Australian Government
Australian Fisheries Management Authority

Torres Strait Beche-de-mer Fishery Harvest Strategy

November 2019*

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This harvest strategy is based on outcomes from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Oceans and Atmosphere Division project, *Harvest Strategies for the Torres Strait Beche-de-mer (sea cucumber) Fishery*. The project was funded by the Australian Fisheries Management Authority (AFMA).

AFMA Project No. 2016/0823.

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*This harvest strategy was edited by AFMA on 7 April 2021 to correct the reference in the last column of Table 5 (page 41) to surf redfish as part of the 80t basket species limit as it is a no take species.

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Glossary

Types of reference points:

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

Notation:

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

Other acronyms:

Acronym	Description
AFMA	Australian Fisheries Management Authority
BDM	Beche-de-mer
CPUE	Catch per unit effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
HCR	Harvest Control Rule - pre-determined rules that control fishing activity according to the biological and economic conditions of the fishery (as defined by monitoring or assessment). Also called ‘decision rules’. HCR are a key element of a harvest strategy[1]

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

Acronym	Description
HCWG	Hand Collectables Collectables Working Group
HS	Torres Strait Beche-de-mer Fishery Harvest Strategy
HSF	Harvest Strategy Framework
HSP	Commonwealth Harvest Strategy Policy and Guidelines 2018
MSE	Management Strategy Evaluation - a procedure whereby alternative management strategies are tested and compared using simulations of stock and fishery dynamics[1]
PZJA	Protected Zone Joint Authority
RBC	Recommended Biological Catch
RNTBC	Registered Native Title Body Corporate
TAC	Total Allowable Catch
Tiered approach	A framework that uses different control rules to cater for different levels of uncertainty about a stock
TSRA	Torres Strait Regional Authority
QDAF	Queensland Department of Fisheries and Agriculture

Overview

The Torres Strait Sea Cucumber or Beche-de-mer Fishery (the Fishery) Harvest Strategy (HS) sets out the management actions needed to achieve the agreed Fishery objectives. The HS describes the performance indicators used for monitoring the condition of a stock, the analytical procedures and the rules applied to determine the recommended biological catch each fishing season.

The need to formalise a harvest strategy for the Torres Strait Beche-de-mer fishery has been discussed at management forums (e.g. Hand Collectables Working Group 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 BDM species, with these classified into groups; closed species, target species, curryfish species and basket species.

The HS depends critically on fishery data provided through the Torres Strait Fish Receiver System that was implemented on 1 December 2017. The strategy 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 HS framework is a tiered system which accounts for understanding that more data and more information reduces the risk to a resource and reduces the need for precautionary management. This means higher catch limits are possible if there are more, better quality data available.

The HS 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)
c) Proportional composition of different species in catch if individual species mass is not recorded
d) Size composition (per species) of a representative catch sample
e) Area (and depth) of each species 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 increase TACs if high quality fishery data are available and indicate an increase is possible

4. Rules for how to further increase TACs if high quality survey data become available.
5. Rules for how to re-open a fishery that has been closed. This includes fisheries that have been closed due to overfishing (e.g. sandfish), concerns about underreporting (e.g. black teatfish), or due to TACs being exceeded. 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.

The strategy also includes some static controls such as minimum size limits and the option for spatial closures to complement fishery management measures and other traditional community management initiatives (e.g. a proposed 10 nautical mile voluntary spatial closure 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 harvest control rules (HCR) 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 stock status. This intends to maintain the same level of risk across the different tiers.

Harvest Strategy 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 HS 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 Background

This Harvest Strategy has been developed in accordance with the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines 2018* (HSP) and is consistent with objectives of the *Torres Strait Fisheries Act 1984* (the Act).

The Protected Zone Joint Authority (PZJA) is responsible for management of commercial fishing in the Australian waters of the Torres Strait Protected Zone. The PZJA objectives adopted for the Torres Strait Beche-de-mer Fishery are:

- to provide for the sustainable use of all Beche-de-mer stocks in Torres Strait;
- to develop Beche-de-mer 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 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 where relevant. 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 Malo ra GELAR (Malo's Law) of Kemer Kemer Meriam Nation, Saabi law of Maluialgal Nation, Saabi law of Gudamalulgal Nation and Kulkalgal Nation and Saabi law of Kaurareg Nation.

The HS uses a tiered approach to cater for different amounts of data available and different species groups and types of assessments (e.g. target species with species-specific Catch-Per-Unit-Effort (CPUE) and surveys). Underpinning a tiered HS is increased levels of precaution with increasing levels of uncertainty about the stock status. Each tier has its own HCR and associated rules that are used to determine an RBC.

1.1 Commonwealth Fisheries Harvest Strategy Policy

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

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

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

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

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

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

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

f) minimise discarding of commercial species as much as possible

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

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

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

With a harvest strategy in place, fishery managers and stakeholders are able to operate with pre-defined rules, management decisions are more transparent, and there are likely fewer unanticipated outcomes necessitating hasty management responses.

1.2 Development of the BDM Harvest Strategy

The HS has been developed in close consultation with the HCWG (and as part of HS development workshops led by CSIRO) and involving a broader group of stakeholders (3 November 2016; 27-29 June 2017; 25-26 October 2017; 24-26 July 2018; 23-24 October 2018; 1-2 August 2019 and out of session 16-30 September 2019).

2 The Beche-de-mer Fishery Harvest Strategy

2.1 Scope

This HS applies to the whole Torres Strait Beche-de-mer Fishery comprised of 18 commercial species (Table 1).

The HS outlines the control rules used to develop advice on the recommended biological catch (RBC) and recommend Total Allowable Catches. The HS sets the criteria that pre-agreed management decisions will be based on in order to achieve the Fishery objectives.

Over time, the HS will be subject to periodic reviews and updates with ongoing opportunities to refine and improve the strategy in future. Summaries of local knowledge, observations, preferences, outcomes of local management practices including community-specific closures and spatial rotations as to where fishing takes place could be used in an iterative manner to continually improve the HS and ensure customary practices receive appropriate acknowledgement.

Table 1. Summary of key Beche-de-mer species in Torres Strait.

Common name	Scientific name	Common name	Scientific name
Sandfish	*Holothuria scabra*	Deepwater redfish	*Actinopyga echinites*
Surf redfish	*Actinopyga mauritiana*	Curryfish vastus	*Stichopus vastus*
Black teatfish	*Holothuria whitmaei*	Burrowing blackfish	*Actinopyga spinea*
White teatfish	*Holothuria fuscogilva*	Deepwater blackfish	*Actinopyga palauensis*
Prickly redfish	*Thelenota ananas*	Golden sandfish	*Holothuria lessoni*
Hairy blackfish	*Actinopyga miliaris*	Brown sandfish	*Bohadschia vitiensis*
Curryfish common	*Stichopus herrmanni*	Leopardfish	*Bohadschia argus*
Elephant trunkfish	*Holothuria fuscopunctata*	Greenfish	*Stichopus chloronotus*
Lollyfish	*Holothuria atra*	Stonefish	*Actinopyga lecanora*

2.2 Objectives

The objectives of this Harvest Strategy are:

a) to provide for the sustainable use of all Beche-de-mer in Torres Strait to take account of long-term sustainability for future generations;
b) to develop Beche-de-mer populations for the benefit of Australian Traditional Inhabitants (as defined by the Torres Strait Treaty) and accommodating commercial considerations;
c) to acknowledge area-specific issues;
d) where possible, to consider an ecosystem approach to management that reduces impacts on, or optimises interactions with, other harvested and dependent species and acknowledges the important ecological role of sea cucumbers and
e) to develop long-term recovery strategies for species, where appropriate.

2.3 Recommending TACs From RBCs

The Recommended Biological Catch (RBC) is the recommended total catch of BDM (both retained and discarded) that can be taken from throughout the area by the Fishery in a fishing season. The HSP states that when setting the TAC for the next fishing season the HS should take into account all sources of fishing mortality.

