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Ecological Risk Assessment for the Effects of Fishing

Report for the Torres Strait Fishery: Bêche-de-mer Fishery 2016-2020

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Report for the Australian Fisheries Management Authority

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Notes to this document:

This fishery ERA Report document contains figures and tables with numbers that correspond to the full methodology document for the ERAEF method:

> Hobday, A. J., A. Smith, H. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, A. Williams, M. Sporcic, J. Dambacher, M. Fuller, T. Walker. (2007). Ecological Risk Assessment for the Effects of Fishing: Methodology. Report R04/1072 for the Australian Fisheries Management Authority, Canberra

Thus, table and figure numbers within the fishery ERA Report document are not sequential as not all are relevant to the fishery ERA Report results.

Additional details on the rationale and the background to the methods development are contained in the ERAEF Final Report:

> Smith, A., A. Hobday, H. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, A. Williams, M. Sporcic, J. Dambacher, M. Fuller, D. Furlani, T. Walker. (2007). Ecological Risk Assessment for the Effects of Fishing: Final Report R04/1072 for the Australian Fisheries Management Authority, Canberra.

This document also reflects some changes in methods that are detailed in AFMA's ERA guide (2017).

> Australian Fisheries Management Authority (2017). Guide to AFMA's Ecological Risk Management. 130 pp. (Commonwealth of Australia, Canberra).

Contents

Figures

Tables

Acknowledgments

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Executive summary

The “Ecological Risk Assessment for Effect of Fishing” ERAEF was developed jointly by CSIRO and the Australian Fisheries Management Authority [1, 2]. This assessment of the ecological impacts of the Torres Strait Bêche-de-mer Fishery was undertaken using the ERAEF method version 9.2, with some additional modifications currently in final stages of development with AFMA [3]. This revised ERAEF provides a hierarchical framework for a comprehensive assessment of the ecological risks arising from fishing, with impacts assessed against five new ecological components –key commercial and secondary commercial species; byproduct and bycatch species; protected species; habitats; and (ecological) communities [3].

ERAEF proceeds through four stages of analysis: scoping; an expert judgement-based Level 1 analysis (SICA – Scale Intensity Consequence Analysis); an empirically based Level 2 analysis (PSA – Productivity Susceptibility Analysis); and a model-based Level 3 analysis. This hierarchical approach provides a cost-efficient way of screening hazards, with increasing time and attention paid only to those hazards that are not eliminated at lower levels in the analysis. Risk management responses may be identified at any level in the analysis.

Application of the ERAEF methods to a fishery represents a set of screening or prioritization steps that work towards a full quantitative ecological risk assessment. At the start of the process, all components are assumed to be at risk. Each step, or Level, potentially screens out issues that are of low concern. The Scoping stage screens out activities that do not occur in the specific fishery. Level 1 screens out activities that are judged to have low impact, and potentially screens out components with all low impact scores. Level 2 is a screening or prioritization process for individual species, habitats and communities at risk from direct impacts of fishing, using either PSA or the Sustainability Assessment for Fishing Effect (SAFE) methods. The Level 2 methods do not provide absolute measures of risk. Instead, they combine information on productivity and exposure to fishing to assess potential risk – the term used at Level 2 is risk. Because of the precautionary approach to uncertainty, there will be more false positives than false negatives at Level 2, and the list of high-risk species or habitats should not be interpreted as all being at high risk from fishing. Level 2 is a screening process to identify species or habitats that require further investigation. Some of these may require only a little further investigation to identify them as a false positive; for some of them managers and industry may decide to implement a management response; others will require further analysis using Level 3 methods, which do assess absolute levels of risk.

This 2016-2020 assessment of the Torres Strait Bêche-de-mer Fishery (TSBDMF) consists of the following:

- Scoping
- Level 1 results for the Key/Secondary commercial species, Habitat and Community components

Fishery Description

Method:	Hand collectable
Area:	16,844 km^2
Depth range:	0-10 m
Fleet size:	40 (2019) and 30 (2020) active vessels
Effort:	Traditional Inhabitant Boat (TIB) licence holders reporting catch: 40 (2019)
Landings:	36 t (2019); 32 t (2020)
Discard rate:	2.7% (1 t of Curryfish had spoiled; discarded in 2018)
Commercial species (ERA classification):	15
Management:	Competitive total allowable catches (TACs).
Observer program:	There is no Observer program currently for the Torres Strait Bêche-de-mer Fishery.

Ecological Units Assessed

Table ES1.1. Ecological units assessed in 2021.

ECOLOGICAL COMPONENT	2021
Key/secondary commercial species	2 key; 13 secondary
Byproduct and bycatch species	0 byproduct; 0 bycatch
Protected species	0
Habitats	4 demersal, 1 pelagic
Communities	5 demersal, 2 pelagic

A total of 15 species across the three ecological components were assessed in this ERAEF (Table ES1.1).

Level 1 Results and Summary

All ecological components were eliminated at Level 1 (i.e. no components with risk scores of 3 – moderate – or above). Fishing for sea cucumbers is very selective as they are harvested by hand and no by-catch or by products result from fishing. The direct ecological impact on the benthos from harvesting these species is low. Also, no interaction with Protected species have been reported. As a result, the 'Bycatch, byproduct', and 'Protected species' ecological components were not assessed.

All hazards (fishing activities and external) were considered as low risk and eliminated at Level 1 (i.e. no components with risk scores of 3 – moderate – or above). The highest risk scores (2 (minor); with high confidence level) were reported as a result of direct capture on key/secondary species, habitats and communities.

As a result of direct capture, the most vulnerable commercial species was the Prickly redfish (*Thelenota ananas*) as it is the mostly caught species (AFMA catch disposal record) and was assessed as minor risk as the 2019 survey estimates suggest that current catch limits are sustainable [4], and the CPUE trend is increasing (noting the low sample size).

The impact of fishing represented a minor risk to habitats largely due to the effort along shallow reef top and forereef zones fishing for sea cucumbers (secondary species) involves walking/trampling and diving on coral reefs, which may affect species directly and also break or damage benthic communities and coral reef structures.

Although still considered a 'low risk' hazard, coastal development was the highest scored risk (risk score = 2) to key/secondary species, habitats and communities because of localised pollution in some Islands and sediment runoff from coastal developments in the Fly river (PNG). Sediments can smother sessiles species like corals and increased turbidity and reduction in light penetration can negatively affect species that depend on light, such as corals, algae and seagrasses. Confidence is low because impacts from Fly river are still poorly understood and there is a lack of data on water quality issues and recovery times of species and habitats. All of the assessed direct and indirect impacts to the TSBDMF were either low or negligible based on scale and nature of the fishery as well as available survey data.

Table ES1.2. Outcomes of assessments for ecological components conducted in 2021.

ECOLOGICAL COMPONENT	2021
Key/secondary commercial species	Level 1
Byproduct and bycatch species	Not required*
Protected species	Not required*
Habitats	Level 1
Communities	Level 1

*: there are no byproduct, bycatch or protected species in this fishery

Table ES1.3. Key and secondary commercial species stock status, assessment and tier status, and ERA classification for Torres Strait bêche-de-mer Fishery. NSTOF: Not subject to overfishing; NOF: Not overfished; OF: Overfished; UNC: uncertain. Primary: C1; Secondary: C2. ^: based on ABARES classification. ^^ based on stock assessment.

COMMON NAME	SPECIES NAME	ERA CLASSIFICATION	BIOMASS^	REFERENCES	YEAR LAST ASSESSED
Prickly redfish	*Thelenota ananas*	Key	NSTOF / NOF	[4-7]	2009
Curryfish Herrmanni or Common	*Stichopus herrmanni*	Key	UNC[1]	[4, 7]	
White Teatfish	*Holothuria (Microthele) fuscogilva*	Secondary	NSTOF / NOF	[4-7]	2009
Deepwater redfish	*Actinopyga echinites*	Secondary	UNC. Status still remains relatively unknown	[4, 5, 7]	2009
Elephant's Trunkfish	*Holothuria (Microthele) fuscopunctata*	Secondary	UNC. Status still remains relatively unknown	[4, 7]	
Stonefish	*Actinopyga lecanora*	Secondary	UNC. Status still remains relatively unknown	[4, 7]	
Greenflsh	*Stichopus chloronotus*	Secondary	NSTO / NOF.	[4, 7]	
Blackfish - AKA Hairy blackfish	*Actinopyga miliaris*	Secondary	UNC. Status still remains relatively unknown	[4-7]	2009
Lollyfish	*Holothuria (Halodeima) atra*	Secondary	NSTO /NOF	[4, 7]	
Burrowing Blackfish	*Actinopyga spinea*	Secondary	UNC. Status remains relatively unknown	[4, 7]	
Brown Sandfish	*Bohadschia vitiensis*	Secondary	UNC. Status still remains relatively unknown.	[4, 7]	
Golden Sandfish	*Holothuria (Metriatyla) lessoni*	Secondary	UNC. Status still remains relatively unknown	[4, 7]	
Curryfish Vastus	*Stichopus vastus*	Secondary	UNC[1]	[4, 7]	
Leopardfish	*Bohadschia argus*	Secondary	NSTO / NOF	[4, 7]	
Deepwater Blackfish	*Actinopyga palauensis*	Secondary	UNC. Status still remains relatively unknown	[4, 7]	

[1] 2019/20 survey results indicate combined Curryfish (*Stichopus herrmanni;* Curryfish common and *S. vastus*; Curryfish vastus) CPUE trend shows an initial decline which is expected as these species are being harvested from pristine levels and therefore such initial increase in CPUE is not of concern (HCRAG meeting on 6-7 October 2021;[4])

1 Overview

1.1 Ecological Risk Assessment for the Effects of Fishing (ERAEF) Framework

1.1.1 The Hierarchical Approach

The Ecological Risk Assessment for the Effects of Fishing (ERAEF) framework involves a hierarchical approach that moves from a comprehensive but largely qualitative analysis of risk at Level 1, through a more focused and semi-quantitative approach at Level 2, to a highly focused and fully quantitative “model-based” approach at Level 3 (Figure 1.1). This approach is efficient because many potential risks are screened out at Level 1, so that the more intensive and quantitative analyses at Level 2 (and ultimately at Level 3) are limited to a subset of the higher risk activities associated with fishing. It also leads to rapid identification of high-risk activities, which in turn can lead to immediate remedial action (risk management response). The ERAEF approach is also precautionary, in the sense that risks will be scored high in the absence of information, evidence or logical argument to the contrary.

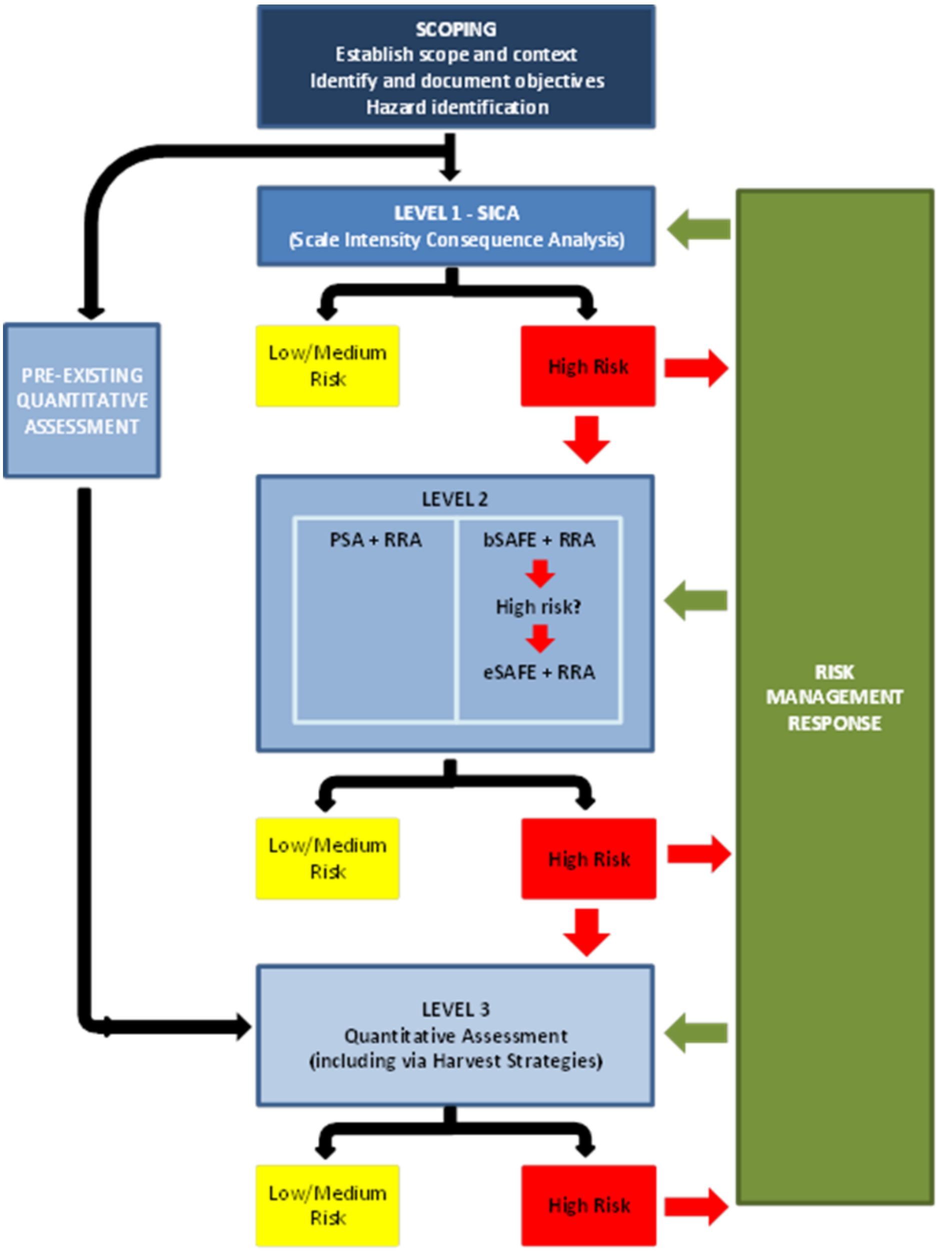


Figure 1.1. Structure of the 3 level hierarchical ERAEF methodology. SICA – Scale Intensity Consequence Analysis; PSA – Productivity Susceptibility Analysis; SAFE – Sustainability Assessment for Fishing Effects; RRA – Residual Risk Analysis. T1 – Tier 1. eSAFE may be used for species classified as high risk by bSAFE.

Conceptual Model

The approach makes use of a general conceptual model of how fishing impacts on ecological systems, which is used as the basis for the risk assessment evaluations at each level of analysis (Levels 1-3). For the ERAEF approach, five general ecological components are evaluated, corresponding to five areas of focus in evaluating impacts of fishing for strategic assessment under EPBC legislation. The five revised *components* are:

- Key commercial species and secondary commercial species

- Byproduct and bycatch species
- protected[2] species (formerly referred to as threatened, endangered and Protected[3] species or TEPs)
- Habitats
- Ecological communities

This conceptual model (Figure 1.2) progresses from *fishery characteristics* of the fishery or sub-fishery, → *fishing activities* associated with fishing and *external activities*, which may impact the five ecological components (target, byproduct and bycatch species, protected species, habitats, and communities); → *effects of fishing and external activities* which are the direct impacts of fishing and external activities; → *natural processes and resources* that are affected by the impacts of fishing and external activities; → *sub-components* which are affected by impacts to natural processes and resources; → *components*, which are affected by impacts to the sub-components. Impacts to the sub-components and components in turn affect achievement of management objectives.

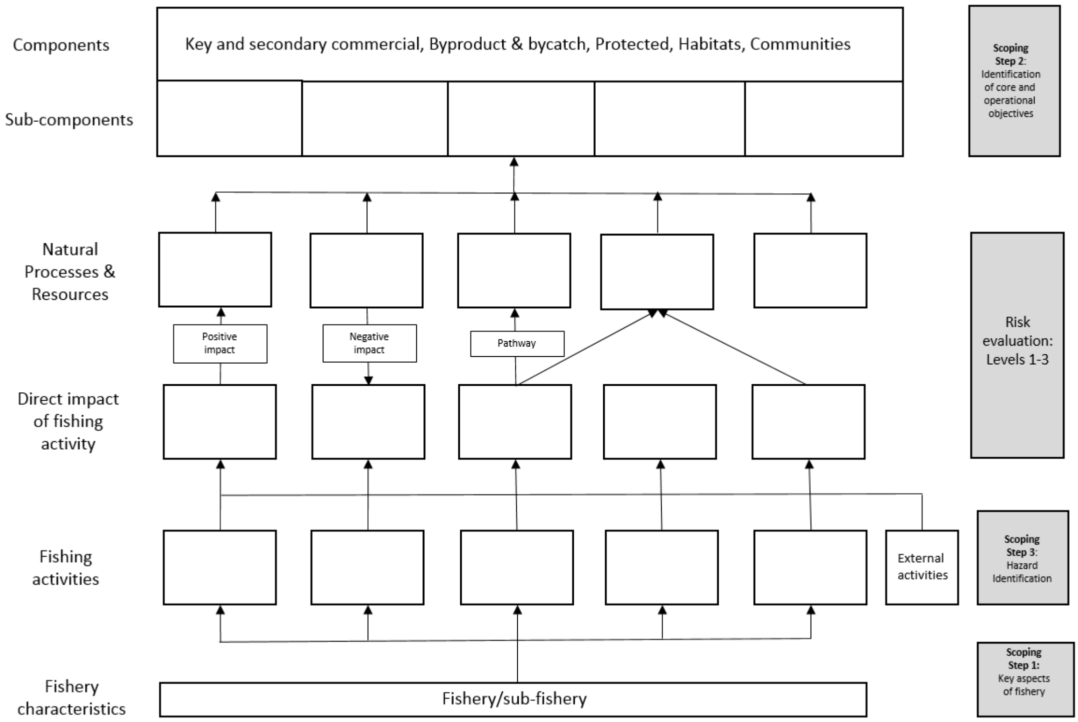


Figure 1.2. Generic conceptual model used in ERAEF.

[1] The term "protected species" refers to species listed under [Part 13] of the EPBC Act (1999) and replaces the term "Threatened, endangered and protected species (TEPs)" commonly used in past Commonwealth (including AFMA) documents.

[2] Note "protected" (with small "p") refers to all species covered by the EPBC Act (1999) while "Protected" (capital P) refers only to those protected species that are threatened (vulnerable, endangered or critically endangered).

The external activities that may impact the fishery objectives are also identified at the Scoping stage and evaluated at Level 1. This provides information on the additional impacts on the ecological components being evaluated, even though management of the external activities is outside the scope of management for that fishery.

The assessment of risk at each level takes into account current management strategies and arrangements. A crucial process in the risk assessment framework is to document the rationale behind assessments and decisions at each step in the analysis. The decision to proceed to subsequent levels depends on

- Estimated risk at the previous level
- Availability of data to proceed to the next level
- Management response (e.g. if the risk is high but immediate changes to management regulations or fishing practices will reduce the risk, then analysis at the next level may be unnecessary).

1.1.2 ERAEF stakeholder engagement process

A recognized part of conventional risk assessment is the inclusion of stakeholders involved in the activities being assessed. Stakeholders can make an important contribution by providing expert judgment, fishery-specific and ecological knowledge, and process and outcome ownership. The ERAEF method also relies on stakeholder involvement at each stage in the process, as outlined below. All stakeholder interactions are recorded in the process. This ERA will be presented and discussed with stakeholders as part of Hand Collectables Resource Assessment Group meeting to be held in Thursday Island 21-23 July 2021. Input from HCRAG will be incorporated to the ERA after the meeting.

1.1.3 Scoping

In the first instance, scoping is based on review of existing documents and information, with much of it collected and completed to a draft stage prior to full stakeholder involvement. This provides all the stakeholders with information on the relevant background issues. Three key outputs are produced from the scoping exercise, each requiring stakeholder input.

1. <u>Identification of units of analysis</u> (species, habitats and communities) potentially impacted by fishery activities (Section 2.2.2; Scoping Documents S2A, S2B1, S2B2 and S2C1, S2C2).
2. <u>Selection of objectives</u> (Section 2.2.3; Scoping Document S3). The primary objective to be pursued for species assessed under ERAEF is that of ensuring populations are maintained at biomass levels above which recruitment failure is likely, as stated in Chapter 2 (ERM Guide [3]). This is consistent with current legislation and fisheries policies and represents a change from when the ERAEF was first developed and there was less policy or legislation-based guidance on sustainability objectives, with stakeholders able to choose from a range of “sustainability” objectives (e.g.: tables 5A-C in [1]).

3. Selection of activities (hazards) (Section 2.2.4; Scoping Document S4) that occur in the sub-fishery is made using a checklist of potential activities provided. The checklist was developed following extensive review, and allows repeatability between fisheries. Additional activities raised by the stakeholders can be included in this checklist (and would feed back into the original checklist). The background information and consultation with the stakeholders is used to finalize the set of activities. Many activities will be self-evident (e.g. fishing, which obviously occurs), but for others, expert or anecdotal evidence may be required.

1.1.4 Level 1. SICA (Scale, Intensity, Consequence Analysis)

The SICA analysis evaluates the risk to ecological components resulting from the stakeholder-agreed set of activities. Evaluation of the temporal and spatial scale, intensity, sub-component, unit of analysis, and credible scenario (consequence for a sub-component) should be prepared by the draft fishery ERAEF report author and reviewed at an appropriate stakeholder meeting (e.g. Resource Assessment Group meeting). Due to the number of activities (up to 24) in each of five components (resulting in up to 120 SICA elements), preparation before involving the full set of stakeholders may allow time and attention to be focused on the uncertain or controversial or high-risk elements. Documenting the rationale for each SICA element ahead of time for the straw-man scenarios is crucial to allow the workshop debate to focus on the right portions of the logical progression that resulted in the consequence score.

SICA elements are scored on a scale of 1 to 6 (negligible to extreme) using a "plausible worst case" approach (see ERAEF Methods Document for details [1, 8]). Level 1 analysis potentially result in the elimination of activities (hazards) and in some cases whole components. Any SICA element that scores 2 or less is documented, but not considered further for analysis or management response.

1.1.5 Level 2. PSA and SAFE (semi-quantitative and quantitative methods)

When the risk of an activity at Level 1 (SICA) on a species component is moderate or higher and no planned management interventions that would remove this risk are identified, an assessment is required at Level 2 (to determine if the risk is real and provide further information on the risk). The tools used to assess risk at Level 2 allow units (e.g. all individual species) within any of the ecological species components (e.g. key/secondary commercial, byproduct/bycatch, and protected species) to be effectively and comprehensively screened for risk. The analysis units are identified at the scoping stage. To date, Level 2 tools have been designed to measure risk from direct impacts of fishing only (i.e. risk of overfishing, leading to an overfished fishery), which in all assessments to date have been the hazard with the greatest risks identified at Level 1[4].

In the period since the first ERAEF was implemented across Commonwealth fisheries, much of the management focus has been on the assessment results associated with Level 2 and Level

[4] Future iterations of the methodology will include PSAs modified to measure the risk due to other activities, such as gear loss.

2.5 or 3 risk assessment methods, which comprise semi-quantitative or rapid simple quantitative methods (e.g. PSA and SAFE). This level has been subject to the greatest level of change and improvement which are discussed in the following sections. Additional improvements are being developed for implementation in the near future (see Chapter 4.13 of AFMA ERM Guide in [3]).

Level 2 was originally designed to rely on a single risk assessment methodology, the Productivity-Susceptibility Analysis (PSA) (see Chapter 4.8.3 of AFMA ERM Guide in [3]), however a more quantitative method called the Sustainability Assessment for Fishing Effects (SAFE) (see Chapter 4.8.4 of AFMA ERM Guide in [3]) was developed early in the implementation of the ERAEF and classed as a Level 2.5 or Level 3 tool.

Under the revised ERAEF:

- bSAFE has now been reclassified as the preferred Level 2 method (over PSA) where sufficient spatial and biological data (to support bSAFE) are available. Typically, this has been used for teleost and chondricthyan species.
- Species estimated to be at high risk under bSAFE may then be assessed under eSAFE which may provide reduced estimates of uncertainty pertaining to the actual risk.
- Where either the data or species biological characteristics are insufficient to support bSAFE analyses, it is recommended that PSA be applied instead. This will be the case for many protected species, invertebrate bycatch species and some other species.
- At Level 2, either PSA or SAFE methods should be applied to any given species, not both.
- For high risk species it is a management choice whether to progress to eSAFE, pursue a Level 3 fully quantitative stock assessment, or to take more immediate management action to reduce the risk. The types of considerations required in making that choice (ie: moving up the ERAEF assessment hierarchy or taking direct management action) are outlined in Chapter 5.5 of the AFMA ERM Guide [3].

It is also recognised that a number of additional tools, including some of the “data poor” assessment tools that are used to inform harvest strategies, could potentially be included within the Level 2 toolkit. They are distinguished from Level 3 quantitative tools (i.e. stock assessment models) that are more data rich and able to more precisely quantify uncertainty.

PSA (Productivity Susceptibility Analysis)

Details of the PSA method are described in the accompanying ERAEF Methods Document and also summarised in Section 4.8.3 of the AFMA ERM Guide [3]. Stakeholders can provide input and suggestions on appropriate attributes, including novel ones, for evaluating risk in the specific fishery. Attribute values for many of the units (e.g. age at maturity, depth range, mean trophic level) can be obtained from published literature and other resources (e.g. scientific experts) without initial stakeholder involvement. Stakeholder input is required after preliminary attribute values are obtained. In particular, where information is missing, expert opinion can be used to derive the most “reasonable” conservative estimate. For example, if species attribute values for annual fecundity have been categorized as low, medium or high on the set (<5, 5-500, >500), estimates for species with no data can still be made. Also, estimated fecundity of a broadcast-spawning fish species with unknown fecundity is still likely to be greater than the high fecundity category (>500). Susceptibility attribute estimates, such as “fraction alive when landed”, can also be made based on input from experts such as scientific observers. Feedback to stakeholders regarding comments received during the preliminary PSA consultations is considered crucial. The final PSA is completed by scientists and results are presented to the relevant stakeholder group (e.g. RAG and/or MAC) before decisions regarding Level 3 analysis are considered. The stakeholder group may also decide on priorities for analysis at Level 3.

Residual Risk Analysis

There were several limitations due to the semi-quantitative nature of a Level 2 PSA assessment. For example, certain management arrangements which mitigate the risks posed by a fishery, as well as additional information concerning levels of direct mortality, may not be easily taken into account in assessments. To overcome this, Residual risk analyses (RRA) are used to consider additional information, particularly mitigating effects of management arrangements that were not explicitly included in the ERAs or introduced after the ERA process commenced. Priority for this process has typically been focused on those species attributed a high-risk rating (those likely to be most at risk from fishing activities). It could in theory be used to also determine if some species have been incorrectly classified as low risk.

