estimate of PNG catches by mid-November. CSIRO to liaise closely with PNG regarding reporting timeframes and provision of catch data. In parallel, the RAG data sub-group to examine ways to adjust the stock assessment model to account for delayed catch data from PNG.
TVH and TIB CPUE series	TRLRAG 25	The model incorporates six different standardised CPUE series. There is little difference between these series. The RAG requested the data sub-group have further discussions as to the best series to use. The reference case CPUE series currently used in the assessment is 'Int-1'. 4 different standardised CPUE series are used for the TIB sector. The RAG agreed to use the 'Seller' series as the reference case as the remaining three standardisations are impacted by the issue of area caught vs area landed. This issue is to be discussed further by the RAG data sub-group.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG) DATA SUB-GROUP	**[date to be confirmed]**
DRAFT TERMS OF REFERENCE	**Agenda Item 2** **For Noting**

RECOMMENDATIONS

1. That the TRLRAG Data Sub-Group **CONSIDER** the terms of reference, below.

RAG DATA SUB-GROUP TERMS OF REFERENCE

2. The Tropical Rock Lobster Resource Assessment Group (TRLRAG) Data Sub-Group will assess, identify and report to the TRLRAG on fishery dependent data inputs to the Torres Strait TRL Fishery assessment framework, in particular:
    a. improvements and refinements to data collection, in particular, fishery dependent data collected through logbooks, catch disposal records and other methods;
    b. improvements and refinements to data analyses as they relate to fishery dependent data;
    c. improvements and refinements to fishery assessment methodology as they relate to fishery dependant data;
    d. the use of data collection technology to improve collection of fishery dependent data e.g. electronic logbooks;
    e. the use of monitoring technology to improve fishery dependent data verification and analyses e.g. VMS coverage;
    f. liaise with other researchers, experts and industry members.
3. The RAG Data Sub-Group will be established for an initial term of 18 months and will comprise of persons nominated by the TRLRAG.

Attachment 5b

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP Data (TRLRAG 25)

[Date to be confirmed, between 19-21 March or 17-18 April 2019] (9:00 AM – 5:00 PM)

Queensland Bioscience Precinct (University of Queensland, St Lucia), Brisbane

DRAFT AGENDA

1 PRELIMINARIES

Attendees will be welcomed.

2 TERMS OF REFERENCE

The Data Sub-Group will be invited to consider the terms of reference.

3 OVERVIEW OF CURRENT DATA NEEDS AND COLLECTION IN THE TRL FISHERY

The Data Sub-Group will be invited to consider the range of data currently collected in the TRL Fishery and how it is used in the integrated stock assessment. How the data will be used through the application of the empirical Harvest Control Rule (eHCR) under the draft Harvest Strategy will also be considered.

4 CATCH PER UNIT EFFORT (CPUE)

The Data Sub-Group will be invited to discuss and provide advice on a range of issues affecting catch per unit effort (CPUE) data in the TRL Fishery, as previously identified by the RAG. In particular, advice will be sought from the Sub-Group as to how fishing operations are conducted and consequent data is recorded by fishers.

5 DATE AND VENUE FOR NEXT MEETING

The Data Sub-Group will be invited to consider a date and venue for the next meeting.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
TERMS OF REFERENCE FOR PEER REVIEW OF SURVEY DESIGN	**Agenda Item 6** **For Discussion and Advice**

RECOMMENDATIONS

1. That the RAG:
    a. **DISCUSS** and **PROVIDE ADVICE** on the draft terms of reference for an independent peer review of the TRL Fishery survey design (**Attachment 6a**). Please note, Attachment 6a was pending at the time these papers were sent.
    b. **PROVIDE ADVICE** on potential researchers to undertake the review, noting any conflicts of interest.

KEY ISSUES

2. At the RAG meeting held on 18-19 October 2018, the RAG recommended an independent review be conducted of the TRL Fishery survey design. Pending further input by the RAG, the review should examine the following:
    a. pre-season survey methodology;
    b. merits of alternative survey approaches (e.g. benchmark and mid-year surveys);
    c. CPUE vs. survey mismatch and hyper-stability in CPUE;
    d. availability and merits of alternative data collection technologies.
3. A draft terms of reference as developed by the Chair is provided at **Attachment 6a** (this paper is pending) for discussion and advice.
4. At the TSSAC meeting on 5-6 December 2018, it was agreed that the independent peer review of the TRL Fishery survey design will be considered for funding in 2019-20, however this projects will be directly sourced from specific researchers due to the expected low cost and specialist service.
5. Following this meeting the final draft terms of reference will be provided to TSSAC at their next meeting on 26 February 2019, prior to a proposal being sought directly from specific researchers for consideration at the TSSAC meeting from 28-30 May 2019.

External Review of Tropical Rock Lobster Survey
Draft Terms of Reference

Background

The Torres Strait Tropical Rock Lobster (TRL) fishery provides an important source of income for more than 400 Torres Strait islanders and many island communities; and also supports a non-islander sector, involving ~11 licensed primary vessels. The TRL ornate rock lobster (*Panulirus ornatus)* stock is shared with adjacent fisheries in PNG and on the northern Queensland coast. Given its significant traditional, economic and social importance there is a need to ensure the long-term biological sustainability of the stock through research supporting management d plans aimed at optimising the sustainability and utilisation of this resource.