2.4 Monitoring

The Fishery 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 as catch reporting was only made compulsory in December 2017. It is anticipated that there will be a time lag before reliable catch and effort data are available for analysis.

The HS therefore outlines a starting point in terms of data collection, analysis and use to inform decision making, however this may need to be revised as more data become available and as data needs arise. 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 strategy clearly maps a pathway for ongoing improvements and refinements, including further data collection as well as a clear role for community-level data and local knowledge.

2.4.1 Fishery independent surveys

There are a number of surveys and other biological studies (Long et al. 1996; Skewes et al. 2000; Skewes et al. 2002; Skewes et al. 2010) conducted in Torres Strait which have been used to inform aspects of harvest strategy development. Fishery-independent surveys are highly recommended where appropriate to inform decisions related to whether increases or decreases in TACs may be warranted. 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:

a) Small-scale experimental fishing surveys with local fisher participation and possible cost-recovery via fishers being permitted to sell animals surveyed;

b) 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)
c) Full-scale scientific surveys conducted over a large representative area and surveying multiple species.

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

2.4.2 Catch and effort information

Fishers are required to record catch information on Torres Strait Catch Disposal Records (TDB02) as part of the mandatory Fish Receiver System. This includes reporting the total mass of each species landed, as well as the processing method so that conversion ratios (see Table 4) can be used to convert all reported catch to a standard weight (wet gutted). It is important that these records also include an accurate estimate of the total discards (which includes product lost in the processing phase). Accurate total catch per species, including discards needs to be provided in a timely manner and is a critical data input to the low tier decision rules. While catch disposal records do not require reporting of discards, changes to reporting requirements may be needed to facilitate this.

It is important that total catches are separated by species and 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). In this instance 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 herrmanni* 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). A Torres Strait Beche-de-mer species identification guide is available to assist in identifying individual species (Murphy et al. 2019).

Catch per day and per spatial location are needed to support scientific assessments of the fishery (lumped and stockpiled data are less useful). Other very useful data to support scientific assessment include fishing effort (e.g. hours fished) and size of animals caught. Information about the area where the sea cucumbers were caught is extremely valuable and needs to be recorded as accurately as possible. If high quality area-specific and depth information are recorded, these data could be used as inputs to the middle tier decision rules. The provision of effort information under the TDB02 is voluntary, but is strongly encouraged to support scientific assessments of the fishery. Detailed logbook information including fishing effort, area fished and depth supplied on HC01 Daily Fishing Log can be completed and submitted now on a voluntary basis. This data is treated by AFMA as confidential.

Fishing effort is a key measure that is used to calculate Catch-Per-Unit-Effort (CPUE) which can serve as an index of abundance and inform on stock status and trends. 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. 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 data provide a valuable input that can be used to support decision making and progression to the middle tier.

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 in some instances, (e.g. when re-opening a fishery) additional constraints may be imposed on the recording of catch and effort information.

2.4.3 Catch sub-sampling information

Estimates of the size distribution of individual species are additional data required as inputs to the middle tier decision rule for use in adjusting TACs. It isn't necessary to measure every animal caught, however accurate measures of the length and mass of a representative (by area and species) sub-sample is an important data input. 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.

2.4.4 Environmental Indicators

Data on environmental indicators are not currently collected in the BDM fishery. However, as a longer term objective for the fishery, some fishers indicated as part of the HS workshops that they were eager to undertake local reporting and to take responsibility for local management. As such, a framework was developed to operationalise these indicators in a decision framework to provide a defensible basis on which to make recommendations for local management measures. The 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). Examples of indicators include condition of feeding grounds (algae abundance etc.), density estimated from diver camera surveys, surveys of dead individuals on the beach and perceived extent of illegal, unreported or unregulated (IUU) fishing. This framework is described in Plagányi et al. (2019) as no such data are currently available for evaluation, but if these data are collected on a regular basis in future, then it might be possible to more formally incorporate them in the HS given that it is anticipated the HS will regularly be revised and updated in future years.

2.4.5 Information based on local knowledge

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 supported 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.

2.5 Static Management Controls

The Harvest Strategy framework (Figure 1) identifies a number of static controls that can be implemented to complement and strengthen other management actions. The key static controls used to strengthen the HS are as described below, with dynamic (i.e. changing over time) controls outlined in later sections of this document.

2.5.1 Size limits[2]

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. 2015) 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. Table 5 summarises recommended HS size limits.

2.5.2 Spatial and temporal closures

Beche-de-mer temporal/seasonal closures are not currently implemented as a compulsory component of this HS but could be used as an additional management measure by local communities and may be more formally incorporated in future versions depending on level of support and need. An example of industry proposed spatial closures discussed during HS workshops can be found at Figure 7.

2.6 Species Classification

The HS recognises that the TS BDM fishery is a multispecies fishery comprising species with different life histories, economic value, distributions and fishing pressure. All species have therefore been assigned to one of four species categories as described in Table 2.

[2] This HS includes recommended changes in some current size limits to bring them in line with updated information on the age-at-first-maturity as well as to better align them with comparable size limits from other fisheries such as the East Coast Beche-de-mer Fishery.

Species may change categories over time depending on available information and the associated management decisions made.

Table 2. TS BDM species category definitions as at November 2019.

Category	Examples of species in category as at November 2019	Category definition
Closed	sandfish surf redfish black teatfish	Species closed to fishing due to concerns of overfishing or stock depletion, underreporting, or significant overcatch of the TAC
Target species	white teatfish prickly redfish hairy blackfish deepwater redfish greenfish	Target species with own individual TAC
Curryfish	3 curryfish species	Increasingly targeted curryfish species
Basket species	all other species	Remaining species basket with trigger to identify species of growing commercial interest

2.7 Total Allowable Catch (TAC)

Changes to the TACs (pre-Harvest Strategy implementation, see Table 3) are recommended to reflect the revised classification of the component fishery species into categories. Starting TACs and trigger limits are based on a series of stock surveys carried out between 1995 and 2011 (Skewes et al., 2010; Murphy et al., 2011), and estimates of fishery harvests up to 2018. Starting TACs under the HS have been set at less than 10% of population biomass and are designed to be sustainable medium-term annual limits that result in low risk to overexploitation. The trigger limits are even more conservative and include species with a high uncertainty in population estimates and/or biological parameters, allowing for potential increase if more information on species stock status is forthcoming. Changes in market value and demand mean that several additional species were identified as target species needing to have specific TACs or triggers (with associated actions). These include curryfish, greenfish, hairy blackfish and deepwater redfish (Table 3).

