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Final Report: Harvest Strategy for the Torres Strait Bêche-de-mer (sea cucumber) fishery

AFMA Project **2016/0823**

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Australian Fisheries Management Authority
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Contents

Figures

Tables

Acknowledgments

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Community Summary

Key messages

What is the harvest strategy and how was it developed?

- A harvest strategy for the Torres Strait Bêche-de-mer (sea cucumber) Fishery (TSBDMF) is a set of pre-agreed rules that provides clear and practical guidance for sustainably managing the fishery, including what data are needed and whether the fishery can be expanded.
- It has been put together based on scientific evidence from CSIRO, Australia's national science agency, and in consultation with the Hand Collectables Working Group (HCWG), AFMA, TSRA, Malu Lamar and other stakeholders.

Why is the strategy important?

- Having a formal harvest strategy is a key building block for the future of the TSBDMF. It provides certainty to fishers, communities, scientists and managers about how the fishery will be managed
- It outlines what data are needed and how the information will be used to adjust total allowable catches to provide positive benefits for industry, the environment and the communities.

Data requirements

- Without lots of good data, it is difficult to measure the health of the fishery and manage it well, including for potential growth.
- The harvest strategy depends critically on the new Fish Receiver System where the fishery provides compulsory catch data, as well as fisher logbook data including:
    - accurate total catch per species
    - catch records per day and per fishing area
    - discards and wasted product
    - fishing effort (e.g. how many hours spent fishing) and size of animals caught
    - local area and depth fished (this can be submitted confidentially)
    - correct species identification, with tools available to help with this

What the strategy includes

- A tiered (or step-wise) approach for how fishery data can be used to manage the fishery to reduce the risk to a resource and potentially support higher TACs.
- Requirements for monitoring, with agreement that a fishery will be closed if no data are provided by fishers and fish receivers.
- Managing mixed species/basket catches through the monitoring of as many individual target species as possible. This is to ensure that we have good data to

potentially support the development of selected species to meet growing market demands.

- Requirements for re-opening a fishery/species that has been closed. This includes, for example, rules to support re-opening the black teatfish fishery and the need for accurate and daily reports. If total catch exceeds the TAC or data are not accurately recorded this will put future fishery openings at risk. For the sandfish species that was previously overfished, there are guidelines for supporting species recovery as well as how surveys (either full scale scientific surveys or smaller experimental surveys with local participation) can be used to inform whether the fishery could be re-opened.
- Potential for increasing TACs based on high-quality new and existing fishery data, including using extensive survey data.

Next steps

Following the success of the Fish Receiver System, the harvest strategy is the next step to ensure the TSBDMF remains sustainable for future generations. The harvest strategy has been a combined effort with extensive consultation with stakeholders. The draft harvest strategy was made available for stakeholder comment.

Executive summary

Australia’s Commonwealth Harvest Strategy Policy defines a harvest strategy 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 other key stakeholders utilise pre-agreed (and preferably pre-tested) rules as to how to adjust management actions given updates of data and/or model outputs about the fishery. The need to formalise a harvest strategy for the Torres Strait Bêche-de-mer (sea cucumber) Fishery (TSBDMF) has been the subject of some discussion at management forums (e.g. Hand Collectables Working Group; HCWG) and community meetings for some time. The new harvest strategy is currently being reviewed as part of a community consultation process, and will provide the platform for a transparent protocol, agreed on by stakeholders, for monitoring, information gathering, assessment and management into the foreseeable future.

This document summarises key information and results from CSIRO’s project to develop a harvest strategy for the TSBDMF. The report includes details of the latest version of the harvest strategy as well as providing additional Supporting Information to provide further background to reasons and justification for choices made, further scientific information as well as summaries of key stakeholder inputs.

This Report summarises progress made during four Harvest Strategy Development Workshops carried out in Torres Strait between June 2017 and July 2018 (Appendices 1, 2), usually in conjunction with Torres Strait HCWG meetings, the last of which was held at Aunty Norah’s Ark on Erub (Darnley) Island. The success and progress made during the workshops was largely due to the collaborative and enthusiastic participation and inputs from all stakeholders, and the project team thank everyone for their participation.

The TSBDMF Harvest Strategy (HS) sets out the management actions needed to achieve the agreed Fishery objectives. The HS describes the performance indicators used to monitor the condition of the stock, the analytical procedures and the rules applied to determine the recommended biological catch each fishing season.

The need to formalise a HS for the TSBDMF has been discussed at management forums (e.g. HCWG) for some time. In consultation with the HCWG, AFMA, TSRA, QDAF, Malu Lamar (Torres Strait Islander) Corporation RNTBC and other stakeholders, CSIRO have led drafting a scientifically-sound harvest strategy.

The HS describes a clear and transparent protocol, agreed on by stakeholders, for monitoring, information gathering, assessment and management into the foreseeable future. It applies to all Torres Strait sea cucumber species, with these classified into groups; closed/paused (recovering) species, target species, curryfish species (comprising 2 target curryfish species) and basket species (all other species lumped into a basket category).

The HS depends critically on fishery data provided through the Torres Strait Fish Receiver System that was implemented on 1 December 2017. It specifies the data that are needed to effectively manage the fishery and how these data will be used to adjust catch limits and manage the fishery to meet the biological, social and economic objectives.

The draft HS framework is a tier system which accounts for understanding that more data and more information reduce the risk of over-exploitation to a resource by reducing uncertainty around stock status and reduces the need for precautionary management. This means higher catch limits are possible if there is more, better quality data available.

It uses data from fishers and surveys (where available). Primary Indicators (in order of importance) from fisher data are:

a) Catch per species per day (including discards) converted to gutted weight (using revised conversion ratios compiled as part of the HS)
b) Catch Per Unit Effort (CPUE) – requires Effort (e.g. hours fished) to be recorded
c) Proportional composition of different species in catch if individual species mass not recorded
d) Size composition (per species) of representative catch sample
e) Area (and depth) each species was caught (preferably fine-scale information)

The HS includes different rules for the following cases:

1. Monitoring and adjusting TACs annually, with agreement that a fishery will be closed if no catch-reported data are provided.
2. Rules for managing mixed species/basket catch limits. Species specific monitoring is necessary to support future growth of the fishery. This requires as many target species as possible to be monitored as individual species. Species specific data collection will help support future development of selected species in response to growing market demands.
3. Rules for how to re-open a fishery/species that has been closed. This includes fisheries that have been closed due to overfishing (e.g. sandfish) or concerns about underreporting (e.g. black teatfish). There are guidelines for supporting species recovery and improved catch reporting as well as how surveys (either full scale scientific surveys or smaller experimental surveys with fisher participation) can be used to inform whether the fishery could be re-opened.
4. Rules for how to increase TACs if good quality fishery data are available and indicate an increase is possible.
5. Rules for how to further increase TACs if high quality survey data become available.

The framework also includes some static controls such as size limits and spatial closures to complement fishery management measures and other traditional community management initiatives (e.g. a proposed 10 nautical mile voluntary ban on fishing for prickly redfish around home reefs).

The HS meets the requirements of the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines 2018 (*HSP) by applying a precautionary approach as well as a tiered approach that applies different 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 HS development is an ongoing process, with the immediate requirement for some basic primary indicators which can be used in setting rules to inform first order decisions. Simultaneously the framework maps a pathway for ongoing improvements and refinements, through further data collection and a clear role for community-level data and local knowledge.

The HS has been developed in close consultation with stakeholders, incorporates local knowledge and has been designed to have regard to traditional knowledge and the ability for communities to manage fishery resources locally (e.g. voluntary spatial closures), through acknowledging and incorporating customary and traditional laws.

1 Introduction

The Torres Strait Bêche-de-mer (sea cucumber) Fishery (TSBDMF) (Figure 1) began in the late 1800s and continued up until about 1939 when it ceased production due to World War (WW) 2 and a decline in demand from China. It restarted on the Papua New Guinea (PNG) side of Torres Strait in the late 1980s, and on the Australian side in in about 1990. Sea cucumbers are mostly collected by free diving from small dinghies or collected by hand along reefs at low tide, and is an important commercial fishery to Torres Strait Islanders. Collected animals are processed in a range of ways that may include gutting, salting, boiling and drying. As a result of their easy accessibility, high value and benthic nature they are easily over-harvested. The value and demand for sessile marine resources such as sea cucumber is rising (Purcell et al. 2013) resulting in the general over-exploitation and even high extinction risk for some sea cucumber populations globally (Purcell et al. 2018; Purcell et al. 2014; Purcell et al. 2013), even in seemingly well managed fisheries such as in the GBR Marine Park (Eriksson and Byrne 2013; Plaganyi et al. 2015; Plagányi et al. 2015b; Purcell et al. 2015).

Echinoderms (translated as spiny skin) include starfish, sea urchins and sea cucumbers and are the largest marine phylum with no freshwater or terrestrial representatives. They occur throughout the world's oceans, predominantly along shorelines. Sea cucumbers (Echinodermata: Holothuroidea) have been termed the earthworms of the sea because of their important ecological role in bioturbation (Purcell et al. 2016). However, their calcareous skeletal structures are directly affected by seawater CO_2 concentrations and resulting ocean acidification (Dupont et al. 2010; Yuan et al. 2015).

Sandfish (*Holothuria scabra*) on Warrior Reef provided the bulk of the early catches in the fishery, which peaked at over 1200 t (wet gutted weight) in 1995. A survey in 1998 (Skewes et al. 2000a) found that the population was severely depleted and the sandfish fishery was closed. Subsequent surveys found a small recovery in the population, especially of the breeding cohort, but it is still considered heavily depleted (Murphy et al. 2011) and has remained closed. After the closure of sandfish in 1998, the fishery mostly targeted black teatfish (*H. whitmaei*), deepwater redfish (*Actinopyga echinites*), surf redfish (*A. mauritiana*), blackfish (mostly *A. miliaris*) and white teatfish (*Holothuria fuscogilva*). However, a survey in March 2002 found that black teatfish and surf redfish were probably overexploited (Skewes et al. 2003), and a prohibition on the harvest of these species was introduced in January 2003. A survey in 2009 found that the density of black teatfish had recovered to near natural (unfished) densities (Skewes et al. 2010b) and it was recommended that this species be reopened to fishing but with a modest TAC of 25t and community-based harvest strategies to manage the spatial effort of this species (Skewes et al. 2010b). Trial openings of the black teatfish fishery with a maximum catch of 15 tonnes were conducted in 2014 and 2015. However, on both occasions the catch limit was exceeded and the fishery was closed again. Given concerns regarding the effectiveness of catch monitoring systems, considerable effort has been invested in recent years in establishing a more reliable catch reporting system. As a result, the Torres Strait Fish Receiver System was implemented for the TSBDMF on 1 December 2017.

The need to formalise a harvest strategy (HS) for the TSBDMF has been the subject of some discussion at management forums (e.g. Hand Collectables Working Group - HCWG) and community meetings for some time. In consultation with the HCWG, AFMA, TSRA, QDAF, Malu Lamar (Torres Strait Islander) RNTBC and other stakeholders, CSIRO have led drafting a scientifically-sound HS. The development of a new HS agreement/document will provide the platform for a transparent protocol, agreed on by stakeholders, for monitoring, information gathering, assessment and management into the foreseeable future. The HS depends critically on fishery data provided through the Torres Strait Fish Receiver System that was implemented on 1 December 2017. It specifies the data that are needed to effectively manage the fishery and how these data will be used to adjust catch limits and manage the fishery to meet the biological, social and economic objectives.

Australia's Commonwealth Harvest Strategy Policy defines harvest strategies 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).

This report summarises progress made in developing a HS framework at a number of workshops held in conjunction with HCWG meetings, to collaboratively progress the development of a HS (workshop Agendas shown as Appendix 1 and HCWG meeting minutes available on request). The workshop included relevant stakeholders in addition to the HCWG members. The CSIRO project team – Éva Plagányi, Nicole Murphy, Leo Dutra, Natalie Dowling – supported by independent scientific expert Tim Skewes, facilitated discussions with participants in plenary and in small group discussions, and this report summarises some of the key discussion items. The report also provides some more in-depth background information pertaining to the HS under development.

The draft HS framework is a tier system (Figure 2) which accounts for understanding that more data and more information reduce the risk to a resource and reduces the need for precautionary management. This means higher catch limits are possible if there is more, better quality data available. The HS therefore meets the requirements of the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines 2018 (*HSP) by applying a precautionary approach as well as a tiered approach that applies different rules to cater for different amounts of data available and to account for changes to uncertainty on stock status.

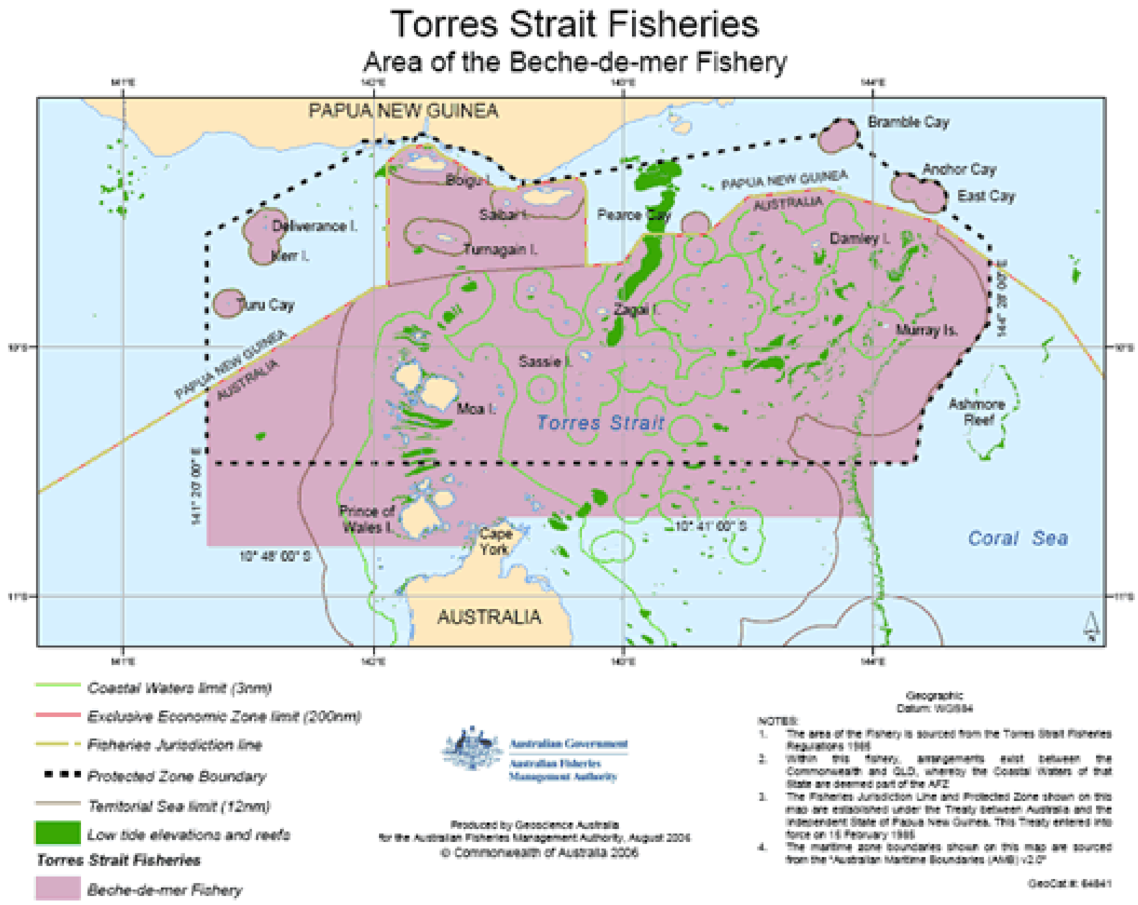


Figure 1. Map showing the Torres Strait Protected Zone and the boundary of the Torres Strait Beche-de-mer Fishery

1.1 Project Objectives

The CSIRO Harvest Strategy (HS) project, co-funded by AFMA, aims to develop and ratify a single harvest strategy for the Torres Strait Bêche-de-mer Fishery (TSBDMF) as per the design criteria in the Commonwealth Fisheries Harvest Strategy Policy and Guidelines. It will be focused on collating past management and research for sea cucumbers in Torres Strait, and establishing first order harvest strategy approaches such as global fishery TACs, size limits and temporal closures. It will include clear guidance for future sustainable fishing, the data requirements that underpin higher order management strategies, including indicators, reference points and decision rules, including data requirements for potential fishery expansion. Any harvest strategy development will need to be pragmatic given the limitations in terms of fishery operational characteristics, socio-economics and governance issues.

Initial discussions to provide an overview of harvest strategies, summarise biological and life history information on sea cucumber as well as results of previous studies, were held as part of a HCWG meeting on Thursday Island, 3 November 2016, under the following Agenda item:

Harvest strategy – getting information to inform the next steps

1.1. Overview of Commonwealth Harvest Strategy Policy

1.2. Environmental information relevant to understanding stocks status

1.3. Overview of previous management strategy evaluation work and examples of harvest strategy options

1.4. Industry fishing trends and objectives for the fishery

1.5. Work plan for Harvest Strategy

These discussions highlighted the need for improved data collection in particular, from both logbooks and a fish receiver system, with these data needed as inputs to inform on the status and trends in the fishery, and hence on appropriate management actions via decision rules that will form part of a HS. As the TSBDMF is relatively data-poor, so-called data-poor harvest strategy approaches (Dowling et al. 2008) will be used, but with a minimum criterion of not using subjective qualitative information only (i.e. quantitative catch estimates are a minimum requirement) and with a transparent pathway for incorporating additional data as these become available (i.e., embracing an adaptive approach).

The objectives of the subsequent HS workshops were to expand on these discussions, collate information on all aspects of the fishery, potential monitoring and data gathering options, discuss the operational and socio-cultural feasibility of a range of alternative management controls that could be used, and integrate all available information into a harvest strategy framework. The workshops aimed to explore both static management controls such as size limits and spatial and temporal closures, as well as adaptive approaches, such as using fishery data as inputs to rules for adjusting TACs. The latter also necessitated discussion as to whether the current TAC allocations are appropriate for individual and lumped species groups, and a number of associated logistical aspects were tabled for discussion, such as the need to accurately identify and record information on individual species to inform management at a species-specific level for key species. The workshop also introduced examples of decision rules that could be used as part of a HS, and these are continuing to be refined with stakeholder input. Where relevant, the results of previous studies are being used to evaluate the effectiveness of proposed approaches.

Simulation models are increasingly being used to evaluate alternative management approaches or harvest control rules, to identify the potential for trade-offs among fisheries management objectives, using the approach of Management Strategy Evaluation (MSE) (Butterworth and Punt 1999; Dankel and Edwards 2016; Pascoe et al. 2016; Smith et al. 2007). MSE approaches can serve as formal risk assessment methods, given their focus on the identification and modelling of uncertainties as well as in balancing different representations of resource dynamics rules (Plaganyi et al. 2013b; Rademeyer et al. 2007; Sainsbury et al. 2000). This includes consideration of the implications, for both the resource and its stakeholders, of alternative combinations of monitoring data, analytical procedures, and decision rules (Rademeyer et al. 2007; Sainsbury et al. 2000; Smith et al. 2007). By identifying and evaluating trade-offs in performance across a range of management objectives, it provides indicators on whether different objectives can be reconciled and whether the outcomes are robust to inherent uncertainties in the inputs and assumptions on which decisions are based (Cooke 1999).

Management Strategy Evaluation (MSE) has been used to evaluate management procedures for several bêche de mer fisheries in Australia (Plagányi et al. 2011; Plaganyi et al. 2015; Plagányi et al. 2013a) and these studies inform the current study. There are also a considerable number of surveys and other biological studies (Long et al. 1996; Skewes et al. 2000b; Skewes et al. 2002; Skewes et al. 2010a) conducted in Torres Strait which are being used to inform aspects of harvest strategy development. Finally, harvest strategies are also under development for other Torres Strait fisheries, namely finfish and the more data-rich tropical rock lobster fishery, and lessons learnt from these applications are also being used to inform development of harvest strategies for the TSBDMF.

2 Progress on Harvest Strategy Development

2.1 Specify Management Objectives:

The Protected Zone Joint Authority (PZJA) is responsible for management of commercial and traditional fishing in the Australian area of the Torres Strait. The PZJA objectives adopted for the TSBDMF are:

- to provide for the sustainable use of all sea cucumber stocks in Torres Strait;
- to develop sea cucumber stocks for the benefit of Australian Traditional Inhabitants (as defined by the Torres Strait Treaty); and
- to develop an appropriate long term management strategy for sandfish.

The HS workshops discussed modifying and extending these objectives to include mention of overarching objectives for the TSBDMF such as to acknowledge, empower and operationalise Native Title Rights and customary and traditional laws including Malo’s law of other communities. This also includes acknowledging and incorporating local knowledge and the ability to locally manage resources. The fishery objectives were therefore revised as follows:

- to provide for the sustainable use of all sea cucumber in Torres Strait to take account of long-term sustainability for future generations;

- to develop sea cucumber populations for the benefit of Australian Traditional Inhabitants (as defined by the Torres Strait Treaty) and accommodating commercial considerations;
- to acknowledge area-specific issues;
- where possible, to consider an ecosystem approach to management that reduces impacts on, or optimises interactions with, other harvested and dependent species; and
- to develop long-term recovery strategies for species, where appropriate.

The HS has been designed to have regard to traditional knowledge and the ability for communities to manage fishery resources locally (e.g. by applying voluntary spatial closures), through acknowledging and incorporating customary and traditional laws. It is recognised that there are differing cultural laws for individual nation groups which may be applied by communities to supplement fishery management measures. These include but are not limited to Malo ra Gelar (Malo's Law) of Kemer Kemer Meriam Nation, Saabi Law of Maluilgal Nation, Saabi Law of Gudumalulgal Nation, Kulkalgal Nation and Saabi Law of Kaurareg Nation.

2.2 Harvest Strategy Scope and Development

A harvest strategy (HS) for the TSBDMF needs to apply to all sea cucumber species (Table 1) but not other species such as trochus that are generally managed as part of the Hand Collectable Fisheries. The HS sets the criteria that pre-agreed management decisions will be based on in order to achieve the Fishery objectives. It will be a formal framework for guiding the overall management of a fishery rather than dictating day-to-day fishing activities or decisions. The HS outlines the decision rules used to develop advice on the recommended biological catch (RBC) and recommend Total Allowable Catches (TACs) (an enforced limit on total catches). Prior to the harvest strategy project, the TACs for most species were set based on conservative estimates of biomass from historical surveys.

The HS uses a tiered approach to cater for different amounts of data available and different species groups and types of assessments (for example target species with species-specific Catch-Per-Unit-Effort (CPUE) and surveys) (Figure 2). 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.

Hence there are pre-agreed transparent set of rules for making tactical management decisions including specifications for:

i. a monitoring program,

ii. the indicators to be calculated from monitoring data (usually via a stock assessment but this can be a relatively simple assessment for fisheries with limited data), and

iii. the use of those indicators and their associated reference points in management decisions, through application of decision (or control) rules.

Table 1. Summary of key bêche de mer (sea cucumber) species in Torres Strait, their minimum size limit and Total Allowable Catch (TAC) (Murphy et al. 2014) the commencement of the HS project, which has recommended changes to some of the size limits and TACs.

Common name	Scientific name	Commercial value	Minimum size limit (mm)	TAC (t)
Sandfish	*Holothuria scabra*	High	180	Closed
Surf redfish	*Actintopyga mauritiana*	Medium	220	Closed
Black teatfish	*Holothuria whitmaei*	High	250	Closed[#]
White teatfish	*Holothuria fuscogilva*	High	320	15[$]
Prickly redfish	*Thelenota ananas*	High	300	20
Hairy blackfish	*Actinopyga miliaris*	Medium	220	Part of 80t limit
Curryfish common	*Stichopus herrmanni*	Medium	270	Part of 80t limit
Elephant trunkfish	*Holothuria fuscopunctata*	Low	240	Part of 80t limit
Lollyfish	*Holothuria atra*	Low	150	Part of 80t limit
Deepwater redfish	*Actintopyga echinites*	Medium	120	Part of 80t limit
Curryfish vastus	*Stichopus vastus*	Medium	270	Part of 80t limit
Burrowing blackfish	*Actinopyga spinea*	Medium	220	Part of 80t limit
Deepwater blackfish	*Actinopyga palauensis*	Medium	220	Part of 80t limit
Golden sandfish	*Holothuria lessoni*	High	180	Part of 80t limit
Brown sandfish	*Bohadschia vitiensis*	Medium	nil	Part of 80t limit
Leopardfish	*Bohadschia argus*	Medium	nil	Part of 80t limit
Greenfish	*Stichopus chloronotus*	Medium	nil	Part of 80t limit
Stonefish	*Actinopyga lecanora*	Medium	nil	Part of 80t limit

***Size limits off PZ JA website – http://pzja.gov.au/the-fisheries/torres-strait-bêche-de-mer-fishery/**

[#]WG agreed Black teatfish has had some trial re-openings already but that it will not be re-opened again until the compulsory catch reporting is in place.

[$] WG discussed considerations for proposed allowance for hookah to use on White teatfish

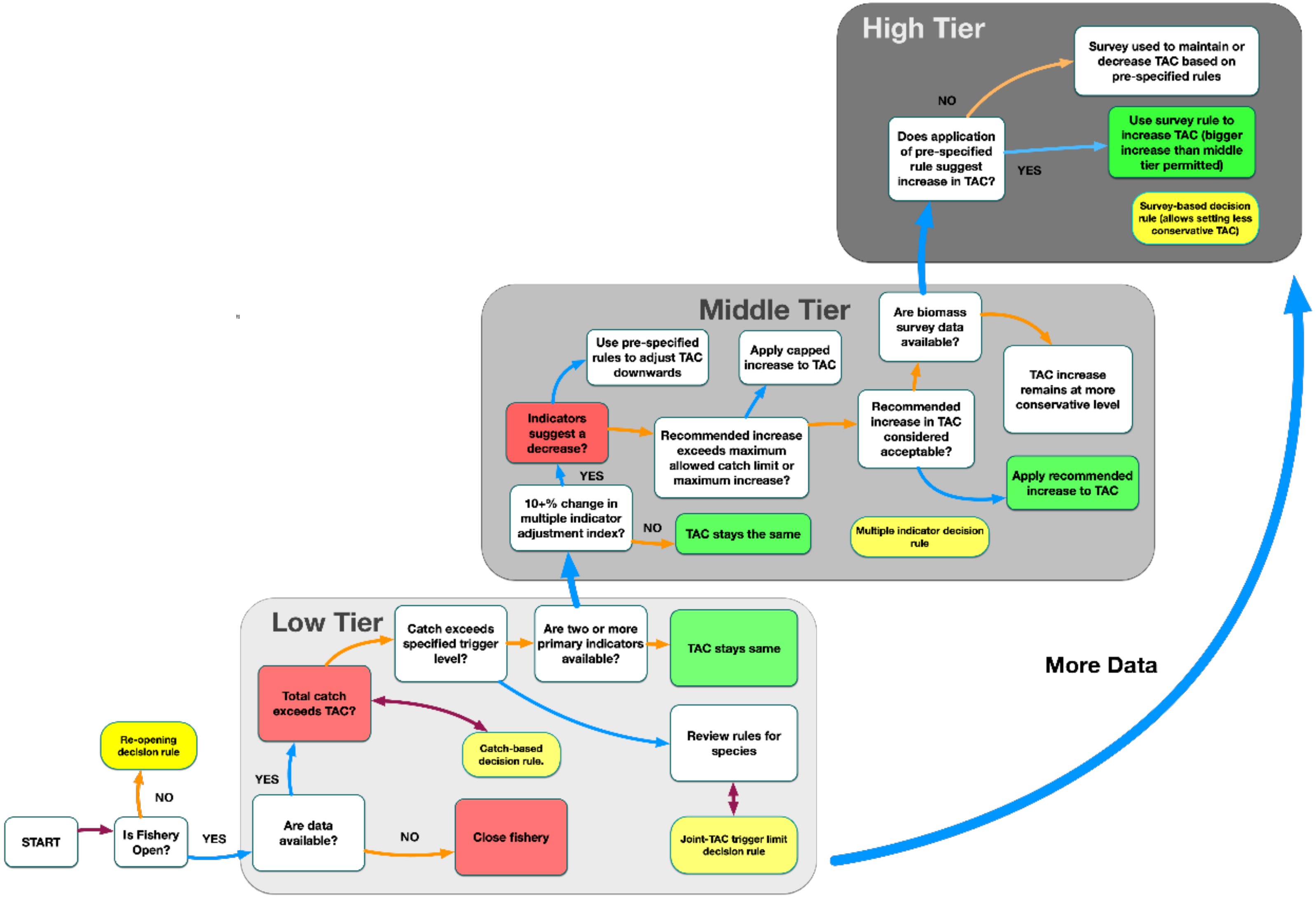


Figure 2. Schematic summary of tiered framework for Torres Strait Bêche-de-mer Fishery harvest strategy showing starting point with limited data at bottom left hand corner and pathways to move to higher tiers for cases with more data.

Summaries of small group discussions held at the workshops are provided in Appendix 1 and 2. Several summaries of Harvest Strategies and management considerations were provided during the project, including the following:

Harvest Strategy Basics

Harvest Strategies are tools to sustainably manage fish stocks to ensure the stock is available long-term and provides a good economic yield
Harvest Strategies set out the process on how to achieve this

COMPONENTS:

1. Indicator – something you can measure
2. Goal – measure success against this goal which is therefore a target
3. Critical limit – should never go below this point as too risky for resource
4. Specify how to move stock towards target and keep it there

How do we do this? Most important thing is to control fishing mortality so don't overfish (as this isn't sustainable) and don't unnecessarily waste resource, so on average want to aim for target level

How does it work for different stocks with more or less information and data

If we have less data then assessments need to be simpler and the harvest strategy needs to be more precautionary eg the aim might be to maintain catch rates at historical levels

With better information and data for a stock, a stock assessment model that uses all the information can be used

But stock assessments also differ – can be high quality vs more uncertainty in stock assessment:

- when more certain can approach more robustly
- but when less certain about stock status then need to be more precautionary as you have less certainty about stock status

Methods to manage a stock to be sustainable, profitable & socio-culturally supportable: BDM HS includes a mix of all three approaches:

1.
Effort Controls - limit fishers and limit times one can fish eg seasonal closures

2.
Spatial Management – limit where fish eg spatial rotation, closed areas

3.
TACs – limit total amount caught eg based on surveys

+ minimum size limit complements all approaches by allowing animals a chance to breed before being caught

Methods to manage a stock to be sustainable, profitable & socio-culturally supportable: BDM HS includes a mix of all three approaches for some of the reasons summarised

Effort Controls: limit fishers

- In theory good for data poor stocks where it is difficult to calculate catch and to assess stock status relative to reference levels
- BUT TS has open access so can't easily limit numbers participating (ie need to also satisfy social objective) and BDM are easy to catch so even a few operators or short season could still deplete resource – problem is that some species are highly valuable which makes the management harder
- Can complement management by considering temporal closures (eg spawning season), re-opening fisheries during times when participation more controlled (eg align TRL&BDM seasons) & consider culturally appropriate ways to restrict access for small biomass high value species

Spatial Management – limit where fish

- Research demonstrates spatial rotation strategies work well for BDM, but difficult to implement large scale across entire TS region – close 2/3rd of fishing area every year which limits access spatially by some fishers? But could work if community-controlled or even smaller reef scale
- Closed areas – closures around home reefs as proposed are beneficial to allow recovery – ideally need series of small closed areas around TS but participants have queried how compliance could work
- Need equity re closures

TACs – limit total amount caught

- TACs work well for fisheries with good reliable data collection so that is the major challenge, but for the more valuable target species there's no reason it can't be done, and less valuable species can be lumped into a joint category and revised if demand increases for a species
- If adhered to, TAC limits total take and there is a sound basis from surveys for computing conservative sustainable levels – especially for high value species eg BTF – only other option is to close fishing area for 3-5 yrs between fishing but would still be risky if no limit on catch as stock could drop too low for re-seeding of area in nonfished yrs
- But for data poor stocks it is hard (& can't be done with too few data) to evaluate stock status relative to reference levels and adjust TACs accordingly, so TACs need to be more conservative

+ minimum size limit complements all approaches by allowing animals a chance to breed before being caught

3 Draft TSBDMF Harvest Strategy Framework

A Harvest Strategy (HS) needs to include the following components (Dowling et al. 2015):

1. Indicators (data from the fishery; Docket books & Logbooks)
2. Reference points (targets and limits, and/or intermediate triggers; Stock biomass, Fishing mortality)
3. Monitoring (agreed protocols to obtain data; Population surveys, Size/age monitoring)
4. Method of assessment (Stock assessment, Catch per Unit of Effort (CPUE) trends, Species composition changes)
5. Decision rules (agreed rules for setting catch levels; called Harvest Control Rules)

The HS framework (Figure 2) encapsulates the principles of a tier system whereby it is acknowledged that more data and more information reduce the risk to a resource and hence reduce the need for precautionary management such that higher catches are possible.

The schematic in Figure A.1 was developed based on inputs from participants at the June 2017 workshop, and shows the connections between the different components which collectively constitute the harvest strategy. It acknowledges that development of a harvest strategy is an ongoing process, with the immediate requirement for some basic primary indicators which can be used in setting rules to inform first order adjustments needed. Simultaneously the framework clearly maps pathways for ongoing improvements and refinements such as through further data collection as well as a clear role to contribute community-level data and local knowledge.

