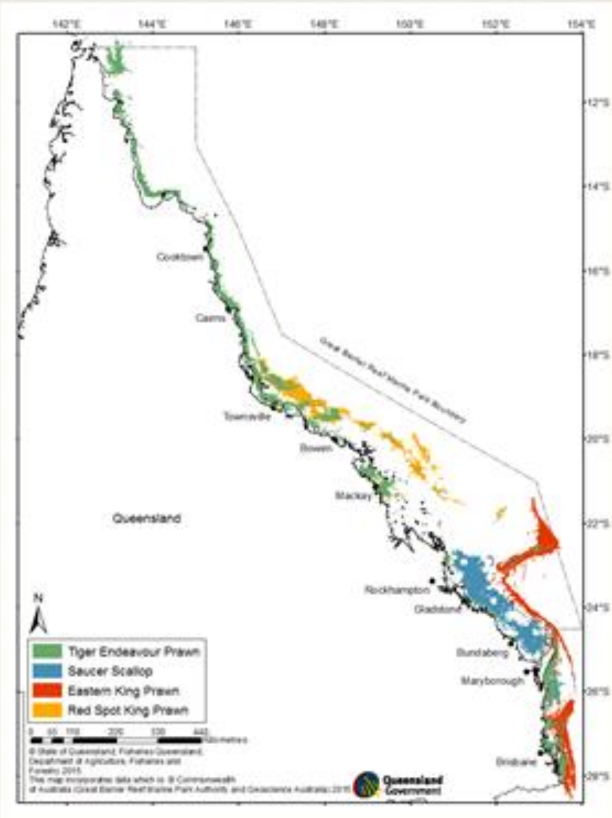
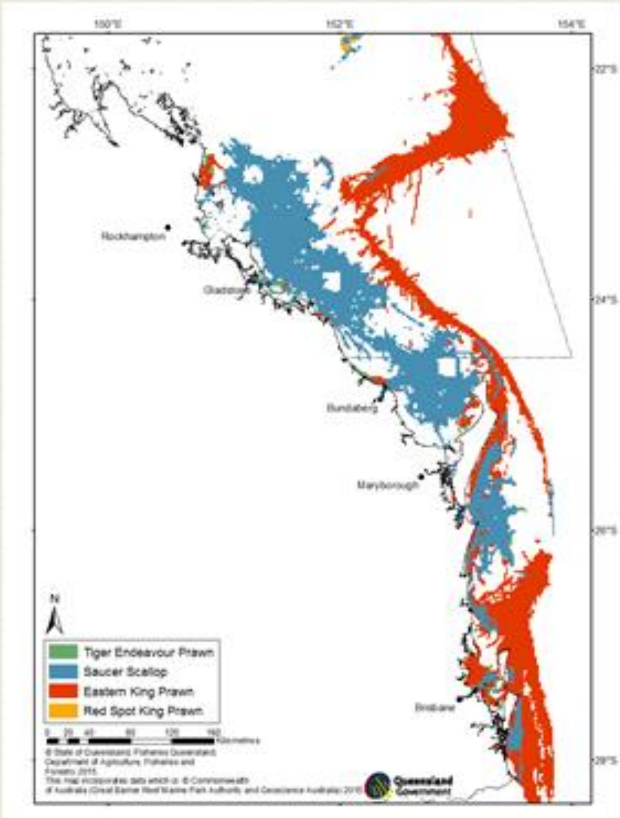
An Ecological Risk Assessment of the Southern Queensland East Coast Otter Trawl Fishery and River & Inshore Beam Trawl Fishery





I. Jacobsen., B. Zeller., M. Dunning., A. Garland., T. Courtney & E. Jebreen.

Department of Agriculture and Fisheries

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This publication has been compiled by I. Jacobsen., B. Zeller., M. Dunning., A. Garland., T. Courtney & E. Jebreen of Fisheries Queensland, Department of Agriculture and Fisheries.

NOTE TO READER / UPDATE

This report was prepared in 2015 and is based on the management regime used in the East Coast Trawl Fishery (ECTF) at that point in time. Risk assessments contained in this report will not take into consideration more recent changes to management or reform initiatives that have been implemented in the fishery.

Similarly, this report does not take into account the *Sustainable Fisheries Strategy 2017 – 2017* which was released by the Queensland Government on 9 June 2017. This Strategy includes a detailed commitment to publish a guideline on Ecological Risk Assessments and undertake ERAs for priority fisheries or species by 2020. The methodology used to construct these ERAs will differ from that used in the ECTF.