Table 3. Starting HS TAC Recommendations

Common name	Scientific name	Commercial value	Pre-HS TAC (t) [3]	Recommended HS Starting TAC (t)	Basket triggers (t)	Notes	Max middle tier TAC increase (based on indicators) before needing survey	Max recorded historical catch and year (not necessarily sustainable catch)
Sandfish	*Holothuria scabra*	High	Closed	Closed			5	1200t (1995)
Surf redfish	*Actintopyga mauritiana*	Medium	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 (↓ from 20)	15			20	28.1t (2015)
Deepwater redfish	*Actintopyga echinites*	Medium	Part of 80t basket	5#			40t based on surveys	5.5t (2015)*
Hairy blackfish	*Actinopyga miliaris*	Medium	Part of 80t basket	5			10 (lower CI survey as uncertain)	28.5t (2001)
Greenfish	*Stichopus chloronotus*	Medium	Part of 80t basket	40t			40	1.2t (2002)
Curryfish common	*Stichopus herrmanni*	Medium	Part of 80t basket	60t curryfish			60 (hermanni)	6.1t (2015); 15t (mid-2018)
Curryfish vastus	*Stichopus vastus*	Medium	Part of 80t basket	60t curryfish	15	new trigger	20 (vastus)	see curryfish
Elephant trunkfish	*Holothuria fuscopunctata*	Low	Part of 80t basket	Part of 50t basket	15	existing trigger	15	0.4t (2004)
Lollyfish	*Holothuria atra*	Low	Part of 80t basket	Part of 50t basket	40	half existing	80	0
Burrowing blackfish	*Actinopyga spinea*	Medium	Part of 80t basket	Part of 50t basket	5	trial new species	10 (survey e.g. high around Warrior)	0
Deepwater blackfish	*Actinopyga palauensis*	Medium	Part of 80t basket	Part of 50t basket	0.5	previous catch	10	0.5t (2001)*
Golden sandfish	*Holothuria lessoni*	High	Part of 80t basket	Part of 50t basket	0.5	previous catch	5	0.35t (2014)
Brown sandfish	*Bohadschia vitiensis*	Medium	Part of 80t basket	Part of 50t basket	3	previous catch	5	3.4t (2002)
Leopardfish	*Bohadschia argus*	Medium	Part of 80t basket	Part of 50t basket	40	existing trigger	40	9.6t (2003)
Stonefish	*Actinopyga lecanora*	Medium	Part of 80t basket	Part of 50t basket	5	existing trigger	5	0.5t (2010)
TOTAL			110t	205t$			415t	

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

[3] Prior to Harvest Strategy implementation, the TACs for most species were set based on a conservative estimate of biomass from historical surveys.

2.8 Reference Points

There were no existing adopted proxy reference points consistent with the HSP for the Torres Strait BDM fishery, 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. Instead, starting TACs are set conservatively and in that respect reflect an intention to meet the HSP. Additionally, the HS proposes use of some reference point proxies that are fairly conservative and consistent with the HSP.

Where required, proxies for reference points were based on Plaganyi 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 severely 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 $0.4*K$ 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 Figure 5 and Figure 8. 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 biomass 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 (see Figure 8).

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 pre-existing conservative fishing mortalities to conservative biomass estimates.

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. The status of each stock depends on comparison with agreed Reference Points as specified. For example, if total catch exceeds a pre-specified limit or CPUE is below a pre-specified limit reference level then it may indicate that a 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 catch limits to achieve desired targets and satisfy the overall fishery objectives.

2.9 Stock Assessment Cycle

The Hand Collectables Working Group (HCWG) meets at least once annually to review all available catch data as well as primary indicators data, and advises on analyses needed as well as any future monitoring needs and revisions to the HS.

2.10 Data Summary

The annual data summary reviews the catch and catch per unit effort (CPUE) from the fishery as well as all other information, including the size-frequency information provided from sub-samples of commercially caught BDM. The data summary is used as an indicator to identify if catches correspond to the RBC, and to monitor CPUE.

2.11 Decision Rules

In order to manage the TS BDM stocks to meet the operational objectives of the HS and the BDM Fishery more broadly, the HS includes a mix of approaches as described above:

a) Effort controls and temporal closures;
b) Spatial management;
c) Total Allowable Catches to limit total amount caught; and
d) Complementary minimum size limits to allow animals a chance to breed before being caught.

A summary of the harvest strategy framework is provided below, and includes Decision Rules specified within each tier.

Low Tier:

i. **Catch-based Decision Rule** – TACs are monitored and adjusted annually, with agreement that a fishery will be closed if no data are provided. Overcatch of the TAC may result in a corresponding reduction from the TAC the following year, a 1 year pause in fishing, or a closure of the species, depending on the severity of the overcatch.
ii. **Joint TAC trigger-limit Decision Rule** – Basket species are managed under a joint TAC with species specific triggers. If the trigger limit of an individual basket species is exceeded by more than 10 per cent, all available information must be considered and changes to basket TACs or individual basket species trigger limits may be possible.

Middle Tier:

i. **Multiple Indicator Decision Rule** – TACs may be increased or decreased if high quality fishery data are available from at least two primary indicators. The potential increase to TACs may be capped at a specified level depending on the proportional change (10% or more) in the multiple indicator adjustment factor. If the proportional change in the multiple indicator adjustment factor is less than 10%, the TAC stays the same.

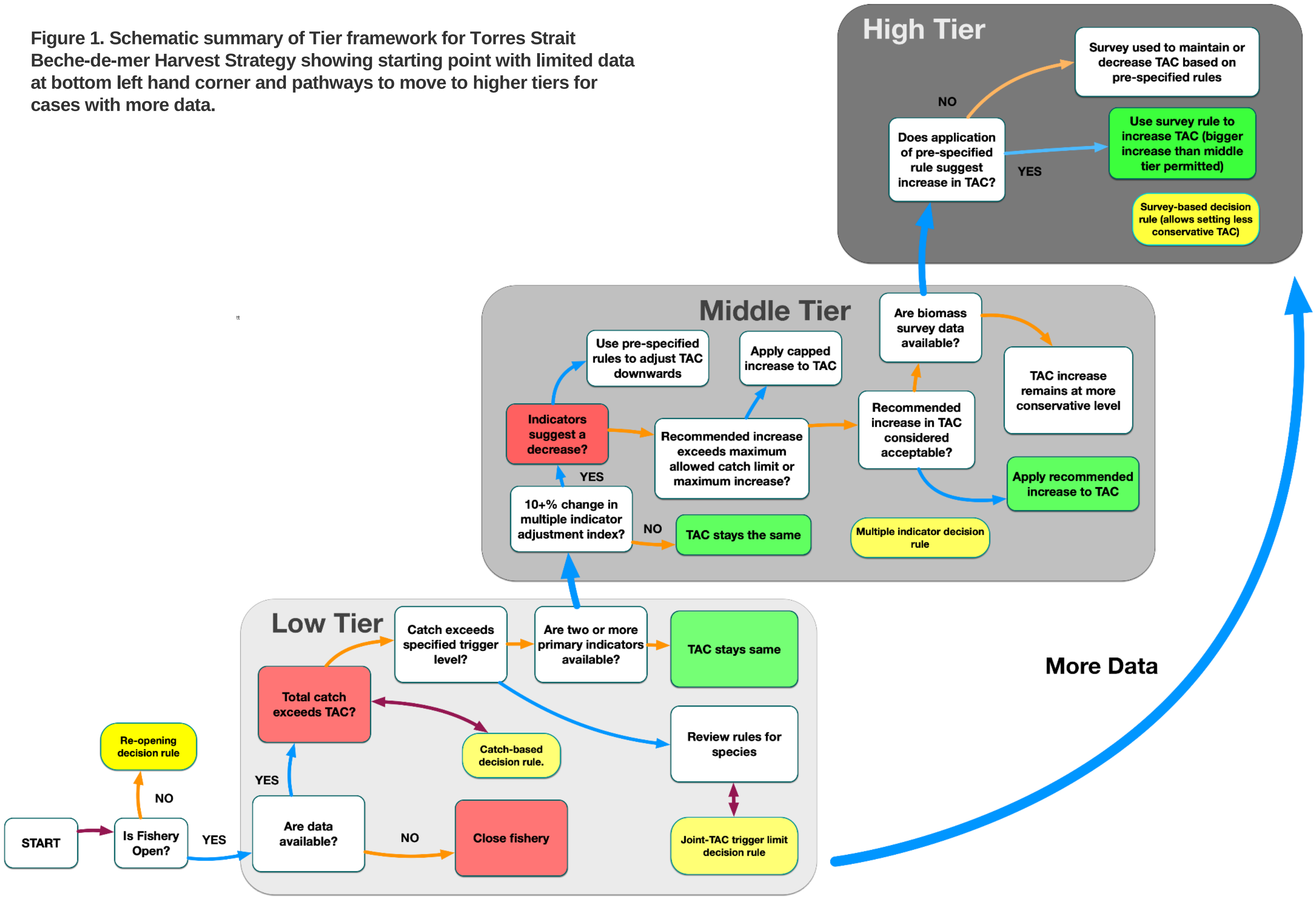
High Tier:

i. **Survey-based Decision Rule** – TACs may be increased or decreased using high quality survey data based on trends or total biomass estimates.