3.1 Monitoring and data collection to determine indicators

The HS framework encapsulates the principles of a tier system (Figure 2) whereby it is acknowledged that more data and more information reduce the risk to a resource and hence reduce the need for precautionary management such that higher catches are possible. The early framework shown in Figure A.1 summarised the following aspects that workshop participants agreed:

1. If there are no data (red shading = lowest tier) provided for the TSBDMF fishery (species-specific or for a group) then no quota should be allocated. There was also strong support for the right of a TIB license holder to have access to the resources to be contingent on the provision of data.
2. Next, the basic data, (together with monitoring methods) that need to be collected for use as primary indicators are shown in light green shading: the most critical data

are total catch per species as well as Catch Per Unit Effort (CPUE) (which could be measured as total catch per species per day or similar measures such as the number of tubs per day). If data are accurately recorded in logbooks, then other useful indicators can be derived, such as the spatial footprint of the fishery (e.g. whether the area fished or depth fished is expanding, species composition and discard mortality). Representative (species-specific) size frequencies from samples of catches were identified as another useful primary indicator. For species subgroups where it might be difficult to accurately record the composition of the catch, participants suggested that other methods could be used, such as photo samples of catches to be analysed by experts.

3. The next step up in the tier system would be to use scientific or community-based surveys (dark green shading = top tier) to provide fishery-independent data (e.g. biomass surveys) for use as an indicator of relative abundance and density of key species.
4. Finally, there is considerable potential for local community collection of additional data (turquoise) which could be used as secondary indicators. A draft community-level multiple indicator framework was developed at the June 2017 workshop (see Appendix 2 for fuller description) based on local knowledge and provides a platform for establishing and implementing a spatial multiple indicator status categorisation and corresponding colour-coded strength of adjustment. As local depletion is a concern for bêche-de-mer fisheries, this community-based monitoring and feedback system could improve sustainable management of stocks in community clusters and thereby empower local recommendations from communities as well as facilitate self-organisation of allocations amongst community clusters. Over time, demonstrated success in implementation could see these indicators being upgraded to primary indicators for use in decision rules.

The framework therefore acknowledges that development of a harvest strategy is an ongoing process, with the immediate requirement for some basic primary indicators which can be used in setting rules to inform first order adjustments needed. Simultaneously the framework clearly maps pathways for ongoing improvements and refinements such as through further data collection as well as a clear role to contribute community-level data and local knowledge. In addition, consistent with the proposed fishery objectives, participants encouraged development of a management system that also included community-enforced or community-regulated local spatial or temporal exclusion bans where appropriate – for example the proposed 10 nm ban on fishing for prickly redfish around home reefs, with devolved responsibility to native title holders.

3.1.1 **MONITORING**

The TSBDMF is monitored by a range of methods listed below. Currently there is no ongoing monitoring strategy in place to collect economic information. In addition, very limited historical fishery-dependent monitoring data are available because catch reporting was only made compulsory in December 2017, and it is anticipated that there will be a time lag before reliable catch and effort data are available for analysis. Hence the HS outlines a starting point in terms of data collection, analysis and use to inform decision making, but this may need to be revised as more data and data needs arise. Hence it is acknowledged that development of a harvest strategy is an ongoing process, with the immediate requirement for some basic primary indicators which can be used in setting rules to inform first order decisions. Simultaneously the framework will clearly map a pathway for ongoing improvements and refinements, such as through further data collection as well as a clear role for community-level data and local knowledge.

3.1.2 Fishery independent surveys

There are a considerable number of surveys and other biological studies (Long et al. 1996; Skewes et al. 2000b; Skewes et al. 2002; Skewes et al. 2010a) conducted in Torres Strait which have been used to inform aspects of harvest strategy development. Previous surveys have included a high level of interaction with Torres Strait Islanders, both in the design and carrying out of the survey, and interpretation of results. For example, in 2009 a trochus and bêche-de-mer survey training workshop was held to introduce Torres Strait Islanders to the survey and stock assessment methods used in research and management of these fisheries. The workshop also endeavoured to gain an understanding of Islander knowledge and skills, and identified knowledge gaps in biology, ecology and understanding of research in Torres Strait (Murphy et al. 2009).

Fishery-independent surveys are not a compulsory component of the HS but are highly recommended where appropriate to inform decisions related to whether increases or decreases in TACs may be warranted, or to inform decisions regarding trial re-openings. Considering the costs of surveys relative to the value of the fishery, its multispecies nature and spatial heterogeneity, there are a range of different survey types that could be used as inputs to the HS. These include:

1. Small-scale experimental fishing surveys with local fisher participation and possible cost-recovery via fishers being permitted to sell animals surveyed (e.g. Warrior Reef sandfish experimental fishing survey, 2012);
2. Species-specific dedicated surveys (which could be conducted by fishers and/or scientists) and are tailored to effectively survey stocks that are not otherwise easily included in more general surveys, e.g. white teatfish (due to depth), black teatfish (due to high value and sensitivity to overexploitation), deepwater redfish (restricted distribution)
3. Full-scale scientific surveys conducted over a large representative area and surveying multiple species.

Ideally any survey design needs to be tailored based on information for each species, habitat, fishery and population status, as per example shown in Table 2. There are a number of existing protocols for survey design based on previous surveys and it is recommended that these be adhered to in designing future surveys for use as inputs to the HS. This is also to ensure that new data are consistent with and comparable to historical information and can therefore be used as an index of relative abundance (see decision rules). Relative abundance is usually measured using site counts at repeated survey sites. Analyses may include an assessment of recruitment from site counts and size frequency data, a technique that has been shown to be viable from previous surveys. Estimates of gross environmental parameters such as seagrass and coral cover, can also usefully be collected during surveys, not only for assessing the effects of fishing, but for extending previous habitat survey data.

Surveys need to be undertaken at similar times to previous surveys to coincide with seasonal and lunar phase cycles of sea cucumber activity. This reduces differences in survey observer rates that may result from changes in sea cucumber burrowing behaviour, due to seasonal and tidal factors and can better detect changes in sea cucumber population abundance.

Most surveys will yield an index of relative stock abundance, but some of the above survey designs could also be used to estimate total standing stock biomass or average density (Table 3). To be useful for management, surveys need to demonstrate that they are conducted in an adequately representative manner and underpinned by scientific principles, and hence all references to survey data in the HS assume that the survey design and execution have been approved by qualified scientific expertise.

3.1.3 **Analysis of survey data from other sources**

Other potential sources of sea cucumber density and distribution data include annual (and sometimes bi-annual) tropical rock lobster surveys (Dennis et al. 2015; Plagányi et al. 2019) and benthic biogeography surveys (Pitcher et al. 2007).

Historical data from Tropical rock lobster surveys carried out since 1998 were reanalysed to provide information on inter-reefal (deep water) distribution and population density estimates for commercially important species, especially those recognised as increasing in commercial importance (e.g. curryfish species). Although there are limited data and the survey was not designed for sea cucumbers as such, the spatial data records are being analysed to determine whether they provide any new insights into the spatial distribution of the different species to complement previous information form sea cucumber surveys. Any additional information will be incorporated into the revised Identification Guide (based on Murphy et al. 2014), and will be used to complement existing survey data.

Deeper (inter-reefal) biogeographical surveys carried out in the mid 2000’s could also potentially be a source of information about deep water populations, however, the identification of sea cucumbers during this project was limited. Future sea cucumber stock assessment projects may include an analysis of this data.

Table 2. Summary of Sea cucumber Species ecology, status and sampling approaches that could be used to support the Harvest Strategy.

Species (value)	Location/habitat	Fishery status	Population status	Approach
Sandfish **(high)** ***Holothuria scabra***	Sandfish are almost exclusively found on Warrior Reef. It is a shared stock with PNG, with approximately half the population on each side. Muddy-sand seagrass beds and reef flats 0.5-20m	The Australian fishery was closed in 1998, after a few years of heavy fishing pressure. The PNG sandfish fishery was closed in 2009, after it was severely depleted. It has recently reopened but we have really no idea what is happening there.	The virgin biomass of the entire population was likely in the order of 6,000 tonnes (landed weight) or more. On the Australian side, several population surveys have been carried out since, the most recent being in February 2010 (survey) and March 2012 (Experimental fishing). While there is a significant population of sandfish on Warrior Reef, there did not appear to a full recovery of the population at that time.	The most efficient way to determine the current status of the stock is to carry out a stock survey of Warrior Reef. Surveying the PNG side at the same time would provide a whole of population stock status estimate. Requires careful consideration of diurnal, seasonal, tidal and moon phase survey timing due to burrowing. Therefore, needs a dedicated survey.
Black teatfish **(high)** ***Holothuria whitmaei***	Found on the shallow reefs of east Torres Strait. It is almost entirely an Australian population. Reef flats, reef fronts and between reefs 1-20m	The Australian fishery closed in 2001, after a decade of fishing pressure. This species has been recently reopened after a decade long closure, based on survey data from 2009. It has been fished in 3 of the last 6 years under a conservative TAC of 15 t.	The 2009 survey indicated that the BTF population had recovered to near virgin biomass levels. The fishing effort since the fishery has reopened has not been large (even though annual quotas have been exceeded in years that it has opened). There are anecdotal reports of high densities in east Torres Strait.	Stratified dive survey of shallow reefs in east Torres strait.

Species (value)	Location/habitat	Fishery status	Population status	Approach
White teatfish **(high)** ***Holothuria fuscogilva***	This species is found in deeper reef edge and pass waters in far east Torres Strait. There is no evidence it is found in deeper open water habitats (e.g. Torres Strait pipeline survey). Lagoons and passes on pavement or sand 3-40m	Catches have been modest over the years, and below the recommended TAC. The current ban on hookah gear in the fishery limits the susceptibility of the population to fishing.	Currently uncertain but likely to be above sustainable limits, due to inaccessibility of most of the population.	This species is difficult to survey as it is found in deeper reef edge and pass waters. A survey using remote cameras could be trialled (as a pilot study first). A targeted sample design would be essential for a feasible survey approach, using previous survey and fishery data. Habitat estimation will also be a critical component of this study. Note: This species is also the focus of an effort to carry out a survey on the Qld east coast fishery.
Prickly redfish **(medium)** ***Thelenota ananas***	This species is found in reef edge and pass waters in east Torres Strait. Lagoons, in areas with rubble and passes 1-35m	This species has been heavily targeted in recent years, with a likely overshoot of the TAC.	The most recent survey in 2009 indicated that the population was above sustainable population levels. However, the population has been heavily targeted in recent years. There are anecdotal reports of at least localised depletion. There is the possibility of some protection of this species due to deep water populations.	Stratified dive survey of reef edges and passes in east Torres strait. This information would be comparable to previous surveys. Deeper populations could also be investigated using remote cameras.
Surf redfish **(medium)** ***Actinopyga mauritiana***	High energy zone on the front of east Torres Strait reefs. Murray Island, Don Cay 0-10m	This species is currently closed. Catches of deepwater redfish was mistakenly reported as surf redfish early in the modern Torres Strait fishery.	Generally unknown. Previous survey data is uncertain due to sampling difficulties and identification problems. There have been anecdotal reports of high densities of surf redfish in east Torres Strait reefs.	Difficult to survey due to high energy habitat and cryptic nature. Will require a dedicated survey approach – of one can be formulated that is feasible.

Species (value)	Location/habitat	Fishery status	Population status	Approach
Deepwater redfish **(medium)** ***Actinopyga echinites***	Shallow reef habitat in central Torres Strait and Warrior Reef. Coastal reef in rubble, seagrass beds or sand between corals 0-10m	Unknown	Unknown	Stratified dive survey of shallow reefs in central Torres strait and Warrior Reef
Blackfish (possible 3 species) **(medium)** ***Actinopyga miliaris*** ***A. spinea*** ***A. palauensis***	Broad distribution. High density on shallow reef habitat in central Torres Strait and Warrior Reef. Muddy-sand lagoons, reef flats, fore reef pavement 1-20m	Unknown	Unknown	Stratified dive survey of shallow reefs in east Torres strait and Warrior Reef. Species ID an important component of research.
Curryfish (3 species) **(medium)** ***Stichopus herrmanni*** ***S. vastus*** ***S. ocellatus***	Protected reef edges in central, east Torres Strait and Warrior Reef.	Currently being heavily targeted.	Unknown? Initial large population estimate for common curryfish (*S. herrmanni*) but lowered for other species.	Stratified dive survey of protected reef edges in central and east Torres strait and Warrior Reef.

Table 3. Average density (per ha) of sea cucumbers sampled at 122 repeated sample sites in eastern Torres Strait during the 2002 and 2005 abundance surveys (Skewes et al. 2010)

Species	Common name	Average density (per ha)		% change
		2002	2005	
All sea cucumber		150.94	153.28	1.6
High value		18.03	14.74	-18.3
Med value		55.99	53.93	-3.7
Holothuria whitmaei	Black teatfish	4.00	3.08	-22.8
H. fuscogilva	White teatfish	5.43	3.57	-34.1
Thelenota ananas	Prickly redfish	8.61	8.09	-6.0
Actinopyga miliaris	Blackfish	1.64	3.79	131.3
A. lecanora	Stonefish	0.10	0.00	-100.0
A. mauritiana	Surf redfish	1.02	0.00	-100.0
A. echinites	Deep water redfish	1.43	0.51	-64.3
All Actinopyga		4.20	4.30	2.4
H. atra	Lollyfish	25.60	33.91	32.5
H. fuscopunctata	Elephant trunkfish	15.30	15.43	0.9
H. coluber	Snakefish	0.61	4.41	616.7
H. edulis	Pinkfish	30.79	27.97	-9.2
Bohadschia graeffei	Flowerfish	3.59	3.72	3.8
B. argus	Leopardfish	12.91	11.32	-12.3
Stichopus chloronotus	Greenfish	23.16	24.71	6.7
T. anax	Amberfish	2.56	2.59	1.3
S. herrmanni	Curryfish	10.60	10.18	-4.0
H. leucospilota		1.54	2.56	66.7

3.1.4 Catch and effort information

Fishers are required to record catch information as part of the mandatory Fish Receiver System. This includes reporting the total gutted weight of each species landed, as well as the processed stage so that conversion ratios (see Appendix Table A.4) can be used to convert all catch measures to landed (gutted) weight (which is the measure used to assess the biological impact on the stock). It is essential that these records also include an accurate estimate of the total discards (which includes product lost due to processing losses). It is important to separate total catch into the different species and record species names as accurately as possible. Where there is uncertainty regarding accurate species identification, it is recommended that representative photos of the catch be taken for later identification (e.g. with the assistance of scientists or experienced industry persons) and the catch record reference needs to be stored with the photos. For species such as curryfish with a mixed bag of similar species (and in instances where it isn't practical to separate the species due to handling and processing constraints), the proportion of each individual species (in particular *Stichopus hermanni* and *S. vastus*) should be estimated (noting that several fishers have indicated they are able to distinguish these species in a variety of product forms – alternatively, representative photos of the catch should be provided).

As part of the data recording process, the area where the sea cucumbers were caught needs to be recorded as accurately as possible. Although it is important to know where catch is landed and by whom, for scientific assessments, information about the location (e.g. even if within say 5km) where the sea cucumbers were caught is extremely valuable. If high quality area-specific and depth information are recorded, these data could be used as inputs to the decision rules described below.

Although it is not currently compulsory to record fishing effort, this is a key measure that is used to calculate the Catch-Per-Unit-Effort (CPUE) which can serve as an index of abundance and hence inform on stock status and trends. High quality CPUE data are needed as inputs to decision rules that can be used to adjust TACs upwards or downwards. If no regular fishery-independent (survey) data are available, high quality CPUE provide a valuable input that can be used to support decision making. The default unit of effort is assumed to be one day, but data quality can be improved by recording the total number of hours per trip (corresponding to the catch landed), and number of fishers in the vessel. For these reasons, it is also required that total catch be recorded on a daily basis, rather than accumulating catch and completing a single data entry for more than one day's fishing.

For some high value target species or species with a restricted distribution, the CPUE data are expected to index a single species only, and this should be obvious from the data entries submitted. For catches comprised of mixed species, the total catch and effort information are still useful provided an accurate breakdown of the component species is provided. If a fishing trip involved targeting different species or areas, data would be most useful for analyses if an estimate is provided of the total time spent on different activities.

Note also that for high value species such as black teatfish, there are additional constraints imposed on the recording of catch information as detailed in this HS document.

3.1.5 **Catch sub-sampling information**

Additional data that are required as inputs to decision rules for use in adjusting TACs include estimates of the size distribution of individual species caught. It isn't necessary to measure every animal caught, but accurate measures of the length and mass of a representative (by area and species) sub-sample is important as an input to the decision rules. Size frequency sub-sample information could be collected by volunteers, nominated fishers or trained fish receivers. These data could also be complemented by additional detailed information such as the proportion of each species comprising a mixed bag catch.

Information based on local knowledge and the ability to locally manage resources

The stated objective of acknowledging and incorporating local knowledge and the ability to locally manage resources has been achieved to some extent as all elements of the HS, developed in close consultation with Traditional Owners, have been informed by local indigenous knowledge:

- For example, species targeted, processing challenges, discard rates, areas fished, species distribution
- Local knowledge has informed which strategies are likely to be successful and implementable
- Local knowledge being used to propose additional management measures, such as voluntary spatial closures for sensitive species

In addition, customary practices are being acknowledged and included as "voluntary" (i.e. self-managed) components of the HS.

The HS will be subject to periodic reviews and updates, and hence there will be ongoing opportunities to refine and improve the HS in future. Summaries of local knowledge, observations, preferences, outcomes of local management practices such as community-specific closures and spatial rotations as to where fishing takes place should all be recorded (e.g. via the HCWG) and could be used in an iterative manner to continually improve the HS and ensure customary practices receive appropriate acknowledgement.

3.2 Species classification

The HS recognises that the TSBDMF fishery is a multispecies fishery comprising species with different life histories, economic value, distributions and fishing pressure. All species were therefore assigned to one of 5 species categories initially, but this was later simplified down to 4 categories (after combining highly targeted and target species into a single target species category) as described in Table 4 and Fig. 3.

Table 4. TSBDMF species category definitions (see Table 1 for list of scientific species names)

	Species in category	Category definition
Closed/Paused (recovering)	sandfish, surf redfish	Overfished species on recovery plan; need survey to evaluate if recovered sufficiently to reopen
Target species	black teatfish, white teatfish, prickly redfish, hairy blackfish, deepwater redfish, greenfish	High value target species with own individual TAC and that may require specialised assessment and monitoring methods
Curryfish	3 curryfish species	Increasingly targeted curryfish species
Basket species	all other species	Remaining species lumped but with trigger to identify species of growing commercial interest

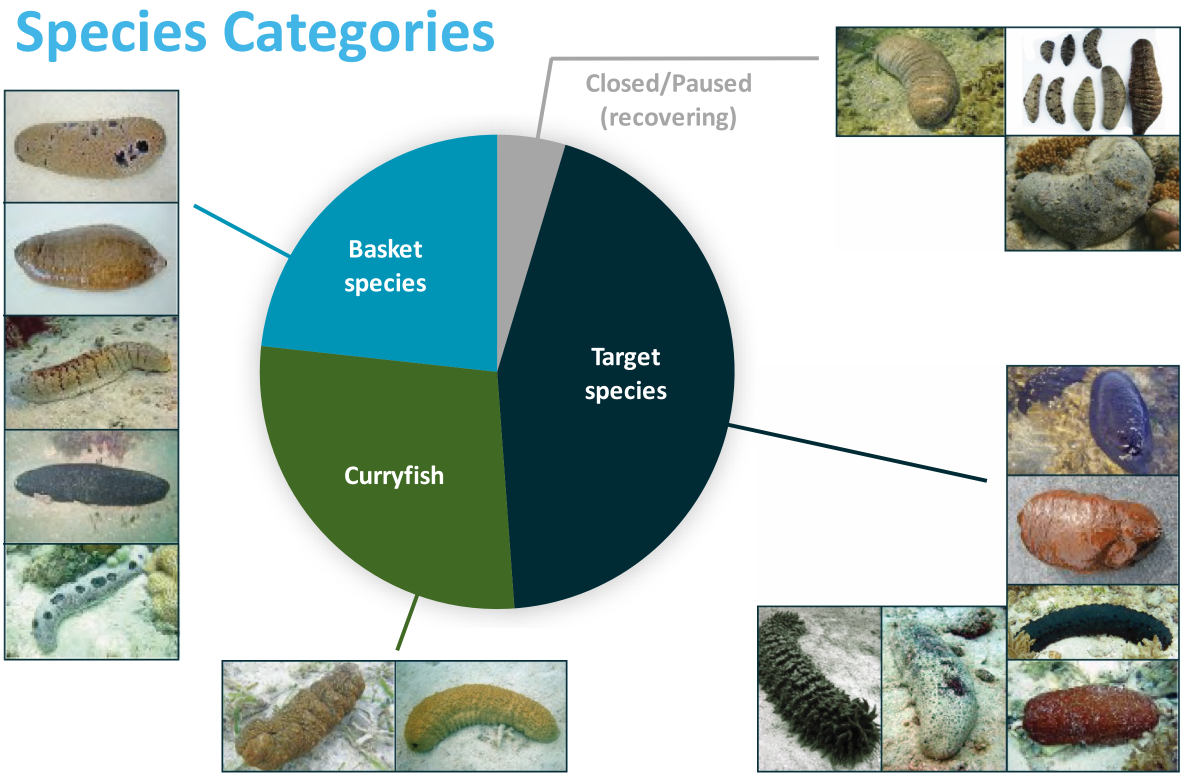


Figure 3. Summary of species classification used in HS.

3.2.1 Total Allowable Catch (TAC)

A critical requirement for the HS is that the right policies are in place to support data collection. The Fish Receiver system is therefore an integral part of the HS. The HS therefore assumes that there is accurate data collection and compliance with pre-agreed decision rules as outlined in this document. As this is an advance on previous practises, adoption of the HS means that it is possible to set slightly less conservative TACs for stocks, consistent with the underlying philosophy of the tier system. The HS includes recommendations for changes to the current TACs (Table 5), with these changes also reflecting the revised classification of the component fishery species into categories as shown in Figure 3. Changes in market value and demand mean that several additional species were identified as needing to have specific TACs or triggers (with associated actions). These include curryfish, greenfish, hairy blackfish and deepwater redfish (Table 5). Systems such as the AFMA catch watch are recommended for use to alert fishers when approaching the TAC

Table 5. Harvest Strategy TAC recommendations

Common name	Scientific name	Value	TAC (t)	Recommended Starting TAC (t)	Basket triggers	Note re trigger	Max TAC level (based on indicators) before needing survey	Max recorded historical catch and year (not necessarily sustainable catch)
Sandfish	*Holothuria scabra*	High	Closed	Closed			5	200t (1994)
Surf redfish	*Actintopyga mauritiana*	Med	Closed	Closed			5	60.2t (1998)*
Black teatfish	*Holothuria whitmaei*	High	Closed	Trial 15t			25	52.7t (1996)
White teatfish	*Holothuria fuscogilva*	High	15	15			20	16.3t (2014)
Prickly redfish	*Thelenota ananas*	High	15 (reduced from 20)	15			20	28.1t (2015)
Deepwater redfish	*Actintopyga echinites*	Med	Part of 80t limit	5#			40t based on surveys	5.5t (2015)*
Hairy blackfish	*Actinopyga miliaris*	Med	Part of 80t limit	5			10 (lower CI survey as uncertain)	28.5t (2001)
Greenfish	*Stichopus chloronotus*	Med	Part of 80t limit	40t			40	1.2t (2002)
Curryfish common	*Stichopus herrmanni*	Med	Part of 80t limit	60t curryfish			60 (herrmanni)	6.1t (2015); 15t (mid-2018)
Curryfish vastus	*Stichopus vastus*	Med	Part of 80t limit	60t curryfish	15	new trigger	20 (vastus)	see curryfish
Elephant trunkfish	*Holothuria fuscopunctata*	Low	Part of 80t limit	Part of 50t limit	15	existing value	15	0.4t (2004)
Lollyfish	*Holothuria atra*	Low	Part of 80t limit	Part of 50t limit	40	half existing	80	0?
Burrowing blackfish	*Actinopyga spinea*	Med	Part of 80t limit	Part of 50t limit	5	trial new species	10 (survey eg high around Warrior)	0
Deepwater blackfish	*Actinopyga palauensis*	Med	Part of 80t limit	Part of 50t limit	0.5	previous catch	10	0.5t (2001)*
Golden sandfish	*Holothuria lessoni*	High	Part of 80t limit	Part of 50t limit	0.5	previous catch	5	0.35t (2014)
Brown sandfish	*Bohadschia vitiensis*	Med	Part of 80t limit	Part of 50t limit	3	previous catch	5	3.4t (2002)
Leopardfish	*Bohadschia argus*	Med	Part of 80t limit	Part of 50t limit	40	existing value	40	9.6t (2003)
Stonefish	*Actinopyga lecanora*	Med	Part of 80t limit	Part of 50t limit	5	existing value	5	0.5t (2010)
TOTAL			110t	205t$				

$ including trial openings for black teatfish   #catches over 2013-15 approx 5.5t/yr   *possible misidentification

3.3 Reference Points

There are no adopted proxies consistent with the Commonwealth Fisheries Harvest Strategy Policy and Guidelines (HSP) for the TSBDMF, and it isn't necessarily sensible to derive these because of the highly variable nature of the fishery as well as the cost-benefit relationship when considering the large spatial area that would need to be reliably assessed for relatively small catches of some species. However, the current TACs are set conservatively and in that respect reflect an intention to meet the HSP. Moreover, some of the proxies used in the HS are fairly conservative and consistent with the HSP.

Nonetheless, where required, proxies for reference points were based on Plagányi et al. (2015) as follows:

- The unfished biomass B_0 – defined as the pristine or survey-based spawning biomass estimate, noting however that with large recruitment variability, it is possible for populations to exceed B_0 in some years, or conversely appear depleted in other years, even in the absence of fishing.
- The limit biomass B_{LIM} – a more conservative value (than the default harvest strategy limit reference point of $0.2B_0$) of $0.4* B_0$ is used. Where available, survey data are used to select a lower limit reference level below which stock density is considered unacceptably low and the fishery should be closed – see example in Re-opening Decision Rule section below. A threshold limit can also be specified as the level above which the fishery is allowed to re-open.
- The target biomass B_{TARG} – it's difficult to define a proxy for the HSP target because of the large natural variability (both in time and space) and insufficient data. For some species such as sandfish an estimate can be obtained based on historical survey data and/or comparison with densities in less fished areas.
- F_{TARG}, F_{LIM} and F_{MSY} – as above, it is difficult to derive sensible estimates of these quantities, and none currently exist. It is also difficult to estimate fishing mortality in practice because accurate catch records are needed, as well as regular assessments of resource status. Some of the TAC estimates are based on applying default fishing mortalities to conservative biomass estimates based on historical surveys.
- HS analyses are also informed by existing data on the average density (per ha) of sea cucumbers sampled at 122 repeated sample sites in eastern Torres Strait during the 2002 and 2005 abundance surveys (from Skewes et al. 2010).

The HS is tailored to the specific data available for this fishery, and a range of indicators are used to inform on the status of each species. Whether or not the status is considered good, bad or average for example, depends on comparison with agreed Reference Points as specified below – for example if total catch exceeds a pre-specified limit or CPUE is below a pre-specified limit reference level then it may mean that species is being fished too heavily. An assessment process is therefore needed to assess the current status and trends in the biomass of each species. A decision rule is then used to describe what action is needed to adjust catches to achieve desired targets and satisfy the overall fishery objectives.

3.4 Decision Rules

To manage the TSBDMF stocks to be sustainable, profitable, and socio-culturally supportable, the HS includes a mix of compulsory and voluntary community managed (through cultural protocols) approaches as described above:

1. Effort controls to limit fishers and limit times one can fish;
2. Spatial management (limit where to fish (e.g. spatial rotation, closed areas))
3. TACs: limit total amount caught, e.g. based on surveys
4. <u>PLUS</u> minimum size limit complements all approaches by allowing animals a chance to breed before being caught.

A summary of the harvest strategy framework is provided below, and includes Decision Rules specified based on an overall Tier Structure (Figure 2) as well as tailored for different species categories as shown in Figure 4.

Low tier:

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

Middle tier:

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

High tier:

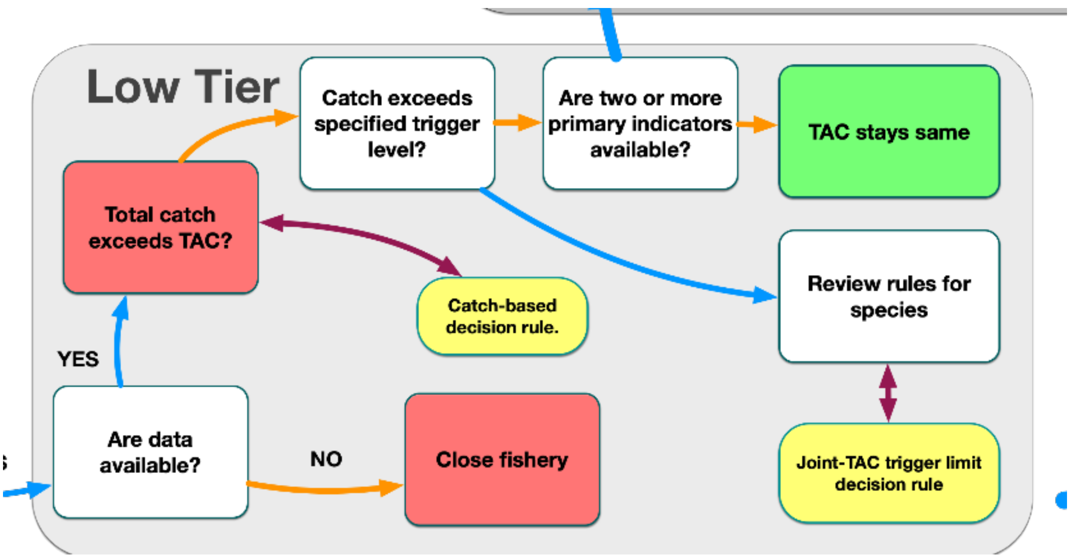
5. Survey-based Decision Rule

Below the different decision rules for the Fishery Harvest Strategy are described in more detail (and accompanied where relevant with graphical representations). The decision rules are presented sequentially from the lowest tier to the top tier, and the mapping between rules and species categories is also summarised in Table 4.

Figure 4. Schematic showing mapping of the different species categories to the different HS decision rules

It was noted at the workshop that there are a number of existing approaches which would be suitable for adoption in this fishery. Below is a short summary of the basis and justification for selecting different decision rules under different circumstances.

3.5 Low Tier Decision Rules



3.6 Low Tier Catch-Based Decision Rule

This is a low tier rule that is applied to all species in the absence of data other than total annual catch per species (Figure 5). The rules were designed based on feedback from stakeholders to allow the carry-over of a small TAC overshoot, as well as imposing increasingly stringent penalties where total catch exceeds the recommended biological catch.

- If no reliable catch reported data then TAC = 0
- If exceed by <20% then carry over catch and subtract from following year's total
- If exceed by >20% and <100% (double) pause fishing 1 year
- If exceed by more than double, close fishery

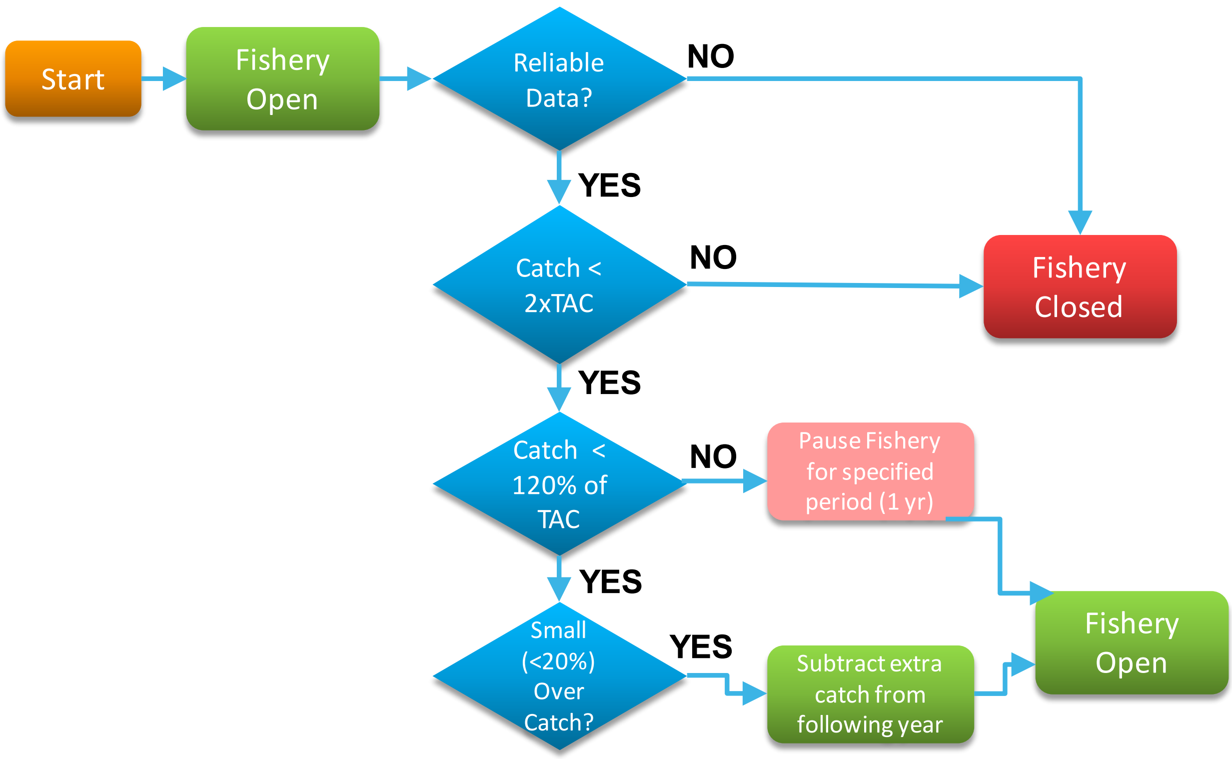


Figure 5. Flowchart summarising low tier catch-based decision rule

3.7 Low Tier Joint TAC trigger-limit Decision rule

This is a low tier rule that is applied to combined and basket species (Figure 6):

- Compute the total catch (including discards) of all species in the group

- Compute the estimated total catch of each species, either from direct species-specific catch data or from (representative) catch samples used to infer proportional abundance of different species
- If the catch of any species exceeds the species-specific trigger (Table 3) by more than 10%, then collect data and information to decide whether (1) a change to the joint TAC or (2) trigger level is required, or (3) a species-specific TAC is justified or (4) a closure deemed necessary or (5) recommend further data (e.g. in the form of a survey) be collected before any change to the joint TAC or trigger limit is allowed.
- The current TAC and trigger limit remain in place unless the above suggests a change.

