Conditions during the 11-day survey varied with winds ranging between 5-25 knots. From days 1-3 of the survey, winds were strong (20-25 knots), dropping to 10-15 knots in the remainder of the survey (Figure 3). Underwater visibility averaged around 4m (range 0.5-10m) with neap tidal flows allowing for a good visual census and collection of TRL.

Figure 2. Boats used during the 2022 pre-season survey: Mothership "Wild Blue" (left) and CSIRO tender (right) used to support dive operations.

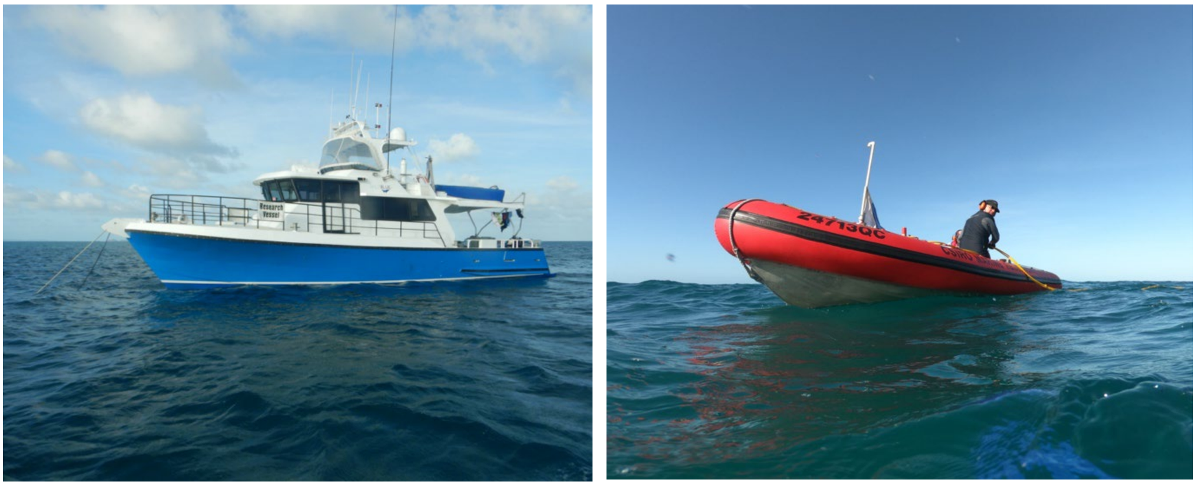


Figure 3. Weather and sea conditions during the 2022 TRL pre-season survey. Top: windy and rainy conditions prevailing at the initial 3 days of the survey. Bottom: good weather and wind conditions for the remainder of the survey.

1.1 Survey permits

Three research permits are required and were obtained in 2022 to conduct research associated with TRL population surveys. These include:

- Protected Zone Joint Authority Permit
    - Collect no more than 400 lobster per survey within the area of Australian Jurisdiction in the Torres Strait Tropical Rock Lobster Fishery
- Queensland General Fisheries Permit
    - Collect lobster in tidal waters east of longitude 142˚ 31′ 49″ east and north of latitude 14˚ south
- Great Barrier Reef Marine Park Authority Permit
    - Collect no more than 30 juvenile lobster in total (≤90mm carapace length) per year from 7 sites from within the Great Barrier Reef Marine Park Zone (Figure 1; sites E19, 471, 541, 551, 571, 751, 801), and
    - Collect no more than 5 juvenile lobster per site per year from within the Great Barrier Reef Marine Park Zone

1.2 Site survey

The CSIRO TRL Dive Team used the standard 2000m^2 belt transect method (2 divers per site each scanning 2m by 500m; Figure 4) with transect distance measured using a Chainman® device. For a proportion of sites (n=11) where the full 500m distance could not be swum the observed lobster counts were standardised to an area of 2000m^2. At the completion of each transect divers recorded:

- The number of lobsters caught per age-class;
- The number and age-class of those observed but not caught;
- Depth;
- Visibility;
- Current speed;
- Distance and direction swum from site co-ordinate;
- Habitat and substrate characteristics of the site.

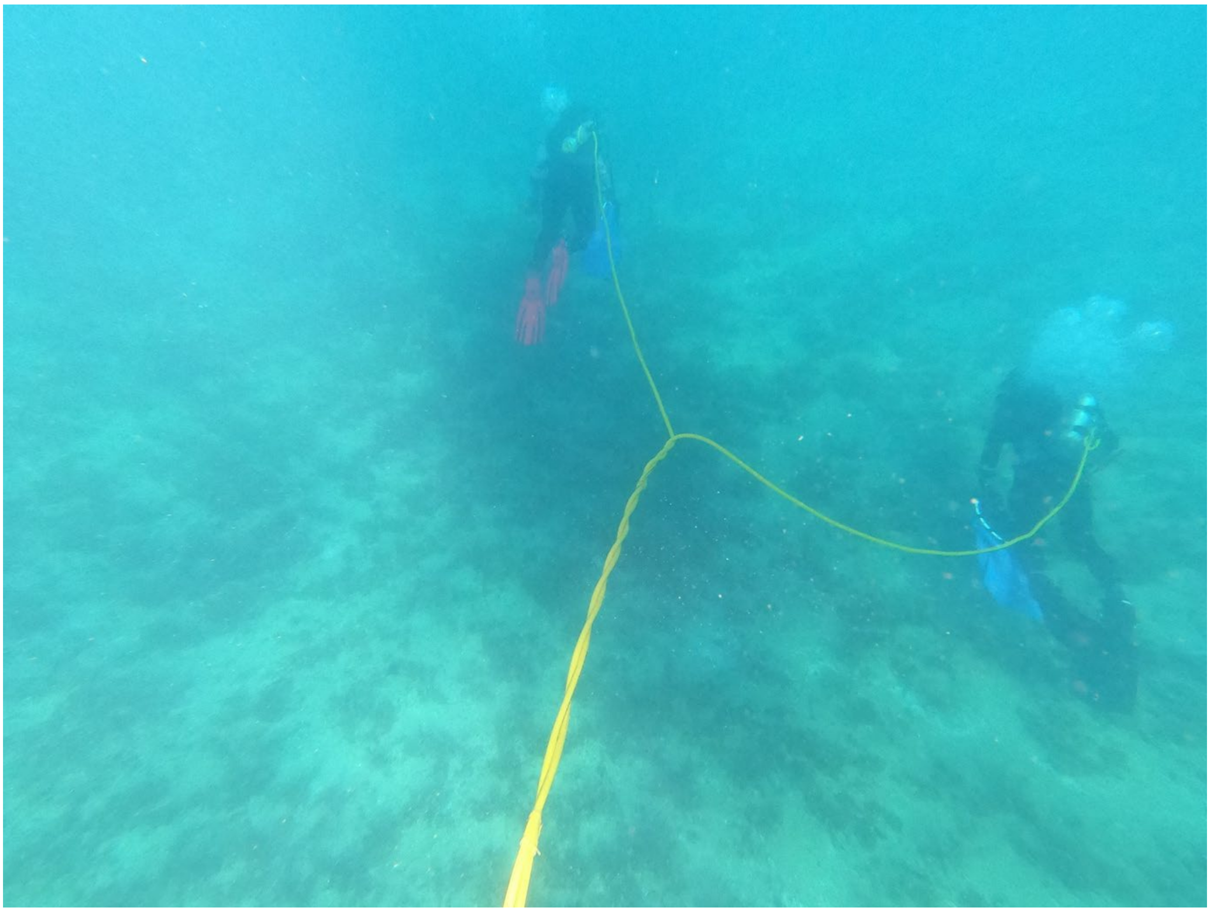
In addition, species of interest (i.e. pearl oyster (*Pinctada maxima*), crown-of-thorns starfish and holothurian species) were counted and the habitat characterised using percent cover for the various substrate and biota types (percent cover of sand, mud, consolidated rubble, limestone pavement, boulders, seagrass, algae, sponges, whips and live coral). The presence of bleached coral was also noted, where applicable.

Caught lobsters (n=124) were measured (tail width, TW) to provide fishery-independent size-frequency data. As in the previous three years, temperature and depth profiles were measured at sites using a small Van Essen CTD Diver logger attached to a diver's harness. In 2021 and 2022 additional water column data (Chlorophyll, Depth, fluorescent dissolved organic matter, conductivity, dissolved oxygen, salinity, turbidity, total suspended solids, total dissolved solids, pH and temperature) were collected (up to 25m deep) using a hand-held sounder (Xylem - YSI EXO2 Multiparameter water quality sonde) deployed from the mothership Wild Blue.

1.2.1 Survey data analysis

Upon completion of the dives, the data were entered into the project's relational database and verified for accuracy. Post survey data analyses will be presented at TRL RAG meeting on the 14th of December 2022. Some preliminary results are presented below.

Figure 4. CSIRO Divers sampling on standard belt transect used during the annual Torres Strait Tropical Rock Lobster surveys.



1.3 Results

A total of 77 sites were dived. As previously, divers attempted to complete the full transect length at each site but occasionally only a partial transect was completed due to bottom time limits of dive tables and weak currents. In 2022 additional safety measures were added to CSIRO dive policy, which reduced divers' bottom time at deeper dives in the Eastern side. Additional survey pre-planning was done to reduce the probability of partial transects resulting in only 11 partial transects out of the 77 sites (or 14% of total) out of the 19 transects expected to be partial (i.e. with bottom time < 18 minutes). Out of the 11 partial transects, five were ≥ 400m, hence the survey covered 96% of the total planned survey transect length. In total, 266 TRL were observed and categorised into three age classes in the 2022 pre-season survey compared to a total of 356 categorised in 2021 and 333 categorised in 2020 (Table 1). Of these, 124 were measured (TW) and their sex determined. Males comprised 49% of the lobsters measured (n=61) and females 51% (n=63). This is similar to

the 2021 survey 172 lobsters were measured, where males comprised 55% of the measured lobster population and females 45%.
As in previous surveys, age 1+ lobsters comprised the majority of the lobsters observed in the 2022 survey (n=205). Age 2+ lobsters were rarely observed–but more frequently observed compared to previous years (n=11)–as most fished lobsters are expected to have emigrated from Torres Strait during August/September to undertake the breeding migration. Age 0+ lobster numbers (n=50) were slightly higher in 2022 compared to 2021.

Table 1. Comparison of lobster numbers per age class observed between 2020, 2021 and 2022 pre-season surveys.

Age	2020	2021	2022
0+	101	45	50
1+	225	307	205
2+	7	4	11
Total	333	356	266

1.3.1 Age 1+ TRL lobsters

In 2022, Age 1+ abundance index for the mid-year only (MYO) sites (red line in Figure 5) was lower than the previous year and below average, i.e. below the long-term average for the pre-season surveys (2005-2022) shown in dashed grey line. The 2022 survey variance was similar to 2021, and well below higher variances observed in the 2018 and 2019 surveys.
In 2022, counts of Age 1+ lobsters had lower spatial variability compared to 2021 (i.e. circle sizes shown in Figure 6 vary less in 2022 compared to 2021). As in previous years, in 2022 there were higher counts of 1+ lobsters on the Eastern side of the surveyed area. It is important to note that the changes in spatial distribution over time and space are natural occurrences and happen from time to time as seen from 2019-2022 (Figures 5-8). The figure suggests that 2020 and 2022 were similar with regards to spatial distribution of lobsters, with higher counts of Age 1+ lobsters on the eastern side of the surveyed area, which were generally consistent between sites (see similar size of 'bubbles'). However, counts on the Eastern central region of the surveyed area in 2022 were lower compared to 2020-21 (Figure 6). Similar to 2021, counts of Age 1+ lobsters on the SE region were relatively higher compared to 2020.

The abundance index for Age 1+ lobster in 2022 indicates that recruitment to the fishery is generally widespread across the different strata surveyed. The highest recruitment was recorded at sites in the South-East, Buru and Kirkaldie_Rubble, while at TI_Bridge recruitment was the lowest. A larger standard error for Buru, Kirkaldie_Rubble and Reef Edge reflects the high variability in counts between sites. The 2022 results for the Age 1+ (point estimate) abundance index was above average in Buru, Kirkaldie_Rubble, Reef Edge and South-East and below average at Mabuiag, TI Bridge and Warraber_Bridge (historically the indices of these three strata are generally below the overall average, Figure 8). This is potentially due to habitat differences and possibly varying currents/settlement.

Figure 5. Torres Strait Tropical Rock Lobster (*P. ornatus*) Age 1+ abundance index (2022) shown for a number of alternative scenarios as indicated. Standard errors for Mid Year Only (MYO) sites are shown as vertical bars.

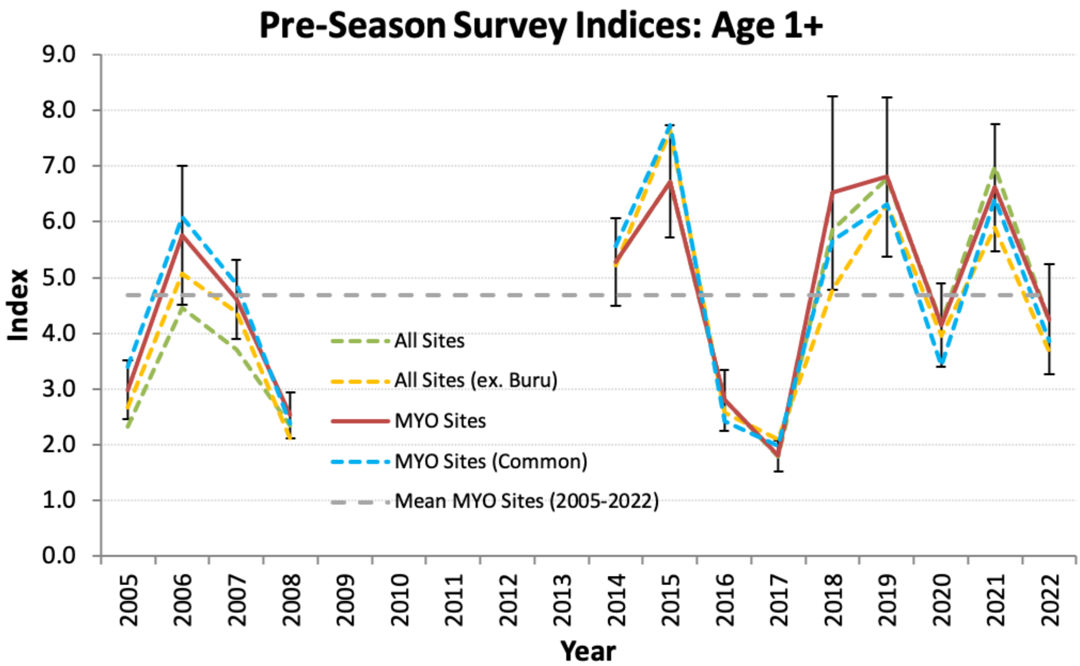


Figure 6. Torres Strait Tropical Rock Lobster (*P. ornatus*) Age 1+ counts per transect across 76 common sites surveyed in 2022. The red box shows a representative area for the survey, where numbers were lower compared to 2020 and 2021 survey years.

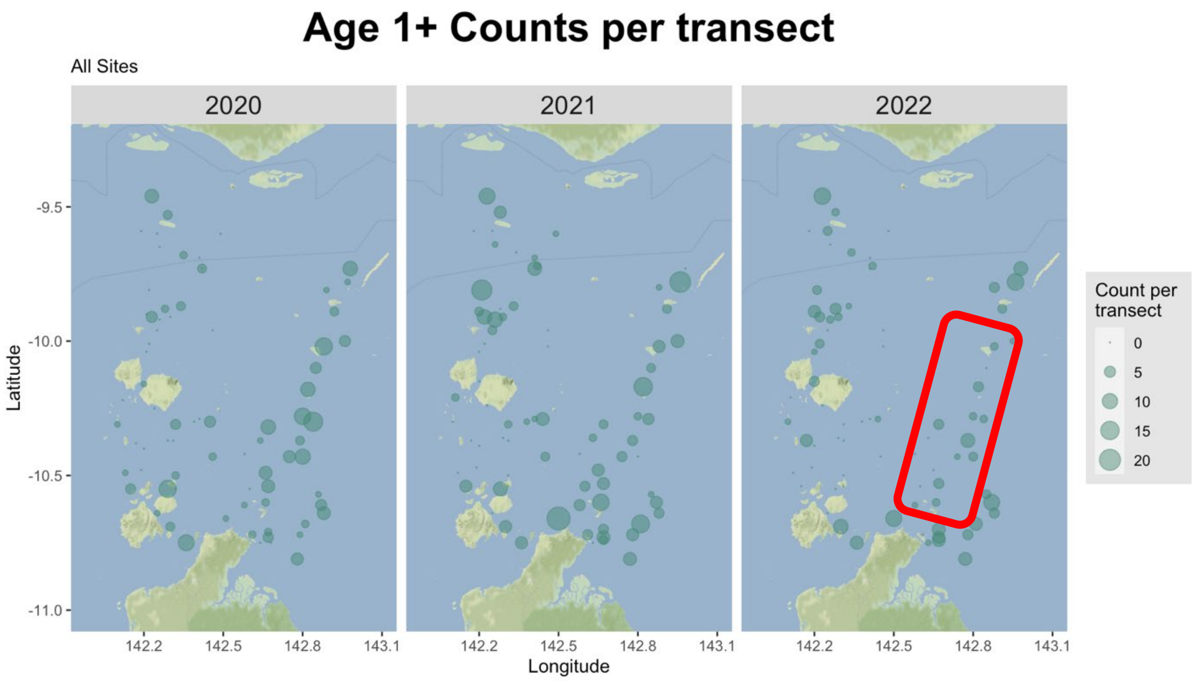
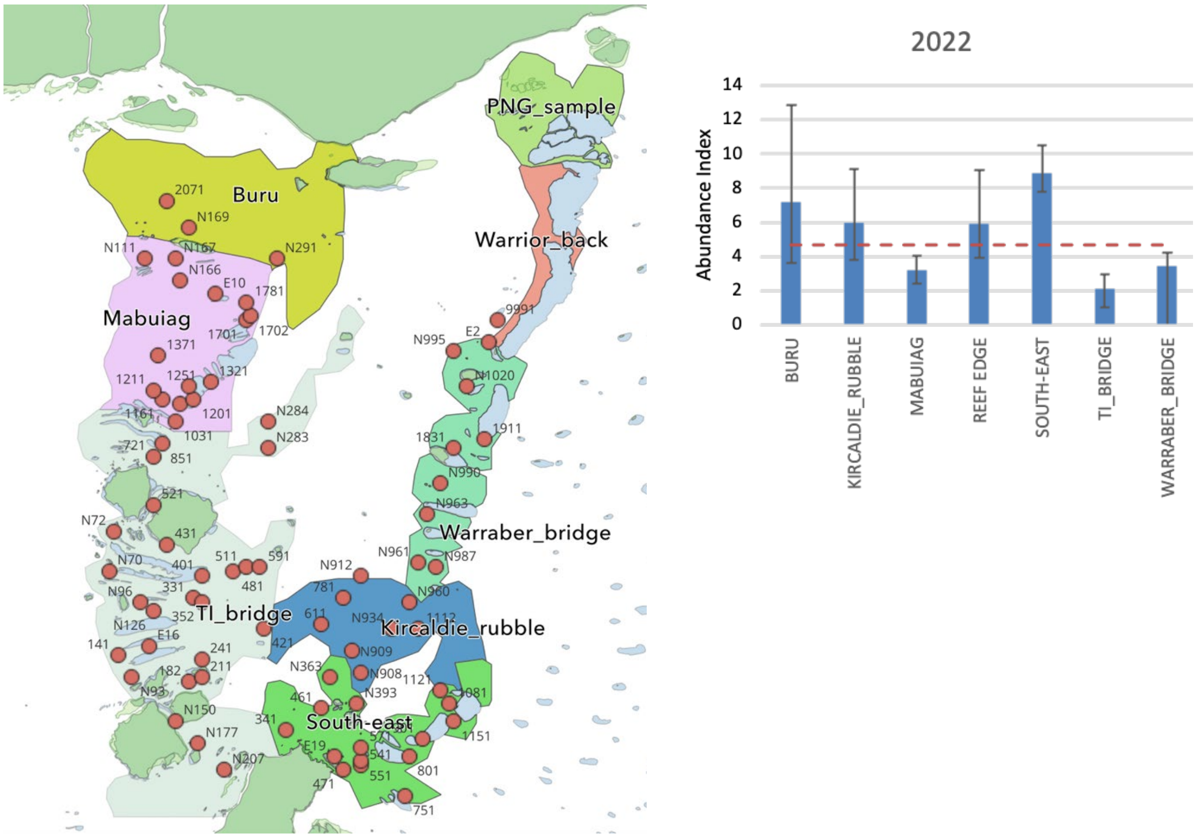


Figure 7. A) Strata sampled during the annual Torres Strait Tropical Rock Lobster (TRL; *P. ornatus*) surveys. B) Torres Strait TRL 2022 Age 1+ abundance index and standard errors) by stratum. Red dashed line indicates mean abundance index for period between 2005 and 2022. Note that 'Reef Edge' stratum is not shown on the map due visualisation issues. The stratum consists of sites 1321, 9991, E10, E16, E19 and E2.



Counts of Age 1+ lobsters in 2022 were variable (Figure 8). Similar to 2021, the counts were spread more evenly across the strata surveyed when compared to indices from 2019 and 2020 (Figure 8) meaning there were fewer sites with high (>10) counts in 2022 compared to the previous 3 years (Figures 6-8).

1.3.2 Age 0+ TRL lobsters

In 2022 the 0+ abundance index point estimate showed a slight but nonsignificant decline from last year to levels that are the second lowest after 2017 (Figure 9). Historically survey data indicate that Age 0+ lobsters typically settle on the western side of survey area (Figure 10). Until 2020 there were more than 3 times more Age 0+ lobsters settling on the west relative to the east side of the survey area (Figure 10). In 2021 Age 0+ lobsters were more consistently observed across both western and eastern sides of the survey area (55% Age 0+ lobsters observed in the west and 45% in the east; Figure 10) and in 2022 the east side had slightly less than half of the number of Age 0+ lobsters compared to the west side (or 30% Age 0+ lobsters observed on the east and 70% on the west side of the survey area).

Figure 8. Torres Strait Tropical Rock Lobster (*P. ornatus*) Age 1+ abundance indices (and standard errors) across years and strata. Red dashed line represents mean abundance index for the period between 2005-2022 for Mid-Year Only (MYO) sites.

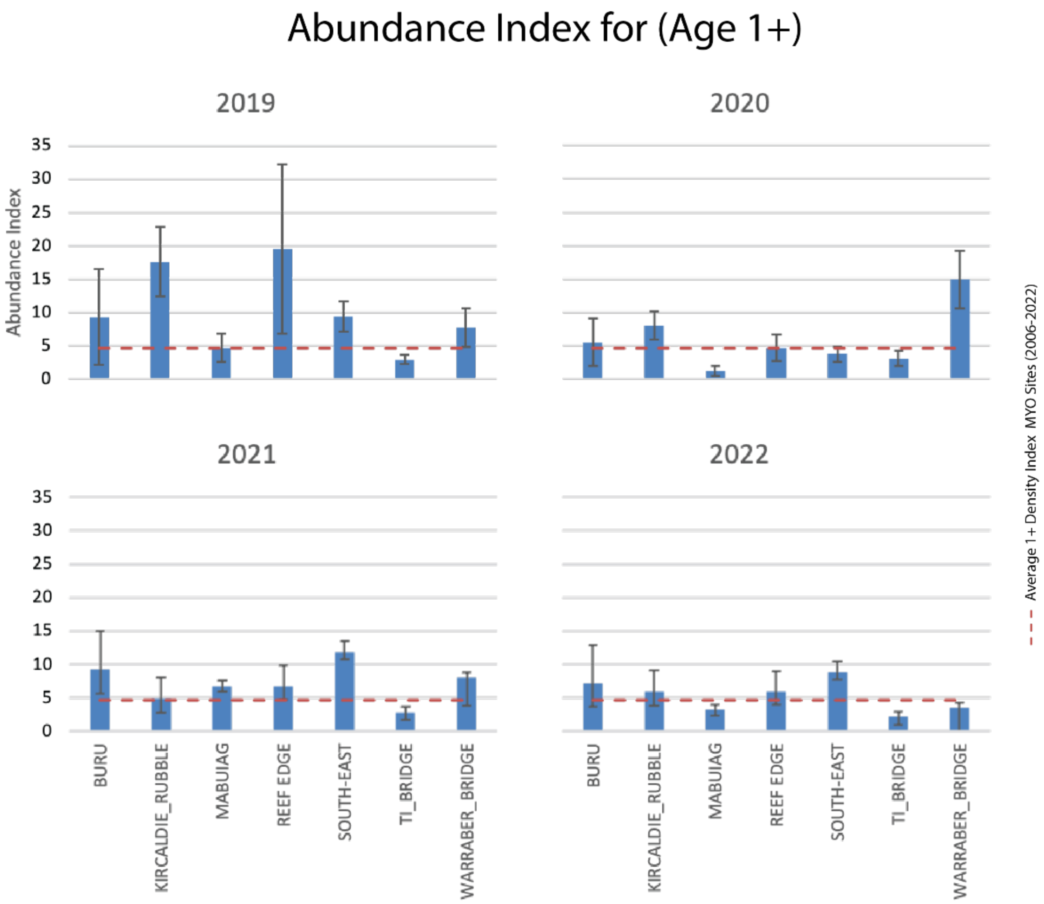


Figure 9. Torres Strait Tropical Rock Lobster (*P. ornatus*) Age 0+ abundance index (2022) and standard error for mid-year only sites shown in the vertical bars.