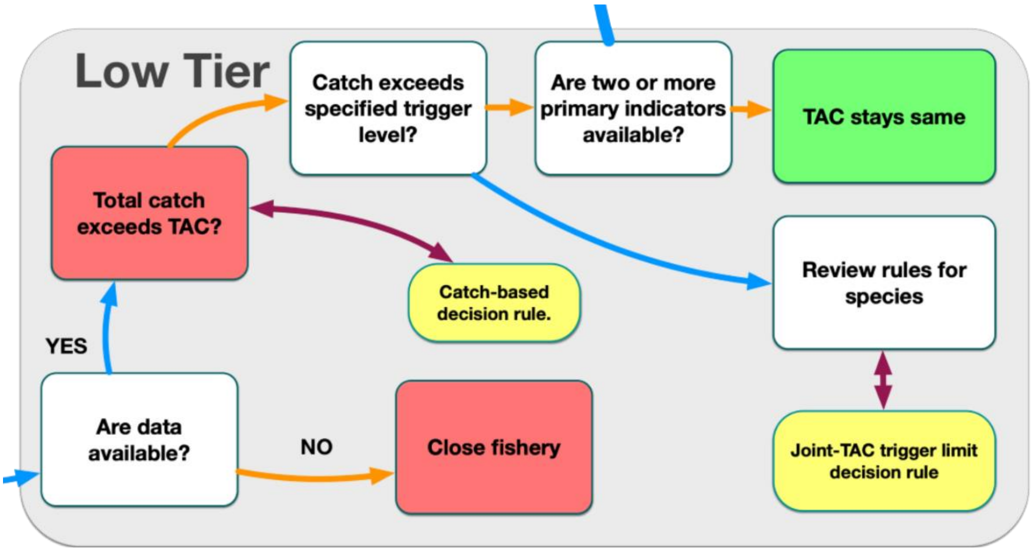
Closed Species:

An additional **Re-opening Decision Rule** applies for species that have been closed to fishing due to concerns of overfishing or stock depletion, significantly exceeding catches beyond the TAC, or in the absence of reported catches.

Figure 1. Schematic summary of Tier framework for Torres Strait Beche-de-mer 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.



2.11.1 Low Tier Decision Rules



When is the low tier applied?

In the absence of data other than the total amount of reported catch by species or combined basket.

What are the decision rules?

There are two decision rules that operate within the low tier:

- Catch-based decision rule
- Joint TAC trigger-limit decision rule

What do the decision rules allow?

For species with individual TACs, the low tier allows the TAC to either be maintained or reduced depending on the information available. A transition to the middle tier, and increased TACs is not possible unless two or more primary indicators are available.

For species with individual triggers, within a basket with a joint TAC, the low tier may allow changes to the joint TAC, or individual triggers, depending on the information available.

2.11.1.1 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:

1. If no reliable catch-reported data, then TAC = 0;
2. If reported catches exceed the TAC by more than double, close the fishery;
3. If reported catches exceed the TAC by >20% and <100% (double), then pause fishing for one fishing season;
4. If the cumulative reported catches over a three year period exceed the TAC by >5% and <20%, then deduct the total overcatch from the TAC in the next full fishing season.

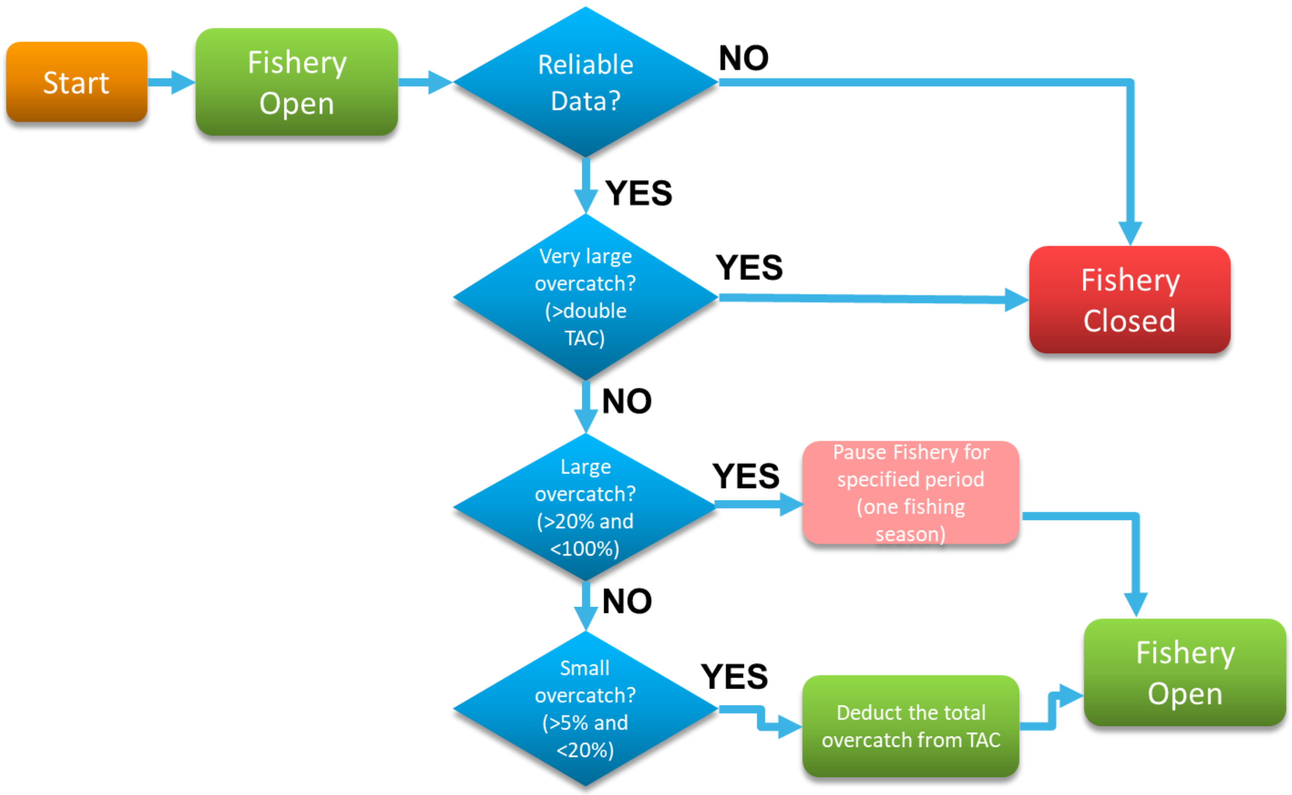


Figure 2. Flowchart summarising low tier catch-based decision rule.

2.11.1.2 Low Tier Joint TAC Trigger-Limit Decision Rule

This is a low tier rule that is applied to species with specific triggers within a basket:

1. Calculate the total catch (including discards) of all species in the species basket;
2. Calculate 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;
3. 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:
   a) to make a change to the basket TAC, or individual species trigger, or
   b) a species-specific TAC is justified, or
   c) a closure is deemed necessary, or
   d) recommend further data be collected (e.g. in the form of a survey, or indicator before any change to the joint TAC or trigger limit is allowed.

Such data and information may include but is not limited to, updated information on stock distribution, stock status or biomass estimates from nearby fisheries (e.g. Queensland East Coast BDM Fishery) of the same species, or new information on life history characteristics, biology, or market value.

The current TAC and trigger limit will remain in place unless the above (3a – d) suggests a change. For 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 3). 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 herrmanni* and *S. vastus*) due to improved processing methods and market opportunities (Purcell et al., 2014).