For combined (curryfish) and basket species groups, triggers are specified such that when the catch of a particular species reaches or exceeds a trigger, the reasons need to be established and appropriate management action implemented (Figure 6). This could include specifying the need for additional data to monitor the expansion of a fishery for a species, a good example being the recent growth in fishing effort on curryfish (*Stichopus hermanni* and *S. vastus*) due to improved processing methods and market opportunities (Purcell 2014). The trigger levels for individual species are as shown in Table 3.

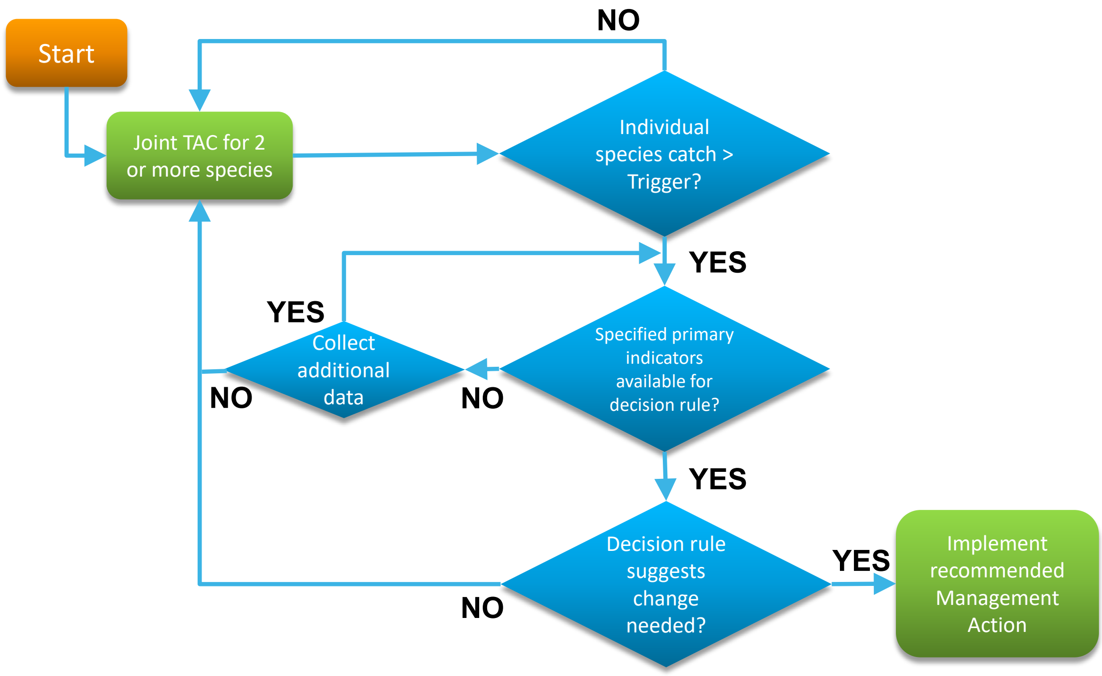


Figure 6. Flowchart summarising decision rule for reviewing whether a trigger is exceeded for any species caught as part of a lumped species allocation.

The development of this rule was informed by workshop discussions regarding considerations related to basket TACs and current trigger levels as summarised below:

Basket TACs

Species	Trigger (t)
Deepwater redfish	5
Blackfish	5
Stonefish	5
Pinkfish	5
Elephant trunkfish	15
Leopardfish	40
Greenfish	40
Curryfish	**40**
Curryfish vastus	**8**
Lollyfish	80

Individual TAC? Conservative as a start but know can catch more (restricted distribution so need more intensive surveys)

- Target species so should have TAC
- That also means get more data
- Note misidentification with surf redfish

need individual TAC

- Include size limits for all species.

Workshop participants noted that changes in market value and demand mean that several additional species need to have specific TACs or triggers (with associated actions). These include curryfish, greenfish, hairy blackfish and deepwater redfish.

The HS framework also accommodates combined species groups, for which triggers need to be specified such that when the catch of a particular species reaches or exceeds a trigger, the reasons need to be established and appropriate management action implemented. This could include specifying the need for additional data to monitor the expansion of a fishery for a species, a good example being the recent growth in fishing effort on curryfish due to improved processing methods and market opportunities. Workshop participants supported a separate TAC for curryfish given the growing interest and expansion of the fishery for these species. Although there are several curryfish species, the focus is predominantly on two species (*Stichopus hermanni* and *S. vastus*). A draft plan for determining an initial curryfish TAC and trigger level was developed as follows (Table 6):

1. Compute TAC for each of these species based on same methods as previously and add together = Joint curryfish TAC
2. As vastus has lower abundance (based on survey), set trigger = 2 x vastus-specific TAC calculation
3. If trigger reached, implement decision rules for case where trigger exceeded

It was noted at a previous workshop that the current basket TAC of 80t included curryfish, hence the following was discussed regarding setting a revised basket TAC excluding curryfish:

1. Subtract 60t curryfish, so new basket TAC = 20t – but this doesn't account for curryfish not historically having been a target;

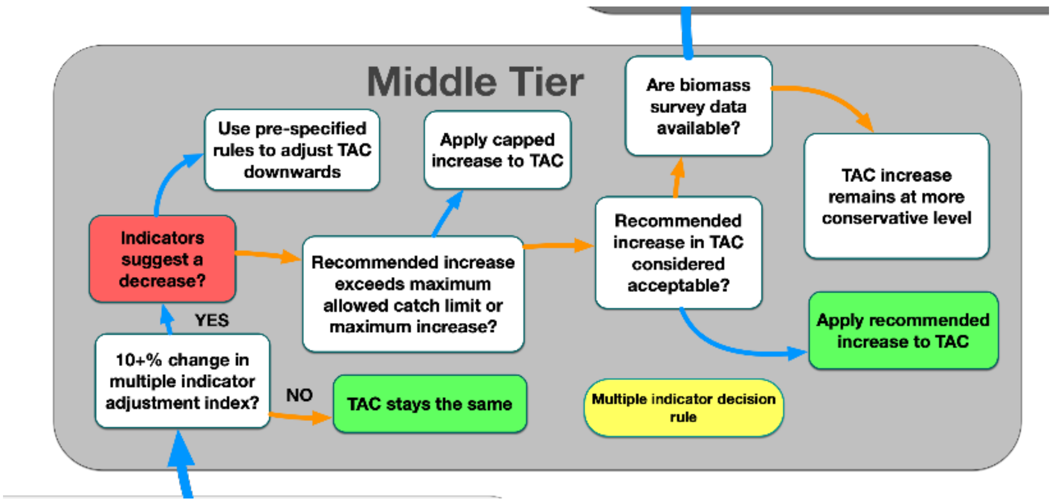
2. Alternatively, subtract curryfish proportional allocation (ca. 20%) from original basket TAC (i.e. subtract 20t) so new basket TAC = 60t

Option (2) was recommended but in addition, two further species that were previously part of the basket TAC, namely deepwater redfish and hairy blackfish, were also allocated species-specific TACs of 5t each, and hence a further 10t was subtracted from the total basket TAC. The revised basket TAC starting recommendation for the HS was therefore 50t. Greenfish were previously part of the basket but recent improvements in processing of this species led to the recommendation that it be accorded its own TAC based on survey estimates.

Table 6. Derivation of joint TAC for curryfish based on survey data.

Species	Common name	Percentage of combined biomass estimate	HS Catch limit recommendation
S. hermannii	Curryfish common	75%	45t
S. vastus	Curryfish vastus	25%	15t
Total	Curryfish		60t

3.8 Middle Tier Decision Rules



The Middle tier applies when high quality data are available from several primary indicators in addition to total catch per species. The Middle Tier Decision Rules specify how to increase catches (TACs) if good quality fishery data are available and indicate an increase is possible.

The Tier System is hierarchical such that Tier 1 rules must first be met (e.g. catch data recorded, TAC not exceeded) before it is possible to progress to the middle tier. This is because the lower tier is informed by less data and hence decisions need to be more conservative (i.e. maintain or reduce the TAC only) whereas the Middle Tier provides an incentive to collect additional high quality data to reduce uncertainty as to stock status and therefore potentially allow increases in TAC.

The Middle Tier is not immediately applicable as no detailed historical fishery data are available, but it provides a pathway for improving and growing the fishery to address the objective “to develop sea cucumber populations for the benefit of Australian Traditional Inhabitants (as defined by the Torres Strait Treaty) and accommodating commercial considerations”. This acknowledges also that the HS is part of an ongoing process of improving the fishery, and that improvements to these preliminary decision rule guidelines could be made in future, for example, after testing using Management Strategy Evaluation (MSE) (Plaganyi et al. 2015; Plagányi et al. 2013b).

The Middle Tier uses the Multiple Indicator Decision Rule, with the condition that high quality data are required from at least two of the additional primary indicators (Figure 7).

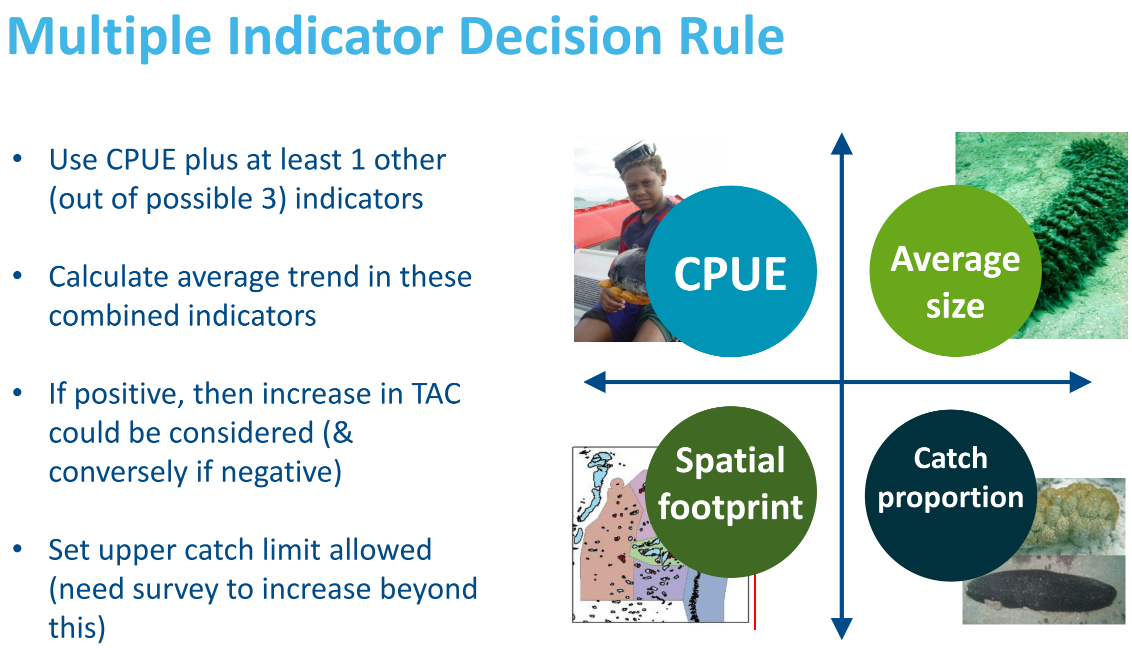


Figure 7. Schematic summary of Middle Tier Multiple Indicator Rule and its components.

3.8.1 Middle Tier Multiple indicator rule

Catch-Per-Unit-Effort (CPUE) has not been demonstrated to be a reliable indicator on its own. However, as more data are collected, the value of CPUE data as an index of abundance will increase, especially if used in combination with other indicators such as changes in average size of animals caught, catch composition and spatial footprint. Decision rules using a combination of these indicators could be used to increase or decrease the Recommended Biological Catch (RBC) calculated using 2 or more of the following primary indicators, where the weights assigned to each indicator are denoted w_1, w_2, w_3, w_4 for respective indicators CPUE, average Size, spatial footprint (Area) and changes in catch composition (Fig. 7):

$A = w_1 \times \text{CPUE} + w_2 \times \text{Size} + w_3 \times \text{Area} + w_4 \times \text{Catch proportion}$

The default weights are set at 0.25 (i.e. equal weighting), but renormalised if any of the indicators are missing and have associated zero weight.

The overall recommended adjustment in the RBC is computed by scaling the average of the adjustment factors by the average (3 yr) Catch, but with the constraints that the adjustment proportion not exceed the pre-specified cap A_{cap} and adjustment factor *A* must be less than the maximum increase permitted (MAX_{sp}):

$$RBC = \min(A, A_{cap}) \times C_{CUR} \quad RBC \leq MAX_{sp}$$
$$RBC = TAC \qquad \min(A, A_{cap}) \times C_{CUR} > MAX_{sp}$$

The **Multiple indicator rule** can be summarised as follows:

- Calculate 2 or more of the individual Indicator adjustment factors described below
- Work out the average *A* of these values or a weighted average if assigning different weights to different contributions
- Calculate the average recent catch (past 3 years)
- If the average *A* exceeds a pre-specified maximum increase proportion (default value 0.10) then use the maximum capped value rather than calculated value
- Multiply the average recent catch by the indicator average to obtain the new Recommended Biological Catch (RBC)
- Check that the RBC does not exceed a pre-specified maximum catch limit (see Table 5).

The multiple indicator rule will typically be applied to species which are highly targeted and hence the rules below assume that available data and information are largely species-specific. Additional considerations are necessary if the target species is typically caught together with one or more other species, and this is discussed elsewhere. The middle tier also recognises that the use of CPUE is problematic as an index of abundance of sea cucumbers (noting potential for hyperstability in particular for highly aggregated species) as well as the limitations of the other primary indicators used here, and for this reason, increases based on these data are more conservative than possible if using survey data based on sound scientific methods.

Individual indicator adjustment factors are computed as described below, with a mathematical formulation first specified followed by plain English summary of the rule.

3.8.2 **Calculating Middle Tier Individual Indicator Adjustment factors**

CPUE indicator (based on recent trend in CPUE)

$$I_{CPUE} = 1 + c_1 \times slope_{CPUE}$$

- Where "slope" is the slope in the trend in (standardised if available) CPUE index over the past 3 years for which data are available
- Parameter c_1 accounts for how reliable data are, with guidance provided on default settings

CPUE Indicator Rule

- Use all available reliable data converted to consistent units (e.g. kg/hour fishing) to compute the annual average CPUE (preferably standardised to the extent possible, and this may include accounting for hyperstability with default recommended hyperstability parameter 0.5 for highly aggregated species) for a target species (and/or area)
- Use the past series of comparable CPUE data (at least 3 years' data required) and compute the slope of a regression line fitted through the data (i.e. quantify the trend in the data to determine whether CPUE is increasing, decreasing or stable over time) (e.g. a population increasing at 10% per year would have an average slope value of 0.1).
- Select a value for the scaling parameter which downweights the empirical slope estimate to take into account that the CPUE data do not provide a very reliable index of stock abundance. The default setting is 0.5 (see also comparison with survey factor below). Hence for example this downweights a perceived stock increase of 0.1 to 0.05, as a basis for recommending a 5% increase in the TAC).
- The CPUE Index contribution to the multiple indicator rule is then 1 plus the slope factor.

3.8.3 Average Size Indicator (based on recent average size relative to historic average)

$$I_{size} = 1 + c_2 \left(\frac{\sum_{y-2}^{y} s_y \Big/ 3 - \overline{s}}{\overline{s}} \right)$$

- Where *s* is the average annual size of animals from a catch sample, with the average computed over the past 3 years and compared with the historical average size of caught animals $\overline{s}$
- Parameter c_2 accounts for how reliable data are (eg is the size sample representative), with guidance provided on default settings

Average Size Indicator Rule

- Use all available representative size data converted to consistent units (e.g. length of live animal in cm or average individual mass of boiled individual animal in kg) to compute the average size of the catch of a target species (and/or species in a particular area) over the past 3 years
- Calculate the ratio of the recent measured size compared with the base estimate to determine whether average size has been increasing or decreasing over time.
- Select a value for the scaling parameter which downweights the empirical size ratio to account for potential errors and biases in this measurement. The default setting is 0.5.
- The Size Indicator Index contribution to the multiple indicator rule is then 1 plus the scaled size ratio.

3.8.4 Percentage of areas fished Indicator (based on recent average area fished relative to historic average)

$$I_{area} = 1 + c_3 \left(\frac{\overline{a}}{a} \right)$$

- Where *a* is the proportion of areas fished relative to the historical average proportion of area fished – note that an expansion of the area fished is assumed to indicate a decline in stock status (e.g. due to local depletion)
- Parameter c_3 accounts for how reliable data are (e.g. are there spatial references in the logbook used to compute the change in spatial footprint), with guidance provided on default settings

Area Fished Indicator Rule

- Use all available data on the area fished for a target species, converted to consistent units (e.g. square kilometres of fished area; number of reefs fished; depth range fishing occurred), to compute the average recent fished area of a target species
- Use data from observations to compute an average historical fishing area for the fished population
- Calculate the ratio of the recent fished area compared with the base estimate to determine whether average fished area has been increasing or decreasing over time.
- Select a value for the scaling parameter which downweights the empirical area fished ratio to account for potential errors and biases in this measurement. The default setting is 0.5.
- The Area Fished Indicator Index contribution to the multiple indicator rule is then 1 plus the scaled area ratio.

3.8.5 Catch proportion Indicator (based on recent average catch proportion of species being considered, relative to total catch of all TSBDMF species)

$$I_{prop} = 1 + c_4 \left(\frac{\sum_{y-2}^{y} p_y \big/ 3 - \overline{p}}{\overline{p}} \right)$$

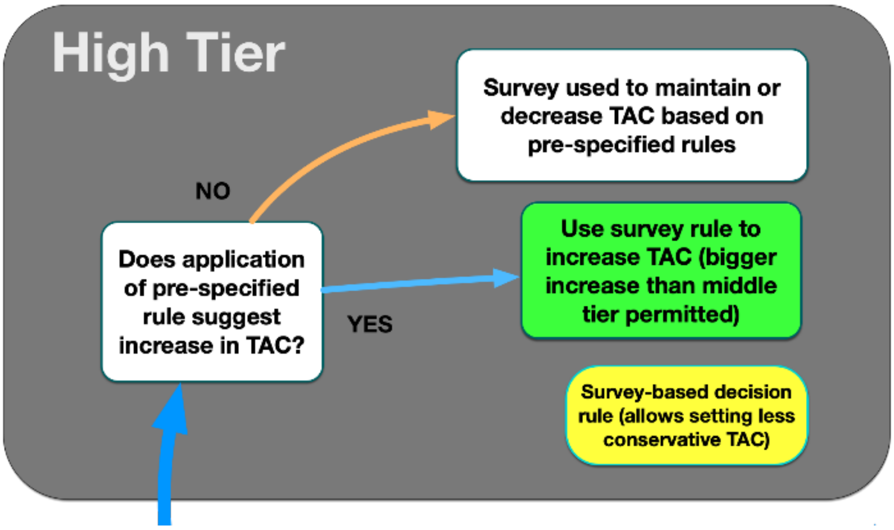
- Where *p* is the average annual catch proportion (of the species being considered) from a catch sample, with the average computed over the past 3 years and compared with the historical average catch proportion $\overline{p}$
- Parameter c_4 accounts for how reliable data are (eg were representative catch samples used, data from logbooks), with guidance provided on default settings

Catch Proportion Indicator Rule

- Use all available reliable data (but excluding data from highly targeted single-species catches such as for black teatfish) to compute the average (past 3 years) catch proportion for a target species
- Use data from past observations (including survey data) to compute the average expected catch proportion of the fished population
- Calculate the ratio of the recent measured catch proportion compared with the base estimate to determine whether the proportional representation of a species in a mixed basket catch has been increasing or decreasing over time.

- Select a value for the scaling parameter which downweights the empirical catch proportion ratio to account for potential errors and biases in this measurement. The default setting is 0.5.
- The Catch Proportion Indicator Index contribution to the multiple indicator rule is then 1 plus the scaled catch proportion ratio.
- Before using this index, information (such as from market prices and fisher local knowledge pertaining to drivers to target particular species) should be considered to determine whether the change in catch proportion is likely due to fisher targeting behaviours or reflects changes in the relative abundance of the target species relative to other species. This indicator therefore needs to be used with caution, but may be particularly useful for species such as curryfish where data on component species are required.

3.9 High Tier Decision Rules



The high tier utilises high quality survey data (see earlier section outlining requirements for survey data to meet the criterion of being adequately high quality and representative).

3.10 Survey-based Decision Rule for adjusting TACs

This section describes first the use of survey data as relative indices of abundance and second use of surveys to estimate total standing stock. There are a number of extensive historical surveys which can be used as a baseline for comparison with future survey data to quantify trends in abundance of key species. An example is provided in Figure 8 below. Before comparing new and old survey data, it is critical that an evaluation is made of the extent to which the data are comparable (e.g. were they collected from comparable areas and habitats? How extensive was the survey?) and where necessary, data should be reconfigured to ensure optimal comparability. In evaluating the quality of a trend based on survey data, the inter-survey interval also needs to be considered as long gaps between surveys mean that data may be less informative. Additional considerations (such as survey timing – season and time of day) are outlined in the data monitoring section of this report.

Fishery-independent or dedicated surveys conducted by fishers are generally considered more reliable than CPUE data, hence survey trends can be used to adjust TACs upwards (in cases where there is evidence of scope to increase TACs) or downwards (in cases where there are concerns about the status of a fished species). This is usually only necessary is total catch of a species is close to the current TAC.

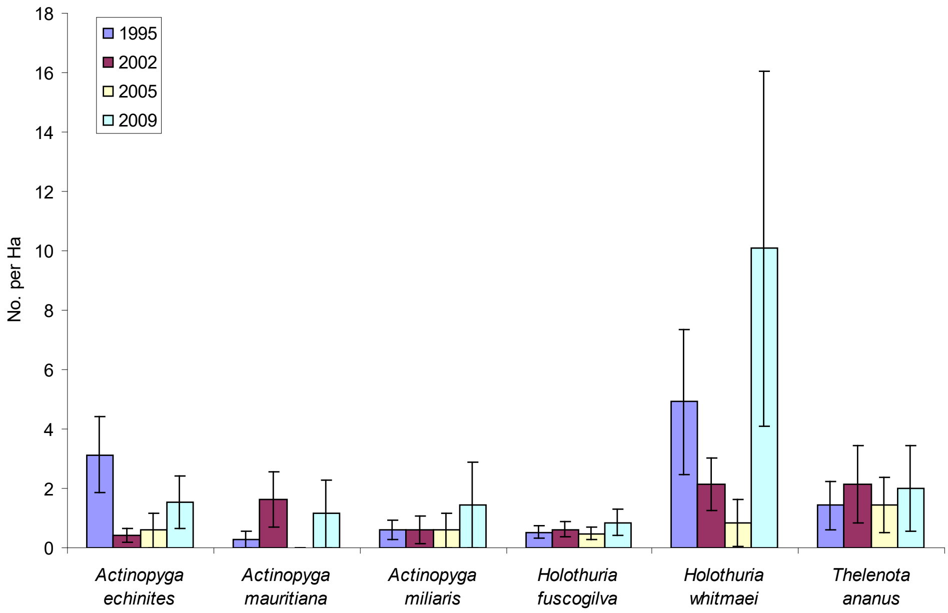


Figure 8. Density (stratified) estimates for high priority commercial sea cucumber species found at sites within 4 common zones (Cumberland Passage, Don Cay, Darnley and GNEC) for 3 survey years (error bars are s.e.) from (Skewes et al. 2010a).

3.10.1 Survey-Based Decision Rule based on trends

- If Average (3 yr) Catch between 80% and total TAC, use index of abundance (survey) to adjust:
    - TAC = (1+b*slope)*C_{CUR} and maximum increase pre-specified
- where C_{CUR} is average catch over the past three years, and includes landings plus discards;
- "slope" is the slope in the trend in standardised biomass survey index over the past 3 years for which data are available, noting that it isn't necessary for past data to be available on an annual basis
- Parameter *b* differs based on how reliable data are (e.g. survey extent, intensity and standard error). Default settings are shown below.

Settings:

- If excellent survey data available, set ***b* = 1**
- If survey less comprehensive and lag since last survey, set ***b* = 0.8**
- Lower *b* adjusts for data being less reliable

Slope:

- If slope is positive it suggests resource is increasing and TAC can be increased
- Conversely, if slope is negative, it suggests resource is decreasing and TAC should be decreased
- If slope is large positive i.e. fast increase, a cap (limit) on the maximum permissible increase in TAC should be implemented. Default setting is 10% for fixed period of 2 years.

Example Application

Below follows an example that was presented during the HS workshops:

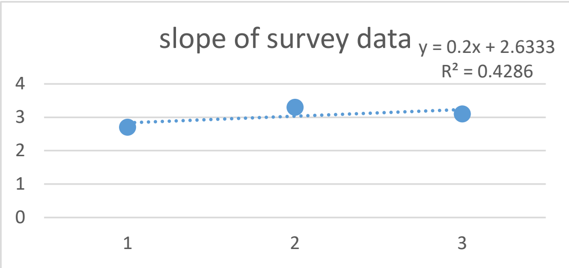
<u>Example - increasing resource:</u>

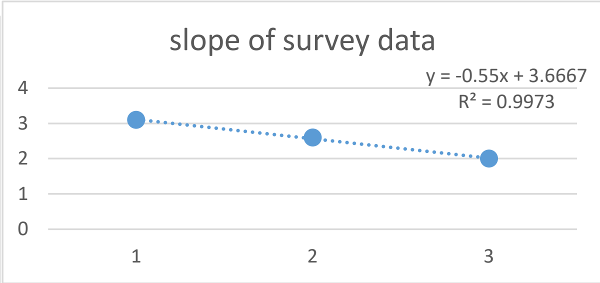
	2013	2014	2015	2016		Average last 3 yrs	slope
Catch	10	15	25	32		24	
Survey Index	2	2.7	3.3	3.1		3.03	0.2
Case with b=							
0.8	TAC = **(1+0.8*0.2)*24**			b*slope=	0.16		
TAC	27.84						
if b=1	28.8						

<u>Example - decreasing resource:</u>

	2013	2014	2015	2016		Average last 3 yrs	slope
Catch	20	29	25	32		28.7	
Survey Index	2	3.1	2.6	2		2.57	-0.55
Case with b=							
0.8	TAC = **(1+0.8*(-0.55))*28.7**			b*slope=	-0.44		
TAC	16.1						
if b=1	12.9						

Increasing vs decreasing trend based on indicators





<u>Example - increasing resource - apply cap:</u>

<u>If b=1 cap=25% thus if b=0.8 cap=20% maximum increase per year</u>

	2013	2014	2015	2016		Average last 3 yrs	slope
Catch	10	15	25	32		24	
Survey Index	2	2.5	3.3	3.8		3.20	0.65
Case with b=							
0.8	TAC = **(1+0.8*0.65)*24**			b*slope=	0.52		
TAC	36.48						
But maximum increase capped at 20%, hence revise calculation:							
TAC	28.8						
if b=1	39.6						
with cap	30						

3.10.2 Survey-Based Decision Rule based on total biomass estimate

Given that the TSBDMF Fishery includes very many species occupying different habitats, the HS recognises that the same survey design isn't appropriate for all species. The HS also recognises that technologies and hence survey techniques are changing fast and hence that innovative new survey methods may need to be included in future revisions of the HS. For species such as sandfish which is concentrated in a specific area (Warrior Reef), a dedicated survey design can be used to estimate the local density and biomass and this can then be compared with limit reference points (see Reference Points section) to determine whether or not the fishery can be re-opened (see Re-opening Decision Rules). Once open, future surveys can be used to obtain an estimate of relative abundance as described above. On the other hand, for species such as white teatfish which occur mostly in deeper waters, a survey with representative sites could be used to estimate the total standing stock occupying previously unsurveyed areas or depths (in this case, depths in excess of 20m). This new information informs on total stock standing biomass and can be used to make adjustments to existing TACs using the same process that was used previously to estimate conservative initial TACs for species (Skewes et al. 2010). Similarly, for species of concern, such as prickly redfish, surveys could be used to either assess trends in abundance or to evaluate standing stock biomass for the purpose of comparing with estimates of sustainable catch. Surveys are also less straightforward for prickly redfish but it is possible to select reference sites for use in obtaining a trend from future surveys.

In summary:

- For most species the current TAC is set based on a conservative estimate of historical biomass (Figure 9).
- The survey biomass estimates can be used to inform baseline target and limit densities for species such as sandfish, but challenges need to be recognised in obtaining comparable and representative estimates for species such as black teatfish. Other species such as surf redfish are also difficult to survey reliably
- Density standardised by habitat type and reference sites is proposed as the reference measure because it is measurable locally rather than requiring a full survey across all spatial areas, but any density measure needs to be sufficiently representative of the broader area in which that species occurs.

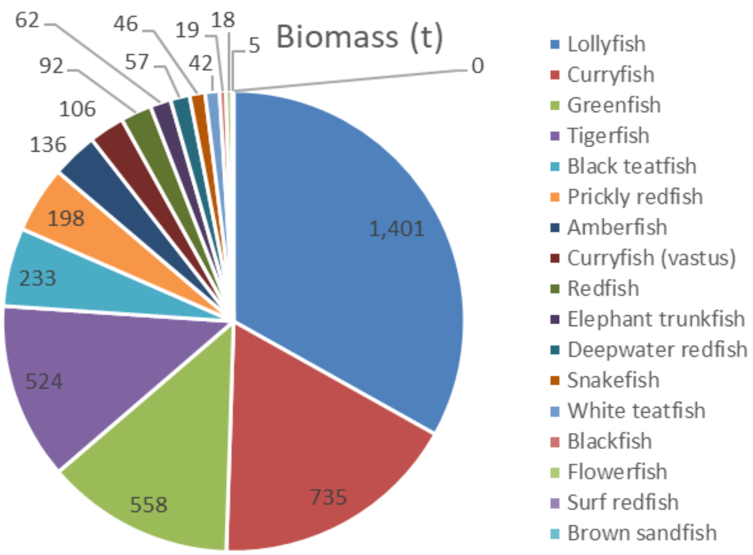


Figure 9. Schematic showing average survey-based Torres Strait biomass estimates (t) for species as shown for use in comparing with future survey-based biomass estimates.

3.11 Re-opening Decision rule: for re-opening a fishery or area

This is a low tier rule that is applied to re-open a fishery (where the term "fishery" here refers to a specific TSBDMF species in Torres Strait) that has been closed, paused or is recovering (Figure 10).

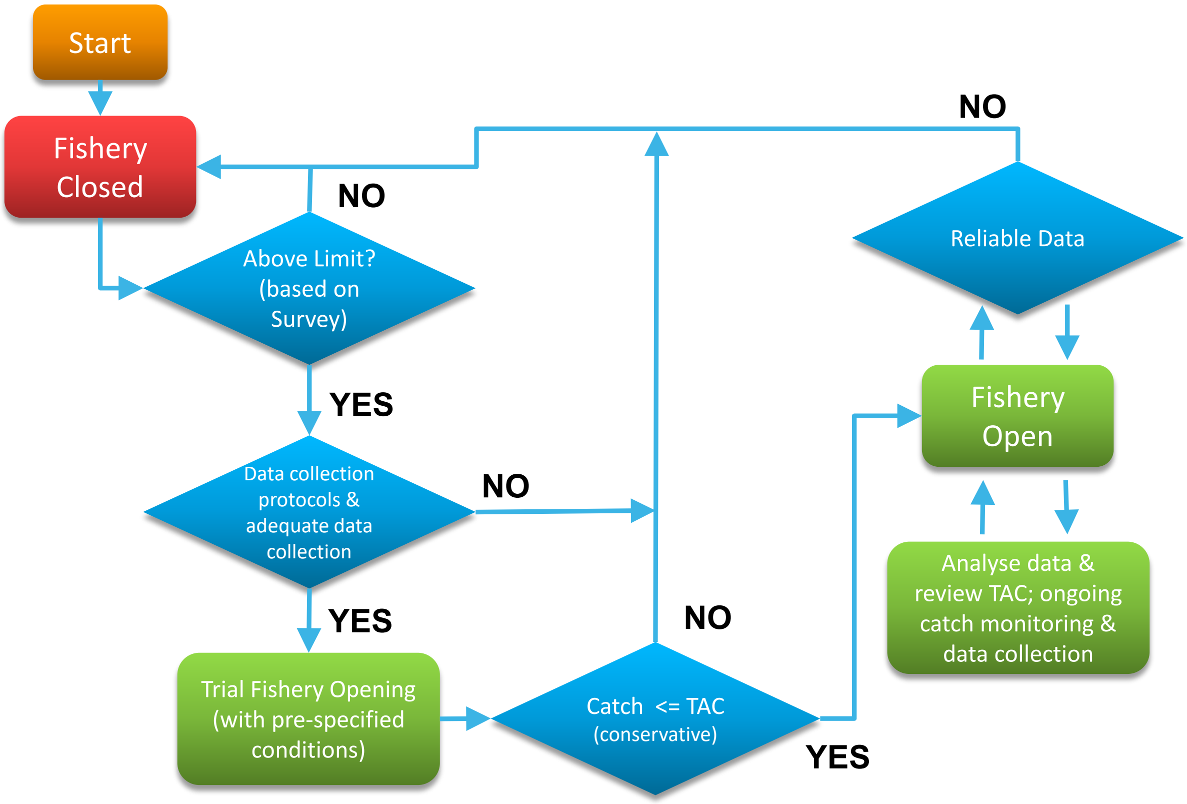
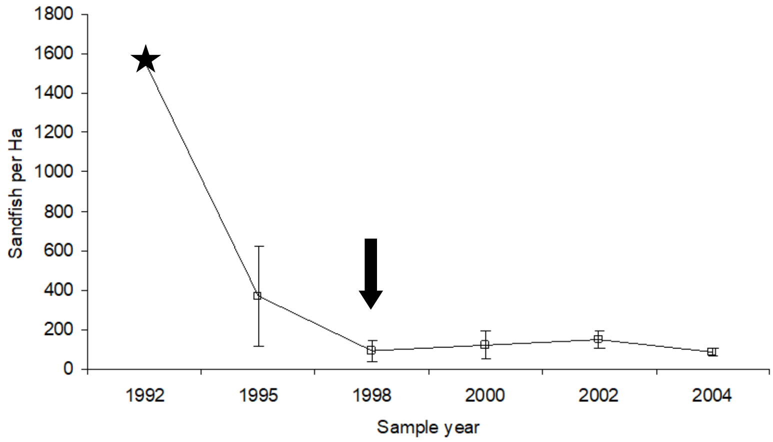


Figure 10. Flowchart summarising process for re-opening a closed fishery.