Annual fishery-independent scientific diving surveys of the Torres Strait ornate rock lobster population have been carried out annually or biannually over 1989 to 2018. These surveys, conducted either mid-year (June, in 1989-2014, 2018) and/or pre-season (November, in 2005-2008 and 2014-2018), have provided consistent long-term estimates of the relative abundance of pre-recruit (0+), recruiting (1+) and recruited (2+) lobsters Pre-season population surveys of recruiting (1+) lobster abundance were, in particular, identified by the TRL RAG as essential to support the move to a quota managed system (QMS) proposed in 2005 and implemented during 2019.

These survey data sets are integral to the fishery model developed to assess fishery status and to forecast stock size and TAC as well as the key input to the empirical harvest control rules (eHCR) to set TACs. The survey design has been modified at various stages since the 1989 “benchmark survey”.

Put in the changes….

The main change over the years has been a reduction in the number of sites that have been sampled and a move from mid-year to pre-season surveys over the last five years, focussing on providing 1+ estimates from which the next year’s TAC can be determined. The survey methods have otherwise stayed the same. CSIRO divers use a standardised 2000m^2 belt transect method; 2 divers per site each scanning 2m by 500m. Transect distance is measured using a Chainman™ device and divers swim a generally straight line, following a compass bearing chosen at the time of the dive, in line with any prevailing current. At the completion of each transect divers record:

- The number of lobsters caught per age-class;
- The number and age-class of those observed but not caught;
- Depth;
- Visibility;
- Distance and direction swum from the site co-ordinate.

In addition, species of interest (i.e. pearl oyster (*Pinctada maxima*), crown of thorns starfish and holothurian species) are counted and the benthic habitat and geomorphology characterised. Caught lobsters are measured (tail width, TW) to provide fishery-independent size-frequency data and returned to the water.

Requirement

It is considered good scientific practice to have long-term fishery monitoring programs externally reviewed at regular periods (5-10 years) to ensure that survey and statistical analysis techniques are consistent with contemporary methods and that survey approaches remain relevant and cost-efficient given the requirements for assessment and management of the fishery. In this case, the push for an external review of the TRL survey was intensified by a portion of industry considering that the (1+) abundance results of the 2017 pre-season survey did not align with their perception of the stock status based on commercial catch rates and size distribution during the first few months of the 2018 fishery.

The results of the 2017 pre-season survey showed:

- 1+ lobster abundance index – 1.78 lobsters observed per transect. This was the ***lowest recorded*** for a pre-season survey, just 25% of the highest index in 2015.
- 1+ lobster abundance and distribution – low abundance around the Western survey sites (Thursday Island, Mabuiag, Buru (Turnagain)). The South East survey sites were up 250% from the 2016 survey. Distribution is similar to previous surveys but with an absence of 1+ lobsters around Buru.
- 0+ lobster abundance index – ***lowest ever recorded***, just 20% of the 2016 survey index.
- 0+ lobster abundance and distribution – very low abundance around Mabuiag and Thursday Island and low across most other sites except the South East. The distribution is unusual compared to the 2016 survey.
- Certainty - CSIRO were confident about the 1+ lobster results, with a little less certainty about the 0+ lobster results because 0+ lobsters are harder to see.

As one of the major inputs into the assessment, the 2017 pre-season 1+ abundance index resulted in an assessment RBC (and TAC) recommendation that was the lowest on record (TACs have been calculated for the Fishery from 2006). Consequently, the RAG agreed to conduct a 2018 mid-year survey to as a comparison to the pre-season survey and commercial catch rates. Ultimately, the md-year survey generally supported the low 1+ abundance index of the previous survey.

In virtually all previous years, the abundance indices derived from the fishery-independent surveys have been in line with industry's perception of the status of the stocks and there has been little, if any cause for concern about the survey design. During 2018, however, the low TAC resulted in significant adverse social and economic impact throughout the Torres Straits. Consequently, industry wanted significantly more scientific scrutiny applied to the design of the survey – particularly the number and position of the sites used for the pre-season surveys, and whether this may be leading to bias in the resultant abundance indices.

Scope of the review

The review is restricted to evaluating the design of the mid-year and pre-season surveys. It does not include an examination of the stock assessment methods, eHCR methods or how the survey abundance indices are used in these processes.

With regard to the survey design.

1) Explore the potential for bias in the 0+, 1+ and 2+ abundance estimates that may be derived from the choice of site positions and the number of sites:
    a. How well does the number of sites and their distribution reflect the historical year-to-year dynamics of the commercial fishery (TIB and TVH)?
    b. How robust is the design to likely spatial changes in TRL populations?
    c. How robust is the design to likely spatial changes in commercial targeting?
        i. Fine-scale (100s of metres)
        ii. Broad regional scale (10s of kilometres)
    d. Will an increase in the number of sites lead to a significant and/or cost-effective improvement?
    e. Will a change in the distribution of sites lead to a significant and/or cost-effective improvement?
    f. Provide recommendations for improvement.
2) Explore the potential for bias in the 0+, 1+ and 2+ abundance estimates that may be derived from inter-diver variation and its application in undertaking the transect method:
    a. Is there a need for diver standardisation?
    b. Provide recommendations for improvement.
3) How robust is the design to expected changes that may be associated with climate change?
    a. Changes in distribution and/or abundance of TRL?
    b. Changes in ecosystem structure or habitat distribution?
    c. Provide recommendations for improvement.
4) Consider whether integration of surveys conducted by other jurisdictions would be cost-effective:
    a. What would be the most useful survey that could be conducted in PNG waters?
    b. What would be the most useful survey that could be conducted in QLD waters?