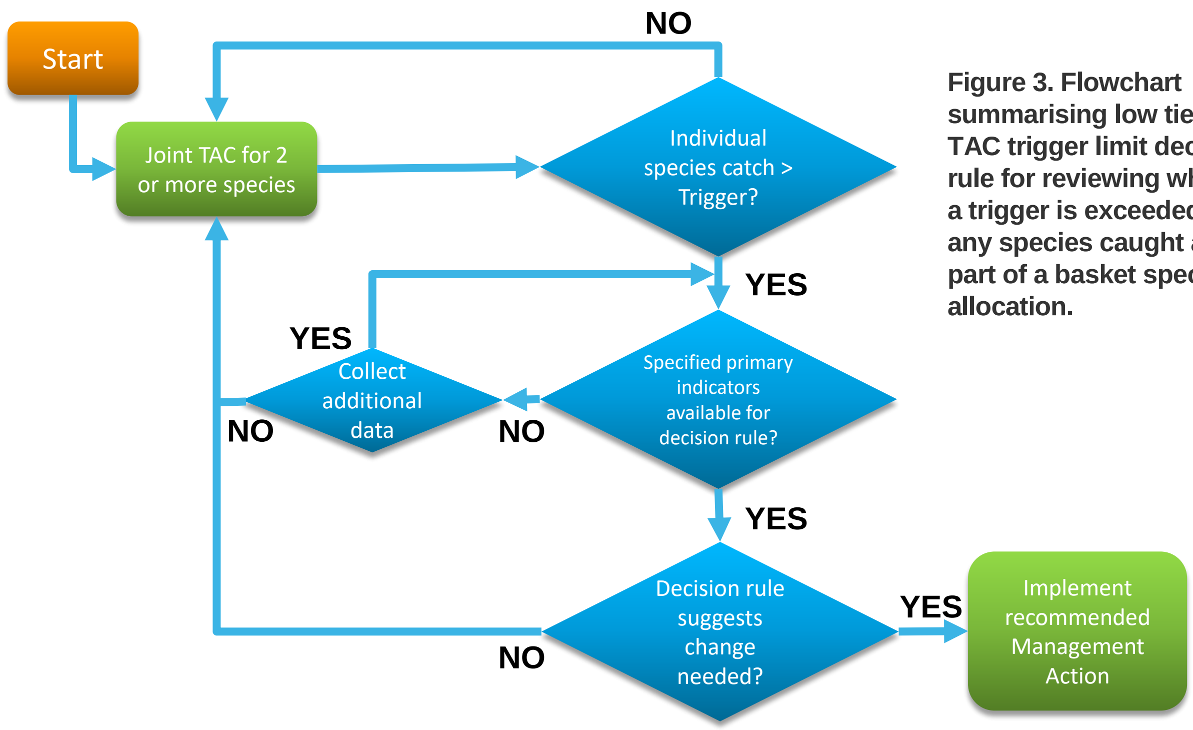
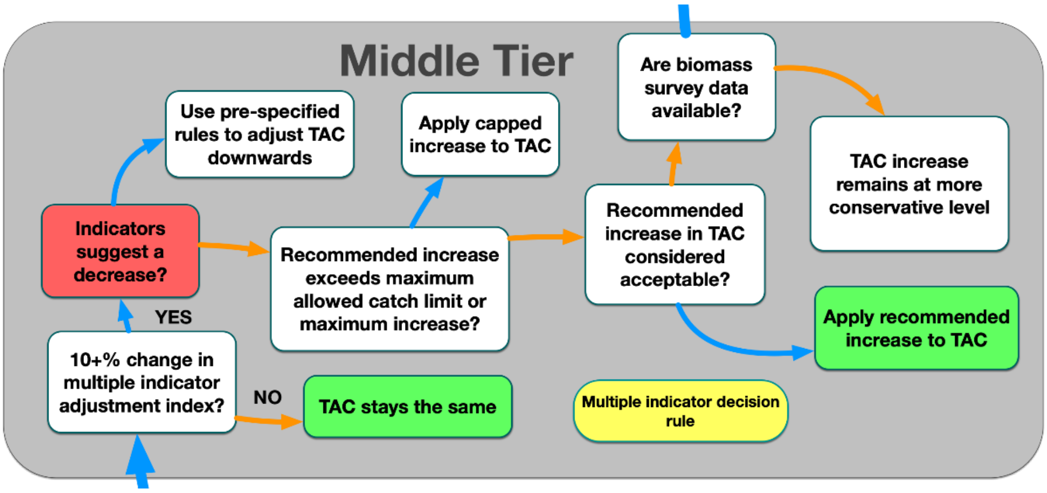


Figure 3. Flowchart summarising low tier Joint TAC trigger limit decision rule for reviewing whether a trigger is exceeded for any species caught as part of a basket species allocation.

2.11.2 Middle Tier Decision Rules



When is the Middle Tier applied?

The Middle tier applies when high quality data are available from several primary indicators in addition to total catch per species.

The Middle Tier is not applicable during the initial years of HS implementation as insufficient detailed historical fishery data are available, but it provides a pathway for improving and growing the fishery in line with the HS objectives.

What does the Middle Tier decision rule allow?

The Middle Tier Decision Rules specify how to increase TACs if good quality fishery data are available and indicate a capped increase is possible (see Table 3, maximum middle tier TAC increase).

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 4).

2.11.2.1 Middle Tier Multiple Indicator Rule

Catch-Per-Unit-Effort (CPUE) has not been demonstrated to be a reliable indicator on its own, but 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 TAC based on a Recommended Biological Catch (RBC) calculated using two 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 (Figure 4):

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

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 A<maximum increase permitted (MAX_{sp}):

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

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

a) Calculate 2 or more of the individual Indicator adjustment factors described below

b) Work out the average *A* of these values or a weighted average if assigning different weights to different contributions

c) Calculate the average recent catch (past 3 years)

d) 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

e) Multiply the average recent catch by the indicator average to obtain the new Recommended Biological Catch (RBC)

f) Check that the RBC does not exceed a pre-specified maximum catch limit (Table 3).

The multiple indicator rule will typically be applied to species which are highly targeted and 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. 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 calculated as described below, with a mathematical formulation first specified followed by plain English summary of the rule.