Recently revised Residual risk guidelines have been developed (see below) to assist in making accurate judgments of residual risk consistently across all fisheries. At the moment, they are applied to species and not applicable to habitats or communities.

These guidelines are not seen as a definitive guide on the determination of residual risk and it is expected they may not apply in a small number of cases. Care must also be taken when applying them to ensure residual risk results are appropriate in a practical sense. There are a number of conditions which underpin the residual risk guidelines and should be understood before the guidelines are applied:

- All assessments and management measures used within the residual risk assessment must be implemented prior to the assessment with sufficient data to demonstrate the effect. Any planned or proposed measures can be referred to in the assessment but cannot be used to revise the risk score.
- When applied, the guidelines generally result in changes to particular "attribute" scores for a particular species. Only after all of the guidelines have been applied to a particular species, should the overall risk category be re-calculated. This will ensure consistency, as well as facilitating the application of multiple guidelines.
- Unless there is clear and substantiated information to support applying an individual guideline, then the attribute and residual risk score should remain unchanged. All supporting information considered in applying these Guidelines must be clearly documented and referenced where applicable. This is consistent with the precautionary approach applied in ERAs, with residual risk remaining high unless there is evidence to the contrary ensuring a transparent process is applied.

The results (including supporting information and justifications) from residual risk analyses must be documented in “Residual Risk Reports” for each fishery (or can be integrated into the Level 2 risk assessment report). These will be publically available documents.

SAFE (Sustainability Assessment for Fishing Effects)

The SAFE method developed is split into two categories: base SAFE (bSAFE) and an enhanced SAFE (eSAFE). eSAFE has greater data processing requirements and is recommended to only be used to assess species estimated to be at high risk via the bSAFE. It is also able to more appropriately model spatial availability aspects when sufficient data are available.

bSAFE

Relative to the PSA approach, the bSAFE approach [9, 10] (Zhou and Griffiths, 2008; Zhou et al. 2011):

- is a more quantitative approach (analogous to stock assessment) that is able to provide absolute measures of risk by estimating fishing mortality rates relative to fishing mortality rate reference points (based on life history parameters),
- requires less productivity data than the PSA,
- is able to account for cumulative risk and
- potentially out performs PSA in several areas, including strength of relationship to Tier 1 assessment classifications [11].

Like PSA, the bSAFE method is a transparent, relatively rapid and cost effective process for screening large numbers of species for risk, and is far less demanding of data and much simpler to apply than a typical quantitative stock assessment.

As such it is recommended that bSAFE be used as the preferred Level 2 assessment tool for all fish species and some invertebrates and reptiles (eg: some sea snakes) with sufficient data.

In estimating fishing mortality, bSAFE utilises much of the same information as the PSA, to estimate:

- Spatial overlap between species distribution and fishing effort distribution,
- Catchability resulting from the probability of encountering the gear and size-dependent selectivity and
- Post-capture mortality.

The fishing mortality is essentially the fraction of overlap between fished area and the species distribution area within the jurisdiction, adjusted by catchability and post-capture mortality. Uncertainty around the estimated fishing mortality is estimated by including variances in encounterability, selectivity, survival rate and fishing effort between years.

The three biological reference points are based on a simple surplus production model:

- **F_{MSY}** – instantaneous fishing mortality rate that corresponds to the maximum number of fish in the population that can be killed by fishing in the long term. The latter is the maximum sustainable fishing mortality (MSM) at B_{MSM}, similar to target species MSY.

- **F_{LIM}** – instantaneous fishing mortality rate that corresponds to the limit biomass B_{LIM} where B_{LIM} is a assumed to be half of the biomass that supports a maximum sustainable fishing mortality ($0.5B_{MSM}$)
- **F_{CRASH}** – minimum unsustainable instantaneous fishing mortality rate that, in theory, will lead to population extinction in the long term.

This methodology produces quantified indicators of performance against fishing mortality based reference points and as such does allow calibration with other stock assessment and risk assessment tools that measure fishing mortality. It allows the risk of overfishing to be determined, via the score relative to the reference line. Uncertainty (error bars) are related to the variation in the estimation of the scores for each axis.

It is recommended that species assessed as being potentially at high risk under bSAFE are then progressed to analysis by eSAFE which is able to narrow uncertainties around the risk (but is more time and resource intensive than bSAFE).

Assumptions and issues to be aware of:

- Comparisons of PSA and SAFE analyses for the same fisheries and species support the claim that the PSA method generally avoids false negatives but can result in many false positives. Limited testing of SAFE results against full quantitative stock assessments suggest that there is less "bias" in the method, but that both false negatives and false positives can arise.
- SAFE analyses retain some of the key precautionary elements of the PSA method, including assumptions that fisheries are impacting local stocks (within the jurisdictional area of the fishery).
- Although the bSAFE analyses provide direct estimates of uncertainty in both the exploitation rate and associated reference points, they are less explicit about uncertainties arising from key assumptions in the method, including spatial distribution and movement of stocks.
- The method assumes there would be no local depletion effects from repeat trawls at the same location (ie: populations rapidly mix between fished and unfished areas). The fishing mortality will likely be overestimated if this assumption is not satisfied (ERA TWG 2015)[5].
- The method also assumes that the mean fish density does not vary between fished area and non-fished area within their distributional range. Hence, the level of risk would be over-estimated for species found primarily in non-fished habitat, while risk would be under-estimated for species that prefer fished habitat (ERA TWG 2015).
- The SAFE methodology makes greater assumptions than Tier 1 stock assessments in coming to its F estimates (due to a lack of the data relative to that used in a Tier 1 assessment) and it is not capable of measuring risk of a stock being already overfished (so the type of risk it measures relates only to overfishing, which may then lead to

[5] ERA Technical Working Group, September 2015

future overfished state). The limitations of SAFE with respect to measuring overfished risks are the same essentially as for PSA.

eSAFE

Enhanced SAFE (eSAFE) appears, based on calibration with Level 3 assessments, to provide improved estimates of fishing mortality relative to the base SAFE (bSAFE) method. The eSAFE requires more spatially explicit data and takes more analysis time than bSAFE, and so might only be used to further assess species that were identified as at high risk using bSAFE (and which have not had further direct management action taken). The eSAFE enhances the bSAFE method by estimating varying fish density across their distribution range as well as species- and gear-specific catch efficiency for each species.

1.1.6 Level 3

This stage of the risk assessment is fully-quantitative and relies on in-depth scientific studies on the units identified as at medium or greater risk in the Level 2. It will be both time and data-intensive. Individual stakeholders are engaged as required in a more intensive and directed fashion. Results are presented to the stakeholder group and feedback incorporated, but live modification is not considered likely.

1.1.7 Conclusion and final risk assessment report

The results presented in this document are based on desktop review and inputs from AFMA according to the ERAEF methods. These results are preliminary as yet to be considered by stakheolders during Hand Collectables RAG 6-7 October 2021. It is envisaged that the completed assessment will be finalised after adequate stakeholder consultation process, which involves presentation to and inputs from HCRAG. It is expected that the final risk assessment report will be adopted by the fishery management group and used by AFMA for a range of management purposes, including to address the requirements of the Wildlife Trade Operation approval for the fishery under the EPBC Act as evaluated by Department of Agriculture, Water and the Environment.

1.1.8 Subsequent risk assessment iterations for a fishery

The frequency at which each fishery must revise and update the risk assessment is not fully prescribed. As new information arises or management changes occur, the risks can be re-evaluated, and documented as before. The fishery management group or AFMA may take ownership of this process, or scientific consultants may be engaged. In any case the ERAEF should again be based on the input of the full set of stakeholders and reviewed by independent experts familiar with the process.

Fishery re-assessments for byproduct and bycatch species under the ERAEF will be undertaken every five years[6] or sooner if triggered by re-assessment triggers. The five-year timeframe is based on a number of factors including:

- The time it takes to implement risk management measures; for populations to respond to those measures to a degree detectable by monitoring processes; and to collect sufficient data to determine the effectiveness of those measures.
- Alignment with other management and accreditation processes.
- The cost of re-assessments.
- The review period for Fisheries Management Strategy (FMS).

For byproduct and bycatch species, in the periods between scheduled five-year ERA reviews[7], AFMA will develop and monitor a set of fishery indicators and triggers, on an annual basis, so as to detect any changes (increase or decrease) in the level of risk posed by the fishery to any species. Where indicators exceed specified trigger levels, AFMA will investigate the causes and provide opportunity for RAG to comment and advice during that process. Pending outcomes of that review, and RAG advice, AFMA can, if necessary, request a species specific or full fishery re-assessment (i.e. prior to the scheduled re-assessment dates).

The ERA Technical Working Group (TWG) (September 2015)[5] identified five key indicators upon which such triggers could be based, these being changes in:

- Gear type/use
- Mitigation measures (use or type)
- Area fished
- Catch or interaction rate
- Fishing effort

Where possible, the triggers should look to take into account additional sources of risk from interacting with non-Commonwealth fisheries. In addition, if a major management change is planned for a fishery, such as a move from input to output controls, the fishery will need to be reassessed prior to that management change coming into effect. In considering each indicator and trigger level, the RAG should consider the following:

- The data upon which the indicator is based must be sufficiently representative of actual changes in catch, effort, area, gear or mitigation methods. Consideration should be given to the level of uncertainty associated with the data underpinning any prospective indicator.

[6] Based on a recommendation by the ERA Technical Working Group, September 2015.

[7] In contrast to key and secondary commercial species managed via catch/effort limits under Harvest Strategies, which depending on species and Harvest Strategy, can be re-assessed any time between 1 and 5 years.

- The trigger level chosen should not be overly sensitive to the normal inter-annual variance that is typical of the indicator and independent of fishing pressure, assuming such variance is unlikely to relate to a significant change in the risk posed by the fishery to any or all species.
- The trigger level should equate to the minimum level of change that the RAG (by its expert opinion) considers might potentially represent a significant change in the risk posed by the fishery.
- The trigger level could represent an absolute change (number/level) in an indicator or a percentage change in an indicator.
- The RAG should consider whether a "temporal" condition should be placed on the trigger (i.e. the trigger is breached 2 years in a row) to further reduce the likelihood of natural population variance or data errors triggering a re-assessment unnecessarily.

The final set of indicators and triggers will be developed for each fishery by AFMA in consultation with its fishery RAG (or for fisheries lacking a RAG, the ERA TWG), in association with the next planned re-assessment (see Table 8 in AFMA ERM Guide in [3]). A RAG may choose a subset of these indicators and triggers, or include an additional indicator/trigger(s), based on consideration of the availability and reliability of data upon which to base any of the above indicators/triggers, however justification of this must be provided.

Research is currently underway to develop specific guidance for RAG to aid in the selection of appropriate triggers, which will in the meantime be determined using RAG expert opinion. In the longer term it may be possible to refine indicators and triggers using the existing PSA and SAFE methods to test which attributes the end risk scores are most sensitive to (ERA TWG 2015)[8]. The RAG will record both the final set of indicators and triggers chosen, and a justification for those, in the RAG minutes. Once the final set of indicators and triggers is determined for a fishery, they will require implementation within the FMS and a monitoring and review process.

[8] ERA TWG recommendation, September 2015

2 Results

The focus of analysis is the fishery as identified by the responsible management authority. The assessment area is defined by the fishery management jurisdiction within the Australian Fisheries Zone (AFZ). The fishery may also be divided into sub-fisheries on the basis of fishing method and/or spatial coverage. These sub-fisheries should be clearly identified and described during the scoping stage. Portions of the scoping and analysis at Level 1 and beyond are specific to a particular sub-fishery. The fishery is a group of people carrying out certain activities as defined under a management plan. Depending on the jurisdiction, the fishery/sub-fishery may include any combination of commercial, recreational, and/or indigenous fishers.

The results presented below are for the Torres Strait Bêche-de-mer Fishery. A full description of the ERAEF method is provided in the methodology document [1, 2]. This fishery report contains figures and tables with numbers that correspond to this methodology document. Thus, table and figure numbers within this fishery ERAEF report are not sequential, as not all figures and tables are relevant to the fishery risk assessment results.

2.1 Stakeholder Engagement

This TSBDM ERA report considered inputs provided by AFMA and scientists. Engagement and consultation with industry and other stakeholders occurred during the first Hand Collectables RAG held on Thursday Island 6-7 October 2021 (Table 2.1).

Table 2.1. Summary Document SD1. Summary of stakeholder involvement for Torres Strait bêche-de-mer Fishery.

FISHERY ERA REPORT STAGE	TYPE OF STAKEHOLDER INTERACTION	DATE OF STAKEHOLDER INTERACTION	COMPOSITION OF STAKEHOLDER GROUP (NAMES OR ROLES)	SUMMARY OF OUTCOME
Scoping	MS TEAMS meeting, Phone calls and emails	Various	Danait Ghebrezgabhier (AFMA), Selina Stoute (AFMA), E. Plaganyi (CSIRO)	Discussions about catch data, protected species, traditional catches, key/secondary commercial species, fishing methods and areas fished. Black teatfish work in fishery
Draft report	Submitted draft report	25 June 2021	AFMA: Danait Ghebrezgabhier, Selina Stoute, Natalie Couchman	
Draft report	Submitted draft report	30 June 2021	AFMA: Danait Ghebrezgabhier, Selina Stoute, Natalie Couchman	Report submitted incorporating comments from AFMA
Draft report	Submitted draft report	26 July 2021	AFMA: Danait Ghebrezgabhier, Selina Stoute, Natalie Couchman	Report submitted incorporating comments from AFMA
Draft report	Presentation of results at HCRAG meeting	7 October 2021	HCRAG members, participants, observers, scientists, AFMA	Presented overall ERA Level 1 results
Final report	Submitted final report	December 2021	AFMA: Danait Ghebrezgabhier, Selina Stoute	Report submitted incorporating comments from AFMA in Dec. 21.

2.2 Scoping

The aim in the Scoping stage is to develop a profile of the fishery being assessed. This provides information needed at stakeholder meetings and to complete Levels 1 and 2. The focus of analysis is the fishery, which may be divided into sub-fisheries on the basis of fishing method and/or spatial coverage. Scoping involves six steps:

Step 1. Document the general fishery characteristics
Step 2. Generating “unit of analysis” lists (species, habitat types, communities)
Step 3. Selection of objectives
Step 4. Hazard identification
Step 5. Bibliography
Step 6. Decision rules to move to Level 1

2.2.1 General Fishery Characteristics (Step 1).

The information used to complete this step came from a range of documents such as Survey and Assessment Reports, and any other relevant background documents.

Scoping Document S1 General Fishery Characteristics

Fishery Name: Torres Strait Bêche-de-mer Fishery
Assessment date: May 2020
Assessor: AFMA and authors of this report

Table 2.2. General fishery characteristics

GENERAL FISHERY CHARACTERISTICS	
Fishery Name	Torres Strait Bêche-de-mer Fishery
Sub-fisheries	There are no sub-fisheries within this fishery but targeting of certain Sea cucumber species within the fishery is prohibited outside of specific trial openings (e.g. Black teatfish openings in 2014 and 2015). Currently, Black teatfish, Surf redfish and Sandfish have a zero t TAC.
Sub-fisheries assessed	No sea cucumber species in the TSBDMF have previously undergone an ecological risk assessment.
Start date/ history	The Torres Strait Sea Cucumber (Bêche-de-mer) Fishery has a history that dates back to at least the 19th century. In 1916-17 558 tons (567 tonnes) of Bêche-de-mer was exported from Thursday Island with 124 boats registered to collect it. The fishery is now accessed only by Traditional Inhabitants and is wholly commercial and export only). It forms an important source of income for some Torres Strait traditional inhabitants in East Torres Strait, where the Tropical Rock Lobster Fishery is less active.
Geographic extent of fishery	The TSBDMF area covers 16,844 km^2 of Torres Strait, situated at its eastern extreme which includes the Australian side of the Torres Strait Protected Zone east of Warrior Reef. The TSBDMF comprises tidal waters within the Torres Strait Protected Zone (TSPZ) and the area declared under the TSF Act to be ‘outside but near’ the TSPZ for commercial fishing for sea cucumber. For the TSBDMF, the outside but near area extends to waters just south of Prince of Wales Island to the west and to due east of Cape York Peninsula [12]. The area contains about 1,388 km^2 of shallow reefs, which accounts for about 64 % of all the reefs in Torres Strait [4]. The area of the Bêche-de-mer Fishery is the area consisting of:

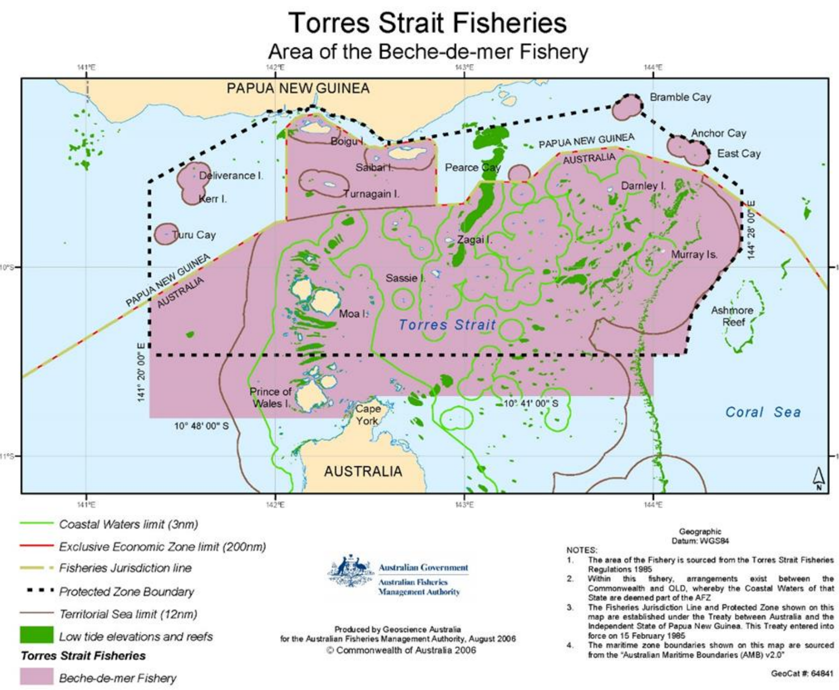
(a) the area of waters in the Protected Zone to the south of the Seabed Jurisdiction Line; and

(b) the area of waters (excluding any waters within the limits of Queensland) bounded by a line beginning at the point of latitude 10° 48’ 00” south, longitude 141° 20’ 00” east and running progressively:

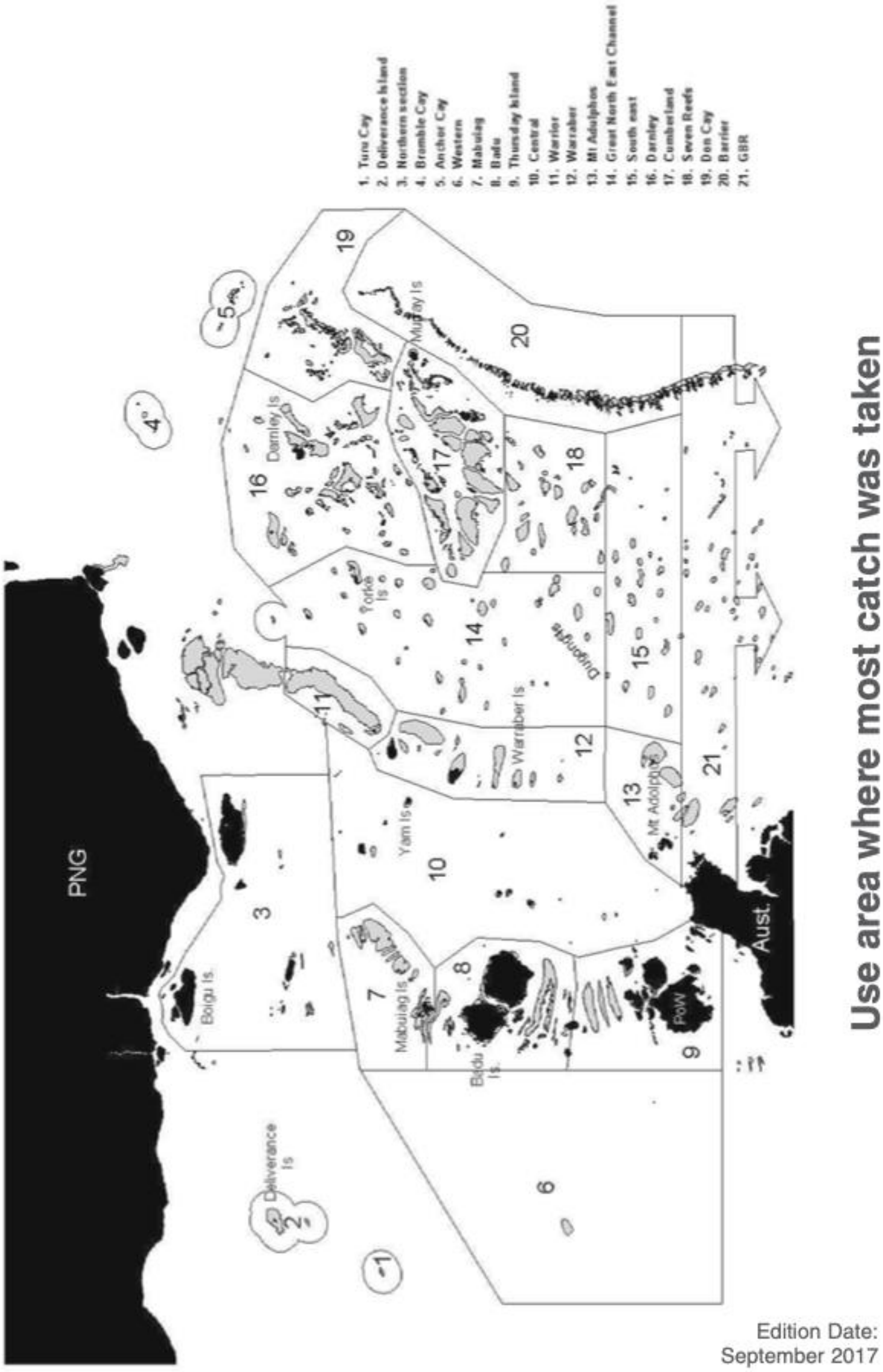
- north along the meridian of longitude 141° 20’ 00” east to its intersection with the parallel of latitude 10° 28’ 00” south;
- east along that parallel to its intersection with the meridian of longitude 144° 00’ 00” east;
- south along that meridian to its intersection with the parallel of latitude 10° 41’ 00” south;
- west along that parallel to its intersection with the meridian of longitude 142° 31’ 49” east;
- south along that meridian to its northernmost intersection with the coastline of Cape York Peninsula at low water;
- generally south-westerly along the western coastline of Cape York Peninsula, that is along the low water line on that coast and across any river mouth, to its intersection with the parallel of latitude 10° 48’ 00” south;
- west along that parallel to the point where the line began; and

(c) the territorial sea of Australia north of the Seabed Jurisdiction Line

Source: Schedule 2 (1) Torres Strait Fisheries Regulations 1985
https://www.legislation.gov.au/Details/F2016C00633



Area of the Torres Strait Bêche-de-mer Fishery.
Source:
https://www.pzja.gov.au/sites/default/files/content/uploads/2011/05/beche_map.gif?acsf_files_redirect

Regions or Zones within the fishery	There are 21 areas in the fishery for the Catch Disposal Record and they are reflected in the catch database as well.  **Twenty one fishing areas for the catch disposal record of the Torres Strait Bêche-de-mer Fishery. Source: https://www.afma.gov.au/sites/default/files/uploads/2018/07/2.2a-catch-disposal-record-TDB02.pdf?acsf_files_redirect**
Fishing season	1 January – 31 December
Key/secondary commercial species and stock status	This fishery targets a range of sea cucumber species. Historically, the main species of sea cucumber harvested in the Torres Strait have been Black teatfish (*Holothuria whitmaei*), Prickly redfish (*Thelenota ananas*), Sandfish (*Holothuria scabra*), White teatfish (*H. fuscogilva*), Surf redfish (*Actinopyga mauritiana*), Deepwater redfish (*A. echinites*) and other Blackfish species (*Actinopyga*

spp.) [12]. In recent years, market demand and fishing effort for Curryfish species (*Stichopus* spp.) and Prickly redfish have increased significantly [4, 5, 12].

Fishing for Sandfish ceased in 1998 due to sustainability concerns following a considerable decline in abundance. This was followed by the closure of fishing for Black teatfish and Surf redfish in 2003. There have been two trial openings of fishing for black teatfish in 2014, and 2015.

Currently (2020), fishing is mainly focused on Prickly redfish (*Thelenota ananas*), White teatfish (*H. fuscogilva*), Deep-water blackfish (mostly *A. palauensis*), Deep-water redfish (*A. echinites*) and since 2018, Curryfish (*Stichopus herrmanni* and *S. vastus*) [4]. The key and secondary commercial species are presented in the table below.

Species list and their roles (key, secondary) in the fishery. Key species comprise > 20% of the average catches between 2016-2020. Secondary species comprise < 20% of average catches between 2016-2020. Stock status information from [4, 5].