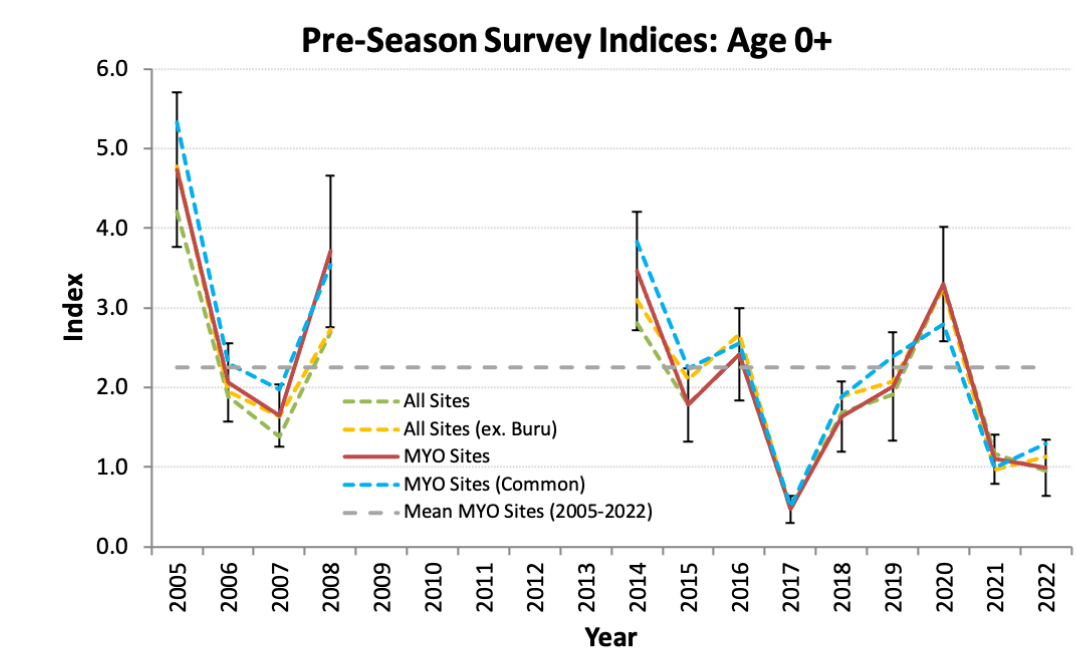
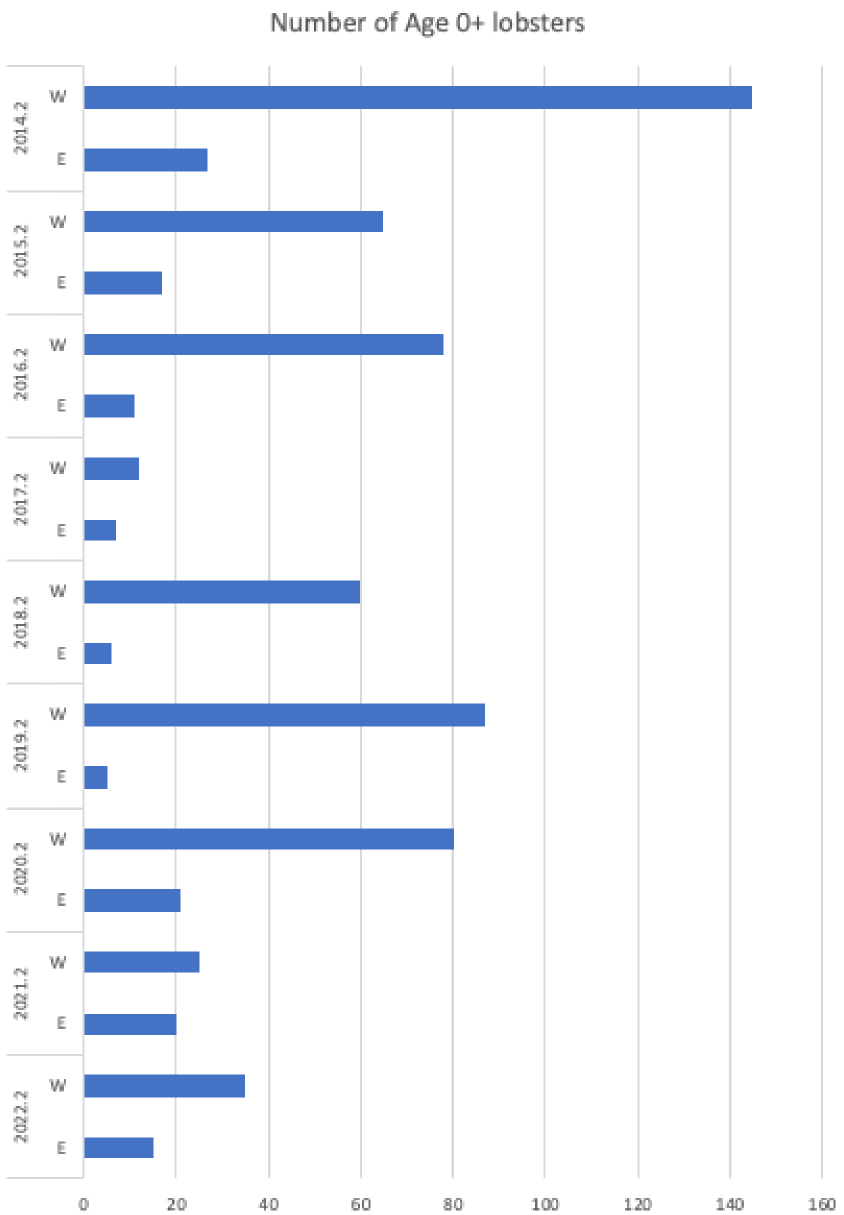
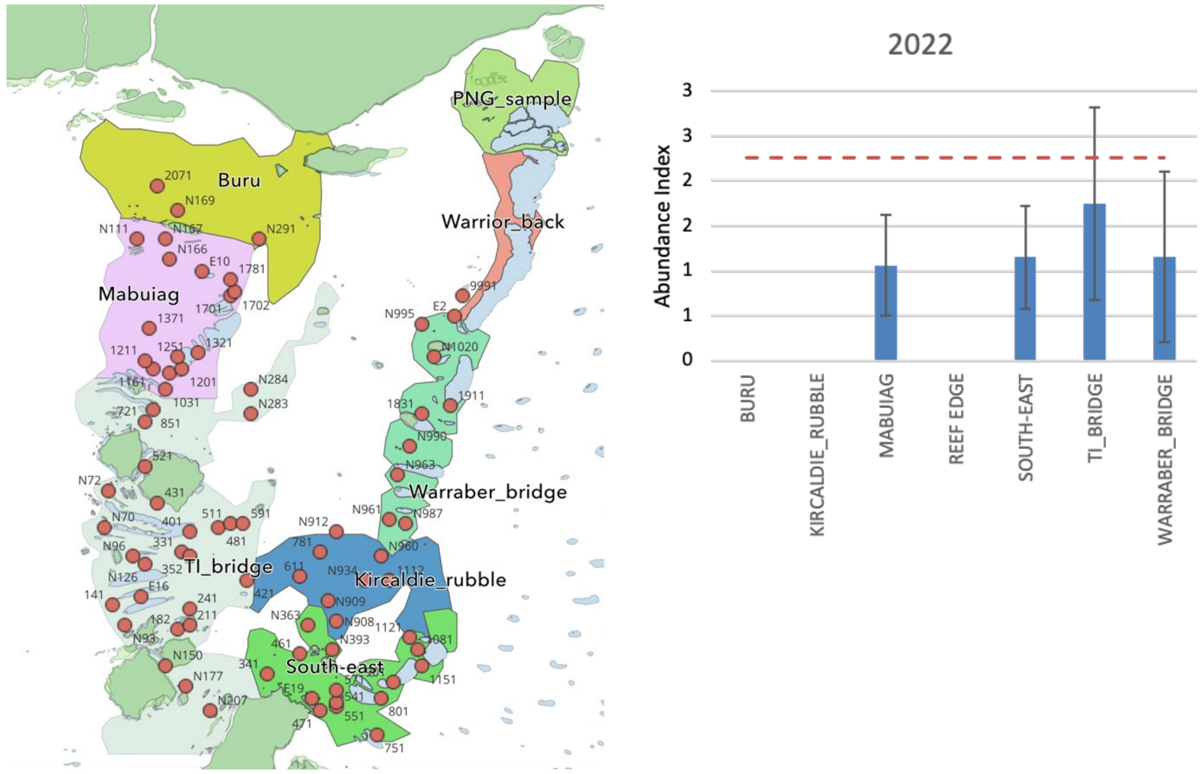


Figure 10. Torres Strait Tropical Rock Lobster (*P. ornatus*) Age 0+ counts for 2022 across Western and Eastern sides of the surveyed area.



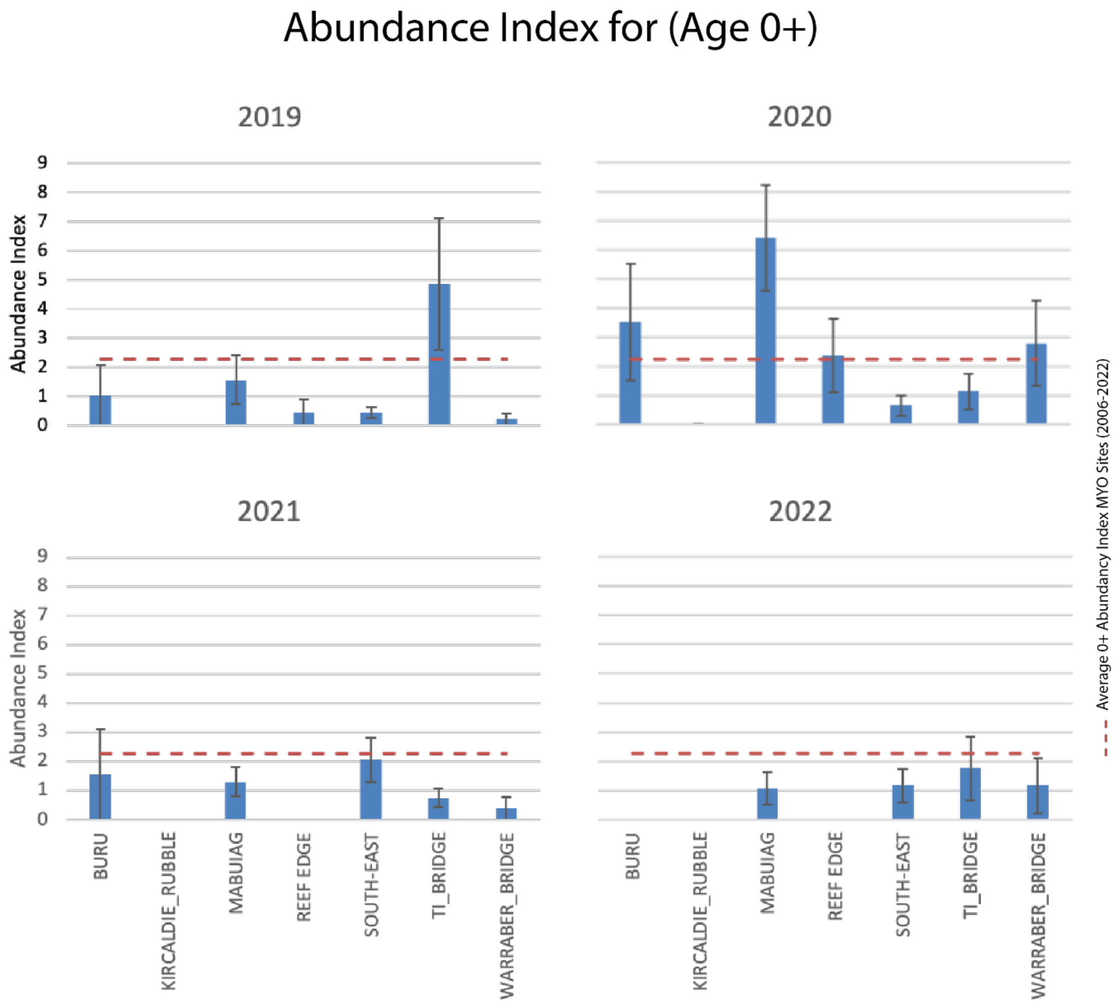
The highest abundance of Age 0+ lobster indices were recorded for TI_Bridge, Warraber_Bridge and South East, noting large variability in TI_Bridge and Warraber_Bridge and no 0+ lobsters observed in Buru, Kirkaldi_Rubble and Reef Edge. Overall, similar to 2021, in 2022 abundance indices (point estimates) for recently settled lobsters (Age 0+) were below average across all strata (Figures 10 and 11). Unlike in the previous 3 surveys, there were no observations of recently settled lobsters (Age 0+) in Buru, which occurred only in 3 previous surveys (2007, 2014 and 2015).

Figure 11. Strata sampled during the annual Torres Strait Tropical Rock Lobster (TRL; *P. ornatus*) surveys. B) Torres Strait TRL 2022 Age 0+ abundance index and standard errors) by stratum. Red dashed line indicates mean abundance index for period between 2005 and 2022. Note that 'Reef Edge' stratum is not shown on the map due visualisation issues. The stratum consists of sites 1321, 9991, E10, E16, E19 and E2.



Similar to 2021 and unlike in previous surveys up to 2020, there was not a stratum that stood out in terms of its abundance index for Age 0+ lobsters. Indices were consistently below the long-term average across the strata. Survey results show year to year variability in spatial distribution where the lobsters settle with a declining trend from the peak observed in the 2020 survey (Figure 12).

Figure 12. Torres Strait Tropical Rock Lobster (*P. ornatus*) Age 0+ abundance indices (and standard error) across years and strata.



1.4 Preliminary summary results of 2022 TRL survey

A total of 77 sites were surveyed in 2022. Good weather and sea conditions prevailed during the survey. As previously, divers attempted to complete the full transect length at each site but occasionally only a partial transect was completed due to bottom time limits of dive tables and weak currents. In 2022 additional safety measures were added to the CSIRO dive policy, which reduced divers' bottom time at deeper sites in the Eastern side. Additional survey pre-planning was done to reduce the probability of partial transects resulting in only 11 partial (or 14% of total) transects out of the 19 transects expected to be partial (i.e. with bottom time < 18 minutes).

In total, 266 TRL were observed and categorised into three age classes in the 2022 pre-season survey. Of these, 124 were measured (TW) and their sex determined. Males comprised 49% of the lobsters measured (n=61) and females 51% (n=63). As in previous surveys, age 1+ lobsters comprised the majority of the lobsters observed in 2022 (n=205). Age 2+ lobsters were rarely observed–but more frequently observed in 2022 compared to previous years (n=11)–as most fished lobsters are expected to have emigrated from Torres Strait during August/September to undertake the breeding migration.

The Age 1+ abundance index for 2022 was lower than the 2021 index and the point estimates were below average for MYO Sites and above average for Buru, Kircaldie_Rubble, Reef Edge and South-East strata. There were lower counts on the central east side of the survey area compared to 2020 and 2021. Similar to 2021, the South East stratum showed the highest Age 1+ abundance index in 2022.

Age 0+ abundance index point estimate for 2022 showed a slight decline compared to 2021 and was the 2nd lowest point estimate on record. In 2022 Age 0+ counts on the east side of the survey area were slightly less than half of the Age 0+ lobsters observed in the west, but not as even as observed in 2021; prior to 2020, counts for Age 0+ lobsters were more than 3 times higher on the west compared to the east. These results further corroborate that there is year to year variability in spatial distribution where lobsters settle. Further detail on the lobster spatial distribution as well as habitat monitoring results will be presented at the forthcoming TRLRAG meeting.

Acknowledgements

We wish to sincerely thank the master (Rob Benn) and crew (Carmel Benn) of the Wild Blue and Mr Tony Salam for excellent assistance in all aspects of the pre-season dive survey in Torres Strait, and in logistic support. We gratefully acknowledge funding support for the survey from AFMA and CSIRO.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG)	MEETING 33 13-14 December 2022
UPDATE ON CLIMATE CHANGE WORK IN TORRES STRAIT FISHERIES	Agenda Item 6 For Noting

RECOMMENDATIONS

1. That the RAG:
   a. **NOTE** an overview of previous work undertaken in Torres Strait fisheries related to climate change;
   b. **NOTE** an update from AFMA's Climate Adaptation Senior Program Manager, Alice McDonald on work being undertaken to incorporate climate change information into fisheries management advice and decisions in AFMA's other Commonwealth fisheries, with a view to implementing a similar process for Torres Strait Fisheries, and
   c. **DISCUSS** a draft Climate and Ecosystem Status report that has been prepared by CSIRO for the Torres Strait TRL fishery.

KEY ISSUES

Building climate change information into fisheries management processes

2. In other Commonwealth fisheries (fisheries managed elsewhere in Australia by AFMA), a program of work is being undertaken to ensure that climate impacts are more strategically incorporated into the management of these fisheries to ensure that AFMA continues to meet legislative objectives relating to ecological sustainability. This work is a follow up action from the *Adaption of Commonwealth fisheries management framework to climate change project (FRDC 2016-059)* (the climate adaptation project) that looked at the readiness of Commonwealth Fisheries Management Arrangements to the potential impacts of climate change and provided a range of resources to assist with adaptation.
3. As a foundational element of the Climate Adaptation Program, the AFMA Commission endorsed a suite of actions to build explicit and structured consideration of climate change impacts into decision-making processes. These actions include adding a standing agenda item on climate change to advisory body meetings and preparing Climate and Ecosystem Status reports for key fisheries.
4. Recognising the priority that the Torres Strait community places upon management of climate change impacts and the vulnerability of Torres Strait fisheries to climate change, AFMA hopes to commence similar work for Torres Strait fisheries through the PZJA's advisory committees starting with the Tropical Rock Lobster fishery and gradually expanding to other Torres Strait Fisheries.
5. The RAG is invited to note the presentation from Alice McDonald on a body of work that is looking to build climate change information into fisheries management advice and decisions in AFMA's other Commonwealth fisheries. The RAG is invited to consider how this may apply to Torres Strait Fisheries.

Draft Climate and Ecosystem Status Report

6. To inform management decision-making processes, including advisory body discussions, annual Climate and Ecosystem Status reports are being developed for key Commonwealth fisheries. These reports are intended to provide a short, accessible update on key indicators of climatic or ecosystem status and trends relevant to the fishery, utilising readily available information.

7. Noting the considerable interest in climate impacts on the Torres Strait tropical rock lobster fishery, and the body of work to better understand the effect of climate change on this fishery, CSIRO has prepared a draft Climate and Ecosystem Status report for consideration by the RAG (see **Attachment 6a**). This report utilises currently available information, noting that limited climate and ecosystem/oceanographic observations are available in the Torres Strait. And while this draft has been developed for the tropical rock lobster fishery, a number of the indicators would also be relevant to other important Torres Strait fisheries.

8. The intent is that this report will be refined over time based on RAG, WG and expert feedback. Feedback in particular is encouraged on the following:

   a. What key indicators would the RAG like included in the report?

   b. Is it useful and appropriate to capture fishers observations in the report?

   c. What would be the preferred timing for production of this report?

9. Consideration of climate and ecosystem impacts in the context of fisheries management is complementary to a range of other work being undertaken by CSIRO to understand and model climate impacts on Torres Strait and related fisheries in northern Australia (see further information below).

Climate related changes expected in Northern Australia

10. The FRDC climate adaptation project produced a series of regional projections of climate impacts for Australian fisheries. While this did not include projections specific to the Torres Strait, the regional projection for northern Australia predicted climate-related changes as summarised in the table below.

	Observed change (vs 1950)	Future change (vs today)
OCEAN TEMPERATURE	0.6 - 0.8°C increase	0.6 - 1.0°C increase
MARINE HEATWAVE	15 - 20 day increase	>200 day increase
STORMS	Conflicting information	Stronger & more variable
DROUGHTS	Shorter, more intense	Longer, twice as frequent
RAINFALL	Roughly steady	Roughly steady
SEALEVEL RISE	20cm increase	20 - 40cm increase
OXYGEN	Approx 2% decrease	5% decrease
ACIDIFICATION	30% increase	20 - 120% increase

(Excerpt from: Regional Projection for Northern Australia. FRDC 2016-059: Guidance on Adaptation of Commonwealth Fisheries management to climate change)

11. The draft Climate and Ecosystem Status Report provided at (**Attachment 6a**) provides an insight into recent trends in the Torres Strait, including valuable knowledge on changes being seen by fishers. Seasonal forecasts suggest that water temperatures over the next 3 months will remain above the long-term average due to the La Nina conditions, however these may ease in early 2023. The draft report will be presented by CSIRO and discussed with the RAG.

BACKGROUND: OVERVIEW OF PREVIOUS AND ONGOING WORK ON CLIMATE CHANGE IMPACTS ON TORRES STRAIT FISHERIES

Outcomes of the Torres Strait climate change scoping project

12. The need to better understand the species-specific effects of climate change and variability on Torres Strait Fisheries was initially identified as a research priority by TSSAC in December 2018 (meeting 71). TSSAC agreed a scoping study should be undertaken on the possible methods and resources needed to build an information framework that can evaluate the implications of future climate variability and change scenarios on fisheries to better allow fisheries managers and industry to respond and adapt to any changes.
13. The project delivered an evaluation of the over-arching data requirements and framework that are needed to support a climate change model that will evaluate the implications of future climate variability and change scenarios on key fisheries. The study considered previous reviews of climate implications for Torres Strait, consulted extensively with relevant fishery researchers, managers and key stakeholders and convened a workshop, with relevant fishery modelling expert end-users and stakeholders.
14. The TSSAC considered the project's outcomes and recommendations at their 79th meeting on 9-10 June 2021 and agreed that if the project was to progress beyond this scoping phase, it would provide a range of information that is of value to fisheries management, including improved understanding of the interactions between fisheries and ecosystems, and the impact of different climate change scenarios.
15. The full project report is available from the PZJA website: https://www.pzja.gov.au/sites/default/files/hcrag02_5b_climate_change_finalreport_2021_dutra.pdf

Climate change modelling project update

16. Following on from the TSSAC's recommendations on the climate change scoping project, a follow up call for research proposals was made in February 2022 with one proposal received from CSIRO (**Attachment 6b**). Having regard to feedback from all PZJA advisory committee RAGs and Working Groups out of session, the TSSAC considered this research proposal at their meeting on 6-7 April 2022 (TSSAC 81).
17. The project is intended to:
    a. enable fisheries managers and communities to better prepare for climate change mitigation and adaptation, where possible;
    b. integrate new and existing fisheries and environmental data within an over-arching data framework;
    c. provide estimates of the impacts that different climate change scenarios could have on the marine ecosystem and associated fisheries/species;

d. provide estimates of the economic, social and other fisheries-related livelihood impacts of climate change on communities in the short (2 yrs), medium (5 yrs) and longer term (10+ yrs), and suggest some possible actions for adaptation; and

e. help differentiate between the relative effects of fishing and climate change on marine resources.

f. provide results in formats (e.g. graphical, video, written) which can be communicated to stakeholders (Torres Strait Island Communities, Fishers, Fisheries Managers and local and regional organisations).

18. Due to limited AFMA funding available to support all recommended research projects in 2022-23, the climate change modelling project is to be partially funded through a $500,000 co-contribution from the Torres Strait Regional Authority and the remainder of the project funds are being considered for funding through the Fisheries Research and Development Corporation (FRDC).

19. An outcome on FRDC funding is pending.

Other relevant research to date on climate change impacts on Torres Strait Fisheries

20. In terms of assessing the likely impacts of climate change on Torres Strait Fisheries the following has been undertaken:

    a. Qualitative Sensitivity Analysis: Assessing the vulnerability of Torres Strait fisheries and supporting habitats to climate change (Welch and Johnson 2013);

    b. Management Strategy Evaluation to integrate climate changes into the TRL Stock Assessment: An Integrated Management Strategy Evaluation (MSE) for the Torres Strait Rock Lobster *Panulirus ornatus* fishery (Plaganyi *et al* 2012);

    c. System Modelling: Models of Intermediate Complexity of Ecosystems (MICE) – applied to TRL in the Torres Strait. Used in the following projects:

        i. AFMA project 2017/0816 – Environmental drivers of variability and climate projections for the Torres Strait tropical lobster *Panulirus ornatus.* (Plaganyi *et al* 2018).

        ii. Decadal-Scale Forecasting of Australian Fish and Fisheries (Fulton *et al 2018*). A non-technical summary of the decadal-scale forecasting project[1] is provided at **Attachment 6c.**

    d. TRL stock assessment model sensitivity analyses when explicitly incorporating climate change influences on survival and growth – presented in TRLRAG meetings, milestone reports (Plagányi et al. 2020[2]) and published paper (Plagányi et al. 2019[3])

21. In June 2018 the TSRA and National Environmental Science Programs (NESP) Earth Systems and Climate Change Hub convened a workshop on climate change implications for fisheries and marine ecosystems in the Torres Strait. The workshop identified initial

[1] AFMA led project *Adaption of Commonwealth fisheries management framework to climate change project (FRDC 2016-059)*
[2] Plagányi, É., Tonks, M., Murphy, N., Campbell, R., Deng, R., Edgar, S., Salee, K., Upston, J. (2020) Torres Strait Tropical Rock Lobster (TRL) Milestone Report 2020 on fishery surveys, CPUE, stock assessment and harvest strategy: AFMA Project R2019/0825. May 2020 Draft Final Report. 183 pp
[3] Plagányi, É.E., Haywood, M., Gorton, R., Siple, M. & Deng, R. 2019. Management implications of modelling fisheries recruitment. *Fisheries Research* 217: 169-184

thoughts on priority areas for research that may help fisheries and marine ecosystem management in the Torres Strait (**Attachment 6d**).

***Adaption of Commonwealth fisheries management framework to climate change project (FRDC 2016-059)* (the climate adaptation project)**

22. The climate adaptation project was completed in 2021 (https://www.frdc.com.au/adaptation-fisheries-management-handbook-climate-change) and looked at the readiness of Commonwealth Fisheries Management Arrangements to the potential impacts of climate change and options to adapt to changes. Its key output is a climate adaption handbook that provides detailed steps for fisheries and other stakeholders to conduct climate risk assessment of their fishery management arrangements and operations. During the project, AFMA worked with the CSIRO, IMAS and other researchers to answer the following questions:
    a. *What changes does AFMA need to make to its regulatory system so that it can effectively deliver its management objectives?*
    b. *What are the consequences of those changes for the fishing industry and other fishery stakeholders?*
23. While AFMA's current management strategies have flexibility built in them, it was important to assess the extent to which the direct and indirect impacts of climate change will challenge Australian fisheries and the management framework that they are currently managed under. The climate adaptation project did this by developing a risk assessment approach that tests the adaptability of current and potential management arrangements to projected, climate driven, changes of fish stocks on three case study fisheries, the Northern Prawn, Heard and MacDonald Island and Southern Bluefin Tuna Fisheries as part of the project.
24. The project consulted with key stakeholders from those fisheries, as well as recreational, indigenous and state fishery stakeholders to develop the final approach.
25. Elements of the project will be incorporated in the Climate Change modelling project if funded.

Climate & Ecosystem Status Report

TRL / Kaiar Fishery

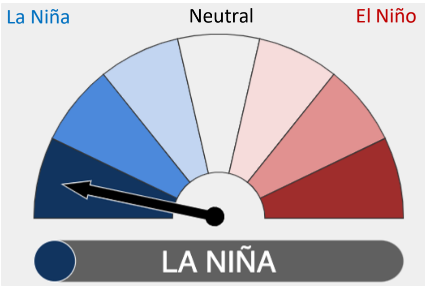
2021

Attachment 6a

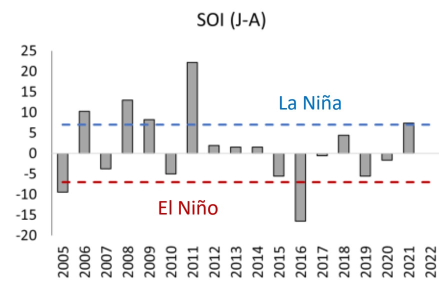
146

Draft Example

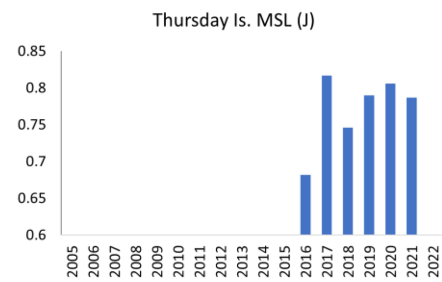
Indicators



2022 was another La Niña year

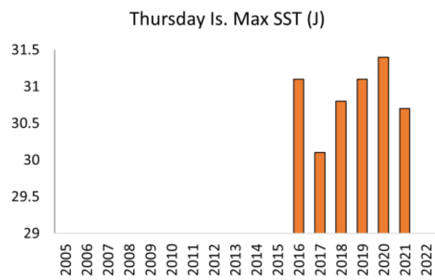


Southern Oscillation Index was 12.2 over the wet season

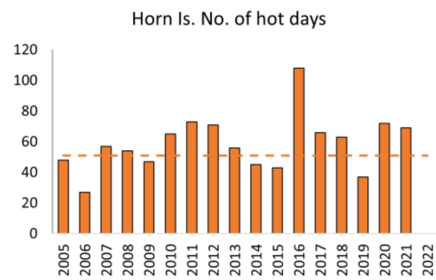


Min. Mean Sea Level (m) in January was down from previous years

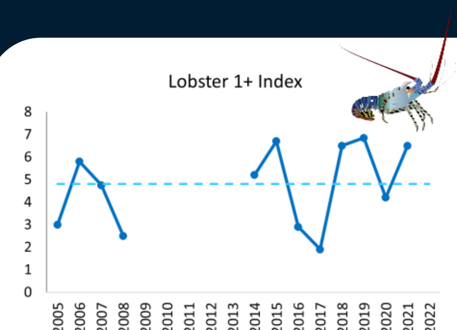
Wind...



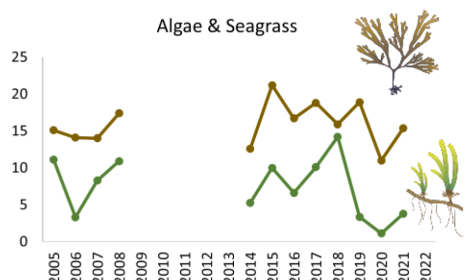
Max. sea surface temperature (°C) in January was similar to 2021



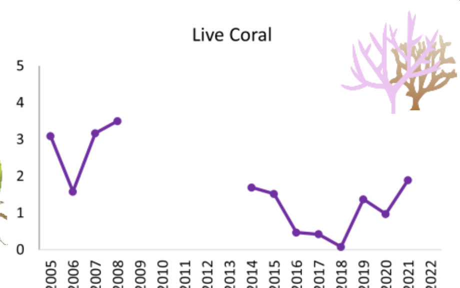
Number of hot days was above the average



Lobster 1+ index was above the long-term average



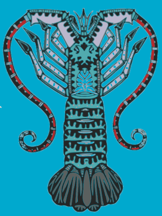
Algae & seagrass (% cover) both up from 2020



Coral (% cover) continues to increase since 2018

Fishers' Observations

- Unusual movement of Kaiar in the Eastern islands (around Erub), with movement heading towards the Central islands (Poruma) since the start of the season.
- For the last three years, Kuki (north west winds) have come late (January/February) but this year Kuki is early with wind & rains having started in November.
- A number of double skin/soft Kaiar seen
- Lots of small Kaier on the reef top
- A lot of fine white sand moving around, more than normal, covering the bottom including seagrass

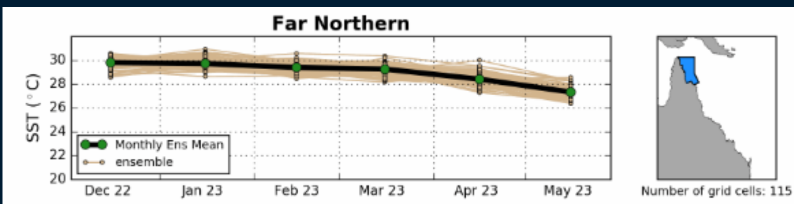

Laurie Nona, Badu Island

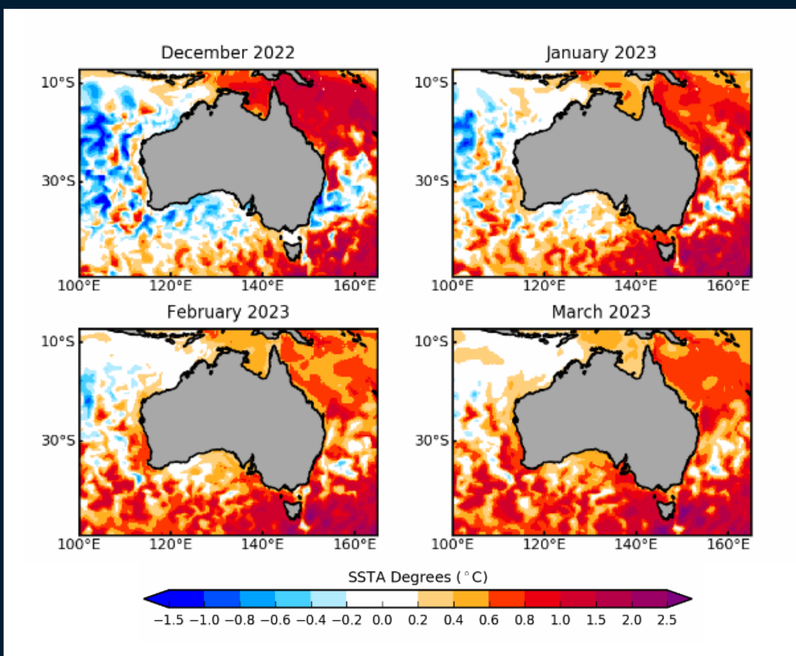
Climate & Ecosystem Status Report
TRL / Kaiar Fishery
2022

147

Draft Example

Seasonal Forecasts





Images from BOM

Sea surface temperature

Water temperatures for the northern Great Barrier Reef (closest to Torres Strait) are forecast to be about 30 °C in December 2022 and January 2023, decreasing to approximately 27 °C by May 2023.