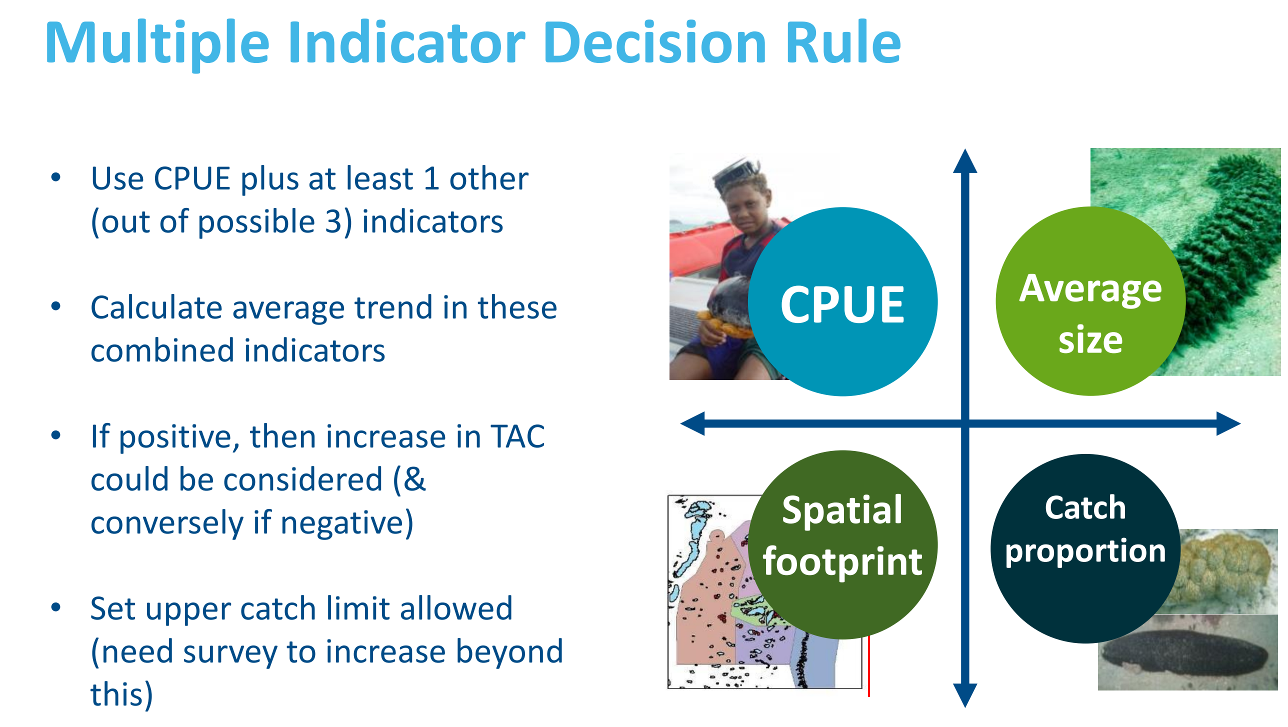


Figure 4. Schematic summary of the Middle Tier Multiple Indicator Decision Rule and its components

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

Calculating the Middle Tier CPUE Indicator Adjustment Factor

- 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) 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.

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

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

- 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 $\bar{s}$ of previously sampled animals
- Parameter c_2 accounts for how reliable data are (e.g. is the size sample representative), with guidance provided on default settings

Calculating Middle Tier Average Size Indicator Adjustment Factor

- 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
- Use data from past observations (see Plagányi et al. (2019) and noting that these data should be reviewed and updated over time) to compute an average historical size of the fished population
- 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

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

Calculating Middle Tier Area Fished Indicator Adjustment Factor

- 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 past 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 down weights 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.

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

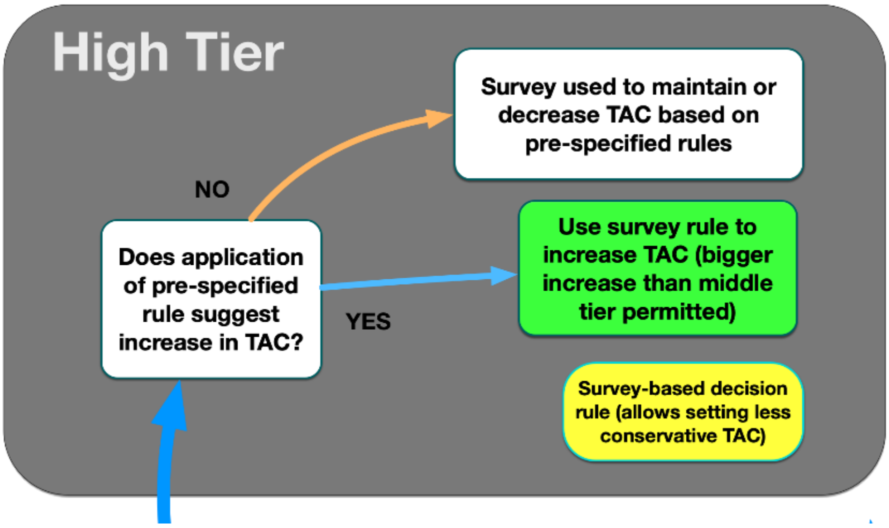
$$I_{prop} = 1 + c_4 \left(\frac{\sum_{y-2}^{y} p_y \Big/ 3 - \bar{p}}{\bar{p}} \right)$$

- 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 $\bar{p}$
- Parameter c_4 accounts for how reliable data are (e.g. were representative catch samples used, data from logbooks), with guidance provided on default settings

Calculating the Catch Proportion Indicator Adjustment Factor

- 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 down weights 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.

2.11.3 High Tier Decision Rules



When is the High Tier applied?

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).

What do the High Tier decision rules allow?

The high tier 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 if total catch of a species is close to the current TAC.

2.11.3.1 Survey-based Decision Rule for adjusting TACs

This section describes the use of survey data as relative indices of abundance, as well as for estimating total standing stock biomass. There are a number of spatially-representative historical surveys which can be used as a baseline for comparison with future survey data to quantify trends in abundance of key species. 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 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. As fishery-independent or dedicated surveys conducted by fishers are generally considered more reliable than CPUE data, 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 if total catch of a species is close to the current TAC.

2.11.3.2 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.

2.11.3.3 Survey-Based Decision Rule based on total biomass estimate

For most species the starting TAC is set based on a conservative estimate of historical biomass (Figure 5). The survey biomass estimates can be used to inform baseline target and limit densities. 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. However, challenges need to be recognised in obtaining comparable and representative estimates for different species with differing habitants or spatial distributions. Any density measure needs to be sufficiently representative of the broader area in which that species occurs.

Given that the BDM Fishery includes many species occupying different habitats, the HS recognises that the same survey design isn't appropriate for all species. For species concentrated in a specific area (e.g. sandfish on Warrior Reef), a dedicated survey design can be used to estimate the local density 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 pursued to obtain an estimate of relative abundance as described above.

In contrast, for species which occur mostly in deeper waters (e.g. white teatfish), a survey with representative sites could be used to estimate the total standing stock biomass occupying previously unsurveyed areas or depths (in this case, depths in excess of 20m). This new information can inform 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, (e.g. 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.

The HS also recognises that technologies and survey techniques are developing and that innovative new survey methods may need to be included in future revisions of the HS.

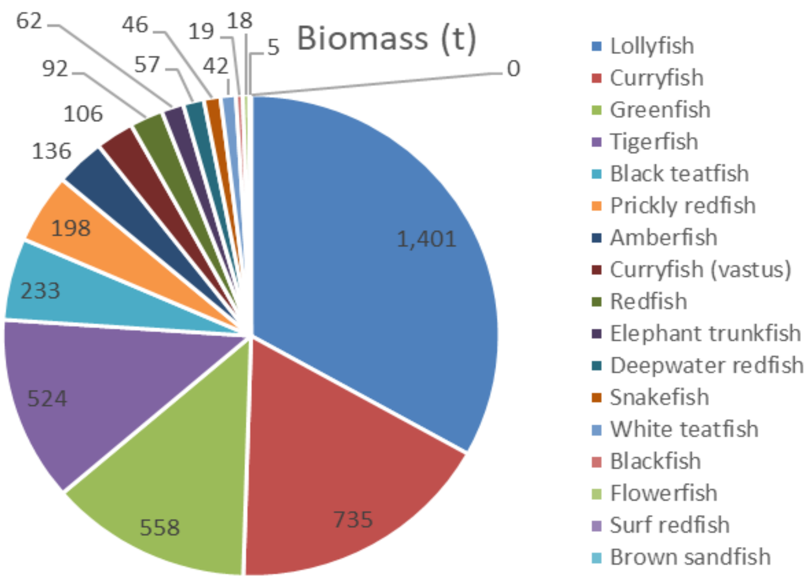
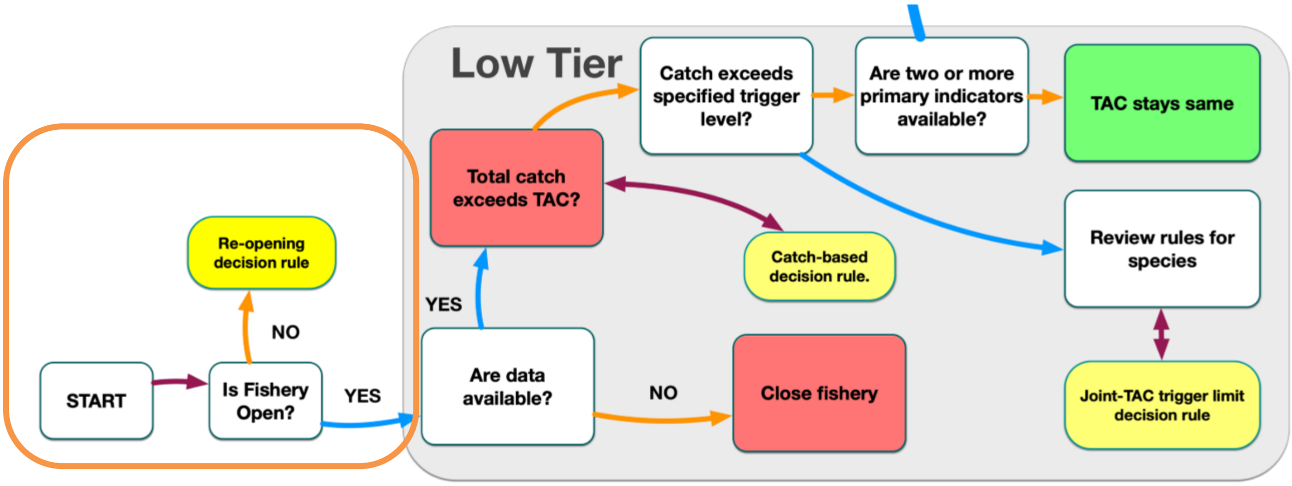