COMMON NAME	SCIENTIFIC NAME	STATUS	ROLE
Prickly redfish (Sea Cucumber)	*Thelenota ananas*	not subject to overfishing / not overfished 2019/20 survey results indicate possible fishing increase but still within TAC [4].	Key
Curryfish Herrmanni (Sea Cucumber) - AKA Curryfish (common)	*Stichopus herrmanni*	Uncertain. 2019/20 survey results indicate possible CPUE decline for combined Curryfish species (*S. heremanni* and *S. vastus*) but still within TAC [4]. This is expected as the species is being harvested from pristine levels and not of concern (HCRAG meeting on 6-7 October 2021.	Key
White Teatfish (Sea Cucumber)	*Holothuria (Microthele) fuscogilva*	not subject to overfishing / not overfished	Secondary
Deepwater redfish	*Actinopyga echinites*	status still remains relatively unknown [4]	Secondary
Elephant's Trunkfish (Sea Cucumber)	*Holothuria (Microthele) fuscopunctata*	not subject to overfishing / not overfished	Secondary
Stonefish (Sea Cucumber)	*Actinopyga lecanora*	status still remains relatively unknown [4]	Secondary
Greenflsh (Sea Cucumber)	*Stichopus chloronotus*	not subject to overfishing / not overfished	Secondary
Blackfish (Sea Cucumber) - AKA Hairy blackfish	*Actinopyga miliaris*	status still remains relatively unknown [4]	Secondary
Lollyfish (Sea Cucumber)	*Holothuria (Halodeima) atra*	not subject to overfishing / not overfished	Secondary
Burrowing Blackfish (Sea Cucumber)	*Actinopyga spinea*	status still remains relatively unknown [4]	Secondary
Brown Sandfish (Sea Cucumber)	*Bohadschia vitiensis*	status still remains relatively unknown [4]	Secondary
Golden Sandfish (Sea Cucumber)	*Holothuria (Metriatyla) lessoni*	status still remains relatively unknown [4]	Secondary
Curryfish Vastus (Sea Cucumber)	*Stichopus vastus*	Uncertain. 2019/20 survey results indicate possible CPUE decline for combined Curryfish species (*S.*	Secondary

		heremanni and *S. vastus*) but still within TAC [4]. This is expected as the species is being harvested from pristine levels and not of concern (HCRAG meeting on 6-7 October 2021.	
Leopardfish (Sea Cucumber)	*Bohadschia argus*	not subject to overfishing / not overfished	Secondary
Deepwater Blackfish (Sea Cucumber)	*Actinopyga palauensis*	status still remains relatively unknown [4]	Secondary

The harvest strategy outlines the species categories as at November 2019. https://www.pzja.gov.au/sites/default/files/bdm_harvest_strategy_adopted_nov_2019_070421_0.pdf

The species i.d. guide, which also provides an indication of the relative value of these species: https://www.pzja.gov.au/sites/default/files/torres_strait_bdm_id_guide_2019_web_version.pdf

Comprehensive Information on the status of the stocks can be found on the ABARES Fishery Status Reports 2020 [5]: https://www.agriculture.gov.au/abares/research-topics/fisheries/fishery-status/torres-strait-beche-de-mer-trochus-fisheries

Bait collection and usage	This is a hand collection fishery and does not require the use and/or collection of bait.
Current entitlements	The TSBDMF can only be accessed by Traditional Inhabitant (as defined by the Torres Strait Treaty[9]) fishers. There is no limit on the number of Traditional Inhabitants that can participate commercially in the fishery. However, they are required to hold a current Traditional Inhabitant Boat (TIB) licence with a specific endorsement to be able to fish for BDM. Total TIB licences area generally around 130. The level of participation in the BDM Fishery has increased in recent years although the number of active TIB fishing licences tends to fluctuate from year to year [12]. For information on current licences please refer to the publically available licence register available at: https://www.afma.gov.au/fisheries-services/concession-holders-conditions Non-traditional inhabitants have fished for BDM historically but the last non-traditional inhabitant licence was taken out of the fishery in 2014 and held in trust by the Torres Strait Regional Authority (TSRA).
Current and recent TACs, quota trends by method	As of 1 January 2020, the Total Allowable Catch (TAC) that apply to the target species in the TSBDMF are as follows:

[9] a traditional inhabitant is:

1) A Torres Strait Islander who lives in the Protected Zone or adjacent coastal area of Australia and is an Australian citizen who maintains traditional customary associations with the area in relation to subsistence or livelihood or social, cultural or religious activities; or

2) An Aboriginal traditional inhabitant of the Torres Strait or the Northern Peninsula Area as defined under the Torres Strait Treaty and who is resident in that area; or

3) A Papua New Guinea traditional inhabitant from the PNG area of jurisdiction of the Protected Zone who is now an Australian citizen and resides in the Protected Zone or adjacent coastal area of Australia and who was granted permanent residency status under the 1978/79 Immigration Taskforce Amnesty List. Or is a descendent of such a person.

SPECIES OR GROUP (SCIENTIFIC NAME)	2020 TAC (t) (WET WEIGHT OF GUTTED FISH)	2016-2019 TAC (t) [12]
Prickly redfish (*Theleonata ananas*)	15	15 (reduced from 20t in 2017)
White teatfish (*Holothuria fuscogilva*)	15	15
Deepwater redfish *(Actinopyga echinites)*	5	Part of 80 t combined TAC (basket)
Hairy blackfish (*Actinopyga miliaris*)	5	Part of 80 t combined TAC (basket)
Greenfish (*Stichopus chloronotus)*	40	Part of 80 t combined TAC (basket)
Curryfish species (*Stichopus herrmanni, S. vastus and S. occellatus*)	60 t combined TAC (basket)	Part of 80 t combined TAC (basket)
Black teatfish (*Holothuria whitmaei*)	0	0
Surf redfish (*Actinopyga mauritania*)	0	0
Sandfish (*Holothuria scabra*)	0	0
All other BDM species (inc. those in the families Holothuridae and Stichopidae)	50 t combined TAC (basket)	Part of 80 t combined TAC (basket)

There are no quota allocations in the TSBDMF, i.e. TACs are competitive.

TACs are also outlined in the Harvest Strategy for the fishery which was adopted by the PZJA in November 2019 https://www.pzja.gov.au/sites/default/files/bdm_harvest_strategy_adopted_nov_2019.pdf

Species that are overfished have been closed to commercial fishing (zero TAC; see table above).

Current and recent fishery effort trends by method

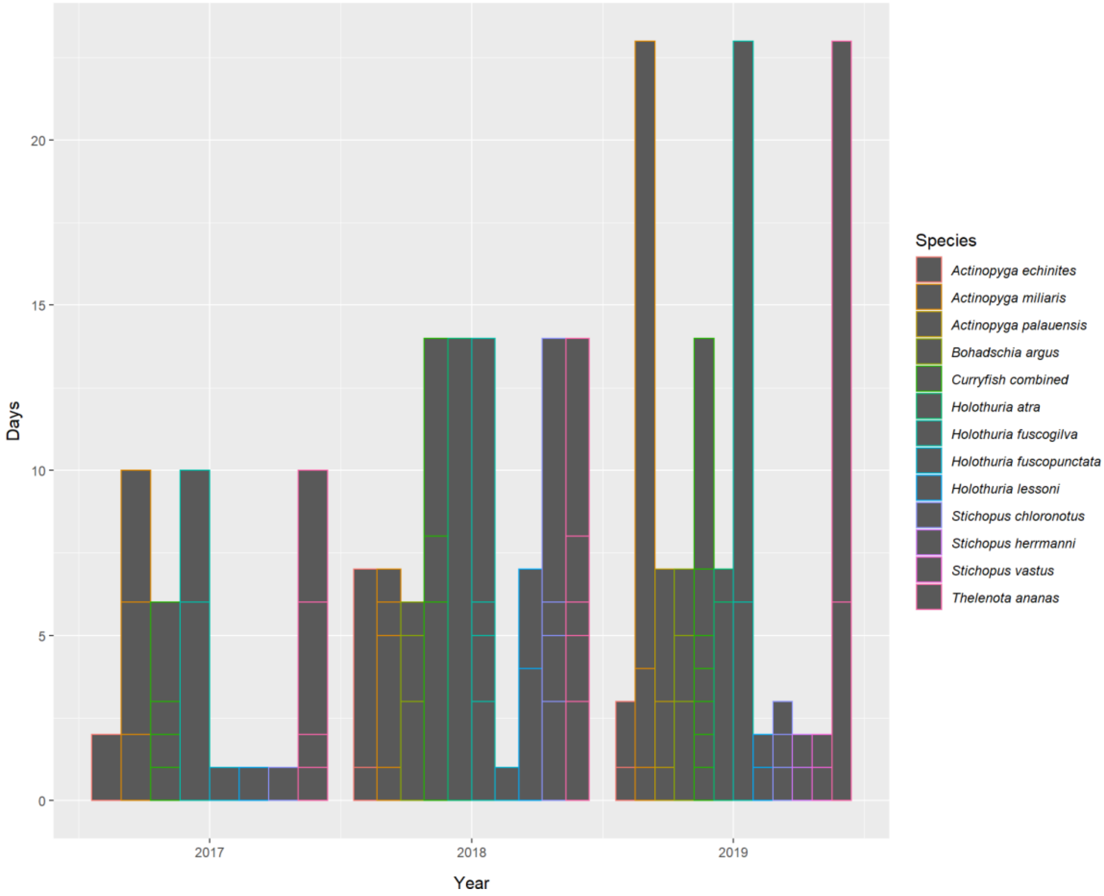
Effort information for the Fishery is provided in the data summary in Attachment 2. Fishing method is hand collection only.

The fish receiver data also provides useful information on effort. Data from 2017-19 shows that the majority of fishing trips last between 1-3 days (~80%). The number of trips lasting between 3 and 6 days have increased in 2018-19 compared to 2017 and trips can last up to 21 days.

YEAR	FISHING TRIP LENGTH (DAYS)	FREQUENCY	%
2017	1	64	63.4%
	2	10	9.9%
	3	4	4.0%
	4	5	5.0%
	5	8	7.9%
	6	7	6.9%
	10	3	3.0%
	Total:	**101**	**100%**

2018	1	157	58.1%
	2	14	5.2%
	3	30	11.1%
	4	12	4.4%
	5	16	5.9%
	6	24	8.9%
	7	8	3.0%
	8	2	0.7%
	14	7	2.6%
	Total:	**270**	**100%**
2019	1	167	61.2%
	2	26	9.5%
	3	31	11.4%
	4	13	4.8%
	5	11	4.0%
	6	16	5.9%
	7	6	2.2%
	14	1	0.4%
	21	2	0.7%
	Total:	**273**	**100%**

The figure below shows a 'fishing trip length' with regard to the catch data. Segments on the bars are roughly equal (data was auto binned in R). Data shows how reporting has improved at the species level, with Curryfish species – *Stichopus herrmanni* and *S. vastus* being identified in the catch in 2019, as opposed to 2017 and 2018.

	
Current and recent fishery catch trends by method	Catch data from the TSBDMF improved in recent years as a result of a concerted effort by the Australian Fisheries Management Authority (AFMA) in 2017 to follow up on unreported catch and implement a fish receiver system. This process resulted in substantially higher catches being reported for some sea cucumber species in some years [5]. Catch reports of BDM for the last season and a half are available on the PZJA website through the links provided below. A summary of the historical catches in the fishery (2005-2020) is also provided in Appendix A. Fishery catch watch reports: https://www.pzja.gov.au/fishery-catch-watch-reports **end of season catch report for 2019:** https://pzja.govcms.gov.au/sites/default/files/torres_strait_beche-de-mer_bdm_fishery_catch_watch_report_18_february_2020.pdf **2020 catch reports as at December:** https://www.pzja.gov.au/sites/default/files/bdm_catch_watch_31_dec_2020_final.pdf
Current and recent value of fishery ($)	There are currently no available estimates of GVP for this fishery. ABARES is aiming to calcultate GVP for the next ERAEF assessment. The latest Torres Strait Bêche-de-mer (Sea cucumber) species ID guide [13] provides some indication of the relative value for the species that are found in the TSBDMF:

COMMON NAME	SCIENTIFIC NAME	VALUE (HIGH (H), MEDIUM (M), LOW (L)) [13]
Amberfish (Sea Cucumber)	*Thelenota anax*	L
Surf redfish (Sea Cucumber)	*Actinopyga mauritiana*	H*
Sandfish (Sea Cucumber)	*Holothuria (Metriatyla) scabra*	H*
White Teatfish (Sea Cucumber)	*Holothuria (Microthele) fuscogilva*	M
Black Teatfish (Sea Cucumber)	*Holothuria (Microthele) whitmaei*	H**

Deepwater redfish	*Actinopyga echinites*	M
Elephant's Trunkfish (Sea Cucumber)	*Holothuria (Microthele) fuscopunctata*	L
Stonefish (Sea Cucumber)	*Actinopyga lecanora*	M
Greenflsh (Sea Cucumber)	*Stichopus chloronotus*	M
Blackfish (Sea Cucumber) - AKA Hairy blackfish	*Actinopyga miliaris*	M
Lollyfish (Sea Cucumber)	*Holothuria (Halodeima) atra*	L
Prickly redfish (Sea Cucumber)	*Thelenota ananas*	M
Burrowing Blackfish (Sea Cucumber)	*Actinopyga spinea*	M
Brown Sandfish (Sea Cucumber)	*Bohadschia vitiensis*	M
Golden Sandfish (Sea Cucumber)	*Holothuria (Metriatyla) lessoni*	H
Curryfish Herrmanni (Sea Cucumber) - AKA Curryfish (common)	*Stichopus herrmanni*	M
Curryfish Vastus (Sea Cucumber)	*Stichopus vastus*	M
Leopardfish (Sea Cucumber)	*Bohadschia argus*	M
Deepwater Blackfish (Sea Cucumber)	*Actinopyga palauensis*	M

* zero TAC in this assessment period.
** species was closed to fishing (zero TAC) in this assessment period, but likely to be a key commercial species in the future.

Relationship with other fisheries

Traditional Inhabitant Boat (TIB) fishers in the TSBDMF can also get endorsement to operate in other Torres Strait Fisheries such as the Torres Strait Rock Lobster (TRL) Fishery. This information can be found on the public licence register on the AFMA website: https://www.afma.gov.au/fisheries-services/concession-holders-conditions.

No overlap with the TRL Fishery which is hand collection only.

No overlap with the Finfish fishery which is a line only fishery.

No overlap with Prawn Fishery, which is a trawl fishery [4, 14]

GEAR

Fishing methods and gear

The TSBDMF operates in tidal waters within the Torres Strait Protected Zone (TSPZ) and south of the TSPZ, in the waters defined as the 'outside but near area' [5] (see fishing area shown on map above). Bêche-de-mer (sea cucumber) has historically been harvested in the eastern parts of Torres Strait, with most of the catch typically taken from the Great North East Channel, Don Cay, Darnley Island, Cumberland Channel and Barrier regions. Western Torres Strait is included in the fishery, but is documented as having naturally low abundance of sea cucumbers [5].

Fishing for Bêche-de-mer in the Torres Strait is by hand collection, mainly by free diving from dinghies crewed by two or three fishers, or by walking along reef tops and edges at low tide. Dry picking' or 'walking the reef' occurs occasionally in the fishery with most of the catch being taken whilst diving. Prickly redfish, Curryfish and White teatfish can only be taken by diving. The only species that may be taken by 'dry picking', include species that are infrequently targeted such as stone fish, black fish, deepwater redfish, lolly fish, leopard fish and green fish (HCRAG 6-7 October 2021). Most (60%) of the fishing trips last for 1 day but they can last up to 21 days (2017-2019 fish

	receiver data). When working on boats, two fishers can be towed on snorkel to search for species of interest (see photo below). Fishers can also walk dragging bins full of sea water (tied by rope), that are filled with species that are hand collected. Catches are stored on boats either on bilges or nally bins filled with sea water. Only secondary species are targeted during reef walking (HCRAG, October 7 2021). Fishers sometimes camp closer to fishing locations. The depth ranges of the most frequently sought species occur in a range of 0 – 20 m but a combined hookah (surface-supplied underwater breathing apparatus)/SCUBA ban means that most fishing occurs within 0-10m, where fishers reported most of the catches for Curryfish (common) and Prickly redfish between 7-10 m (HCRAG, October 7 2021).  **Two fishers towed on snorkel in search of sea cucumbers. Photo: Mike Passi, TO Murray Island** Following collection, Sea cucumbers are processed for market; typically, this involves gutting, grading, cleaning, boiling and salting. A few operators also dry the product before sending it to market.
Fishing gear restrictions	The taking of Sea cucumbers in the area of the TSBDMF with the use of any underwater breathing apparatus or by any method other than collection by hand, is prohibited (legislative instrument). There is a maximum of 7 m boat length limit in the fishery (policy-based restriction).
Selectivity of fishing methods	Highly selective fishing method as it is hand collection only.
Spatial gear zone set	Hand collection only method applies to the entire fishery.
Depth range gear set	It is estimated that most fishing occurs within 0 – 10 m due to the ban on hookah/SCUBA gear.
How gear set	n/a as hand collection fishery.
Area of gear impact per set or shot	unknown
Capacity of gear	n/a
Effort per annum all boats	ABARES reports effort in the fishery measured by number of active TIB fishers reporting catch and has increased in 2019 compared to 2018 [5]:

	Effort (# of sellers) 2018: 34 Effort (# of sellers) 2019: 40
Lost gear and ghost fishing	n/a as this is currently a hand-collection only fishery.
ISSUES	
Key/second-ary commercial species issues and Interactions	n/a as this is a primarily sea cucumber fishery but there is a value differential among the various sea cucumber species that are available for harvest in the fishery. The fishery is unlikely to have an unsustainable ecological impact in the last three years [15]. Participation in the fishery is restricted to Traditional Inhabitants and (as of 1 December 2017) all commercial fishers are required to unload their catch to licensed fish receivers. The BDM Fishery is a wholly commercial fishery and catches by the recreational and traditional sectors are considered to be negligible. Black and white teatfish are both no-take species for the recreational sector managed by the Queensland Government. AFMA understands that there is no traditional fishing for sea cucumbers based on advice from stakeholders [12]. Overall, survey data from 2019/20 show the TSBDMF is healthy and can support moderate long-term income to local Islander communities. Nominal CPUE trends for Prickly redfish are increasing over the survey conducted in years 2017, 2018 and 2019 [4]. Also, combined Curryfish (i.e. *Stichopus herrmanni;* Curryfish common and *S. vastus*; Curryfish vastus) CPUE trend shows an initial decline which is expected as these species are being harvested from pristine levels and therefore such initial increase in CPUE is not of concern (HCRAG meeting on 6-7 October 2021; [4]). The data gathered during the 2019/20 survey showed that Black teatfish, a previously depleted high value species closed to fishing in 2003, has continued to recover. High densities observed in preferred Black teatfish habitats and observations shared by Traditional Inhabitants with long-term fishing experience, indicate the population is likely near virgin biomass levels [4]. The maximum size recorded for the 2019/20 survey was 325 mm and the average size was 219 mm, which was lower than the 2009 survey but larger than historical (1995/96) surveys. This indicates that full size adults are present in the population, with average size Black teatfish above common size and almost at size at maturity - determined as 220-260 mm [4]. In 2021 there was a successful trial opening for black teatfish and this species will likely become a key species in the next ERA assessment.
Byproduct and bycatch issues and interactions	Due to the high selectivity of fishing methods used to catch Bêche-de-mer (i.e. hand collection) there is likely to be no byproduct or bycatch caught or retained: "No bycatch usually occurs in hand collection fisheries and risks are likely to be low" [15].
Protected species issues and interactions	There are no bycatch or protected species issues reported in the fishery. Interactions with protected species is highly unlikely because the fishery is highly selective (collected by hand). Some fishers may hunt (Turtles and Dugongs) on the same trip but this would be classified as traditional fishing and not fishing within the TSBDMF (AFMA 2021, pers. Comms.). Risks to protected species (Turtles and Dugongs) are likely to be relatively low, but may include impacts such as boat strikes, anchoring or trampling [15]. Dugongs spend much of their time in depths between five to 20 metres, so may be less at risk of boat strike than Turtles which spend more time around reef habitats in waters less than five metres deep. Large carrier boats which supply fishing boats and sometimes transport the catches in wharves, typically anchor in sheltered areas and not over reef [15]. Anchoring of large commercial boats in channels adjacent to Dugong feeding grounds was identified as a potential concern in a study on Western and Central Torres Strait [16], but as BDM fishing occurs mostly in eastern Torres Strait, this risk of boat strikes is very small. AFMA requires interactions with Threatened, Endangered or Protected (TEP) species to be recorded in logbooks. There have been no interactions with TEP species reported in this fishery to date, and the risks are likely to be relatively low [15]. No interactions with EPBC Act listed [17] species have been reported in the fishery [15, 18].

Habitat issues and interactions	Results from the 2019/20 survey suggest that the surveyed reef habitats within the TSBDMF appear to be in very good condition [4]. Sea cucumbers are caught by hand and the direct ecological impact on the benthos from harvesting these speciesis likely to be low based on the scale and nature of the fishery [15]. Although direct impacts from fishing have not been measured or reported, there is significant concern related to potential physical damage to coral reef structures from walking during collection at low tide [5]. AFMA considered that indirect impacts of the fishery on the ecosystem may include: over-exploitation of target species; translocation of species via hull and anchor fouling; and impacts of anchoring/mooring and other anthropogenic activities such as treading and walking on reef top habitat [15]. Results from the 2019/20 survey [4] showed Hard and Soft coral have declined since 2002, which was also the same for Sponges, with Giant clams down from 2009 (but higher than previous years). By contrast, seagrass cover increased, compared to previous years, where lower seagrass cover was recorded. Crown of thorn numbers were low with no suggestion of an outbreak and Trochus numbers were lower, but considered stable as Trochus specific habitat was not surveyed. The decline of Corals and other biota (Sponges) is of concern as they represent key ecosystem roles and habitat, and may indicate a wider and ongoing environmental and physical effect occurring for Torres Strait.
Community issues **and interactions**	n/a
Discarding	Due to the high selectivity of fishing method used to catch Bêche-de-mer (i.e. hand collection) there is likely to be minimal discarding and limited to the disposal of unmarketable product or illegal catch. In 2019, AFMA confiscated some illegal catch of sea cucumber (229 kg of White teatfish, 27 kg of Prickly redfish and 6 kg of Deepwater black fish) from unlicensed fishers, or because the fish did not go through licensed receivers. In addition, approximately 1 t of Curryfish,(a more difficult species to process)had spoiled and was rejected by receivers in 2018 [5].
MANAGEMENT: PLANNED AND THOSE IMPLEMENTED	
Management **objectives**	The TSBDMF is managed by the PZJA that consists of the Australian Government (represented by the Minister responsible for fisheries, as the Chair of the PZJA), the Queensland Government (represented by the Minister responsible for fisheries) and the Torres Strait Regional Authority (TSRA) (represented by the TSRA Chair). The Australian Fisheries Management Authority (AFMA) coordinates and delivers fisheries management and now also delivers compliance programs in the Torres Strait on behalf of the PZJA and in accordance with the *Torres Strait Fisheries Act 1984* (TSF Act). Management objectives for the fishery, with regard to the the rights and obligations conferred on Australia by the *Torres Strait Treaty 1984* (the Treaty) and the objectives to be pursued under the TSF Act, are: a) to acknowledge and protect the traditional way of life and livelihood of traditional inhabitants, including their rights in relation to traditional fishing[10]; b) to protect and preserve the marine environment and indigenous fauna and flora in and in the vicinity of the Protected Zone; c) to adopt conservation measures necessary for the conservation of a species in such a way as to minimise any restrictive effects of the measures on traditional fishing; d) to manage the fishery for optimum utilisation;

[10] Traditional fishing means non-commercial fishing as defined in the TSF Act.

e) to have regard, in developing and implementing licensing policy, to the desirability of promoting economic development in the Torres Strait area and employment opportunities for traditional inhabitants.

Licences are granted under either subsection 19(2) or 19(3) of the TSF Act that entitles that person to take, process or carry trochus.

https://www.legislation.gov.au/Details/C2016C00677

Fishery management plan

n/a

There is no formal management plan for the fishery, but management arrangements [15] are outlined below:

- A guide to management arrangements for Torres Strait Fisheries, June 2004
- Community Fishing Notice No. 1 (pdf copy on PZJA website but not found on legislation.gov.au)
- Torres Strait Fisheries Management Instrument No. 15
- Fisheries Management Notice No. 47

The management regime is likely to achieve the objective of maintaining ecologically viable stock levels [15].

Input controls

- Hand collection only, maximum 7 m boat length limits
- Traditional Inhabitant Boat (TIB) licence and BDM endorsement required
- Prohibition of hooka and scuba gear [5].

Output controls

Zero Total Allowable Catches (TAC) for Sandfish, Black teatfish and Surf redfish; and TAC's (Appendix A) for selected species,and combined (basket) sea cucumber species, minimum size limits on 10 species (see table below showing Sea cucumber species revised as part of the Harvest Strategy), conversion ratios used to convert processed product to whole weight (wet gutted whole weight) [5]. TACs are listed above, conversion ratios are in the Harvest Strategy document. Minimum size limits over the assessment period (2016-2020) are shown in the -table below. Please note that these limits may have changed since this assessment. These will be updated to reflect the revised and recommended size limits in the Harvest Strategy.

COMMON NAME - SCIENTIFIC NAME	PREVIOUS SIZE LIMIT (CM)	REVISED HARVEST STRATEGY SIZE LIMIT (CM)
Deepwater redfish – *A. echinites*	12	20
Stonefish – *A. lecanora*		
Surf redfish – *A. mauritiana*	22	22
Hairy blackfish – *A. miliaris*	22	22
Deepwater blackfish – *A. palauensis*	22	22
Burrowing blackfish – *A. spinea*	22	22
Leopardfish – *B. argus*		30
Brown sandfish – *B. vitiensis*		25
Lollyfish – *H. atra*	15	15
Elephant trunkfish – *H. fuscopunctata*	24	24
White teatfish – *H. fuscogilva*	32	32
Golden sandfish – *H. lessoni*	18	22
Sandfish – *H. scabra*	18	18
Black teatfish – *H. whitmaei*	25	25
Greenfish – *S. chloronotus*		
Curryfish (common) – *S. herrmanni*	27	31
Curryfish (vastus) – *S. vastus*		15

	Prickly redfish – *T. ananas*	35	35
Technical measures	n/a		

Regulations	1. Fisheries Management Instruments (FMIs) and Fisheries Management Notices (FMNs) are issued under the TSF Act and give effect to the regulations in place for each of the Torres Strait fisheries. <u>Torres Strait Fisheries Management Instrument No. 15 (Torres Strait Sea Cucumber Fishery)</u> Prohibitions: • Prohibition on the taking, processing or carrying of Bêche-de-mer. Exemptions from the prohibitions: • A person holding a licence to take, process or carry Bêche-de-mer; • where a person takes or carries sea cucumbers without the use of a boat – the number of sea cucumber in that person's possession does not exceed three; or • where a person takes or carries sea cucumbers with the use of a boat, or by diving from a boat, and no other person is in the boat – the number of sea cucumbers in the boat does not exceed three; or • where the person takes or carries sea cucumbers with the use of a boat, or by diving from a boat, and there is at least one other person in the boat – the number of sea cucumbers in the boat does not exceed six; and • A person who takes, processes or carries Bêche-de-mer in the course of traditional fishing. Size Limit: • minimum size limits apply. Gear restrictions: • the taking of sea cucumber in the area of the Torres Strait Sea Cucumber Fishery with the use of any underwater breathing apparatus or by any method other than collection by hand, is prohibited. • https://www.legislation.gov.au/Details/F2017L00370 2. Licensing arrangements Fishing is limited to traditional inhabitants only in the commercial BDM Fishery. Traditional inhabitants can enter this fishery by obtaining a Traditional Inhabitant Boat (TIB) fishing licence with a Bêche-de-mer (BD) endorsement. The Australian Fisheries Management Authority (AFMA) assesses and issues licences on behalf of the PZJA. 3. Licence conditions Implemented by way of licence conditions, boat lengths are limited to a maximum of seven metres in the fishery, which does not apply to processor/carrier boats.
Initiatives, strategies and incentives	• **HARVEST STRATEGY**: In November 2019 the PZJA endorsed the implementation of a Harvest Strategy in the TSBDMF which was implemented for the 2020 fishing season starting on 1 January [18]. • **FISH RECEIVER SYSTEM:** The Torres Strait Fish Receiver System was implemented on 1 December 2017. This is a requirement for all commercial fishers to unload their catch to licensed fish receivers. Fish receivers can only receive catch from licenced fishers and are required to weigh all catch and return the associated paperwork to AFMA within three days of receiving the catch. This allows AFMA to better monitor and manage catches than was possible under the voluntary reporting arrangements [15]. There is still however, limited information available to assess the status of fishery populations, with incomplete catch and effort time series data available prior to 2017 [4]. The fish receiver system provides an incentive for fishers to collect data which will feed into the Harvest Strategy. 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 biological, social and economic objectives [18].