Between December 2022 and March 2023, water temperatures will be between 0.2 – 1.5 °C above the long-term average water temperature.

El Niño Southern Oscillation (ENSO)

ENSO is forecast to remain in a La Niña phase during December 2022 and return to ENSO-neutral values during January or February 2023. A La Niña phase typically produces wetter years.

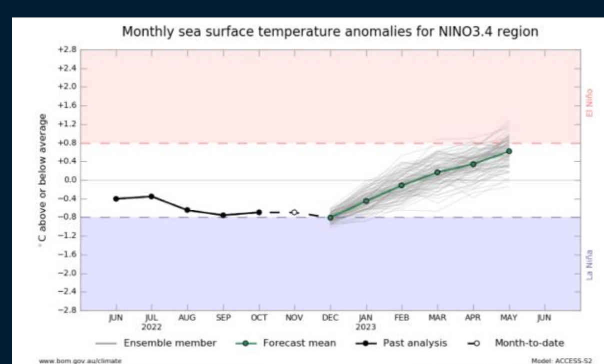


Image from BOM

Further Information:

Bureau of Metrology climate data: http://www.bom.gov.au/climate/data/

Bureau of Metrology seasonal forecasts: http://www.bom.gov.au/oceanography/oceantemp/sst-outlook-index.shtml

Northern Australia Projections summary: https://research.csiro.au/cor/wp-content/uploads/sites/282/2021/07/Summary-of-Regional-projections-N-Australia-v3.pdf

Torres Strait Scientific Advisory Committee research application 2021

Please note TSSAC research applications have changed. There are no longer pre proposals. As such, please complete all sections of this proposal. You are also required to attach a copy of your stakeholder engagement strategy and community consultation plan with your proposal. See Attachment A for instructions on completing these documents.

SECTION 1 - ADMINISTRATIVE SUMMARY

Project title:	Understanding climate variability and change relevant to key fisheries resources in the Torres Strait and adaptation and mitigation strategies
Applicant (organisation or person):	CSIRO Oceans and Atmosphere
Contacts	

Administrative			
Title/Name:	Sandie Cloos	Phone:	02 6246 4235
Position:	Finance Advisor	Email:	sandie.cloos@csiro.au
Organisation:	CSIRO Oceans & Atmosphere	Postal address:	GPO Box 1700
Principal Investigator (person)			
Title/Name:	Leo Dutra	Phone:	07 3214 2850
Position:	Senior Research Scientist	Email:	leo.dutra@csiro.au
Organisation:	CSIRO Oceans & Atmosphere	Postal address:	Queensland BioSciences Precinct (QBP) 306 Carmody Rd, St Lucia, QLD 4072
Co-investigator (s)			
Title/Name:	Eva Plaganyi	Phone:	07 3833 5955
Position:	Senior Principal Research	Email:	eva-plaganyi-lloyd@csiro.au
Organisation:	CSIRO Oceans & Atmosphere	Postal address:	Queensland BioSciences Precinct (QBP) 306 Carmody Rd, St Lucia, QLD 4072
Co-investigator (s):			
Title/Name:	Laura Blamey	Phone:	07 3214 2378
Position:	Research Scientist	Email:	laura.blamey@csiro.au
Organisation:	CSIRO Oceans & Atmosphere	Postal address:	Queensland BioSciences Precinct (QBP) 306 Carmody Rd, St Lucia, QLD 4072
Planned Start and End Date			
Start Date:	01/07/2022	End Date: 01/03/2026	

SECTION 2 – PROJECT BUDGET

PROJECT BUDGET: (Excluding GST)

Financial Year	AFMA	Applicant (in kind)	Applicant	Other
2022-23	$270,561	$114,407		$0.00
2023-24	$405,687	$171,545		$0.00
2024-25	$235,000	$99,370		$0.00
2025-26	$137,711	$58,231		$0.00
Totals	$1,048,959	$443,553		$0.00

SECTION 3 – PROJECT DESCRIPTION

Background and need (max 250 words) - *detail any important background relating to the project. Why it is important and being proposed (need). Any related projects or other information the TSSAC should know when considering it for funding.*

Fisheries in Torres Strait strongly support lifestyles, livelihoods and economic activities, but are at risk from climate change. Understanding the nature and extent of climate change impacts, and their socio-economic and livelihood consequences will help stakeholders better manage risks and adapt.

The research proposed will provide to fishers and managers up-to-date evidence-based information about current and future risks to fisheries associated with climate change. It will develop an integrated model of intermediate complexity for ecosystem assessment (i-MICE) to estimate climate change impacts on selected fisheries/species. Model development follows a stepwise approach. In **Phase 1** available data and models will be combined in a data framework, i-MICEv.1 will be developed by extending and linking current biological models of key species (TRL, BDM, dugongs), known environmental drivers (SST) and habitat (seagrass). i-MICEv.1 will investigate the impacts of climate change scenarios on fisheries/species in the short (2yr), medium (5yr) and long-term (20 yrs), also considering socio-economic and livelihood metrics. **Phase 2** will develop a 3-dimensional ocean model to generate additional oceanographic data, based on climate change scenarios. The new data will feed into a refined i-MICEv.2 to investigate broader implications (i.e. not only related to SST) of climate change on the selected fisheries. Model results in both phases will be used to inform stakeholders and co-develop adaptation strategies via workshops.

Phases 1 and 2 are designed to be 'stand-alone' sequential exercises, but could be done in parallel which would allow the generation of timely results to stakeholders and development of adaptation strategies.

Objectives / performance indicators (max 250 words) **-** *list the major objectives or planned outcomes of the project. These will form your project milestones (Section 5):*

Phase 1

1. Establish a project steering committee (PSC) with guidance from AFMA and TSRA.
2. Develop data framework which will include collated fisheries and environmental datasets identified in the scoping study.
3. Integrate available data and models for Tropical Rock Lobster, bêche-de-mer, dugongs and seagrass into an integrated spatial MICE (i-MICEv.1) for the Torres Strait region and provide estimates of relative impacts from climate change (sea surface temperature for base case and a high emission scenario) on fisheries resources in the short (2yrs), medium (5yrs) and longer term (10+ yrs).
4. Refine social, economic and livelihood metrics (from previous Torres Strait Lobster MSE project) with PSC and link these metrics with the i-MICEv.1 model and present results from i-MICEv.1 to stakeholders and based on results, co-develop adaptation actions during workshops (if Phase 2 is funded, adaptation strategies will be finalized at a later stage (8).

Phase 2

5. Establish a monitoring program to collect physical data needed to calibrate the 3-dimensional ocean model of Torres Strait. Publish calibration data in Torres Strait data framework (2).
6. Develop and calibrate 3-dimensional ocean models (to cover the Torres Strait area). Generate outputs for physical processes for baseline and climate change scenarios. Deliver model outputs in the Torres Strait data framework (2).
7. Build i-MICEv.2 based on new variables from Torres Strait 3-dimensional ocean models and update estimated impacts.
8. Present results of the project to stakeholders and communities and co-develop adaptation strategies via stakeholder workshop(s).

Consultation and Engagement – *Note: community consultation is required with key Torres Strait community stakeholders as a part of a TSSAC research project application being considered for funding.*

This consultation will be required following conditional approval of a research proposal by the TSSAC. In order to facilitate this consultation, you are asked to develop a "stakeholder engagement strategy" and "community consultation package" as part of this research application. Please follow the instructions at Attachment A.

If there has been any initial consultation and engagement with Torres Strait communities already for this project, or for similar projects in the past, please outline with whom and the key outcomes. Please also outline any other consultation you have completed with other stakeholders too. (

In 2021 CSIRO delivered the scoping study “Scoping a future project to address impacts from climate variability and change on key Torres Strait Fisheries” to AFMA which evaluated the availability and suitability of existing data required to develop future models to assess the impacts of climate change in Torres Strait fisheries. The findings from the scoping study included extensive consultation with fishery researchers, managers and key Torres Strait stakeholders, and included a technical workshop organised in October 2020 to present the proposed data and modelling frameworks, where input from participants were used in the final project scope specifications and preliminary costs provided.

The scoping study found that some datasets and models are available to start the modelling exercise. It recommended the consolidation of the available data into an overarching data framework and integration of existing data and models into a model of intermediate complexity for ecosystem assessment (MICE). The scoping study also recommended the construction of MICE in a stepwise fashion, adding new data and complexity as these become available or necessary, and engage with stakeholders to communicate model results at early stages and draw on local knowledge to further refine models. Also, given the paucity of hydrodynamic and physical data for the region, the scoping study recommended the development of a dedicated hydrodynamic model for Torres Strait because previous hydrodynamic models and supporting data are outdated. The Torres Strait hydrodynamic model would provide new oceanographic predictions at scales relevant to the management of fisheries by dynamically downscaling climate change scenarios that could then be used to refine and further develop MICE. As discussed during presentation of the scoping study with TSSAC in 2021, developing 3-dimensional ocean models and collecting the necessary data for its calibration and validation is expensive, but would be useful to investigate broader impacts of climate change in the region. For example, on other fisheries, different ecosystems and communities. The current proposal implements the recommended stepwise approach in the developments of models, also incorporating local knowledge, community and management needs via actively engaging with stakeholders.

Methods (max 250 words) – *Detail the methods that will be used to undertake this project.*

Phase 1
A project steering committee (PSC) will be established with support from AFMA and TSRA. The PSC will meet at least for 2h, 3 times/year to guide and advise on progress, stakeholder engagement, communication, adaptation strategies and other relevant matters.

The overarching data framework will use CSIRO IT infrastructure to collate, manage and describe datasets identified in the scoping study. These descriptions will be made public to allow non-CSIRO researchers to access and visualise data.

i-MICEv.1 will extend and link current biological models of key species (TRL, BDM, dugongs), known environmental drivers (sea surface temperature) and habitat (seagrass). The model will provide quantitative estimates of impacts from baseline and climate change scenarios on habitat and fisheries/species in the short (2yr), medium (5yr) and long-term (20 yrs). Previous social, economic and other fisheries-related livelihoods metrics will be refined with PSC and linked to i-MICE.

i-MICEv.1 results will be presented to stakeholders in a workshop, where adaptation strategies will be co-developed. Techniques such as scenario planning, impact and livelihood adaptation pathways will be applied in the workshop. Adaptation actions will only be developed here if Phase 2 is not funded.

Phase 2
Field work: Two moorings will be deployed for two months each over wet and dry seasons to collect the required physical data to extend boundaries, calibrate and validate a 3-dimensional ocean model of Torres Strait. The model will run baseline and climate change scenarios to generate new oceanographic data to develop i-MICEv.2, and updated results will be presented to stakeholders in a workshop where adaptation strategies will be co-developed.

Planned outcomes and benefits (max 150 words) – *this should include how the research will be used by management to benefit the fishery and other stakeholders:*

The research will integrate existing and new data and models into a data framework and develop i-MICE to estimate changes in fisheries and ecosystem resources due to climate change. It will integrate these results with socio-economic and livelihood metrics, present research results back to stakeholders, and draw on local knowledge to further refine models. Model results will be presented and discussed with stakeholders and used to co-develop adaptation actions and to inform existing planning and adaptation processes. This will allow local communities and fisheries management to proactively prepare for short-long term changes anticipated under climate change. All data collected and produced in the project will be securely stored and managed via the proposed overarching data framework, where stakeholder information (e.g. local knowledge) will only be used with formal consent.

Project extension (max 100 words) - *are there possible future research options that could result from this project?*

Several research projects can result or benefit from this project. For example, the i-MICE modelling framework will allow the addition of complexity (e.g. new habitats, species and environmental conditions) depending on needs and data availability in the future. The combined i-MICE and ocean models will provide new hydrodynamic data and quantified impacts from climate change scenarios that could be used to support a broad range of further research on impacts and adaptation in Torres Strait. For example, they will allow the investigation of: (a) interactions between different fisheries and ecosystem functioning, (b) climate change impacts on abundance and distribution of a broader range of fisheries and species, (c) impacts of incidents (e.g. oil spills, ships running aground), (d) synergistic and cumulative climate and non-climate impacts on species, ecosystems and livelihoods, and e) the evaluation of alternative adaptation options.

Risk Analysis - *be sure to consider risks specific to conducting research in the Torres Strait including community support or lack there-of.*

The project team has a long history of research and stakeholder engagement in the region, and this considerably reduces the risk of a lack of support for the research. The project scope in which this proposal is based has invested time and effort to engage with stakeholders and the technical and fisheries management communities, inviting their inputs, and involving them in the research scope to the extent possible. As a result, there is strong interest and support from TSSAC to better understand climate change impacts in the fisheries of Torres strait and more broadly. There are a number of risks associated with conducting fieldwork in a remote region to collect the environmental data needed to develop the ocean model, such as strong currents, remote locations, and prevailing weather conditions, but CSIRO has strong expertise and experience in managing and avoiding any risks as they arise, plus stringent protocols in place to minimize these, which include mothership compliance with AMSA regulations, survey equipment inspection checklists, regular equipment servicing, and field work management.

Related Projects and Research Capacity (max 100 words) - *Are there any past or current projects relevant to this proposal funded through the TSSAC, TSRA, FRDC or other organisation? Outline the Investigators' experience in the proposed research and Torres Strait region.*

CSIRO has conducted research (e.g. surveys, assessment and harvest strategy development projects) on Rock Lobsters, bêche-de-mer and other fisheries in Torres Strait, including seabed habitat monitoring (including seagrass) and subsequent stock assessments since 1989 (PIs: Eva Plaganyi, Nicole Murphy et al.). This project builds also on a recent project led by Leo Dutra (CSIRO): Climate variability and change relevant to key fisheries resources in the Torres Strait and is also complemented by an FRDC project (led by Leo Dutra), which aims to build research capacity in the Torres Strait by engaging Torres Strait Islanders and CSIRO researchers in the co-production and presentation of research at international conferences.
CSIRO has collaborated with Torres Strait islander communities, organizations and individuals throughout its history working in the area to ensure research outcomes are relevant to Torres Strait. Torres Strait islanders are provided with results of the research projects.

SECTION 4 - Schedule of Payments

As a general rule, up to 10% of the total project cost may be provided as an initial payment and a minimum of 30% of the total project cost must be left for the final report.

Milestones	Deliverable date (Please refer to instructions)	Schedule of AFMA payment(s) (excluding GST)
Initial payment on signing of contract	01/07/2022	$0.00
Establish project steering committee	01/11/2022	$0.00
PHASE 1		
Data framework	30/07/2023	$87,356
Fisheries and socioecological estimates of climate change impacts on ecosystem and fisheries (iMICEv.1)	30/09/2024	$360,107
Presentation of model results to stakeholders and adaptation strategies	30/10/2024	$35,108
Phase 1 report	30/11/2024	-
PHASE 2		
Data collection to calibrate and validate hydrodynamic model	01/04/2025	$157,929
Hydrodynamic model runs for climate change scenarios	30/07/2025	$277,185
Assessment of climate change impacts using new oceanographic data from TS hydrodynamic model (i-MICEv.2	27/02/2026	$95,460
Presentation of model results to stakeholders and development of adaptation strategies	31/03/2026	$35,814
Draft final report	15/04/2026	-
Final report	30/04/2026	-
TOTAL		$1,048,959

SECTION 5 - Description of Milestones

Details on each milestone must provide sufficient information to justify the milestone cost and should match the performance indicators. The description field will describe the work to be completed for that milestone with the justification field elaborating further on the categories of cost - for example salary.

Milestone: Initial payment on signing of contract **Date:** 01/07/2022

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: Establish project steering committee **Date:** 01/11/2022

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

A project steering committee (PSC) composed of fisheries managers, fishers, community members and other relevant stakeholders will be established at the beginning of the project. Lisa Cocking (AFMA) agreed to further discuss the process to establish a steering committee with TSRA and the project team if the project is funded. The PSC is expected to meet at least 3 times a year for 2h, where meetings can be conducted online or face-to-face depending on funds, time and needs of PSC members. **Please note that no funds were budgeted in the proposal** to cover travel, incidentals, sitting fees or any other costs for PSC members (assumed to be voluntary).

Justification:

Climate change is a contentious issue in Torres Strait and requires adequate mechanisms to ensure expectations about the project are adequately managed. A PSC will be important to address these issues by providing advice to the project team on research results, and guidance to select relevant metrics for fisheries and livelihood impacts that could be used to support management and planning processes. The PSC will also guide the project team about appropriate communication of research results and limitations, stakeholder engage during the development of the adaptation strategies and provide advice on extra-ordinary matters if they arise.

Milestone: Data framework **Date:** 30/07/2023

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$60,098	$0.00	$2,108	$0.00	**$62,206**
2023-24	9,226				9,226
2024-25	9,486				9,486
2025-26	6,438				6,438
TOTAL					$87,356

Description:

The proposed data framework identifies how the physio-chemical and ecological data will be managed and delivered to support the development of the proposed integrated MICE models and other research in Torres Strait. Datasets will be managed on CSIRO IT infrastructure, utilising relational database systems and enterprise file servers. Datasets will be described using geonetwork (www.marlin.csiro.au) and these descriptions will be made public to allow third parties (non-CSIRO) to access data depending on level of permission granted (i.e. licence restrictions). Datasets will be shared using Open Geospatial Consortium (OGC) standards where appropriate, by using a standards-compliant webserver (geoserver) linked to the collated data. This framework is scalable, robust and compliant with open data/metadata standards, allowing a flexible data delivery method to data visualisation portals, such as Torres Strait eAtlas and the Australian Ocean Data Network (AODN) portal (to be decided with PSC). The project will ensure confidentiality of local knowledge, which will only be used in the project or stored in the data framework with formal consent, following strict human ethics protocols.

Justification:

The data framework described will support the development of the integrated MICE model to investigate impacts of climate change on the selected fisheries, and other future research efforts in the region. It will also be the repository of data generated in the project, including calibration data for the hydrodynamic model and its outputs. The data framework will include metadata to allow the identification of datasets, access or permissions required to access data, restrictions, and spatial-temporal coverage of datasets. The data framework is flexible and has the potential to be deployed in other regions of interest.

Milestone: Fisheries and socio-ecological estimates of climate change impacts on ecosystem and fisheries (iMICEv.1)

Date: 30/09/2024

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$125,430	$0.00	$2,109	$0.00	**$127,539**
2023-24	$182,661	$0.00	$0.00	$0.00	**$182,661**
2024-25	$49,907	$0.00	$0.00	$0.00	**$49,907**
TOTAL					**$360,107**

Description:

i-MICEv.1 will extend and link current biological models of key species (TRL, BDM, dugongs), known environmental drivers (sea surface temperature) and habitat (seagrass). The model will provide quantitative estimates of impacts from baseline and climate change scenarios on habitat and fisheries/species in the short (2yr), medium (5yr) and long-term (20 yrs). Social, economic and other fisheries-related livelihoods metrics from previous Lobster MSE project will be refined with PSC and linked to i-MICEv.1. Risk statistics from climate change scenarios relative to base line will be produced. This will allow stakeholders to understand, for example, under climate change, how frequently the abundance or catch of a certain species might be expected to change compared to baseline scenario and to compare the relative risks for each spatial (e.g. fishing) region and socio-economic consequences.

The custom-designed modelling framework will be flexible and scalable, will account for uncertainty, and complexity could be added if needed by including additional species, and new climate, oceanographic and environmental data, as they become available (e.g. from Stage 2).

Justification:

i-MICEv.1 will provide the modelling framework linked to existing data and models to generate quantitative estimates of impacts from climate change scenarios on selected habitats and fisheries. This modelling framework will be extended into i-MICEv.2 if Phase 2 is funded which would allow the further investigation of climate change impacts considering a broader range of oceanographic conditions (e.g. currents, sea level, rainfall, etc.). Outputs will be presented and discussed with stakeholders during workshops and adaptation actions will be co-developed with them (adaptation actions will only be finalised here if Phase 2 is not funded).

Milestone: Presentation of Phase 1 model results to stakeholders and adaptation strategies

Date: 30/10/2024

Financial Year	Salaries	Travel	Operating	Capital	Total
2024-25	$22,106	$8,082	$4,920	$0.00	**$35,108**

Description:

Regular updates and results from i-MICEv.1 will be presented to PSC and to broader stakeholders at workshops to provide an opportunity for Q&A, feedback, and discussions including how to communicate results suitable to inform existing planning processes. Methods such as scenario planning and impact and livelihood adaptation pathways will also use i-MICEv.1 results to co-develop adaptation actions with stakeholders. Communication methods will be previously developed with PSC and discussed with broader stakeholder groups during the workshop.

If Phase 2 is funded, this workshop will involve: (a) information session to provide and discuss i-MICE results to guide the developments in the next phase, and (b) refinement of communication methods with stakeholders.

Justification:

There is a need to adequately and regularly communicate i-MICEv.1 results to PSC and broader stakeholders to inform the process to develop adaptation strategies. Stakeholders will have the opportunity to provide inputs into the delivery of climate change information to the different audiences in Torres Straits, thus making the information more salient to stakeholders.

Milestone: Phase 1 report **Date:** 30/11/2024

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Final report containing results from assessment of climate change impacts on ecosystem and fisheries/species, feedback from stakeholders on results collected during workshop and adaptation strategies (if Phase 2 is not funded).

Justification:

This will be final report of project if Phase 2 is not funded and a preliminary report to inform development of models in Phase 2 if proposal is fully funded.

Milestone: Data collection to calibrate and validate hydrodynamic model **Date:** 01/04/2025

Financial Year	Salaries	Travel	Operating	Capital	Total
2022-23	$42,317	$5,271	$33,228	$0.00	**$80,816**
2023-24	$37,828	$5,271	$34,015	$0.00	**$77,114**
TOTAL					**$157,929**

Description:

A monitoring program to collect physical data to calibrate the hydrodynamic model will involve 2 deployments of moorings (ADCP, CTD to collect physical data such temperature, salinity, currents (velocity, direction), surface elevation) at sea surface and bottom. Each deployment will last for 2 months over the wet and a dry seasons of years 2022-23.

Justification:

Developing the ocean model will require a data collection program for model calibration. The ocean model will provide valuable oceanographic data under different climate conditions that will improve our understanding about tides, currents sea temperature, salinity, pH and other physical drivers. Such data could be integrated in i-MICEv.2 to investigate, for example, the influence of physical drivers on reproduction, growth, larval dispersal and settlement, recruitment, abundance and distribution.

Milestone: Hydrodynamic model runs for climate change scenarios **Date:** 30/07/2025

Financial Year	Salaries	Travel	Operating	Capital	Total
2023-24	$134,579	$0.00	$2,108	$0.00	**$136,687**
2024-25	$138,390	$0.00	$2,108	$0.00	**$140,498**
TOTAL					**$277,185**

Description:

CSIRO will apply a full 3 dimensional ocean model to simulate oceanographic conditions for a baseline and climate change scenarios. The ocean model will produce 3D hydrodynamic fields of the environment on a variable resolution grid that can be nested within operational Ocean models and CMIP style ocean models. The grid will be designed to resolve the area of interest for the MICE study. If needed, model resolution for specific fisheries areas will be increased by nesting high resolution models (10s to 100s of meters) inside the regional ocean model, through the relocatable coastal ocean model.

Outputs from the hydrodynamic model will be produced for the Torres Strait Region at a minimum of 1km grid cell resolution (finer in specific areas if required) as monthly averages for specific regions of interest (e.g. MSE sub-regions, or fishing sub-areas). New data generated will be used to add complexity to i-MICEv.2 to evaluate the effects of climate change on a broader range of oceanographic conditions and their impacts on the selected ecosystem and fisheries/species.

Justification:

Currently, only existing datasets for sea surface temperature have adequate spatial and temporal resolution to be used in i-MICE. Timeseries of other oceanographic variables exist but cover limited temporal or spatial scale. There are model outputs from downscaled models that are also available, but discrepancies between model outputs and observations were previously identified and need careful consideration and calibration before their use. Ocean model outputs will be used to extend the range of climate change variables to be explored in i-MICEv.2 to provide outputs that can support additional research in Torres Strait.

Milestone: Assessment of climate change impacts using new oceanographic data from TS Hydrodynamic model (i-MICEv.2)

Date: 27/02/2026

Financial Year	Salaries	Travel	Operating	Capital	Total
2025-26	$95,460	$0.00	$0.00	$0.00	**$95,460**

Description:

Phase 1 is the starting point to initiate the investigation of climate change impacts in Torres Strait fisheries. Phase 2 is about generating new oceanographic data to allow for a more comprehensive investigation of climate impacts on physical variables and their effects on fisheries. New oceanographic data generated with the ocean model will be used to add complexity in the i-MICEv.2 to further investigate climate change impacts on the fisheries. Updated results will be presented to stakeholders.

Justification:

We use a step-wise approach in the development of i-MICE where in Phase 1, existing data are currently available to start modelling and investigate potential climate change impacts on the selected fisheries. In Phase 2, we add new data and complexity (from the ocean model) as these become available. This step-wise process allows time to obtain feedback from stakeholders on model development/assumptions/results in i-MICEv.1 and incorporate this into i-MICEv.2, allowing time to communicate model results, as well as drawing on local knowledge to further refine models and the information they generate.

Milestone: Presentation of model results to stakeholders and development of adaptation strategies

Date: 31/03/2026

Financial Year	Salaries	Travel	Operating	Capital	Total
	$25,623	$5,271	$4,920	$0.00	**$35,814**

Description:

If funds for Phase 2 are available, a second workshop will be organised to present and discuss updated results from i-MICEv.2 and to co-develop adaptation actions using scenario planning, and impact and livelihood adaptation pathways techniques.

Justification:

There is a need to adequately present and discuss research findings with stakeholders and identify ways of providing information to support existing planning and management process. I-MICEv.2 results will also support a process to co-develop adaptation strategies.

Milestone: Draft report **Date:** 15/05/2026

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Milestone: Final report **Date:** 10/06/2026

Financial Year	Salaries	Travel	Operating	Capital	Total
	$0.00	$0.00	$0.00	$0.00	**$0.00**

Description:

Justification:

Section 6 – Special Conditions

If relevant, this field will be used to assist in contract preparation for any special conditions. Examples of special conditions *may relate to marine spatial closures (including access) or any other clauses not specifically contained in the contract.*

N/A

Section 7 - Data management

Identify the appropriate Intellectual Property category applicable to this application. Choose ONE from below:

Code	Description
1	Published, widely disseminated and promoted, and/or training and extension provided. Relates mainly to outputs that will be available in the public domain.
2	Published, widely disseminated and promoted, and/or training and extension provided. Related products and/or services developed. Relates mainly to outputs that will largely be available in the public domain, but components may be commercialised or intellectual property protected.
3	Published, widely disseminated and promoted, and/or training and extension provided. Related products and/or services developed. Relates mainly to outputs that may have significant components that are commercialised or intellectual property protected.

The following IP category applies to this application:

1. Published, widely disseminated and promoted, and/or training and extension provided. Relates mainly to outputs that will be available in the public domain.