Figure 5. Schematic showing average survey-based Torres Strait biomass estimates (t) for species as shown for use in comparing with future survey-based biomass estimates.

2.11.4 Re-opening Decision Rule



This rule that is applied to re-open a fishery (where the term "fishery" here refers to a specific BDM species in Torres Strait) that has been closed due to concerns around stock status and depletion, or for reasons such as needing to first ensure adequately precautionary measures are in place so that overfishing does not occur or the stock does not become overfished.

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 (e.g. black teatfish). Note this also takes into account findings from testing spatial rotation strategies for Beche-de-mer (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 decision rule which prescribes a pause in fishing following instances of heavy fishing (see Low Tier Catch-Based Decision Rule).

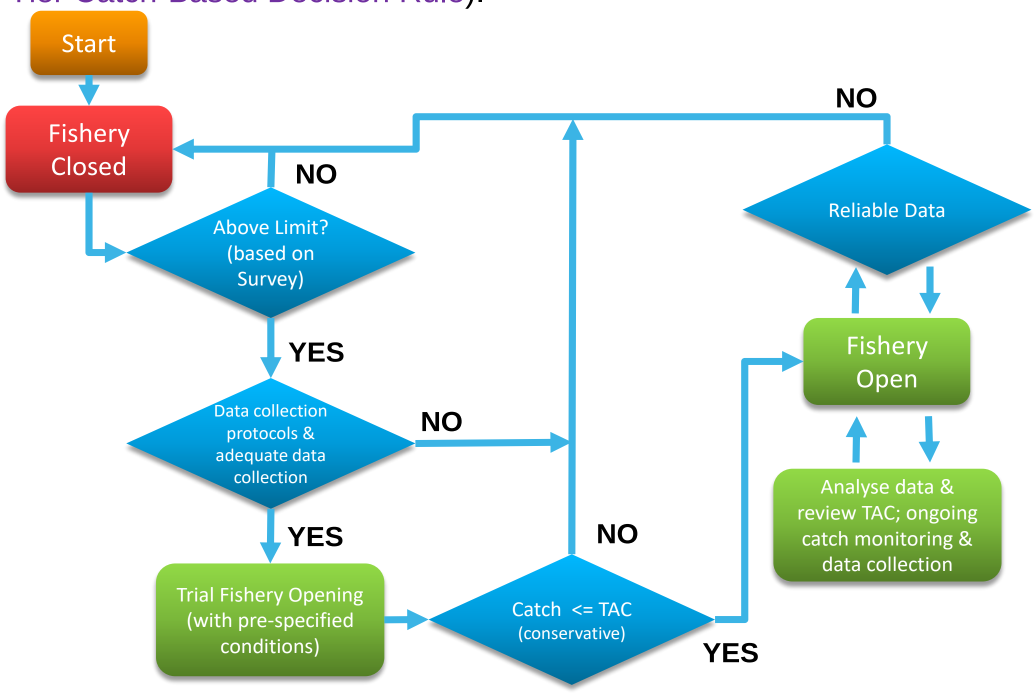


Figure 6. Flowchart summarising process for re-opening a closed fishery

If considering re-opening a closed fishery (Figure 6):

1. Using all available information, first establish that the stock is above a limit reference point level.
    - In the absence of reliable information, this may require conducting a new stock survey and comparing the biomass results with the limit reference point (see High Tier Decision Rules).
    - Only proceed to the next step in potential opening if the survey or available information suggests the stock is above a limit reference point.
2. Evaluate 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.
3. If the above conditions are met, then a trial opening is possible with the following conditions attached:
    - Accurate daily catch and effort reporting is required
    - A precautionary 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 trial TAC to allow all catch reported data to be entered and processed.
    - Further conditions may also be considered, including limitations on which species can be harvested in conjunction with a re-opened species, or with a particular gear (e.g. hookah).
    - Trial opening dates should be considered in relation to seasonal fishing dates. For example, industry have advised that the opening of a high value species such as black teatfish should preferably occur during the same time that the TRL fishery is open to hookah fishing to reduce pressure on the BDM stocks This may also account for equity considerations for fishers dedicated to working in eastern areas where the BDM 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.
4. The Trial opening TAC needs to be set at a demonstrably conservative level with reference to values as shown in Table 3.
5. If the Trial TAC is exceeded by more than 5%, then the fishery is automatically paused (i.e. no fishing allowed) for the following year.
6. If data collection during the Trial opening was not conducted satisfactorily, then the fishery is closed again and the re-opening decision rule process can commence again.
7. 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.
8. 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 Rule).

3 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.

4 Review

Under certain circumstances, it may be necessary to amend the harvest strategy. For example if:

- there is new information that substantially changes the status of a fishery, leading to improved estimates of indicators relative to reference points; or
- drivers external to management of the fishery increase the risk to BDM stock/s; or
- it is clear the strategy is not working effectively and the intent of the HSP is not being met; or
- alternative techniques are developed (or a more expensive but potentially more cost-effective harvest strategy that includes surveys and annual assessments is agreed) for assessing the Fishery. The HS may be amended to incorporate decision rules appropriate for those assessments.

5 References

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Appendix A.1 – Conversion Ratios

Table 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*	-	-	-	-	-	-	-	-

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
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 chloronotus*	-	-	-	-	-	-	-	-
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]

References – Table 4

[1]Ngaluafe, P. & Lee, J. 2013. Change in weight of sea cucumbers during processing: Ten common commercial species in Tonga. SPC Beche-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 beche-de-mer: Filling gaps for some exploited tropical species. SPC Beche-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 beche-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.