Enabling processes

Data available for the TSBDMF is described below. The PZJA has an advisory committee for the Fishery, the Hand Collectables Working Group and has established a Resource Assessment Group for the Fishery with inaugural meeting to be held on Thursday Island 23-25 August 2021.

Other initiatives or agreements

AFMA continues to engage Papua New Guinea including issues related to illegal PNG fishing of stocks on Warrior Reef. Illegal catch taken by PNG nationals has been reported in previous years, but no such reports have been received since the 2017 to 2018 fishing season [5, 12].

PNG NFA are members of the Torres Strait Scientific Advisory Committee. The aim of this forum is to facilitate a collaborative approach to research.

DATA

Logbook data

Logbook reporting is voluntary in the TSBDMF, however there is some historical data from logbooks and docket books used in the fishery. As a result, 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 some time before reliable catch and effort data are available for analysis [18].

Observer data

nil

Scientific data

A number of Sea cucumber fishery-independent surveys were conducted in Torres Strait since 1995, across representative habitats [4]. Number of zones (equivalent to TSBDMF logbook areas) surveyed and number of survey sites in each habitat, are shown in the table below (from [4]):

YEAR	ZONES	REEF TOP	REEF TOP BUFFER	REEF EDGE	DEEP WATER^	Total
1995/96	14	1089	164	365	0	1618
2002	6	136	139	159	0	434
2005	5	35	52	40	0	127
2009	5	33	25	45	0	103
2019/20	6	88	86	70	53	297

^: defined as the the deep (>20 m) outer reef edge and deep reef lagoon habitats.

The *Torres Strait Hand Collectables, 2009 survey: Sea cucumber* ([6]) completed in March 2009 was not by definition a stock assessment analysis, however, provided some insight into stock status.

Formal analysis of stock recovery strategies (prohibition of the take of overfished species and increased foreign compliance capabilities), has not been undertaken for the fishery. However, results from the 2009 and 2010 surveys indicate recovery for some species (Black teatfish and Surf redfish), as a result of a zero TAC since 2003.

http://pzja.gov.au/wp-content/uploads/2011/06/tshcwg-meeting-4-27-28-july-2010_attachment-2.2a-torres-stra.pdf

Other data

Catch disposal record data: a fish receiver system was implemented in 1 December 2017 and has led to increased availability of catch data for the fishery. Catch reports are available at: https://www.pzja.gov.au/fishery-catch-watch-reports

Harvest strategy: https://pzja.govcms.gov.au/sites/default/files/bdm_harvest_strategy_adopted_nov_2019_070421.pdf

BDM surveys: 1995/96, 2002, 2005, 2009, 2019/20 [4, 6, 19-22]

	Submission for a further export approval for the Torres Strait Bêche-de-mer Fishery under the EPBC Act 1999 [12] See reference list
Legislative instruments and directions	See previous section
Management plans	n/a

2.2.2 Unit of Analysis Lists (Step 2)

The units of analysis for the fishery are listed by component:

- Species Components (key commercial and secondary commercial; byproduct/bycatch and protected species components). [Scoping document S2A Species]
- Habitat Component: habitat types. [Scoping document S2B1 and S2B2 Habitats]
- Community Component: community types. [Scoping document S2C1 and S2C2 Communities]

Ecological Units Assessed

Key commercial and secondary species:	2 (C1); 13 (C2)
Byproduct and bycatch species:	0
Protected species:	0
Habitats:	4 demersal; 1 pelagic
Communities:	7 (5 demersal, 2 pelagic)

Scoping Document S2A. Species

Each species identified during the scoping is added to the ERAEF database used to run the Level 2 analyses. A CAAB code (Code for Australian Aquatic Biota) is required to input the information. The CAAB codes for each species may be found at http://www.marine.csiro.au/caab/

Key commercial/secondary commercial species

- *Key commercial species* – defined in the Harvest Strategy Policy (HSP) Guidelines as a species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery.
- *Secondary commercial species* – commercial species that, while not specifically targeted, are commonly caught and generally retained, and comprise a significant component of a fishery's catch and economic return. These can include quota species in some fisheries.

For the purpose of this ERA, species need to have TAC greater than zero to be considered as key or secondary commercial species. Key commercial species are defined as the species that comprised more than 20 % of the average catch between 2016-2020, while secondary commercial species comprised less than 20 % of average catch between 2016-2020.

Table 2.3. Key commercial (C1) and secondary commercial (C2) species list (comprising of Sea cucumbers) for the Torres Strait Bêche-de-mer Fishery.

ROLE IN FISHERY	TAXA NAME	FAMILY NAME	CAAB CODE	SCIENTIFIC NAME	COMMON NAME	SOURCE
C1	Holothuroidea	Stichopodidae	25417003	*Thelenota ananas*	Prickly redfish	[7, 13, 23]
C1	Holothuroidea	Stichopodidae	25417006	*Stichopus herrmanni*	Curryfish herrmanni - AKA Curryfish (common)	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416006	*Holothuria (Microthele) fuscogilva*	White teatfish	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416001	*Actinopyga echinites*	Deepwater redfish	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416032	*Holothuria (Microthele) fuscopunctata*	Elephant's trunkfish	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416009	*Actinopyga lecanora*	Stonefish	[7, 13, 23]
C2	Holothuroidea	Stichopodidae	25417001	*Stichopus chloronotus*	Greenflsh	[7, 13, 23]

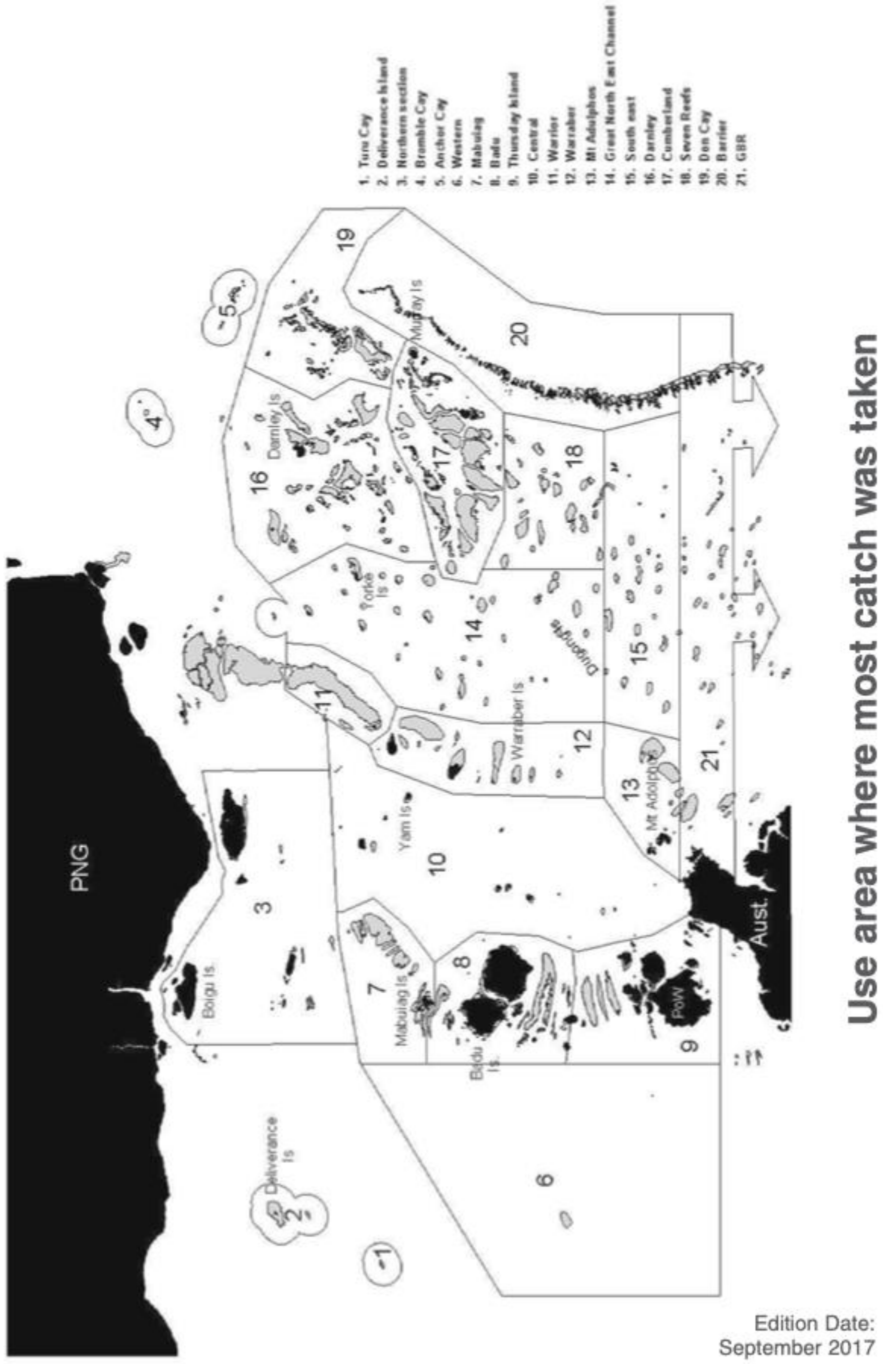
ROLE IN FISHERY	TAXA NAME	FAMILY NAME	CAAB CODE	SCIENTIFIC NAME	COMMON NAME	SOURCE
C2	Holothuroidea	Holothuriidae	25416007	*Actinopyga miliaris*	Blackfish - AKA Hairy blackfish	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416003	*Holothuria (Halodeima) atra*	Lollyfish	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416064	*Actinopyga spinea*	Burrowing blackfish	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416065	*Bohadschia vitiensis*	Brown sandfish	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416031	*Holothuria (Metriatyla) lessoni*	Golden sandfish	[7, 13, 23]
C2	Holothuroidea	Stichopodidae	25417012	*Stichopus vastus*	Curryfish vastus	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416013	*Bohadschia argus*	Leopardfish	[7, 13, 23]
C2	Holothuroidea	Holothuriidae	25416070	*Actinopyga palauensis*	Deepwater Blackfish	

Scoping Document S2B1. Benthic Habitats

Risk assessment for benthic habitats considers both the seafloor structure and its attached invertebrate fauna. Because data on the types and distributions of benthic habitat in Australia's Commonwealth fisheries are generally sparse, and because there is no universally accepted benthic classification scheme, the ERAEF methodology has used the most widely available type of data – seabed imagery – classified in a similar manner to that used in bioregionalisation and deep seabed mapping in Australian Commonwealth waters. Using this imagery, benthic habitats are classified based on an SGF score, using sediment, geomorphology, and fauna. Where seabed imagery is not available, a second method (Method 2) is used to develop an inferred list of potential habitat types for the fishery. For details of both methods, see [1].

The TSBDMF area covers 16,844 km^2 of Torres Strait, but Sea cucumbers have been historically harvested on coral reefs in eastern Torres Strait, with most of the catch (and effort) typically taken from the Great North East Channel (zone 14 in Figure 2.2), Don Cay (zone 19), Darnley Island (zone 16), Cumberland Channel (zone 17) and Barrier (zone 20) regions. Western Torres Strait is included in the fishery, but is documented as having naturally low abundance of Sea cucumbers [5]. The area with most catch contains about 1,388 km^2 of shallow reefs, which accounts for about 64 % of all reefs in Torres Strait (Figure 2.2) [20].

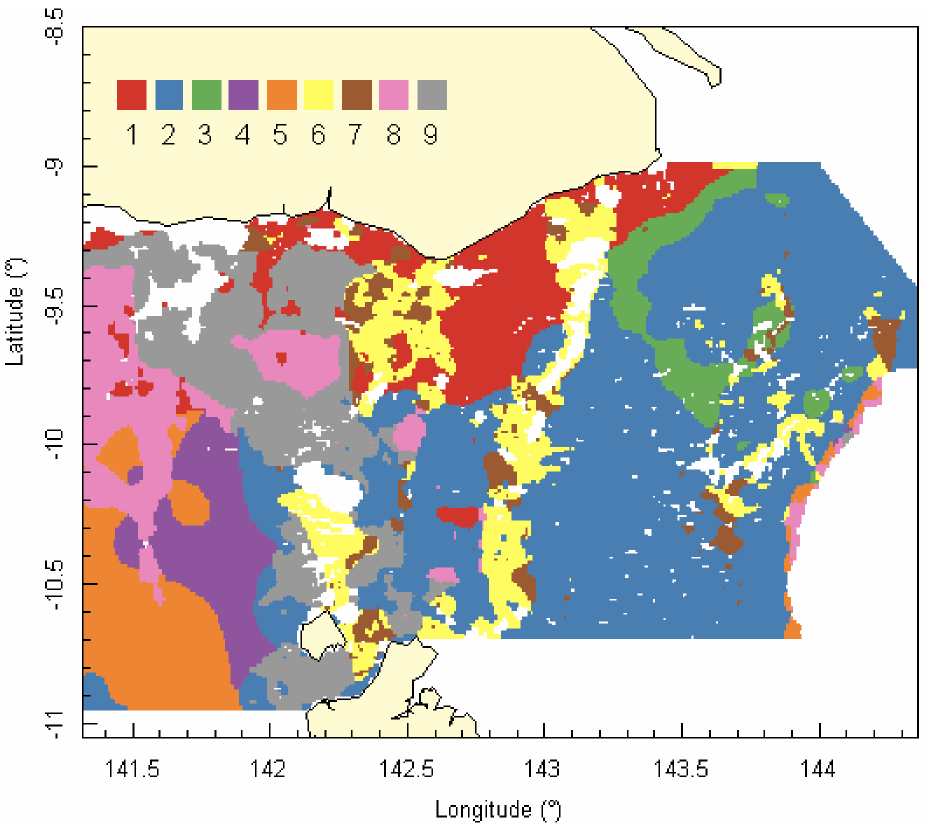
Recent surveys in Torres Strait have documented 275 coral species, of which approximately 75 are new records for the region. Corals build reef structures that provide habitat for the Sea cucumbers. The reefs are in good to excellent condition with high coral cover, presence of the major taxonomic and functional groups and minimal incidence of coral disease [24]. Torres Strait coral reefs have the highest diversity of fungiid corals (mushroom corals) in the eastern coast of Australia [25]. For both corals and reef fishes, the communities from central sites differ from those in eastern sites, reflecting a gradient in turbidity and wave exposure, where water is more turbid and energy is lower from west to east [26].



Source: https://www.afma.gov.au/sites/default/files/uploads/2018/07/2.2a-catch-disposal-record-TDB02.pdf?acsf_files_redirect.
Figure 2.1. Twenty one fishing areas for the Catch Disposal Record of the Torres Strait Bêche-de-mer Fishery.

Seabed imagery was used to characterise key biotic and physical attributes of the Torres Strait inter-reefal ecosystems [14, 27]. Murphy et al.[4] reviewed these datasets and found that "[…]the inter-reefal seabed data does not indicate a significant population of high value commercial species in the inter-reefal seabed areas of Torres Strait (apart from *S. horrens*, a commercial but not currently targeted species), such as White teatfish and Prickly redfish. Nor does it indicate the existence of significant populations of Burrowing blackfish (*Actinopyga* *spinea*) that now forms the largest single species on the Qeensland east coast (GBR) Sea cucumber fishery."

As discussed above, the commercial species in Torres Strait are harvested on coral reefs, mostly on reef tops and reef edges [4], with species having preferences to different reef habitats (Table 2.4). Therefore, instead of relying solely on seabed imagery, we also used survey data to create the habitat categories used in this report. The relevant broad inter-reefal benthic habitats and assemblages (Figure 2.2) were grouped into a single category (inter-reefal habitats). The habitats 'reef flat', 'forereef zone', 'deep reef' and 'seagrass beds' habitats were created based on habitat preferences of commercially caught species (Table 2.4) according to historical Sea cucumber surveys [4, 6, 13, 19-22, 28, 29] and summarised in [13]. The revised habitat types and their descriptions are provided in Table 2.5.



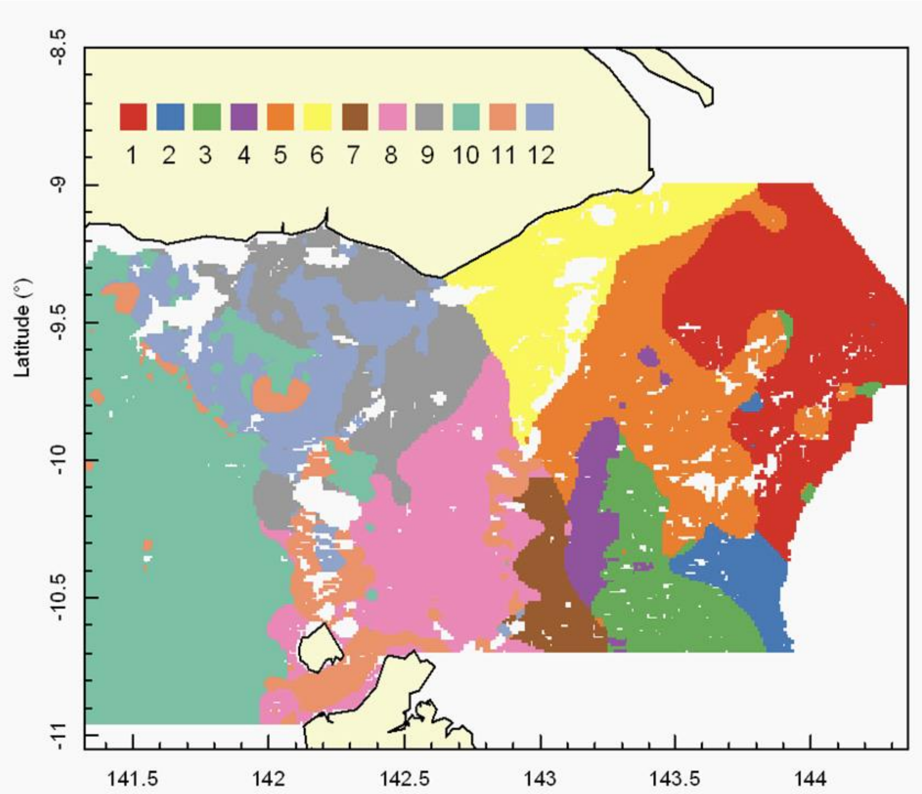


Figure 2.2. Map of the Torres Strait Bêche-de-mer Fishery showing the nine inter-reefal habitats (top) and 12 inter-reefal assemblages (bottom) derived from [14, 27].

Table 2.4. Commercial Sea cucumber species, their preferred habitats and respective characterisation [based on 13, 14, 27].

SPECIES	BROAD HABITAT PREFERENCE [13]	DETAILED HABITAT PREFERENCE [13]	WHERE FOUND
Deepwater redfish	Reef flat Seagrass beds	**Unconsolidated substrate**. Coastal reefs in rubble, seagrass beds and sand between corals	Moa Island, Orman reefs, Darnley Island, Murray Island, Campbell Island, Aureed Island, Hannah bank, Warrior reef, Auwamaza Reef
Surf redfish	Forereef zone	**Consolidated substrate.** Surf zone on outer reefs	Murray Island, Don Cay
Hairy blackfish	Reef flat	**Unconsolidated substrate.** Sandy lagoons and reef flats	Warrior Reef, Campbell Island
Deepwater blackfish	Forereef zone	**Consolidated substrate.** Forereef pavement and reef passes	Very uncommon
Burrowing blackfish	Reef flats	**Unconsolidated substrate.** Lagoons and reef flats	Western side of Warrior reef
Stonefish	Reef flats Forereef zone	**Unconsolidated or consolidated substrate.** Deeper seabed in areas with live coral, coral rocks and reef ledge	Reasonably uncommon, found in deeper seabed from Warrior and western Torres Strait. Also at Orman Reeef, Mabuiag Island, Bet Reef, Buru Island, Tudu Island, Nagai Island
Leopardfish	Reef flats Forereef zone Inter-reef seabed	**Unconsolidated substrate.** Sand base of reef slopes or on reef flats and lagoons	Widespread. Commonly on sand at base of reef slopes or on reef flats and in lagoons

SPECIES	BROAD HABITAT PREFERENCE [13]	DETAILED HABITAT PREFERENCE [13]	WHERE FOUND
Brown sandfish	Reef flats	**Unconsolidated substrate.** Lagoons and inner reef flats with soft sediments	Calm water of coastal lagoons and inner reef flats with soft sediments eg. sand
Lollyfish	Reef flats	**Unconsolidated substrate.** Sandy lagoons and reef flats	Widespread. Sand lagoons and reef flat
White teatfish	Reef flats Inter-reef seabed Deep reef	**Consolidated or unconsolidated substrate.** Lagoons, reef passes on pavement or sand	Widespread, but more common in north eastern Torres Strait
Elephant trunkfish	Reef flats	**Unconsolidated substrate.** Rubble sandy lagoons and reef flats	Widespread. Rubble sand lagoons and reef flats
Golden sandfish	Reef flats	**Unconsolidated substrate.** Sandy reef flats and lagoons	Sandy reef flats and lagoons. Very restricted distribution in western Torres Strait
Sandfish	Reef flats Seagrass beds	**Unconsolidated substrate.** Muddy-sand seagrass beds and reef flats	Warrior Reef, Dungeness Reef
Black teatfish	Reef flats Forereef zone Inter-reef seabed	**Unconsolidated or consolidated substrate.** Sandy reef flats, reef fronts and between reefs	Widespread throughout Torres Strait
Greenfish	Reef flat Forereeef zone	**Unconsolidated or consolidated substrate.** Reef flats and upper slopes	Widespread throughout Torres Strait
Curryfish (common)	Reef flat	**Unconsolidated substrate.** Reef flats and lagoons in rubble and muddy-sand bottoms	Widespread. Coastal reefs and lagoons in rubble and muddy-sand bottoms
Curryfish (vastus)	Forereef zone	**Unconsolidated substrate.** Inshore reef edges on sand, coral rubble or muddy-sand in shallow waters	Widespread. Inshore reefs edges on sand, coral rubble or muddy sand in shallow waters
Prickly redfish	Reef flat	**Unconsolidated substrate.** Lagoons, in areas with rubble and passes	Widespread. Lagoons, in areas with rubble and passes

Table 2.5. Habitats and corresponding faunal assesmblages in the Torres Strait Bêche-de-mer Fishery.

HABITAT (BASED ON [13])	RELEVANT HABITAT TYPES [14, 27]	DESCRIPTION	ASSEMBLAGE
Inter-reef seabed	1	Habitat Type 1 was among the most barren seabed types, almost entirely bare and/or bioturbated with very little biohabitat — distributed in low current stress, low salinity, muddy–sandy areas adjacent to the PNG coast and extending south behind the Warrior Reefs.	6. occurred in areas of low variability in temperature and salinity with high turbidity, distributed primarily in the lee of the Warrior Reefs to the PNG coast and northeast towards the Fly River delta. At the species level, a few species had moderately strong affinities for assemblage#6; those most aligned were: Actinopterygii: *Torquigener whitleyi*, *Apogon fasciatus*; Crustacea: *Phalangipus filiformis*, *Thalamita sima*. [14]
	2	somewhat similar to habitat types 1 and 3, being also very barren with little epibenthos or algae, though sandier and much less bioturbated — distributed in low current stress, high salinity, low phosphate, low silicate variability, sandy areas located over most of eastern TSPZ including the trawl grounds and open areas of southern central TSPZ.	1. occurred in areas of low variability in temperature and salinity with sediment carbonate <85%, distributed primarily in the northeast outer shelf of the TSPZ. Several species had very strong affinities for assemblage#1; those most aligned were Actinopterygii: *Fistularia petimba*, *Rogadius pristiger*, *Paramonacanthus filicauda*, *Upeneus* cf sp. 1 (Sainsbury), *Suggrundus macracanthus*, *Nemipterus* sp juv/unident, *Apogon septemstriatus*, *Onigocia* sp b; Crustacea: *Paguristes* sp2358-2, *Trachypenaeus curvirostris*, *Penaeus longistylus*; Asteroidea: *Luidia hardwicki*. [14]

HABITAT (BASED ON [13])	RELEVANT HABITAT TYPES [14, 27]	DESCRIPTION	ASSEMBLAGE
			3. occurred in areas of low variability in temperature and salinity with low turbidity and chlorophyll and low trawl effort, distributed primarily in southeast TSPZ in a mid-shelf position. Some of the most barren habitats occurred in some of these areas, although the sled and trawl revealed significant biodiversity. Few individual species had strong affinities for assemblage#3; those most aligned were: Crustacea: *Portunus tenuipes*, Actinopterygii: *Rhynchostracion nasus*, *Sorsogona tuberculata*. [14]
			4. occurred in areas of low variability in temperature and salinity with low turbidity and chlorophyll and high trawl effort, distributed primarily in southern-central eastern TSPZ, corresponding with a large part of the trawl grounds. Again, few individual species had strong affinities for assemblage#4; those most aligned were: Actinopterygii: *Scolopsis taeniopterus*, *Paramonacanthus choiro/otisensis*, *Priacanthus tayenus*, *Cynoglossus maculipinnis*, *Euristhmus nudiceps*. [14]
			5. occurred in areas of low variability in temperature and salinity with low turbidity and high chlorophyll, distributed primarily in the Great Northeast Channel straddling the trawl grounds from the Warrior Reefs to the Hibernia Reef matrix in central eastern TSPZ. At the species level, a relatively large number of species showed moderately strong affinities for assemblage#5; those most aligned were: Actinopterygii: *Grammatobothus polyophthalmus*, *Pseudorhombus elevatus*, *Nemipterus peronii*, *Nemipterus hexodon*, *Repomucenus belcheri*, *Priacanthus tayenus*, *Saurida grandi/undosquamis*, *Pegasus volitans*, *Leiognathus leuciscus*, *Apistus carinatus*, *Pentaprion longimanus*, *Apogon truncatus*; Crustacea: *Portunus gracilimanus, Portunus hastatoides*, *Charybdis truncata*, *Scyllarus demani*, *Penaeus esculentus*; Bivalvia: *Placamen calophyllum*, *Amusium pleuronectes* cf; Cephalopoda: *Sepia elliptica*. [14]
	3	very similar to habitat type 1, being also very barren with very little epibenthos or algae, though sandier with less bioturbation — distributed in low current stress, high salinity, low phosphate, high silicate variability, muddy-sand areas located across and along the Great Northeast Channel in north-eastern TSPZ and spanning part of the northern trawl grounds.	5 [14]
	6	mostly rubbly with ~30% cover of sponge and other epibenthos gardens interspersed with ~15% cover of mixed algae and ~45% bare areas — distributed in high current stress, low	6. (see above)
			8. occurred in areas of high variability in temperature, low current stress, intermediate phosphate and low variability in salinity, distributed primarily in south central TSPZ between the lines of

HABITAT (BASED ON [13])	RELEVANT HABITAT TYPES [14, 27]	DESCRIPTION	ASSEMBLAGE
		phosphate, low sand, rubbly areas located along the western and Warrior lines of reefs and islands, and some inter-reef area of eastern TSPZ.	the western reefs and islands and the Warrior line of reefs. A few individual species had moderately weak affinities for assemblage#8; those most aligned were: Anthozoa: *Dichotella* sp1; Gastropoda: *Murex brevispina*; Actinopterygii: *Stolephorus* sp juv/unidentified; Gymnolaemata: *Parasmittina* spp. [14]
	7	similar to 6 though sandier with coarse sand and with ~45% cover of sponge and other epibenthos gardens interspersed with ~15% cover of mixed algae and ~40% bare areas — distributed in high current stress, low phosphate, high sand areas located along the western and Warrior lines of reefs and islands, and some inter-reef area of eastern TSPZ.	1. (see above) 5. (see above)
Reef flat (reef top and reef top buffer)	-	**Consolidated and unconsolidated substrate** in low-moderate energy environnments in lagoons and inner reef flats	13. Live coral cover between 1-4%; <1% soft coral cover; <1% seagrass cover; algae cover > 5% sponges. Crinoids, hydroids and sea urchins are the most common species groups [4]
Forereef zone (reef edge)	-	**Consolidated or unconsolidated substrate** located at high energy environments at reef edges, upper reef slopes and reef ledge < 20m deep	14. >5% coral live cover; >2% soft corals; algae cover <2%. Gorgonians and whip corals and crinoids are the most abundant species groups; fungiid corals are most abundant in this area (~0.5% cover) [4]
Deep reef	-	**Consolidated or unconsolidated substrate** located at deep (>20 m) outer reef edge and deep-reef lagoon.	15. Substrate is mostly barren. Filter feeders (whip corals, sponges and gorgonians) are the most frequently organisms found. Some corals, soft corals, algae and seagrass found but their percentage cover is low. < 1% coral cover, <1% soft coral cover; <0.5% seagrass cover; algae cover <2% whips, sponges and gorgonians are the most abundant species groups [4]

Scoping Document S2B2. Pelagic Habitats

Table 2.6. Pelagic habitats for the Torres Strait Bêche-de-mer Fishery. Shading denotes habitats occurring within the jurisdictional boundary of the fishery. Bold text refers to pelagic habitats where fishing effort has occurred.