Workshop participants agreed that evidence of recovery was a necessary criterion for re-opening and could be assessed based on data such as a biomass estimate from a survey. Consistent with the fishery objectives, a strategy for a gradual return was then needed, including a conservative initial TAC for example, and ongoing monitoring would be essential. It was noted that analyses of stock recovery could be informed by existing data on the average density (per ha) of sea cucumbers sampled at 122 repeated sample sites in eastern Torres Strait during the 2002 and 2005 abundance surveys as well as the 2009 surveys (from Skewes et al. 2010). An example is provided in Figure 11 below which shows the trend in the density of sandfish over time at Warrior Reef, which can be sued to define target, limit and threshold levels, such that the fishery is closed if the stock is assessed to below the limit but could be conservatively re-opened once the stock has recovered to the threshold level.



Warrior Reef sandfish example

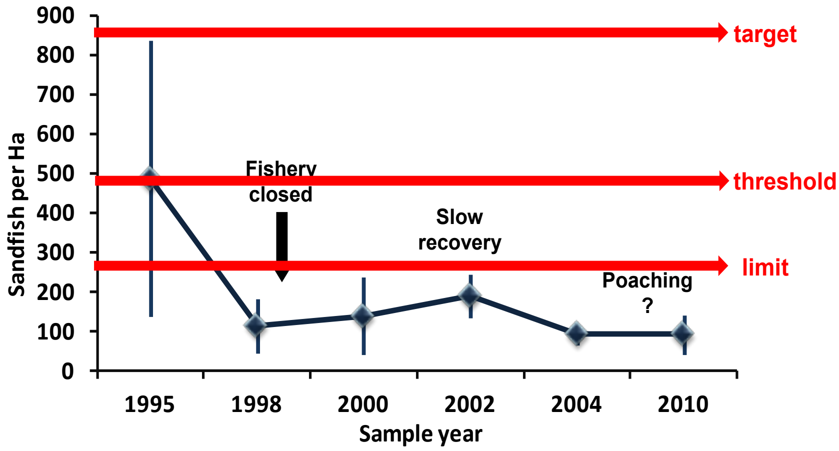


Figure 11. Graph showing average number of sandfish per ha for repeated sites on Warrior Reef for the five sample years. (Error bars are 1 s.e.) Source: (Skewes et al. 2010a)

Workshop participants also suggested additional rules be imposed such as summarised below:

- If a trial opening is allowed for a species such as black teatfish, then fishers should only be allowed to catch that species during the trial (i.e. no other species caught in combination with black teatfish)
- One suggestion for a trial opening period would be in the months June to July (during the right tide) as this is during the tropical rock lobster season and therefore fairer for fishers working in the East.
- Cultural laws could be used to limit or control who can fish
- An effective warning system should be established so that everyone stops and pauses when approaching the experimental TAC to allow extra data to be processed and reduce risk of overshooting the TAC.

A species may have been closed due to concerns around stock status and depletion or (temporarily) closed/paused to fishing for reasons such as needing to first ensure adequately precautionary measures are in place so that overfishing does not occur. A decision that the fishery may potentially be re-opened should also take into account previous survey information as well as recent catch history (both legal and illegal) and periods over which the fishery has been closed – the black teatfish provides an example. Note this also takes into account findings from testing spatial rotation strategies for sea cucumber (Plaganyi et al. 2015) which suggest that larger annual catches need to be followed by rest periods (with no fishing for 2-3 years) to keep risks to the fishery the same as lower but constant annual average catches. This notion is also consistent with, and underpins, the catch-based rule which prescribes a pause in fishing following instances of heavy fishing (Fig. 4).

- Given stock status concerns, first establish that the stock is above a limit reference point level or conduct a survey and compare with limit reference point (see survey-based reference levels section of this document), only proceeding to next step in potential opening if the survey or available information suggests the stock is above a limit reference point.
- The next step involves evaluating whether monitoring and management are adequate. This involves ensuring data collection and monitoring are clearly specified and in place before proceeding to next step in potential opening.
- If the above conditions are met, then a Trial opening is possible with the following conditions attached:
    - Accurate daily catch reporting is a compulsory requirement
    - A trigger limit may be set to temporarily pause fishing while catch records are collated to ensure that overfishing does not inadvertently occur.
    - An effective warning system needs to be put in place to ensure everyone stops and waits while approaching the experimental TAC to allow all data to be entered and processed.
    - A condition of the experimental opening is that no other species may be harvested at the same time as the trial re-opened species (e.g. no other caught species permitted on fishing boat during trial)
    - Trial opening dates need to be set taking into account seasonal fishing dates for tropical lobster (TRL) in particular, with the TSBDMF opening preferably during the same time that the TRL fishery is open to hookah fishing to reduce pressure on the TSBDMF resource and also account for equity considerations for dedicated fishers working in eastern areas where the TSBDMF stocks are mostly located. Trial opening dates also need to take into account favourable weather and tides to ensure safe and efficient fishing can occur.
    - Consideration should also be given to cultural laws and community agreements with respect to who can fish where.

- The Trial opening TAC needs to be set at a demonstrably conservative level with reference to values as shown in Table 3.
- If the Trial TAC is exceeded by more than 5%, then the fishery is automatically paused (i.e. no fishing allowed) for the following year.
- If data collection during the Trial opening was not conducted satisfactorily, then the fishery is closed again.
- If the TAC wasn't exceeded and reliable data were collected, these data need to be analysed to review the TAC and potential for the fishery to stay open in future, or be re-opened periodically after a pre-specified interval.
- An ongoing condition of the fishery remaining open is that reliable data collection continues, and preferably includes additional data such as CPUE, spatial footprint and size composition (see multiple indicator section).

3.12 Governance

The status of the Fishery and how it is tracking against the HS is reported to the Working Group and the PZJA as part of the yearly management process.

3.13 Management controls – static

The harvest strategy specifies a number of static controls that can be implemented to complement and strengthen other management actions. The key controls proposed by participants are briefly discussed below.

3.13.1 **Size limits**

Recent research on Australia's sea cucumber fisheries recommended that for data-poor species in regions where more sophisticated management controls are difficult to implement (Plagányi et al. 2015a) a minimum legal size (MLS) limit enhances benefits. Where data are available to inform as to the choice of this, it should be selected to protect at least the first age-at-maturity. Workshop participants endorsed that changes in some current size limits would be advisable to bring them in line with updated information on the age-at-first-maturity (Table 1 & Appendix 3). A secondary consideration in reviewing current size limits would be to better align them with comparable size limits from other fisheries such as the ECBDMF. Appendix 3 summarises this information for ongoing consideration by the HCWG. There was also discussion around providing tools, such as stickers with size measures on the side of boats. In addition, it was noted that it would be useful to apply conversion ratios to the MLS to facilitate cross-checking different product forms (Appendix 4).

3.13.2 **Spatial and temporal closures**

Several workshop participants expressed that there might be value in bans on fishing during part or all of the peak sea cucumber spawning time, which was identified from Appendix 5 as November to January. Moreover, it was felt that another advantage of banning fishing over this period was because it coincides with a closure and hookah-ban closure in place for the tropical lobster fishery (and hence prevents shifting effort from one fishery to another).

At the Working Group meeting held on 27 June 2017, Mer and Erub industry members and observers proposed voluntary spatial closures for Prickly Redfish, noting that further consultation with Ugar and Masig communities was required before such closures could be finalised and implemented. The proposed closures include (Figure 12):

1. 10 nautical mile radial closures from Mer and Erub communities
2. Area closures on the following reefs: Big Mary Reef; Small Mary Reef; Bramble Cay; Brown Reef; Laxton Reef.

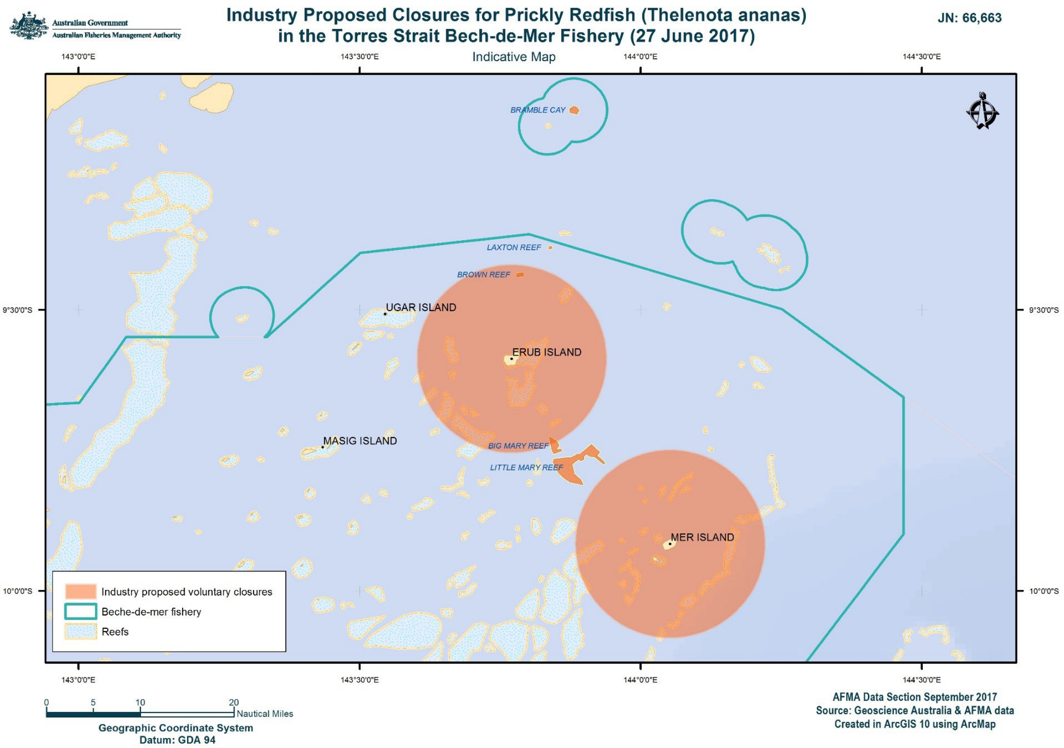


Figure 12. Industry proposed closures for Prickly redfish in the TSBDMF.

Workshop participants expressed that the management needs to account for native title and spatial structure, and fishers need to follow local rules as the preferred model is one where management is complemented by community ownership and people looking after their own areas. There was discussion as to the extent to which voluntary spatial closures would be adhered to. Some stakeholders expressed a preference for closing whole areas, say within 10 nm, rather than specific reefs.

3.13.3 **Processing restrictions**

Workshop participants discussed the merits or otherwise of additional management controls such as a restriction on allowing processing of sea cucumber onboard fishing vessels, but there was no consensus reached due to concerns that this would impact negatively on some fishers.

3.14 Value Adding and economic considerations

The workshop included discussion on opportunities for value adding – such as improved processing and handling of curryfish. These initiatives were encouraged as ways to optimise utilisation of the resource form a biological, economic and social perspective as outlined in the objectives.

Workshop participants also suggested additional management measures to optimise biological, economic and social performance of the fishery, including a suggestion to close the TSBDMF fishery in Dec/Jan. This gives all species a chance to rest and spawn. Allow free dive of TRL for TIB Dec/Jan, open TSBDMF/black teatfish in Feb to coincide with TRL, no primary vessels.

Participants also noted that there may be ways to increase economic profit and value through industry awareness and co-ordination. This includes working as a cluster to attract higher prices, co-ordinating product/quality control.

3.15 Environmental Influences

Sea temperatures, sea levels, prevailing current systems, storms and cyclones, and ocean chemistry are abiotic environmental conditions that could potentially affect sea cucumbers, and many of these parameters are predicted to change due to anthropogenic climate change. Also, any changes to critical habitats, such as seagrass and coral reefs; and phytoplankton productivity which is an important survival parameter for larval holothurians, are also likely to impact on sea cucumber populations and their fisheries productivity.

Recent studies have shown that considerable uncertainty exists for the potential impacts on sea cucumbers for most combinations of physical and biological variables (Plagányi et al. 2013). Climate change impacts may have both negative and positive effects on sea cucumbers, however and when they were assessed on the various life history stages of sea cucumber in combination, the net effect was slightly more negative for most species (Plagányi et al. 2013).

Growth in all life history stages (larval, juvenile and adults) was assessed as being at high risk related mostly to a likely increase in sea temperatures. This effect was assessed as being mostly positive for production and yields given the expected faster growth leading to larger sizes and increased fecundity. Positive effects were also associated with an increase in larval growth due to projected increases in primary production, and faster adult growth and bigger sea cucumbers resulting in an increase in adult reproduction. Negative effects were associated with increased larval and juvenile mortality related to higher sea surface temperatures and detrimental effects on the juvenile sandfish seagrass habitats. Sea level rise was assessed as being mostly positive for shallow water species (e.g. sandfish, black teatfish).

Monitoring of critical habitats (coral reefs and seagrass) and abiotic parameters will be important in the future to correlate with any non-fishery related changes in sea cucumber density and distribution, and to modify management accordingly. Some of these data are already being routinely collected, for example water temperature monitored daily at automated weather stations located at Thursday Island, Masig and Saibai – http://data.aims.gov.au/aimsrtds/. Habitat data should be the focus of developing monitoring programs being carried out by the Torres Strait Ranger Program.

3.16 Operationalising Fishery Objectives

Table 7 below provides a preliminary overview of proposed components of the harvest strategy that will be used to operationalise the agreed fishery objectives:

Table 7. Preliminary overview of proposed components of the harvest strategy for the TSBDMF

Objective	How being operationalised
Consider Native Title Rights and customary and traditional laws and acknowledging and incorporating local knowledge and the ability to locally manage resources	• Community-controlled and enforced complementary management controls such as 10 nm closures • Clearly identified pathway for incorporating local knowledge and building a platform to move to greater spatial and community management
To provide for the sustainable use of all sea cucumber in Torres Strait to take account of long-term sustainability for future generations;	• Specification of monitoring and data needs, together with rules for adjusting management to ensure sustainability of stocks • Rules for closing or re-opening to ensure consistent with sustainability objectives
To develop sea cucumber populations for the benefit of Australian Traditional Inhabitants (as defined by the Torres Strait Treaty) and accommodating commercial considerations;	• Transparent tier system for improving and growing monitoring and data collection to support increasing fishing on species/areas where appropriate • Measures to take economic considerations into account e.g. timing of harvest considered relative to East Coast BDM fishery, trigger limits to instigate action when there is increased focus on selected species
Acknowledging area-specific issues;	• Drawing on community systems to complement controls • Identified pathway for communities to self-regulate to avoid local depletion effects

Where possible, considering an ecosystem approach to management that reduces impacts on, or optimises interactions with, other harvested and dependent species; and	• Consider interactions with TRL fishery e.g. timing of closed seasons • Identify indicators that could be collected to start identifying impacts of different harvest levels on the ecosystem
Develop long-term recovery strategies for species where appropriate	• Include decision rules to guide recovery strategies

3.17 Formal evaluation of whether the harvest strategy options are likely to achieve the management objectives

The development of the harvest strategy draws extensively on testing done using a Management Strategy Evaluation (MSE) approach, during research on sea cucumber fisheries on the Queensland east coast (Plagányi et al. 2015a) and in Torres Strait (Plagányi et al. 2013b; Skewes et al. 2010a). These studies form part of the workshop discussions and aspects and key recommendations have also been summarised in the project milestone reports 1 and 2 (Plagányi et al. 2017a; Plagányi et al. 2017b). The section below provides a brief summary of the basis and justification for selection of different decision rules under different circumstances.

Basis for TSBDMF decision rules

(I) No data = Zero fishing allowed

In order to manage a stock with at least some certainty of not overfishing, data (e.g. catches, CPUE, survey index of abundance) are needed to inform on stock status and trends. The minimum data requirement is to have catch data with a reasonable degree of reliability, and hence if no data are available, a fishery should be closed.

(II) Setting TAC with minimum size limit

Catch limits are based on previous biomass surveys, and using a conservative approach to estimate biomass and hence fishing mortality given uncertainty. Previous MSE testing (Plaganyi et al. 2013a; Plaganyi et al. 2015) suggested fishing mortality rate performs acceptably when used in combination with a minimum size limit as is proposed here. Previous MSE testing highlighted advantages of selecting MLS that is ≥ size at first spawning, and MLS have been reviewed accordingly. Previous MSE testing showed sensitivity to overly large catches and risk of stocks becoming locally and globally depleted, hence rules are needed to ensure that the catch doesn't exceed the TAC and that mitigating steps are implemented if Catch>TAC in any year (as per Figure 5).

Trigger limits are also recommended to keep track of growing catches of a species that is part of a lumped TAC

(III) Spatial rotation strategies

Previous MSE testing (Plaganyi et al. 2015) suggests that spatial rotation strategies outperform non-rotation strategies and that the rotation cycle length should ideally be longer for slower-growing species. This approach is difficult to implement formally in Torres Strait but there are aspects included either explicitly or implicitly as follows:

- Some communities (eg Mer) self-manage using a form of spatial rotation and community-based approaches to manage the spatial effort on species is strongly encouraged
- Closing areas around communities for slower-growing species such as prickly redfish will have some equivalent benefits
- Closing specific areas for specified periods (as has been done eg or sandfish on Warrior Reef) will have a similar effect.

(IV) Adjusting TACs up or down

In order to motivate for a change in the TAC for a species, data are needed to inform on the stock status and trends in the resource to assess whether an increase is possible or a decrease is necessary. As it is difficult to obtain reliable data for TSBDMF at an appropriate spatial and temporal scale, below are some suggested approaches considering different data sources. The proposed approaches also draw on the following findings from previous TS MSE testing (Plaganyi et al. 2013a):

- Higher profits (for the same risk levels) could only be achieved with strategies that included monitoring and hence adaptive management
- Spatial management approaches (such as spatial rotation and periodic closures) based on adaptive feedback performed best overall
- Harvest adjustments based on multi-species composition i.e. changes in proportions of species in the catch, was useful as an indicator to reduce risks to the resource.

Biomass survey data (also called fishery-independent data)

These data are considered a more reliable index of abundance than CPUE (Catch-Per-Unit-Effort) data and an approach has been suggested that could be used to adjust the TAC up or down at pre-specified intervals.

Previous TSBDMF MSE testing (Plaganyi et al. 2013a) suggested that the current catches and TACs perform acceptably in terms of maintaining the risk of depletion at an acceptable level, even when considering a range of potential environmental impacts on the stocks. The MSE testing did not explicitly represent all species but rather a range of species that reflected the typical nature and amplitude of sea cucumber population fluctuations and life history and hence was an appropriate basis for testing alternative harvest strategies. Over the period tested (up to 2010), the following fishing mortality rates F (and associated average catches) performed reasonably and hence there is support for setting catch limits up to this level, but the levels tested do not necessarily represent the maximum possible for all species (Table 8).

Table 8. Fishing mortality rates F (and associated average catches) from previous TSBDMF MSE testing

Species		F value tested in TS MSE	Catch based on model F x survey biomass estimate (t)	Current TAC
H. fuscogilva	White teatfish	0.1	15.6	15
H. whitmaei	Black teatfish	0.043	10.8	-
T. ananus	Prickly redfish	0.075	25.7	20
A. mauritiana	Surf redfish	0.01	0.2	joint 80t
A. echinites	Deepwater redfish	0.1	0.5	joint 80t
Based on testing for East Coast fishery:				
S. vastus	Curryfish	*0.04*	8.8	joint 80t
S. herrmannii	Curryfish	*0.104*	79.3	joint 80t

We won't have a formal stock assessment fitted to data to inform on targets and limits, but the set of decision rules collectively aim to be consistent with the intent of the policy to avoid low (limit) biomass levels corresponding to overfishing and to aim for target levels that maximise sustainability and fishing opportunities. Choices of these goals and targets are predominantly guided by historical surveys.

For most species the current TAC is set based on a conservative estimate of historical biomass (Skewes et al. 2010). The survey biomass estimates can be used to inform baseline target and limit densities – density is proposed as the reference measure because it is measurable locally rather than requiring a full survey across all spatial areas, but any density measure needs to be sufficiently representative of the broader area in which that species occurs.

For species with a recent sustainable catch history, where the TAC is set based as above, then the HS aims to maintain the stock at the level that yields that TAC by carrying over any over-catch (Catch Rule) as well as using complementary static measures such as closed areas, minimum size limits and spatial rotation.

The decision rules are tuned to the level of available data – hence if more data are available to inform indicators, then the survey or multiple indicator decision rule could be used to adjust catches. As TACs are mostly set at conservative levels, a higher target TAC can be defined based on a less conservative biomass survey estimate – this provides a pathway to maximise sustainable catch if sufficient data are collected to inform this process.

Conversely, if stock density falls below a lower limit (as defined from historical surveys) than the fishery is closed. To re-open the fishery, it is necessary to demonstrate that the stock density has increased above a trigger limit set at a pre-specified proportion greater than the limit reference density.

3.18 Implementation

The Harvest Strategy Workshops focussed on developing a draft harvest strategy as a basis for obtaining further feedback from the HCWG and other stakeholders, as well as to guide any additional research and data collection needs before development of the final draft. Additional communication outreach was also conducted to complement this process. This included a Harvest Strategy Workshop held on 23 October 2018 on Erub (Darnley) Island, and included (1) an overview of the Fish Receiver System in Torres Strait Fisheries, (2) presentation of the draft final Harvest Strategy for the TSBDMF with an invitation for all participants to discuss and provide comments and (3) a general question and answer session.

In order to ensure accurate catch information is recorded, materials are also being provided with regard to species identification (see e.g. Appendix 6) and this project includes revising and printing an updated bêche-de-mer (sea cucumber) identification guide (based on Murphy et al. 2014).

Throughout the process of HC development, we have acknowledged the challenges and limitations to harvest strategy development and implementation in the Torres Strait, as there is need to be cognisant of the ability for a HS to be implemented in the context of the fishery’s operational and socio-economic issues.

4 Next Steps

The draft Harvest Strategy has been endorsed by the HCWG and PZJA, and a round of community consultation and feedback has just been completed. The HS development project led by CSIRO is also in the process of revising and printing copies of the Torres Strait bêche-de-mer identification guide (Murphy et al. 2014). There is also ongoing research to finalise conversion ratios (Appendix 4), with in-field training and equipment provided to a number of fishers (October 2018) who volunteered to assist with collecting data from their own processing operations to assist in filling data gaps.

There are ongoing fisheries-independent surveys being planned which will provide further updates of the status of species. In addition, compulsory data collection has commenced as part of the Fish Receiver System, and early problems with data recording are being addressed. As more data become available, it will be possible to start implementing some of the decision rules. Once more data are available it will also be possible to more fully test aspects of the harvest strategy using Management Strategy Evaluation to ensure that all the decision rules achieve the stated objectives. It is anticipated that there will be some changes to the harvest strategy over time, noting that development and improvement will be an ongoing process in consultation with stakeholders.

5 Glossary of technical terms

Assessment:	A mathematical population model coupled to a statistical estimation process that integrates data from a variety of sources to provide estimates of past and present abundance, fishing mortality and productivity of a resource (Rademeyer et al. 2007)
BDM:	bêche de mer or sea cucumber
CPUE:	Catch Per Unit Effort
ECBDMF	Queensland east coast bêche-de-mer fishery
Harvest Strategy HS:	Harvest Strategy: a framework that specifies the pre-determined management actions in a fishery necessary to achieve the agreed ecological, economic and/or social management objectives
Limit reference points:	highlight conditions to be avoided
Management objectives:	Broad objectives pertaining to the management of a resource as set by decision makers and stakeholders
MSE:	Management Strategy Evaluation – the process of testing alternative decision rules by simulation, in particular for robust performance in the presence of uncertainty
MSY:	Maximum Sustainable Yield – the maximum yield/catch that can be taken from a resource on an ongoing sustainable basis
Reference Point:	Particular levels that reflect stock status (eg spawning Biomass *Bsp* or fishing mortality rate *F)*
TAC:	Total Allowable Catch to be taken from a resource within a specified period
Target reference points:	specify where management should aim, which stakeholders usually decide
TSBDMF	Torres Strait Bêche de mer (sea cucumber) Fishery

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Appendix 1 Agenda and questions for TSBDMF Harvest Strategy Workshops

Workshop 1: 27-29 June 2017

Torres Strait Hand Collectables Working Group

Draft outline for workshop sessions on developing harvest strategies

Workshop co-ordinators: Éva Plagányi, Nicole Murphy, Natalie Dowling (CSIRO)

Assisted by Tim Skewes (Independent scientific member)

List of Workshop sessions and action items

First session: (2x1.5 hr)

Introduction and background: Overview of Harvest Strategies and recap from first workshop

Workshop Action 1: Obtain consensus on key management objectives for the fishery as well as more specific objectives for individual species

Workshop Action 2: Update and obtain consensus on revised minimum size limits for individual species and generic limit for remaining species

Workshop Action 3: Discuss feasibility of reliably measuring size of animals, and whether additional resources would facilitate this process (eg ruler or size gauge)

Workshop Action 4: Review conversion ratios for sea cucumbers

Workshop Action 5: Review and update species names for sea cucumbers

Workshop Action 6: Discussion of species identification challenges for sea cucumbers

Second session: (2 hr)

Workshop Action 7: Additional species-specific limits for individual or groups of sea cucumbers

Workshop Action 8: Review and discuss sandfish

Workshop Action 9: Review and discuss black teatfish

Workshop Action 10: Review and discuss white teatfish

Third session: (2 hr)

Workshop Action 11: Review and discuss potential use of spatial rotation strategies and move-on provisions

Workshop Action 12: Review potential use of additional indicators

Workshop Action 13: Finalise agreement on different monitoring information that will be collected

Workshop Action 14: Review tiered harvest strategy potential framework

Fourth session: (2x1.5 hr)

Workshop Action 15: Develop draft harvest strategies

Workshop 2: 25-26 October 2017

AGENDA

CSIRO HARVEST STRATEGY WORKSHOP

Dates: 25-26 Oct 2017

Following Torres Strait Hand Collectables Working Group (24 Oct)

Venue: Thursday Island – Port Kennedy Association hall, 64-66 Douglas Street

Workshop Chair: Anne Clarke

Workshop Co-ordinators: Éva Plagányi & Nicole Murphy, assisted by Tim Skewes

Wednesday 25 October

8:30-9:00	Opening prayer and acknowledgement of traditional owners Introduction and outline of workshop objectives (Éva)
9-11am	• Recap of progress to date on developing a Harvest Strategy for Torres Strait bêche der mer Fishery (with reference to June 2017 workshop report) • Short report back regarding CSIRO/TIB science capacity workshop, 16-20 October, Brisbane (CSIRO & TS reps) • Communication strategies to explain what harvest strategies are and why they are needed • Progress on action items (size measures, conversion ratios) – presentations later in the day (or earlier if time permits)
11-11:30am	Morning tea
11:30-12	Summary of size limit information (Nicole)

12-1pm	Outline of Harvest Strategy framework and details and decision rules that need to be agreed on (Éva)
1-2pm	Lunch
2-3 pm	SMALL GROUP BREAKOUT SESSION 1 – Harvest Strategy Components: participants to discuss and provide their feedback on questions in background document provided, to inform on settings in the Harvest Strategy
3 -3:30	Afternoon tea
3:30-4:30pm	Small group report back, opportunity for questions, further discussion and synopsis of participant inputs
4:30 – 5pm	Conversion ratios – the latest (Nicole & Tim) End of Day 1

Thursday 26 October

8:30-9:30am	Summary of progress previous day and objectives for Day 2 and breakout session
9:30-10am	SMALL GROUP BREAKOUT SESSION 2 – Process for monitoring and re-opening a fishery: participants to discuss and provide their feedback on questions provided – focus on monitoring, surveys, roadmap for re-opening fisheries
10-10:30am	Small group report back, opportunity for questions, further discussion and synopsis of participant inputs
10:30-11am	Morning tea
11-12 pm	Summary presentation on HS framework, decision rules and any outstanding issues Discussion of next steps
12 pm	Meeting close (lunch or depart for flights)

Background questions for bêche de mer Harvest Strategy Workshop, 25-26 October 2017

The workshop on 25-26 October will build on the previous workshop during which a draft harvest strategy (HS) framework was developed with participants (Fig. A.1 – at end of this document). Below are some of the discussion items that input will be sought from participants (both in small-group and plenary sessions) in order to refine the specific details of the HS.

SMALL GROUP BREAKOUT SESSION 1 – Harvest Strategy Components:

Indicators:

- Are necessary improvements in data recording and collation on track? As explained in the last workshop report, the HS can be updated and refined as more and better quality data become available. During Stage 1, which of the following data will definitely be available as inputs to the HS:
    - Catch per species
    - Catch and Effort i.e. CPUE; what are the units effort will be measured in (eg dive time, no. tubs etc)
    - Size samples of selected species (who will collect)
    - Species composition sample (from logbooks and/or sample collected by whom?)
    - Spatial footprint (sample) – if sufficient information recorded in logbooks could be obtained from that source
    - Discard mortality – how to get an estimate?

Monitoring:

- What is the most cost-effective way to get survey data that is needed to re-open a fishery on a species or to monitor several TSBDMF species in the fishery?

Assessment:

- Are there any issues that need to be considered in moving to a separate TAC for curryfish? Also will it be possible to monitor roughly what proportion of the total curryfish catch is comprised of common curryfish (hermanni) vs vastus curryfish (vastus)?
- Is there support and are there any issues if a separate TAC is set for (A) Deepwater redfish and (B) Hairy blackfish?
- How soon after the end of the fishing season will data be available?
- Are there existing CPUE data or do we need to wait 3 years before one can start using CPUE to provide a reliable index of abundance?

Decision Rules:

- Is there agreement that increasingly stringent penalties should be applied where total catch exceeds the recommended biological catch in a year (eg the additional catch to be subtracted from next year's catch)
- Please consider draft decision Rules (summarised also in flowchart form) in decision Rule section below – comments or suggested changes to these.
- Please also consider Tier Flowchart (Fig. 5) – any comments?

SMALL GROUP BREAKOUT SESSION 2 – Monitoring and process for re-opening a fishery:

Monitoring and Rules for Re-opening a fishery:

- Sandfish – a full scale stock survey of Warrior Reef, potentially in collaboration with Papua New Guinea was recommended. Are there suggestions for how and by whom a survey could be run to assess the extent to which this species has recovered and whether the fishery could be re-opened
- There has been some discussion around the need for and use of biomass surveys (fishery-independent surveys), particularly for key species such as sandfish, but what are the most cost-effective ways of collecting data needed to inform management?
- Trial re-openings for a species – are you happy with the suggested rules below or suggest changes or additions (see also Fig. 5 below)?
    - Biomass survey is needed
    - Stock needs to be demonstrated to be above pre-specified limit reference level
    - Condition for re-opening is a commitment to data recording – could specify a compliance catch reporting limit of eg (A) 80%; (B) 90% OR (C) 100%
    - There needs to be no overshoot of the experimental TAC – an overshoot of more than 5% results in continued closure the following year
    - The catch and effort (diving time) must be recorded during experimental trial for use in evaluating the stock
    - A conservative initial TAC should be set

SMALL GROUP BREAKOUT SESSIONS – Additional questions to be considered in session 1 or 2 time-permitting

- **Static Controls:**
    - Revise and recirculate size limit summary information for consideration and comment
    - Previously strong support was expressed for communities self-regulating and overseeing spatial exclusions such as the proposed 10 nm exclusion zone around home reefs for fishing prickly redfish – should this be considered for any other species?
    - Is there support for seasonal closure recommendation Nov-Jan
    - How much support is there for a new management control in the form of a restriction on allowing processing of TSBDMF onboard fishing vessels

- **Other indicators**: Is there support and suggestions for advancing the community multiple indicator scoring framework to complement primary indicators?

Summary of local data could be collected for use as indicators:

LOCAL:	Size composition - small: large ratios Condition index of animals Surveys of dead individuals on beach Distance travelled to fish Local CPUE Perceived extent of illegal fishing Environmental conditions favourable or not, in terms of temperature, state of habitat (algae), predators Density estimates (e.g. by diver cameras)

Workshop 3: 25-26 July 2018

DRAFT AGENDA
CSIRO HARVEST STRATEGY WORKSHOP
Dates: 25-26 July 2018
Following Torres Strait Hand Collectables Working Group (24 July)
Venue: Thursday Island – TSRA Boardroom on 24th and 26th and Thursday Island Boat Shed on the 25th

Workshop Chair: Anne Clarke

Workshop Co-ordinators: Éva Plagányi & Leo Dutra, assisted by Tim Skewes (apologies Nicole Murphy)

WORKSHOP AIMS AND OUTLINE

There are many components to a Harvest Strategy, and a summary of some of the key components of the TSBDMF strategy being developed with stakeholders is summarised below. The details of each component are described in previous workshop reports and presentations, and are being updated and refined in consultation with stakeholders, taking into account feedback from plenary sessions and small breakout discussion groups.