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
RESEARCH PRE-PROPOSALS FOR 2019/20	Agenda Item 7 For Discussion and Advice

RECOMMENDATIONS

1. That the RAG:
   a. **NOTE** as part of its 2019 funding round, TSSAC made an annual public call for research applications on Friday 21 December 2018 to address research priorities identified for potential funding in 2019-20;
   b. **DISCUSS** and **PROVIDE ADVICE** on the **draft** research pre-proposal submitted for funding in 2019/20, in response to the 2019 call for research (**Attachment 7a**);
   c. **NOTE**, that:
      i. as research pre-proposals are not due until 5 February 2019, any further proposals submitted by this date will be provided to the RAG for out of session consideration and comment by 20 February 2019;
      ii. full research proposals will be due 12 April 2019 and will be provided to the RAG for out of session consideration and comment by 7 May 2019.

KEY ISSUES

2. The Torres Strait Scientific Advisory Committee (TSSAC) is a Protected Zone Joint Authority advisory body that that guides fisheries related research priorities, and assesses proposals for Torres Strait Fisheries related research each year. As part of its 2019 funding round, TSSAC made an annual public call for research applications on Friday 21 December 2018 to address research priorities identified for potential funding in 2019-20. The final scopes can be found at: www.pzja.gov.au/resources/research. The call for research was also advertised in NRM jobs.
3. The TSSAC met on 5-6 December 2018 to consider fishery-specific research priorities identified by individual fisheries Resource Assessment Groups (RAGs), Working Groups (WGs) and Management Advisory Committees (MACs). The TRL Fishery Rolling Five Year Research Plan for 2019/20-2022/23 was considered at this meeting (**Attachment 7b**). The below scopes were subsequently developed:

Fishery	Scopes	Reference
All Torres Strait fisheries	1. Climate variability and change relevant to key fisheries resources in the Torres Strait — a scoping study.	Please refer to **Attachment 7c**.
	2. Measuring non-commercial fishing (indigenous subsistence fishing and recreational fishing) in the Torres Strait in order to improve fisheries	Please refer to **Attachment 7d**.

	management and promote sustainable livelihoods.	
Tropical Rock Lobster Fishery	3. Fishery independent survey, stock assessment, Harvest Strategy and Recommended Biological Catch calculation for the Torres Strait Tropical Rock Lobster Fishery.	Please refer to **Attachment 7e**.
Hand Collectables Fisheries	4. Torres Strait Sea Cucumber Stock Status Survey.	Please refer to PZJA website https://www.pzja.gov.au
Finfish Fishery	5. Management Strategy Evaluation of Torres Strait Finfish Harvest Strategy	Please refer to PZJA website https://www.pzja.gov.au
	6. Enhancing biological data inputs to Torres Strait Spanish mackerel stock assessment.	Please refer to PZJA website https://www.pzja.gov.au
	7. Scoping for Spanish mackerel stock assessment – Torres Strait Scientific Advisory Committee.	Please refer to PZJA website https://www.pzja.gov.au

4. Research funding is assessed in two stages by the TSSAC, through pre-proposals, then successful applications will be asked to submit full proposals. Further details on the process are provided at **Attachment 7f**. Applicants should use the fishery-specific project scopes provided as a guide when developing their pre-proposals to meet the identified need for the project.

5. Pre-proposals are due 5 February 2019. The PZJA will seek RAG and Working Group comments on pre-proposals by 20 February 2019 before consideration by the TSSAC at its March 2019 meeting.

6. To date, one draft research pre-proposal has been submitted by CSIRO (**Attachment 7a**) in response to the research scope "*Fishery independent survey, stock assessment, Harvest Strategy and Recommended Biological Catch calculation for the Torres Strait Tropical Rock Lobster Fishery*" (**Attachment 7e**). The RAG is asked to consider and provide comment on this pre-proposal, taking into account TSSAC's evaluation criteria provided at **Attachment 7g**.

7. Applicants will be advised in late March 2019 whether a full proposal should be submitted. Full proposals will be due by 12 April 2019. The full proposal process has changed and now includes a pre-consultation process with traditional inhabitants.

8. There will also be 2 ERAs (BDM and TRL) funded through the 2019-20 budget which will not be a part of the call for research, as they are required to support fisheries export approvals, and will be completed by the CSIRO under an existing agreement. Finally, a Torres Strait Prawn Fishery project and the TRL peer review will be considered for funding, however these projects will be directly sourced from specific researchers due to their low cost and specialist service.

BACKGROUND

9. The TSSAC seeks input from each fishery advisory body (RAG, MAC or WG) to identify research priorities over five year periods from 2019/2020 to 2022/23. Rolling five-year research plans are to be developed for each fishery 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.
10. 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.
11. 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.
12. 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.

Torres Strait Scientific Advisory Committee research application

Please indicate the type of application you are submitting – an EOI in response to a call for research; or a full proposal in response to TSSAC advice that your initial application has been approved for further development:

X **Pre-proposal** **(Please complete Sections 1-4 inclusive)**

Full Research Proposal **(Please complete sections 1-8)**

SECTION 1 - ADMINISTRATIVE SUMMARY

Project title:	Torres Strait TRL survey SA and HS		
Applicant (organisation or person):	Éva Plagányi, CSIRO		
Contacts			
Administrative			
Title/Name:	Cathy Minnucci	Phone:	+61 3 6232 5505
Position:	Finance Advisor	Email:	Cathy.Minnucci@csiro.au
Organisation:	CSIRO	Postal	CSIRO, Hobart
Principal Investigator (person)			
Title/Name:	Dr Eva Plaganyi	Phone:	0438500926
Position:	Principal Research Scientist	Email:	Eva.Plaganyi-lloyd@csiro.au
Organisation:	CSIRO	Postal address:	Queensland BioSciences Precinct (QBP), 306 Carmody Rd, St Lucia, QLD 4072
Co-investigator (s)			
Title/Name:	Mark Tonks	Phone:	07 38335973
Position:	Experimental scientist	Email:	Mark.Tonks@csiro.au
Organisation:	CSIRO	Postal address:	Queensland BioSciences Precinct (QBP), St Lucia, QLD 4072
Co-investigator (s):			
Title/Name:		Phone:	
Position:		Email:	
Organisation:		Postal	
Planned Start and End Date			
Start Date:	1/7/2019	End Date: 15/6/2022	

SECTION 2 – PROJECT DESCRIPTION

PROJECT BUDGET: (Excluding GST)

Financial Year	AFMA	Applicant (in kind)	Applicant	Other
2019/2020	$305,940.00	$128,890.00		$0.00
2020/2021	$298,478.00	$125,746.00		$0.00
2021/2022	$309,092.00	$130,217.00		$0.00
Totals	$913,510.00	$384,853.00		$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.*

To support quota management and catch sharing arrangements, a Total Allowable Catch must be determined for the Torres Strait Tropical Rock Lobster Fishery (TRL Fishery) each year. This requires collection and analysis of both fishery-dependent data (including catch, CPUE, length frequency) and fisheries –independent data (scientific surveys). CSIRO have conducted annual fishery-independent surveys of the TRL population and associated habitat since 1989, and there is a need for ongoing surveys using comparable protocols and critical review of survey data. There is also a need to standardise and critically evaluate annual catch per unit effort data from the fishery sectors for use as inputs to stock assessments and the empirical harvest control rule. The stock assessment needs to be updated and rerun once every three years, or more frequently dependent on the Harvest Strategy in place as well as the status of the stock. In addition, periodic revisions and improvements to the stock assessment model are needed to ensure that it remains a reliable tool for use in assessing stock status and recommending a Recommended Biological Catch (RBC).

The eHCR has recently been proposed for use in providing a RBC for the following fishing season and needs to be run in November each year. There is also a possibility that the eHCR may need some further refinements before final adoption. In addition, there is a need to build further on initial work that has been done to simulation test risk-equivalent options for a tiered harvest strategy, and further analyses and stakeholder consultation are required in order to support a tiered harvest strategy for TRL.

Objectives / performance indicators (max 250 words) **-** *list the major objectives or planned outcomes of the project. These will form your project milestones:*

1. Manage all the data held by CSIRO pertaining to the Torres Strait Rock Lobster fishery
2. Annually provide statistical analyses of all CPUE and survey data, including any new data provided by PNG, as well as consideration of ongoing analyses (in close consultation with fishers) of changes due to changes in technology and the management system
3. Recommend a RBC (Recommended Biological Catch) annually for each of the fishing seasons based on implementation of the harvest control rule or stock assessment as appropriate.
4. Every third year, update and implement the long-term stock assessment using the integrated fishery model with updated fishery-independent and commercial catch data, to assess and review stock status and RBC recommendations.
5. Conduct a reduced scale (74 sites) pre-season survey in November each year or, if required (and subject to additional funding being provided) an extended preseason survey.
6. Continue any required refinement of the empirical harvest control rule (HCR) and a tiered harvest strategy, with the performance of each tested using Management Strategy Evaluation (MSE), and the final choice decided in consultation with stakeholders.
7. Conduct concurrent seabed habitat monitoring, including coral bleaching and crown of thorns surveys, during the pre-season population surveys and provide annual summaries of the abiotic and biotic categories to assess the long-term status of the western Torres Strait environment. Collate additional oceanographic and environmental data, including water temperature, to extend the current data time-series and supplement the habitat data time-series.
8. Coordinate the collection of monthly size data from commercial catches taken in Torres Strait to allow continued assessment of the mean size and age distribution of TRL taken by the fishery.
9. Present the outcomes of this research project to Torres Strait communities at its completion

Consultation and Engagement - *Note consultation is required for both the pre- and full-proposal phases for TSSAC projects. This differs from AFMA Research Committee Proposal requirements.*

Pre-proposal phase consultation

Briefly detail (this will form the skeleton of your community engagement strategy which must be developed as part of full proposal phase):

- *the areas in the Torres Strait region where the proposed research activities may occur*
- *the Torres Strait community groups or individuals that you will engage/involve from these areas in the development of and or during the project if it reaches full proposal phase (refer to Step 2 of Attachment A - Procedural Framework for Researchers in the Torres Strait).*
- *how you plan to engage/involve key stakeholders (e.g. community notices, telephone, email, employment, interviews, meetings, workshops) in the project development. Note, any potential fee for service rates need to be factored into your research project budget.*

The aims and methods of the survey and stock assessment research have been developed through consultation principally at TRL RAG, WG and TSSAC meetings, involving AFMA and state managers, independent scientists, TVH and TiB fisher representatives and flow-on business stakeholders. Representatives from these groups have made significant contributions to the development of the fishery-independent surveys, commercial catch and effort monitoring and the integrated fishery model through these consultative meetings. The project team also regularly prepare nontechnical summaries and community notices, as well as holding science communication workshops and capacity building initiatives which will be continued going forward.