ERAEF PELAGIC HABITAT NO.	PELAGIC HABITAT TYPE	DEPTH (M)	SOURCE
P1	Eastern Pelagic Province - Coastal	0 – 200	ERA pelagic habitat database based on pelagic communities definitions
P2	Eastern Pelagic Province - Oceanic	0 – > 600	ERA pelagic habitat database based on pelagic communities definitions

ERAEF PELAGIC HABITAT NO.	PELAGIC HABITAT TYPE	DEPTH (M)	SOURCE
P3	Heard/ McDonald Islands Pelagic Provinces - Oceanic	0 - >1000	ERA pelagic habitat database based on pelagic communities definitions
P4	North Eastern Pelagic Province - Oceanic	0 – > 600	ERA pelagic habitat database based on pelagic communities definitions
P5	**Northern Pelagic Province - Coastal**	**0 – 200**	**ERA pelagic habitat database based on pelagic communities definitions**
P6	North Western Pelagic Province - Oceanic	0 – > 800	ERA pelagic habitat database based on pelagic communities definitions
P7	Southern Pelagic Province - Coastal	0 – 200	ERA pelagic habitat database based on pelagic communities definitions
P8	Southern Pelagic Province - Oceanic	0 – > 600	ERA pelagic habitat database based on pelagic communities definitions
P9	Southern Pelagic Province - Seamount Oceanic	0 – > 600	ERA pelagic habitat database based on pelagic communities definitions
P10	Western Pelagic Province - Coastal	0 – 200	ERA pelagic habitat database based on pelagic communities definitions
P11	Western Pelagic Province - Oceanic	0 – > 400	ERA pelagic habitat database based on pelagic communities definitions
P12	Eastern Pelagic Province - Seamount Oceanic	0 – > 600	ERA pelagic habitat database based on pelagic communities definitions
P13	Heard/ McDonald Islands Pelagic Provinces - Plateau	0 -1000	ERA pelagic habitat database based on pelagic communities definitions
P14	North Eastern Pelagic Province - Coastal	0 – 200	ERA pelagic habitat database based on pelagic communities definitions
P15	North Eastern Pelagic Province - Plateau	0 – > 600	ERA pelagic habitat database based on pelagic communities definitions
P16	North Eastern Pelagic Province - Seamount Oceanic	0 – > 600	ERA pelagic habitat database based on pelagic communities definitions
P17	Macquarie Island Pelagic Province - Oceanic	0 – 250	ERA pelagic habitat database based on pelagic communities definitions
P18	Macquarie Island Pelagic Province - Coastal	0 - > 1500	ERA pelagic habitat database based on pelagic communities definitions

Scoping Document S2C1. Demersal Communities

In ERAEF, communities are defined as the set of species assemblages that occupy the large-scale provinces and biomes identified from national bioregionalisation studies. The biota includes mobile fauna, both vertebrate and invertebrate, but excludes sessile organisms such as corals that are largely structural and are used to identify benthic habitats. The same community lists are used for all fisheries, with those selected as relevant for a particular fishery being identified on the basis of spatial overlap with effort in the fishery. The spatial boundaries for demersal communities are based on IMCRA boundaries for the shelf, and on slope bioregionalisations for the slope [30, 31]. The spatial boundaries for the pelagic communities are based on pelagic bioregionalisations and on oceanography [32, 33]. Fishery and region-specific modifications to these boundaries are described in detail in [1] and briefly outlined in the footnotes to the community Tables below.

The area of the TSBDMF encompasses inner shelf and reef (0-110 m) North Eastern and Timor Transitions demersal communities. However, most of the catch and effort (Scoping Document S2B1) occurs on reefs in the North East Transition. The assemblages/communities described on the bioregionalisation [30, 31] were predominately focussed on fish assemblages/communities (not on invertebrates).

Table 2.7. Demersal communities in which fishing activity occurred in the Torres Strait Bêche-de-mer Fishery (x). Shaded cells indicate all communities within the province.

DEMERSAL COMMUNITY	CAPE	NORTH EASTERN TRANSITION	NORTH EASTERN	CENTRAL EASTERN TRANSITION	CENTRAL EASTERN	SOUTH EASTERN TRANSITION	CENTRAL BASS	TASMANIAN	WESTERN TAS TRANSITION	SOUTHERN	SOUTH WESTERN TRANSITION	CENTRAL WESTERN	CENTRAL WESTERN TRANSITION	NORTH WESTERN	NORTH WESTERN TRANSITION	TIMOR	TIMOR TRANSITION ARAFURA	TIMOR TRANSITION GROOTE	TIMOR TRANSITION CAPE YORK	TIMOR TRANSITION G. OF CARPENTARIA	HEARD & MCDONALD IS	MACQUARIE IS
Inner Shelf 0 – 110m [1,2]		X																	X	X		
Outer Shelf 110 – 250m [1,2,]																						
Upper Slope 250 – 565m [3]																						
Mid–Upper Slope 565 – 820m[3]																						
Mid Slope 820 – 1100m[3]																						
Lower slope/ Abyssal > 1100m[6]																						
Reef 0 -110m[7, 8]		X															X					
Reef 110-250m[8]																						
Seamount 0 – 110m																						

DEMERSAL COMMUNITY	CAPE	NORTH EASTERN TRANSITION	NORTH EASTERN	CENTRAL EASTERN TRANSITION	CENTRAL EASTERN	SOUTH EASTERN TRANSITION	CENTRAL BASS	TASMANIAN	WESTERN TAS TRANSITION	SOUTHERN	SOUTH WESTERN TRANSITION	CENTRAL WESTERN	CENTRAL WESTERN TRANSITION	NORTH WESTERN	NORTH WESTERN TRANSITION	TIMOR	TIMOR TRANSITION ARAFURA	TIMOR TRANSITION GROOTE	TIMOR TRANSITION CAPE YORK	TIMOR TRANSITION G. OF CARPENTARIA	HEARD & MCDONALD IS	MACQUARIE IS
Seamount 110- 250m																						
Seamount 250 – 565m																						
Seamount 565 – 820m																						
Seamount 820 – 1100m																						
Seamount 1100 – 3000m																						
Plateau 0 – 110m																						
Plateau 110- 250m[4]																						
Plateau 250 – 565m[4]																						
Plateau 565 – 820m[5]																						
Plateau 820 – 1100m[5]																						

[1] Four inner shelf communities occur in the Timor Transition (Arafura, Groote, Cape York and Gulf of Carpentaria) and three inner shelf communities occur in the Southern (Eyre, Eucla and South West Coast). At Macquarie Is: [2]inner & outer shelves (0-250m), and [3]upper and midslope communities combined (250-1100m). At Heard/McDonald Is: [4]outer and upper slope plateau communities combined to form four communities: Shell Bank, inner and outer Heard Plateau (100-500m) and Western Banks (200-500m), [5]mid and upper plateau communities combined into 3 trough (Western, North Eastern and South Eastern), southern slope and North Eastern plateau communities (500-1000m), and [6] 3 groups at Heard Is: Deep Shell Bank (>1000m), Southern and North East Lower slope/abyssal, [7]Great Barrier Reef in the North Eastern Province and Transition and [8] Rowley Shoals in North Western Transition.

Scoping Document S2C2. Pelagic Communities

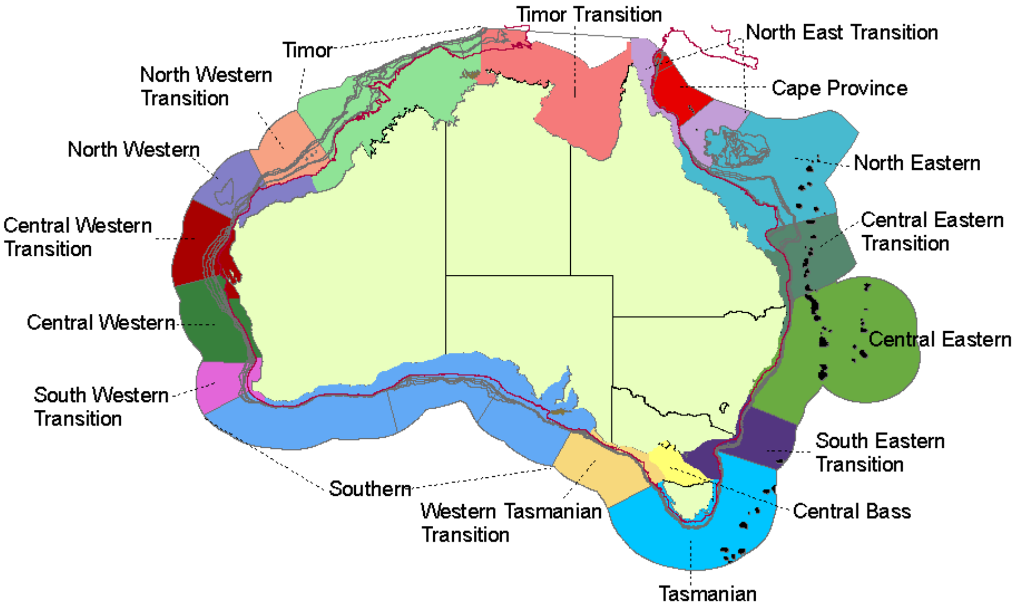
This fishery does not interact with pelagic communities, but the area of the TSBDMF encompasses coastal pelagic communities from the Northern Pelagic Province. However, most catch and effort (Scoping Document S2B1) occurs in northern east of Cape York.

Table 2.8. Pelagic communities in which fishing activity occurs in the Torres Strait Bêche-de-mer Fishery (x). Shaded cells indicate all communities that exist in the province.

PELAGIC COMMUNITY	NORTHEASTERN	EASTERN	SOUTHERN	WESTERN	NORTHERN NWS	NORTHERN BONAPARTE	NORTHERN ARAFURA	NORTHERN GULF	NORTHERN EAST CAPE YORK	NORTHWESTERN	HEARD AND MCDONALD IS2	MACQUARIE IS
Coastal pelagic 0-200m[1,2]								X	X			
Oceanic (1) 0 – 600m												
Oceanic (2) >600m												
Seamount oceanic (1) 0 – 600m												
Seamount oceanic (2) 600–												
Oceanic (1) 0 – 200m												
Oceanic (2) 200-600m												
Oceanic (3) >600m												
Seamount oceanic (1) 0 – 200m												
Seamount oceanic (2) 200 –												
Seamount oceanic (3) 600–												
Oceanic (1) 0-400m												
Oceanic (2) >400m												
Oceanic (1) 0-800m												
Oceanic (2) >800m												
Plateau (1) 0-600m												
Plateau (2) >600m												
Heard Plateau 0-1000m[3]												
Oceanic (1) 0-1000m												
Oceanic (2) >1000m												
Oceanic (1) 0-1600m												
Oceanic (2) >1600m												

[1] Northern Province has five coastal pelagic zones (NWS, Bonaparte, Arafura, Gulf and East Cape York) and Southern Province has two zones (Tas, GAB). [2] At Macquarie Is: coastal pelagic zone to 250m. [3] At Heard and McDonald Is: coastal pelagic zone broadened to cover entire plateau to maximum of 1000 m.

(a)



(b)

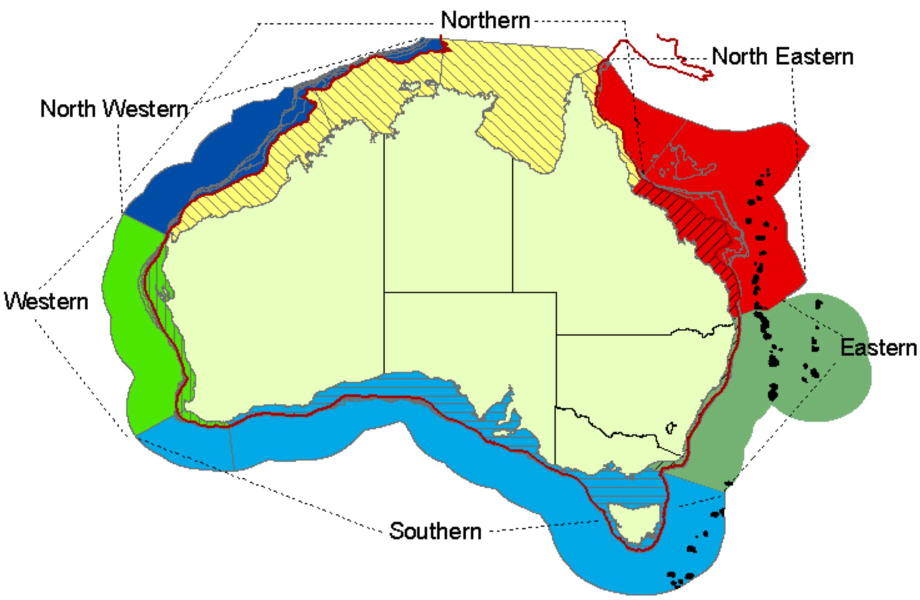


Figure 2.3 (a) Demersal communities around mainland Australia based on bioregionalisation schema [31]. Some inshore (0-110 m) communities comprise more than one community e.g. Timor Transition comprises 4 distinct communities. (b) Australian pelagic provinces. Hatched areas indicate coastal epipelagic zones overlying the shelf. Offshore (oceanic) provinces comprise two or more overlaying pelagic zones as indicated in Table 2.10. Seamounts (black) and plateaux (light green) are illustrated in their demersal or pelagic provinces.

2.2.3 Identification of objectives for components and sub-components (Step 3)

Objectives are identified for each sub-fishery for the five ecological components (target, bycatch/byproduct, protected species, habitats, and communities) and sub-components, and are clearly documented. It is important to identify objectives that managers, the fishing industry, and other stakeholders can agree on, and that scientists can quantify and assess. The criteria for selecting ecological operational objectives for risk assessment are that they:

- be biologically relevant;
- have an unambiguous operational definition;
- be accessible to prediction and measurement; and
- that the quantities they relate to be exposed to the hazards.

For fisheries that have completed Ecological Sustainable Development (ESD) reports, use can be made of the operational objectives stated in those reports.

Each 'operational objective' is matched to example indicators. **Scoping Document S3** provides suggested examples of operational objectives and indicators. Where operational objectives are already agreed for a fishery (Existing Management Objectives; EMOs), those should be used (e.g. Strategic Assessment Reports). The objectives need not be exactly specified, with regard to numbers or fractions of removal/impact, but should indicate that an impact in the sub-component is of concern/interest to the sub-fishery. The rationale for including or discarding an operational objective is a crucial part of the table and must explain why the particular objective has or has not been selected for in the (sub) fishery. Only the operational objectives selected for inclusion in the (sub) fishery are used for Level 1 analysis (**Level 1 SICA Document L1.1**).

Scoping Document S3. Components and sub-components identification of objectives

Table 2.9. Components and sub-components identification of operational objectives and rationale. Operational objectives that are eliminated are shaded out. EMO: Existing Management Objective; AMO: Existing AFMA Objective. Cells that are not relevant to this ERA are coloured in grey.

COMPONENT	CORE OBJECTIVE	SUB-COMPONENT	EXAMPLE OPERATIONAL OBJECTIVES	EXAMPLE INDICATORS	RATIONALE
Key Commercial and secondary commercial species	All objectives of the TSF Act are relevant: a) to acknowledge and protect the traditional way of life and livelihood of traditional inhabitants, including their rights in relation to traditional fishing[11]; b) to protect and preserve the marine environment and indigenous fauna and flora in and in the vicinity of the Protected Zone; c) to adopt conservation measures necessary for the conservation of a species in such a way as	1. Population size	1.1 No trend in biomass 1.2 Maintain biomass above a specified level 1.3 Maintain catch at specified level 1.4 Species do not approach extinction or become extinct	Biomass, numbers, density, CPUE, yield	1.1 Increases in biomass of the key/secondary commcerical species would be acceptable. 1.2. To ensure that population at acceptable level by the assessment. 1.3. TAC levels are specified. 1.4. Additional objectives with regards to this addressed by the EPBC Act – inc expectation for CITES listed species such as black and white teatfish. In general these objectives underlie the sustainable management of the Fishery.
		2. Geographic range	2.1 Geographic range of the population, in terms of size and continuity does not change outside acceptable bounds	Presence of population across the known distribution range	2.1 this is monitored to a certain extent through a time series of fishery independent surveys.
		3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (N_e), number of spawning units	3.1 Studies of the genetic structure of Sandfish in the Northern Territory (NT) showed two distinct populations occurring in the Arafura Sea and the Gulf of Carpentaria, with results also indicating limited larval dispersal [34]. Another study for Black teatfish on the Great Barrier Reef showed no significant genetic structure [35]. Given differences at a regional scale for the NT and little difference across the whole GBR, the genetic structure of sea cucumber species in Torres Strait is likely to be one stock.

[11] Traditional fishing means non-commercial fishing as defined in the TSF Act.

COMPONENT	CORE OBJECTIVE	SUB-COMPONENT	EXAMPLE OPERATIONAL OBJECTIVES	EXAMPLE INDICATORS	RATIONALE
	to minimise any restrictive effects of the measures on traditional fishing; d) to manage the fishery for optimum utilisation; e) to have regard, in developing and implementing licensing policy, to the desirability of promoting economic development in the Torres Strait area and employment opportunities for traditional inhabitants These management objectives can be grouped into the following objectives: Avoid recruitment failure of the key/secondary commcercial species Avoid negative consequences for species or population sub-components	4. Age/size/sex structure	4.1 Age/size/sex structure does not change outside acceptable bounds (e.g. more than X% from reference structure)	Biomass, numbers or relative proportion in age/size/sex classes Biomass of spawners Mean size, sex ratio	4.1 Covered in general by 1.2. Overall, survey data show a healthy fishery with the potential to provide moderate long-term income to local Islander communities [4]
		5. Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity) 5.2 Recruitment to the population does not change outside acceptable bounds	Egg production of population Abundance of recruits	5.1 Covered by 1.2.Reproductive capacity in terms of egg production may be easier to monitor via changes in Age/size/sex structure. 5.2 Covered by 1.2. May be easier to monitor via changes in Age/size/sex structure in the fishery.
		6. Behaviour /Movement	6.1 Behaviour and movement patterns of the population do not change outside acceptable bounds	Presence of population across space, movement patterns within the population (e.g. attraction to lights)	6.1. Changes behavior that are deleterious to the species and populations are to be avoided. Covered by 1.2.

COMPONENT	CORE OBJECTIVE	SUB-COMPONENT	EXAMPLE OPERATIONAL OBJECTIVES	EXAMPLE INDICATORS	RATIONALE
Byproduct and Bycatch	TSF Act objectives: a-c Avoid recruitment failure of the byproduct and bycatch species Avoid negative consequences for species or population sub-components	1. Population size	1.1 No trend in biomass 1.2 Species do not approach extinction or become extinct 1.3 Maintain biomass above a specified level 1.4 Maintain catch at specified level	Biomass, numbers, density, CPUE, yield	1.1 Increases in biomass of the key/secondary commcerical species would be acceptable. 1.2. To ensure that population at acceptable level by the assessment. 1.3. TAC levels are specified. 1.4. Maintaining bycatch / byproduct levels is not a specific objective but an indirect one related to TSF Act objective b.
		2. Geographic range	2.1 Geographic range of the population, in terms of size and continuity does not change outside acceptable bounds	Presence of population across space	2.1 Not currently monitored. No specific management objective based on the geographic range of byproduct/bycatch species. No specific management objective based on the geographic range of bycatch/byproduct species as no bycatch/byproduct in the fishery.
		3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (N_e), number of spawning units	3.1 Not currently monitored. No reference levels established. No specific management objective based on the genetic structure of bycatch species. no bycatch/byproduct in the fishery.
		4. Age/size/sex structure	4.1 Age/size/sex structure does not change outside acceptable bounds (e.g. more than X% from reference structure)	Biomass, numbers or relative proportion in age/size/sex classes Biomass of spawners Mean size, sex ratio	4.1Not relevant to TSBDMF as no bycatch/byproduct in the fishery.
		5 Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity) Recruitment to the population does not change outside	Egg production of population Abundance of recruits	5.1. 1Not relevant to TSBDMF as no bycatch/byproduct in the fishery

COMPONENT	CORE OBJECTIVE	SUB-COMPONENT	EXAMPLE OPERATIONAL OBJECTIVES	EXAMPLE INDICATORS	RATIONALE
			acceptable bounds		
		6. Behaviour /Movement	6.1 Behaviour and movement patterns of the population do not change outside acceptable bounds	Presence of population across space, movement patterns within the population (e.g. attraction to bait, lights)	6.1 Not relevant to TSBDMF as no bycatch/byproduct in the fishery.
Protected species	TSF Act objectives: a-e Avoid recruitment failure of protected species Avoid negative consequences for protected species or population sub-components Avoid negative impacts on the population from fishing	1. Population size	1.1 Species do not further approach extinction or become extinct 1.2 No trend in biomass 1.3 Maintain biomass above a specified level 1.4 Maintain catch at specified level	Biomass, numbers, density, CPUE, yield	1.1 The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species. 1.2 A positive trend in biomass is desirable for protected species. 1.3 Maintenance of protected species biomass above specified levels not currently a fishery operational objective. 1.4 Not currently a fishery operational objective.
		2. Geographic range	2.1 Geographic range of the population, in terms of size and continuity does not change outside acceptable bounds	Presence of population across space, i.e. the Southern Ocean	2.1 Change in geographic range of protected species may have serious consequences e.g. population fragmentation and/or forcing species into sub-optimal areas.
		3. Genetic structure	3.1 Genetic diversity does not change outside acceptable bounds	Frequency of genotypes in the population, effective population size (N_e), number of spawning units	3.1 Because population size of protected species is often small, protected species are sensitive to loss of genetic diversity. Genetic monitoring may be an effective approach to measure possible fishery impacts.
		4. Age/size/sex structure	4.1 Age/size/sex structure does not change outside	Biomass, numbers or relative proportion in	4.1 Monitoring the age/size/sex structure of protected species populations is a useful management tool allowing the identification of possible fishery

COMPONENT	CORE OBJECTIVE	SUB-COMPONENT	EXAMPLE OPERATIONAL OBJECTIVES	EXAMPLE INDICATORS	RATIONALE
			acceptable bounds (e.g. more than X% from reference structure)	age/size/sex classes Biomass of spawners Mean size, sex ratio	impacts and that cross-section of the population most at risk.
		5. Reproductive Capacity	5.1 Fecundity of the population does not change outside acceptable bounds (e.g. more than X% of reference population fecundity) Recruitment to the population does not change outside acceptable bounds	Egg production of population Abundance of recruits	5.1 The reproductive capacity of protected species is not of concern to this fishery because potential fishery induced changes in reproductive ability (e.g. reduction in prey items may critically affect seabird brooding success) may have immediate impact on the population size of protected species.
		6. Behaviour /Movement	6.1 Behaviour and movement patterns of the population do not change outside acceptable bounds	Presence of population across space, movement patterns within the population (e.g. attraction to bait, lights)	6.1 BDM fishing operations are very unlikely to alter behaviour and movement patterns of protected species (Turtles and Dugongs) because boats are small, Dugongs are more frequent on the Western size (where fishery is minimal).
		7. Interactions with fishery	7.1 Survival after interactions is maximised 7.2 Interactions do not affect the viability of the population or its ability to recover	Survival rate of species after interactions Number of interactions, biomass or numbers in population	7.1, 7.2 The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species. Fishery is by hand collection, waste, and discards are minimal and not relevant to protected species of interest. Interactions with protected species are therefore minimal and attraction of the vessel is null.
Habitats	TSF Act objectives: a-c Avoid negative impacts on quality of environment Avoid reduction in	1. Water quality	1.1 Water quality does not change outside acceptable bounds	Water chemistry, noise levels, debris levels, turbidity levels, pollutant concentrations, light pollution from artificial light	1.1 EMO control the discharge or discarding of waste and limit lighting on the vessels. MARPOL regulations prohibit discharge of oils, discarding of plastics.
		2. Air quality	2.1 Air quality does not	Air chemistry, noise levels,	2.1 Not currently perceived as an important habitat sub-component,

COMPONENT	CORE OBJECTIVE	SUB-COMPONENT	EXAMPLE OPERATIONAL OBJECTIVES	EXAMPLE INDICATORS	RATIONALE
	the amount and quality of habitat		change outside acceptable bounds	visual pollution, pollutant concentrations, light pollution from artificial light	seining operations not believed to strongly influence air quality.
		3. Substrate quality	3.1 Sediment quality does not change outside acceptable bounds	Sediment chemistry, stability, particle size, debris, pollutant concentrations	3.1 The scale of operation of the fishery is small, with boats <7m using outboard engines. Skippers would try as much as possible to minimise impacts on benthic habitats due to risk of damage to vessels. Accidental interaction with benthic habitats may occur but scale of impacts would be very small and localised.
		4. Habitat types	4.1 Relative abundance of habitat types does not vary outside acceptable bounds	Extent and area of habitat types, % cover, spatial pattern, landscape scale	4.1 Although sea cucumbers are hand collected and direct impacts of it is likely to be minimal, the fishing activity also involves walking over reef areas and snorkeling, which may result in changes to the local habitat types on fishing grounds.
		5. Habitat structure and function	5.1 Size, shape and condition of habitat types does not vary outside acceptable bounds	Size structure, species composition and morphology of biotic habitats	5.1 Although sea cucumbers are hand collected and direct impacts of it is likely to be minimal, the fishing activity also involves walking over reef areas and snorkeling, which may result in local disruption to benthic processes.
Communities	TSF Act objectives: a-c Avoid negative impacts on the composition/function/distribution/structure of the community	1. Species composition	1.1 Species composition of communities does not vary outside acceptable bounds	Species presence/absence, species numbers or biomass (relative or absolute) Richness Diversity indices Evenness indices	1.1 The fishery is conducted, in a manner that minimises the impact of fishing operations on the ecosystem generally.
		2. Functional group composition	2.1 Functional group composition does not change outside acceptable bounds	Number of functional groups, species per functional group (e.g. autotrophs, filter feeders, herbivores,	2.1 The presence/abundance of 'functional group' members may fluctuate widely, however in terms of maintenance of ecosystem processes it is important that the aggregate effect of a functional group is maintained.