The Department of Agriculture and Fisheries notes that additional work has been undertaken in the ECTF since the commissioning of this report including a quantitative ERA involving high-risk bycatch species within the otter trawl fishery. As such, the results of this report should be considered in conjunction with those contained in the following:

Campbell, M., Courtney, A., Wang, N., McLennan, M. & Zhou, Shijie. (2018). *Estimating the impacts of management changes on bycatch reduction and sustainability of high-risk bycatch species in the Queensland East Coast Otter Trawl Fishery.* FRDC Final Report Project number 2015/014, Brisbane, Queensland. 64 pp.

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NON-TECHNICAL SUMMARY

The East Coast Trawl Fishery (ECTF) provides significant benefits to the Queensland economy. Risks associated with the fishery are assessed and managed at both a whole-of-fishery and species-specific level with high emphasis placed on the long-term sustainability of both target and non-target species. The following report describes outcomes of a comprehensive qualitative ecological risk assessment (ERA), which was undertaken as part of a formal review of the *Fisheries (East Coast Trawl) Management Plan 2010*. The assessment included all waters fished by otter trawls between the southern limit of the Great Barrier Reef Marine Park (GBRMP) and the New South Wales (NSW) border, as well as areas of the River and Inshore Beam Trawl Fishery (RIBTF). The assessment focused specifically on the prawn-trawl and tropical saucer scallop fishery, including both targeted and non-targeted species that interact with or have the potential to interact with the ECTF during normal fishing operations.

The assessment described here expands on similar reports prepared by Pears *et al*. (2012a) and Astles *et al*. (2009) to assess trawl risk in the GBRMP and the NSW Ocean Trawl Fishery respectively. Together these three assessments create a composite model of trawl related risks to marine species and habitats on the east coast of Australia. This is a substantial body of information that can be used effectively as part of a broader ecosystem based fishery management (EBFM) approach. The primary aim of the current study was to build on the results obtained by Pears *et al*. (2012a) and Astles *et al*. (2009) by assessing the risks associated with trawl fishing in areas not included in those assessments, namely areas fished by otter trawlers in southern Queensland and beam trawl operations.

Where possible the methodology used to assess trawl risk in the GBRMP (Pears *et al*., 2012a) was adopted for the current assessment. Under this approach, an overall risk rating is assigned to each of the respective species, species groupings or marine habitats (referred to herein as ecological subcomponents) based on their resilience capabilities and a fishery impact profile. In this context, resilience is the ability of an ecological subcomponent to resist or recover from disturbance or decline and is principally assessed on its biological and/or ecological characteristics. The fishery impact profile was defined as the pressure exerted on the ecological subcomponents by the ECTF (Pears *et al*., 2012a) in southern Queensland and RIBTF areas. Final resilience capability scores and fishery impact profiles were calculated using a series of characteristics and decision rules designed to evaluate the level of risk for each characteristic ranging from ‘risk averse’ (A), through to ‘prone to risk’ (P) and ‘double risk prone’ (PP).

Characteristics and decision rules used to calculate resilience and fishery impact profile scores were based on the GBRMP ERA (Pears *et al*. 2012a). In some instances, modifications were required to account for data limitations in the southern Queensland and RIBTF sample area, or to account for an absence of information on habitat distributions and characterisations. As part of this process, the number of ecological components (*i.e.* broader categories) was reduced from six to four with harvest species, bycatch species, species of conservation concern and marine habitats all included in the analysis. Species assemblages and ecosystem processes, which were included in the GBRMP ERA (Pears *et al*. 2012a), were omitted from the current assessment due to data inadequacies. Significant changes to the marine habitat ecological component were also required to accommodate regional data discrepancies including a complete divergence from the subcomponents used by Pears *et al.* (2012a) for the GBRMP ERA.

For the purposes of this ERA, 'risk' was defined as (Astles *et al*., 2006; Pears *et al*., 2012a):

a) an expected loss incorporating the probability (likelihood) and severity (consequence) of an undesirable event; and

b) the "probability (likelihood) of something undesirable happening" that if it were to occur would cause a change in the ecosystem as a result of some behaviour or action.

For the purpose of this ERA, consideration was given to the risk of an undesirable event or outcome occurring over the next 20 years due to trawl fishing activities. An undesirable event or outcome was broadly defined as a serious or irreversible change *e.g.* a substantial reduction in population biomass or a reduced ability to recover from decline (Astles *et al*., 2009). The specific risk context for each ecological component is detailed within this report.