*If there has been any initial consultation and engagement outline with whom and key outcomes (note consultation is **not** necessary at the EOI stage but has sometimes occurred through existing relationships).*

Islanders are engaged in a 2-way process with this research in providing inputs to the model and analyses and then evaluating and commenting on model outputs. In the numerous forums where this research is and will be discussed with Islanders, their inputs are also sought as to areas of interest or high priority questions that the research is able to support. Our team regularly meet with or talk by phone with stakeholders from across the Torres Strait region to listen to their insights and feedback on the stock status and fishery operations.

Full proposal consultation and engagement

In accordance with the Procedural Framework for Researchers in the Torres Strait (Nakata 2018; Procedural Framework), the TSSAC full proposal requires two different aspects be completed.

1. Develop a stakeholder engagement strategy, including a plain-English community consultation package which should be used to undertake preliminary consultation with relevant stakeholders as part of your full proposal application. Follow instructions in Appendix 4 of the procedural framework (Attachment A).

2. Provide documentation and outcomes from the preliminary consultation and engagement conducted, including:

- *The level of stakeholder support – particularly from Traditional Inhabitants for the proposed work (include a list of who was contacted and whether they support the project, or if not, why).*
- *Any perceived risks or stakeholder considerations with the project.*
- *How traditional knowledge might be considered or incorporated to enhance the project, its outcomes and benefits.*
- *Any activities suggested by Traditional inhabitants to improve the project, or bring it into alignment with community needs.*
- *How the research outcomes will benefit Traditional Inhabitants directly or indirectly, or why it is not relevant/ applicable (i.e. projects in the prawn fishery).*

Attach the stakeholder engagement strategy (which should have been updated as required following initial consultation) with your full proposal application.

Methods (max 250 words) – *Please detail the basic methods that will be used to undertake this project.*

The field sampling methods employed during the pre-season population surveys will mostly be consistent with those used during all previous surveys, and approximately 74 sites corresponding to the mid-year survey sites will be included to ensure inter-annual comparisons of lobster abundance and habitat are consistent. The seabed habitat at each site will be recorded using standard categories established during previous surveys.

Data updates (including new AFMA Catch Receiver data, processor catch-disposal records and size-monitoring data, any new PNG data, CSIRO survey data and relevant oceanographic and environmental data) will be obtained from relevant agencies on a routine basis and entered into the existing ORACLE database managed by the project. This database is part in the large ORACLE database managed by CSIRO Oceans and Atmosphere and is fully secure. All data will be checked for errors and updated where possible in collaboration with the data providers. Catch and effort data summaries will be compiled providing a current snapshot and time-series trends of fishery performance. A suite of fishery indicators will be calculated including standardised CPUE indicators using Generalised Linear Models and other statistical methods as required. Data summary reports will be presented to the TRL RAG and additional data summaries will be provided as requested. Size and sex data from commercial lobster catches will be recorded monthly at M. G. Kailis Pty Ltd in Cairns and entered into the historical data-base. Finally, the output from models used to assess the stock status of TS rock lobster (such as time-series of spawning biomass) will also be stored in the project database.

Every third year, the integrated stock assessment model will be updated with all available information, and appropriate sensitivity tests run, in order to provide forecasts of recommended RBCs. Continued refinements will be made to the method for standardising both the TVH and TIB CPUE data.

Further refinements to the empirical harvest control rule (eHCR), in consultation with stakeholders, will be developed and the eHCR will be implemented to inform a RBC. A simple Excel version of the final eHCR will be provided to stakeholders to facilitate understanding of the decision rule and its implementation. Work will continue to develop a a tiered harvest strategy that accounts for different risk-catch-cost trade-offs of different stock assessment and monitoring options for the fishery, pre-tested using Management Strategy Evaluation.

Estimates of recruiting (1+) and fished lobster (2+) abundance, the size distributions of sampled lobsters, spatial distributions of lobsters and maps of seabed habitats and the updated stock assessment and TAC estimates will be reported at the annual TRL RAG and TRL WG meetings.

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:*

This research project will provide annual estimates of recruiting (1+) and pre-recruit (0+) lobster abundance as inputs annually to a HCR, and every 3 years to an updated stock assessment model. The model will be updated every three years using all available commercial catch, survey, CPUE and catch at age data. Annual data summaries will be produced and a harvest control rule (HCR) implemented annually to inform setting of a RBC. All relevant data pertaining to the fishery will be collected, analysed and managed.

The final Harvest Strategy, including details of the HCR, will provide a framework that specifies the pre-determined management actions in the fishery necessary to achieve the agreed ecological, economic and/or social management objectives.

Project extension (max 100 words) - *are there possible future research options that could result from this project?*

There are many future research options that could result from this project, including ongoing refinement and improvement of the models (eg. Length-based model would be helpful) and analysis methods and harvest strategy development. This study also provides a baseline for a range of future surveys such as larger scale/benchmark surveys or additional survey effort (eg sampling 0+) lobsters undertaken by Islanders to complement existing surveys, as well as any planned surveys by PNG. There is also a need for an indepth review of the fisheries-dependent data given changes in the fishery management, fisher behavior and technology and future studies can build on this research to further improve the assessment and management of TRL. In addition, scientists and Torres Strait stakeholders have both recognized the importance and impact of changing environmental conditions and anthropogenic climate change and this study will provide a solid foundation for ongoing research on these aspects, both in terms of longterm baseline data collection (eg habitat monitoring during the surveys) and modelling. There is also potential for future research to expand considerably research on economic and socio-cultural aspects that can be further integrated into the research. Finally, there are opportunities to further involve Islanders in aspects of the research (eg additional length frequency samples) as well as to integrate traditional knowledge into the analyses to the extent possible.