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 A.2 – Size limit information

Table 5. Size limits

Common name	Species	Maximum length cm (guide)	Size at maturity cm	Size limit TS	Proposed size limit TS*	Size limit East Coast	Age at maturity TS yrs (size, cm) (model)	TAC Torres Strait (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)*	*No take*
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	Leave	*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*	*15*[1] *(5t trigger)*	*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 chloronotus*	*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 (TS BDM 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 A.3 – Sea cucumber Spawning Information

Table 6. 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**

Common name	Species	Spawning time	Country
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 chloronotus*	*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 A.4 – Average density from surveys

Table 7. Average density (per ha) of sea cucumbers from surveys. Densities were sampled at 122 repeated sample sites in eastern Torres Strait during the 2002 and 2005 abundance surveys (from 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**
H. whitmaei	Black teatfish	4.00	3.08	**-22.8**
H. fuscogilva	White teatfish	5.43	3.57	**-34.1**
T. ananas	Prickly redfish	8.61	8.09	**-6.0**
A. 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**
B. graeffei	Flowerfish	3.59	3.72	**3.8**
B. argus	Leopardfish	12.91	11.32	**-12.3**
S. 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	Black tarzan	1.54	2.56	**66.7**

Appendix A.5 – Industry proposed closures

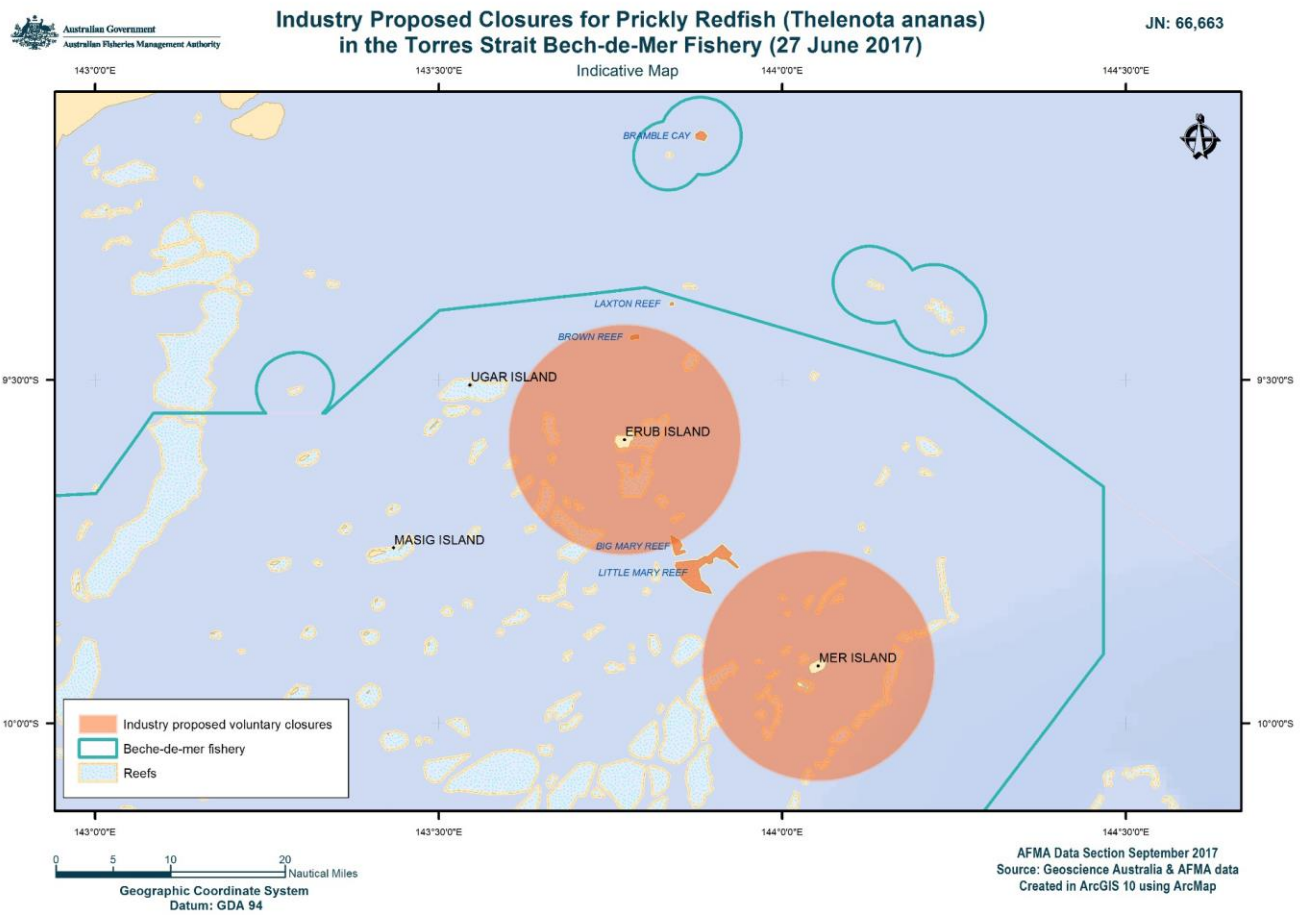

Figure 7. Industry proposed closures for Prickly Redfish (*Thelenota ananas*) in the Torres Strait Beche-de-mer Fishery (27 June 2017).

Appendix A.6 – Sandfish historical survey data

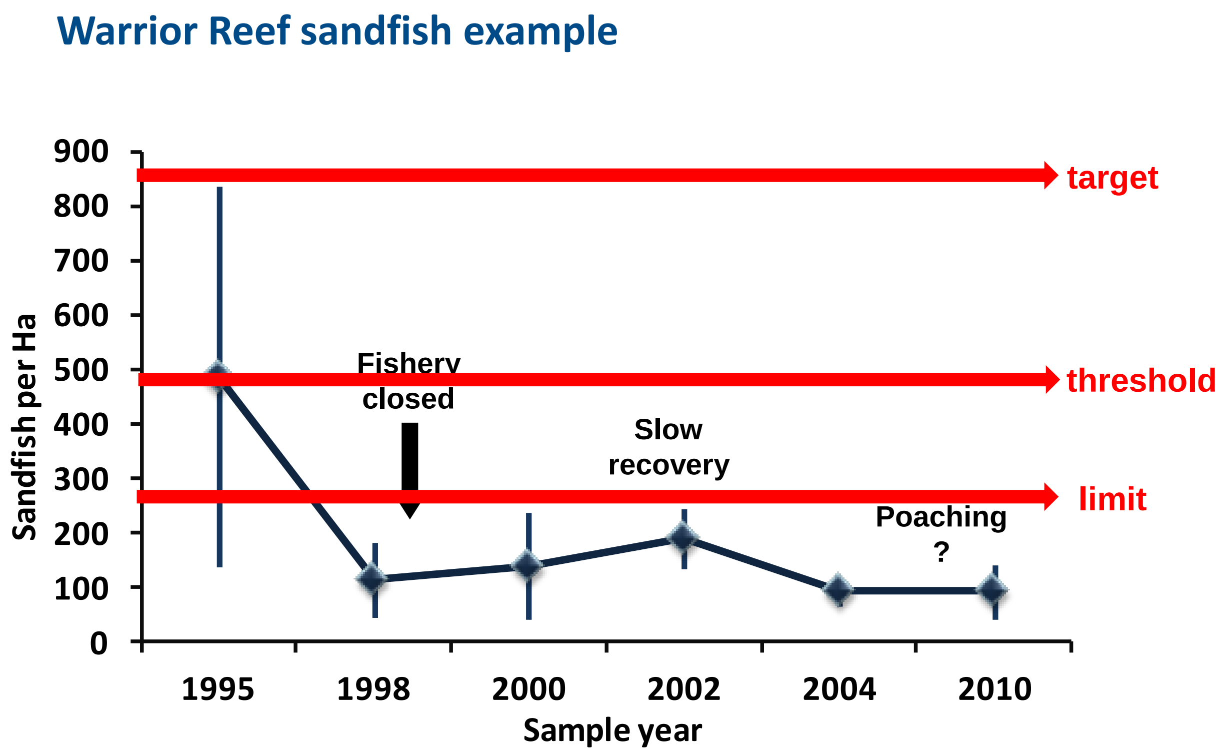

Figure 8. Example using Warrior Reef historical survey data for sandfish and comparison with sandfish density estimates from other locations, to inform choice of a limit reference point (below which the fishery should be closed), a threshold reference point (which is set higher than the limit reference point and serves as a trigger to re-open a fishery) and a target level that should ideally be aimed for.