COMPONENT	CORE OBJECTIVE	SUB-COMPONENT	EXAMPLE OPERATIONAL OBJECTIVES	EXAMPLE INDICATORS	RATIONALE
				omnivores, carnivores)	
		3. Distribution of the community	3.1 Community range does not vary outside acceptable bounds	Geographic range of the community, continuity of range, patchiness	3.1 Although sea cucumbers are hand collected and direct impacts of tis likely to be minimal, the fishing activity also involves walking over reef areas and snorkeling, which impacts on the benthos in the fishing grounds. The current MPA and conservation areas reserve large areas of the known habitat types from fishing disturbance.
		4. Trophic/size structure	4.1 Community size spectra/trophic structure does not vary outside acceptable bounds	Size spectra of the community Number of octaves, Biomass/number in each size class Mean trophic level Number of trophic levels	4.1 Fishing for key/secondary commercial species have the potential to remove a significant component of the detritivore functional group with unknown consequences in the food web and. other trophic groups.
		5. Bio- and geo-chemical cycles	5.1 Cycles do not vary outside acceptable bounds	Indicators of cycles, salinity, carbon, nitrogen, phosphorus flux	5.1 Sea cucumbers play an important role in nutrient recyclying. Over-explitation of sea cucumbers is know to reduce nutrient recycling, thus affecting biogeochemical cycles.

2.2.4 Hazard Identification (Step 4)

Hazards are the activities undertaken in the process of fishing, and any external activities, which have the potential to lead to harm.

The effects of fishery/sub-fishery specific hazards are identified under the following categories:

- capture
- direct impact without capture
- addition/movement of biological material
- addition of non biological material
- disturbance of physical processes
- external hazards

These fishing and external activities are scored on a presence/absence basis for each fishery/sub-fishery. An activity is scored as a zero if it does not occur and as a one if it does occur. The rationale for the scoring is also documented in detail and must include if/how the activity occurs and how the hazard may impact on organisms/habitat.

Scoping Document S4. Hazard Identification Scoring Sheet

This table is completed once. Table 2.11 provides a set of examples of fishing activities for the effects of fishing to be used as a guide to assist in scoring the hazards.

Fishery name: Torres Strait Bêche-de-mer Fishery

Date completed: June 2021

Table 2.10. Hazard identification, score and rationale(s) for the Torres Strait Bêche-de-mer Fishery.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	SCORE (0/1)	DOCUMENTATION OF RATIONALE
Capture	Bait collection	0	Not required by this fishery method.
	Fishing	1	Most of the fishing occurs at the Great North East Channel, Don Cay, Darnley Island, Cumberland Channel and Great Barrier Reef regions, which maximum diagonal in the area is ~90NM so in the 10-100 miles range (3), but there may be occasional longer trips as the maximum diagonal for the whole fishing area is ~200NM so used (4) (100-500nm). In terms of temporal scale of fishing activity, the data from 2017-19 suggests this is a daily activity. Although there are overlapping fishing days among fishers s (i.e. total days fishing for the period (1558)/ yearly average (519) > 365 days), it seems fishing happens quite often. Therefore, we assume this is a 'daily' activity (score 6) and revise if additional temporal data is available.
	Incidental behaviour	1	Sea cucumbers are not used traditionally but are exported - traditional / subsistence fishing of non sea cucumber species may occur. For example, fishers may catch finfish or other species during BDM fishing trips for personal consumption (considered as traditional fishing).
	Bait collection	0	Does not occur

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	SCORE (0/1)	DOCUMENTATION OF RATIONALE
Direct impact without capture	Fishing	1	Fishing occurs mostly on coral reef shallow (0-10m) waters, resulting on impacts on benthic orghanisms via trampling or movement underwater. Dry picking' or 'walking the reef' occurs occasionally in the fishery with most of the catch being taken whilst diving. Prickly redfish, curry fish and white teatfish can only be taken by diving. The only species that may be taken by 'dry picking', include species that are infrequently targeted such as stone fish, black fish, deepwater redfish, lolly fish, leopard fish and green fish (HCRAG 6-7 October 2021)
	Incidental behaviour	1	Sea cucumbers are not used traditionally but are exported - traditional / subsistence fishing of non sea cucumber species may occur as fishers may catch some marine species for personal consumption or subsistence during BDM fishing trips (considered as traditional fishing).
	Gear loss	0	Species are harvested by hand.
	Anchoring/ mooring	1	Fishing involves the use of small (<7 m) boats operating at shallow waters (0-10). Anchors are therefore small and intensity of impacts is minor as restricted to areas where fishing is more intense but detectability is difficult due to small size of boats.
	Navigation/steaming	1	As fishing occurs in shallow coral reef areas (0-10 m), steaming/navigation to fishing grounds may result in collisions with benthos (e.g. seagrasses, sponges, coral reefs, macrolage) and species such as turtles and, to a lesser extent, dugongs (because they are mostly found on central and western parts of Torres Strait and fisheries occurs mostly on the East. intensity is negligible as boat skippers will try to avoid damage to hull of boats as much as possible and therefore, very difficult to detect at any scale.
Addition/ movement of biological material	Translocation of species	0	Translocation via hull and anchor fouling unlikely as boats operate locally within same fishery area and no aquaculutre in the region that could introduce new species.
	On board processing	0	No onboard processing. Fishers catch sea cucumbers alive and keep them in bilges, tanks or nally bins onboard until they can be processed at facilities.
	Discarding catch	1	Discarding is uncommon, mostly associated with autotomy (e.g. evisceration / falling apart) which makes it difficult to process.
	Stock enhancement	0	None occurs
	Provisioning	0	None occurs
	Organic waste disposal	1	Some food (uncontaminated) may be discharged into the sea while fishers are fishing, on camps, or in transit. MARPOL regulations via Protection of the Sea (Prevention of Pollution from Ships) Act 1983 prohibits food waste if contaminated by any other garbage types.
Addition of non-biological material	Debris	0	MARPOL regulations via Protection of the Sea (Prevention of Pollution from Ships) Act 1983 prohibits rubbish generated during general fishing vessel operations to be discharged at sea. Rubbish must be collected onboard and disposed of ashore. No evidence of disposal of marine debris found.
	Chemical pollution	1	MARPOL regulations via Protection of the Sea (Prevention of Pollution from Ships) Act 1983 prohibits domestic and operational waste discharge from vessels. Leakage of substances such as fuel, oil, bilge discharges, natural decay of antifouling agents may occur in normal course of operations.
	Exhaust	1	Vessels introduce exhaust into the environment resulting in noise and impact air quality within shallow reef areas.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	SCORE (0/1)	DOCUMENTATION OF RATIONALE
	Gear loss	0	No gear used for fishing sea cucumbers so accidental gear losses is extremely unlikely.
	Navigation/ steaming	1	Navigation to and from fishing grounds introduces noise and visual stimuli into the environment. Depth sounders have potential to disturb sea cucumbers and other species like corals, fish, dugongs and turtles.
	Activity/ presence on water	1	Fishing for sea cucumbers involves diving in shallow waters. Vessels and divers introduce noise and visual stimuli in the environment which may result in changes in behaviour of sea cucumbers and interfere with biological processes of coral reef organisms, such as corals, fish and algae. Sea cucumbers can detect sound [36].
Disturb physical processes	Bait collection	0	Bait not required by fishery.
	Fishing	1	Fishing is by hand collection and involves diving and walking on coral reefs (lagoons, hard substrates and passes). Trampling and movement of hands / flippers underwater may disturb seabed sediments and break corals, and damage seagrass beds, sponges and algae.
	Boat launching	1	Some boats used in the fishery are stored on beaches / out of the water and dragged into the water when needed. Movement of the boat in and out of the water can break corals, and damage seagrass beds, sponges, algae and other benthic organisms.
	Anchoring/ mooring	0	Anchors used in the fishery are relatively small as used in boats <7 m long and unlikely to affect the physical processes in the area.
	Navigation/ steaming	1	Navigation /steaming may affect the physical processes on the benthos by turbulent action of propellers or wake formation on shallow waters. The fishery uses relative small (<7 m) boats and engines.
External Hazards	Other capture fishery methods	1	Other Torres Strait fisheries may operate on same fishing grounds (e.g. finfish, Rock Lobster). Fishers (divers), gear (e.g., line, hook, spearguns) and boat operation may accidentally interact with sea cucumbers.
	Aquaculture	0	None happening at this stage that would have any kind of impact on the TSBDMF due to the extremely low and localised nature of farms.
	Coastal development	1	Coastal development has caused localised pollution (e.g. oil spills, sewage contamination) in some Islands (e.g. Boigu, Iama), and caused increase in sediment runoff from coastal developments in the Fly river (Saibai, Dauan and Boigu). These impacts can affect coral reef and seagrass habitats via smothering, increased turbidity and reduction in light penetration. Sewage contamination can also facilitate growth of algae which may outcompete corals for space.
	Other extractive activities	0	No oil and gas extractive activities in Torres Strait.
	Other non-extractive activities	1	Major shipping activity in Torres Strait, which produce noise, which can affect sea cucumbers and coral reef organisms. There is also the potential leakage of contaminants from antifouling paints.
	Other anthropogenic activities	1	Charter boats can introduce noise and pollution (oil) into the environment. Oil contamination can negatively affect sea cucumbers directly and their habitats.

Table 2.11. Examples of fishing activities (modified from [37]).

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	EXAMPLES OF ACTIVITIES INCLUDE
Capture		Activities that result in the capture or removal of organisms. This includes cryptic mortality due to organisms being caught but dropping out prior to the gear's retrieval (i.e. They are caught but not landed).
	Bait collection	Capture of organisms due to bait gear deployment, retrieval and bait fishing. This includes organisms caught but not landed.
	Fishing	Capture of organisms due to gear deployment, retrieval and actual fishing. This includes organisms caught but not landed.
	Incidental behaviour	Capture of organisms due to crew behaviour incidental to primary fishing activities, possible in the crew's down time; e.g. crew may line or spear fish while anchored, or perform other harvesting activities, including any land-based harvesting that occurs when crew are camping in their down time.
Direct impact, without capture		This includes any activities that may result in direct impacts (damage or mortality) to organisms without actual capture.
	Bait collection	Direct impacts (damage or mortality) to organisms due to interactions (excluding capture) with bait gear during deployment, retrieval and bait fishing. This includes: damage/mortality to organisms through contact with the gear that doesn't result in capture, e.g. Damage/mortality to benthic species by gear moving over them, organisms that hit nets but aren't caught.
	Fishing	Direct impacts (damage or mortality) to organisms due to interactions (excluding capture) with fishing gear during deployment, retrieval and fishing. This includes: damage/mortality to organisms through contact with the gear that doesn't result in capture, e.g. Damage/mortality to benthic species by gear moving over them, organisms that hit nets but are not caught.
	Incidental behaviour	Direct impacts (damage or mortality) without capture, to organisms due to behaviour incidental to primary fishing activities, possibly in the crew's down time; e.g. the use of firearms on scavenging species, damage/mortality to organisms through contact with the gear that the crew use to fish during their down time. This does not include impacts on predator species of removing their prey through fishing.
	Gear loss	Direct impacts (damage or mortality), without capture on organisms due to gear that has been lost from the fishing boat. This includes damage/mortality to species when the lost gear contacts them or if species swallow the lost gear.
	Anchoring/ mooring	Direct impact (damage or mortality) that occurs and when anchoring or mooring. This includes damage/mortality due to physical contact of the anchor, chain or rope with organisms, e.g. An anchor damaging live coral.
	Navigation/ steaming	Direct impact (damage or mortality) without capture may occur while vessels are navigating or steaming. This includes collisions with marine organisms or birds.
Addition/ movement of biological material		Any activities that result in the addition or movement of biological material to the ecosystem of the fishery.
	Translocation of species (boat movements, reballasting)	The translocation and introduction of species to the area of the fishery, through transportation of any life stage. This transport can occur through movement on boat hulls or in ballast water as boats move throughout the fishery or from outside areas into the fishery.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	EXAMPLES OF ACTIVITIES INCLUDE
	On board processing	The discarding of unwanted sections of target after on board processing introduces or moves biological material, e.g. heading and gutting, retaining fins but discarding trunks.
	Discarding catch	The discarding of unwanted organisms from the catch can introduce or move biological material. This includes individuals of target and byproduct species due to damage (e.g. shark or marine mammal predation), size, high grading and catch limits. Also includes discarding of all non-retained bycatch species. This also includes discarding of catch resulting from incidental fishing by the crew. The discards could be alive or dead.
	Stock enhancement	The addition of larvae, juveniles or adults to the fishery or ecosystem to increase the stock or catches.
	Provisioning	The use of bait or berley in the fishery.
	Organic waste disposal	The disposal of organic wastes (e.g. food scraps, sewage) from the boats.
Addition of non-biological material		Any activities that result in non-biological material being added to the ecosystem of the fishery, this includes physical debris, chemicals (in the air and water), lost gear, noise and visual stimuli.
	Debris	Non-biological material may be introduced in the form of debris from fishing vessels or mother ships. This includes debris from the fishing process: e.g. cardboard thrown over from bait boxes, straps and netting bags lost. Debris from non-fishing activities can also contribute to this e.g. Crew rubbish – discarding plastics or other rubbish. Discarding at sea is regulated by MARPOL, which forbids the discarding of plastics.
	Chemical pollution	Chemicals can be introduced to water, sediment and atmosphere through: oil spills, detergents other cleaning agents, any chemicals used during processing or fishing activities.
	Exhaust	Exhaust can be introduced to the atmosphere and water through operation of fishing vessels.
	Gear loss	The loss of gear will result in the addition of non-biological material, this includes hooks, line, sinkers, nets, otter boards, light sticks, buoys etc.
	Navigation /steaming	The navigation and steaming of vessels will introduce noise and visual stimuli into the environment. Boat collisions and/or sinking of vessels. Echo-sounding may introduce noise that may disrupt some species (e.g. whales, orange roughy)
	Activity /presence on water	The activity or presence of fishing vessels on the water will noise and visual stimuli into the environment.
Disturb physical processes		Any activities that will disturb physical processes, particularly processes related to water movement or sediment and hard substrate (e.g. boulders, rocky reef) processes.
	Bait collection	Bait collection may disturb physical processes if the gear contacts seafloor-disturbing sediment, or if the gear disrupts water flow patterns.
	Fishing	Fishing activities may disturb physical processes if the gear contacts seafloor-disturbing sediment, or if the gear disrupts water flow patterns.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	EXAMPLES OF ACTIVITIES INCLUDE
	Boat launching	Boat launching may disturb physical processes, particularly in the intertidal regions, if dredging is required, or the boats are dragged across substrate. This would also include foreshore impacts where fishers drive along beaches to reach fishing locations and launch boats. Impacts of boat launching that occurs within established marinas are outside the scope of this assessment.
	Anchoring /mooring	Anchoring/mooring may affect the physical processes in the area that anchors and anchor chains contact the seafloor.
	Navigation /steaming	Navigation /steaming may affect the physical processes on the benthos and the pelagic by turbulent action of propellers or wake formation.
External hazards		Any outside activities that will result in an impact on the component in the same location and period that the fishery operates. The particular activity as well as the mechanism for external hazards should be specified.
	Other capture fishery methods	Take or habitat impact by other commercial, indigenous or recreational fisheries operating in the same region as the fishery under examination.
	Aquaculture	Capture of feed species for aquaculture. Impacts of cages on the benthos in the region.
	Coastal development	Sewage discharge, ocean dumping, agricultural runoff.
	Other extractive activities	Oil and gas pipelines, drilling, seismic activity.
	Other non-extractive activities	Defense, shipping lanes, dumping of munitions, submarine cables.
	Other anthropogenic activities	Recreational activities, such as scuba diving leading to coral damage, power boats colliding with whales, dugongs, turtles. Shipping, oil spills.

2.2.5 Bibliography (Step 5)

All references used in the scoping assessment are included in the References section.

Key documents can be found on the PZJA web page at https://www.pzja.gov.au and include the following:

- The Harvest Strategy for the fishery outlines the species categories as at November 2019. https://www.pzja.gov.au/sites/default/files/bdm_harvest_strategy_adopted_nov_2019.pdf
- Sea cucumber surveys (2009)
- Bycatch Action Plans and implementation reports
- Bêche-de-mer catch watch reports: https://www.pzja.gov.au/fishery-catch-watch-reports
- Relevant legislation

Other publications that provided information include

- ABARES Fishery Status Reports [5]
- Assessment of the Torres Strait Bêche-de-mer fishery [38]
- The species i.d. guide [4], which also provides an indication of the relative value of these species: https://www.pzja.gov.au/sites/default/files/torres_strait_bdm_id_guide_2019_web_version.pdf

2.2.6 Decision rules to move to Level 1 (Step 6)

Any hazards that are identified at Step 4 Hazard Identification as occurring in the fishery are carried forward for analysis at Level 1. In this case, 19 out of 26 possible internal activities were identified as occurring in this fishery. Four external scenarios were also identified. Thus, a total of 23 activity-component scenarios will be considered at Level 1. This results in 69 (i.e., excluding bycatch, byproduct, and protected species x direct impact by capture activity) total scenarios (of 160 possible) to be developed and evaluated using the unit lists (key commercial/secondary, habitats, communities).

2.3 Level 1 Scale, Intensity and Consequence Analysis (SICA)

Level 1 aims to identify which hazards lead to a significant impact on any species, habitat or community. Analysis at Level 1 is for whole components (key/secondary commercial; bycatch and byproduct; protected species; habitat; and communities), not individual sub-components. Since Level 1 is used mainly as a rapid screening tool, a "worst case" approach is used to ensure that elements screened out as low risk (either activities or components) are genuinely low risk. Analysis at Level 1 for each component is accomplished by considering the most vulnerable sub-component and the most vulnerable unit of analysis (e.g. most vulnerable species, habitat type or community). This is known as credible scenario evaluation (Richard Stocklosa e-systems Pty Ltd (March 2003) Review of CSIRO Risk Assessment Methodology: ecological risk assessment for the effects of fishing) in conventional risk assessment. In addition, where judgments about risk are uncertain, the highest level of risk that is still regarded as plausible is chosen. For this reason, the measures of risk produced at Level 1 cannot be regarded as absolute.

At Level 1 each fishery/sub-fishery is assessed using a scale, intensity and consequence analysis (SICA). SICA is applied to the component as a whole by choosing the most vulnerable sub-component (linked to an operational objective) and most vulnerable unit of analysis. The rationale for these choices must be documented in detail. These steps are outlined below. Scale, intensity, and consequence analysis (SICA) consists of thirteen steps. The first ten steps are performed for each activity and component, and correspond to the columns of the SICA table. The final three steps summarise the results for each component.

Step1. Record the hazard identification score (absence (0) presence (1) scores) identified at Step 3 at the scoping level (Scoping Document S3) onto the SICA table

Step 2. Score spatial scale of the activity

Step 3. Score temporal scale of the activity

Step 4. Choose the sub-component most likely to be affected by activity

Step 5. Choose the most vulnerable unit of analysis for the component e.g. species, habitat type or community assemblage

Step 6. Select the most appropriate operational objective

Step 7. Score the intensity of the activity for that sub-component

Step 8. Score the consequence resulting from the intensity for that sub component

Step 9. Record confidence/uncertainty for the consequence scores

Step 10. Document rationale for each of the above steps

Step 11. Summary of SICA results

Step 12. Evaluation/discussion of Level 1

Step 13. Components to be examined at Level 2

2.3.1 Record the hazard identification score (absence (0) presence (1) scores) identified at step 3 in the scoping level onto the SICA Document (Step 1)

Record the hazard identification score absence (0) presence (1) identified at Step 3 at the scoping level onto the SICA sheet. A separate sheet will be required for each component (key/secondary commercial, bycatch and byproduct, and protected species, habitat and communities). Only those activities that scored a 1 (presence) will be analysed at Level 1.

2.3.2 Score spatial scale of activity (Step 2)

The greatest spatial extent must be used for determining the spatial scale score for each identified hazard. For example, if fishing (e.g. capture by longline) takes place within an area of 200 nm by 300 nm, then the spatial scale is scored as 4. The score is then recorded onto the SICA Document and the rationale documented.

Table 2.12. Spatial scale score of activity.

<1 NM	1-10 NM	10-100 NM	100-500 NM	500-1000 NM	>1000 NM
1	2	3	4	5	6

Maps and graphs may be used to supplement the information (e.g. sketches of the distribution of the activity relative to the distribution of the component) and additional notes describing the nature of the activity should be provided. The spatial scale score at Step 2 is not used directly, but the analysis is used in making judgments about level of intensity at Step 7. Obviously, two activities can score the same with regard to spatial scale, but the intensity of each can differ vastly. The reasons for the score are recorded in the rationale column of the SICA spreadsheet.

2.3.3 Score temporal scale of activity (Step 3)

The highest frequency must be used for determining the temporal scale score for each identified hazard. If the fishing activity occurs daily, the temporal scale is scored as 6. If oil spillage occurs about once per year, then the temporal scale of that hazard scores a 3. The score is then recorded onto the SICA Document and the rationale documented.

Table 2.13. Temporal scale score of activity.

DECADAL (1 DAY EVERY 10 YEARS OR SO)	EVERY SEVERAL YEARS (1 DAY EVERY SEVERAL YEARS)	ANNUAL (1-100 DAYS PER YEAR)	QUARTERLY (100-200 DAYS PER YEAR)	WEEKLY (200-300 DAYS PER YEAR)	DAILY (300-365 DAYS PER YEAR)
1	2	3	4	5	6

It may be more logical for some activities to consider the aggregate number of days that an activity occurs. For example, if the activity “fishing” was undertaken by 10 boats during the same 150 days of the year, the score is 4. If the same 10 boats each spend 30 non-overlapping days fishing, the temporal scale of the activity is a sum of 300 days, indicating that a score of 6 is appropriate. In the case where the activity occurs over many days, but only every 10 years, the number of days by the number of years in the cycle is used to determine the score. For example, 100 days of an activity every 10 years averages to 10 days every year, so that a score of 3 is appropriate.

The temporal scale score at Step 3 is not used directly, but the analysis is used in making judgments about level of intensity at Step 7. Obviously, two activities can score the same with regard to temporal scale, but the intensity of each can differ vastly. The reasons for the score are recorded in the rationale column.

2.3.4 Choose the sub-component most likely to be affected by activity (Step 4)

The most vulnerable sub-component must be used for analysis of each identified hazard. This selection must be made on the basis of expected highest potential risk for each 'direct impact of fishing' and 'fishing activity' combination, and recorded in the 'sub-component' column of the SICA Document. The justification is recorded in the rationale column.

2.3.5 Choose the unit of analysis most likely to be affected by activity and to have highest consequence score (Step 5)

The most vulnerable 'unit of analysis' (i.e. most vulnerable species, habitat type or community) must be used for analysis of each identified hazard. The species, habitats, or communities (depending on which component is being analysed) are selected from **Scoping Document S2 (A – C)**. This selection must be made on the basis of expected highest potential risk for each 'direct impact of fishing' and 'fishing activity' combination, and recorded in the 'unit of analysis' column of the SICA Document. The justification is recorded in the rationale column.

2.3.6 Select the most appropriate operational objective (Step 6)

To provide linkage between the SICA consequence score and the management objectives, the most appropriate operational objective for each sub-component is chosen. The most relevant operational objective code from **Scoping Document S3** is recorded in the 'operational objective' column in the SICA document. Note that SICA can only be performed on operational objectives agreed as important for the (sub) fishery during scoping and contained in **Scoping Document S3**. If the SICA process identifies reasons to include sub-components or operational objectives that were previously not included/eliminated then these sub-components or operational objectives must be re-instated.

2.3.7 Score the intensity of the activity for the component (Step 7)

The score for intensity of an activity considers the direct impacts in line with the categories shown in the conceptual model (Figure 1.2) (capture, direct impact without capture, addition/movement of biological material, addition of non-biological material, disturbance to physical processes, external hazards). The intensity of the activity is judged based on the scale of the activity, its nature and extent. Activities are scored as per intensity scores below.

Table 2.14. Intensity score of activity (modified from [37]).