The July 2018 workshop will provide an opportunity to comment on all aspects of the harvest strategy, but given limited time, a few key areas have been selected for more in-depth discussion to assist with refining specification of these components in the harvest strategy. There are 3 related categories that have been discussed at the ongoing workshops, and this workshop will focus on the second of these:

1. Management structures (e.g. the issue of allocation/control of the fishery to island clusters)
2. **Decision Rules (also called harvest control rules) for adjusting catches (including how to get useful indicators of stock status and how to obtain and analyse these indicators)**
3. Static controls (eg size limits which provide additional support for achieving the biological, economic and socio-cultural aims of the harvest strategy)

Background questions to guide discussions during the breakout sessions are provided in a separate document.

Draft Torres Strait Bêche-de-mer Harvest Strategy Framework Components

- Monitoring and data collection to determine indicators
- Reference points, Method of Assessment and Decision Rules
    - Decision rules for species-specific recommended biological catches
    - Decision rules for lumped species category
    - Decision rules for re-opening a fishery or area
- Management controls – static
    - Size limits
    - Temporal closure
    - Processing Restrictions
- Value Adding and economic considerations
- Environmental Influences
- Operationalising Fishery Objectives
- Formal evaluation of whether the harvest strategy options are likely to achieve the management objectives
- Implementation

Wednesday 25 July

8:30-9:00	Opening prayer and acknowledgement of traditional owners Introduction and outline of workshop objectives (Éva)
9-11am	• Recap of progress to date on developing a Harvest Strategy for Torres Strait bêche der mer Fishery (with reference to October 2017 workshop & framework summarised in Fig. 1, and summary at end of Agenda) • Progress on action items (size measures, conversion ratios, 10 nautical mile radial closures from Mer and Erub communities)
11-11:30am	Morning tea
11:30-12:30	SMALL GROUP BREAKOUT SESSION 1 – Harvest Strategy Components: Obtaining useful Catch and Effort indicators (see Background questions in Appendix)
12:30-1pm	Small group report back, opportunity for questions, further discussion and synopsis of participant inputs
1-2pm	Lunch
2-2:15 pm	Short overview of previous sea cucumber surveys: choosing representative sites, obtaining density estimates and trend information to support management (Tim Skewes)
2:15-3:15pm	SMALL GROUP BREAKOUT SESSION 2 – Harvest Strategy Rules for Re-opening a fishery and use of survey data in setting TACs (see Background questions in Appendix)

3:15 -3:45	Afternoon tea
3:45-4:30pm	Small group report back, opportunity for questions, further discussion and synopsis of participant inputs
4:30 – 5pm	Planning for next workshop on Eastern Island/s and including community consultation – suggestions, communication strategies, planning, comments on draft HS Tentative dates: 22-26 October 2018? End of Day 1

Thursday 26 July

8:30-9:30am	Summary of progress previous day and objectives for Day 2 and breakout session
9:30-10:30 am	SMALL GROUP BREAKOUT SESSION 3 – Review of overall Harvest Strategy Framework: what's missing? Suggested changes etc
10:30-11am	Small group report back, opportunity for questions, further discussion and synopsis of participant inputs
11am	Morning tea
11:15-12 pm	Summary presentation on HS framework, decision rules and any outstanding issues Discussion of next steps
12 pm	Meeting close (lunch or depart for flights)

Summary of Workshop Planning

The July 2018 workshop will be run in a similar dynamic format to previous ones, which allows for a high level of interaction from members. Topics previously discussed will be touched on with regard to obtaining members desire to cover again, and in what detail. In addition, prior meeting transcripts are reviewed and comments and questions prepared for, such as:

Request for example scenarios that can be simulated and run through at the next meeting.

Question - How is discard rate accounted for?

Question – How is TAC allocated for other species? If Prickly Redfish and Curryfish fished heavily, other species then fished instead. Concern no one knows what is being taken. How can this be captured.

Comment – Note or mark out reefs where know species have been declining eg. Curryfish and Prickly Redfish. Used as a red flag for managers, can record in comments on docket books, or add a map.

The workshops will include both small group discussion sessions and plenary sessions aimed at filling knowledge gaps and reviewing and seeking endorsement of the draft harvest strategy. Inputs from stakeholders will be used to refine details of the harvest strategy, with basic elements as summarised in Fig. 1. The harvest strategy will focus in the main on rules that can currently be implemented based on current data availability, but will also include options for moving to higher tiers in future (eg if survey data become available) and these options could be further refined in future. As with the previous workshops, they have been planned to involve the HCWG members and observers, plus additional key stakeholders are invited to try and ensure broad representation of stakeholders who in turn represent the many communities.

The workshop will also provide an opportunity to refine the details of some of the rules being considered for incorporation in the harvest strategy. This includes:

1. Defining a decision rule and trigger limits for the 2 curryfish species
2. decision rules based on survey information
3. the proposed multiple indicator decision rule based on CPUE, size composition, spatial footprint and catch proportion

CSIRO HARVEST STRATEGY WORKSHOP

Background questions for participants 25-26 July 2018

SMALL GROUP BREAKOUT SESSION 1 – Wednesday 11:30-12:30

Harvest Strategy Components: Obtaining useful Catch and Effort indicators

- How well can we separate catch data for individual species e.g. curryfish (vastus and hermanni)?
- For shallower water species and mixed species assemblages, do fishers collect all suitable animals as they are encountered, or optimise time in the water to focus on specific species. If the former, then for a fixed diving time, we should be able to use the catch per species divided by total combined dive time as an index of abundance of that species. If the latter, we need information on relative preferences for species.
- For deeper water or target species (eg white teatfish, prickly redfish), how can we get an index of abundance? For example, if the stock is highly aggregated, then CPUE will stay high until the aggregation is close to being depleted. Can we get information on the spatial extent and depth of fishing? What difference are different fishing methods likely to have?
- Can we use a single combined CPUE index for each species, or do we need to consider separate indices for different fishing areas? If so, for which species and what is the minimum number of separate indices we would need?

SMALL GROUP BREAKOUT SESSION 2 – Wednesday 2:15-3:15pm

Harvest Strategy Rules for Re-opening a fishery

Decision rules are needed to inform decisions related to re-opening a closed fishery or closed area. Participants at previous workshops agreed that evidence of recovery was a necessary criterion and could be assessed based on data such as a biomass estimate from a survey. Consistent with the fishery objectives, a strategy for a gradual return was then needed, including a conservative initial TAC for example, and ongoing monitoring would be essential (Figure 5).

- Is it feasible that surveys of key species could be done to inform whether to re-open the fishery for a species? Will these be done by the community or outsourced to researchers?
- Are there alternative ways to get adequate information to inform potential re-opening?
- Is it sufficiently conservative to set the starting TAC as half the target value for the first year?

- Based on discussions at previous workshop, can we set a trigger at 75% (three quarters) of the TAC at which point all fishers need to pause activity to wait for data to be submitted and analysed to ensure no overshoot of the TAC. As per suggestion from stakeholders, the system could also include rapid sms/text (other?) of catch even before formal records submitted to help keep track of catch?

SMALL GROUP BREAKOUT SESSION 3 – Thursday 9:30-10:30am

Review of overall Harvest Strategy Framework (Fig. 1-5): what's missing? Suggested changes etc

- Is the distinction between the 3 tiers clear?
- Does the flowchart in Fig. 1 (see also Fig. 2) cover most scenarios? Anything missing?
- Does the Harvest Strategy Framework (as per Fig. 1) make sense in terms of allowing increases in TAC as more data become available?
- Which rules need changing or refining or do you think will be difficult to implement?
- **Any further comments on suggestions raised during previous HCWG:**
- If trial opening of species eg BTF, then only allow to catch that species on boat
- Consider opening during June-July (during right tide) – TRL season so fairer for dedicated fishers working in East
- Ways to limit/control who can fish given cultural laws?
- System to submit sample photos of mixed species catches to inform on species composition and validate species identification? There were mixed views as to whether scientific observers might be available to assist in looking at catch samples eg once per month – any further thoughts?

For recovering/re-opening species:
Establish effective warning system so everyone stops and pauses when approaching experimental TAC to allow extra data to come in
Rule: Experimental TAC cannot be exceeded by more than 5%

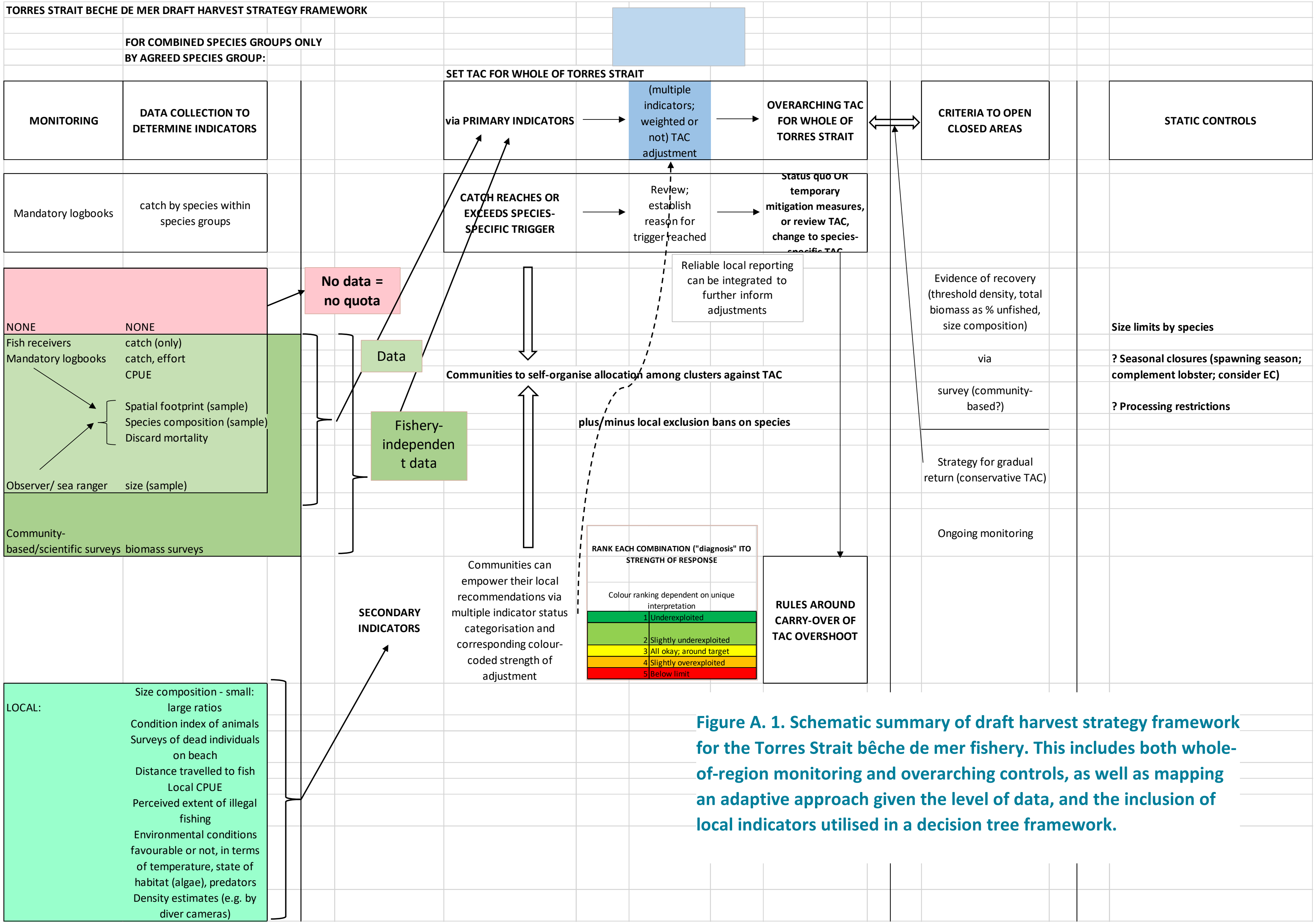

Figure A. 1. Schematic summary of draft harvest strategy framework for the Torres Strait bêche de mer fishery. This includes both whole-of-region monitoring and overarching controls, as well as mapping an adaptive approach given the level of data, and the inclusion of local indicators utilised in a decision tree framework.

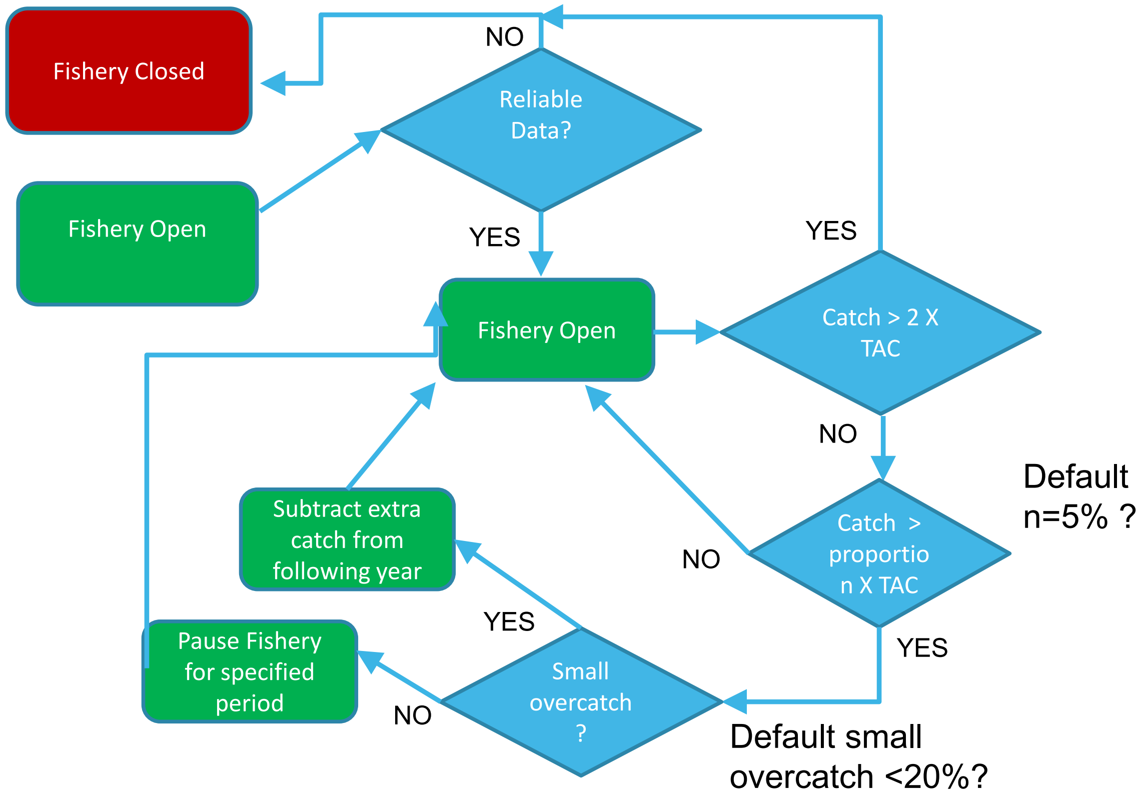

Figure A.2. Flowchart summarising illustrative decision rule based on catch

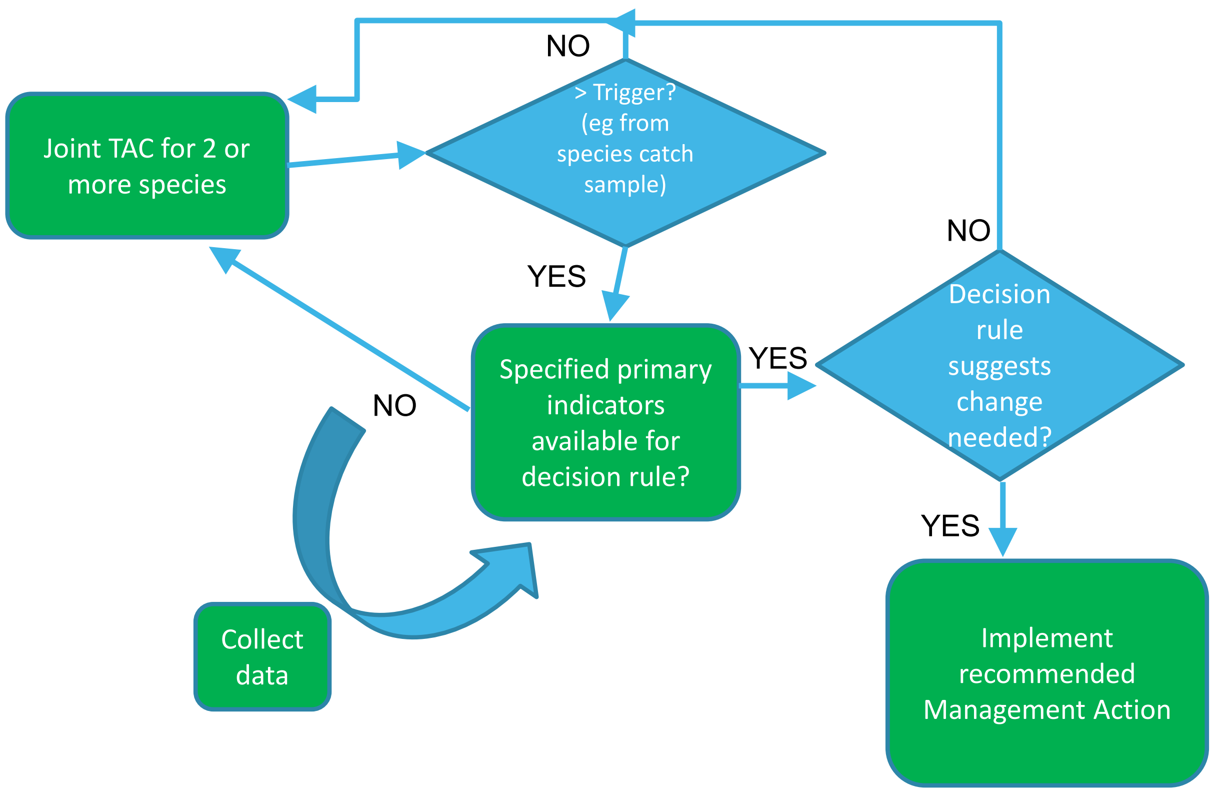

Figure A.3. Flowchart summarising illustrative decision rule for reviewing whether a trigger is exceeded for any species caught as part of a lumped species allocation.

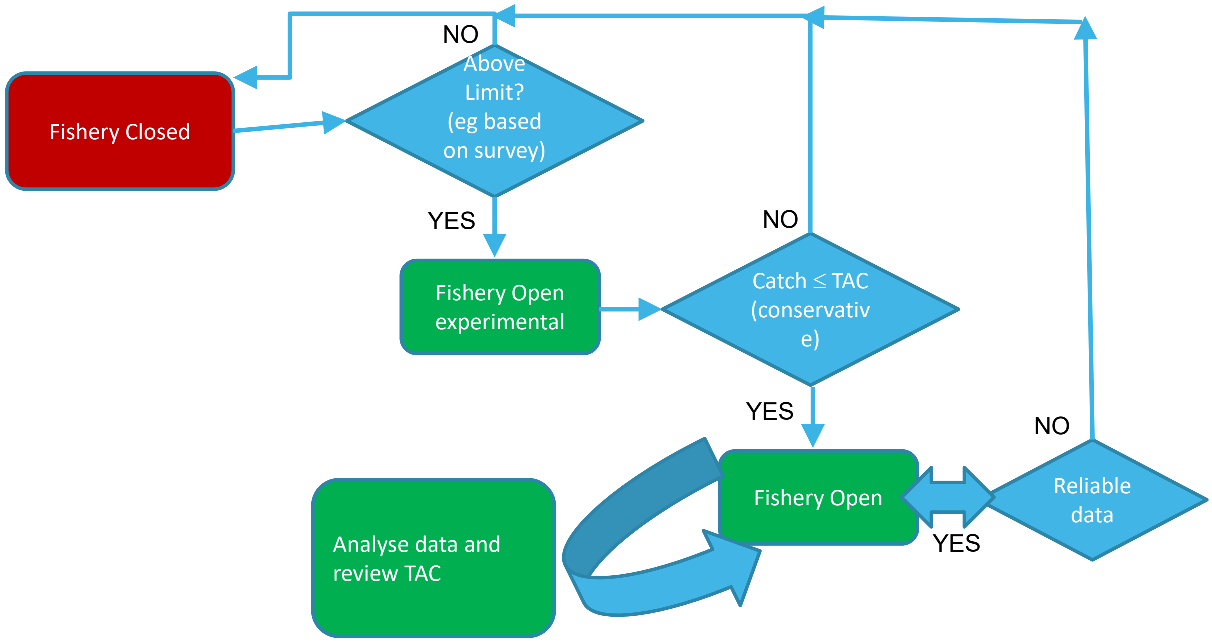

Figure A.4. Flowchart summarising proposed process for re-opening a closed fishery.

Workshop 4: 23 October 2018

Torres Strait Beche-de-mer Fishery
Harvest Strategy Workshop

Tuesday 23 October 2018 (10:30 am – 4:00 pm)

Venue: TSIRC Conference Room

Erub (Darnley) Island

DRAFT AGENDA

Workshop Chair: Anne Clarke

Workshop Coordinators: Éva Plagányi, Nicole Murphy, Tim Skewes and AFMA Staff

Morning tea, lunch and afternoon tea will be provided

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1. **Workshop Opening**

   Opening prayer and acknowledgement of traditional owners.

2. **Beche-de-mer Harvest Strategy**

   CSIRO will present on the draft final Harvest Strategy for the Torres Strait Beche-de-mer Fishery. Participants are invited to discuss and provide comments on all aspects of the harvest strategy.

3. **Fish Receiver System and Catch Reporting Information Session**

   AFMA will provide an overview of the Fish Receiver System in Torres Strait Fisheries and present some catch reporting information since the FRS was implemented in December 2017.

4. **General AFMA / CSIRO Question & Answer**

   Participants are encouraged to engage with CSIRO and AFMA staff on all things Torres Strait Fisheries for a general question and answer session.

Appendix 2 Summary discussion points from Small Group Breakout Sessions

Workshop 1: June 2017

Summary discussion points from Sub-Group 1

Indicators:

- Stressed need for good data: TIB fishers to take responsibility – need greater awareness and education as data needed to inform decisions
- Identify committed divers/industry – ongoing fishing needs to be dependent on reporting – particularly important for high value species; communities also have responsibility in overseeing the number of active fishers; fishers do not need to reveal individual confidential information but it needs to be clear whether they are reporting their data
- Agreement if there are no data, fishery should be closed
- Need data from buyers and logbooks
- Challenge: getting data from logbooks to AFMA eg fax, mailing – risk if lost; electronic poses challenges eg on Murray Island there isn't often reception; need additional resources?
- How to get information recorded in timely period?
- Buyers considered important for data collection
- Logbooks – data recorded that could be used as indicators includes:
    - Catch
    - Species – which species recorded; mainly 5 species
    - Effort – fishers daily catch is recorded so have Catch/day
    - Spatial longitude and latitude co-ords can be used as indicator of spatial footprint
    - Depth not usually recorded
    - The area fished can be recorded eg reefs around Thursday Island are numbered

Monitoring Methods – the following categories were proposed as valuable:

- Logbooks
- Docketbooks / Fish Receiver System
- Scientific surveys (eg biomass or density surveys)
- Onboard Observers, possibly Sea Rangers – discussed whether TSRA/AFMA could resource scientific observers for analysing Torres Strait catch composition for example

- Use of camera monitoring eg changes in product size could be monitored by camera; could take sample photos and use to review which species – particularly for curryfish, area fished, size of animals; could also use cameras as part of scientific surveys. Could use camera on specific dives; bus stop approach taking photos at set time periods/locations for comparison; could compare densities at different depths; could possibly see changes in aggregation over seasons; need resources.

- Agreement at meeting regarding voluntary closures
- Need surveys to look at biomass at periodic intervals to check on status of key species such as prickly redfish

Management Controls in the form of Exclusion Zones:

- Recommend 10nm exclusion zone for prickly redfish
- Need to recognise differences in terms of where/depth different species can be fished, and there are also differences between different areas – for example for Ugar and Erub Islands need to fish closer than for Murray Island
- Might be a good idea to set up exclusion zones around some areas thought to be important for large breeding animals

Decision Rules for Adjusting

- Suggested needed to split curryfish and allocate separate TAC
- Need trigger level set for different species
- To implement, need to know how many of each species – for difficult to identify species, suggested could use a skipper with training to look at catch composition say once per month. Also suggested scientific observers could be used.
- Discussed comparison with rules used for ECBDMF to adjust TAC up or down
- Reference levels (target and limit) can be based on survey biomass estimates or density estimates

Rules for Re-Opening a Fishery

- Use a survey to analyse trends and inform whether recovery taking place
- If recovering, re-open with conservative TAC
- Comparison with east Coast approach where CPUE information from logbooks is used to adjust TAC up or down

Regional Management

- Need care in managing data so doesn't lead to more exploitation – native title stakeholders to decide how to protect.
- Suggest could set total catch limit and devolve responsibility to native title stakeholders regarding allocations such as spatial sharing
- Need mapping of Native Title spatial structure
- Need to follow local rules

- Ownership is key – people take ownership for looking after their own area

Summary discussion points from Sub-Group 2

- Impediments to data recording:

Not compulsory; lack of education/awareness; sporadic fishing; records not going to AFMA; concern about confidentiality; concern about reaching TAC; doesn't capture damaged, lost or discarded catches.

- Which species need own quota – mentioned curryfish:

Curryfish, Prickly Redfish, Greenfish.

- Does this change as marketing changes and new markets emerge – can we have rule to accommodate?

Changes with market demand/value – aim to have TAC or triggers for each species, with the triggers having associated actions.

- What are minimum information requirements to re-open fishery eg. sandfish:

Reliable catch reporting/monitoring. Assessment and knowledge of current stock level. A conservative TAC. Consideration of harvest strategy outcomes.

- Should we have minimum and maximum size limits (eg. prickly redfish discussion):

Definite minimum sizes. Maximum where science convinces.

- Breeding/egg area closures (seasonal closures?); green areas – support and ideas for these? Don't close same time as TRL. How to monitor and enforce:

Spatial closures difficult to manage/compliance/conflict. Suggestion – close TSBDMF fishery Dec/Jan (coincides with spawning season for most cucumber species, gives all species chance to rest and spawn), allow free dive of TRL for TIB Dec/Jan. No primary vessels.

- Is there a preference for closing areas around reefs (eg. 10nm exclusion zone/voluntary closure proposed for prickly redfish) – target species only or several species:

Prefer whole areas eg. within 10nm rather than specific reefs and is voluntary – more likely to be supported. Noted that it may not be respected if voluntary, especially if fishers not from adjacent island community.

- Is there a way to increase economic profit and value adding through consideration of harvest control rules:

There may be ways to increase economic profit and value adding through diversifying, more awareness and co-ordination. Suggestion to work as a cluster to attract higher prices, co-ordinating product and can control quality. Example for community TAC eg. 5-7 tonnes each, if you overfish it comes off your allocation/TAC the following year - with built in review (species/catch).

- Data that could be used as indicators – could we get effort information, species size composition, spatial extent of fishery:

Can get catch and species. Numbers and size are not recorded. Some note down co-ordinates/where fished. Suggestion to write down in comment section some observations/environmental eg. reef dead, algae over grown. Question – can this data be captured on other logbooks.

- If there is a lag before confirmation that total TAC reached, should this be averaged in some way over 3 years or so eg. fishery TAC zero in 2nd year if large over catch in first year:

Yes, there is a lag/no real time fishery management. Support for idea of a community TAC eg. 5-7 tonnes each, if you overfish it comes off your allocation/TAC the following year - with built in review.

- What actions are required short-term in response to problem or concern detected vs how to manage risks, longer term harvest strategy to ensure sustainability:

Short term actions – Compulsory catch monitoring, better understanding eg biology and specific actions per species, size limits, triggers.

Long term – Ability for real time management.

- Spatial management – thoughts re allocations to home communities as discussed at the hand collectable working group. Could this be implemented? Would facilitate ownership and not being penalised for over catches in other areas. How feasible to draw up and get agreement on spatial boundaries and catch sharing? Would have to be done and agreed by community not scientist or managers:

Not supported/not recommended.

- How to integrate community plans into harvest strategy:

Community plans are important for informing the harvest strategy eg. indicators and also need evidence.

- TIER approach:

All about risk, TIER approach is supported.

Summary from Sub-Group 3 including Community-level framework

Sub-Group 3 identified a number of indicators that collectively reflected the general status of the sea cucumber stocks locally. These indicators were felt to be easy to report at a local level, and were in currencies relatable to local industry members.

The Sub-Group indicated that TIB fishers are eager to undertake local reporting and to take responsibility for local management. As such, the Sub-Group sought to operationalise these indicators in a decision framework to provide a defensible basis on which to make recommendations for cluster catch allocations and for other local management measures.

Under the proposed harvest strategy, clusters of communities would be responsible for monitoring key species and species groups, which could in future inform local allocations of a regional total allowable catch. The framework presented here provides a bottom-up means to diagnose the status of sea cucumber stocks locally, and thus provide a transparent, replicable and defensible basis by which to seek local allocations, and/or to adjust management at a local level.

Industry representatives in the Sub-Group felt that such a framework provided a formal means to assimilate their local knowledge, and drew an analogy to a doctor considering a range of symptoms in combination to form a diagnosis, and then responding with an appropriate level of severity.

Such an approach could empower stakeholders through operationalising their local knowledge and providing a vehicle for determining allocation and for responding to local conditions and changes. If the approach is broadly embraced, and is deemed to work well, there is scope for the indicators to become considered in the higher level determination of the TAC and/or for this to influence a regional TAC.

Within the draft hierarchical decision tree framework considered two groups of local indicators: “primary” local indicators (those felt to be most reliable/important, and thus invoking the greatest change in management), and “secondary” local indicators (used to make further, more minor adjustments to management recommendations) (noting that the use of “primary” and “secondary” here is specific to the local decision tree context, and does not equate to the use of these terms in the main document (per Figure 1). An example of a hierarchical decision tree may be found in Prince et al. (2011).

For the draft decision framework presented, the delineation of local indicators as “primary” or “secondary” was somewhat arbitrary; this would require further discussion prior to these being finalised.

Table A3.1 summarises the list of local indicators determined by Sub-Group 3. For ease of use in a decision tree context, these indicators are summarised into 6 groups of broad performance measures. Performance measures can be considered as “diagnostics” in terms of assigning where the indicator sits relative to a target or limit reference point.

A first draft ‘straw man’ decision tree is presented in Table A3.2. This takes two sets of “primary” indicators (each with two possible alternative performance measure categories), and, according to the 4 corresponding combinations of performance measures, assigns an initial strength of response (increase, status quo, or decrease) in terms of a catch adjustment. The 16 possible combinations of the 4 “secondary” sets of performance indicators (each with two possible alternative performance measure categories, highlighted by red or green coloured text in Table A3.2) were then used to further weight the strength of the proposed catch adjustment, such that there were 7 possible levels of response: strong increase in catch, moderate increase in catch, small increase in catch, maintain status quo, small decrease in catch, moderate decrease in catch, and fishery closure.

Note that the exact magnitude of these catch adjustments was not specified, and indeed, that the strength of responses could instead equate to (for example), spatial measures in combination with catch adjustments.

The distribution of the strength of management responses was such that the majority of indicator combinations resulted in a status quo response of no change, while a "strongest increase" or "closure" response occurred with the least frequency.

Some of the combinations of secondary performance measures were deemed to be unrealistic (not sensible) or unlikely/unusual, with no strength of management response assigned to the former. In total, there were 64 combinations of primary and secondary performance measures.

Erub and Ugar representatives proposed initial target levels of local annual catch for curryfish, black teatfish (when open), prickly redfish, and white teatfish.

References:

Prince, J.D., Dowling, N.A., Davies, C.R., Campbell, R.A., Kolody, D.S., 2011. A simple cost-effective and scale-less empirical approach to harvest strategies. ICES Journal of Marine Science 68, 947-960

Table A3.1 Proposed local indicators, provisionally assigned as "primary" or "secondary", and combined into 6 performance measures.

			"Diagnosis" (performance measure)
Primary indicators	Catch		At/above or below target
		Temperature	Favourable or not
	Environmental conditions favourable or not, in terms of	Condition of feeding grounds (algae etc.)	
		Predators	
Secondary indicators	Density, estimated by	Diver camera surveys	At/above or below target
		By habitat type (sand, algae, seagrass)	
	Size composition		recruitment and spawning potential
	Distance travelled to fish		localised depletion
	Catch-per-unit-effort	Tubs per day OR kg/day, fuel cost/day	
	Condition index of animals		animals under external stress
	Surveys of dead individuals on beach		
	Perceived extent of illegal fishing		
	Recovery time of hotspots		

Table A3.2 Initial draft of a proposed decision tree framework to assist with assessing bêche de mer stocks at a local scale, and to provide a defensible basis on which to make recommendations for cluster catch allocations and for other local management measures.