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 have 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. To date the research has been well supported, and the CSIRO team have consistently invested a lot of time and effort into engaging with stakeholders, inviting their inputs, capacity building and involving them in the research to the extent possible.

There are a number of risk associated with conducting fieldwork in a remote region with strong currents, low visibility and subject to prevailing weather, but the team have 30 years' experience in managing and avoiding any risks as they arise, plus stringent protocols in place to minimize these.

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 TRL population surveys, including seabed habitat monitoring and subsequent stock assessments since 1989. CSIRO has collaborated with Torres Strait islander communities, organizations and individuals throughout its research history to ensure research outcomes are relevant. to Torres Strait and Torres Strait islanders are provided with results of the research projects.
This project builds on the current TRL survey, assessment and harvest strategy development project, as well as environmental influences project and contributions to the AFMA-CSIRO climate projections project. The project pre-proposal also links closely with a second pre-proposal being submitted and led by Leo Dutra (CSIRO): Climate variability and change relevant to key fisheries resources in the Torres Strait.

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	Schedule of AFMA payment(s) (excluding
Initial payment on signing of contract	On signing	$91,782.00
Conduct a reduced scale (74 sites) pre-season survey	1 Dec 2019	$91,782.00
Recommend a RBC based on the harvest control rule and/or stock assessment and present research to RAG and stakeholders	31 May 2020	$122,376.00
Conduct a reduced scale (74 sites) pre-season survey	1 Dec 2020	$149,239.00
Recommend a RBC based on the harvest control rule and/or stock assessment and present research to RAG and stakeholders	31 March 2021	$29,848.00
Progress Report and non-technical summary	31 May 2021	$119,391
Conduct a reduced scale (74 sites) pre-season survey	1 Dec 2021	$154,546
Recommend a RBC based on the harvest control rule and update stock assessment and present research to RAG and stakeholders	31 May 2022	$30,909
Draft final report		$0.00
Final report		$123,637
TOTAL		$0.00

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: **Date:**

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: **Date:**

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: **Date:**

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: **Date:**

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: **Date:**

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: **Date:**

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.

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:

I have searched for existing data (refer to guidelines on how to search the Australian Spatial Data Directory and Oceans Portal):

[Yes / No]

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:

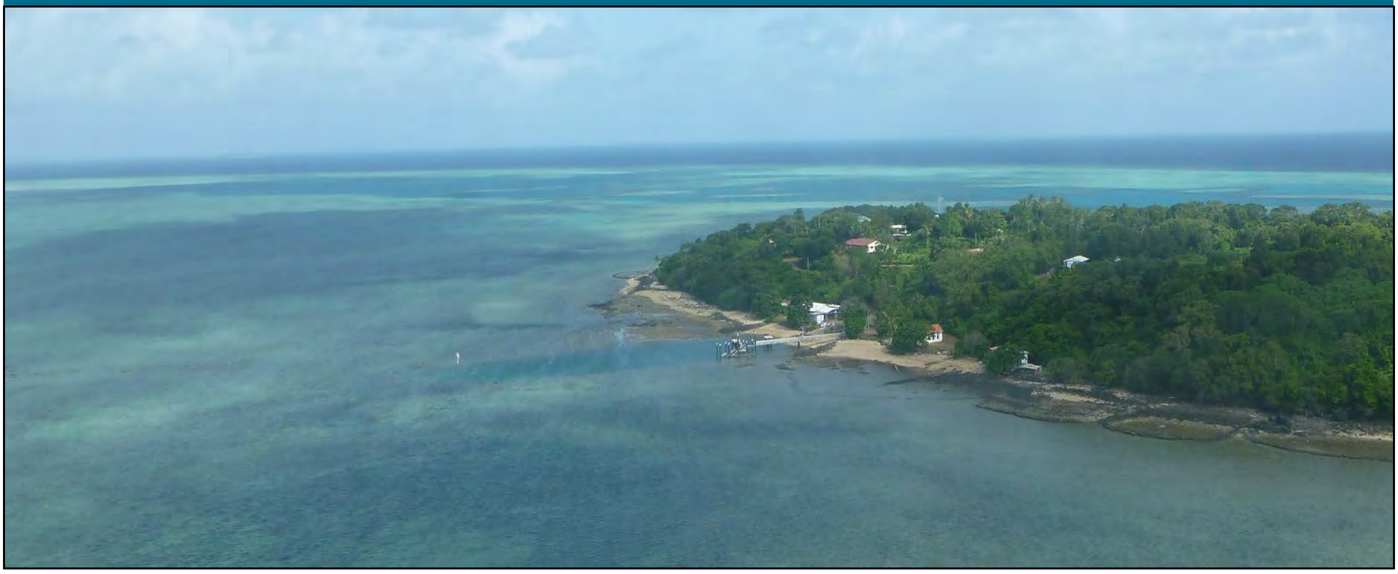
- information on data security or privacy issues and applying to the data
- Nominated data custodian

- 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?

Rolling Five Year Research Plan

2019/20-2022/23

Torres Strait Tropical Rock Lobster Fishery



Compiled by AFMA

October 2018

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 2019/2020 to 2022/23. 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.

RESEARCH PRIORITIES

Table 1. Five year Torres Strait Tropical Rock Lobster Fishery research plan for 2018/19 – 2022/23.