I have searched for existing data (refer to guidelines on how to search the Australian Spatial Data Directory and Oceans Portal):

[Yes]

Provide a brief description of the data to be generated from the project and how this data will be stored for future protection and access, including:

- information on data security or privacy issues and applying to the data

- Nominated data custodian

Physio-chemical data from monitoring program to calibrate ocean model (e.g. profiles of temperature, salinity, currents, etc) will be entered into and stored in the future overarching data framework that will also be delivered as part of the project. Data storage, protection and access is governed and managed according to CSIRO policy guidelines, in accordance with CSIRO rules and regulations.

- Document how research data, traditional knowledge and intellectual property will be handled during your project, including but not limited to:
- Acknowledging where the data or information used in research comes from, so that any income made from selling a concept in the future will be adequately linked to a community's contribution/ knowledge so they also receive financial or other benefit from "selling" a concept onward.
- How you will negotiate use and publish of traditional knowledge with communities. For example do traditional inhabitants allow public publication of information or only for project activities and reported on in internal reports? This will depend on data sensitivity and privacy (such as fishing grounds etc).
- Are there any other ethical considerations you have identified for this project which need to be managed?
- Are you committed to gaining ethics approval for this project from a suitable body such as a university or AIATSIS?

Acknowledging where the data or information used in research comes from, so that any income made from selling a concept in the future will be adequately linked to a community's contribution/ knowledge so they also receive financial or other benefit from "selling" a concept onward.
N/A – research will not include commercialisation of any products.

- How you will negotiate use and publish of traditional knowledge with communities. For example do traditional inhabitants allow public publication of information or only for project activities and reported on in internal reports? This will depend on data sensitivity and privacy (such as fishing grounds etc).

Special consideration will be taken with any Traditional Knowledge (TK) collected during the project. TK will only be used with the express permission and consent of the traditional owners. Guidance will be sought from local Island leaders and the TSRA to ensure full local support and agreement over the handling of TK information.

- Are there any other ethical considerations you have identified for this project which need to be managed?

Yes, participation in planned workshop sessions will be voluntary and participants will be given the opportunity to withdraw form participation at any time during or after the workshop. The project will follow established ethical guidelines prepared by the CSIRO Human Ethics committee.

- Are you committed to gaining ethics approval for this project from a suitable body such as a university or AIATSIS?

Yes – CSIRO has its own Human Research Ethics committee which considers the Code of Ethics for Aboriginal and Torres Strait Islander Research from AIATSIS. The project will seek human ethics approval from the CSIRO human ethics committee.

STAKEHOLDER ENGAGEMENT STRATEGY AND COMMUNITY CONSULTATION PACKAGE

Planning & development – who to engage and how

Researchers are required to develop a stakeholder engagement strategy as part of their TSSAC research proposal application process, which will include a short community consultation package which will be provided to the relevant stakeholders. This plain English package will be reviewed by the TSSAC along with your research application. You are required to work with the TSSAC Secretariat on the development of these documents. You **are not** required to undertake this consultation until conditional approval is given to your project and this engagement strategy. However, your full proposal submitted to the TSSAC can detail engagement and consultation undertaken with stakeholders and communities in developing the proposal to date, or relevant consultation from past projects, if this is an extension project, or continuing project.

Stakeholder engagement strategy

The stakeholder engagement strategy should detail the level of engagement required with the key stakeholders throughout the stages of the project (including the preliminary consultation phase as part of this research proposal, project implementation, updates about project progress and results dissemination following project completion).

The strategy should be no more than 2 pages and include:

- the areas in the Torres Strait region where the proposed research activities may occur (i.e. eastern or central communities, specific islands/ communities); and which Torres Strait community groups or individuals you will engage/involve from these areas during your research project? e.g. does your project involve community workshops or meetings? Will it employ any Torres Strait Islanders (paid or on a voluntary basis) and if not - why not, will your project interview Torres Strait Islanders? Will your project require you to visit any Torres Strait communities (or is it solely at sea)?
- The types of engagement you plan to use during different phases of the project (e.g. during the initial consultation, for updates during the project, to disseminate results of the project). The project such as posting community notices, developing plain English summary reports, recording short educational videos or infographics, phone calls or emails);
- how research data, traditional knowledge and intellectual property will be handled during the project;
- how researchers will show respect for Traditional Inhabitant culture at all times.

The strategy should consider the projects' schedules and fieldwork and allow for extra lead-time, longer engagement periods in the community and appropriate response times when drafting milestones.

Note, depending on the level of engagement with the RNTBCs this may be on a fee for service basis. Researchers need to factor in any potential fee for service rates into the research project budget.

Example stakeholder engagement strategy

Timing	Task	Method of communication
March	Complete engagement with communities about proposed project seeking feedback	Community notices, email to key stakeholders, follow up with phone calls at least twice if no response
August	Email key stakeholders to provide plain English project progress information	email to key stakeholders with contact number if they wish to discuss.
December	Email key stakeholders to provide plain English project progress information	email to key stakeholders with contact number if they wish to discuss.

June	Create and disseminate plain English summary of project outcomes.	Email to key stakeholders, community notice with QR code to website with summary.
June	Create short video with slides showing main project outcomes	Email video to key stakeholders, place community notice with QR code to website with the video link.

Community Consultation Package

The community consultation package should contain plain language information about the proposed research, be no more than two pages and may include:

- a process for clearly noting, upfront, that the project is in the application stage which is why you are seeking community views and consideration;
- the research objectives and timeframes;
- areas to be accessed for the study, and a detailed description of areas and details of what will be done there;
- materials, equipment and techniques to be used and how you will minimise risk of negative impacts on the area (environment and communities);
- involvement of key stakeholders (including local knowledge informants, local research assistants, and community information- sharing and research dissemination intentions) OR a brief explanation of why community involvement does not fit the nature of the project);
- anticipated outcomes including direct or indirect benefits* to key stakeholders such as any future benefit-sharing expectations, protections for traditional knowledge sources. AFMA may use the project summary for developing papers to communicate the research at relevant PZJA forums;
- likelihood and details of any extension activities following the research;
- how research data and intellectual property will be handled; and
- seeking advice about relevant traditional knowledge which could assist the project, or suggest changes to improve the projects' plan or success.

*For example, a) a greater understanding of a fishery through participation (potentially employment) in the research project and extension activities following the research (direct); b) improved understanding of stock status may lead to less precautionary Total Allowable Catch therefore increased utilisation of resource (indirect).

What happens following community engagement, as a part of my research application process?

Once you have undertaken the community consultation (following conditional approval of your project), provide a clear summary of the results to the TSSAC secretariat detailing:

- A list of Torres Strait communities you consulted and how this occurred including engagement methods.
- The feedback provided by each individual or group (or the number of attempts of contact if you didn't not receive a response).
- Any perceived risks or stakeholder considerations with the project.
- Any changes to be made to the proposal based on feedback.
- How traditional knowledge might be considered or incorporated to enhance the project, its outcomes and benefits including IP issues associated with this
- How the research outcomes will benefit Traditional Inhabitants directly or indirectly, or why it is not relevant/ applicable.

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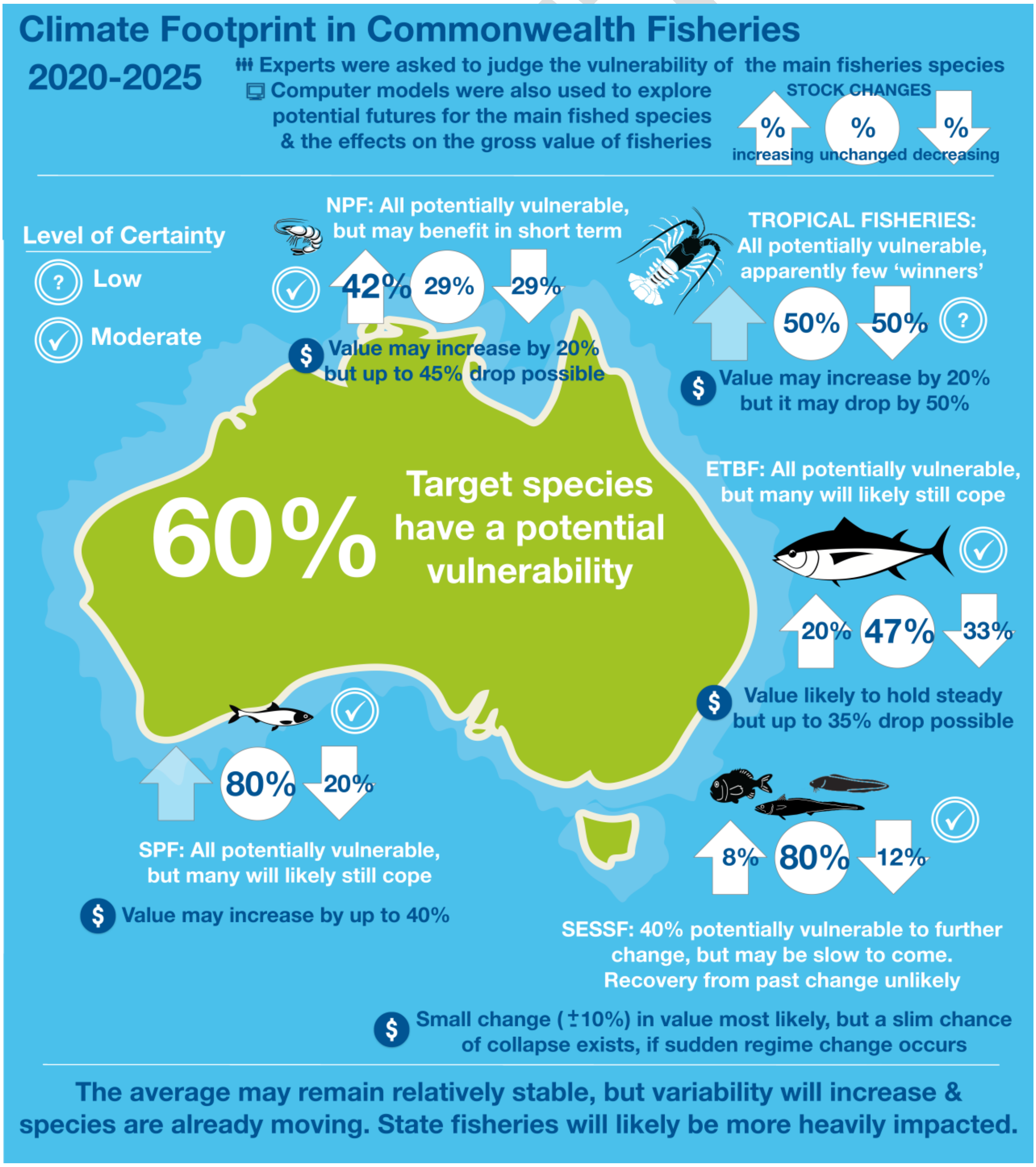
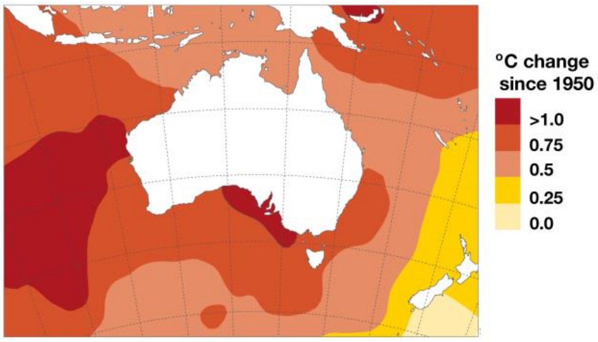
Australian fisheries stocks under climate change

Over the next twenty years Australia's marine ecosystems are expected to exhibit some of the largest climate-driven changes in the Southern Hemisphere. These changes will extend from the ecosystems to the local communities and businesses of the Australian fisheries sector. The CSIRO and its collaborators have pulled together all available information on how climate may affect fished species in Australia – identifying those most sensitive to climate. This information helps highlight those species that may be at risk and those that might benefit, allowing fisheries to be better prepared.



Climate change in Australian Waters



Water temperature change around Australia since 1950. Image updated from BOM data. These temperature increases mean water temperatures often record breaking.

Australia's oceans are undergoing rapid change. The waters off south-east and south-west Australia are hotspots, warming much more rapidly than most of the world's oceans. Australia's tropical ocean is also warming rapidly, almost twice as fast as average for the rest of the world. It is important to understand what this means for the ecosystems in these warming waters if we are to continue to be sustainably manage Australian fisheries. Understanding the changes and being climate ready is important for both industry and management, because it allows them to plan their operations to avoid or mitigate negative impacts and to make the most of new opportunities that arise.

Australian fish species have already begun to move. Over 100 Australian species have already started migrating south towards cooler southern waters. There have also been a series of marine heatwaves and other extreme events that have harmed Australia's seagrass, kelp forests, mangroves and coral reefs. These changes in the distribution, abundance and species composition in Australia's marine ecosystems mean that Australia's commercial fisheries are being affected by climate change. It is unavoidable. The ocean also has a long memory, which means that the effects of past and present human activities have already locked the world in to a further 0.5-1 °C warming. This is why fisheries managers (e.g. at AFMA) have asked for a rapid and thorough update of information so that they can base their strategic planning on the latest and best information.

Sensitivity of Australian Fisheries Target Species

Australian fisheries catch more than 100 species. There is not enough data or resources available to perform fine scale assessments for each species. Instead experts on the fisheries and target species were asked identify the key target species in State and Commonwealth fisheries. The experts then had to rank each species in terms of how sensitive it was to climate change. This sensitivity was judged in terms of factors that affect:

- abundance (how old they are when they mature, how often they reproduce, number of eggs, diet and habitat needs);
- movement and spatial distributions (distance they can move, how widely spread they are already, available habitats):
- behaviour (needing special triggers for reproduction or migration, having special behaviours that only happen for short periods)

Across all Australia 70% of all key target species are have moderate to high sensitivity in one of these factors. Within the AFMA managed fisheries at least 50% of the target species per fishery are moderately to highly sensitive and in many AFMA managed fisheries all the target species are sensitive in one way or another.

Most species were sensitive to factors determining their distribution or behaviour, while only about 25% were sensitive in terms of factors that directly influence abundance. The greatest sensitivity to the timing of key behaviours was along the coastline of eastern Australia (north and south), while shifts in distribution are the most likely responses in the west and in the tropical north. Invertebrates had higher sensitivity scores than other species. As a consequence, dive – and other gears targeting invertebrate – show the highest sensitivities. Purse seine fisheries for small pelagic species has the lowest sensitivities.

The sensitivity analysis suggests that fisheries should first consider how changes in distribution and the timing of key events affect them and their management and then consider potential than changes in abundance.

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Sensitivity of Species Targeted by Australian Fisheries

Summary of sensitivity per fishery. Low sensitivity is for those species with a low rating across all 3 factors – abundance, distribution and behaviour. Moderate sensitivity indicates that a species had 1 factor that was scored as being moderately sensitive to climate change. High sensitivity covered both the case where a species was rated as having a factor that was highly sensitive to climate change or they had multiple factors rated as moderately sensitive. Sensitivity does not automatically indicate a likely decline it indicates the potential for change (including possible increases)

Commonwealth Fishery	Low	Moderate	High
Bass Strait Scallop			Scallops: behaviour and distribution
Coral Sea			Coral trout: distribution and abundance
Eastern Tuna and Billfish		Behaviour of all target species	
Northern Prawn			Behaviour and distribution of all target species
South and Eastern Scalefish and Shark	Species already showing shifts (warehou, morwong, redfish, ling) show low sensitivity to further climate driven change	Gemfish: abundance. Trevalla, flatheads, and whiting behaviour.	**All/majority** of properties of squids, sharks, blue grenadier and orange roughy.
Small Pelagics		Behaviour of sardine and blue mackerel	Jack mackerel and red bait behaviour and distribution
Torres Strait			**All** properties of tropical rock lobster
State Fisheries			
New South Wales, Victoria, South Australia		Behaviour of snapper, tuna and some small pelagics.	Many small pelagic, estuarine and invertebrate species (mainly via behaviour and distribution). **All** properties of sharks and blue grenadier.
Queensland		Behaviour of estuarine and shelf fish, as well as Spanish mackerel and billfish.	Behaviour and distribution of all reef fish. **All** properties of the majority of invertebrates and sharks.
Gulf of Carpentaria (Queensland and Northern Territory)	Bream and sharks	Majority of mackerels, estuarine fish and mangrove associated species (due to a mix of factors).	**All/majority** of properties of snappers, emperors and all valuable invertebrate species (prawns, lobster, sandfish).
Northern Territory and Western Australia	Many sharks, estuarine and large pelagic fish	Large sharks: abundance. Behaviour or distribution of fish non-reef shelf fish	**All/majority** of properties of reef associated fish and all invertebrates.
Western Australia		Distribution or behaviour of herring, reef associated predators, some abalone, octopus and sandfish.	**All/majority** of properties of prawns, crabs, many small pelagics, some abalone, oysters, bream and dhufish.

Fisheries projections

The other approach to consider the future climate change effects on Australia's fisheries was to take existing models of Australian marine ecosystems (which together cover the entire EEZ) and run them under the conditions that might exist over the next 40 years. The results of these models were then used to see how species abundance and distribution might change and how ecosystems might restructure.

The modelling work found that the different ecosystems around Australia face different types and levels of climate change – including temperature changes, changes in rainfall patterns, ocean acidification, shifting ocean oxygen levels. For fisheries as large as the SESSF different parts of a fishery will be undergoing different levels of change. In most instances, larger changes in the climate led to larger model responses. The tropics, however, might see some large changes despite only small shifts because those shifts will influence the productivity of phytoplankton that supports the entire food web.

Those models that only look at the physical environments preferred by species predicted there would be reasonably large declines for the majority of fish populations around Australia. However, once all the other processes that occur in ecosystems (e.g. feeding, movement, habitat use) were included in the models the picture is more complicated – some species decline, but others benefit and grow in abundance, though perhaps living in new locations.

The models also predict that the ecosystems will become more variable. The Tasman Sea, for example, could have strings of very productive years interspersed by series of years with exceptionally low production. This variability is reflected across the entire food web, with many of the species shifting their distributions in response – seeking out desirable habitats and food sources.

For many species the different models are in agreement, increasing confidence in the robustness of results. When the models disagree this highlights uncertainty and where more information is needed. Many of the species ranking highly in the sensitivity analysis also show enhanced responses to climate change in the models. In the short term many of the models predict little further change for most species (noting that this means that already depleted species do not show signs of recovery). Further in to the future (30-40 years) things become more uncertain, with the different models not always agreeing on whether species will increase or decrease in abundance. This is because simple physical responses alone may not dictate a species response to climate change. As abundances change, predation and competition within food webs will also change. This means that new or novel food webs may form, changing ecosystems unexpected ways. In some regions (such as south eastern Australia) the ecosystem may eventually shift into a new state that is quite different to today, though this will be dependent on exactly how the physical climate drivers interact with the many different responses of all the species making up the food web and habitats in that region.

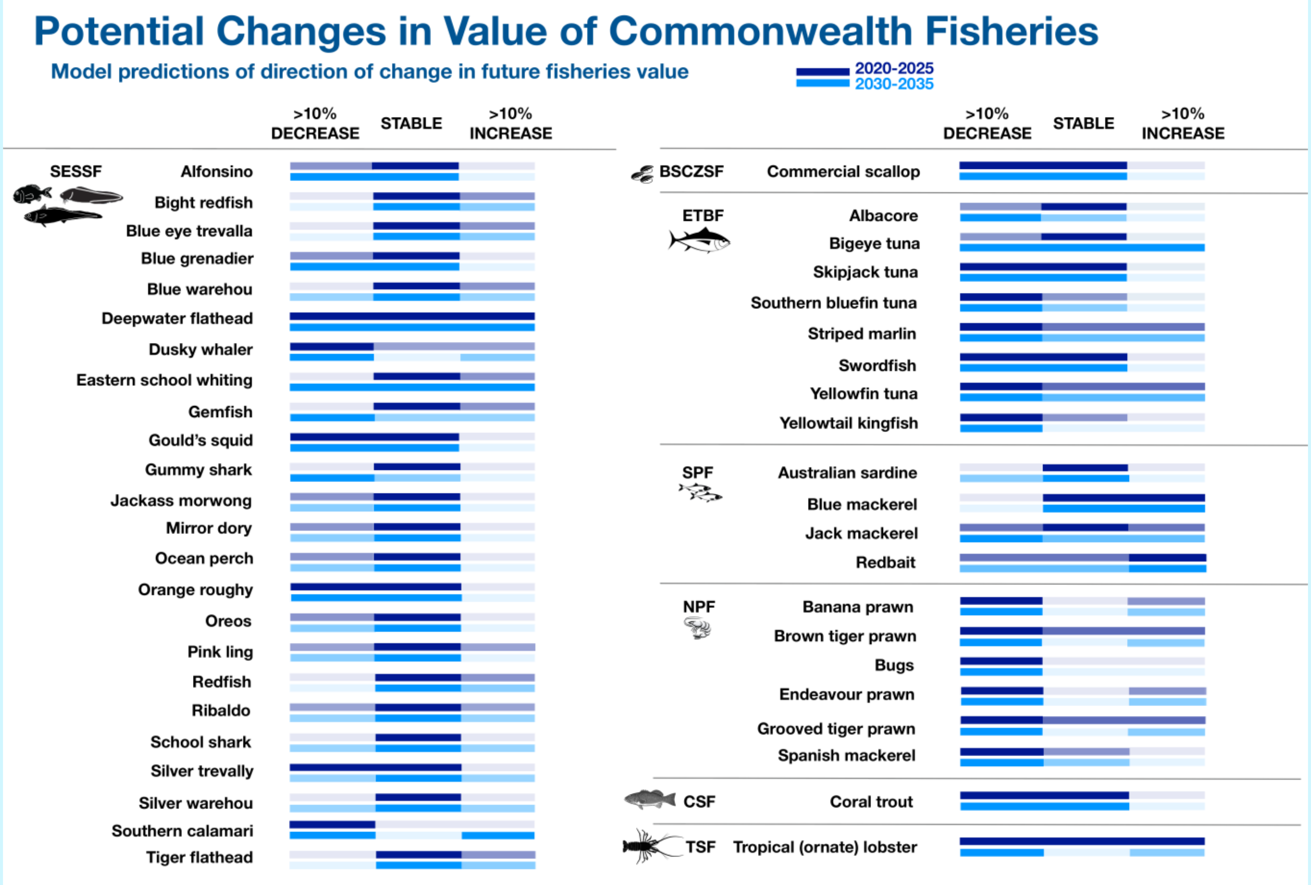
Implications of Climate Change

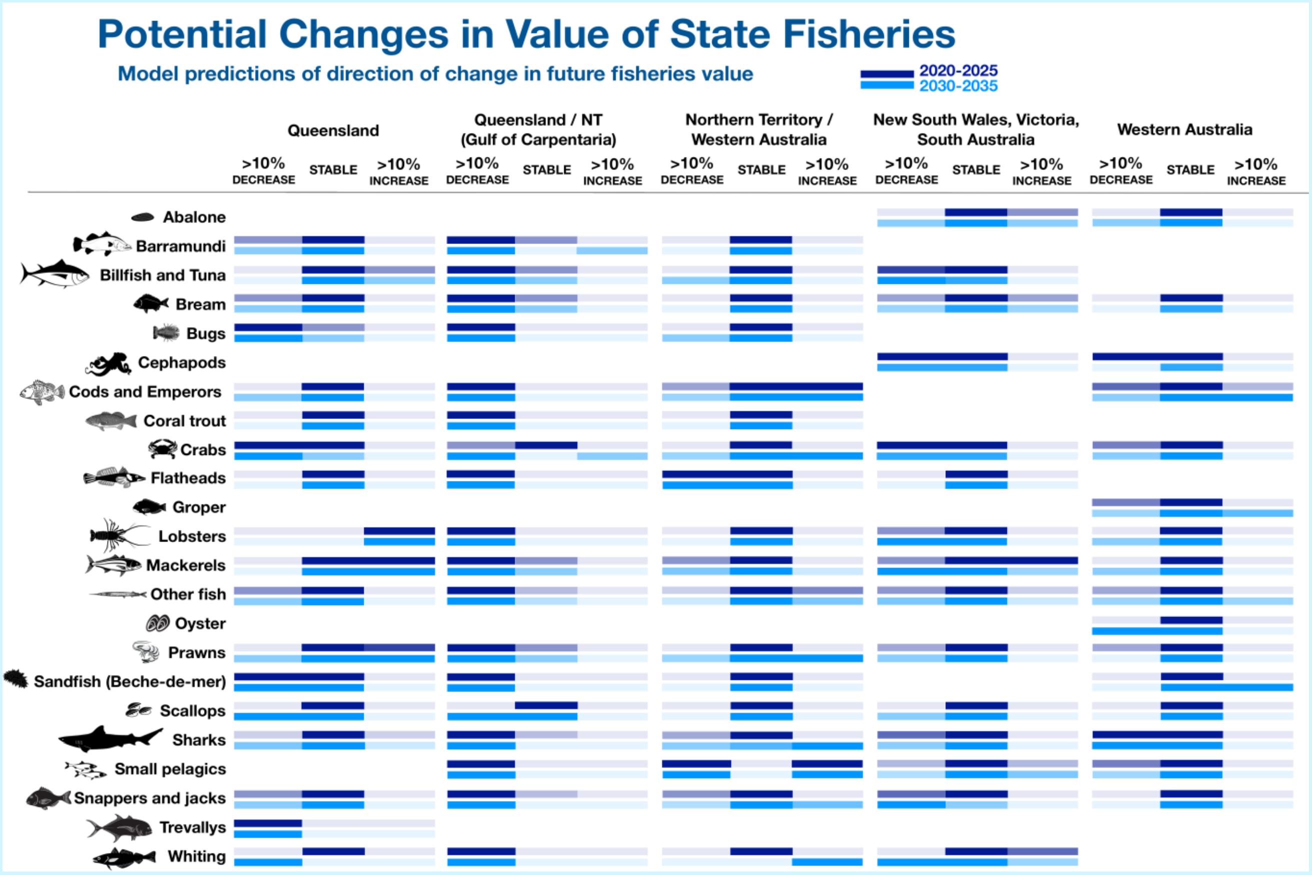
It is clear from the changes that have already occurred, and what the sensitivity and models predict, that there will be strong differences in the level of effects and responses across different species and food webs. Demersal food webs, those species that live near to or amongst habitats on the seabed, appear to be more strongly affected by climate change. Invertebrates, who are amongst Australia's most valuable target species, are particularly sensitive. Pelagic food webs, where species live up in the water column, appear less sensitive and may even benefit from the environmental changes.

This is a concerning finding as much of Australia's seafood is sourced from species that are members of demersal food webs or reliant upon them. Individuals in shallower (more effected) waters, or already living on the edge of what they can tolerate, will be the first to respond and will show the greatest magnitude of response. Some of these changes have already begun. The decline of species such as abalone associated with marine heatwaves and tens of species already observed to be moving south (e.g. into Tasmania and other places where they have not previously been recorded).

Invertebrates may be among the most heavily impacted species. They are often highly productive, but with relatively short life spans; meaning they can respond quickly, but often have little buffering capacity (they cannot ride out many poor years before suffering significant decline at the population level). Many invertebrates also have specific habitat requirements. Altogether these characteristics mean that invertebrates are more volatile and are quite sensitive to variation in climate and extreme events.

Both Commonwealth and State fisheries will face changes in gross value as a result of climate change effecting both the fish stocks and (potentially) the behaviour of the fishers. While the majority of the model results suggest little change in the short term, some simulations did suggest that larger changes (both positive and negative) were possible.





Ecosystem responses will not only respond to changes in temperature, precipitation or to ocean acidification. Variability in primary production (i.e. production by the plants and algae at the bottom of the food web) will also be important. For instance, if there is little change in primary production then ecosystems will likely show little change (so long as temperatures do not shift beyond what may species can physically tolerate). Unfortunately, it is not yet clear what future primary productivity will look like around Australia – as some important processes are still not completely understood. This means that understanding and predicting future changes in primary production remains an active area of research and updates will be provided as rapidly as possible.

Many mechanisms can lead to changes in ecosystems – whether through behaviour, distribution or abundance of the species and habitats in them. The drivers causing the changes can be different species to species. For some it will be due to changes in environmental conditions, this can cause the timing of seasonal events (like spawning) to move which can affect the success of those behaviours. If environmental conditions move beyond preferred ranges species will move to more favourable conditions or dwindle in abundance. For many species change will result from a loss (or shift) in habitat but for others changes will occur because the availability of their prey changes. For still other species it could be due to a shift in what their predator(s) are doing – if a predator moves away the prey abundance might grow, whereas if a predator starts to eat more of the prey (due to a shift in diet) then the prey population might decline. As frustrating as it may be for managers, industry and researchers looking for simple explanations and a way to make things more straight forward, it will likely come down to a case-by-case basis (which may even vary spatially across a species' geographic range).

Human responses to all these changes could also complicate things. Well informed decisions are one of the best ways of avoiding negative outcomes and maximising opportunities. A nested approach – where models and vulnerability assessments are used to identify the most at risk species and locations – appears to be the best way of targeting monitoring and management responses.