LEVEL	SCORE	DESCRIPTION
Negligible	1	remote likelihood of detection at any spatial or temporal scale
Minor	2	occurs rarely or in few restricted locations and detectability even at these scales is rare
Moderate	3	moderate at broader spatial scale, or severe but local
Major	4	severe and occurs reasonably often at broad spatial scale
Severe	5	occasional but very severe and localized or less severe but widespread and frequent
Catastrophic	6	local to regional severity or continual and widespread

This score is then recorded on the **Level 1 (SICA) Document** and the rationale documented.

2.3.8 Score the consequence of intensity for that component (Step 8)

The consequence of the activity is a measure of the likelihood of not achieving the operational objective for the selected sub-component and unit of analysis. It considers the flow on effects of the direct impacts from Step 7 for the relevant indicator (e.g. decline in biomass below the selected threshold due to direct capture). Activities are scored as per consequence scores defined below. A more detailed description of the consequences at each level for each component (key/secondary commercial, bycatch and byproduct, protected species, habitats, and communities) is provided as a guide for scoring the consequences of the activities in the description of consequences table (Table 2.15).

Table 2.15. Consequence score for ERAEF activities (modified from [37]).

LEVEL	SCORE	DESCRIPTION
Negligible	1	Impact unlikely to be detectable at the scale of the stock/habitat/community
Minor	2	Minimal impact on stock/habitat/community structure or dynamics
Moderate	3	Maximum impact that still meets an objective (e.g. sustainable level of impact such as full exploitation rate for a target species)
Major	4	Wider and longer term impacts (e.g. long-term decline in CPUE)
Severe	5	Very serious impacts now occurring, with relatively long time period likely to be needed to restore to an acceptable level (e.g. serious decline in spawning biomass limiting population increase)
Intolerable	6	Widespread and permanent/irreversible damage or loss will occur-unlikely to ever be fixed (e.g. extinction)

The score should be based on existing information and/or the expertise of the risk assessment group. The rationale for assigning each consequence score must be documented. The conceptual model may be used to link impact to consequence by showing the pathway that was considered. In the absence of agreement or information, the highest score (worst case scenario) considered plausible is applied to the activity.

2.3.9 Record confidence/uncertainty for the consequence scores (Step 9)

The information used at this level is qualitative and each step is based on expert (fishers, managers, conservationists, scientists) judgment. The confidence rating for the consequence score is rated as 1 (low confidence) or 2 (high confidence) for the activity/component. The score is recorded on the SICA Document and the rationale documented. The confidence will reflect the levels of uncertainty for each score at steps 2, 3, 7 and 8 (see description; Table 2.16).

Table 2.16. Description of Confidence scores for Consequences. The confidence score appropriate to the rationale is used, and documented on the SICA Document.

CONFIDENCE	SCORE	RATIONALE FOR THE CONFIDENCE SCORE
Low	1	Data exists, but is considered poor or conflicting
		No data exists
		Disagreement between experts
High	2	Data exists and is considered sound
		Consensus between experts
		Consequence is constrained by logical consideration

2.3.10 Document rationale for each of the above steps (Step 10)

The rationale forms a logical pathway to the consequence score. It is provided for each choice at each step of the SICA analysis.

SICA steps 1-10. Tables of descriptions of consequences for each component and each sub component provide a guide for scoring the level of consequence (see Table above)

Level 1 (SICA) Document L1.1 Key commercial/secondary commercial species.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
Capture	Bait collection	0									
	Fishing	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	3	2	2	Removal of sea cucumbers will affect population size. Catches for Prickly redfish have increased during the assessment period. Catch data shows that Prickly redfish is the species mostly caught (37% for the period between 2016-2020) in the fishery. The 2019 survey estimates suggest that current catch limits are sustainable for Prickly redfish [4], with nominal CPUE trends increasing for this species over the years 2017, 2018 and 2019 (noting the low sample size). Intensity: moderate, as can be severe but local which increased catches during the assessment period (e.g. from about 11 t in 2016 to about 15 t in 2020). Consequence: minor as has caused minimal impact (sustainable catches) on the species. Confidence: high, as survey data gives us strong confidence on score.
	Incidental behaviour	1	4	6	Population size	Prickly redfish	1.2	1	1	2	Incidental behaviour (traditional / subsistence fishing) of non sea cucumber species may occur. For example, fishers may catch finfish or other species during BDM fishing trips for personal consumption (considered as traditional fishing) [12]. Spatial and

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
						(*Thelenota ananas*)					temporal scales are similar for fishing activity (see comments on 'fishing' above). Intensity: negligible as unlikely to be detected at any spatial or temporal scale as subsistence catches are low due to small size of boats and number of fishers (boats <7 m with 2-3 fishers). Consequence: negligible, as unlikely to be detectable at the scale of the stock. Confidence: high, via logical consideration.
Direct impact without capture	Bait collection	0									
	Fishing	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	2	1	2	Fishing for Prickly redfish occurs on coral reef lagoons, reef edge and passes at depths <10 m. Trampling and free diving may break or damage corals and other benthic orgnisms. Intensity: minor, as occurs in few restricted locations where fishing occurs more frequently. Consequence: negligible, as very difficult to be detected at the scale of the stock. Confidence: high via logical consideration.
	Incidental behaviour	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	1	1	2	Incidental behaviour (catch of traditional / subsistence species while fishing for sea cucumbers) may affect benthic species (corals, sponges, seagrass and algae) via trampling or free diving (e.g. flippers). This may occur in a few restricted locations where fishers may catch for subsistence while they fish for sea cucumbers. Intensity: negligible, as unlikely to be detected at any spatial or temporal scale as subsistence catches are low due to small size of boats and number of fishers (boats <7 m with 2-3 fishers). Consequence: negligible, as unlikely to be detectable at the scale of the stock. Confidence: high via logical consideration.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Gear loss	0									
	Anchoring/ mooring	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	2	1	2	Anchoring / mooring may break, kill or damage sponges, corals, seagrasses and other benthic species. Intensity is negligible as this impact can occur in specific locations where fishing activity is high but difficult to be detected due to size of anchors/moorings required for 7 m long boats. Consequence: negligilble, as impact is unlikely to be detected at the scale of the stock. Confidence: high via logical consideration.
	Navigation/ steaming	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	1	1	1	Navigation to and from fishing grounds introduces noise and visual stimuli into the environment. Depth sounders also emit sound, which can disturb sea cucumbers as they are able to detect noise [36]. The fishery uses small boats with outboard engines, which are equipped with depth sounders and one of the fishing techniques includes towing fishers in search of sea cucumbers, producing noise. Intensity: minor, as impacts are restricted to some fishing grounds and are difficult to detect. Consequence: negligible, because it is very difficult to detect. Confidence: low as little is known about impacts of noise on sea cucumbers.
Addition/ movement of biological material	Translocation of species	0									
	On board processing	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Discarding catch	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.1	1	1	2	Discarding is uncommon, mostly associated with autotomy (e.g. evisceration / falling apart) which makes it difficult to process. Spatial and temporal scales are similar for fishing activity (see comments on 'fishing' above). Intensity and consequence are negligible as impacts of discards are very difficult to detect at any scale because it is uncommon. Confidence is high via logical consideration.
	Stock enhancement	0									
	Provisioning	0									
	Organic waste disposal	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.1	1	1	2	Some food (uncontaminated) may be discharged into the sea while fishers are fishing, on camps, or in transit. MARPOL regulations via Protection of the Sea (Prevention of Pollution from Ships) Act 1983 prohibits food waste if contaminated by any other garbage types. As a detritivorous species, prickly redfish can benefit from disposal of uncontaminated food into the sea. Spatial and temporal scales are similar for fishing activity (see comments on 'fishing' above). Intensity: negligible, as impacts of discharge of food scraps are very difficult to detect at any scale because of scale of operations (small boat <7m long and 2-3 crew). The consequence is also negligible as very difficult to detect. Confidence: high, via logical consideration.
	Debris	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
Addition of non-biological material	Chemical pollution	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	4.1	2	1	1	Leakage of substances such as fuel, oil, bilge discharges, natural decay of antifouling agents may occur in normal course of fishing operations. For example, oil and fuel leakages from engines and accidental spills during refuelling operations may occur. Given small size of boats (and engines) operating in the fishery discharges and accidental leaks likely disperse relatively fast and impact on fishery is difficult to detect. Intensity:minor, as can occur at specific locations such as refuelling ports on Islands. Consequence: negligible as very difficult to detect at the scale of the stock. Confidence: low, due to lack of data on contamination and impacts on species in Torres Strait.
	Exhaust	1	4	6	Behaviour / movement	Prickly redfish (*Thelenota ananas*)	6.1	1	1	1	Vessels introduce exhaust into the environment resulting in noise and impact air quality within shallow reef areas. There is some evidence (from laboratory studies) that sea cucumbers can distinguish the pitch of sound [36] and may move in response to noise. Intensity: negligible, as the lieklihood of detection is very small given size of boats. Consequence:negligible as impact unlikely to be detectable at the scale of the stock. Confidence:low, as study was done in the laboratry using a species that does not occur in the Torres Strait (*Apostichopus japonicus*). Little is known about impacts of sound on sea cucumbers.
	Gear loss	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Navigation/ steaming	1	4	6	Behaviour / movement	Prickly redfish (*Thelenota ananas*)	6.1	2	1	1	Navigation to and from fishing grounds introduces noise and visual stimuli into the environment. The fishery uses small boats with outboard engines that are equipped with depth sounders, producing noise; one of the fishing techniques include towing fishers in search of sea cucumbers. Sea cucumbers can distinguish the pitch of sound and as a result can respond to noise [36]. Intensity: minor as impacts are restricted to some fishing grounds and difficult to detect. Consequence:negligible, as impact unlikely to be detectable at the scale of the stock. Confidence: low, as little is known about impacts of sound on the behaviour/movement of sea cucumbers. The study was done in the laboratory using a species that does not occur in Torres Strait (*Apostichopus japonicus*).
	Activity/ presence on water	1	4	6	Behaviour / movement	Prickly redfish (*Thelenota ananas*)	6.1	2	1	2	Fishing for sea cucumbers involves diving in shallow waters. Vessels and divers introduce may visual stimulli in the environment which may result in changes in behaviour. Intensity: minor, as impacts are restricted to some fishing grounds and difficult to detect. Consequence: negligible, as impact unlikely to be detectable at the scale of the stock. Confidence: high via logical consideration, as scale of activity (i.e. number of divers) is low and any visual impacts most likely to be very minimal.
Disturb physical processes	Bait collection	0									
	Fishing	1	4	6	Population size	Prickly redfish	1.2	2	1	2	Fishing involves diving and walking on coral reef areas (lagoons, hard substrates and passes). Trampling and movement of hands / flippers underwater may disturb and resuspend seabed

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
						(*Thelenota ananas*)					sediments. Intensity: minor, as this occurs in few restricted locations where fishing is more intense. Consequence: negligible, as the scale of impact is quite small (2-3 fishers per boat <7 m) and detectability is very difficult and impact is unlikely to be detectable at scale of the stock [1]. Confidence: high, via logical consideration.
	Boat launching	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	2	1	2	Some boats used in the fishery are stored on beaches / out of the water and dragged into the water when needed. Movement of the boat in and out of the water can affect sea cucumbers directly as they move very slowly. Intensity: minor, as this impact occurs at specific locations and is difficult to detect. Consequence: negligible, as the impact of boat launching on sea cucumbers are very difficult to detect. Confidence: high, via logical consideration.
	Anchoring/ mooring	0									
	Navigation/ steaming	1	4	6	Behaviour / movement	Prickly redfish (*Thelenota ananas*)	6.1	1	1	2	Navigation /steaming may affect the physical processes on the benthos by turbulent action of propellers or wake formation resulting in sea cucumbers moving to other places. Intensity: negligible, as the fishery uses relative small (<7 m) boats and engines and impacts are unlikely to be detectable at any scale. Consequence: negligible, as unlikely to be detectable at the scale of the stock. Confidence: high, via logical consideration - boats are relatively small.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
External Impacts	Other fisheries (TS-Rock lobster; TS-finfish)	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	1	1	2	Other Torres Strait fisheries may operate on same fishing grounds (e.g. finfish, Rock Lobster). Fishers (divers), gear (.e.g line, hook, spearguns) and boat operation may accidentally interact with sea cucumbers. Intensity: negligible, as unlikely to be detectable at any scale. Consequence: negligible: impact is very difficult to detect at the scale of the stock. Confidence: high, via logical consideration - interaction with other fisheries are unlikely.
	Aquaculture	0									
	Coastal development	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	3	2	1	Localised pollution (e.g. oil spills, sewage contamination) in some Islands at boat ramps and ports (Boigu, Iama), as well as sediment runoff from coastal developments in the Fly river (Saibai, Dauan and Boigu) [39] could affect sea cucumbers directly and also their habitats (i.e. cause declines on corals, and impact seagrasses, sponges and algae). These impacts are localised and although inside the sea cucumber fishery, these Islands are not inside the zones of high fishing effort. Intensity: moderate as can be severe at Islands. Consequence: minor, as likely to cause minimal impacts to the stock due to scale of impacts. Confidence: low, as no data about effects of sewage and sediment runoff on sea cucumbers in Torres Strait is available.
	Other extractive activities	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Other non extractive activities	1	4	6	Behaviour/ movement	Prickly redfish (*Thelenota ananas*)	6.1	1	1	1	Major shipping activity occurs in Torres Strait which produces noise, that can affect sea cucumbers as they can detect sound [36]. Intensity: negligible, as impacts are very difficult to detect. Consequence: negligible as very difficult to detect at the scale of the stock. Confidence: low as no data on impacts of noise on sea cucumbers found in Torres Strait (especially Prickly redfish).
	Other anthropogenic activities	1	4	6	Population size	Prickly redfish (*Thelenota ananas*)	1.2	2	2	1	Charter boats can introduce noise and pollution (oil) into the environment. Oil contamination can negatively affect sea cucumber populations and decline spawning biomass. There is evidence (from elsewhere in the world) of absence of sea cucumbers in benthic communities after impacted by oil spills (see deepwater horizon oil spill). Intensity: minor, restricted to boat loading facilities [39]. Consequence: minor, as causes minimal impacts on sea cucumbers close to boat loading facilities. Confidence: low, as no data on effects of noise / oil pollution (and recovery time from impacts) on the population size of this species exist for Torres Strait.

Level 1 (SICA) Document L1.4 - Habitat Component (demersal)

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
Capture	Bait collection	0									
	Fishing	1	4	6	Habitat structure and function	Reef flat	5.1	3	2	1	Fishing for Bêche-de-mer in the Torres Strait is by hand collection, mainly by free diving from dinghies crewed by two or three fishers at depths < 10 m, or by walking along reef tops and edges at low tide. Most damage should occur while walking on reef top although snorkeling can also damage or break corals, algae, sponges and other benthic species associated with coral reefs as a result of fishing. Intensity: moderate with localised impacts. Consequence: minor, as regeneration of corals may take between months to years but area of impact is relatively small. Confidence: low because it is not known what proportion of the vulnerable habitat types are damaged, and recovery time is not known.
	Incidental behaviour	1	4	6	Habitat structure and function	Reef flat	5.1	1	2	1	Fishers may catch other species for traditional / subsistence purposes while fishing for BDM (considered as traditional fishing) [12].This may involve fishing from the boat with hand line or opportunistic catch by hand. Intensity: negligible, as very difficult to detect the impact at any scale (scale of impact is liley to be small and unliley to be detactable). Consequence: minor as likely to have miminal impact on the habitat structure and function. Corals and other invertebrates may take months to years to recover but scale of impact is relatively small as concentrated in some areas. Confidence: low, as the exact

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
											proportion of vulnerable damaged habitat and recovery time are both unknown.
Direct impact without capture	Bait collection	0									
	Fishing	1	4	6	Habitat structure and function	Reef flat	5.1	2	2	1	Fishing for Bêche-de-mer in the Torres Strait is by hand collection, mainly by free diving from dinghies crewed by two or three fishers at depths < 10 m, or by walking along reef tops and edges at low tide. Damage or breakage of corals, algae, sponges and other coral reef species may occur even without capture. Intensity: minor with localised impacts that are difficult to detect. Consequence: minor due to minimal impact on stock because area of impact is relatively small although regeneration of corals may take between months to years. Confidence: low because it is not known what proportion of the vulnerable habitat types are damaged, and recovery time is not known.
	Incidental behaviour	1	4	6	Habitat structure and function	Reef flat	5.1	1	1	1	Incidental behaviour (catch of traditional / subsistence species while fishing for sea cucumbers) may affect benthic species such as corals, sponges, seagrass and algae, which are most abundant on the reef flat habitat, via trampling or free diving (e.g. flippers and hands breaking reef structures). Intensity: negligible as remote likelihood of detection of impact at any spatial or temporal scale as subsistence catches are low due to small size of boats and number of fishers (boats <7m with 2-3 fishers). Consequence: negligible, as impact on stock unlikely to be

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
											detectable. Confidence: low, because the recovery time after impact is unknown.
	Gear loss	0									
	Anchoring/ mooring	1	4	6	Habitat structure and function	Reef flat	5.1	2	2	1	Anchoring on lagoons and reef flat may break corals, damage gardens of sponges, soft corals alge and seagrasses. Although anchors and moorings required for the boats used in the fishery are relatively small (boats are less than 7 m long), it can cause localised impacts. Intensity: minor as occurs in a few locations and detectability is difficult due to small size of anchors. Consequence: minor, as it can cause small impacts on specific locations on the reef or seagrass areas. Confidence: low because recovery time is unknown.
	Navigation/ steaming	1	4	6	Habitat structure and function	Reef flat	5.1	1	1	2	Fishing often occurs close to coral reefs in shallow waters and there is a risk of accidental strikes of hull and properller to corals, soft corals, sponges and other reef organisms. Intensity: negligible as although it can happen, skippers will try to avoid this as much as possible to maintain boat and there is a remote likelihood of detection at any scale. Consequence: negligible because such impacts are unlikely to be detectable at the scale of the habitat. Confidence: high, logical considerations given size of boats and scale of habitat.
Addition/ movement of	Translocation of species	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
biological material	On board processing	0									
	Discarding catch	1	4	6	Substrate quality	Reef flat	3.1	1	1	2	Discarding occurs rarely in the fishery mostly due to autotomy (evisceration). Scavengers would quickly take up discarded species causing bioturbation but any impacts unlikely to be detectable beause of small amount of discards that would be quickly consumed by fish and scavengers and dispersed. Intensity: negligible because discards are rare and there is a remote likelihood of detection at any scale. Consequence: negligible because unlikely to be detectable at the scale of the habitat. Confidence: high via logical consideration as reported discards are low.
	Stock enhancement	0									
	Provisioning	0									
	Organic waste disposal	1	4	6	Water quality	Reef flat	1.1	1	1	2	Discharge of organic waste (e.g. uncontaminated food waste) likely to occur daily although relatively small amounts because of scale of operation (2-3 fishers / small boat). Intensity: negligible as very small amounts disposed. Consequence: negligible, volume likely to be small and quickly dispersed through the water column. Confidence: high via logical consideration as increases in nutrient not expected to adversely affect water column.
	Debris	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
Addition of non-biological material	Chemical pollution	1	4	6	Water quality	Forereef zone	1.1	2	2	2	Small amounts of fuel may spill/leak during refuelling as boats use outboard engines. Oil contamination likely to impact sensitive coral species which are more abundant on forereef zone. Spills are likely small due to size of boats and amount of fuel that can be carried, but can cause death and affect growth and reproduction of corals [40]. Intensity: minor, as restricted to some locations and difficult to detect. Consequence: minor, as can cause minimal impacts on habitat. Confidence: low, as data on impacts and recovery times do not exist for Torres Strait.
	Exhaust	1	4	6	Air quality	Reef flat	2.1	1	1	2	Exhaust from running engines may impact the air quality within shallow areas fo the reef flat. Intensity: negligible because although the hazard occurs over a larger range/scale, impact area is only within metres of the vessel. Consequence: negligible, due to rapid dispersal of pollutants in winds, and likely to be physically undetectable over very short time frames. Confidence: high, via logical consideration because effect of exhaust was considered to be very localised.
	Gear loss	0									
	Navigation/ steaming	1	4	6	Water quality	Reef flat	1.1	2	1	2	Steaming/navigation to fishing grounds may result in disruption of water quality from introduction noise, light and changes to water chemistry or turbidity due to boats navigating at shallow waters. Intensity: minor, as localised and difficult to detect due to size of boats. Consequence: negligible, impacts unlikely to be detectable at the scale of the habitat. Confidence: high, logical consideration.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Activity/ presence on water	1	4	6	Water quality	Forereef zone	1.1	2	2	1	Boats and divers can introduce noise into the environment. Boat noise can interfere with the biological processes of coral reef organisms, such as corals and fish [41]. This may occur in specific locations where boat traffic is more intense but very difficult to be detected given the scale of the operations (boats < 7 m). Consequence: minor, as can cause minimal localised impact on areas of heavy boat traffic. Confidence: low, due to lack of data and knowledge about noise pollution on corals in Torres Strait.
Disturb physical processes	Bait collection	0									
	Fishing	1	4	6	Water quality	Reef flat	1.1	2	1	2	Fishing involves diving and walking on coral reef areas (lagoons, hard substrates and passes). Trampling and movement of hands / flippers underwater may disturb and resuspend seabed sediments, smothering corals and obliterating light, affecting corals and seagrasses. This occurs in few restricted locations where fishing is more intense, but still the scale is quite small (2-3 fishers per boat <7m). Intensity: minor, as impacts are localised and difficult to detect [2]. Consequence: negligible, due to scale of impacts on habitat (unlikely to be detectable at the scale of the habitat). Confidence: high, based on logical consideration.
	Boat launching	1	4	6	Habitat structure and function	Shallow Reef flat	5.1	2	2	2	Vessels in fishery are small (<7m) and some may be stored on beaches / out of the water and dragged into the water when needed. Movement of the boat in and out of the water can break corals, damage seagrass beds, sponges, algae and other

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
											benthic organisms on the shallow Reef flat. Intensity: minor, as impact happens at specific locations. Consequence: minor, as impacts are minimal, constrained to specific locations. Confidence: high via logical conseideration.
	Anchoring/ mooring	0									
	Navigation/ steaming	1	4	6	Water quality	Reef flat	1.1	1	1	2	Navigation /steaming may affect the physical processes on the benthos by turbulent action of propellers or wake formation as boats move on shallow areas in the Reef flat, causing sedimentat re-suspension and increase turbidity, which can negatively affect species like corals and seagrasses. Intensity: negligible as the fishery uses relative small (<7m) boats and engines, so impacts are very difficult to detect at any scale. Consequence: negligible as unlikely to be detectable at the scale of the habitat. Confidence: high, via logical consideration - scale of boats is relatively small.
External Impacts	Other fisheries (Torres Strait Tropical Rock Lobster; Torres Strait finfish)	1	4	6	Habitat type, structure and function	Forereef zone	5.1	1	2	2	Other Torres Strait fisheries, including traditional, may operate on same fishing grounds (e.g. finfish, Rock Lobster). Fishers (divers), gear (.e.g line, hook, spearguns) and boat operation may accidentally interact with coral reef habitats. Intensity: negligible, as this happens at very specific locations and impacts are very difficult to detect. Consequence: minor, as minimal impact on habitat. Confidence: high, via logical consideration.
	Aquaculture	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Coastal development	1	4	6	Water quality, substrate quality	Forereef zone	1.1, 3.1	3	2	1	Localised pollution (e.g. oil spills, sewage contamination) in some Islands at boat ramps and ports (Boigu, L (?) ama), as well as sediment runoff from coastal developments in the Fly river (Saibai, Dauan and Boigu) [39] could affect nearby coral reef and seagrass habitats via smothering, increased turbidity and reduction in light penetration [25]. Sewage contamination can also facilitate growth of algae which may outcompete corals for space. Intensity: moderate, as can be severe at specific locations (islands). Consequence: minor, as impacts are restricted to some islands. Confidence: low, due to impacts from Fly river are poorly understood and lack of data on water quality issues and recovery times [42, 43].
	Other extractive activities	0									
	Other non extractive activities	1	4	6	Water quality	Forereef zone	1.1	1	1	1	Major shipping activity in Torres Strait, produce noise and potential leakage of contaminants (oil, chemicals). Intensity: minor, as restricted to shipping lanes. Consequence: negligible, as impacts are very difficult to detect. Confidence: low, due to little information on effects of shipping in the region.
	Other anthropogenic activities	1	4	6	Water quality	Reef flat; Forereef zone	1.1	2	1	1	Charter boats can introduce noise and pollution (oil) into the environment. Oil contamination can negatively affect reef flat, forereef zone and seagrass habitats. Intensity: minor, restricted to boat loading facilities in some islands [39]. Consequence: negligible, as unlikely to be detectable at scale of the stock.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
											Confidence: low, as no data exists on impacts and recovery times in the region.