Proposed Project	Objectives and component tasks	Year project to be carried out and indicative cost*						Other funding bodies[1]	Evaluation		
		2018/19	2019/20	2020/21	2021/22	2022/23	Notes on project timings		Priority essential /desirable	Priority ranking (1-5 – 1 being highest priority)	Theme
Fishery surveys, stock assessment, harvest control rules and recommended biological catch (RBC)	Monitor ongoing changes in the fishery and update or develop fishery performance indicators as required; Recommend a recommended biological catch (RBC) annually for each season; Every third year update and implement the long-term stock assessment; Conduct a pre-season survey in November each year, including seabed habitat monitoring; Continue development of a harvest	277,477 (funded under 2016/ 0822)	260,000	240,000	240,000	240,000	Nil	AFMA CSIRO PNG NFA Industry	Essential	1	1

	strategy for the TRL Fishery including an empirical harvest control rule. Facilitate data sharing with PNG. Development of a tiered harvest strategy for the TRL Fishery.										
Mid-year survey	Conduct mid-year survey, as required under the Harvest Strategy for the TRL Fishery	0	0	0	0	0	To be conducted on an as needs basis – indicative cost $110,000 with in-kind contribution from CSIRO	AFMA CSIRO PNG NFA Industry	Essential (when required)	1	1
Science peer review	Consistent with best practice Guidelines for quality assurance of Australian fisheries research and science information (the Guidelines), a peer review be conducted of the TRL Fishery survey design, stock assessment	0	60,000-80,000 (depen-dent on final scope)	0	0	0	Terms of reference to be developed and considered by the RAG in first quarter of 2019	AFMA	Essential	1	1

	and draft Harvest Strategy.										
Ecological risk assessment (ERA)	Conduct an update to the 2007 ERA for the TRL Fishery.	0	20,400	0	0	0	To be conducted in the next three years	AFMA CSIRO	Essential	1	1
Improvement of data collection	Improved monitoring of commercial catch and effort in all sectors of the fishery; Estimate of non-commercial take of TRL; Alternative monitoring techniques of effort, for example GPS tracking.	0	20,000	0	0	0	Sub-group of the RAG to progress alongside upcoming RAG meetings – funding for sub-group meetings to be sourced from RAG budget	AFMA PNG NFA	Essential	1	1,3
Understanding connectivity, environmental drivers and adaptation strategies	Understanding of migration of lobster between, and within, jurisdictions.; Understanding of recruitment connectivity between, and within, jurisdictions; Management implications of movement and recruitment connectivity	0	0	TBA	TBA	TBA	Nil	AFMA PNG NFA CSIRO	Essential	2	1

	between, and within, jurisdictions.										
Understanding changes to fishing power through time	Understanding changes in fishing behaviour and power over time (e.g. changes to the size of engines, use of GPS, gear, areas fished, time fished, experience of divers), to inform the standardisation of CPUE data.	0	0	TBA	TBA	TBA	Sub-group of the RAG to progress once progress on improving data collection has been made – funding for sub-group meetings to be sourced from RAG budget	AFMA CSIRO	Desirable	2	1
Understanding fishing behaviour	Understanding the drivers and incentives in determining fishing behaviour in all sectors; Understanding fishing behaviour under output controls: the impact of ITQs or competitive quota on the fishery; the extent and impact of discard mortality; the effect of changing market	0	TBA	TBA	TBA	TBA	Timing of project to be considered once a Management Plan has been fully implemented in the TRL Fishery	AFMA	Desirable	3	1

	preferences on fishing behaviour under output controls; the extent of value adding e.g. moving to live product, targeting different sizes; the extent of high grading under output controls.										

Attachment 7c

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.

Contacts

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Torres Strait Scientific Advisory Committee 2019-20 financial year research project scope

Project title: Measuring non-commercial fishing (indigenous subsistence fishing and recreational fishing) in the Torres Strait in order to improve fisheries management and promote sustainable livelihoods.

Project need:

There is limited data available on non-commercial catches and consumption of seafood species for the Torres Strait. Non-commercial catches include both Torres Strait Islander subsistence fishing and non-Torres Strait islander recreational fishing. Of particular interest to stakeholders, such as communities and fishery managers, is the quantity of non-commercial catches of key commercial species of Spanish mackerel, coral trout, and tropical rock lobster.

Improved information on subsistence catches of these species is needed to provide better understanding of the social (including sharing/reciprocity), economic, food security and cultural contributions, values and benefits of fisheries resources to the livelihoods of Torres Strait islanders. Collection of these data will support sound decision making in the management of fisheries resources, including the setting of appropriate harvest levels.

A project, with a strong social and demographic focus, is required to:

Phase 1

- Consider the needs of stakeholders (management and communities) in monitoring and assessing the quantity and scale of non-commercial use of commercial fish species over the longer-term.
- Establish partnerships among research and management agencies, and Torres Strait island communities to develop a research plan and sampling design that will meet the data needs for the fisheries.
- Review past project data and methodologies from other studies and establish linkages with other current or proposed projects supported by other agencies (e.g. FRDC, QDAF) who are also working on the assessment of recreational and non-commercial harvest of fishes.

Phase 2

- Undertake pilot testing, data collection, analysis.
- Provide recommendations on an ideal sampling design (including data collection and analysis), training required, stakeholder communication and feedback and ongoing monitoring and assessment recommendations.

Desired Outcomes

- Through collaboration with Traditional Inhabitant community member champions, development of a methodology for ongoing assessment of the non-commercial fishing catches in Torres Strait.
- A review of outcomes, lessons learnt and relevant methodologies from previous projects.
- A research approach with strong, culturally appropriate community participation that ensures communities are clear as to the benefits that will be gained from the research.