Given existing understanding of ecosystems, climate change and the sensitivities highlighted in this project a small set of management recommendations can be made:

i. A staged response might be necessary, where fishing activities are first adjusted due to shifts in behaviour (e.g. changing the timing of seasonal closures to make sure they continue to line up with seasonal behaviours like spawning or migrations), before looking to respond to changes in spatial distributions.

ii. Not all fisheries and operators will be exposed to the same level of change. Likewise, not everyone will have the same capacity to adapt. This will compound the differential outcomes seen across species and fisheries. One option is to simply accept uneven social and economic consequences. A more attractive alternative is to have information services (websites, newsletters, radio updates) to help explain what is going on, what the options are and the need for change as well as to provide support mechanisms to help those that are struggling to adjust.

iii. Successful management will require a diverse set of good scientific tools. No single approach will be sufficient due to existing uncertainty and the interplay of climate and fishing with the ecosystem components and processes. New management and assessment tools will also be needed. The complexity of possible species responses and the increasing importance of environmental drivers means that current models used in stock assessments to advise on acceptable catch levels maybe insufficient for understanding stock patterns under climate change. Key interactions and dependencies may need to be included to better reflect how the species is responding. This means that models used in fisheries assessments will likely need to be extended along the lines of the approach known as "MICE", which are models that not only include the target species but also the most important environmental (and other) drivers that set the context for the species' responses.

iv. Existing management strategies and objectives must be reviewed in terms of whether they help or hinder long term ecological and resources management objectives. Are they likely to deliver as desired into the future, if a stock is depleted can they rebuild it or help to recover degraded ecosystems? These considerations must go beyond focusing on fisheries to think about the structure of the whole ecosystem and which species are needed to maintain ore rebuild them. Such a rethink will require a greater coordination between conservation and fisheries management.

v. Fisheries policy, management and assessment methods need to allow for the concept of regime shifts and extreme events and for contextual management decision making. Taking lessons from locations that have already faced such challenges suggests that indicators that can track what state the environment is in can be used to let managers know when they need to adjust acceptable levels of fishing pressure and protection.

vi. Fisheries management methods should be made as flexible as possible, so they can change as rapidly as need to respond to changing system state. The speed of change means a no (or at least minimal) regrets approach to management needs to be taken, with updates as new information comes to light. Management instruments may also need to be adapted. Reference points defining an overfished state or a desirable state for target species might need to be modified if there is a regime shift in ecosystem state or stock productivity. Fisheries closures may need to be based on water bodies (large areas of water of a specific temperature) rather than simply relying on the protection of fixed geographic locations.

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vii. Management decision making will need to (i) more explicitly prioritize resources and awareness around vulnerable/ sensitive species and fisheries or (ii) have a clear discussion around whether some species are beyond management (as the environment has made it impossible for the species to recover). Such decisions can't be taken lightly but might be necessary if large environmental changes occur.

viii. Australia-wide coordination of management will be imperative as species shift or environmental changes span State and Commonwealth boundaries. Without such coordination (or centralised management) local stress for fishing communities could become significant and new opportunities will likely be missed.

ix. Fisheries management will need to interlink with the management of other uses of the marine environment – that is Australia will need to use ***integrated marine management***. The number of uses of the marine environment is rapidly expanding and growing to a scale not seen before in the oceans. Mining, energy generation, transport, aquaculture (farming), recreation etc. are now all competing for space and resources in the oceans and along increasingly crowded coastlines. It is important for fisheries to see themselves in the context of all of this activity so they respond appropriately given that bigger picture.

Providing information to industry operators and managers so they can address all these changes will require good data sources. There are still many things we do not know about Australia's ecosystems and how they respond. Fishers and managers (and the scientists helping them) will require as much information as possible if they are to understand what is happening and act wisely to mitigate undesirable outcomes and make the most of any new opportunities. Such a climate robust approach to fisheries will require the combination of a number of different sources of information, including:

- Measurements and forecasts of the physical environment (temperature, salinity, rainfall, storm patterns) extending what is already provided by the Bureau of Meteorology. Sharing the data from net net sensors (for example) can help provide a more accurate picture of the current conditions and the conditions fish prefer.
- Satellite images of ocean colour (which can be used to estimate how much plankton is in the water) can help predict where fish will be and can also forewarn of coming issues with stock productivity and recruitment. Plankton recorders voluntarily mounted on ships (e.g. tankers) can also help collect very useful information about what is happening at the bottom of the food web (this can help us understand how that effects the rest of the food web including those fish that are targeted by fisheries).
- Good quality catch and effort data is the longest and one of the best sources of information on target species in Australia.
- Survey data is also important as it helps give a more complete picture of what is going on. Catch data is very useful but having a second set of information from surveys helps to be sure about what is going on – catches don't always reflect what the fish are doing, especially of the fishers have changed their behaviour in response to markets (for example).
- Citizen science data collected by Australians using smart phones and cameras represents a new source of potential data. Nearly every Australian citizen now owns a 'smart phone' which has sensors and an on-board computer that is more powerful than what was available to scientists as little as a decade ago. Data collected via photographs and voluntary reporting can be a very valuable source of information once it has been processed and scientifically collated. Australians see themselves as an ocean loving people so we shouldn't turn down any help they are eager to provide.

Looking Forward

Australian fisheries are in the midst of a period of rapid environmental change. This change is going to continue into the future and will differ place to place around Australia. Fishers and managers will need to be flexible if they are to cope with these changes. A failure to do so will bring economic (and likely social) hardship. Management will need to allow for spatial shifts and potentially for shifts in targeting and relevant management reference points. Management that is coordinated across State and Commonwealth fisheries and that links with the other users of marine waters is likely to do better than if those links are ignored. Healthy fisheries will also require good information services that are updated regularly with the latest understanding of what Australia's climate, fish, ecosystems and fisheries are doing. This is the summary of the latest (2018) update. If you would like more information please contact us (details below) or check out the websites listed below.

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Useful Websites

Redmap (Range Extension Database & Mapping project) – www.redmap.org.au – this website invites the Australian community to spot, log and map marine species that are uncommon in Australia, or along particular parts of our coast. This helps keep everybody up to date on how Australia's species are moving. The website includes useful summarise on what climate change is and what it means for Australia's oceans.

BOM – www.bom.gov.au/climate – this website has a long list of climate time series and updates, including annual reports on what Australia's climate is doing.

Images: Shutterstock.com

CONTACT US
t 1300 363 400
+61 3 9545 2176
e csiroenquiries@csiro.au
w www.csiro.au

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CSIRO Oceans and Atmosphere
Beth Fulton or Alistair Hobday
t +61 3 6232 5222
e beth.fulton@csiro.au
w www.csiro.au

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG) Thursday Island	MEETING 33 13-14 December 2022
EMPIRICAL HARVEST CONTROL RULE	**Agenda Item 7** **For discussion and advice**

RECOMMENDATIONS

1. That the RAG:
   a. **NOTE** the catch, effort and Catch Per Unit Effort (CPUE) analyses from the 2021-22 fishing season as presented under **Agenda Item 3**, including:
      (i) total reported catch of the Australian Torres Strait TRL fishery including effort trends from both TIB and TVH sectors;
      (ii) the agreed standardised Catch Per Unit Effort (CPUE) indices for the TIB and TVH sectors; and
      (iii) the total catch of the Papua New Guinea Torres Strait TRL fishery including any extrapolation undertaken to account for incomplete or missing data for the season;
   b. **NOTE** the estimated total catch of TRL from the Torres Strait Prawn Fishery as presented and discussed under **Agenda Item 4**;
   c. **NOTE** the pre-season survey indices for 1+ recruiting lobsters and 0+ recently settled lobsters as presented under **Agenda Item 5**;
2. Having regard to the empirical Harvest Control Rule (eHCR) inputs noted above that the RAG:
   a. **CONSIDER** the Recommended Biological Catch (RBC) estimates derived through the application of the eHCR, including any ad-hoc methods required to address a lower than expected average catch multiplier (**Attachment 7a**).

KEY ISSUES

The empirical Harvest Control Rule (eHCR)

3. The eHCR is an integral component of the TRL Harvest Strategy (**Attachment 7b**) that is used to rapidly determine an RBC each fishing season.
4. The eHCR formula is the multiple of the average annual catch over the last five years (using available catch from TIB, TVH, PNG and Torres Strait Prawn Fishery (TSPF) (pending RAG advice under **Agenda Item 4**), and a statistic which measures the relative performance of the fishery based on the following data inputs:
   a. the pre-season survey index of abundance of juvenile recruiting 1+ lobsters (70 per cent weighting);
   b. the pre-season survey index of abundance of newly recruited 0+ lobsters (10 per cent weighting);

   c. the standardised CPUE index from the TVH sector (10 per cent weighting)
   d. the standardised CPUE index from the TIB sector (10 per cent weighting).

5. CSIRO have developed an eHCR RBC calculator to assist stakeholders in understanding how the eHCR works (**Attachment 7c**). A non-technical summary explaining the design of the eHCR is also provided at **Attachment 7d**.

Lower than expected average catch multiplier

6. In recent seasons, the TRL Fishery has experienced a series of disruptions to both the export market and the fishing sector which has resulted in lower than expected, and uncharacteristic trends in total catch for both the TIB and TVH sectors, and the overall catch of TRL against the global TAC.
7. TRLRAG has previously discussed the implications of a lower than expected average catch multiplier on the eHCR, which in one season may not be as influential give the total catch is averaged over a five year period. However, in circumstances where the negative average total catch trend continued (i.e. since 2019-20), it can start to drive the RBC estimates down.
8. While the eHCR has been extensively tested to handle a series of uncertainties and has been demonstrated to be fairly robust, the impacts of exceptional circumstances as experienced in recent seasons are not accounted for.
9. TRLRAG 31 (12 October 2021) and TRLRAG 32 (15 December 2021) considered two possible options for dealing with under-catch in both the 2019-20 and 2020-21 TRL Fishing seasons.
   a. **Option 1:** replace the actual catch values and substitute them with the TAC value in outlier years and use the actual catches in the three years prior and apply an average of all five years catch values.
   b. **Option 2:** noting that there has been a change in the relative proportion of the TAC caught between the TIB and TVH sectors in recent years, use the combined sector (TIB, TVH and PNG) average catch proportion against the global TAC over the recent five-year period, capping any overcatch at 100 per cent of the TAC, and apply this proportion to the TAC for 2019-20 and 2020-21 to obtain an estimated catch value for those years.
10. Having considered both options to address the lower than expected recent two years' catch, the TRLRAG 32 recommended the application of Option 1 (to substitute the anomalous catches of 2019-20 and 2020-21 with the fishery global TAC) in the average catch multiplier in the eHCR. The RAG further recommended that revision of the eHCR be investigated, e.g. to use previous year TAC rather than catch as a multiplier, noting that the stock assessment scheduled for 2022 will help to recalibrate the stock biomass with the eHCR.
11. Having regard to the relevant inputs to the eHCR and any ad-hoc measures that may need to be applied to manage lower than expected total catch, the RAG is being asked to consider the RBC estimates derived from the application of the eHCR.
12. Following a presentation of the preliminary stock assessment results (under **Agenda Item 8**), the RAG will then be asked to consider the performance of the eHCR and in accordance with the TRL Harvest Strategy, identify if any revisions to the eHCR are required.

13. Having regard to the TRL Harvest Strategy decision rules and the preliminary stock assessment results, the RAG will be asked to provide advice on a Recommended Biological Catch value for the 2022-23 fishing season (to be discussed under **Agenda Item 9**).

Summary of Torres Strait TRL 2022 eHCR analyses

Summary Report for TRLRAG33 – December 2022

Éva Plagányi, Roy Deng, Steven Edgar, Laura Blamey, Leo Dutra, Nicole Murphy, Kinam Salee

CSIRO Environment

SUMMARY

The Torres Strait tropical rock lobster *Panulirus ornatus* (TRL) fishery Harvest Strategy uses an empirical (data-based) Harvest Control Rule (eHCR) to rapidly provide a Recommended Biological Catch (RBC) based on the recent catches, survey abundance indices and Catch-Per-Unit-Effort (CPUE) from TIB and TVH sectors. The eHCR recommended catch is generally considered fairly robust across a number of alternative scenarios because it is based on medium-term (5 years) trends in all indices, plus the contributions of the trends in the CPUE indices (10% for each of the 2 CPUE indices) are small relative to the weight accorded to the fishery-independent survey. The eHCR is also designed to dampen variability in the TAC by focussing on 5-year trends in data.

The 2020-2021 and 2019-2020 total catch were only around 55% and 84% respectively of the TAC (lower than the average proportion achieved) due to a number of external factors affecting the fishery. As these factors were outside the range of impacts for which the eHCR was tested, as documented in TRLRAG32 Meeting Record, the RAG recommended to substitute the anomalous catches of 2019-20 and 2020-21 with the fishery global TAC in the average catch multiplier in the eHCR. TRLRAG32 further recommended, as per ongoing work, that the eHCR be formally revised in future to account for exceptional circumstances such as market and COVID-19 impacts, noting that the stock assessment being presented at TRLRAG33 will help to recalibrate the stock biomass with the eHCR. The 2021-22 total catch (after extrapolating the PNG catch to account for October to November) is 62% of the TAC.

The 2022 default updated implementation of the eHCR uses these substituted catches for the 2019-20 and 2020-21 seasons, together with the total 2021-22 catch of 380.2t and hence the average catch multiplier is 516.3t. Substituting into the eHCR formula together with the survey and CPUE information results in a RBC value of 478t for the 2022-23 season. Noting that reports have again been received regarding external factors affecting some sectors during the past fishing season, if the 2021-22 TAC of 615t is substituted in place of the actual catch, the eHCR results in an output value of 521t.

TRL CATCH

A summary of the recent catches is shown in Table 1, which also compares total catch with the total TAC (all sectors). Table 2 shows adjusted values when calculating the catch multiplier for input to the eHCR. The 2022 default updated implementation of the eHCR applies the TRLRAG32 recommendation to substitute the anomalous catches of 2019-20 and

2020-21 with the fishery global TAC catches for the 2019-20 and 2020-21 seasons, together with the total catch of 380.2t and hence the average catch multiplier is 516.3t. If the same approach is applied to replace the 2021-22 catch of 380.2t with the TAC of 615t, the average of the past five year's values becomes 563.2t (Table 2).

TRL CPUE

The full details of the TRL CPUE analyses are presented in accompanying TRLRAG33 documents (Deng et al. 2022a, Deng et al. 2022b). As previously, the default standardised TIB CPUE series used as an input to the eHCR is the Main Effects Model including Seller-effect. For TVH, the default model that is applied is the Int-1 version.

PRE-SEASON SURVEY

An overview of the 2022 Tropical Rock Lobster (TRL) Pre-season Population Survey is provided in the accompanying document by Dutra et al. (2022). As previously, the Midyear Only (MYO) standardised index is the default one used in the eHCR.

Table 1. Summary of recent catch (t) per sector and shown as a percentage of the TAC

SEASON	TIB	TVH	AUS-TOTAL	PNG-TOTAL	TS_TOTAL	TAC	Catch/ TAC
2014	198.8	273.2	472.0	261.2	733.2	616	119.0%
2015	202.6	152.7	355.3	235.7	591.0	769	76.9%
2016	267.1	243.0	510.1	248.0	758.2	796	95.2%
2017	111.5	166.3	277.8	113.0	390.8	495	79.0%
2018	127.4	128.3	255.7	156.4	412.1	320	128.8%
2019	260.6	155.9	416.5	167	583.5	641	91.0%
2020	216.2	145.1	361.3	126.4*	487.7	582	83.8%
2021	126.8*	117.1*	243.9	*97**	340.8	623.5	54.7%
2022	150.6	140.8		88.8#	380.2	615	61.8%

**Note updates provided to values used last year*

#PNG catch used in analysis is an extrapolated value based on the same method as used previously – catch data provided to end of September 2022 (October 2022 considered part-data) hence October and November 2022 assumed to both be equivalent to the average catch over the preceding period December 2021 to September 2022.

Table 2. Summary of average catch multiplier adjusted for input to the eHCR

SEASON	**TS_TOTAL** (actual catches)	**Default eHCR inputs adjusted using TAC for 2020 and 2021**	**Alternative scenario eHCR inputs adjusted using TAC for 2020, 2021 and 2022**
2018	412.1	412.1	412.1
2019	583.5	583.6	583.6
2020	487.7	582	582
2021	340.8	623.5	623.5
2022	380.2	380.2	615
5 yr average to input to eHCR	440.9	516.3	563.2

eHCR Background

The eHCR formula outputs a RBC in December for the following year of fishing. This calculation is the multiple of the average catch over the last five years and a statistic which measures the relative performance of the fishery based on the following five data inputs (Fig. 1): (1) Fishery-independent recruiting lobster (1+) standardised relative numbers; (2) Fishery-independent recently-settled lobster (0+) standardised relative numbers; (3) standardised CPUE for TIB sector and (4) standardised CPUE for TVH sector; and (5) total catch (TIB,TVH,PNG) (using data available up until end of October). Different weightings are applied to the four abundance indices included in the relative performance statistic used in the eHCR. These are based on extensive testing to compare performance of alternative weightings while also considering the information content and reliability of each series, as well as a preference expressed by the stakeholders to use a portfolio approach in determining the RBC (Plagányi et al. 2018).

The fishery-independent Preseason 1+ index is the primary index and is most reliable and direct in terms of indexing the biomass of lobsters that will be available to be caught in the next fishing season. Hence, this index is assigned the highest weighting of 70%. The fishery-independent Preseason 0+ index provides an early indication of the following year's recruitment, whereas the CPUE indices aim to index the relative abundance of the large 2+ lobsters, the survivors of which will migrate out of the Torres Strait to spawning grounds to the East. Each of these three secondary indices (Survey 0+ and CPUE (TIB and TVH)) are assigned a weighting of 10% (30% total) in the eHCR formula.

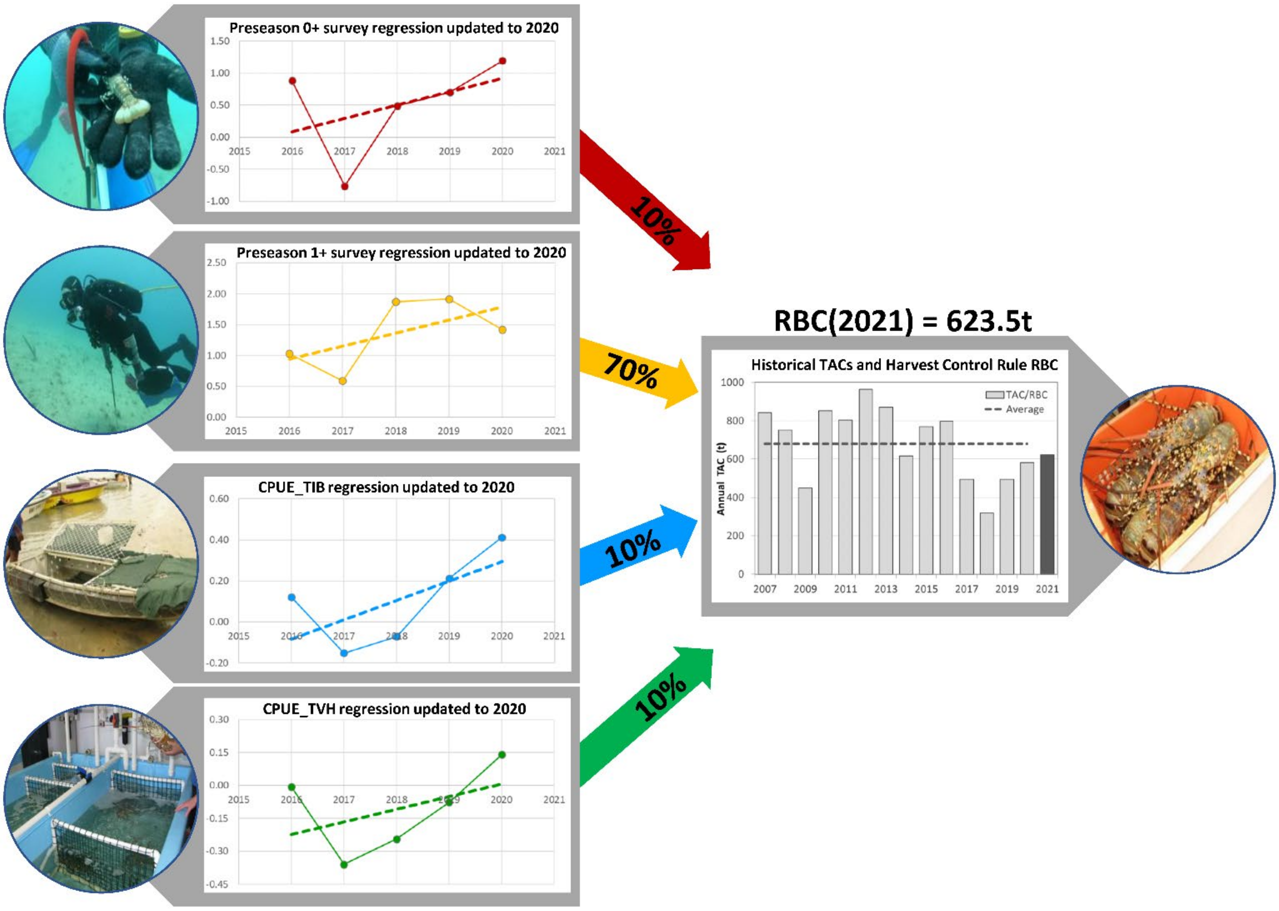

Fig. 1. Schematic summary of the empirical harvest control rule (eHCR) used to calculate the TRL (Tropical Rock Lobster) RBC (Recommended Biological Catch) (**example shown for 2021 RBC**) based on the CPUE (Catch Per Unit Effort) data from two fishery sectors, the scientific survey indices of two age classes, and the total average catch over the past five years (source (Plagányi et al. 2021)).

Simulation testing (Plagányi et al. 2016) showed that the best approach is to use the slope of the trends in the secondary indices over the last five years' data (after first taking the natural logarithm of the data) for each of the abundance indices. This allows the RBC to be based on medium-term trends in abundance, rather than on just the current abundance.

Hence the HCR rule is as follows (see also Figure 3):

$$RBC_{y+1} = \left[0.7\cdot\left(1+s_y^{presurv,1}\right)+0.1\cdot\left(\left(1+s_y^{presurv,0}\right)+\left(1+s_y^{CPUE,TVH}\right)+\left(1+s_y^{CPUE,TIB}\right)\right)\right]\cdot\bar{C}_{y-4,y} \qquad (1)$$

where

$\bar{C}_{y-4,y}$ is the average achieved catch during the past 5 years, including the current year i.e. from year *y*-4 to year *y*,

$s_y^{presurv,1}$ is the slope of the (logarithms of the) fishery-independent survey 1yr abundance index, based on the 5 most recent values;

$s_y^{presurv,0}$ is the slope of the (logarithms of the) fishery-independent survey 0yr abundance index, based on the 5 most recent values;

$s_y^{CPUE,TVH}, s_y^{CPUE,TIB}$ is the slope of the (logarithms of the) TVH and TIB CPUE abundance index, based on the 5 most recent values.

eHCR (Empirical Harvest Control Rule) Application

The TRL fishery transitioned to using an empirical Harvest Control Rule (eHCR) to inform the Recommended Biological Catch (RBC) in December 2019, hence a stock assessment only needs to be conducted every three years unless the stock assessment is triggered by a decision rule. The eHCR used the latest available catch, CPUE and Pre-season survey data as summarised in Table 3 below. The slopes of the log-transformed indicators over the past five years are shown in Figure 2, as pasted from the eHCR accompanying spreadsheet. Note that the most influential trend, namely the Pre-season survey Age 1+ index, has a negative slope estimate, although this is offset to some extent by slightly positive slopes associated with the standardised CPUE input series. The different slopes based on survey data compared with CPUE data are not surprising as these indices reference different components of the population. The CPUE slopes recent average slopes are similar for the TIB and TVH sectors. The eHCR results in a RBC value of 478t for the 2022-23 season. If using the scenario with the TAC substituted for the 2022 catch, the eHCR results in a RBC value of 521t for the 2022-23 season (Table 3).

Table 3: Summary of index (1+slope), average catch (t) and RBC (t) for default eHCR implementation and a scenario with the 2021-22 TAC used to substitute for the catch.

	Base-Case Index_MYO; Seller; Int1; TAC substituted for 2020 & 2021 Catches	**Scenario with Adjusted catch for 2022** Index_MYO; Seller; Int1; TAC substituted for 2020, 2021 & 2022 Catches
Preseas1	-0.092	-0.092
Preseas0	-0.163	-0.163
CPUE_TIB	0.027	0.027
CPUE_TVH	0.035	0.035
Ave Catch (t)	516.28	563.24
RBC (t)	**478**	**521**

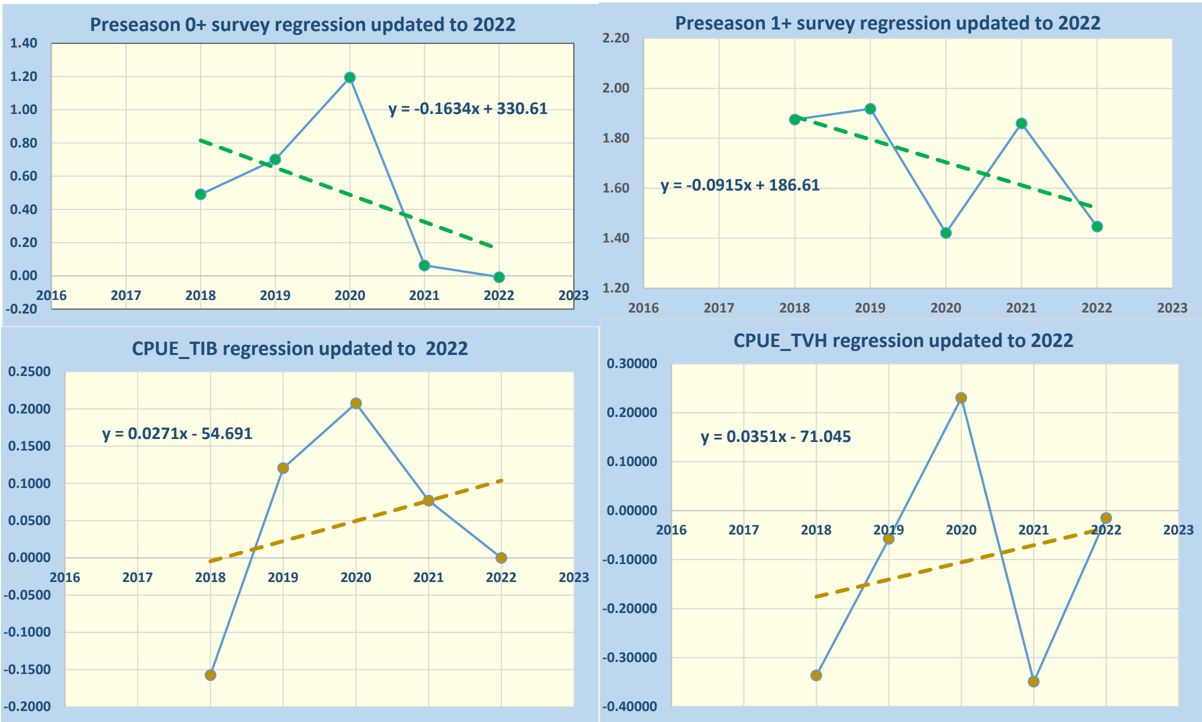

Figure 2. Summary of eHCR inputs and calculations showing the slopes of fitted regression lines to the log-transformed Preseason 0+ and 1+ indices, as well as the standardised CPUE data for the TIB (Seller model version) and TVH (Int-1 Model version) sectors.

Pre-season trigger point

The TRL eHCR specifies that a stock assessment will be conducted every three years to rigorously assess stock status and productivity, and check that the eHCR is working as it is supposed to. As a stock assessment is only scheduled for every third year, action may not be taken quickly enough if the spawning biomass drops to very low levels, and hence an additional precaution has been built into the Harvest Strategy. Based on analysis of the historical pre-season and mid-year survey indices, a pre-season 1yr survey trigger point of 1.25 (average number of lobsters per survey transect and lower than any historically observed values) has been set, such that if this lower limit (LRP) is triggered in any year, then the required action is that a stock assessment be conducted in the following year. This is similar to what is done in some other fisheries, such as decision rules for some of the New Zealand substocks whereby a stock assessment is mandated if CPUE decreases below a specified base level (Bentley et al. 2005). If the stock assessment suggests that the spawning stock biomass is above the LRP, then the process continues as previously. However, if spawning biomass is assessed as below the LRP, then a stock assessment is again triggered in the following year. If the second stock assessment suggests the stock is above the LRP, then the process again continues as previously, but if the spawning biomass is below LRP (i.e. two consecutive years with spawning biomass below LRP), then the fishery is closed and appropriate action (e.g. implementing surveys, analysing size structure and environmental information) is put in place. In general, the eHCR is therefore applied every year unless the LRP is triggered in two consecutive years.