PRIMARY INDICATORS		PRIMARY (largest) ADJUSTMENT (to catch)	SECONDARY (smaller) ADJUSTMENT (to catch, and/or spatial/temporal)	SECONDARY INDICATORS				
Catch at or above target	Environmental conditions favourable (2-3 indicators okay)	INCREASE IN CATCH		Density at or above target	No concerns about recruits or spawners	no localised depletion	no external stress	
				Density at or above target	No concerns about recruits or spawners	no localised depletion	external stressors (1 or more indicators)	
				Density at or above target	No concerns about recruits or spawners	localised depletion (1 or both indicators)	no external stress	Not sensible to see acceptable density if localised depletion
				Density at or above target	No concerns about recruits or spawners	localised depletion (1 or both indicators)	external stressors (1 or more indicators)	Not sensible to see acceptable density if localised depletion
				Density at or above target	Poor recruitment OR low spawner potential	no localised depletion	no external stress	
				Density at or above target	Poor recruitment OR low spawner potential	no localised depletion	external stressors (1 or more indicators)	
				Density at or above target	Poor recruitment OR low spawner potential	localised depletion (1 or both indicators)	no external stress	Not sensible to see acceptable density if localised depletion
				Density at or above target	Poor recruitment OR low spawner potential	localised depletion (1 or both indicators)	external stressors (1 or more indicators)	Not sensible to see acceptable density if localised depletion
				Density below target	No concerns about recruits or spawners	no localised depletion	no external stress	Would be unusual to have low density but no localised depletion
				Density below target	No concerns about recruits or spawners	no localised depletion	external stressors (1 or more indicators)	Would be unusual to have low density but no localised depletion
				Density below target	No concerns about recruits or spawners	localised depletion (1 or both indicators)	no external stress	
				Density below target	No concerns about recruits or spawners	localised depletion (1 or both indicators)	external stressors (1 or more indicators)	
				Density below target	Poor recruitment OR low spawner potential	no localised depletion	no external stress	Would be unusual to have low density but no localised depletion
				Density below target	Poor recruitment OR low spawner potential	no localised depletion	external stressors (1 or more indicators)	Would be unusual to have low density but no localised depletion
				Density below target	Poor recruitment OR low spawner potential	localised depletion (1 or both indicators)	no external stress	
				Density below target	Poor recruitment OR low spawner potential	localised depletion (1 or both indicators)	external stressors (1 or more indicators)	

Catch at or above target	Environmental conditions unfavourable (only 1, or zero indicators okay)	STATUS QUO		Density at or above target	No concerns about recruits or spawners	no localised depletion	no external stress	
				Density at or above target	No concerns about recruits or spawners	no localised depletion	external stressors (1 or more indicators)	
				Density at or above target	No concerns about recruits or spawners	localised depletion (1 or both indicators)	no external stress	Not sensible to see acceptable density if localised depletion
				Density at or above target	No concerns about recruits or spawners	localised depletion (1 or both indicators)	external stressors (1 or more indicators)	Not sensible to see acceptable density if localised depletion
				Density at or above target	Poor recruitment OR low spawner potential	no localised depletion	no external stress	
				Density at or above target	Poor recruitment OR low spawner potential	no localised depletion	external stressors (1 or more indicators)	
				Density at or above target	Poor recruitment OR low spawner potential	localised depletion (1 or both indicators)	no external stress	Not sensible to see acceptable density if localised depletion
				Density at or above target	Poor recruitment OR low spawner potential	localised depletion (1 or both indicators)	external stressors (1 or more indicators)	Not sensible to see acceptable density if localised depletion
				Density below target	No concerns about recruits or spawners	no localised depletion	no external stress	Would be unusual to have low density but no localised depletion
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				Density below target	Poor recruitment OR low spawner potential	localised depletion (1 or both indicators)	external stressors (1 or more indicators)	

Catch below target	Environmental conditions favourable (all 3 indicators okay)	STATUS QUO		Density at or above target	No concerns about recruits or spawners	no localised depletion	no external stress	
				Density at or above target	No concerns about recruits or spawners	no localised depletion	external stressors (1 or more indicators)	
				Density at or above target	No concerns about recruits or spawners	localised depletion (1 or both indicators)	no external stress	Not sensible to see acceptable density if localised depletion
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				Density below target	Poor recruitment OR low spawner potential	localised depletion (1 or both indicators)	external stressors (1 or more indicators)	

Catch below target	Environmental conditions unfavourable (only 1, or zero indicators okay)	DECREASE IN CATCH		Density at or above target	No concerns about recruits or spawners	no localised depletion	no external stress	
				Density at or above target	No concerns about recruits or spawners	no localised depletion	external stressors (1 or more indicators)	
				Density at or above target	No concerns about recruits or spawners	localised depletion (1 or both indicators)	no external stress	Not sensible to see acceptable density if localised depletion
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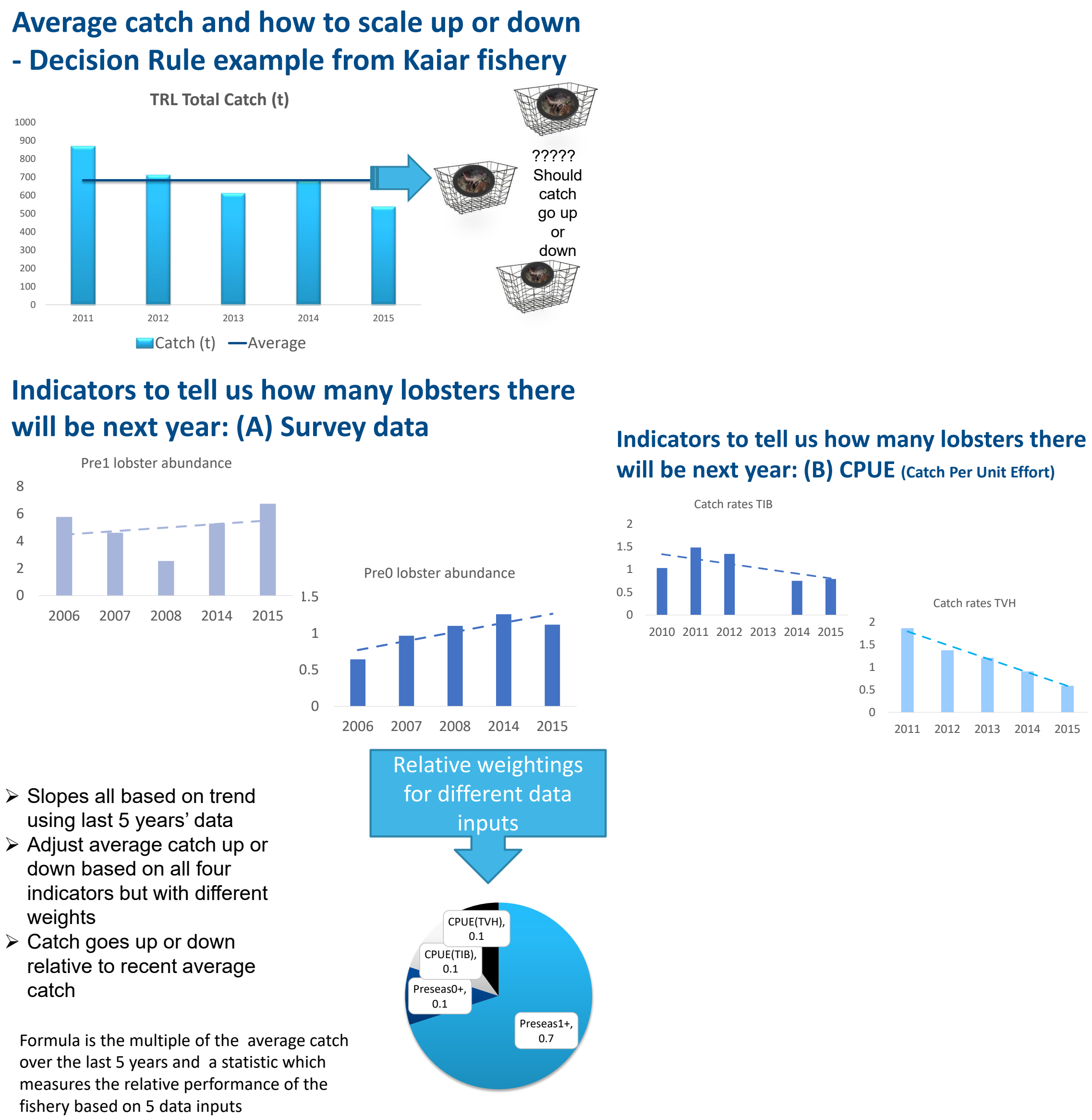
June 2017 Workshop sessions and key summary points discussed

<u>Introduction and background:</u> Overview of Harvest Strategies and recap from first workshop

- Showed example of previous modelling work highlighting the need to maintain catches at sustainable levels, especially for longer-lived species such as prickly redfish which could fairly rapidly become depleted and then take a very long time to recover (see Torres Strait Hand Collectables Working Group No.11 Meeting Record, 27 June 2017)
- Boom and bust cycles observed in other sea cucumber fisheries discussed.
- Recommendations from previous studies being used to inform this study, including from a previous project on evaluating management strategies for data-poor bêche de mer species in Torres Strait by Plagányi, Skewes, Dowling and Haddon (2011) and lessons from the East Coast Bêche de Mer Fishery (ECBDMF)
- An example from the tropical rock lobster harvest control rule was used to illustrate how monitoring information can be combined in a decision rule to adjust a Recommended Biological Catch upwards or down – as per example below.



<u>Workshop Action 1:</u> Obtain consensus on key management objectives for the fishery as well as more specific objectives for individual species

- Recorded key points (see for example Figure 5 below) and a revised draft is under preparation for comment and review

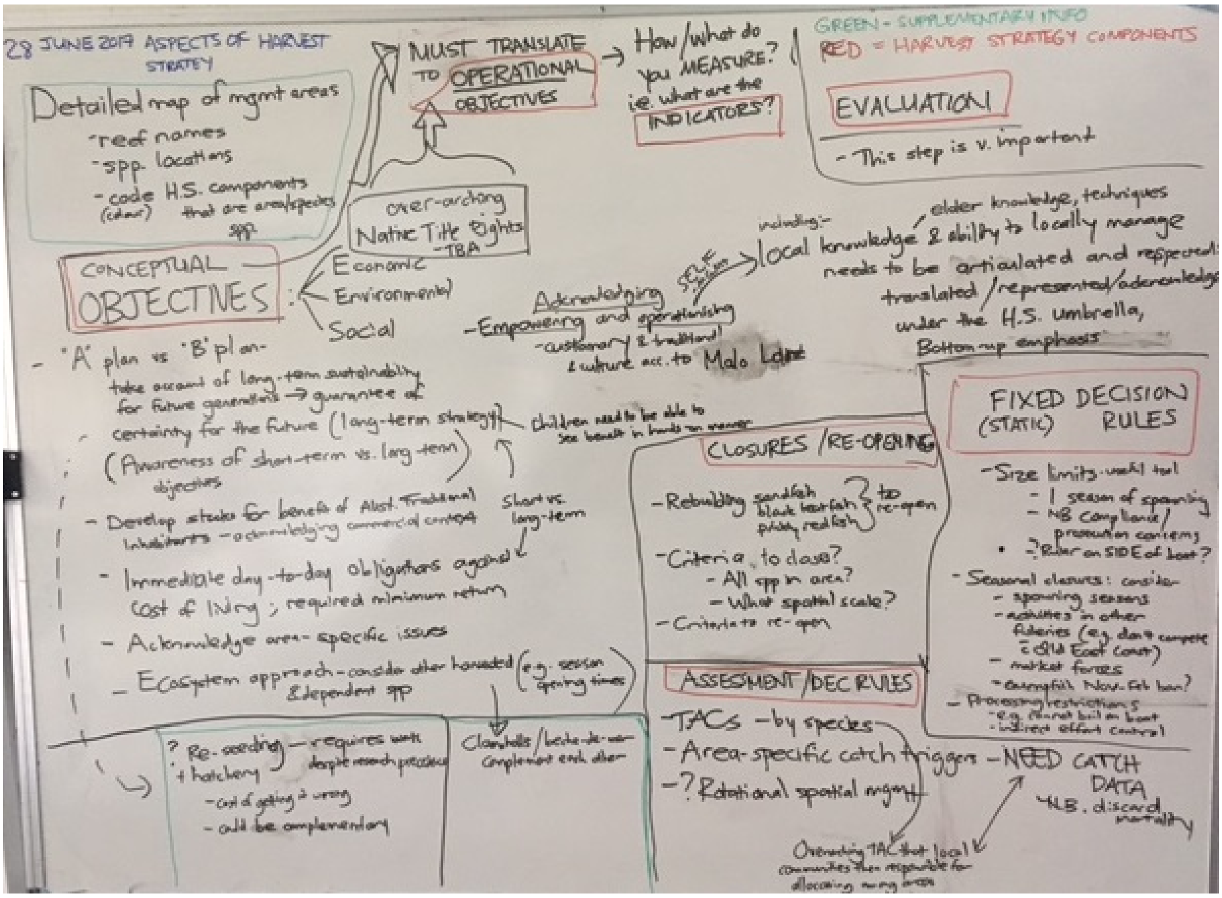


Figure 13. Copy of whiteboard notes from workshop summarising fishery objectives considered important by stakeholders, together with suggestions for static and adaptive management controls and rules for consideration in developing a harvest strategy for the Torres Strait bêche de mer fishery.

<u>Workshop Action 2: </u>Update and obtain consensus on revised minimum size limits for individual species and generic limit for remaining species

- Discussed principles of setting size limits so size set larger than size at maturity
- Allows for sea cucumbers to spawn before being fished
- Reviewed literature for size at maturity for sea cucumber species
- More information on some species than others
- Recorded all information eg. sizes for male or female, age at maturity, weight – base line data for species
- Proposed size limits for Torres Strait
- Noted size limits for Torres Strait, East Coast and Coral Sea Fisheries
- Reviewed based on:
    - Increased as smaller than size at maturity (literature)
    - Better align with East Coast BDM Fishery size limits

    - Based on model recommendation

- Extensive discussion on suggested revisions to size limits (see Appendix 4), with agreement that first consideration should be age at first maturity and next consideration could be to better align with the size limits used for the East Coast BDM Fishery, which are generally more conservative.

Workshop Action 3: Discuss feasibility of reliably measuring size of animals, and whether additional resources would facilitate this process (eg ruler or size gauge)

- Useful suggestions tabled such as a sticker with size measures on the side of boats
- Challenges acknowledged in measuring animals that can shrink or need to be processed rapidly and hence conversion ratios necessary

Workshop Action 4: Review conversion ratios for sea cucumbers

- Request for conversion ratios to facilitate assessing size of animals in different processed forms

Workshop Action 5: Review and update species names for sea cucumbers

- Various actions to improve species identification and naming

Workshop Action 6: Discussion of species identification challenges for sea cucumbers

- Further materials were made available to assist identification of hard-to-identify species such as redfish (Surf Redfish, Deepwater redfish) as well as blackfish (hairy blackfish, burrowing blackfish, deepwater blackfish) as summarised in Appendix 6 – from presentation re size limits and identification, which was also printed and circulated.
- Spatial morphological variation in prickly redfish was acknowledged
- Further materials will also be provided at the next meeting or as part of a science workshop to assist in identification of the different curryfish species

Workshop Action 7: Additional species-specific limits for individual or groups of sea cucumbers

- Curryfish were identified as a group that should be allocated their own TAC, possibly with a trigger limit for individual species
- Other species that were proposed as needing their own TAC included Deepwater redfish and Hairy blackfish as these are both target species that probably need TACs. Greenfish was suggested although is not currently targeted.

Workshop Action 8: Review and discuss sandfish

- Discussion focused on need for a survey to assess the extent to which this species has recovered and whether the fishery could be re-opened
- Full scale stock survey of Warrior Reef, potentially in collaboration with Papua New Guinea is recommended

Workshop Action 9: Review and discuss black teatfish

- Broad agreement consistent with other workshop discussions that a primary requirement before considering re-opening would be demonstration of reliable data reporting for all bêche de mer species

Workshop Action 10: Review and discuss white teatfish

- Discussion as to whether or not hookah should be allowed was discussed primarily as part of the HCWG meeting on 27 June 2017, and is summarised in the minutes from that meeting

Workshop Action 11: Review and discuss potential use of spatial rotation strategies and move-on provisions

- Discussion acknowledged that this could be challenging to implement, but that some communities already use this sort of system for self-management, and hence further and ongoing use of spatial rotation strategies should be encouraged as community-level self-management tools.

Workshop Action 12: Review potential use of additional indicators

- Fishery logbook sheets were examined and discussed to confirm the range of data that could be collected for use as indicators (catch per species, species composition, catch rate measures, spatial location of catches)
- Participants proposed several additional indicators that could potentially be used, such as the condition index of animals, surveys of dead animals, state of habitat (algal relative abundance) – see Appendix 3, Table A3.1

Workshop Action 13: Finalise agreement on different monitoring information that will be collected

- Agreement that fisher logbooks provide critical information that is needed as primary indicators to inform decision rules, and workshop encouraged communication of need to fill in as many of the data entry fields as possible
- Fish receiver system discussed as critical and also providing a way to validate total catches (but it doesn't provide more detailed information as above) – these data are needed as soon as possible to assist in keeping track of total catch during a season, whereas more detailed logbook information is needed at the end of the season to assess fishery status etc.
- There was some discussion of the need for and use of biomass surveys (fishery-independent surveys), particularly for key species such as sandfish, but no firm decisions as to who would do these, how frequently, as well as the process for planning these.

Workshop Action 14: Review tiered harvest strategy potential framework

- As per the framework in Figure 1, there was broad support for using a tier system that acknowledges the advantages and benefits of collecting more information, as per the broad overview presented at the meeting and summarised also in Fig. 6.

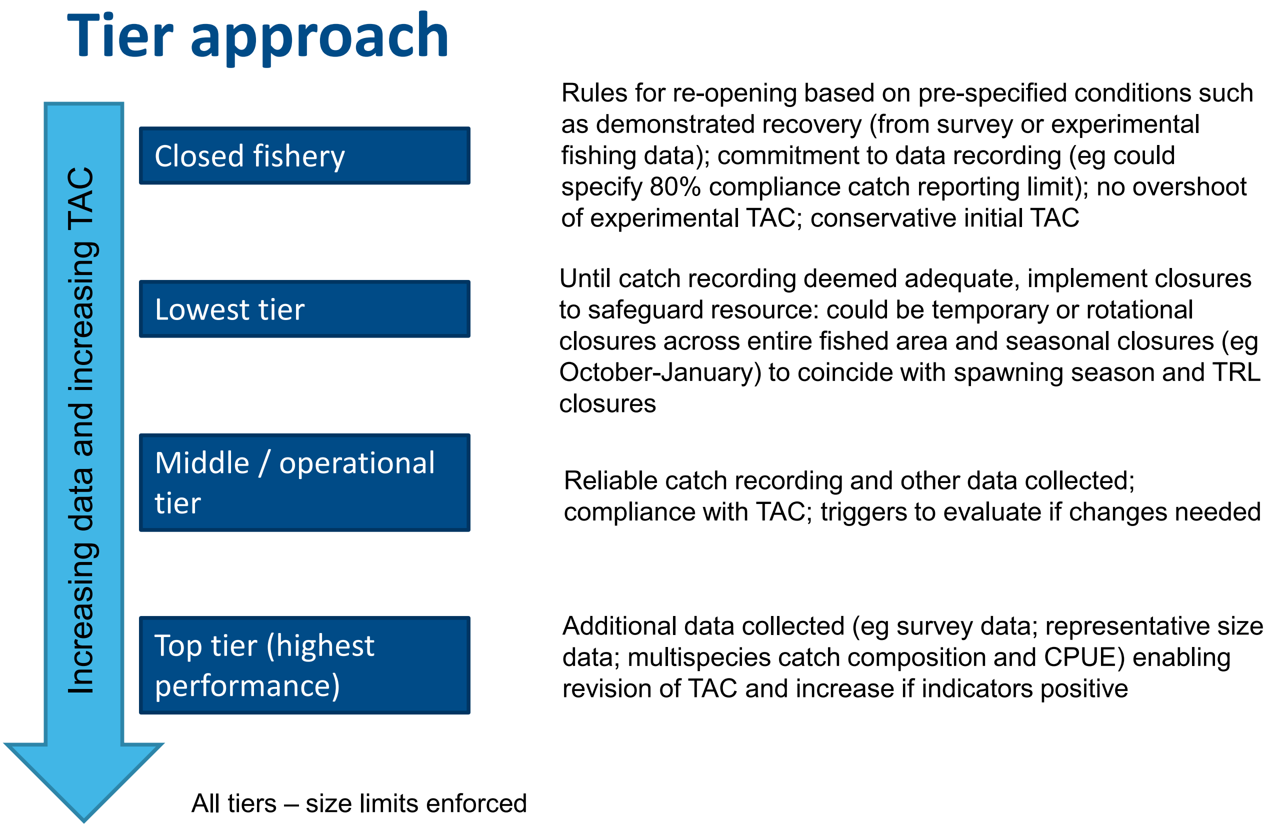
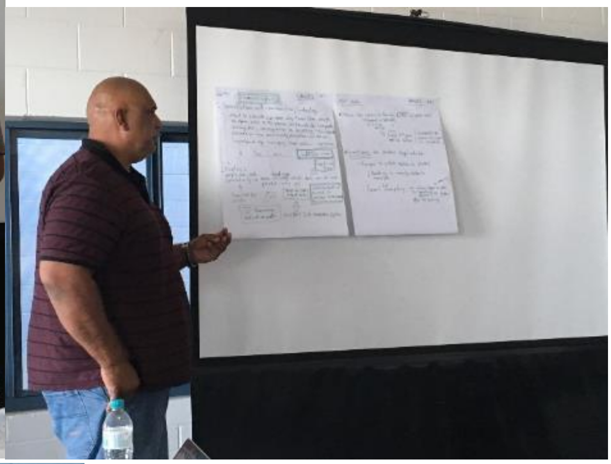


Figure 14. Conceptual overview of tier approach

<u>Workshop Action 15: </u>Develop draft harvest strategies

- As per Figure 1 and summary in this workshop report, substantial progress was made in close collaboration with participants to develop a draft harvest strategy for further review, comment and fleshing out of the details.

Workshop 2: October 2017



SMALL GROUP BREAKOUT SESSION 1 – Harvest Strategy Components:

GROUP 1

Indicators:

- Are necessary improvements in data recording and collation on track? As explained in the last workshop report, the HS can be updated and refined as more and better quality data become available. During Stage 1, which of the following data will definitely be available as inputs to the HS:
  - Catch per species
  - Catch and Effort i.e. CPUE; what are the units effort will be measured in (eg dive time, no. tubs etc)
  - Size samples of selected species (who will collect)
  - Species composition sample (from logbooks and/or sample collected by whom?)
  - Spatial footprint (sample) – if sufficient information recorded in logbooks could be obtained from that source
  - Discard mortality – how to get an estimate?

Log books – species, Lat/Long, effort – how many divers, hours worked, size (undersize returned), discard mortality (not currently recorded)

Blackteat, catch data texted back. Real time reporting, logbook sent later.

Monitoring:

- What is the most cost-effective way to get survey data that is needed to re-open a fishery on a species or to monitor several sea cucumber species in the fishery?

Survey data – working with scientists/fishers undertake survey eg. scallop. TIB operators. Independent: scientists.

Assessment:

- Are there any issues that need to be considered in moving to a separate TAC for curryfish? Also will it be possible to monitor roughly what proportion of the total curryfish catch is comprised of common curryfish (hermanni) vs vastus curryfish (vastus)?
- Is there support and are there any issues if a separate TAC is set for (A) Deepwater redfish and (B) Hairy blackfish?
- How soon after the end of the fishing season will data be available?
- Are there existing CPUE data or do we need to wait 3 years before one can start using CPUE to provide a reliable index of abundance?

Setting TAC properly/sustainable

herrmanni/vastus easy to distinguish, separate. herrmanni bigger

Already separated when fished, use same processing method

Same prices

Support for separate TAC, easier for one

Deepwater redfish – set own TAC, remove from basket – Yes

Hairy Blackfish – set own TAC, remove from basket – Yes

How soon after the end of the fishing season will data be available?

Fish Receiver – 3 days, other (docket?) 2-3 weeks

CPUE Data – Docket book/ 1st year transition; logbooks. Yes, existing data from full time fishers and buyers

Q. How do you deal with part time fishermen? Fish receiver?

Decision Rules:

- Is there agreement that increasingly stringent penalties should be applied where total catch exceeds the recommended biological catch in a year (eg the additional catch to be subtracted from next year's catch)
- Please consider draft decision Rules (summarised also in flowchart form) in decision Rule section below – comments or suggested changes to these.
- Please also consider Tier Flowchart (Fig. 5) – any comments?

Penalties for exceeding catch? Over catch TAC, what happening with stock unknown.

One rule easier to control/don't close

Overfish 5 tonne – Take 5 tonne from following year

Large overcatch – Rest/pause for one year, depends on species/size limits (growth) and depends on what species being paused – high value, decrease TAC, don't pasue

(I) Catch-Based Decision Rule (see Figure 1)

- Hierarchical: First Apply Catch Decision Rule (operational fishery):
    - If no data then TAC = 0

If no data close fishery – Currently do not have to provide data; Will be different with the fish receiver system.

- If exceed by >5% and <20% then carry over catch and subtract from following year's total
- if exceed by >20% and <50% then pause fishing on that species following year
- If exceed by >50% and <100% (double) pause fishing 2 years
- If exceed by more than double, close fishery 4 years

Total catch exceeds/Over – reduce TAC the following year

Don't exceed catch but exceed trigger level eg. Curryfish – Action to review

Other indicators? (not triggered) – two indicators, effort and size (going back to same area

If have indicators – catch, size, effort

5%, 10%, 20% - Need to define, >10% positive, <10% adjust eg TAC

What if in between – Keep fishing, review following year

Who decides where line is drawn – depends on the indicator

Indicators Good, fishing > 10% - positive, can increase TAC. How much/too large eg. 20 tonne to 50 tonne in one year – No, support for a CAP. Upper limit on changing TAC

To increase TAC (capped) – Do you undertake survey? Some support for one and others/TSRA support to focus on catch data

Support for a biomass survey from workshop participants

Pre-specified rule to increase catch – yes, if data, not overfishing & positive indicators (not much algae Uncle William).

Q – Increase TAC, undertake survey – Yes

III Indicators – Abundance, increase or decrease in numbers

CPUE – Logbook, more hours fishing, going further

GROUP 2

Indictors – DATA

Catch – monthly catch, compare tonnage/reef

CPUE – hrs/day, depends on weather/tides

Catch composition; Spatial footprint – Daily log, send book annually, lat/long, species, habitat dived

Size of animals - ?rangers or industry – small monitoring program

Discard mortality – up to individual fishers:

Post capture Bad product, heat, discolour, soggy, moist; drying final stage, moisture.

Live – 5 tubs/boat, 4-5 prickly throw back before or after gutting (soft) some days lose none. Curryfish & Greenfish – handling, worst, use ice?

Deepwater habitat tougher than shallow water habitat

<u>Decision Rules</u>

Catch based: Distinguish

Rebuilding fishery – experimental, TAC vs TAC in place

BTF eg. 15t – over fish 500 kg, flexibility

Communication – alarm at 10t when closer to TAC (stop and wait)

25t – non sustainable

Prolonged and sustained over catch, then ACTION - too risky

12t – pause and wait for data to come in

Normal species

Data – TAC (close fishery), extra data =

	Year 1	Year 2	Year 3	3yr
*	15	15	15	45
x	45	0	0	45
x	20	10	15	45
10% x	25	10	10	45

If fish 17 (overfish by 2t) *50% over = closure

18 – 3t extra

Penalty 2x3t = 6t

Next year TAC 15.6 = 9t

Return to 15t

Sustainability – Alarm, If >10% over TAC, penalty applies; take off tonnage or on notice for a 3yr period/if exceed total then close

Example Curryfish

Separate TAC

60t – discount/discard factor (5%) down from 20%? Yes, live tank on board

Curryfish on processing vessel?

Some places - both abundant (vastus/herrmanni), can be more vastus some places, Dungeness herrmanni/common currfyish. Easy to tell apart, more vastus in deep than shallow

Photos of catch composition – can distinguish dry product

10-15m water depth more vastus – was survey shallower? Sea cucumber? (Depends on location)

Deepwater Redfish – 5t, Hairy Blackfish – 5t, not that much 10t?

Hairy blackfish – night time when come out

Revised basket TAC – 60t? 50t?

Curryfish – weigh after boiling, conversion ratios/some data. Time large re data – Ugar, complete every day but getting back? Fax? Sent within 3 days but mail less reliable ?10 days. No live figures, but regular reports – out to industry, phone. 2 weeks.

Workshop notes/working group 3

<u>10nm Exclusion zone</u> – Prickly redfish

Curryfish after boiling - <100kg; 2 dinghies – not appropriate

Deepwater blackfish sit in pockets

Murray – deepwater black, white teat, prickly – can fish outside

Ugar & Erub – different as need to fish closer

Closures?

New areas with large animals – could be breeding ground? Needs to be analysed. Might be idea to set up protection for certain areas.

Need care in managing data so doesn't lead to more exploitation, native title stakeholders to decide how to protect.

Set total catch limits and devolve responsibility to native title stakeholders re allocation including spatial

<u>Species combined TAC</u>

Split curryfish – separate TAC, trigger for species

How many of each species? Skippers with training to look at catch composition once per month? All scientific observers could be used.

Sea Rangers – TSRA/AFMA, scientific observers for Torres Strait, catch composition

Agreement at meeting – voluntary closures, need survey to look at biomass. Detailed account of how much is there and then again in 6 months. Need now for Prickly red. Other operators can provide data.

<u>Monitoring – survey</u>

1. Logbook

2. Docket book

3. Scientific survey

4. On board observers (sea rangers)

5. Change in product size monitored by camera – review which species, area, size – from dives, scientific survey. Could use cameras eg. specified dives, specific dives to record information (bus stop), routine

monitoring, same spot take photo at set time periods, compare photo at different depth, could see changes in aggregation (breeding). Need resources eg. s130 go-pix /pro has GPS co-ordinates

Indicators

Black teatfish – compare time frame for catch, but also licences

Good data – TIB, take responsibility, good decision, needs awareness, education

Identify committed divers/industry- ongoing fishing dependant on reporting (note, high value species); also up to communities = > no. active fishers.

Don't reveal individual information buy whether recording

Logbook page demo

No information – close fisheries

Need data from buyers and logbooks

Challenge: getting data from docket books – AFMA, fax, mailing – risk if lost ?electronic, Stephen Is? Murray – poor reception, need allowances, resources

How to get information recorded in timely period?

?Average catch over 3 years

Buyers important for data collection

Logbook has spatial co-ordinates

Reefs, number around TI so know area

Which species listed – prickly, curryfish, deepwater, etc. 5 species

Effort – fishers daily catch

Depth? Number, 10nm-12nm

Rules to re-open fishery

East coast – check CPUE trends to adjust TAC up or down – need logbook information, in future regionalise, ownership

Torres Strait – understand native title, spatial structure

1. survey – up or down, or stable

2. conservative – TAC

Region/management

Need to follow local rules

Ownership/people look after their areas

10 nautical miles

Prefer whole areas eg. within 10nm rather than specific reefs (voluntary)

Voluntary more likely to be supported. May not be respected if voluntary, especially if not from adjacent island community

There may be ways to increase economic profit and value through industry awareness and co-ordination

Working as a cluster to attract higher prices, co-ordinating product/quality control

Example for community TAC eg. 5-7 tonnes each, if you overfish it comes off your allocation/TAC following year. With a built in review

Short term actions – Compulsory catch monitoring, better understanding and specific actions per species, size limit triggers

Long term – Ability for real time management

Community plans important to inform Harvest Strategy eg. Indicators, evidence

Tier approach – all about risk, Yes/supported

<u>Impediments to data recording</u>

Not compulsory

Lack of education/awareness

Sporadic fishing

Records not going to AFMA

Concern about confidentiality

Concern about reaching TAC

Doesn't capture damaged/lost/discarded catches

Require specific quota – Curryfish, prickly redfish, greenfish

Changes with market demand/value aim to have TAC or triggers (with actions) for each species

Minimum requirement to reopen fishery/species: reliable catch reporting, monitoring, assessment knowledge of current stock level, a conservative TAC, consideration of harvest strategy

Definite minimum sizes and maximum where science convinces

Spatial closures difficult to manage/compliance conflict

Suggestion: Close TSBDMF fishery Dec/Jan, gives all species a chance to rest and spawn. Allow free dive of TRL for TIB Dec/Jan, open TSBDMF/black teatfish in Feb to coincide with TRL, no primary vessels

Workshop 3: July 2018 - Small Group Summaries

There was a lot of useful information provided and shared during the 3 small group breakout sessions. A summary of some of the points raised is provided in detail in Appendix 2. Several of these provide broader insights than simply to inform a harvest strategy. Below follows a very brief summary of some of the key feedback regarding the questions posed and hence to assist in refining aspects of the harvest strategy.

SMALL GROUP BREAKOUT SESSION 1 – Questions posed and summary responses below

Harvest Strategy Components: Obtaining useful Catch and Effort indicators

- How well can we separate catch data for individual species e.g. curryfish (vastus and hermanni)?
- For shallower water species and mixed species assemblages, do fishers collect all suitable animals as they are encountered, or optimise time in the water to focus on specific species. If the former, then for a fixed diving time, we should be able to use the catch per species divided by total combined dive time as an index of abundance of that species. If the latter, we need information on relative preferences for species.
- For deeper water or target species (eg white teatfish, prickly redfish), how can we get an index of abundance? For example, if the stock is highly aggregated, then CPUE will stay high until the aggregation is close to being depleted. Can we get information on the spatial extent and depth of fishing? What difference are different fishing methods likely to have?

Can we use a single combined CPUE index for each species, or do we need to consider separate indices for different fishing areas? If so, for which species and what is the minimum number of separate indices we would need?