- Provision of data on the current subsistence and recreational catches to contribute to improved management of fisheries in the Torres Strait region and understanding of the contribution of key commercial species to Torres Strait Islander livelihoods.
- Recommendations on data needs for monitoring and assessing non-commercial catches in future.

Contacts

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Torres Strait Scientific Advisory Committee 2019-20 financial year research project scope

Project title: Fishery independent survey, stock assessment, Harvest Strategy and Recommended Biological Catch calculation for the Torres Strait Tropical Rock Lobster Fishery

Project need:

A Total Allowable Catch must be determined for the Torres Strait Tropical Rock Lobster Fishery (TRL Fishery) for the 2019-20 through to 2021/22 fishing seasons to support quota management and catch sharing arrangements between Australia and Papua New Guinea (PNG) under the Torres Strait Treaty. A Management Plan came into effect from 1 December 2018 and includes implementation of a quota management system for the TRL Fishery. The TRL Fishery fishing season runs from 1 December each year through to 30 September the following year.

Since 1989 annual fishery-independent surveys of the TRL population have been conducted. Following a decision to transition to quota management, both mid-year (between May-July) and pre-season (November) surveys were completed in 2005 to 2008, 2014 and 2018. In other years only a pre-season survey has been conducted. These surveys have provided the basis for assessing sustainable catch levels for the Fishery and provide critical long-term information on the relative abundance of recruiting TRL.

The TRL Fishery is currently operating under an interim Harvest Strategy. Data from surveys (including sex and length frequency), along with catch per unit effort (CPUE) and catch-at-age data are used in an integrated stock assessment model to assess the stock and calculate a Recommended Biological Catch (RBC) for each season. The integrated stock assessment is run from December and finalised by February/March each year to provide a RBC for each fishing season.

A draft Harvest Strategy is currently under development for the TRL Fishery. The draft Harvest Strategy has been developed in consultation with the TRL Resource Assessment Group and Working Group. Once implemented, the Harvest Strategy will use an empirical Harvest Control Rule (eHCR) to calculate the RBC each season. The proposed eHCR uses the pre-season survey 1+ and 0+ indices, standardised CPUE indices, applies the natural logarithms of the slopes of the five most recent years' data. The eHCR will be run in November each year to provide a RBC for the following fishing season. A stock assessment will be run on a three year cycle in February/March, unless the stock assessment is triggered by a decision rule. If a stock assessment is triggered this may also entail the conduct of additional surveys (mid-year). The stock assessment will determine the stock status and evaluate the performance of the eHCR and identify if any revisions to the eHCR are required. If the eHCR needs to be revised, the stock assessment will be conducted annually to estimate the RBC until the revised eHCR is agreed.

While it is expected that the draft Harvest Strategy may be implemented by the 2019-20 fishing season, proposals should consider the interim Harvest Strategy to apply until the draft Harvest Strategy is formally adopted. Further, any extraordinary survey and stock assessment work need not be included in proposals, as this will involve separate funding proposals.

A tiered harvest strategy is also being considered for the TRL Fishery. This should be included as part of the proposal.

Desired outcomes

2019-20 fishing season

- Pre-season survey undertaken in accordance with established survey protocols developed by CSIRO.

- Data sharing with PNG facilitated and consideration of PNG data in the integrated stock assessment model.
- RBC calculated for the 2019-20 fishing season with updated fishery independent and commercial catch data using either: a) the integrated fishery assessment model; or if the draft Harvest Strategy has been formally adopted b) the agreed eHCR and associated decision rules.
- If the draft Harvest Strategy has not been formally adopted, any outstanding work is finalised in preparation for adoption.
- Development of a tiered harvest strategy commenced.

2020-21 fishing season

- Pre-season survey undertaken in accordance with established survey protocols developed by CSIRO.
- Data sharing with PNG facilitated and consideration of PNG data in the integrated stock assessment model.
- RBC calculated for the 2020-21 fishing season with updated fishery independent and commercial catch data using either: a) the integrated fishery assessment model; or if the draft Harvest Strategy has been formally adopted b) the agreed eHCR and associated decision rules.
- Development of a tiered harvest strategy progressed.

2021-22 fishing season

- Pre-season survey undertaken in accordance with established survey protocols developed by CSIRO.
- Data sharing with PNG facilitated and consideration of PNG data in the integrated stock assessment model.
- RBC calculated for the 2021-22 fishing season with updated fishery independent and commercial catch data using either: a) the integrated stock assessment model; or if the draft Harvest Strategy has been formally adopted b) the agreed eHCR and associated decision rules.
- If it is the third year of application of the agreed eHCR, an integrated stock assessment to evaluate the performance of the eHCR to identify if any revisions to the eHCR is run.
- If the integrated stock assessment indicates the eHCR needs to be revised, work on this review commenced.
- Development of a tiered harvest strategy progressed.

Applicants are asked to detail monitoring and data collection costs separate from the assessment costs.

Contacts

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TSSAC annual research 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.

Assessment criteria for TSSAC research project applications

	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?												

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 26 5 February 2019
OTHER BUSINESS	Agenda Item 8 For Discussion

RECOMMENDATIONS

1. That the RAG **NOMINATE** any further business for discussion.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	**MEETING 26** **5 February 2019**
DATE AND VENUE FOR NEXT MEETING	**Agenda Item 9** **For Decision**

RECOMMENDATIONS

1. That the RAG **NOMINATE** a date and a venue for the next meeting.