The 2022 Age 1+ survey index was 4.25 and hence well above the survey trigger point. 2022 is also an assessment year and hence a stock assessment will be presented at the TRLRAG33 meeting to provide an update on stock status.

Discussion

The eHCR uses the average catch over the past five years as a multiplier to inform the RBC. This dampens the influence of the most recent catch value, but if the recent value is negatively biased (as is a possibility in this case for the two to three most recent values), then it can have a reasonably substantial effect on the calculation of the RBC. For this reason, the TRLRAG has previously agreed to ad-hoc adjustments to account for recent anomalous influences of COVID-19 and market forces, pending formal development and testing of "exceptional circumstances" clauses as used in many fisheries globally to account for unexpected events (Butterworth 2008) – for example, sizeable "walkouts" of South African west coast lobsters emerging onto beaches in response to low-oxygen events, greatly increasing the stock's mortality rate (Johnston and Butterworth 2005, Plaganyi et al. 2007).

The 2022 implementation of the eHCR formula results in a RBC value of 478t for the 2022-23 season. Noting that reports have again been received regarding external factors affecting some sectors during the past fishing season (for discussion at the forthcoming TRLRAG), if the 2021-22 TAC of 615t is substituted in place of the actual catch, the eHCR results in an output value of 521t.

The current project will use MSE testing to refine exceptional circumstances rules.

Acknowledgements

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Attachment 7b

Australian Government
Australian Fisheries Management Authority

Torres Strait Tropical Rock Lobster Fishery Harvest Strategy

November 2019

Box 7051, Canberra Business Centre, ACT 2610 / Ph (02) 6225 5555 / Fax (02) 6225 5500 / AFMA Direct 1300 723 621 afma.gov.au

This harvest strategy is based on outcomes from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Oceans and Atmosphere Division project, *Torres Strait Tropical Rock Lobster (TRL) fishery surveys, stock assessment, harvest control rules and RBC*. The project was funded by the Australian Fisheries Management Authority (AFMA).

AFMA Project No. 2016/0822.

Project Authors: Éva Plagányi (Principal Investigator), Darren Dennis, Roy Deng, Robert Campbell, Trevor Hutton, Mark Tonks

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CONTENTS

GLOSSARY

Types of reference points:

Reference Point	Description
Metarule	A rule that describes how the RBCs obtained from an assessment should be adjusted in calculating a recommended TAC
Target	The desired state of the stock or fishery (for example, MEY or B_{TARG})[1]
Limit	The level of an indicator (such as biomass or fishing mortality) beyond which the risk to the stock is regarded as unacceptably high[1]
MEY	The sustainable catch or effort level for a commercial fishery that allows net economic returns to be maximised. In this context, maximised equates to the largest positive difference between total revenue and total cost of fishing[1]
MSY	The maximum average annual catch that can be removed from a stock over an indefinite period under prevailing environmental conditions[1]

Notation:

Notation	Description
B	Spawning biomass - the total weight of all adult (reproductively mature) fish in a population[1]
B_0	The unfished spawning biomass (determined from an appropriate reference point)
F	Fishing mortality rate
B_{LIM}	Biomass limit reference point - the point beyond which the risk to the stock is regarded as unacceptably high[1]
B_{TARG}	Biomass target reference point - the desired biomass of the stock[1]

Other acronyms:

Acronym	Description
CPUE	Catch per unit effort
eHCR	Empirical Harvest Control Rule
HCR	Harvest Control Rule - pre-determined rules that control fishing activity according to the biological and economic conditions of the fishery (as defined by monitoring or assessment). Also called 'decision rules'. HCR are a key element of a harvest strategy[1]
HSP	*Commonwealth Fisheries Harvest Strategy Policy: Framework for applying an evidence-based approach to setting harvest levels in Commonwealth fisheries* (June 2018)
HS	Torres Strait Tropical Rock Lobster Fishery Harvest Strategy
PZJA	Protected Zone Joint Authority

[1] Definition sourced from the *Commonwealth Fisheries Harvest Strategy Policy: Framework for applying an evidence-based approach to setting harvest levels in Commonwealth fisheries* (June 2018)

MSE	Management Strategy Evaluation - a procedure whereby alternative management strategies are tested and compared using simulations of stock and fishery dynamics[1]
RBC	Recommended Biological Catch
TRLRAG	Protected Zone Joint Authority Tropical Rock Lobster Resource Assessment Group
TRLWG	Protected Zone Joint Authority Tropical Rock Lobster Working Group
TAC	Total Allowable Catch- the annual catch limit set for a stock, species or species group. Used to control fishing mortality within a fishery[1]
Tiered approach	A framework that uses different control rules to cater for different levels of uncertainty about a stock
TIB	Traditional inhabitant boat
TVH	Transferrable vessel holder
TRL	Tropical Rock Lobster
TSPZ	Torres Strait Protected Zone

OVERVIEW

The Torres Strait Tropical Rock Lobster Fishery (the Fishery) Harvest Strategy (HS) sets out the management actions needed to achieve the agreed Fishery objectives. The HS describes the performance indicators used for monitoring the condition of the stock, the fishery-independent survey and stock assessment procedures and the rules applied to determine the recommended biological catch (RBC) and the total allowable catch (TAC) each fishing season.

The HS uses a single tier approach with an empirical harvest control rule (eHCR) that is used to determine a RBC. The eHCR uses the pre-season survey index of abundance of juvenile (1+) and newly recruited (0+) Tropical Rock Lobster (TRL) and the catch per unit effort (CPUE) indices for the traditional inhabitant boat (TIB) and transferrable vessel holder (TVH) fishing sectors. The eHCR has been extensively tested using Management Strategy Evaluation (MSE) (Plagányi *et al.* 2018). The RBC is the best available scientific advice on what the total fishing mortality (landings from all sectors and discards) should be for the stock. The RBC is used to negotiate Australia-Papua New Guinea catch sharing and recommend TACs (an enforced limit on total catches).

The HS meets the requirements of the *Commonwealth Fisheries Harvest Strategy Policy: Framework for applying an evidence-based approach to setting harvest levels in Commonwealth fisheries* (June 2018) *(*HSP) by applying a precautionary approach to the reference points and measures to be implemented in accordance with the reference points. This is reflected in the use of proxy reference points that are more precautionary than those specified in the HSP. The eHCR is designed to decrease exploitation rate as the stock size decreases below the target reference point. The HS uses a biomass target reference point equal to recent levels (2005-2015) that take account of the fact that the resource is shared and important for the traditional way of life and livelihood of traditional inhabitants and is biologically and economically acceptable. The HS proxies are B_{LIM} is 32% of B_0, B_{TARG} is 65% of B_0.

Further work for the HS will include the development of a tiered approach. The tiered approach applies different types of control rules to cater for different amounts of data available and to account for changes to uncertainty on stock status. A tiered approach adopts increased levels of precaution that correspond to increasing levels of uncertainty about the stock status, in order to maintain the same level of risk across the different tiers.

The status of the stock and how it is tracking against the HS, is reported to the Tropical Rock Lobster Resource Assessment Group (RAG), Tropical Rock Lobster Working Group (TRLWG) and the Protected Zone Joint Authority (PZJA). The stock assessment is conducted periodically to evaluate stock status relative to reference levels and, in doing so, performance of the eHCR. The stock assessment includes considerations of the catch rates in current and previous fishing seasons, how the catches compare to the RBCs, stock status indicators in relation to the reference points and an RBC for the upcoming fishing season.

1 BACKGROUND

This Torres Strait Tropical Rock Lobster Fishery (the Fishery) Harvest Strategy (HS) has been developed in accordance with the *Commonwealth Fisheries Harvest Strategy Policy: Framework for applying an evidence-based approach to setting harvest levels in Commonwealth fisheries* (June 2018) (HSP) and consistent with objectives of the *Torres Strait Fisheries Act 1984* (the Act).

The Fishery HS takes into account key fishery specific attributes including:

a) there is potential for large, unpredictable inter-annual variations in availability and abundance of Tropical Rock Lobster (TRL);

b) TRL is a shared resource important for the traditional way of life and livelihood of traditional inhabitants, commercial and recreational sectors (Tropical Rock Lobster Resource Assessment Group (TRLRAG) 20, 4-5 April 2017); and

c) advice from the TRLRAG industry members to maintain stock abundance at recent levels (2005-2015) (TRLRAG 17, 31 March 2016).

1.1 COMMONWEALTH FISHERIES HARVEST STRATEGY POLICY

The objective of the HSP is the ecologically sustainable and profitable use of Australia's Commonwealth commercial fisheries resources (where ecological sustainability takes priority) - through implementation of harvest strategies.

To pursue this objective the Australian Government will implement harvest strategies that:

a) ensure exploitation of fisheries resources and related activities are conducted in a manner consistent with the principles of ecologically sustainable development, including the exercise of the precautionary principle

b) maximise net economic returns to the Australian community from management of Australian fisheries - always in the context of maintaining commercial fish stocks at sustainable levels

c) maintain key commercial fish stocks, on average, at the required target biomass to produce maximum economic yield from the fishery

d) maintain all commercial fish stocks, including byproduct, above a biomass limit where the risk to the stock is regarded as unacceptable (B_{LIM}), at least 90 per cent of the time

e) ensure fishing is conducted in a manner that does not lead to overfishing - where overfishing of a stock is identified, action will be taken immediately to cease overfishing

f) minimise discarding of commercial species as much as possible

g) are consistent with the *Environment Protection and Biodiversity Conservation Act 1999* and the *Guidelines for the Ecologically Sustainable Management of Fisheries*.

For fisheries that are managed jointly by an international organisation or arrangement, the HSP does not prescribe management arrangements. This includes management arrangements for commercial and traditional fishing in the Torres Strait Protected Zone (TSPZ), which are governed by provisions of the Torres Strait Treaty and the *Torres Strait Fisheries Act 1984*. However, it does articulate the government's preferred approach.

The HSP provides for the use of proxy settings for reference points to cater for different levels of information available and unique fishery circumstances. This balance between prescription and flexibility encourages the development of innovative and cost effective strategies to meet key policy objectives. Proxies, including those that exceed the minimum standards, must be demonstrated to be compliant with the HSP objective.

With a harvest strategy in place, fishery managers and stakeholders are able to operate with pre-defined rules, management decisions are more transparent, and there are likely fewer unanticipated outcomes necessitating hasty management responses. However, due to the inherently natural variability of TRL abundance there may be a need for significant changes in recommended catch on an annual basis.

1.2 DEVELOPMENT OF THE TRL HARVEST STRATEGY

The HS has been developed in consultation with the TRLRAG (meeting no. 17 on 31 March 2016; meeting no. 18 on 2-3 August 2016; meeting no. 19 on 13 December 2016; meeting no. 20 on 4-5 April 2017; meeting no. 22 on 27-28 March 2018; meeting no. 24 on 18-19 October 2018; and meeting no. 25 on 11-12 December 2018; out of session 16 September-9 October 2019) and TRLWG (meeting no. 6 on 25-26 July 2017; meeting no. 9 on 19-20 February 2019; out of session 16 September-9 October 2019). This HS replaces the interim HS developed for the Fishery in 2008.

2 TRL FISHERY HARVEST STRATEGY

2.1 SCOPE

This HS applies to the whole Fishery and it takes into account catch sharing arrangements between Australia and Papua New Guinea (PNG).

The HS outlines the control rules used to develop advice on the recommended biological catch (RBC) and to recommend total allowable catches (TACs) (an enforced limit on total catches). The HS sets the criteria that pre-agreed management decisions will be based on in order to achieve the HS objectives.

Over time the HS may be amended to use a tiered approach to cater for different amounts of data available and different types of assessments (for example mid-season surveys and annual assessments). Underpinning a tiered HS is increased levels of precaution with increasing levels of uncertainty about the stock status. Each tier has its own harvest control rule (HCR) and associated rules that are used to determine a RBC.

2.2 OBJECTIVES

The operational objectives of the HS are to:

a) Maintain the stock at (on average), or return to, a target biomass point B_{TARG} equal to recent levels (2005-2015) that take account of the fact that the resource is shared and important for the traditional way of life and livelihood of traditional inhabitants and is biologically and economically acceptable.

  - The agreed B_{TARG} is more precautionary than the default proxy B_{MEY} (biomass at maximum economic yield) level as outlined in the HSP.

b) Maintain the stock above the limit biomass level (B_{LIM}), or an appropriate proxy, at least 90 per cent of the time.

  - The agreed B_{LIM} is more precautionary than the default proxy HSP B_{LIM}.

c) Implement rebuilding strategies, if the spawning stock biomass is assessed to fall below B_{LIM} in two successive years.

2.3 RECOMMENDING TACs FROM RBCs

The RBC is the recommended total catch of TRL (both retained and discarded) that can be taken by all sectors within the TSPZ and waters declared as areas outside but near to the TSPZ, including Australian and PNG fishers. The HSP states that when setting the TAC for the next fishing season the HS should take into account all sources of fishing mortality.

The HS does not include catches taken by non-commercial fishing sectors, for example traditional, recreational or research catches. The TRLRAG recommended at meeting no. 18 on 2-3 August 2016 that non-commercial catches not be estimated in the stock assessment model or when setting the TAC at this time, noting the likely low level of overall catch and the lack of accurate data. However, if unaccounted fishing mortality were to increase significantly this may impact on the performance of the stock assessment. The HS may be updated in the future to account for changing circumstances in the Fishery, the review provisions are described in **Section 2.13**.

2.4 MONITORING

Biological data for the Fishery are monitored by a range of methods listed below. Currently there is no ongoing monitoring strategy in place to collect economic information.

Fishery independent surveys

A key component of the monitoring program is the fishery-independent survey which provides a time-series of relative abundance indices for TRL. Fishery-independent surveys have been conducted in the Fishery since 1989. Historically (1989-2014 and 2018), mid-season (July) surveys focused on providing an index of abundance of the spawning (age 2+) and juvenile (age 1+) lobsters. Mid-season surveys have been replaced with pre-season (November) surveys (2005-2008; 2014 to current) which focus on providing an index of recruiting (age 1+) lobsters as close as possible to the start of the fishing season to support the transition to quota management and setting of a TAC. Pre-season surveys also provide indices of recently-settled (age 0+) lobsters, which may become useful under quota management as they allow forecasting of stock one year in advance and are used in the eHCR.

Catch and effort information

Fishers in the transferrable vessel holder (TVH) sector are required to record catch and effort information in the Torres Strait Tropical Rock Lobster Daily Fishing Log (TRL04). The following data are recorded for each TVH fishing operation: the port and date of departure and return, fishing area, fishing method, hours fished and the weight (whole or tails) of TRL retained. Fishers in both the TVH and traditional inhabitant boat (TIB) sectors are required to record catch information in the Torres Strait Fisheries Catch Disposal Record (TDB02). The provision of effort information under the TDB02 is voluntary. Some processors previously (2014-2016) reported aggregate TIB catch information directly to AFMA predominantly through the Torres Strait Seafood Buyers and Processors Docket Book (TDB01).

2.5 INTEGRATED STOCK ASSESSMENT MODEL

The stock assessment model (termed the 'Integrated Model') (Plagányi *et al.* 2009) was developed in 2009 and is an Age-Structured Production Model, or Statistical Catch-at-Age Analysis (SCAA) (e.g. Fournier and Archibald 1982). It is a widely used approach for providing RBC advice and the associated uncertainties.

The model integrates all available information into a single framework to assess resource status and provide a RBC. The model addresses all of the concerns highlighted in a review of the previous stock assessment approach (Bentley 2006, Ye *et al*. 2006, 2007). The model is fitted to the mid-season and pre-season survey data and TIB and TVH catch per unit effort (CPUE) data. The growth relationships used in the model were revised from the previous stock assessment model (Ye *et al*. 2006) to ensure that the modelled individual mass at age more closely resembled field measurements. The model has been used as an Operating Model in a Management Strategy Evaluation (MSE) framework to support the management of the Fishery (Plagányi *et al.* 2012, 2013, 2018).

The stock assessment model is non-spatial and assumes (conservatively) that the Torres Strait Tropical Rock Lobster Fishery stock is independent of the Queensland East Coast Tropical Rock Lobster Fishery stock. A spatial version of the model has been developed as part of an earlier MSE project, and can be used to investigate plausible linkages between these stocks (Plagányi *et al*. 2012, 2013).

The model includes three age-classes only (0+, 1+ and 2+ age lobsters) as it is assumed that lobsters migrate out of the Torres Strait in October each year. Torres Strait TRL emigrate in spring (September-November) and breed during the subsequent summer (November-February) (MacFarlane and Moore 1986; Moore and Macfarlane 1984). A Beverton-Holt stock-recruitment relationship is used (Beverton and Holt 1957), allowing for annual fluctuation about the average value predicted by the recruitment curve. The model is fitted to the available abundance indices by maximising the likelihood function. Quasi-Newton minimisation is used to minimise the total negative log-likelihood function (using the package AD Model Builder™) (Fournier *et al*. 2012).

2.6 EMPIRICAL HARVEST CONTROL RULE

The empirical harvest control rule (eHCR) recommended by the TRLRAG uses the pre-season survey 1+ and 0+ indices, both standardised CPUE indices (TVH and TIB), applies the natural logarithms of the slopes of the five most recent years' data and the average catch over the past five years, with an upper catch limit of 1,000 t. The relative weightings of the eHCR indices are 70 per cent pre-season survey 1+ index, 10 per cent pre-season survey 0+ index, 10 per cent TIB sector standardised CPUE and 10 per cent TVH sector standardised CPUE.

The basic formula is:

$$
\begin{aligned}
RBC_{y+1} = {} & wt\_s1 \cdot \left(1 + s_y^{presurv,1}\right) \cdot \bar{C}_{y-4,y} + wt\_s2 \cdot \left(1 + s_y^{presurv,0}\right) \cdot \bar{C}_{y-4,y} \\
& + wt\_c1 \cdot \left(1 + s_y^{CPUE,TVH}\right) \cdot \bar{C}_{y-4,y} + wt\_c2 \cdot \left(1 + s_y^{CPUE,TIB}\right) \cdot \bar{C}_{y-4,y}
\end{aligned}
$$

Or if RBC_{y+1} > 1000t, TAC_{y+1} = 1000.

Where:

$\bar{C}_{y-4,y}$ is the average achieved catch during the past 5 years, including the current year i.e. from year *y*-4 to year *y*,

$s_y^{presurv,1}$ is the slope of the logarithms of the preseason survey 1+ abundance index, based on the 5 most recent values;

$s_y^{presurv,0}$ is the slope of the logarithms of the preseason survey 0+ abundance index, based on the 5 most recent values;

$s_y^{CPUE,TVH}, s_y^{CPUE,TIB}$ is the slope of the logarithms of the TVH and TIB CPUE abundance index, based on the 5 most recent values;

wt_s1, wt_s2, wt_c1, wt_c2 are tuning parameters that assign relative weight to the preseason 1+ (wt_s1) and 0+ (wt_s2) survey trends compared with the CPUE TVH (wt_c1) and TIB (wt_c2) trends.

2.7 REFERENCE POINTS

The HS reference points are:

a) The unfished biomass B_0 is the model-estimate of spawning stock biomass in 1973 (start of the Fishery). $B_0 = B_{1973}$.

b) The target biomass B_{TARG} is the spawning biomass level equal to recent levels (2005-2015) that take account of the fact that the resource is shared and important for the traditional way of life and livelihood of traditional inhabitants and is biologically and economically acceptable. B_{TARG} is the proxy for B_{MEY}, $B_{TARG} = 0.65\ B_0$.

- o The agreed B_{TARG} is more precautionary than the default proxy B_{MEY} (biomass at maximum economic yield) level as outlined in the HSP. The TRLRAG noted a B_{TARG} higher that the HSP default was considered important for the Fishery because: 1) the stock is a shared resource that is particularly important for traditional fishing; 2) the stock has high variability; and, 3) all industry members recommended the HS maintain the stock around the relatively high current levels (TRLRAG meeting no. 17, 31 March 2016 and meeting no. 18, 2-3 August 2016).

c) The limit biomass B_{LIM} is the spawning biomass level below which the risk to the stock is unacceptably high and the stock is defined as ‘overfished’. B_{LIM} is agreed to be half of B_{TARG}, $B_{LIM} = 0.32\ B_0$.

- o The agreed B_{LIM} is more precautionary than the default proxy HSP B_{LIM}.

d) If the limit reference point (B_{LIM}) is triggered in two successive years then the Fishery is closed.

e) The target fishing mortality rate F_{TARG} is the estimated level of fishing mortality rate that maintains the spawning biomass around B_{TARG}. $F_{TARG} = 0.15$.

- F_{TARG} = 0.15 is the target fishing mortality rate that corresponds to an optimal level in terms of economic, biological and social considerations (TRLRAG meeting no. 18, 2-3 August 2016).

Rational for reference points

The HSP recognises that each stock/species/fishery will require an approach tailored to the fishery circumstances, including species characteristics. The HSP identifies that the selection of reference points within harvest strategies need to be realistic with respect to the scale or nature of the fishery and the resources available to manage it. Reference points should be set at levels appropriate to the biology of the species and the proper functioning of the broader marine ecosystem. Further, stocks that fall below B_{LIM} will be subject to the recovery measures stipulated in the HSP. A number of adaptive management approaches may be used to deal with this, such as pre-season surveys to provide estimates of abundance to which the eHCR is applied.

The Fishery is characterised by a highly variable stock where majority of the catch (since 2001 due to the introduction of a minimum size limit) is from a single cohort. The stock assessment model and MSE testing have identified the target biomass should be set between 65 and 80 per cent of the unfished biomass to account for the importance of the stock for the traditional way of life and livelihood of traditional inhabitants and to achieve biological and economic objectives. The HS's higher average target biomass level, compared to the default HSP target of 0.48 per cent of unfished biomass, reduces the risk of recruitment being compromised.

The unfished biomass (B_0) is calculated within the stock assessment model, the value of unfished biomass and target biomass have therefore varied over time in response to annual data updates and model parameter settings and estimates. Estimates of unfished biomass and target biomass are particularly sensitive to changes to parameter *h*, which determines the steepness of the stock-recruit relationship, and the input parameter that controls the level of stock-recruit variability.

Independent of variability to the unfished biomass value, the target fishing mortality rate F_{TARG} = 0.15 is applied to maintain the spawning biomass around the biomass target reference point (B_{TARG}), which is the average level over the past two decades. This is assumed to be a proxy for B_{MEY} because stakeholders agreed that this target level corresponded to an optimal level in terms of economic, biological and social considerations (TRLRAG meeting no. 18, 2-3 August 2016).

The biomass limit reference point (B_{LIM}) is 32 per cent of unfished biomass. The higher limit reference point, compared to the HSP proxy of 20 per cent of unfished biomass, is supported by recommendations of similar limit reference points for other highly variable species such as forage fish (Pikitch *et al.* 2012). Due to the changing values of unfished biomass and target biomass the value of the limit reference point, taken as half the target reference point, has previously varied between 32 and 40 per cent of unfished biomass.

Recent MSE testing identified that a limit reference point of 40 per cent unfished biomass is too conservative, it would result in the limit reference point being breached more frequently and add unnecessary precaution to the HS. The TRLRAG agreed to set the limit reference point at 32 per cent of unfished biomass with the condition that if the stock falls below the limit reference point in two successive years it triggers a Fishery closure. The eHCR is more precautionary than the HSP criterion to 'maintain all commercial fish stocks, including byproduct, above a biomass limit where the risk to the stock is regarded as unacceptable (B_{LIM}), at least 90 per cent of the time'. The HSP provides for the designation of a limit reference point above the proxy (B_{20}) where this has been estimated or is deemed appropriate.

2.8 eHCR AND STOCK ASSESSMENT CYCLE

The eHCR and stock assessment cycle is as follows:

- The eHCR is run in November each year to provide a RBC by 1 December for the following fishing season.
- A stock assessment is run on a three year cycle by March, unless the stock assessment is triggered by a decision rule **(Section 2.10)**. The stock assessment determines the Fishery stock status and evaluates the performance of the eHCR and identifies if any revisions to the eHCR are required.
- If the eHCR needs to be revised, the stock assessment is conducted annually to estimate the RBC until the revised eHCR is agreed.

2.9 DATA SUMMARY

The annual data summary reviews the nominal and standardised CPUE from the TIB and TVH sectors, as well as total catch from all sectors, the size-frequency information provided from a sub-sample of commercially caught TRL and the fishery-independent survey indices of 0+ and 1+ age lobsters. The data summary is used as an indicator to identify if catches correspond to the RBC, and to monitor CPUE.

2.10 DECISION RULES

The decision rules for the HS are:

Maximum catch limit

- The eHCR includes a maximum catch limit of 1000 t. Once the HS is implemented the cap will be reviewed after three years using MSE testing with the updated stock assessment model.

Pre-season survey trigger

- If in any year the pre-season survey 1+ index is 1.25 or lower (average standardised number of 1+ age lobsters per survey transect) it triggers a stock assessment.

Biomass limit reference point triggered

- If the pre-season survey trigger is triggered in the first year, a stock assessment update must be conducted in March.
    - o If after the first year the stock is assessed below the biomass limit reference point, it is optional to conduct a mid-season survey, the pre-season survey must continue annually.
- If the pre-season survey trigger is triggered two years in a row, a stock assessment must be conducted in December (of the second year).

Fishery closure rules

- If the stock assessment determines the stock to be below the biomass limit reference point in two successive years, the Fishery will be closed to commercial fishing.
    - o MSE testing of the eHCR has shown that it is extremely unlikely (<1%) for the Fishery to be closed based on its current performance (Plagányi *et al.* 2018).

Re-opening the Fishery

- Following closure of the Fishery, fishery-independent mid-season and pre-season surveys are mandatory. The Fishery can only be re-opened when a stock assessment determines the Fishery to be above the biomass limit reference point **(Attachment A, Figure 5)**.

Based on the decision rules, there are four alternative possible scenarios **(Section 2.11)** that may occur under the application of the eHCR. Graphic representations of the four scenarios are provided in **Attachment A**.

2.11 DECISION RULE SCENARIOS

Scenario 1 – Pre-season survey trigger not triggered and the eHCR does not require revision

- The pre-season survey trigger is not triggered.
- The eHCR RBCs appear to remain within ranges tested by MSE.
- The updated stock assessment does not indicate any need for revision of the eHCR.
- Application of the eHCR continues unchanged.
- A graphic representation of Scenario 1 is provided in **Attachment A, Figure 1**.

Scenario 2 – Pre-season survey trigger not triggered, eHCR and stock assessment require revision

- The pre-season survey trigger is not triggered.

- The eHCR RBCs appear to remain within ranges tested by MSE.
- The updated stock assessment indicates the eHCR recommended RBCs are outside the revised ranges tested by MSE, indicating that the eHCR should be revised.
- Annual RBCs need to be set using annual stock assessments until a revised eHCR has been agreed, after which the revised eHCR is applied.

A graphic representation of Scenario 2 is provided in **Attachment A, Figure 2**.

Scenario 3– Pre-season survey trigger is triggered, eHCR is reviewed by stock assessment and the biomass limit reference point is not breached

- The pre-season survey trigger is triggered in one year.
- A stock assessment update (March) is required to confirm if the biomass limit reference point has been breached. This assessment update determines that the biomass limit reference point has not been breached.
- If the biomass limit reference point is breached once, discussions will be held on preventative measures to reduce the risk of closure.
- The eHCR RBC is applied and consideration is given to revising the eHCR to prevent future incorrect indications that the biomass limit reference point may have been breached.
- The stock assessment continues on a three year cycle, unless triggered to occur by a decision rule.
- A graphic representation of Scenario 3 is provided in **Attachment A, Figure 3**.

Scenario 4 – Pre-season survey trigger is triggered, stock assessment confirms the biomass limit reference point is breached

- The pre-season survey trigger is triggered in one year.
- A stock assessment update (March) is required to confirm if the biomass limit reference point has been breached. This assessment update determines that the biomass limit reference point has been breached.
- The pre-season survey trigger is triggered for a second successive year.
- A second stock assessment update (December) is required to confirm whether the biomass limit reference point has been breached a second time. This assessment update determines that the biomass limit reference point has been breached a second time.
- The commercial fishery is closed until an assessment update confirms that the stock has recovered to above the biomass limit reference point.
    - If the Fishery is closed to commercial fishing, discussions are held on future management arrangements.

- Fishery-independent mid-season and pre-season surveys are mandatory and conducted on an annual basis. The Fishery will only re-open when the Fishery is assessed to be above the biomass limit reference point by the stock assessment.
- The eHCR must be revised before being re-implemented to reduce the risk of the Fishery breaching the biomass limit reference point and for the eHCR to incorporate rebuilding requirements.

- A graphic representation of Scenario 4 is provided in **Attachment A, Figure 4**.

2.12 GOVERNANCE

The status of the Fishery and how it is tracking against the HS is reported to the TRLRAG, TRLWG and the PZJA as part of the yearly RBC and TAC setting process.