Summary of Responses:

- All curryfish species easy to separate alive, boiled or dry
- Notes on discards: If slug is still alive then it is not counted as discard as it will regenerate (but not good for boiling). If slug is dead it is counted as discard.
- Discards must be counted towards TAC
- Curryfish and Greenfish are very fragile and cannot weigh wet due to risk of losses
- Please consider additional effort for small-scale fishers for fishing processing: fishing full day and processing full night, then reporting. We understand reporting is important and very beneficial for the long-term sustainability of the fishery
- When fishing fishers normally target 1-2 species depending on order from buyers. They collect high-value opportunistic species (white teatfish, golden sandfish, etc.) if found.
- Target species depend on preferences from buyers and availability in reefs. At the moment preferences from some buyers are (but preferences vary during the year): Curryfish, Blackfish. Others currently want curryfish, white teatfish, prickly red and black teatfish. Would be best if they buy other species eg leopardfish. Buyers have a big say. Some only buy 1-2 species

- Greenfish, leopardfish, white teat: very fragile, better when kept in ice or water exchange every 20 minutes
- Can record all depths and species in daily logbook reports but not able to do the same in the fish receiver form. Best to fill in fish receiver and logbook to support businesses and operation.
- Local practices: use all divers working in certain areas/reef for a month or so and leave that reef for re-supplying for a period of 3 months. That's when you get the stocks coming back up. Working well using local knowledge
- Ugar: rotate between the fisheries. At the moment a couple of the fishers are doing coral trout and TRL fishing. They stopped doing curryfish and are targeting finfish and TRL at the moment to give time to re-stock and re-supply sea cucumber on the reef. They fish for periods of 1 week and then swap
- Location of fishing grounds can be sensitive information
- Deepwater species – need hookah – changes in depth and spatial extent of fishing are useful indicators
- White teatfish – limited by freediving so catch rates are not a good indicator of stock. In 1997, catch rates were 80-100kg/day getting the ones on top but now reduced to 8-20 kg/day (but can see them in deeper water)
- Prickly redfish : good catch rates are 150-200 kg/day versus bad 50-80 kg/day. But will move on before and also stop when get to 150kg.
- Deepwater redfish: over 6 months drop form 20 kg/day but very patchy
- Curryfish: over 6 months, good catch rate = 200 kg/day but only when focussed on curryfish; bad = 50 kg/day, but will rotate earlier. Also fish harder to get 200 kg/day.
- Deepwater: without hookah can't use CPUE as stock indicator – suggested to get historical hookah catch rate to compare with as well as East Coast rates as comparison
- For species such as curryfish, some fishers limit daily take to reduce wastage as processing is challenging
- Prickly redfish – similarly stop collecting over processing limit amount
- Training and resourcing for fish receivers needs to be provided

SMALL GROUP BREAKOUT SESSION 2 – Questions and Summary Responses below

Harvest Strategy Rules for Re-opening a fishery

Decision rules are needed to inform decisions related to re-opening a closed fishery or closed area. Participants at previous workshops agreed that evidence of recovery was a necessary criterion and could be assessed based on data such as a biomass estimate from a survey. Consistent with the fishery objectives, a strategy for a gradual return was then needed, including a conservative initial TAC for example, and ongoing monitoring would be essential (Figure 5).

- Is it feasible that surveys of key species could be done to inform whether to re-open the fishery for a species? Will these be done by the community or outsourced to researchers?
- Are there alternative ways to get adequate information to inform potential re-opening?
- Is it sufficiently conservative to set the starting TAC as half the target value for the first year?
- Based on discussions at previous workshop, can we set a trigger at 75% (three quarters) of the TAC at which point all fishers need to pause activity to wait for data to be submitted and analysed to ensure no overshoot of the TAC. As per suggestion from stakeholders, the system could also include rapid sms/text (other?) of catch even before formal records submitted to help keep track of catch?

Summary of Responses:

- Difficult to compare scientific surveys with fishers surveys because fishers know where to look for things and scientists randomise transects

Re-opening fishery requires:

<u>Community support</u>

Consultations with communities and industry: Need to provide information about why the fishery was closed, why re-open, value of the fishery, sustainability (safeguards; tonnage TAC), consequences of exceeding TAC (external pressure on how community perceptions are driven). Importance of managing stocks sustainably: reputation

<u>Plenty/sufficient stocks</u>

We need to show stocks are there

Employ 2 locals at each community and providing training for them so they can carry out surveys which data can be incorporated into HS.

Show we can collect the data (support fish receiver system) and manage the fishery:

<u>Management in place to ensure sustainability</u>

Define temporal and spatial opening & closures (based on TAC and catch rates).

E.g. 5-10 days openings

Open every 2nd year using 2xTAC [safeguard to ensure TAC would not be exceeded]

Compliance – using rangers. They don’t have full authority to apprehend but they can collect evidence so compliance officers can act.

Prevent live stock piling. No fishing before the opening or after the closure or before/after the opening.

- Surf redfish – very deep water. Need to educate people in a way that fishermen knows about where most of the fish stays. We need to have a community talk with fishermen to get this idea through.
- Training on species identification is needed

- Experimental quota -> 5 tons and assess risk and trial this TAC to re-open surf redfish. Fishermen will fill out special data sheet and select full-time fishermen to do this. They will also support analysis of data.
- Sandfish (Warrior): Experimental quota 4-5 tons. (same as before).
- Black Teatfish opening suggestions:
  - Ownership for industry. A fee to get into the industry. Money that goes into industry goes back into research. High-value species
  - Split into 3 short catches (e.g. 3 x 5 tons separated by a closure) to show we can manage the fishery. It will encourage people not to rush in and give the opportunity to do it right.
  - Any catch reporting is a must (daily catch reporting from Fish Receivers System) land-based only.
  - TSRA technological apps iPad: ID guide, photos, reporting. Each fish receiver will get an iPad and will be trained on how to use the app.
  - Length measures data sheets and rulers
- If we have to re-open the fishery again we need to ensure the fish receiver system is working well. Accurate and timely reporting about catches. Fishers need to be encouraged to fill out daily fish logs as well.
- Sandfish: suggest locals do surveys (locally)
- Golden sandfish seen at Mer. Need consultation with Iama and Warrior reef area to identify the right people on the process.
- Mer: seeing a comeback of surf redfish -> could be trialled; use surveys.
- Ugar: very few seen; some evidence on smaller ones.
- Black teatfish: no survey needed as we know there is plenty out there.
- Trial in the 5 Island communities in the East to trial openings.
- Community discussions with TIB reps, TSRA, Malu Lamar (as native title body), and AFMA for community consultations.

SMALL GROUP BREAKOUT SESSION 3 – Questions and Summary Responses

Review of overall Harvest Strategy Framework (Fig. 1-5): what's missing? Suggested changes etc

- Is the distinction between the 3 tiers clear?
- Does the flowchart in Fig. 1 (see also Fig. 2) cover most scenarios? Anything missing?
- Does the Harvest Strategy Framework (as per Fig. 1) make sense in terms of allowing increases in TAC as more data become available?
- Which rules need changing or refining or do you think will be difficult to implement?
- Any further comments on suggestions raised during previous HCWG:
- If trial opening of species eg BTF, then only allow to catch that species on boat

- Consider opening during June-July (during right tide) – TRL season so fairer for dedicated fishers working in East
- Ways to limit/control who can fish given cultural laws?
- System to submit sample photos of mixed species catches to inform on species composition and validate species identification? There were mixed views as to whether scientific observers might be available to assist in looking at catch samples eg once per month – any further thoughts?

Summary of Responses:

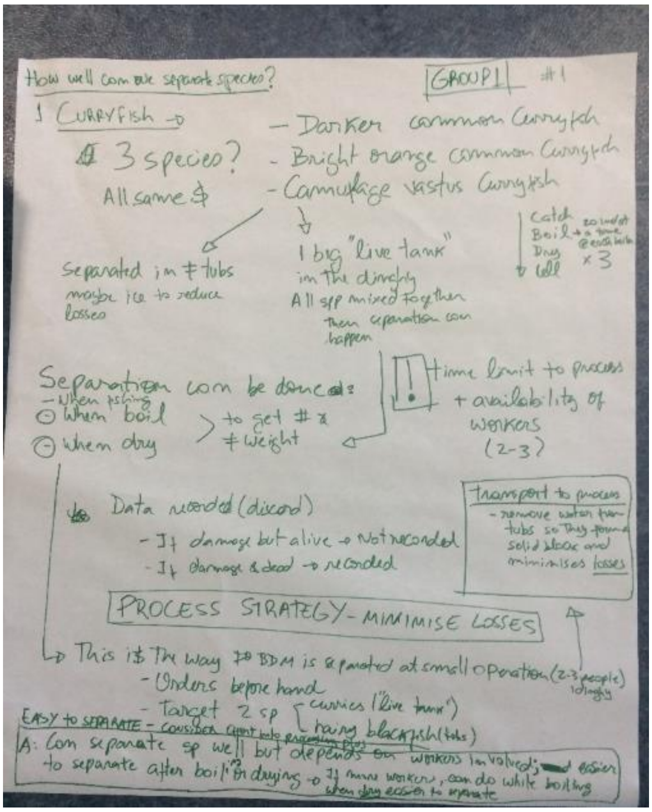
- Several suggestions to improve presentation of overall framework were noted and will be included in revised version of the tier diagram.
- Curryfish joint TAC: Several species but focus predominantly on 2 spp (*S. hermannii* and *S. vastus*). People are talking about similar abundances for both species so will look further into this given it's not what was recorded during surveys. Agreed to include *S. oscellatus* in the same basket as well even though they are not as abundant as the other two. Discarded species must be recorded if we want to accurately monitor the stock. It is a fragile species and it is important that the discarded weight is captured too because at the end of the day we want to ensure the fishery is sustainable
- Each species need to be managed separately and we need to be careful that we don't fish them down and we don't have weird interactions between the three species. Combined TAC is a bit risky in this regard. Trigger is not a cap. A trigger is a way to check what is happening and get more information about what is going on.
- Hairy blackfish – there is high demand at the time for this species. 5 tons may be small for this species. But 5 tons is the trigger and maximum (based on indicators) is 10t, as survey data is uncertain. If we can see some CPUE or other data that people are fishing + information from fishers which indicates the stocks are better and there is more certainty about the stock then it is easy to adjust TAC – data supports TAC and that's how HS starts to work
- If logbooks are filled in correctly these will provide valuable information to manage the stocks
- Any future surveys need to benefit and involve Torres Strait Islanders
- Might be good to know how reliable survey data is (current survey is about 9 years old).
- People paid (fish receivers) as an incentive to make sure the data is filled in accurately.
- Logbook and fish receiver book are two separate books. Daily fishing log has the old style catch disposal data combined. But new system separate this. Fish receiver is mandatory, old logbook is voluntary. It is really important to have the voluntary logbook filled in in conjunction with the fish receiver logbook. Suggested this should be compulsory
- Ways of limiting who can fish given cultural laws in different communities -> should be trialled in the black teatfish. Needs to be discussed in next workshops as to how to do this.

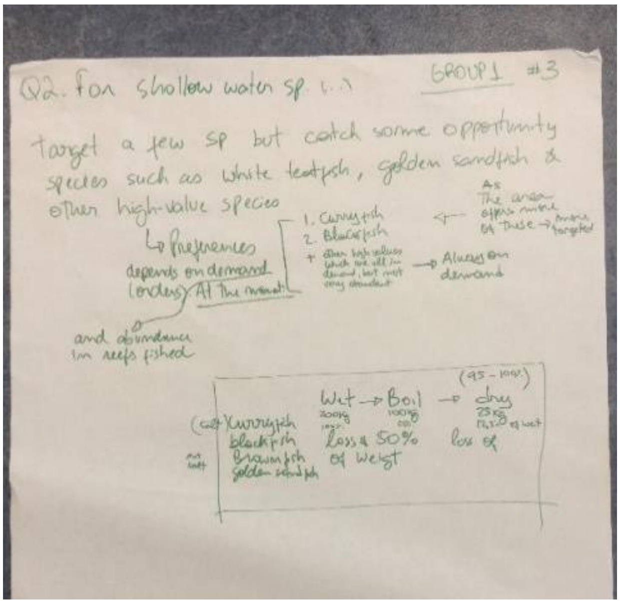
- 3 tiers make sense but it should be interpreted in plain language because when you look at this you can understand but it is very important to understand the details. Who makes the decision about going into the 3 tiers. It needs to come back to the HCWG for making these decisions.
- Black teatfish: used in the first tier at the moment where we want to see it happen next year (1st December). Effort, size limits to be investigated. During the opening time the trial should be opened at the same time as TRL. Daily catch report is very important. We didn't go much into cultural protocols as it needs to be discussed between TS islanders.
- Very excited about potential for technology. We need to keep up with technology. The example about IPad app is a very good idea to help send data quickly, especially in Ugar. This will definitely improve getting catch data report through. Mark gave an example that TS rangers are using this method now, which is very good. But who is going to do it? AFMA/TSRA should take this on.
- New survey techniques are coming. ROVs, drones. These can detect the presence of sea cucumber.
- The current harvest strategy and the 3 tier process is quite detailed and in terms of people understanding how this flow it will take time. Not only fishers, but people in the communities. This will be a bit more difficult for part-timers and recreationals to understand the process. We mentioned that in terms of interpretation of the 3 tiers and the language used will be quite difficult for our people to understand. We highlighted clearly that having this translated isn't necessarily a good idea because English is easier to read. A simplified version could be developed.
- We need to ensure the right policies are in place to support data collection. For example, daily fish logbook. The current diagram needs to be rearranged from low to high. It is easier to read high is high and low is low. Each tier can be broken down into one A4 size instead of having all in one page and expect people to read.
- Flexibility needs to be built into the rules to allow a double TAC in one year and a break in the second year. This could work for species such as black teatfish with regulated openings but not for all species where the TAC is important to observe. Use AFMA catch watch to alert fishers when approaching the TAC. Also recommended that revised species identification guide include a larger map of the species distribution and native title boundaries clearly identified.
- Whenever there is a survey, first consideration should be given to locals for boat and human resources

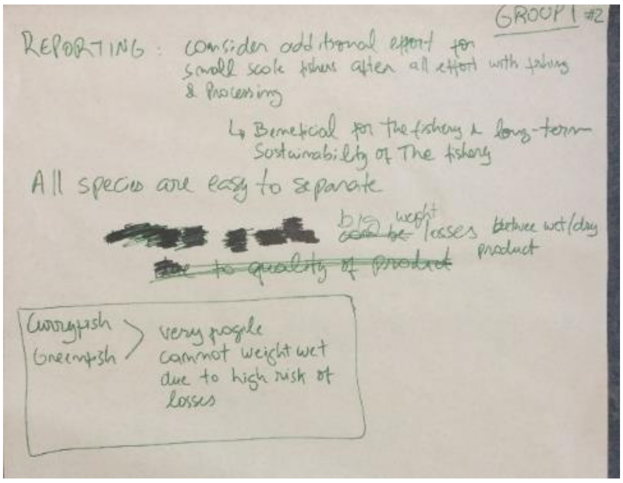
Graphics from Small Group Breakout Sessions, July 2018

SMALL GROUP BREAKOUT SESSION 1

Group 1







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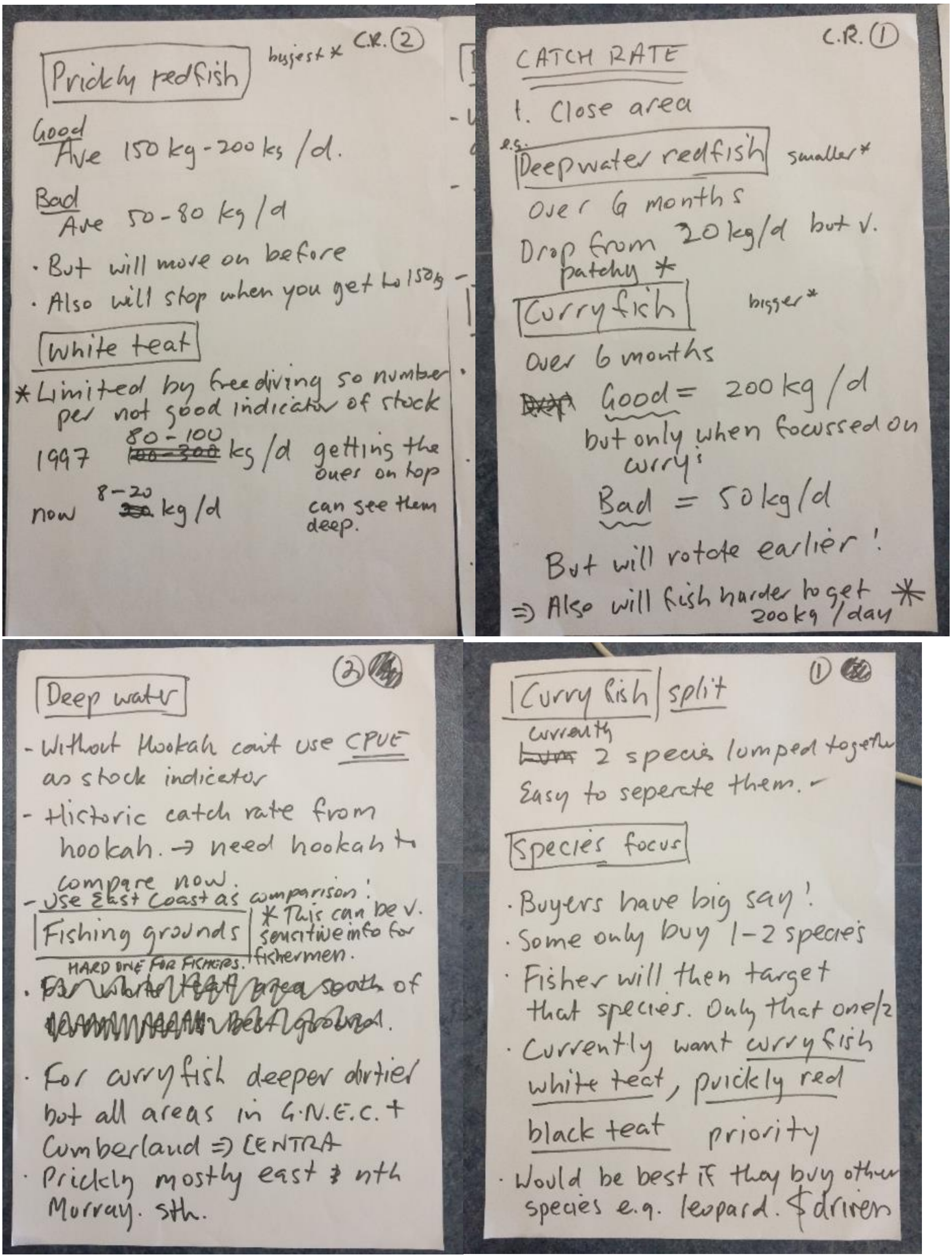


C.R. (2)

Prickly redfish biggest*

Good
Ave 150 kg - 200 kg / d.

Bad
Ave 50-80 kg / d

· But will move on before
· Also will stop when you get to 150kg

White teat

* Limited by freediving so number per not good indicator of stock

1997 ~~100-300~~ 80-100 kg / d getting the ones on top

now ~~30~~ 8-20 kg / d can see them deep.

C.R. (1)

CATCH RATE

1. Close area

e.g. Deepwater redfish smaller*

Over 6 months

Drop from 20 kg/d but v. patchy *

Curryfish bigger*

Over 6 months

~~Bad~~ Good = 200 kg / d
but only when focussed on curry!

Bad = 50 kg/d

But will rotate earlier!

⇒ Also will fish harder to get 200 kg / day *

(2)

Deep water

- Without Hookah can't use CPUE as stock indicator
- Historic catch rate from hookah. → need hookah to compare now.
- Use East Coast as comparison!

Fishing grounds
HARD ONE FOR FISHERS.

* This can be v. sensitive info for fishermen.

· ~~For white teat area south of [illegible] best ground~~.
· For curryfish deeper dirtier but all areas in G.N.E.C. + Cumberland ⇒ CENTRAL
· Prickly mostly east & nth Murray. sth.

(1)

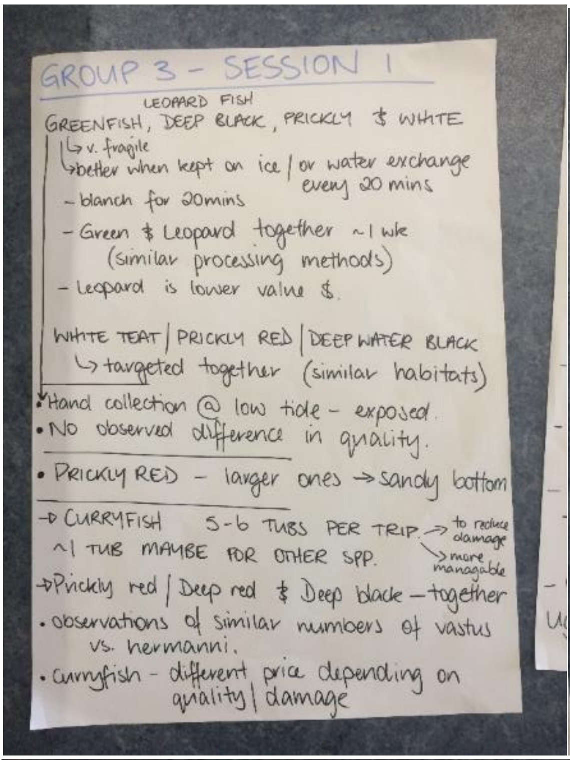
Curry fish split

currently 2 species lumped together
Easy to seperate them.

Species focus

· Buyers have big say!
· Some only buy 1-2 species
· Fisher will then target that species. Only that one/2
· Currently want curryfish white teat, prickly red black teat priority
· Would be best if they buy other species e.g. leopard. $ driven

Group 3:



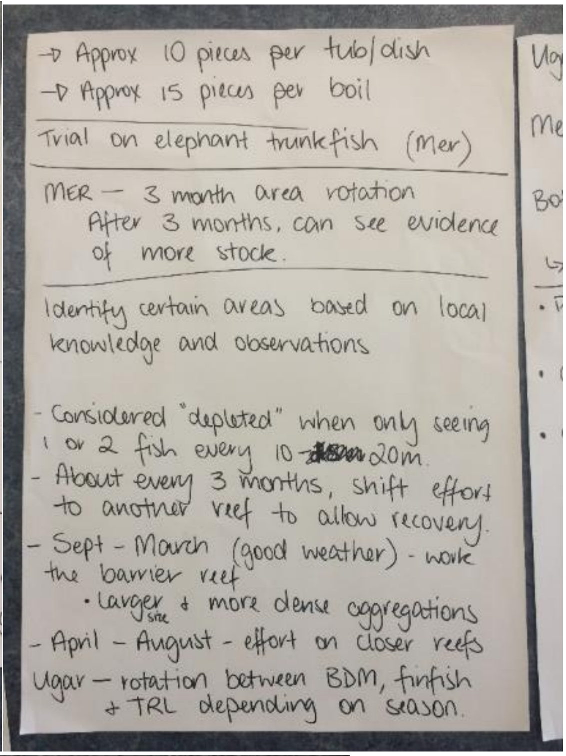
GROUP 3 – SESSION 1

LEOPARD FISH
GREENFISH, DEEP BLACK, PRICKLY & WHITE
↳ v. fragile
↳ better when kept on ice / or water exchange every 20 mins
– blanch for 20mins
– Green & Leopard together ~1 wk (similar processing methods)
– Leopard is lower value $.

WHITE TEAT / PRICKLY RED / DEEP WATER BLACK
↳ targeted together (similar habitats)
• Hand collection @ low tide – exposed.
• No observed difference in quality.

• PRICKLY RED – larger ones → sandy bottom

→ CURRYFISH 5-6 TUBS PER TRIP → to reduce damage → more managable
~1 TUB MAYBE FOR OTHER SPP.
→ Prickly red / Deep red & Deep black – together
• observations of similar numbers of vastus vs. hermanni.
• curryfish – different price depending on quality / damage



→ Approx 10 pieces per tub/dish
→ Approx 15 pieces per boil

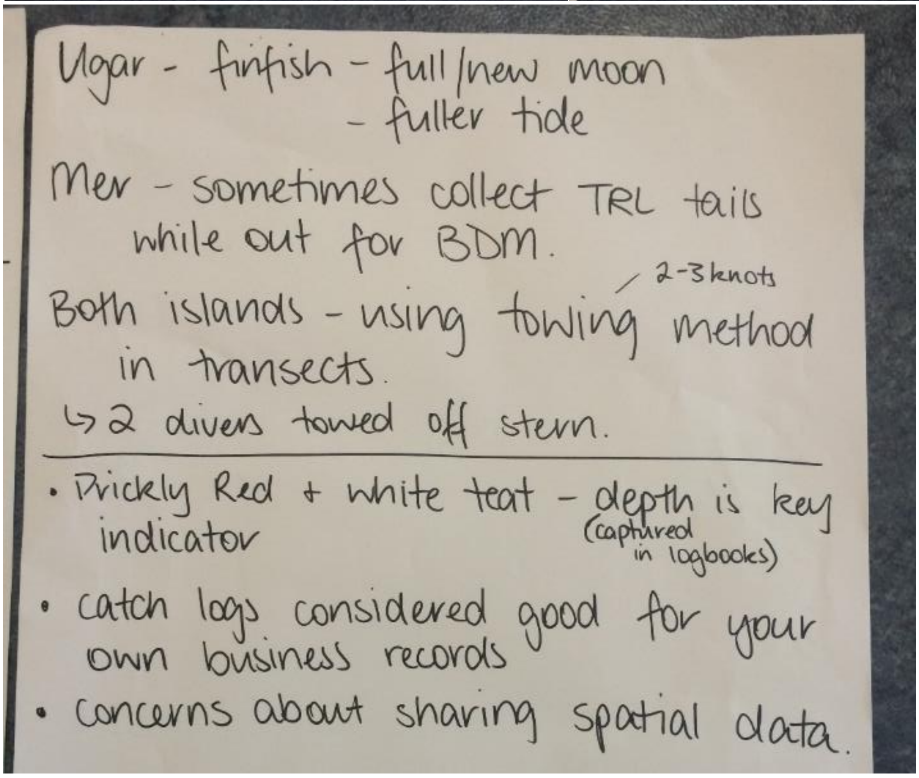
Trial on elephant trunkfish (Mer)

MER – 3 month area rotation
After 3 months, can see evidence of more stock.

Identify certain areas based on local knowledge and observations

- Considered "depleted" when only seeing 1 or 2 fish every 10 ~~[illegible]~~ 20m.
- About every 3 months, shift effort to another reef to allow recovery.
- Sept – March (good weather) – work the barrier reef
  • Larger size & more dense aggregations
- April – August – effort on closer reefs

Ugar – rotation between BDM, finfish & TRL depending on season.



Ugar – finfish – full/new moon
– fuller tide

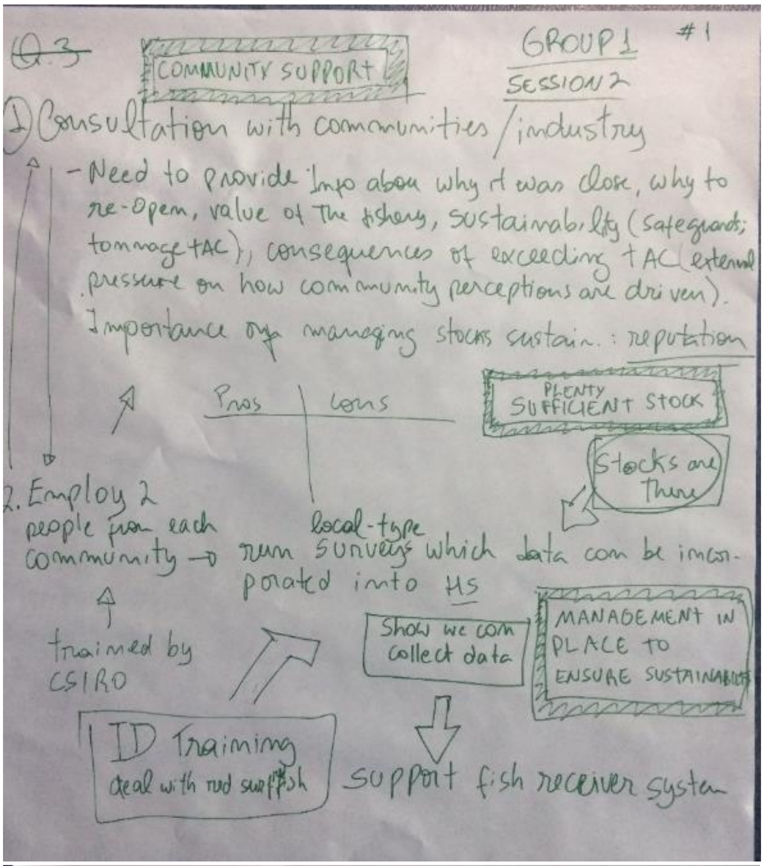
Mer – sometimes collect TRL tails while out for BDM.

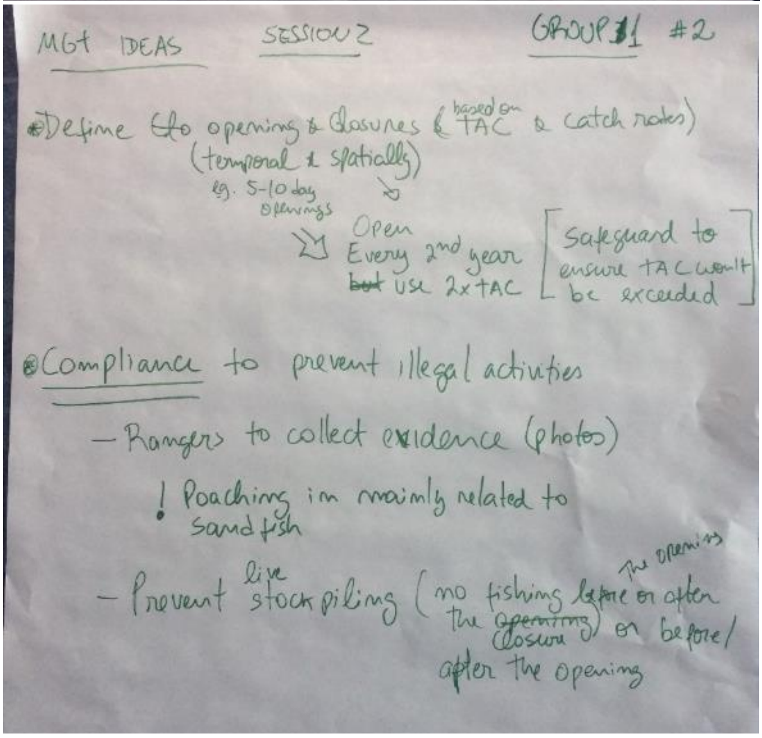
Both islands – using towing (2-3 knots) method in transects.
↳ 2 divers towed off stern.

• Prickly Red + white teat – depth is key indicator (captured in logbooks)
• catch logs considered good for your own business records
• concerns about sharing spatial data.

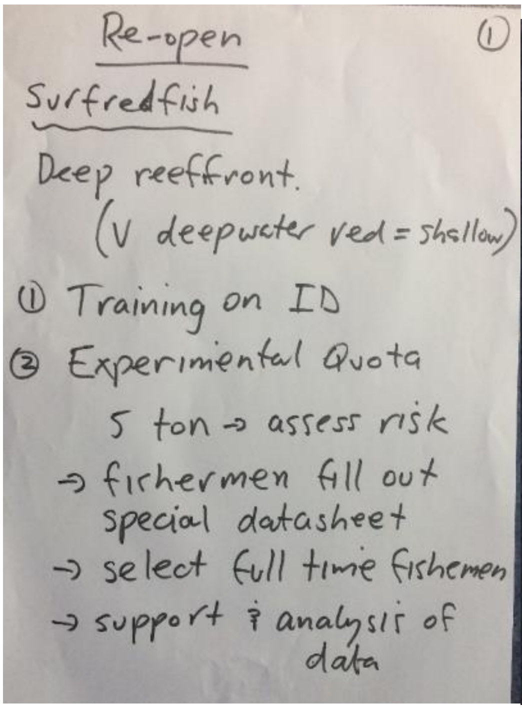
BREAKOUT SESSION 2

Group 1:





Group 2:



Re-open ①

Surfredfish

Deep reeffront.

(V deepwater red = shallow)

① Training on ID

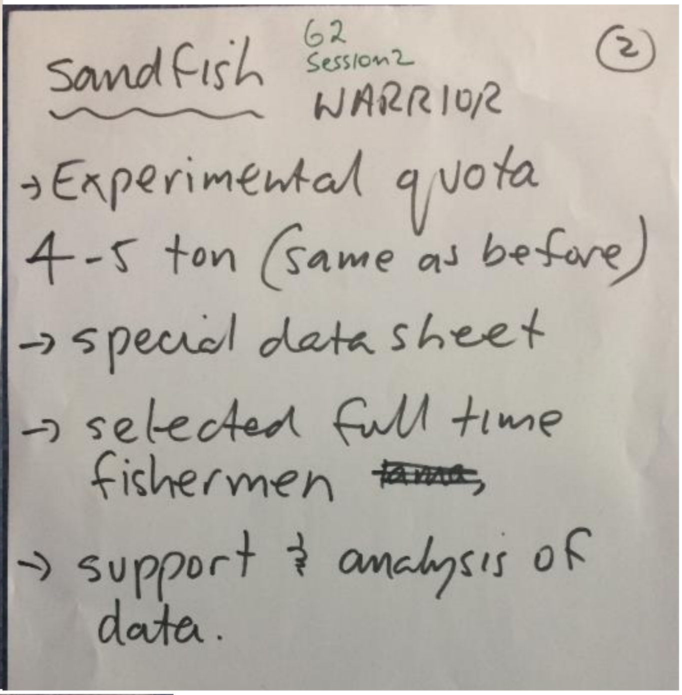
② Experimental Quota

5 ton → assess risk

→ fishermen fill out special datasheet

→ select full time fishemen

→ support & analysis of data



Sandfish G2 Session2 ②

WARRIOR

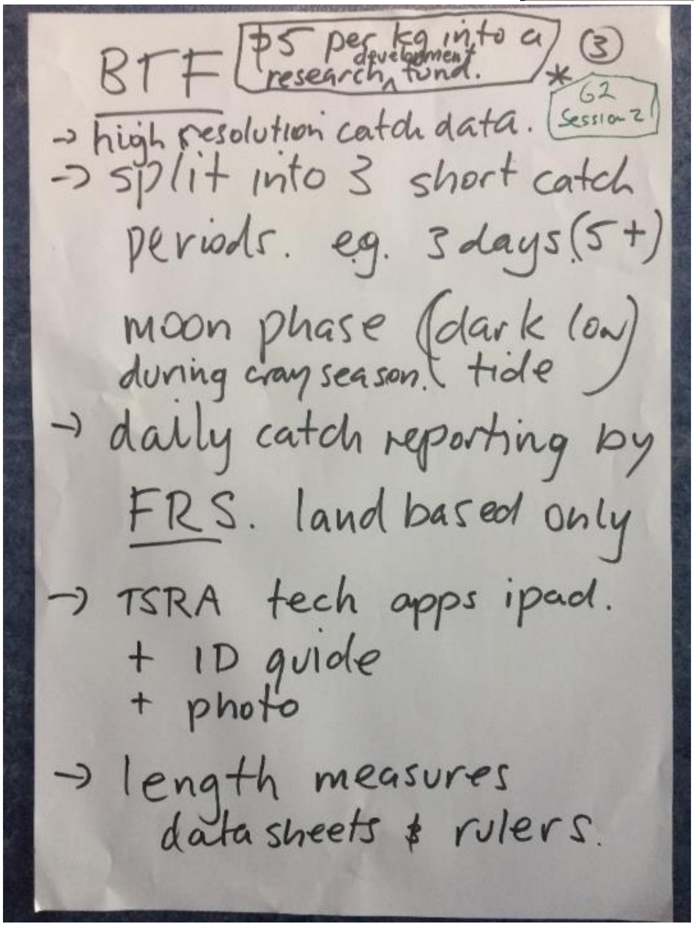
→ Experimental quota

4-5 ton (same as before)

→ special data sheet

→ selected full time fishermen ~~[illegible]~~

→ support & analysis of data.