Level 1 (SICA) Document L1.5 - Community Component.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
Capture	Bait collection	0									
	Fishing	1	4	6	Species composition	Reef communities at Northeastern Transition	1.1	3	2	1	The removal of sea cucumbers can reduce the capacity of sediments to buffer organic matter pulses, impeding the function and productivity of shallow coastal ecosystems [44]. Intensity: moderate with localised impacts (e.g. Prickly redfish). Consequence: minor, as area of impact is relatively small. Confidence: low, because recovery time to rebuild population is unknown.
	Incidental behaviour	1	4	6	Species composition	Reef communities at Northeastern Transition	1.1	1	2	1	Fishers may catch other species for traditional / subsistence purposes while fishing for BDM (considered as traditional fishing) [12]. This may involve fishing from the boat with hand line, spearfishing or opportunistic catch by hand, which may affect species composition and abundance. Intensity: negligible, as very difficult to detect the impact at any scale due to scale of operations. Consequence: minor, as minimal impacts on corals and other invertebrates scale of impact is relatively small, but it may take months to years to recover. Confidence: low as we don't know exactly the proportion of the vulnerable communities damaged and recovery times.
	Bait collection	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
Direct impact without capture	Fishing	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	2	1	Direct hand collection therefore no post-capture mortality but possible some cucumbers are handled for identification before rejection. Intensity: minor and difficult to detect. Consequence: minor. Confidence: low, because the proportion of the vulnerable damaged community types , and recovery time are unknown.
	Incidental behaviour	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	1	2	1	Fishers may catch other species for traditional / subsistence purposes while fishing for BDM (considered as traditional fishing) **[12]**. This may involve fishing from the boat with hand line, spearfishing or opportunistic catch by hand, which may affect species composition and abundance. Intensity: negligible, as very difficult to detect the impact at any scale due to scale of operations. Consequence: minor, as minimal impacts on corals and other invertebrates scale of impact is relatively small, but it may take months to years to recover. Confidence: low, because the proportion of the vulnerable damaged community types , and recovery time are unknown.
	Gear loss	0									
	Anchoring/ mooring	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	2	1	Anchoring on lagoons and reef flat may damage benthic sessile communities (e.g. crinoids, sea cucumbers, crabs, seastars) causing changes in species composition and abundance with potential impact on food chains. Anchors used on boats in the fishery are relatively small and cause relatively small damage. Intensity: minor, as occurs in a few locations and detectability is difficult due to small size of anchors. Consequence: minor, as it can cause small impacts

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
											on specific locations. Confidence: low, because recovery time after impact is unknown.
	Navigation/ steaming	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	1	1	2	Fishing often occurs close to coral reefs in shallow waters and there is a risk of accidental strikes of hull and properller on benthic communities (e.g. crinoids, sea cucumbers, crabs, seastars) causing changes in species composition and abundance with potential impact on food chains. Intensity: negligible as remote likelihood of detection. Consequence: negligible because impact is very difficult to detect at the scale of communities. Confidence: high, logical considerations given size of boats and scale of habitat.
Addition/ movement of biological material	Translocation of species	0									
	On board processing	0									
	Discarding catch	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	1	1	2	Discarding occurs rarely in the fishery mostly due to autotomy (evisceration). Scavengers would quickly take up discarded species causing bioturbation which can affect filter feeders and species that depend on light (e.g. corals and seagrass). Intensity: negligible because discards are rare. Consequence: negligible because unlikely to be detectable at the scale of the habitat. Confidence: high, via logical considerations and reported discards are low.
	Stock enhancement	0									

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Provisioning	0									
	Organic waste disposal	1	4	6	Functional group composition	Reef communities in Northeastern Transition	2.1	1	1	2	Some food (uncontaminated) may be discharged into the sea while fishers are fishing, on camps, or in transit. If uncontaminated, food wastes may be discharged into the sea while the fishing vessel is in transit, if the waste is discharged subject to location-specific conditions. MARPOL regulations via Protection of the Sea (Prevention of Pollution from Ships) Act 1983 prohibits food waste if contaminated by any other garbage types. Discharge of organic waste (e.g. uncontaminated food waste) likely to occur daily although relatively small amounts because of scale of operation (2-3 fishers / small boat). Intensity: can benefit grazers such as sea urchins via increase in organic matter with associated increase in algae cover. Intensity: negligible, as very small amounts disposed due to scale of operations. Consequence: negligible, volume likely to be small and quickly dispersed through the water column. Confidence: high via logical considerations - little disposal of organic matter with negligible increases in nutrient in the water column.
Addition of non-biological material	Debris	0									
	Chemical pollution	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	2	2	Small amounts of fuel may spill/leak during refuelling as boats use outboard engines. Oil contamination likely to impact mobile benthic and demersal species. Spills are likely small due to size of boats and amount of fuel that can be carried, but can cause death and affect growth and reproduction of organisms **[40]**. Intensity:minor as restricted to some locations and difficult to detect. Consequence: minor, as can cause minimal impacts on communities at specific

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
											locations. Confidence:high, given scale of fishing operation and no reports of major leaks in the region.
	Exhaust	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	1	1	2	Exhaust from running engines cause noise and pollution especially in shallow areas of the reef flat and forereef zone. Intensity: negligible because although the hazard occurs over a larger range/scale, impact area is only within metres of the vessel. Consequence: negligible due to rapid dispersal of pollutants in winds, and likely to be physically undetectable over very short time frames. Confidence: high, via logical consideration because effect of exhaust is considered to be very localised.
	Gear loss	0									
	Navigation/ steaming	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	1	1	Steaming/navigation to fishing grounds may result in disruption of water quality from introduction noise, light and changes to water chemistry or turbidity due to boats navigating at shallow waters. This can cause negative impacts on fish and invertebrates [41, 45]. Intensity: minor, as localised and difficult to detect due to size of boats and associated impact. Consequence: negligible because it is unlikely that this impact would be detectable on communities at reef flat or forereef zone. Confidence: low as little is know about impacts of noise and changes in water quality on benthic communities in Torres Strait. Also, litttle is known about recovery times after impacts.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Activity/ presence on water	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	2	1	Boats and divers can introduce noise into the environment. Boat noise can interfere with the biological processes of coral reef organisms, such as corals and reef fish [41]. This is may happen in specific locations where boat traffic is higher but very difficult to be detected given the scale of the operations (boats < 7m). Consequence: minor, as can cause minimal localised impact on areas of heavy boat traffic. Confidence: low, as little is known about long-term effects of noise pollution on coral reef communities.
Disturb physical processes	Bait collection	0									
	Fishing	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	1	2	Fishing involves diving and walking on coral reef areas (lagoons, hard substrates and passes). Trampling and movement of hands / flippers underwater may disturb habitats and resuspend seabed sediments while fishing. This occurs in few restricted locations where fishing is more intense, but the scale of fishing operation is quite small (2-3 fishers per boat <7m). Intensity: minor, as impacts are localised and difficult to detect [2]. Consequence: negligible, due to scale of impacts on habitat (unlikely to be detectable at scale of communities). Confidence: high, based on logical consideration.
	Boat launching	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	2	2	Vessels in fishery are small (<7m) and some may be stored on beaches / out of the water and dragged into the water when needed. Movement of the boat in and out of the water can kill or damage benthic communities. Intensity: minor, as impact happens at specific locations. Consequence: minor, as minimal impacts on distribution of community. Confidence is high via logical conseideration.

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
	Anchoring/ mooring	0									
	Navigation/ steaming	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	1	1	2	Navigation /steaming may affect the physical processes on the benthos by turbulent action of propellers or wake formation as boats move on shallow areas, causing sedimentat re-suspension and increase turbidity affecting habitats and communities. Intensity: negligible, as the fishery uses relatively small (<7m) boats and engines, so impacts are very difficult to detect. The consequence is negligible as impact is unlikely to be detectable at community level. Confidence: high, as scale of boats is relatively small; hence consequence is constrained by logical consideration.
External Impacts	Other fisheries (TS-finfish, TS-Tropical Rock Lobster)	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	1	1	2	Other Torres Strait fisheries, including traditional, may operate on same fishing grounds (e.g. finfish, Rock Lobster). Fishers (divers), gear (e.g. line, hook, spearguns) and boat operation may accidentally interact with habitatas and communities. Intensity: negligible, as this may happen at very specific locations and impacts would be very difficult to detect. Consequence: negligibile, as impact unlikely to be detectable as the scale of the community. Confidence: high, via logical consideration.
	Aquaculture	0									
	Coastal development	1	4	6	Functional group composition	Inner shelf and reef communities	2.1	3	2	1	Localised pollution (e.g. oil spills, sewage contamination) in some Islands at boat ramps and ports (Boigu, Iama), as well as sediment runoff from coastal developments in the Fly river (Saibai, Dauan

DIRECT IMPACT OF FISHING	FISHING ACTIVITY	PRESENCE (1) ABSENCE (0)	SPATIAL SCALE OF HAZARD (1-6)	TEMPORAL SCALE OF HAZARD (1-6)	SUB-COMPONENT	UNIT OF ANALYSIS	OPERATIONAL OBJECTIVE (S2.1)	INTENSITY SCORE (1-6)	CONSEQUENCE SCORE (1-6)	CONFIDENCE SCORE (1-2)	RATIONALE
						in Northeastern Transition					and Boigu) could affect coral reef habitat and communities via reduction of light, sediment smothering, and algae overgrowth due to increase in nutrients **[39]**. Intensity: moderate, as can be severe at specific locations (islands) and locations nearby Fy River mouth. Consequence: minor, as it can cause some impacts at specific lcoations. Confidence: low, because impacts from Fly river as poorly understood and lack of data on water quality issues and recovery times [42, 43].
	Other extractive activities	0									
	Other non-extractive activities	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	1	1	Major shipping activity in TS, which produce noise and potential leakage of contaminants (oil, chemicals) with potential negative impacts on coral reef invertebrates and fish. Intensity is minor as restricted to shipping lanes. Consequence is negligible as impacts are very difficult to detect at any scale. Confidence is low because there is little information on effects of shipping in the region.
	Other anthropogenic activities	1	4	6	Species composition	Reef communities in Northeastern Transition	1.1	2	1	1	Charter boats can introduce noise and pollution (oil) into the environment. Oil contamination can negativelly affect communities. Intensity is minor, restricted to boat loading facilities in some islands [25]. Consequence is negligible as changes in community dynamics are unlikely to be detectable. Confidence is low as no data exists on impacts and recovery times in the region.

2.3.11 Summary of SICA results

The preliminary summary results of SICA are presented in the table below. No results are presented for byproduct, bycatch and protected species given that none have interacted with this fishery due to the highly selective hand collectable nature of this fishery.

Table 2.17. Level 1 (SICA) Document L1.6. Summary table of consequence scores for all activity/component combinations. Those in bold have high confidence. * existing stock assessment – assessment not required. Note: external hazards are not considered at Level 2.

DIRECT IMPACT	ACTIVITY	KEY/SECONDARY COMMERCIAL SPECIES	BYPRODUCT & BYCATCH SPECIES	PROTECTED SPECIES	HABITATS	COMMUNITIES
Capture	Bait collection	0	-	-	0	0
	Fishing	**2**	-	-	**2**	**2**
	Incidental behaviour	**1**	-	-	2	2
Direct impact without capture	Bait collection	0	-	-	0	0
	Fishing	**1**	-	-	**2**	**2**
	Incidental behaviour	1	-	-	1	2
	Gear loss	0	-	-	0	0
	Anchoring/ mooring	1	-	-	2	2
	Navigation/ steaming	1	-	-	1	1
Addition/ movement of biological material	Translocation of species	0	-	-	0	0
	On board processing	0	-	-	0	0
	Discarding catch	1	-	-	1	1
	Stock enhancement	0	-	-	0	0
	Provisioning	0	-	-	0	0
	Organic waste disposal	1	-	-	1	1
Addition of non-biological material	Debris	0	-	-	0	0
	Chemical pollution	1	-	-	2	2
	Exhaust	1	-	-	1	1
	Gear loss	0	-	-	0	0
	Navigation/ steaming	1	-	-	1	1
	Activity/ presence on water	1	-	-	2	2
Disturb physical processes	Bait collection	0	-	-	0	0
	Fishing	1	-	-	**1**	1
	Boat launching	1	-	-	2	2
	Anchoring/mooring	0	-	-	0	0
	Navigation/ steaming	1	-	-	1	1
External Impacts	Other fisheries	**1**	-	-	**2**	**1**
	Aquaculture	0	-	-	0	0
	Coastal development	2	-	-	2	2
	Other extractive activities	0	-	-	0	0
	Other non-extractive activities	1	-	-	1	1
	Other anthropogenic activities	2	-	-	1	1

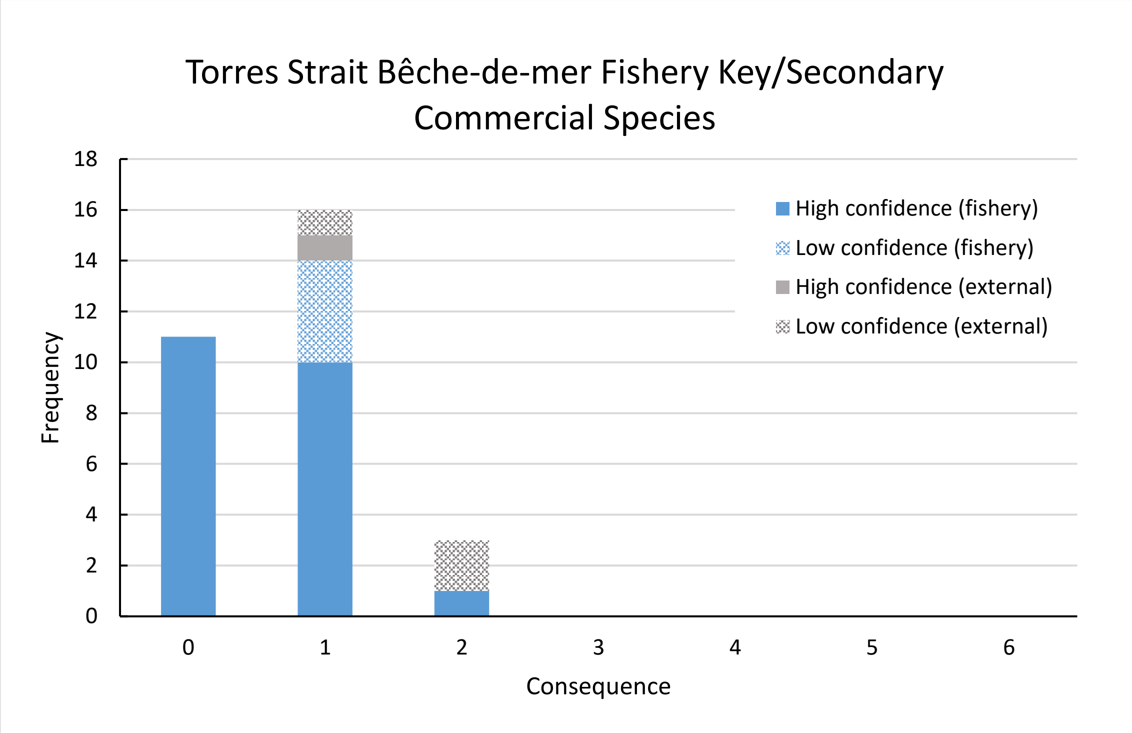


Figure 2.4. Key/secondary commercial species: Frequency of consequence score by high and low confidence.

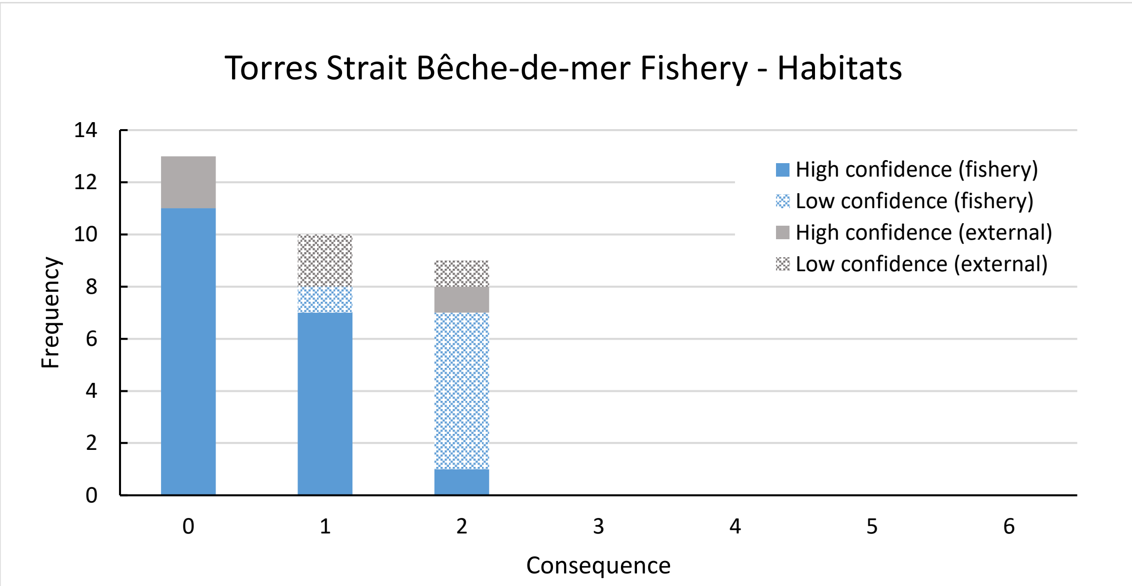


Figure 2.5. Habitat: Frequency of consequence score by high and low confidence.

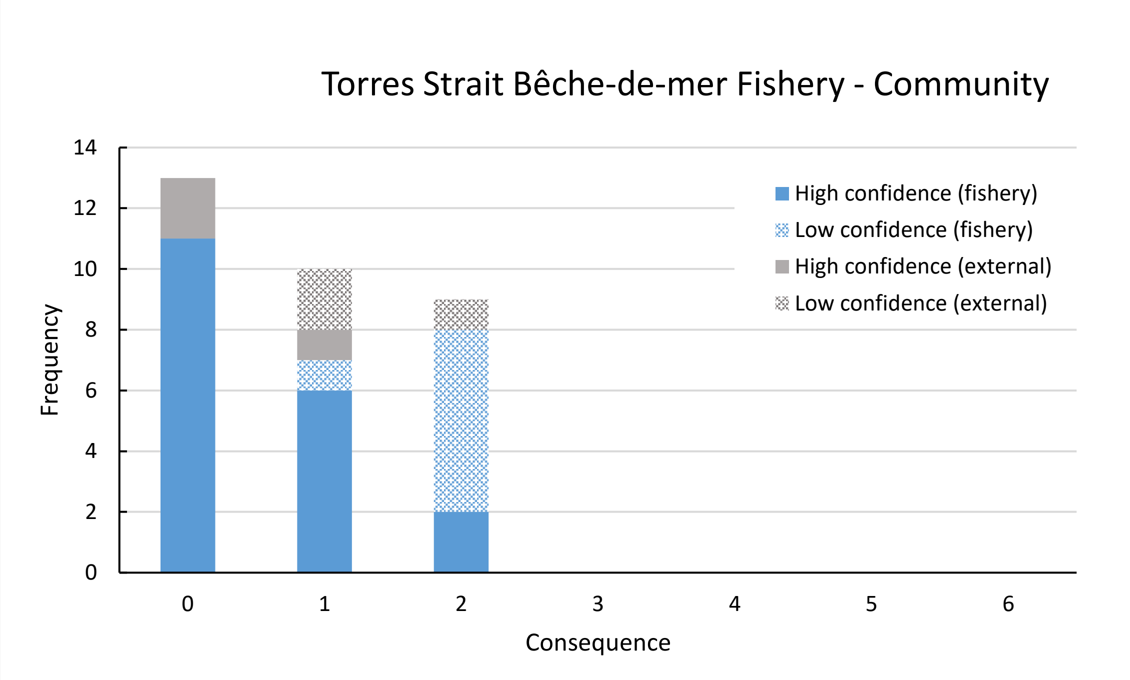


Figure 2.6. Communities: Frequency of consequence score by high and low confidence.

2.3.12 Evaluation/discussion of Level 1

All ecological components were eliminated at Level 1 (i.e. no components with risk scores of 3 – moderate – or above; Table 2.17). Fishing for sea cucumbers is very selective as they are harvested by hand and no by-catch or byproducts result from fishing [15]. Also, no interactions with Protected species have been reported [18]. As a result, the 'Bycatch, byproduct', and 'Protected species' ecological components were not assessed.

All hazards (fishing activities and external) were considered as low risk and eliminated at Level 1 (i.e. no components with risk scores of 3 – moderate – or above). The highest risk scores (2 (minor); with high confidence level) were reported as a result of direct capture on key/secondary species, habitats and communities.

As a result of direct capture, the most vulnerable commercial species was Prickly redfish (*Thelenota ananas*) as it is the mostly caught (AFMA catch disposal record) and was assessed as minor risk as the 2019 survey estimates suggest that current catch limits are sustainable [4], and the nominal CPUE trend is increasing over the years 2017, 2018 and 2019 (noting the low sample size).

The impact of fishing represented a minor risk to habitats largely due to the effort along shallow reef top and forereef zones Fishing for sea cucumbers (secondary species) involves walking/trampling and diving on coral reefs, which may affect species directly and also break or damage benthic communities and coral reef structures.

Although still considered a 'low risk' hazard, coastal development was the highest scored risk (risk score = 2) to key/secondary species, habitats and communities because of localised pollution in some Islands and sediment runoff from coastal developments in the Fly river (PNG) [39]. Sediments can smother sessiles species like corals [45] and increased turbidity and reduction in light penetration can negatively affect spcies that depend on light, such as corals, algae and seagrasses. Confidence is low because impacts from Fly river likely restricted to Northern Islands in the Torres Strait Protected Zone and are still poorly understood and there is a lack of data on water quality issues and recovery times of species and habitats [42, 43].

2.3.13 Components to be examined at Level 2

As a result of the preliminary SICA analysis, no components are to be examined at Level 2.

3 General discussion and research implications

3.1 Level 1

In this case, 19 out of 32 possible internal activities were identified as occurring in this fishery. Four external scenarios were also identified. Thus, a total of 23 activity-component scenarios were considered at Level 1. This resulted in 69 (excluding the Bycatch, byproduct and Protected species x direct impact by capture activity because these activities are not applicable to the fishery) scenarios (of 160 possible) that were evaluated using the unit lists (Key commercial/secondary, habitats, communities).

3.2 Level 2

3.2.1 Species at risk

A Level 2 analysis was not triggered, as all risk (consequence) scores were < 3 in the Level 1 SICA analysis.

Appendix A: TAC (t) and annual recorded catch[12] (t) by species for the Torres Strait Bêche-de-mer Fishery since 2005

COMMON NAME	Pre-2020 TAC	2005	2007	2010	2011	2012	2013	2014	2015	2016	2017[13]	2018[14]	2019	2020
Black teatfish	0 (15[15])				75	2.001	0.138	16.624	23.303					
Prickly redfish	15 (20[16])	5.564	0.128	0.146	11.056	1.255	5.888	9.173	28.110	11.211	12.185	14.741	11.765	15.654
Sandfish	0			0.005	0.031	2.152	0.026	0.006				0.018[17]		
Surf Redfish	0	0.734					0.052	0.001			0.747[18]			0.199[19]
White teatfish	15	0.186			3.179	13.924	12.633	16.341	4.200	0.990		1.774	1.556	1.767

[12] No catch reported in 2006, 2008, 2009

[13] Total catch for 2017 is converted weight- (47 kg unknown), based on recorded catch through tax invoices and logbook data(HC01, TDB01) and Catch Disposal Records (CDR; TBD02). Potential duplicate records were removed.

[14] Data is reported through CDR (TDB02) only and converted to wet weight gutted using CSIRO recommended conversion factors.

[15] 15 t TAC was available in 2014 and 2015 only

[16] 20 t TAC was available until the end of 2017.

Annual catch that exceeded TAC are highlighted in yellow.

[17] Zero TAC

[18] Zero TAC

[19] Zero TAC

COMMON NAME	Pre-2020 TAC	2005	2007	2010	2011	2012	2013	2014	2015	2016	2017[13]	2018[14]	2019	2020
Blackfish	80 basket		0.128		0.507	0.073	0.216	1.960	3.596	1.098	11.118	1.368	3.475	1.399
Burrowing blackfish													0.003	0.003
Curryfish – mixed					1.118				6.099	1.085	0.597	42.392	12.212	10.549
Curryfish common													1.093	0.621
Curryfish vastus													0.215	0.153
Deepwater redfish				0.007			5.024	4.229	5.546		0.160	0.172	0.050	0.050
Elephant trunkfish					0.004	0.028	0.002		0.133			0.190		
Golden sandfish							0.052	0.351	0.055			0.008	0.032	0.032
Greenfish							0.001	0.001	0.014		0.063	1.013	0.271	0.015
Stonefish				0.459							0.006			
Leopardfish											6.876	2.322	0.958	0.958
Brown sandfish												0.030	0.204	0.204
Lollyfish													3.997	3.997
Unidentified BDM												0.067		
'Basket total'		0.186	0.256	0.466	1.629	0.101	5.295	6.541	15.443	2.183	19.831	47.761	22.686	
	TOTAL:	**6.484**	**0.256**	**0.617**	**15.970**	**18.803**	**24.032**	**48.686**	**71.056**	**14.384**	**32.764**	**64.300**	**36.006**	**32.000**

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Glossary of Terms

Assemblage	A subset of the species in the community that can be easily recognized and studied. For example, the set of sharks and rays in a community is the Chondricythian assemblage.
Attribute	A general term for a set of properties relating to the productivity or susceptibility of a particular unit of analysis.
Bycatch species	A non-target species captured in a fishery, usually of low value and often discarded (see also Byproduct).
Byproduct species	A non-target species captured in a fishery, but it may have value to the fisher and be retained for sale.
Community	A complete set of interacting species.
Component	A major area of relevance to fisheries with regard to ecological risk assessment (e.g. target species, bycatch and byproduct species, threatened and endangered species, habitats, and communities).
Component model	A conceptual description of the impacts of fishing activities (hazards) on components and sub-components, linked through the processes and resources that determine the level of a component.
Consequence	The effect of an activity on achieving the operational objective for a sub-component.
Core objective	The overall aim of management for a component.
End point	A term used in risk assessment to denote the object of the assessment; equivalent to component or sub-component in ERAEF
Ecosystem	The spatially explicit association of abiotic and biotic elements within which there is a flow of resources, such as nutrients, biomass or energy [46 and referebces within].
External factor	Factors other than fishing that affect achievement of operational objectives for components and sub-components.
Fishery method	A technique or set of equipment used to harvest fish in a fishery (e.g. long-lining, purse-seining, trawling).
Fishery	A related set of fish harvesting activities regulated by an authority (e.g. Southern and Eastern Scalefish and Shark Fishery).
F_MSM	Maximum sustainable fishing mortality
F_Lim	Limit fishing mortality which is half of the maximum sustainable fishing mortality
F_Crash	Minimum unsustainable fishing mortality rate that may lead to population extinction in the longer term
Habitat	The place where fauna or flora complete all or a portion of their life cycle.
Hazard identification	The identification of activities (hazards) that may impact the components of interest.

Indicator	Used to monitor the effect of an activity on a sub-component. An indicator is something that can be measured, such as biomass or abundance.
Likelihood	The chance that a sub-component will be affected by an activity.
Operational objective	A measurable objective for a component or sub-component (typically expressed as “the level of X does not fall outside acceptable bounds”)
Precautionary approach	The approach whereby, if there is uncertainty about the outcome of an action, the benefit of the doubt should be given to the biological entity (such as species, habitat or community).
PSA	Productivity-Susceptibility Analysis. Used at Level 2 in the ERAEF methodology.
Scoping	A general step in an ERA or the first step in the ERAEF involving the identification of the fishery history, management, methods, scope and activities.
SICA	Scale, Impact, Consequence Analysis. Used at Level 1 in the ERAEF methodology.
Sub-component	A more detailed aspect of a component. For example, within the target species component, the sub-components include the population size, geographic range, and the age/size/sex structure.
Sub-fishery	A subdivision of the fishery on the basis of the gear or areal extent of the fishery. Ecological risk is assessed separately for each sub-fishery within a fishery.
Sustainability	Ability to be maintained indefinitely
Target species	A species or group of species whose capture is the goal of a fishery, sub-fishery, or fishing operation.
Trophic position	Location of an individual organism or species within a foodweb.
Unit of analysis	The entities for which attributes are scored in the Level 2 analysis. For example, the units of analysis for the Target Species component are individual “species”, while for Habitats, they are “biotypes”, and for Communities the units are “assemblages”.

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