2.13 REVIEW

Harvest strategies are to be reviewed every five years. However, it may be necessary to amend harvest strategies earlier if:

- a marked change in stocks targeted occurs, leading to a change in which stocks are categorised as key commercial
- new information substantially changes understanding of the fishery, leading to revised estimates of indicators relative to reference points
- external drivers have unexpectedly increased the risk to a fishery and fish stocks, including environmental or climate drivers that have substantially altered the productivity characteristics (growth or recruitment) of the stock
- performance indicators show that harvest strategies are not working effectively, and that the intent of the HSP is not being met.

Early review may be triggered when either:

- harvest strategies are implemented without formal testing or evaluation using methods such as MSE
- MSE testing did not take adequate account of the changes in risk factors subsequently observed, or
- subsequent estimates of the performance indicators used in the HCR are biased or uncertain to the extent that application of the control rule using these indicators fails to appropriately adjust fishing pressure.

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Torres Strait Tropical Rock Lobster Fishery – alternative annual Harvest Control Rule application scenarios

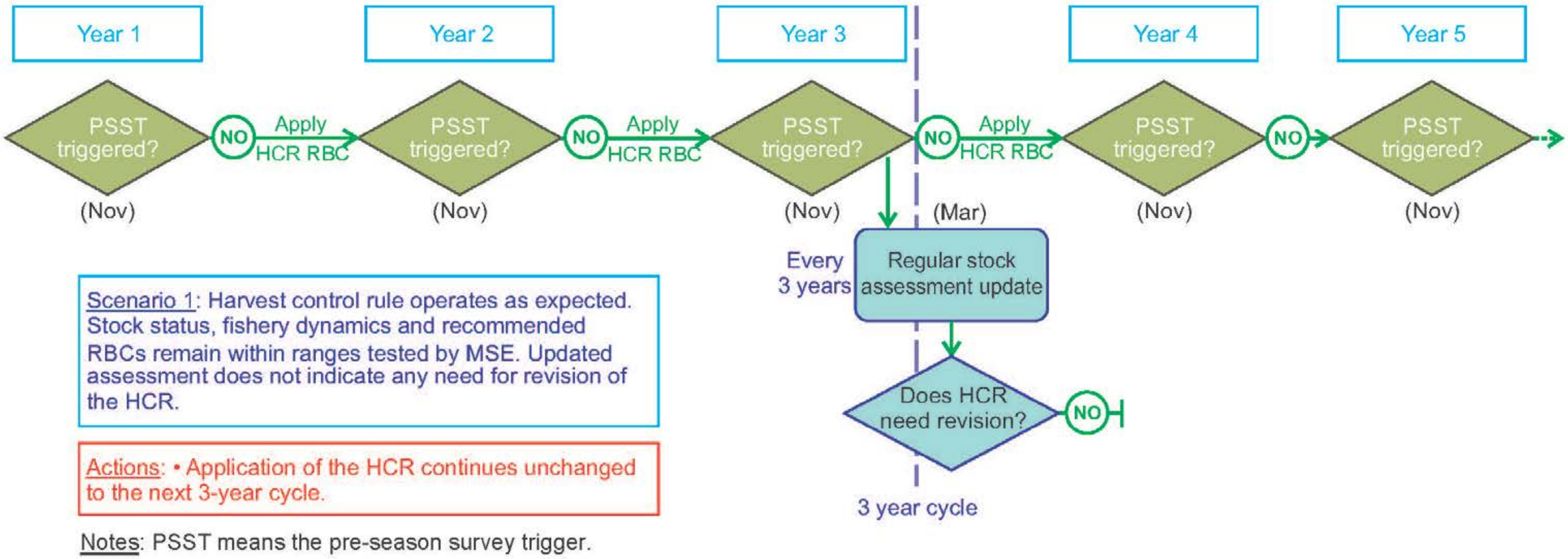


Figure 1. Torres Strait Tropical Rock Lobster Fishery decision rule scenario 1.

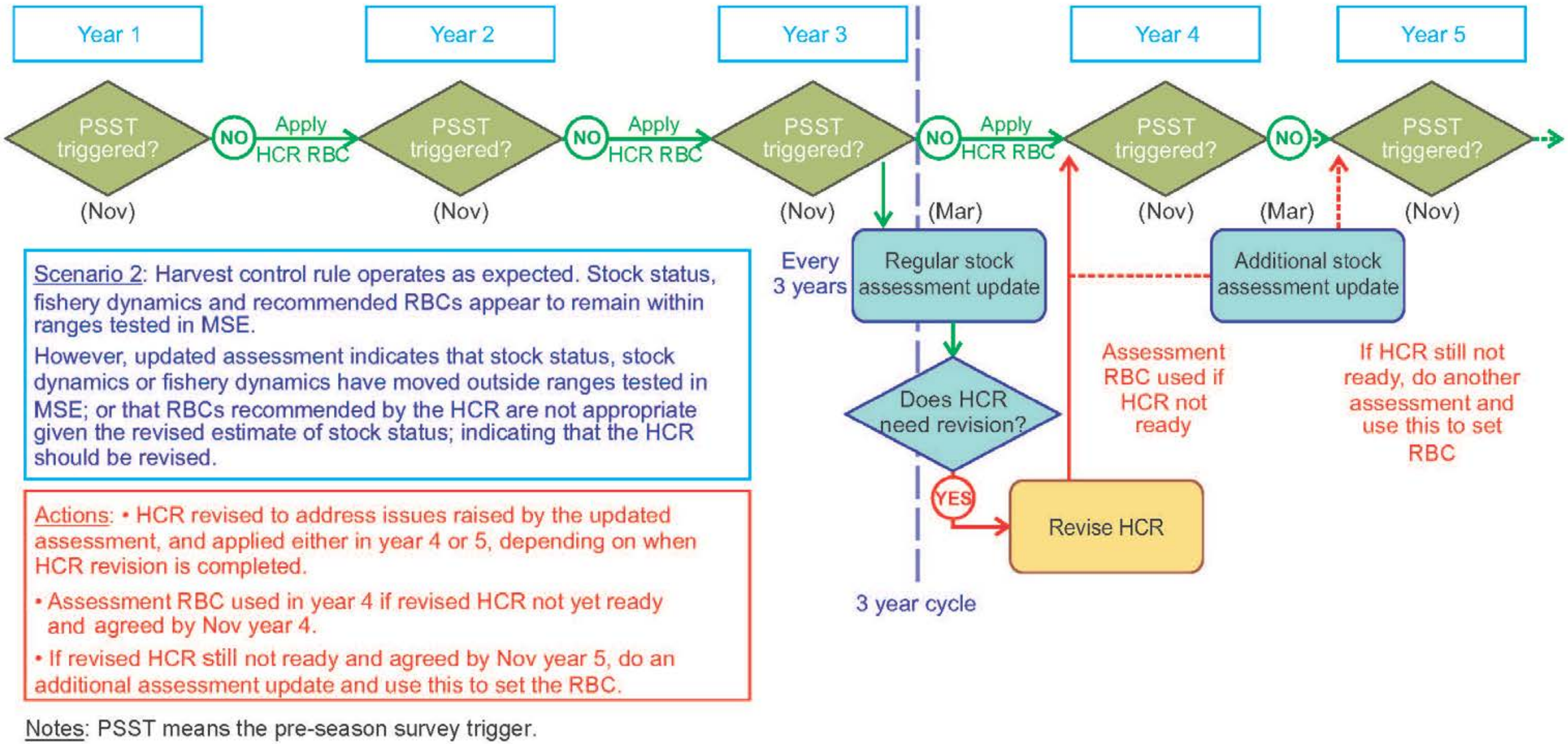


Figure 2. Torres Strait Tropical Rock Lobster Fishery decision rule scenario 2.

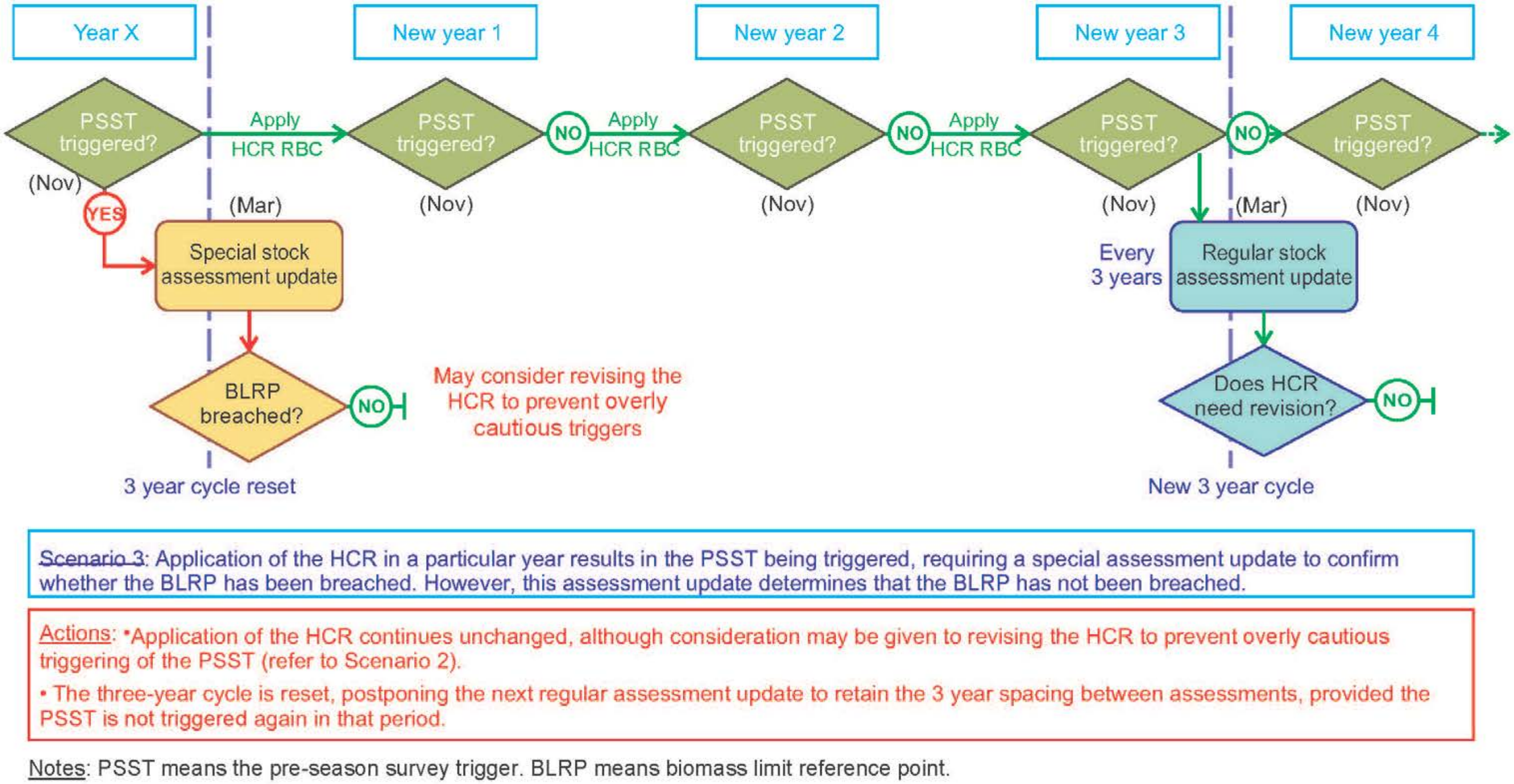
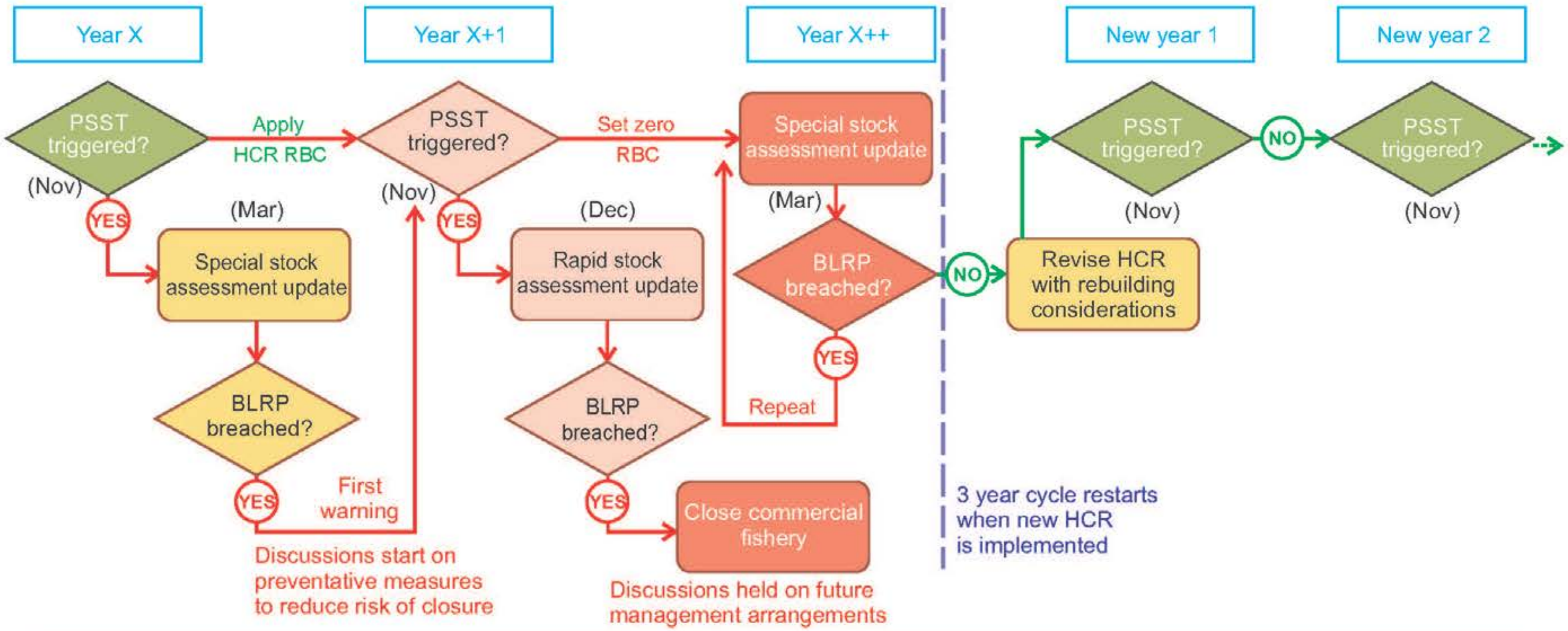


Figure 3. Torres Strait Tropical Rock Lobster Fishery decision rule scenario 3.



Scenario 4: Application of the HCR in a particular year results in the PSST being triggered, requiring a special assessment update to confirm whether the BLRP has been breached. Special assessment update confirms that the BLRP has indeed been breached.

Application of the HCR the following year results in the PSST being triggered for the second successive year, requiring a second rapid assessment update to confirm whether the BLRP has been breached a second time. Assessment update confirms that the BLRP has been breached again.

The commercial fishery is closed until an assessment update confirms that the stock has recovered to above the BLRP.

Actions: • When it has been confirmed that the BLRP has been breached the first time, discussions will be held on preventative measures to reduce the risk of closure.

• If it is confirmed that the BLRP has been breached for a second year and that the commercial fishery must be closed, discussions will be held on future management arrangements to reduce the risk of future closures.

• If the fishery is closed, annual assessments will be done until an assessment update confirms that the stock has recovered to above the BLRP.

• Before being re-implemented, the HCR will be revised to reduce the risk of breaching the BLRP in future and to incorporate rebuilding requirements.

Notes: PSST means the pre-season survey trigger. BLRP means biomass limit reference point.

Figure 4. Torres Strait Tropical Rock Lobster Fishery decision rule scenario 4.

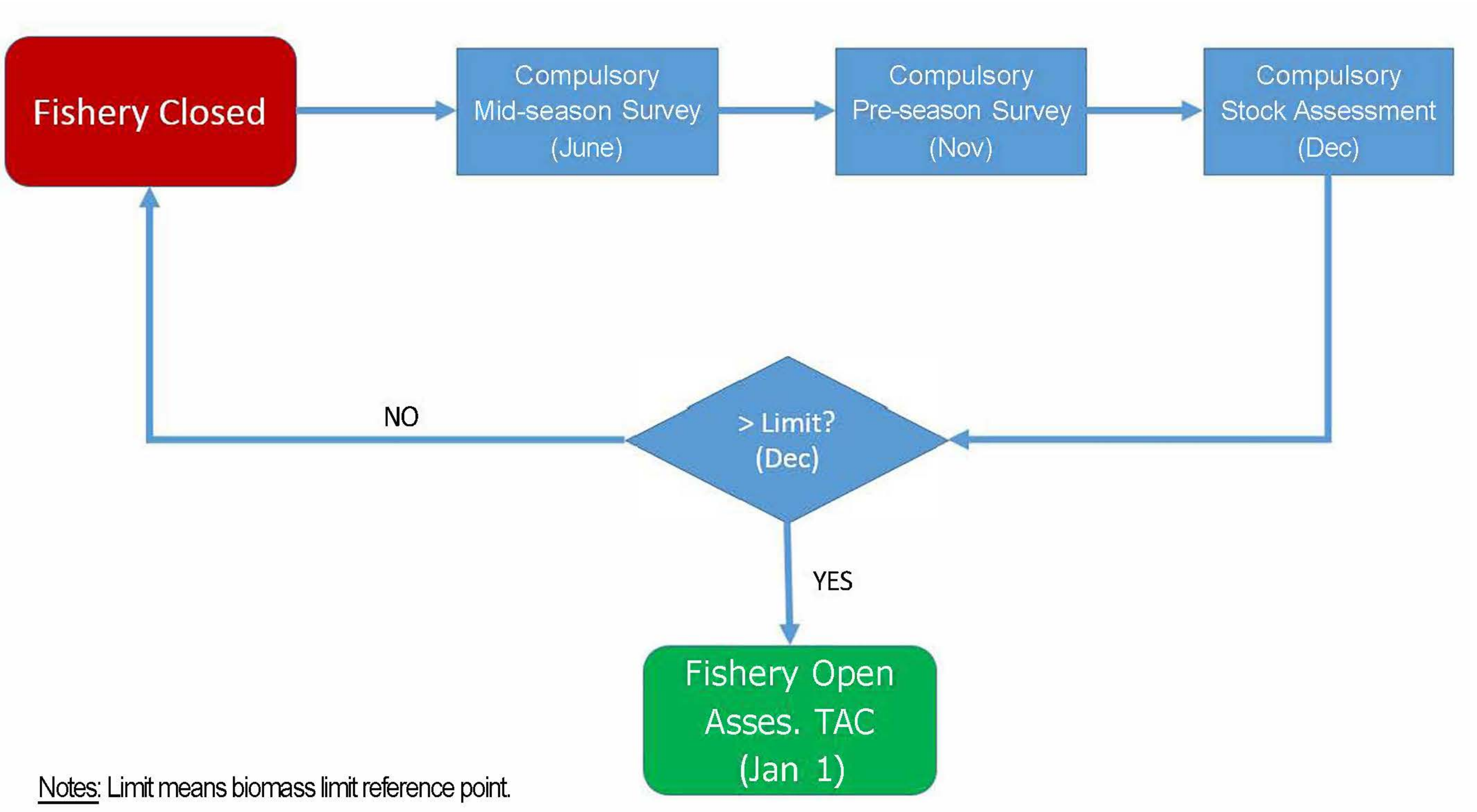
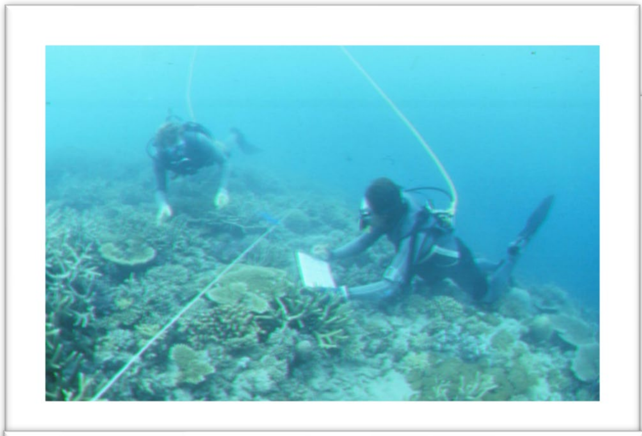
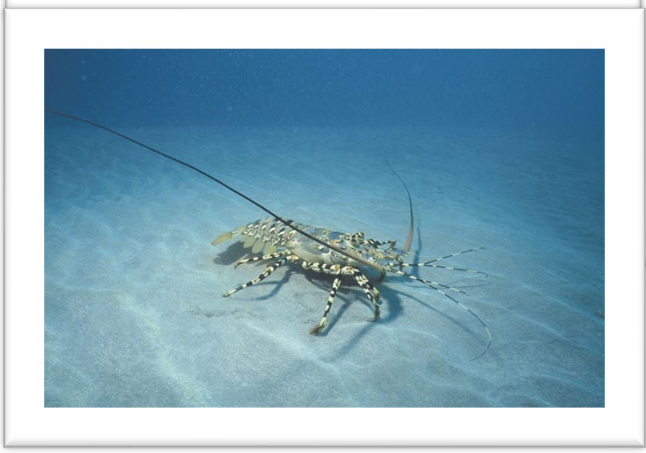


Figure 5. Torres Strait Tropical Rock Lobster Fishery closure and re-opening rule.

NON-TECHNICAL SUMMARY

Torres Strait tropical rock lobster (TRL) *Panulirus ornatus* Harvest Control Rule (HCR) development and evaluation





CSIRO/AFMA

Vers. November 2022

Éva Plagányi, Darren Dennis, Roy Deng, Robert Campbell, Trevor Hutton, Mark Tonks, Mick Haywood, Leo Dutra, Nicole Murphy, Steven Edgar, Kinam Salee, Laura Blamey

CSIRO

Australian Government
Australian Fisheries Management Authority

TRL HCR Non-technical Extended Abstract

Background

The Torres Strait tropical rock lobster *Panulirus ornatus* (TRL) fishery transitioned in 2019 from input controls to output controls which involves the setting of Total Allowable Catch (TAC) levels. The stock is naturally highly variable because the numbers of recruits (1+ lobsters) varies each year, and the fishers catch essentially a single age-class (2+) only. This age-class then leaves Torres Strait to breed. Hence, a TAC needs to be set annually in such a way as to ensure biological and economic sustainability consistent with the principles of the Australian Commonwealth Harvest Strategy as well as the TRL fisheries and PZJA objectives. For this reason, it is important to conduct an annual Preseason survey of Age 1+ recruits as close to the start of the fishing season as possible (November) to inform on the likely size of the fishable stock the next year. We note that 0+ and 1+ lobsters are found in different habitat or ground than 2+ lobsters.

Previously, this information together with all other sources of information and data for the fishery were input to an integrated stock assessment model that was used to set the TAC. However, there is not enough time after the Preseason survey for the TRLRAG to review an updated stock assessment; thus an alternative Harvest Control Rule (HCR) approach is now used. In addition, the TRLRAG identified potential cost savings by only conducting an assessment every three years rather than annually, and replacing this with an approach as described below. There were also additional benefits identified in reducing the frequency of running the full stock assessment model, mainly by allowing additional time to update and improve the model in the intervening years.

Harvest Control Rule

The new approach uses an empirical (data-based) Harvest Control Rule (eHCR) that can be rapidly applied to provide a Recommended Biological catch (RBC) once the catch, survey indices and other data inputs (CPUE or Catch-Per-Unit-Effort) become available. The eHCR is a central component of the Harvest Strategy, defined as "a framework that specifies the pre-determined management actions in a fishery necessary to achieve the agreed ecological, economic and/or social management objectives." A key principle is that fishery managers, fishers and key stakeholders utilise pre-agreed (and preferably pre-tested) rules as to how to adjust management recommendations given updates of data and/or model outputs (http://www.agriculture.gov.au/fisheries/domestic/harvest_strategy_policy).

The eHCR selected by the TRLRAG (August 2016), from a number of alternative candidates that were evaluated, is a mathematical formula that outputs a RBC in December for the following year. This formula is the multiple of the average catch over the last 5 years and a statistic which measures the relative performance of the fishery based on the following 5 data inputs: (1) Preseason recruiting lobster (1+) standardised relative numbers; (2) Preseason recently-settled lobster (0+) standardised relative numbers; (3) nominal CPUE (TIB sector) and (4) standardised CPUE (TVH sector) (using data available up until end of October); and (5) total catch (TIB,TVH,PNG) (using data available up until end of October). This eHCR implies that if the performance of the fishery is improving then the RBC will increase while if the performance of the fishery is decreasing then the RBC will also decrease. Over the long-term this eHCR should maintain the stock around the target biomass level. Different weightings are applied to the four abundance indices included in the relative performance statistic used in the eHCR, based on extensive testing to compare performance of alternative weightings and also on considerations of the information content and reliability of each series, as well as a preference expressed by the stakeholders to use a portfolio approach in determining the RBC. The Preseason Age 1+ index is the most reliable and direct in terms of indexing the biomass of lobsters that will be available to be caught in the next fishing season, and hence this index is assigned the highest weighting of 70%. The Preseason 0+ index provides an early indication of the following year’s recruitment, whereas the CPUE indices reflect the abundance of the large Age 2+ lobsters, the survivors of which will migrate out of the Torres Strait to spawning grounds to the East, and hence they index spawning biomass which is an important consideration in terms of ensuring the future sustainability of the stock. Each of these three secondary indices (Survey Age 0+ and CPUE (TIB and TVH)) are assigned a weighting of 10% in the eHCR formula.

Simulation testing showed that the best approach is to use the slope of the trends in the secondary indices over the last five years’ data (after first taking the natural logarithm of the data) for each of the abundance indices. This allows the RBC to be based on medium term trends in abundance, rather than on just the current abundance. Using the last five years' data gave the best performance in terms of a number of key statistics that were used to compare the performance of alternative candidate rules. Key performance statistics considered by the TRLRAG included those related to resource status (spawning biomass level, and levels relative to target reference levels), average annual catch (averaged over 20 years), average annual variability in catch, as well as risk to the fishery and risk of closure of the fishery. The eHCR candidate that included taking the natural logarithm was preferred because this has the effect of dampening some of the inter-annual variability and hence ensuring that the RBC responds to medium-term changes in resource trends rather than bouncing up or down very erratically. Similarly, a number of alternative options were explored that used the trend fitted to different numbers of years of historical abundance indices, but using the trend based on the past 5 years was shown to perform best.

The preferred eHCR therefore outputs a RBC based on the slopes of the regression lines fitted to the Preseason survey and CPUE indices, with different weightings applied to the different data sources (70% Preseason 1+; 10% Preseason 0+; 10% CPUE_TIB; 10% CPUE_TVH), and the overall resultant trend multiplied by the average of the last 5 years' catch. In essence, this will output annual catches with an average similar to the average of recent catches, but the actual value each year will be scaled up or down based on the resource status. For example if the abundance indices suggest the resource is increasing, the RBC will be increased and conversely, so as to ensure that the stock is not overfished in years when recruitment naturally fluctuates to low levels. Stakeholders also selected an additional rule to cap the total catch at 1000t in the (unlikely) event that the eHCR outputs a RBC that exceeds this tonnage.

Forecast TAC

Consistent with previous approaches, a Forecast TAC is generated each year to provide a heads-up of the likely RBC for year y+2, in case this is useful for planning purposes. The Forecast value uses the Preseason 0+ data only, and is scaled (using a multiplier of 0.85) so that on average the value is 100t less than the final TAC, as the TRLRAG previously agreed that the Forecast should be set lower than the final TAC because of greater uncertainty in predicting more than one year ahead, and also because it would be preferable to increase rather than decrease any preliminary RBC value. Simulation testing suggested that the Forecast performs reasonably in predicting future fishable biomass, and that with increased survey effort (to improve the precision of the 0+ abundance index), the precision and reliability of both the Forecast and RBC (which also uses the 0+ index) could be improved.

Stock Assessment of Resource Status

The eHCR will be applied annually to set a RBC that takes into account recent trends in resource abundance indices, but it does not provide information as to the current stock size, for example relative to important reference levels such as the target biomass level (65% of the comparable unfished biomass) and limit reference point (LRP) (32% of the comparable unfished biomass). The eHCR is tuned so that on average the stock will fluctuate around the target biomass level and avoid the limit biomass level, but to accurately assess resource status, it is necessary to do a stock assessment. A stock assessment will thus be conducted every three years to rigorously assess stock status and productivity, and check that the eHCR is working as it is supposed to. A stock assessment is also necessary to evaluate whether the spawning stock biomass drops below the LRP because if the LRP is triggered in two successive years, then the fishery is closed.