BTF $5 per kg into a development research fund. ③ * G2 Session 2

→ high resolution catch data.

→ split into 3 short catch periods. eg. 3 days (5+)

moon phase (dark low during cray season. tide)

→ daily catch reporting by FRS. land based only

→ TSRA tech apps ipad.

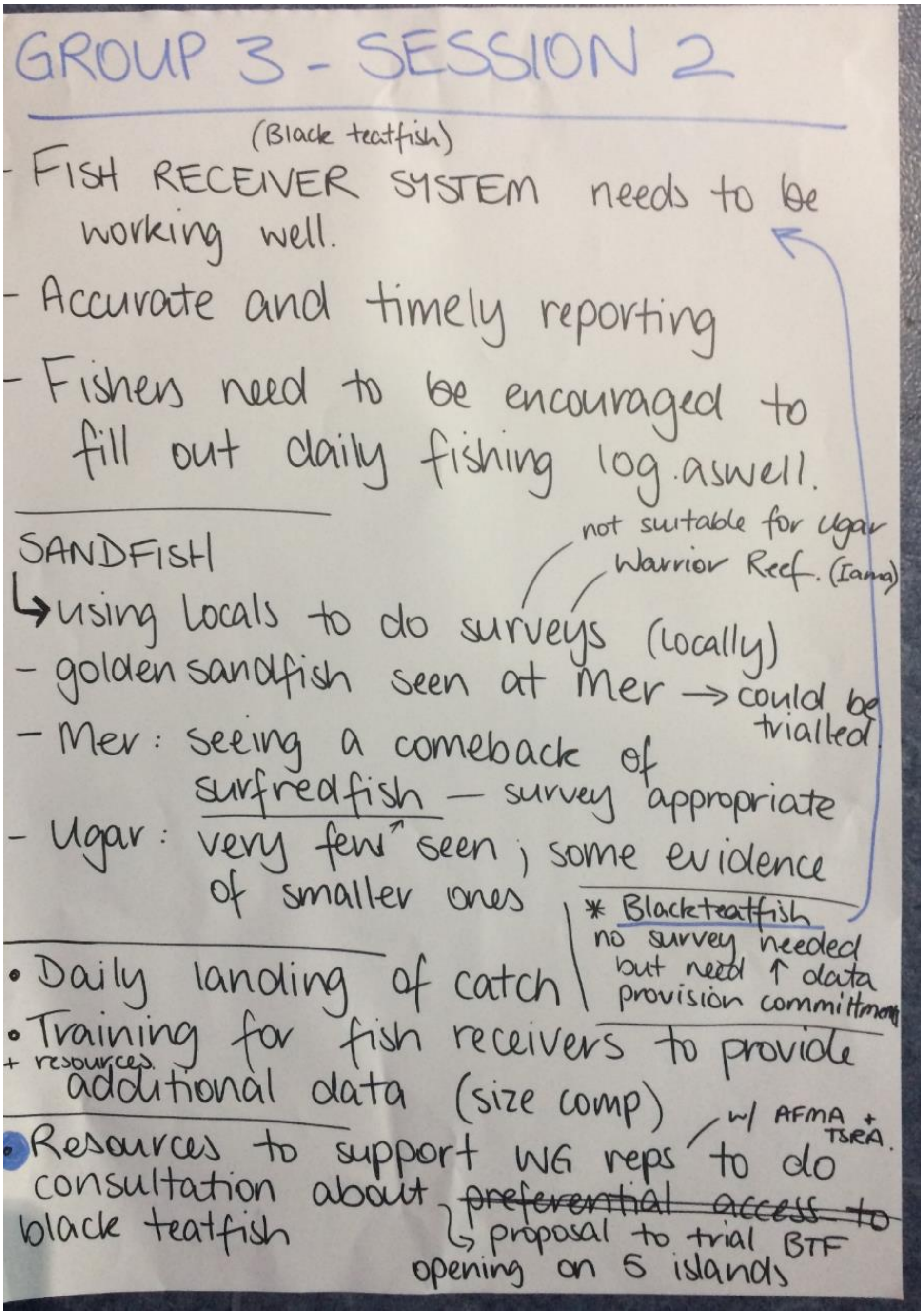
+ ID guide

+ photo

→ length measures

data sheets & rulers.

Group 3:



GROUP 3 - SESSION 2

(Black teatfish)

- FISH RECEIVER SYSTEM needs to be working well.
- Accurate and timely reporting
- Fishers need to be encouraged to fill out daily fishing log aswell.

SANDFISH

↳ using Locals to do surveys (Locally)

not suitable for Ugar

Warrior Reef. (Iama)

- golden sandfish seen at Mer → could be trialled
- Mer: seeing a comeback of surfredfish — survey appropriate
- Ugar: very few seen; some evidence of smaller ones

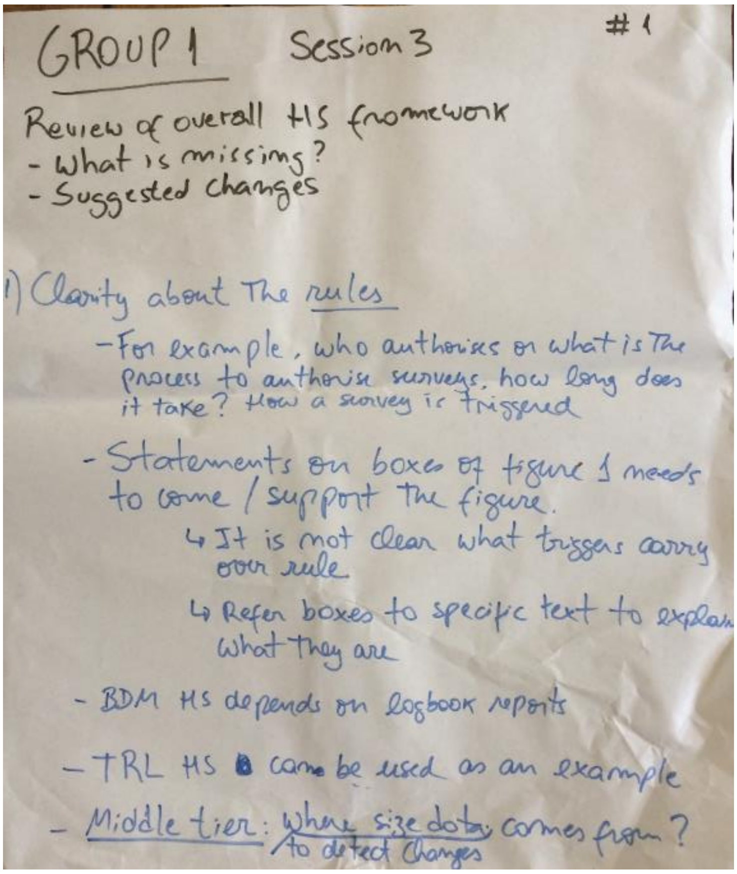
* Blackteatfish

no survey needed but need ↑ data provision committment

- Daily landing of catch
- Training + resources for fish receivers to provide additional data (size comp)
- Resources to support WG reps w/ AFMA + TSRA to do consultation about ~~preferential access to~~ black teatfish
  ↳ proposal to trial BTF opening on 5 islands

BREAKOUT SESSION 3:

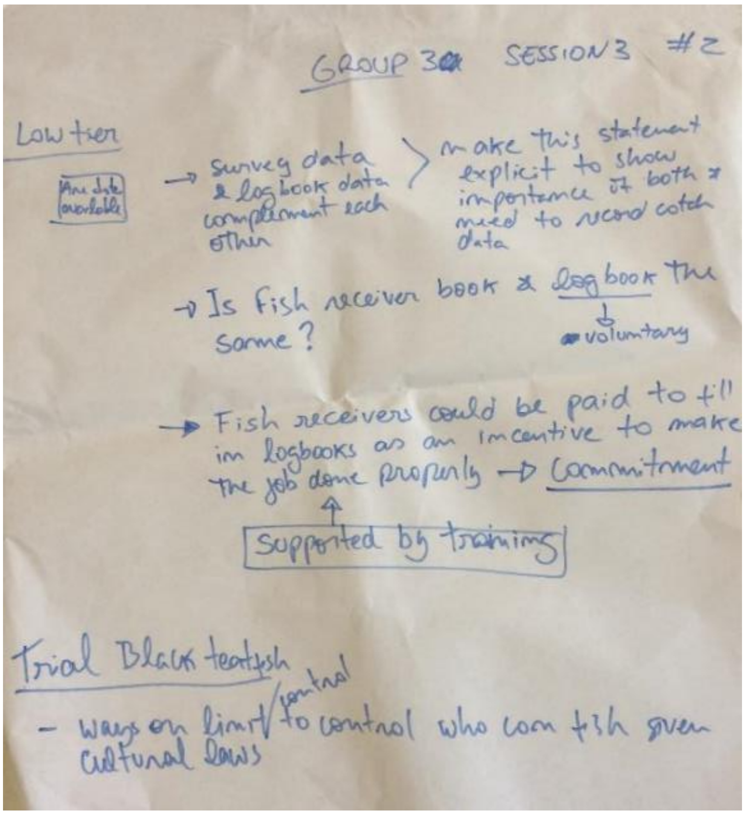
Group 1:



GROUP 1 Session 3 #1

Review of overall HS framework
- What is missing?
- Suggested changes

1) Clarity about the rules
   - For example, who authorises or what is the process to authorise surveys, how long does it take? How a survey is triggered
   - Statements on boxes of figure 1 needs to come / support the figure.
     - ↳ It is not clear what triggers carry over rule
     - ↳ Refer boxes to specific text to explain what they are
   - BDM HS depends on logbook reports
   - TRL HS can be used as an example
   - Middle tier: where size data comes from? / to detect changes



GROUP 3 SESSION 3 #2

Low tier

Are data available

→ survey data & logbook data complement each other > make this statement explicit to show importance of both & need to record catch data

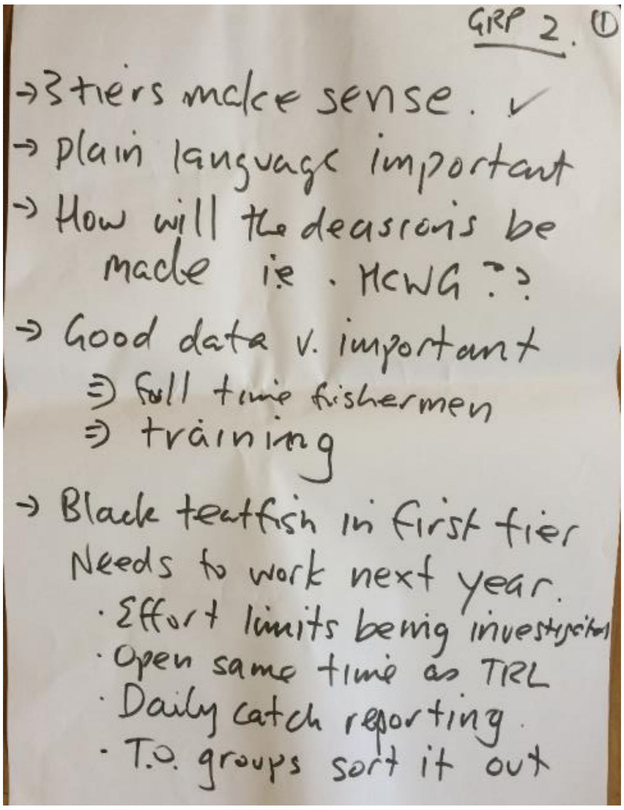
→ Is fish receiver book & logbook the same? voluntary

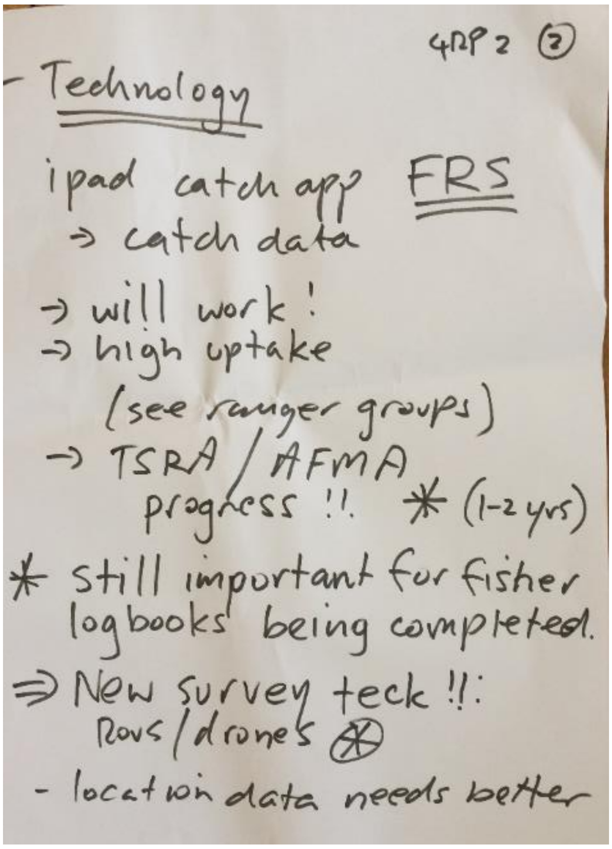
→ Fish receivers could be paid to fill in logbooks as an incentive to make the job done properly → Commitment

Supported by training

Trial Black teatfish
- ways on limit/control to control who can fish given cultural laws

Group 2:


GRP 2. ①
→ 3 tiers make sense. ✓
→ plain language important
→ How will the decisions be made ie. HCWG ??
→ Good data v. important
⇒ Full time fishermen
⇒ training
→ Black teatfish in first tier
Needs to work next year.
· Effort limits being investigated
· Open same time as TRL
· Daily catch reporting.
· T.O. groups sort it out


GRP 2 ②
- Technology
ipad catch app FRS
→ catch data
→ will work!
→ high uptake
(see ranger groups)
→ TSRA / AFMA progress !! * (1-2 yrs)
* still important for fisher logbooks being completed.
⇒ New survey teck !!:
Rovs / drones
- location data needs better

Group 3:

GROUP 3 - SESSION 3

→ 3 tiers are very detailed
- Will take time for fishers to understand.
- may be more difficult for part time and "weekend" fishers
- need a simplified version
- Need to ensure the right policies are in place to support the data collection. eg) filling in daily fishing logs
- Switch tiers from high to low.
- Expand each tier - 1 page each.
- Identify the START point clearly
- Colour code each segment with a key.

GROUP 3 - SESSION 3

→ Flexibility built into rules
eg) double TAC in one year, pause the TAC the next.
some species only eg) BTF WTF

→ Use AFMA Catchwatch notifications to alert fishers when TAC is nearly caught eg) triggers.

→ larger maps of species distribution in next version of guide

→ need to include Native Title boundaries on map (ask Seri!)

Appendix 3 – Revised size limit information for HS

Common name	Species	Maximum length (cm) (guide)	Size at maturity (cm)	Size limit TS (cm)	Proposed size limit TS* (cm)	Size limit EC (cm)	Age at maturity TS (yrs (size, cm)) (model)	TAC TS (t)
Sandfish	*Holothuria scabra*	32	13-25	18	Leave[4]	20	2 (16.5)	No take
Surf Redfish	*Actintopyga mauritiana*	38	22-23	22	Leave	25	3 (13.8)	Part of 80t limit
Black Teatfish	*Holothuria whitmaei*	30	22-26	25	Leave	30	4 (24)	No take
White Teatfish	*Holothuria fuscogilva*	55	32	32	Leave	40	4 (30.4)	15
Prickly Redfish	*Thelenota ananas*	70	30-35	35	Leave	50	4 (30.4)	20
Hairy Blackfish	*Actinopyga miliaris*	35	12	22	20	20	3 (19.2)	Part of 80t limit
Curryfish (common)	*Stichopus herrmanni*	55	27-31	27	31[2]	35	-	Part of 80t limit
Elephants Trunkfish	*Holothuria fuscopunctata*	66	35	24	Leave[5]	40	-	Part of 80t limit
Lollyfish	*Holothuria atra*	65	12-19	15	Leave[5]	20	-	Part of 80t limit
Deepwater Redfish	*Actinopyga echinites*	35	9-12	12	20[3]	20	3 (19.5)	Part of 80t limit
Curryfish (*vastus*)	*Stichopus vastus*	35	-	nil	20	15	-	Part of 80t limit
Burrowing blackfish	*Actinopyga spinea*	40	-	22	Leave	20	-	Part of 80t limit
Deepwater blackfish	*Actinopyga palauensis*	35	-	22	Leave	20	-	Part of 80t limit
Golden sandfish	*Holothuria lessoni*	46	22	18	22[2]	15	-	Part of 80t limit
Brown sandfish	*Bohadschia vitiensis*	40	15-26	nil	25[1,2]	25	-	Part of 80t limit
Leopardfish	*Bohadschia argus*	60	30	nil	30[1]	35	3	Part of 80t limit
Greenfish	*Stichopus chloronatus*	38	14	nil	Leave	20	-	Part of 80t limit
Stonefish	*Actinopyga lecanora*	24	-	nil	Leave	15	-	Part of 80t limit

*Proposed size limit (Torres Strait):
1 = Better align with EC (East Coast BDM fishery); 2 = Too small relative to age at maturity; 3 = Based on model simulation recommendation (TSBDMF Milestone Report, Appendix/Summary); 4 = Species closed to fishing; 5 = Low value species (medium and high value considered for new size limits)

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Appendix 4 – Conversion Ratios

Common name	Species	Live to Gutted	Live to Salted	Live to Dried	Gutted to Salted	Gutted to Dried	Salted to Dried	Salted to Gutted	Dried to Gutted
Sandfish	*Holothuria scabra*	0.496[4]	0.355[4]	AVE=0.049 [a14]	0.758[4]	0.094[4]	0.125[4]	1.319[d]	10.638[e4]
Surf Redfish	*Actintopyga mauritiana*	0.684[2*]	-	AVE=0.084 [a12*]	0.873[4]	AVE=0.187[2*4]	0.286[4]	1.145[d]	AVE=5.930[2*e4g]
Black Teatfish	*Holothuria whitmaei*	AVE=0.677[2*34]	0.529[3]	AVE=0.108 [a12*3]	0.824[f,4]	AVE=0.177[2*f3]	0.220[f]	1.213 [f,4]	AVE=5.663[2*f3g]
White Teatfish	*Holothuria fuscogilva*	AVE=0.627[2*c4]	0.593[c]	AVE: 0.137[1ab2*]	0.775[1]	AVE=0.237[12*]	0.309[1]	1.290[1]	AVE=4.219[12*g]
Prickly Redfish	*Thelenota ananas*	AVE=0.667 [c4]	0.481 [c]	AVE=0.055[1ab4]	AVE=0.736[14]	AVE=0.088[14]	AVE=0.118[14]	AVE=1.382[1d4]	AVE=12.502[1e4]
Hairy Blackfish	*Actinopyga miliaris*	0.480[4]	-	AVE=0.067[a14]	0.964[4]	0.209[4]	0.217[4]	1.037[d]	4.785[e]
Curryfish (common)	*Stichopus herrmanni*	0.651[2]	-	AVE=0.036[a1]	-	0.114[2]	-	-	8.772[2g]
Elephants Trunkfish	*Holothuria fuscopunctata*	0.519[4]	-	AVE=0.133[a1b4]	0.911[4]	0.242[4]	0.263[4]	1.097[d4]	8.772[e4]
Lollyfish	*Holothuria atra*	AVE=0.436[c12*]	0.236[c1]	AVE=0.063[a1bc2*]	0.586[1]	0.150[12*]	0.256[1]	1.706[1]	5.917[12*g]
Deepwater redfish	*Actinopyga echinites*	0.692	-	AVE=0.088[a13]	-	0.152[f3]	-	-	6.600[f3]
Curryfish (vastus)	*Stichopus vastus*	-	-	-	-	-	-	-	-
Burrowing blackfish	*Actinopyga spinea*	0.544[3]	0.375[3]	0.073 [1a]	0.689[f3]	0.135[f3]	0.195[f3]	1.449[f3]	7.424[f3]
Deepwater blackfish	*Actinopyga palauensis*	AVE=0.818[c13]	AVE=0.593[c13]	AVE=0.175[a1b]	AVE=0.728[1f3]	AVE=0.190[1f3]	AVE=0.262[1f3]	AVE=1.374[1f3]	AVE=5.335[1f3]
Golden sandfish	*Holothuria lessoni*	0.645[3]	0.526[3]	0.098[a]	0.815[f3]	0.152[f3]	0.186[f3]	1.226[f3]	6.588[f]
Brown sandfish	*Bohadschia vitiensis*	0.735[c,1]	0.612[c1]	0.116[c1]	0.834[1]	0.157[1]	0.189[1]	1.199[1]	6.337[1]
Leopardfish	*Bohadschia argus*	AVE=0.665 [c12]	0.572[c1]	AVE=0.115 [c12]	0.777[1]	AVE=0.171[12]	0.233[1]	1.286[1]	AVE=5.841[12g]
Greenfish	*Stichopus chloronatus*	-	-	-	-	-	-	-	-
Stonefish	*Actinopyga lecanora*	0.894[c1]	0.652[c1]	AVE=0.154 [c12*]	0.729[1]	AVE=0.158[12*]	0.253[1]	1.372[1]	5.418[1]

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[1]Ngaluafe, P. & Lee, J. 2013. Change in weight of sea cucumbers during processing: Ten common commercial species in Tonga. SPC Bêche-de-mer Information Bulletin 33: 3-8.

[2]Prescott, J., Zhou, S. & Prasetyo, A.P. 2015. Soft bodies make estimation hard: correlations among body dimensions and weights of multiple species of sea cucumbers. Marine and Freshwater Research 66: 857-865.

[2*]Calculations from raw data used in Prescott et al., 2015. (Data provided by Shijie Zhou).

[3]Purcell, S.W., Gossuin, H., Agudo, N.S. 2009. Changes in weight and length of sea cucumbers during conversion to processed bêche-de-mer: Filling gaps for some exploited tropical species. SPC Bêche-de-mer Information Bulletin 29: 3-6.

[4]Skewes, T., Smith, L., Dennis, D., Rawlinson, N., Donovan, A. & Ellis, N. 2004. Conversion ratios for commercial bêche-de-mer species in Torres Strait. AFMA Final Report #R02/119. 20 pp.

[a]Ngaluafe & Lee, 2013. Table 3; percent conversion ratios, total whole/fresh weight, from wet to dry product including values from other studies.

[b]Ngaluafe & Lee, 2013. Table 1; wet-to-dry conversion ratios.

[c]Whole fresh weights noted in Purcell et al., 2009.

[d]Derived: Inverse gutted to salted value Skewes et al. 2004.

[e]Derived: Inverse dried to gutted value Skewes et al. 2004.

[e]Empirical: Values calculated from Purcell et al. 2009.

[g]Inverse: Values calculated from Prescott et al., 2015.

Common name	Species	Live to Gutted	Live to Salted	Live to Dried	Gutted to Salted	Gutted to Dried	Salted to Gutted	Salted to Dried	Dried to ~~Gutted~~ Boiled	Wet to Boiled	Wet to Boiled to Salted	Wet to Boiled to Salted to Dry
Curryfish (common)	*Stichopus herrmanni*	0.651[2] *0.5* *estimate*	-	0.033[f,3] 0.039[a,1] AVE=0.036	-	0.114[2]	-	-	2.66[h]	0.375[h]	-	*0.25* *estimate*
Curryfish (vastus)	*Stichopus vastus*	-	-	-	-	-	-	-	-	-	-	-

References - curryfish

[1]Ngaluafe, P. & Lee, J. 2013. Change in weight of sea cucumbers during processing: Ten common commercial species in Tonga. SPC Bêche-de-mer Information Bulletin 33: 3-8.

[2]Prescott, J., Zhou, S. & Prasetyo, A.P. 2015. Soft bodies make estimation hard: correlations among body dimensions and weights of multiple species of sea cucumbers. Marine and Freshwater Research 66: 857-865.

[3]Purcell, S.W., Gossuin, H., Agudo, N.S. 2009. Changes in weight and length of sea cucumbers during conversion to processed bêche-de-mer: Filling gaps for some exploited tropical species. SPC Bêche-de-mer Information Bulletin 29: 3-6.

Footnote

[a]Ngaluafe & Lee, 2013. Table 3, percent conversion ratios, total whole/fresh weight, from wet to dry product including values from other studies.

[f]Empirical: Values calculated from Purcell et al. 2009.

Data

[h]Data from Ugar Island: Curryfish processing example (Provided by Rocky Stephens)

Curryfish x9
Boil & then weigh 8kg (800gr each, conversion ration boiled to dry = 0.375)

Wet to dry – 2.4kg (300gr each, 0.375 conversion ration dry to boiled = 2.66)

Appendix 5 – Sea cucumber Spawning Information

Common name	Species	Spawning time	Country
Sandfish	*Holothuria scabra*	*October to January**	*Australia**
		March to May, November to December	*India*
		December, January, August, September	*New Caledonia*
		November to December	*Papua New Guinea*
Surf Redfish	*Actintopyga mauritiana*	*June to April*	*Guam*
		December, January	*New Caledonia*
Black Teatfish	*Holothuria whitmaei*	*June, July*	*New Caledonia*
		April	*Aldabra, Seychelles*
		*December**	*GBR, Australia**
White Teatfish	*Holothuria fuscogilva*	*Part of November, December, January*	*New Caledonia*
Prickly Redfish	*Thelenota ananas*	*January, February, March*	*New Caledonia*
		*December**	*John Brewer Reef, GBR, Australia**
Hairy Blackfish	*Actinopyga miliaris*	*July (new moon)*	*Japan*
		May, November to December	*New Caledonia*
		*November**	*Orpheus Island, Australia**
Curryfish (common)	*Stichopus herrmanni*	*December, January*	*New Caledonia*
		June to July	*Straits of Malacca, Malaysia*
		*November, December, January**	*Little Broadhurst Reef, GBR, Australia**
Elephants Trunkfish	*Holothuria fuscopunctata*	*December, January, part of February*	*New Caledonia*
		*December**	*Lizard Island, Australia**
		*December**	*John Brewer, GBR, Australia**
Lollyfish	*Holothuria atra*	*November*	*Solomon Islands*
		August	*Peninsular Malaysia*
		*October**	*Davies Reef, GBR, Australia**
Deepwater Redfish	*Actinopyga echinites*	*January, February*	*New Caledonia*
Curryfish (*vastus*)	*Stichopus vastus*	-	-
Burrowing blackfish	*Actinopyga spinea*	-	-
Deepwater blackfish	*Actinopyga palauensis*	-	-
Golden sandfish	*Holothuria lessoni*	*November, December, January, part of February*	*New Caledonia*
		November	*New Caledonia*
Brown sandfish	*Bohadschia vitiensis*	*November, December*	*New Caledonia*
Leopardfish	*Bohadschia argus*	*October to January**	*GBR, Australia**

		*October , November, December, January**	*GBR, Australia**
Greenfish	*Stichopus chloronatus*	*April to June, December to February*	*Straits of Malacca, Malaysia*
		*November, January**	*Myrmidon Reef, Davies Reef, GBR, Australia**
Stonefish	*Actinopyga lecanora*	*July*	*Peninsular Malaysia*
		*December**	*GBR, Australia**

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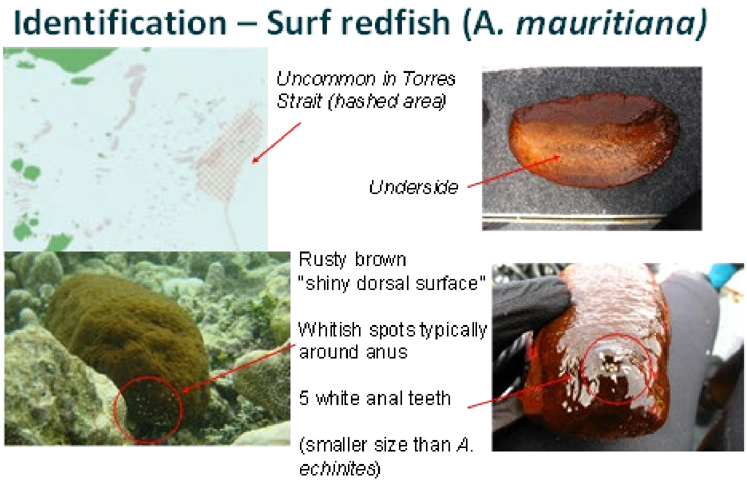
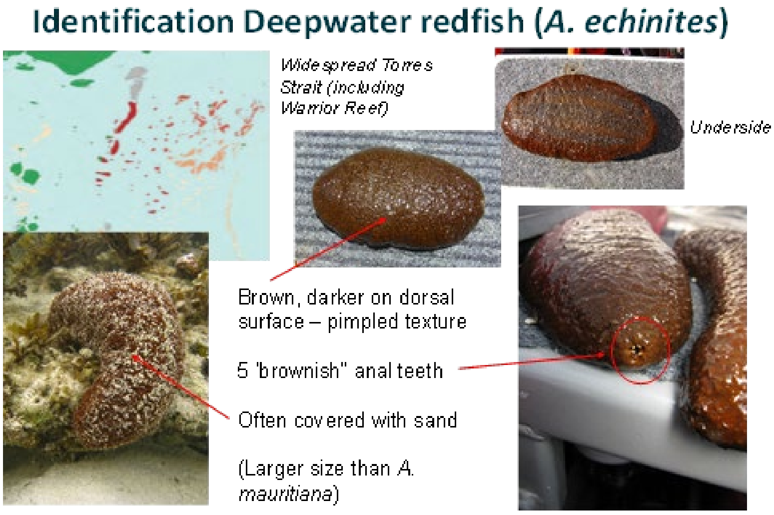
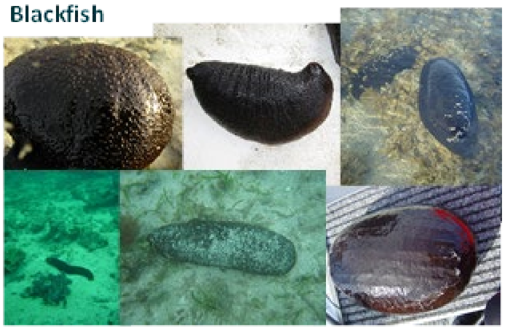
Appendix 6 - Species identification support materials

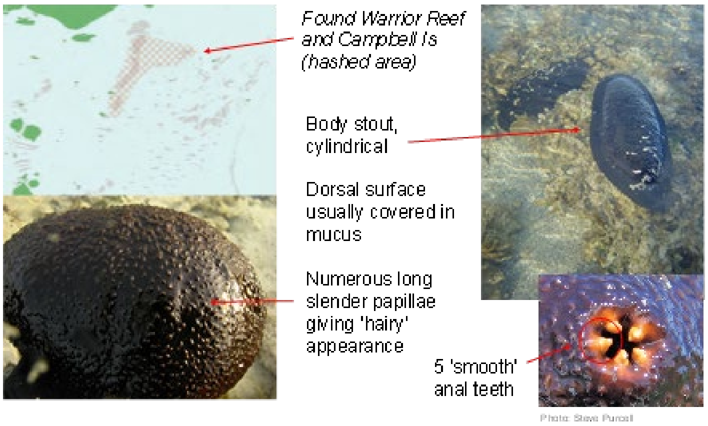




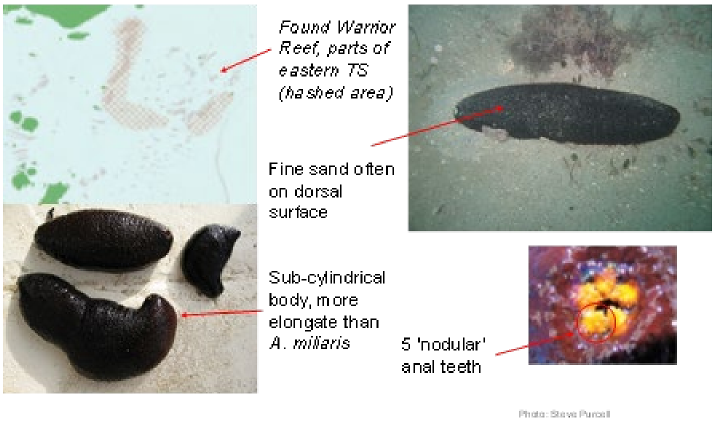
Blackfish



Identification – Hairy blackfish *(A. miliaris)*



Identification – Burrowing blackfish *(A. spinea)*



Identification – Deepwater blackfish *(A. palauensis)*

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