Fishery Closure Rule

As a stock assessment is only scheduled for every third year, this means that action may not be taken quickly enough if the spawning biomass drops to very low levels (which may be due to either fishery or environmental conditions), and hence an additional precaution has been built into the Harvest Strategy. Based on analysis of the historical Preseason and Midyear survey indices, a Preseason 1+ survey trigger point of 1.25 (average number of lobsters per survey transect and lower than any historically observed values) has been set, such that if this lower limit is triggered in any year, then the required action is that a stock assessment be conducted in the following year. If the stock assessment suggests that the spawning stock biomass is above the LRP, then the process continues as previously. However, if spawning biomass is assessed as below the LRP, then a stock assessment is again triggered in the following year. If the second stock assessment suggests the stock is above the LRP, then the process again continues as previously, but if the spawning biomass is below LRP (i.e. two consecutive years with spawning biomass below LRP), then the fishery is closed and appropriate action (e.g. implementing surveys, analysing size structure and environmental information) is put in place to rebuild the stock. In general, the eHCR is therefore applied every year unless the LRP is triggered in two consecutive years, or there are exceptional circumstances. Exceptional circumstances include situations where the new data collected indicate that the resource has moved outside the range for which the eHCR has been tested, or environmental conditions have an impact on the stock that is similarly outside the bounds of what the eHCR has been tested as robust to. An examples would be an extreme weather event resulting in a very low stock.

Harvest Control Rule Testing

The eHCR is a relatively simple formula for calculating the recommended biological catch each year. However, it is important to understand that although simple it has been rigorously and extensively tested using historical information and simulations of likely outcomes. Hence it has a solid foundation based on the wealth of historical data and information for the fishery. To test the performance (in terms of meeting pre-specified objectives) and robustness (i.e. ensuring it doesn't fall over if the stock or fishers behave or change in certain ways) of the eHCR, we use the so-called 'operating model', the 2015 integrated stock assessment model that integrates all historical information (catch records since 1973, Midyear Survey data from 1989-2014, Benchmark surveys, Preseason Survey data (2005-2009; 2014-2015), catch-at-age information, size composition information). In addition, rather than using the single best-case stock assessment model, we use four versions of the model that include alternative parametrisations related to the stock-recruitment assumptions (more conservative steepness parameter; sporadic poorer auto-correlated recruitment) and the form of the assumed relationship between stock biomass and CPUE (hyperstability parameter settings). We project each model forward 20 years, generating random future recruitment scenarios that are based on what has been observed in the past, as well as future survey "data" and CPUE that are assumed collected with observation errors similar to what has been observed in the past. We test how well each alternative candidate eHCR performs by testing it using 200 replicates of each of the four operating models (i.e. 800 future scenarios). We also account for implementation uncertainty which describes the difference between the RBC allocation to each sector (not considered in this study which focuses only on the total RBC) and the actual catch of each sector. The implementation errors assumed for each sector in the testing are similar to past observed differences between "dummy" TAC allocations and actual catches, and hence are greatest for the PNG sector, followed by TIB and TVH sectors.

A large number of alternative types of eHCR rules using different combinations of data inputs were trialled to inform selection of the final rule. There is no one single correct answer in this process of Management Strategy Evaluation (MSE) testing. Rather, selection of a final eHCR is made by comparing trade-offs across a range of different performance statistics (e.g. the trade-off between a rule that sets a very high catch is that it likely results in high risk to a resource) and also that it performs satisfactorily in meeting pre-specified objectives (such as the target biomass level). In addition, the performance of the eHCR needs to be tested using sensitivity and robustness tests, to see whether it still performs satisfactorily even if there are moderate changes in the stock, environment, fisher behaviour, surveys and other aspects of the fishery. For example, sensitivity tests were done assuming higher implementation errors, survey observation errors, future changes in catchability (which might be linked to improvements in efficiency, changes in fishing practices or environmental drivers making lobsters harder to find and catch) as well as future poor recruitment events or increases in the natural mortality rate.

HCR Selected by TRLRAG

The eHCR selected by the TRLRAG performed reasonably across a broad range of sensitivity scenarios, suggesting that it is a reasonably robust method that will respond appropriately to unforeseen future changes to adjust stock size upwards or downwards as necessary, in such a way as to substantially reduce the risk of overfishing or underfishing (i.e. not optimally utilising the resource). This is illustrated by comparing the performance with a constant catch strategy (with catch set at 680t or alternatively, the average of the past 10 years' catch). Results highlight that such a constant catch strategy poses an unacceptably high risk to the resource and importantly a substantially higher risk of invoking a closure of the fishery in the future, compared to the adaptive eHCR presented above, which adjusts catches in line with stock fluctuations. It is worth noting that pre-2015 TAC estimates were as low as 470t; hence a constant catch may result in overfishing by 200t in low stock years. Simulations suggest that to achieve the same level of risk as the adaptive eHCR being proposed, the constant catch would need to be set at a low total of 360t, which is approximately half the average catch that could be achieved using an adaptive eHCR.

Data quality requirements

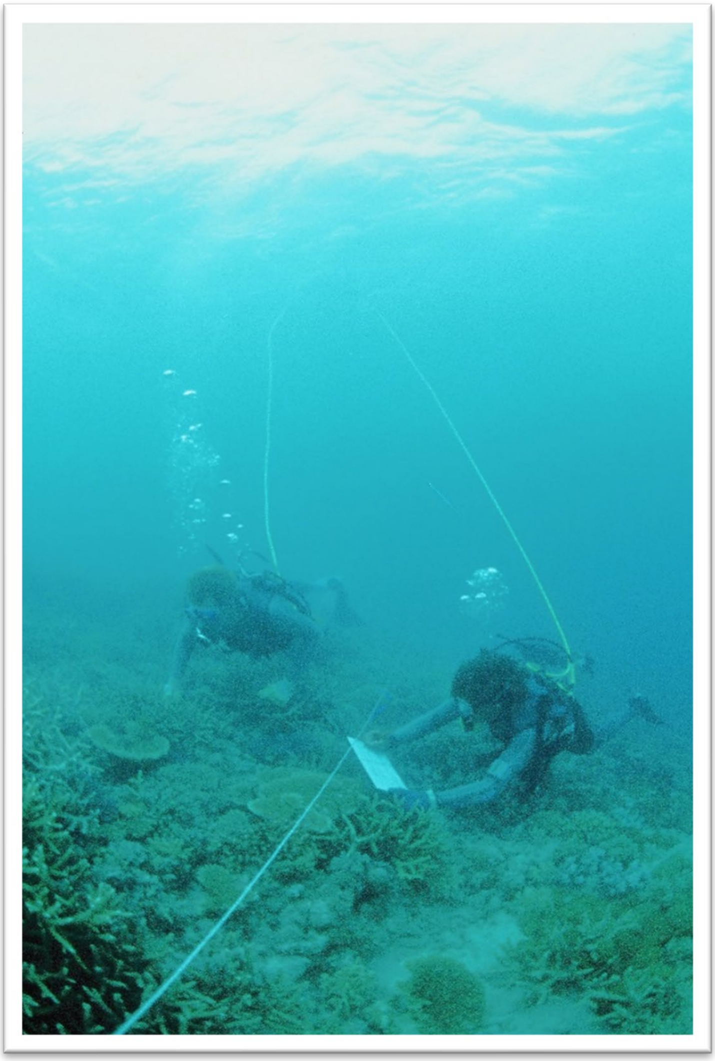
The eHCR relies critically on the provision of high quality data that are provided before pre-specified deadlines. The Australian Harvest Strategy Policy allows for tiered approaches which cater for different levels of certainty about a stock. It is well recognized that increased levels of precaution are necessary as levels of uncertainty about stock status increase (e.g. if there are fewer data to inform on stock status). Hence catch or exploitation levels can be adjusted on the basis of keeping the risk approximately constant across the tiers, such that catch and exploitation rates will decrease as tier levels increase. Future work will quantify what the penalties or bonuses are that should be applied in a tier system that accounts for differences from year to year in the amount and quality of data that are available to inform the setting of a RBC. Simulations are being used to compute how much additional catch could be taken, for the same level of risk, if additional surveys (such as re-implementing a Midyear survey or extending the Preseason 0+ survey) are conducted. On the other hand, a penalty, determined by again calibrating to the same level of risk, needs to be applied to the RBC if the quality or quantity of survey other data are degraded in a particular year. As above, if there are no survey data, then a low constant catch of 360t could be set, and if there are no data at all (i.e. no surveys, CPUE or reliable catch), then the fishery should be closed.

Adopting an eHCR approach means that it is imperative that data are collected reliably and timeously each year in order to manage the stock effectively.

Summary

In summary, the TRLRAG uses a Harvest Control Rule approach, such as is now implemented in a number of fisheries globally, including for Australia's southern rock lobster fishery. Previously, a stock assessment model was used annually to analyse fishery data and assess current status and productivity of the resource. A "best assessment" then provided the RBC and a reference-point hockey-stick HCR informed the TAC recommendation and management action. The new approach involves using a formula for providing the RBC, based on pre-specified data inputs, and therefore for setting the TAC. The formula or harvest control rule (also called a decision rule) is empirical, as it uses the data directly e.g. recent upward or downward trends in abundance indices are used directly as feedback and hence the TAC changes in the same direction. In addition, a full stock assessment using the integrated fishery model will be conducted every third year.

The eHCR has been extensively tested by simulation to provide appropriate trade-offs, taking into account a range of uncertainties and using methods that are now well established internationally and recognised as state-of-the-art approaches to successfully and optimally managing fisheries. The greatest advantages to adopting a HCR approach are that (1) it can be applied quickly and easily to set a TAC in time for the start of the new fishing season; (2) it provides a transparent and easily understandable tool for stakeholders (e.g. the effect on the RBC of negative or positive decreases/increases in stock abundance indices can be readily seen, and a spreadsheet example is provided to stakeholders for this purpose); (3) it provides a sound basis for setting TACs without compromising resource status; (4) it properly addresses concerns about scientific uncertainty through simulation testing to ensure that feedback secures reasonably robust performance across a range of plausible alternative resource dynamics; and (5) it empowers stakeholders by allowing them to transparently assess trade-offs between key performance measures and select the most favourable option taking into account a range of biological, economic, social and cultural considerations. Another advantage of a HCR is: (6) it uses pre-agreed rules for management of the fishery thus allowing management to be pro-active instead of re-active.



Summary explanation of TRL Harvest Control Rules

RULE 1: Total Allowable Catch is equal to a base amount which is increased or decreased each year depending on an index of lobster in the Pre-season Survey *and* depending on whether trends in Catch per Unit of Effort in each fleet have increased or decreased.

The base amount is the average of the last 5 years of total catch and the rule is that the base amount must be increased or decreased according to the Pre-season Survey and fleet catch rates in order to meet the objective of sustainable management of Torres Strait marine stocks.

RULE 2: If the Pre-season Survey index falls below a value (1.25); that is lower than the lowest recorded index value then the stock assessment will be undertaken for the next year; else

RULE 3: The stock assessment is undertaken every 3 years to check if the stock is meeting the Target Reference Point and not falling below the Limit Reference Point; and

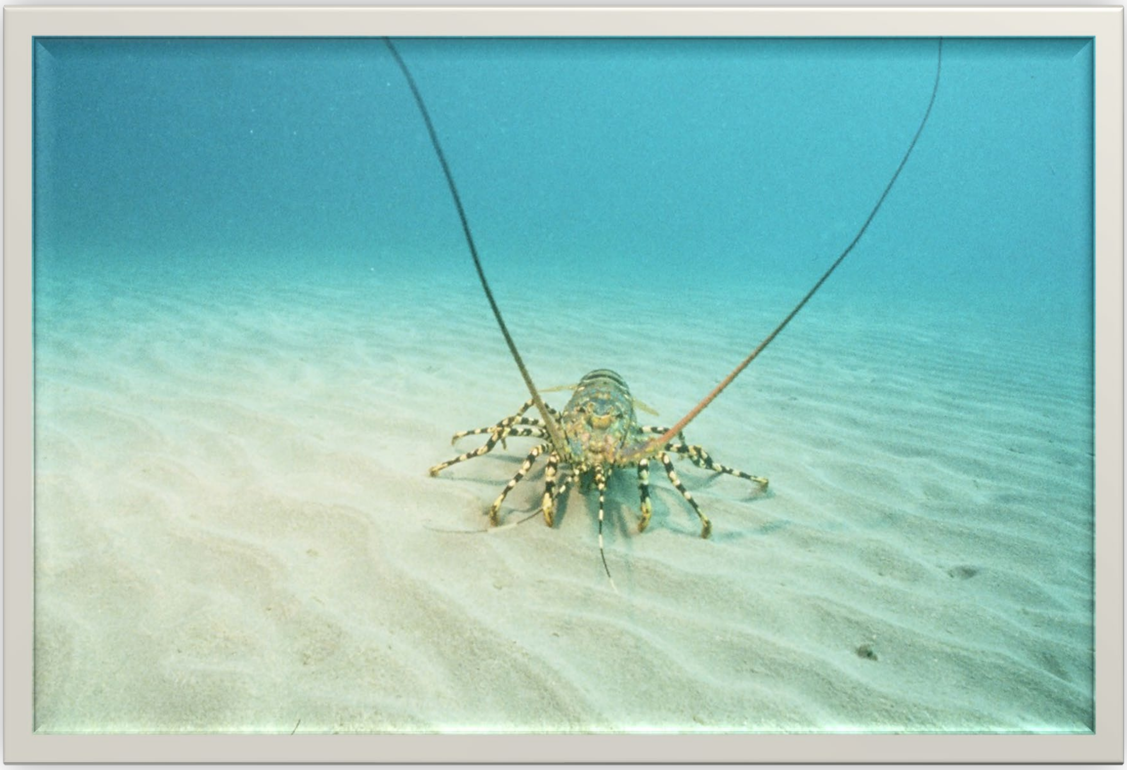
RULE 4: If the stock falls below the Limit Reference Point for two consecutive years as determined by the stock assessments in those two years then Total Allowable Catch will be the minimum (zero).

RULE 5: Finally, the maximum Total Allowable Catch is equal to 1,000 tonnes if **RULE 1** ever evokes a higher value.

Additional info: Target Reference Point is equal to 65% of the pristine total biomass.

Limit Reference Point is equal to 32% of the unfished total biomass.

Rules based on using a fixed (average) catch pose high risk for variable stocks such as TRL.



Contact: Dr Éva Plagányi,

Senior Principal Research Scientist - Fisheries Assessment, Economics & MSE

CSIRO Environment – Sustainable Marine Futures

Brisbane, QLD 4072

Email: eva.plaganyi-lloyd@csiro.au. Tel. 07 38335955

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG) **Thursday Island**	**MEETING 33** **13-14 December 2022**
PRELIMINARY STOCK ASSESSMENT RESULTS	**Agenda Item 8** **For discussion and advice**

RECOMMENDATIONS

1. That the RAG:
   a. **NOTE** that under the TRL Harvest Strategy (**Attachment 7b**), a stock assessment update is required on a three-year cycle, which commenced in 2019 (TRLRAG 27, 10-11 December 2019).
   b. **CONSIDER** the preliminary stock assessment update for the Torres Strait Tropical Rock Lobster Fishery – to be presented by CSIRO at the meeting (**Attachment 8a**).
   c. **DISCUSS** and **PROVIDE ADVICE** on the findings, including any need for revision of the empirical Harvest Control Rule (eHCR).
   d. **NOTE** that a final updated stock assessment will be presented at the next TRLRAG meeting (date TBC).

KEY ISSUES

2. Under the TRL Harvest Strategy (refer to **Attachment 7b**):
   a. a Recommended Biological Catch (RBC) is to be calculated each fishing season by applying the eHCR;
   b. a stock assessment update is to be conducted every three years unless the stock assessment is triggered by a decision rule (sections 2.8, 2.10 and 2.11). The stock assessment determines the TRL Fishery stock status relative to reference levels and, in doing so, the performance of the eHCR. This cycle commenced in 2019.
3. A preliminary stock assessment update will be presented by CSIRO at the meeting (**Attachment 8a**). The stock assessment update will incorporate catch and effort data for the 2021-22 fishing season and the results of the November 2022 pre-season survey.
4. The RAG is being asked to review the preliminary stock assessment update and where relevant provide advice on the findings.
5. Of particular relevance, sections 2.10 and 2.11 of TRL Harvest Strategy provide that:
   a. if the updated stock assessment indicates the eHCR recommended RBCs are outside the revised ranges tested by management strategy evaluation (MSE), RBCs are to be set using an annual stock assessment until a revised eHCR has been agreed, after which the revised eHCR is applied; and
   b. if the updated stock assessment does not indicate any need for revision of the eHCR, the stock assessment continues on a three year cycle, unless triggered to occur by a decision rule (i.e. pre-season survey trigger is triggered).

6. Having regard to the preliminary stock assessment results, the outputs from the eHCR and the decision rules under the TRL Harvest Strategy, the RAG will be asked to provide advice on an RBC for the 2022-23 fishing season under **Agenda Item 9.**

BACKGROUND

Integrated stock assessment model

7. The stock assessment model (or 'Integrated model') was developed in 2009 and is an Age-Structured Production Model, or Statistical Catch-at-Age Analysis (SCAA).
8. The model integrates all available information into a single framework to assess resource status and provide a RBC. The model is fitted to the mid-season and pre-season survey data and TIB and TVH catch per unit effort data. The growth relationships used in the model have been revised to ensure that the modelled individual mass at age more closely resembles field measurements. The model has been used as an Operating Model in a Management Strategy Evaluation (MSE) framework to support the management of the fishery.
9. The stock assessment model is non-spatial and assumes (conservatively) that the Torres Strait Tropical Rock Lobster Fishery stock is independent of the Queensland East Coast Tropical Rock Lobster Fishery stock.
10. The model includes three age-classes only (0+, 1+, and 2+ age lobsters) as it is assumed that lobsters migrate out of the Torres Strait in October each year. Torres Strait TRL emigrate in spring, (September-November) and breed during the subsequent summer (November-February). A Beverton-Holt stock-recruitment relationship is used, allowing for annual fluctuation about the average value predicted by the recruitment curve. The model is fitted to the available abundance indices by maximising the likelihood function. Quasi-Newton minimisation is used to minimise the total negative log-likelihood function.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG) Thursday Island	MEETING 33 13-14 December 2022
RECOMMENDED BIOLOGICAL CATCH	Agenda Item 9 For discussion and advice

RECOMMENDATIONS

1. That the RAG:
    a. **NOTE** on 4 October 2022, Senator the Hon. Murray Watt determined a total allowable catch (TAC) of 200,000 kilograms of TRL in the Australian waters of the TRL Fishery for the 2022-23 fishing season.
        (i) It is expected that the TAC will be increased once the outcomes of the scientific assessment process and the TAC sharing arrangements under the Treaty between Australia and Papua New Guinea (PNG) have been taken into account.
    b. Having regard to:
        (i) the outputs of the eHCR (discussed under **Agenda Item 7**); the findings of the preliminary stock assessment results (discussed under **Agenda Item 8**); and the decision rules under the TRL Harvest Strategy;
        (ii) **DISCUSS** and **PROVIDE ADVICE** on a RBC for the 2022-23 fishing season.
            - noting that the RBC covers the Torres Strait Protected Zone (TSPZ) (Australia and PNG).

KEY ISSUES

Recommended Biological Catch

2. The RAG is being asked to provide advice on a RBC for the 2022-23 fishing having regard to:
    a. The application of the eHCR, in accordance with the TRL Harvest Strategy decision rules:
        (i) section 2.10 Decision Rules of the TRL Harvest Strategy which provides that if in any year the pre-season survey 1+ index is 1.25 or lower (average standardised number of 1+ age lobsters per survey transect) it triggers a stock assessment.
        (ii) Having regard to the pre-season survey results presented under Agenda Item 4, and whether the pre-season survey trigger has been triggered.
        (iii) section 2.10 Decision Rule Scenarios of the TRL Harvest Strategy which provides that under Scenario 1 or 2, if the pre-season trigger has not been triggered, the RAG should consider whether the eHCR RBCs remain within the ranges tested by management strategy evaluation (MSE).

b. The RAG should also note that under the TRL Harvest Strategy, if the updated stock assessment does not indicate any need for revision of the eHCR, the stock assessment continues on a three year cycle, unless triggered to occur by a decision rule (i.e. pre-season survey trigger is triggered).

BACKGROUND

TAC setting process

3. Under subsection 13 of the Plan, the Minister must determine a TAC for the TRL Fishery prior to the start of a fishing season. In making a TAC determination, the Minister must:

   a. consult with any advisory committee that the PZJA has established under subsection 40(7) of the *Torres Strait Fisheries Act 1984*, to provide advice relating to the TRL Fishery; and

   b. have regard to Australia's obligations under the Torres Strait Treaty.

4. Under section 13 the Minister may also consider the views of any person with an interest in the TRL Fishery or the ecologically sustainable use of the TRL Fishery and take into account the amount of TRL taken in the TRL Fishery as a result of other fishing, such as traditional fishing or recreational fishing.

5. Subsection 14 provides for the Minister to determine an increase to the TAC for a fishing season. Subsections 8-11 prescribe how a TAC is to be administered, including the issuing of a notice when the TAC for the Traditional Inhabitant sector has been reached.

6. Further background on the TAC setting process, how catch is shared between Australia and PNG, and how each sector's catches will be managed for the 2022-23 fishing season is provided in the Tropical Rock Lobster Fishery Management Arrangements Booklet 2022-23 available from the PZJA website.

7. At their meeting on 4 October 2022, the PZJA agreed to an amended process for setting the TRL TAC which removes the step of seeking PZJA consideration of start of season and global TAC subject to TRLRAG and TRL Working Group advice. As the TAC setting process for the TRL Fishery has evolved in recent years, this decision by the PZJA seeks to achieve administrative efficiencies and streamline the overall process by removing two largely administrative additional step unless there are exception circumstances.

8. The exceptional circumstances which would require further PZJA consideration on the advice of the TRL RAG and TRL Working Group are:

   a. If any of the Harvest Strategy outputs are outside the bounds of the decision rules. Examples include:

      (i) If in any year the pre-season survey average standardised number of 1+ age lobsters per survey transect is 1.25 or lower; or

      (ii) If a stock assessment is triggered outside of the normal three-year stock assessment cycle;

      or

   b. In circumstances where the TRL stock abundance is exceptionally low and the final RBC is likely to fall below the start of season catch limit (200 tonnes).

Setting the start of 2022-23 season TAC

9. At its meeting on 18-19 October 2018, the TRLRAG advised that the start of season catch limit should cover 1 December through to the end of February, and be based on the maximum annual catch amount for the period 2005-2018, being 200 tonnes. This is to minimise the risk that the limit could artificially constrain fishing effort, particularly in a year of high TRL abundance.
10. The TRLRAG further advised that if needed, an additional 100 tonnes be added to the start of season catch limit amount, to account for catches from PNG.
11. It was further agreed that the start of season catch limit be overridden in seasons where the TRL stock abundance is exceptionally low and the final RBC is likely to fall below the start of season catch limit or where overridden by the Harvest Strategy decision rules. In such cases, the use of the start of season catch limit should not be used in subsequent seasons until reviewed by the TRLRAG.
12. The above approach was applied for setting the start of season TAC for the 2022-23 fishing season with no objections from the TRLRAG.
13. At its meeting on 4 October 2022, the Minister PZJA determined start of season TAC of 200,000 kgs (unprocessed weight) for the 2022-23 fishing season under section 13 of the *Torres Strait Fisheries (Quotas for Tropical Rock Lobster (Kaiar)) Management Plan 2018* (the Management Plan).
14. It is expected that the TAC will be increased once the outcomes of the scientific assessment process and the TAC sharing arrangements under the Treaty between Australia and PNG have been taken into account. Any increase in the TAC is expected to be determined by the end of February 2023. Further details on the expected timeline is provided at **Attachment 9a**.

Expected timeline and process for finalising a global total allowable catch (TAC) for the TSPZ Tropical Rock Lobster Fishery

Key:

Scientific assessment and advice	PNG-Australia agreement	Administrative step for Australia

Steps	Description	Indicative timeline
PNG and Australian catch and effort data compiled	Australian and PNG catch and effort data are compiled[1].	By end October
Pre-season scientific survey	Survey data are collected and used to update TRL survey abundance indices used to calculate a recommended biological catch (RBC)[2]. Survey must be conducted in November to provide comparable results overtime and the most accurate estimate of annual lobster recruitment into the fishery.	Early November
Australian start of season TAC determined	Minister to determine a 200 tonnes start of season[3] TAC for the Australian TRL Fishery for the upcoming fishing season, as per section 13 of the *Torres Strait Fisheries (Quotas for Tropical Rock Lobster (Kaiar)) Management Plan 2018* (the Plan)[4]. Start of season TAC based on advice received from TRLRAG and TRLWG in October-November 2018. TAC to apply to Australian TRL Fishery only.	Mid-November
RBC calculation	CSIRO to use empirical Harvest Control Rule (eHCR) to calculate a RBC. Every three years (starting in 2019), CSIRO to update and run the stock assessment model to evaluate the performance of the eHCR. Preliminary stock assessment results are usually available within 4-5 weeks of the pre-season scientific survey.	Late November through to early December
TRL Resource Assessment Group (TRLRAG) and TRL Working Group (TRLWG) advice[5]	TRLRAG to review the survey results, CPUE analyses and application of the eHCR. Advice provided on a final RBC.	Mid December

[1] These data are provided to CSIRO to update catch per unit effort indices used to calculate a recommended biological catch for the coming fishing season.
[2] A RBC is the total amount of TRL that can be sustainably taken out of the water by all fishers (commercial, traditional, recreational) each season, while leaving enough in the water to breed.
[3] The Australian TRL Fishery fishing season runs from 1 December each year to 30 September the following year.
[4] The Plan is accessible online at https://www.legislation.gov.au/Details/F2018L01645
[5] Officers from PNG NFA are invited to attend all PZJA advisory forums.

	TRLWG to review TRLRAG advice. Advice provided on a final global TAC[6]. Every three years (starting in 2019), TRLRAG and TRLWG to consider preliminary results of stock assessment. Advice provided on finalising the assessment.	
PZJA agreement to final global TAC	PZJA to review TRLRAG and TRLWG advice and agree to final global TAC.	January
Agree final global TAC, shares of the TAC, cross-endorsement apportionments and any preferential entitlements	AFMA CEO and PNG NFA Director General to meet to agree, as per the terms of the Torres Strait Treaty, on: - a final global TAC as per article 23(2); - shares of the final global TAC as per article 22(1) (e.g. 15%:85% split); - cross-endorsement apportionments as per articles 23(4) and 25; - preferential entitlement to any unfished cross-endorsement apportionments as per article 25. An exchange of letters is required to formalise the agreement.	By end January
Australian final TAC determined	Minister to determine a final TAC for the Australian TRL Fishery for the fishing season, as per section 14 of the Plan. TAC to apply to Australian TRL Fishery only.	By end February
TRLRAG advice	Every three years (starting in 2019), TRLRAG to review the final stock assessment results. Advice provided on the need to review the eHCR and conduct a stock assessment in subsequent years, as per Harvest Strategy rules.	February/March
If relevant, submit any formal requests for cross-endorsement in accordance with the Cross-endorsement Guidelines (subject to input from NFA and agreement by the PZJA)	PNG and/or Australia to provide formal request to the other Party seeking cross-endorsement pursuant to article 26 of the Torres Strait Treaty. It will take approximately 6 weeks for Australia to complete the domestic processes to issue a Treaty endorsement/s[7].	By end March

[6] A global TAC is the total amount of TRL that can be sustainably taken out of the water by both Australian and PNG commercial fishers each season.
[7] Australia's domestic process include requirements to undertake native title notification pursuant to sub-sections 24HA(2) and (7) of the Commonwealth *Native Title Act 1993*, which takes a minimum of 1 month, and to seek approvals to issue a Treaty endorsement/s.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG) Thursday Island	MEETING 33 13-14 December 2022
OTHER BUSINESS	Agenda Item 10 For Discussion

RECOMMENDATIONS

1. That the RAG **NOMINATE** any other business for discussion.

TROPICAL ROCK LOBSTER RESOURCE ASSESSMENT GROUP (TRLRAG) **Thursday Island**	**MEETING 33** **13-14 December 2022**
DATE AND VENUE FOR NEXT MEETINGS	**Agenda Item 11** **For Discussion**

RECOMMENDATIONS

1. That the RAG **NOMINATE** a date and a venue for the next meeting noting proposed meeting dates in the table below alongside key agenda items.

Proposed Date	Key agenda items
May 2023 (during a moontide closure) (TBC)	TRLRAG Data Sub-Group (meeting 2) - Assess and identify improvements to fisher dependent data inputs to the Torres Strait TRL Fishery assessment framework - Consider a draft data plan
June 2023 (TBC)	TRLRAG (meeting 34) - Consider any related intersessional work undertaken by CSIRO (e.g. final 2022 stock assessment results) - Discuss research and data needs planning, including: • Consider Data Sub-Group meeting outcomes and future work • Discuss research priorities and any updates to the five-year research plan.
13 December 2023	TRLRAG (meeting 35) - Consider results of the November 2023 pre-season survey - Consider CPUE analyses for the 2022-23 fishing season - Consider the recommended biological catch (RBC) estimates derived through the application of the empirical harvest control rule (eHCR) under the TRL Harvest Strategy and provide advice on a RBC for the 2023-24 fishing season - Consider any intersessional work undertaken by CSIRO