Results of the assessment indicate that trawling represents a relatively low risk for the majority of ecological subcomponents that were assessed. Of the 171 ecological subcomponents that were assessed, 87.8% were at low to intermediate risk from trawling. Only 9.9% of the ecological subcomponents were assessed as high risk over the same period. Based on the results, the following broader observations could be made with respect to the overall risks and the potential impacts of trawling within the study area over the next 20 years:

- the vast majority of harvest species and bycatch ecological subcomponents were assessed as being at low to intermediate risk due to trawl fishing activities;
- most of the 17 species where overall risk was rated as high were from the species of conservation concern ecological component;
- elasmobranchs (sharks and rays) had the highest representation with respect to the number of species (n = 15) at high risk from trawling;
- a high number of the high risk ratings obtained for elasmobranchs are considered to be conservative in nature and were heavily influenced by data deficiencies;
- half of the marine habitat ecological subcomponents had an intermediate risk from trawling; however,
- risk ratings for the marine habitat ecological subcomponents should be considered preliminary as the broader applicability of these evaluations was limited by regional data deficiencies.

While varying between ecological components, regional data deficiencies were influential in a number of the overall risk ratings. Of the ecological components included in this analysis, bycatch species and the species of conservation concern were arguably most affected by data deficiencies. This was most evident in those fishery impact profile characteristics relating to catch, interaction and mortality rates *i.e.* level of interaction and survival after interaction. All characteristics with low information were assigned more conservative scores (*i.e.* higher impact or lower resilience) and consequently this study may have overestimated the risk from trawling for some species including elasmbranchs. Accordingly efforts should be undertaken to improve the level of baseline data used in future iterations of the southern Queensland and RIBTF ERA; particularly for aspects of the species of conservation concern ecological component.

In addition to improving the level of baseline data, a number of other factors were identified as having the potential to reduce risks due to trawl fishing activities. This included mandating the use of more effective bycatch reduction devices in key species sectors, improving the level of protection afforded to non-targeted species and habitats through current temporal and spatial closures and examining avenues within which the catch of non-targeted species can be monitored more effectively within the current catch-reporting regime. These recommendations were tempered by the fact that relatively few species were assigned high-risk gradings.

The completion of the southern Queensland and RIBTF ERA is an important step towards determining long-term risk trends for species and habitats interacting with the fishery within the study area. Each ecological subcomponent now has a detailed risk matrix that includes key information on their resilience capabilities and fishery impact profiles. This will make it easier to incorporate new information, update risk scores for individual characteristics and (where applicable) amend resilience capability scores, fishery impact profiles and overall risk ratings.

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ABBREVIATIONS

BRD	–	Bycatch Reduction Device
DAF	–	Department of Agriculture and Fisheries
EBFM	–	Ecosystem-Based Fisheries Management
ECTF	–	East Coast Trawl Fishery
ECOTF	–	East Coast Otter Trawl Fishery
EKP	–	Eastern King Prawn
ERA	–	Ecological Risk Assessment
FIP	–	Fishery Impact Profile
FOP	–	Fishery Observer Program
GBR	–	Great Barrier Reef
GBRMP	–	Great Barrier Reef Marine Park
GBRMPA	–	Great Barrier Reef Marine Park Authority
GVP	–	Gross Value of Production
M1/M2	–	Represents the Trawl Fishery Symbols used in Moreton Bay
RIBTF	–	River and Inshore Beam Trawl Fishery
T5 to T9	–	Represents the fishing symbols used in the RIBTF
TED	–	Turtle Excluder Device
T1/T2	–	Represents the otter trawl fishing symbols used in the EOCTF

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1. INTRODUCTION

The diversity of prawn trawl catch makes it difficult to monitor overall catch rates and establish long-term management arrangements. Trawl fisheries have relatively poor species selectivity and catch a range of target and non-target species. Catch is either retained for commercial sale or discarded as bycatch due to economic or legislative reasons. While difficult to quantify, the weight of the prawn trawl bycatch is often greater than the weight of commercially important prawns (Saila, 1983; Andrew & Pepperell, 1992; Stobutzki *et al*., 2000). Worldwide, it is estimated that prawn trawl fisheries produce a third of all fisheries discards (Alverson *et al.,* 1994).

The capture of non-target fauna and flora and the broader impacts of trawl fishing remain issues of high interest. Historically, discussions surrounding prawn trawl bycatch has been heavily influenced by the capture of marine megafauna (*i.e*. marine turtles). Over time, this focus has expanded to include broader ecosystem processes and the need to manage risk at a whole-of-fishery level. This change in focus is evident in the evolution of management arrangements for the Queensland *East Coast Trawl Fishery* (ECTF). Currently, there is a strong focus on implementing an *Ecosystem Based Fisheries Management* (EBFM) approach and managing the long-term sustainability of species and environments that interact with the fishery.

1.1 East Coast Trawl Fishery

The geographical distribution of the ECTF is broadly defined as tidal waters between the New South Wales (NSW) border (approximately 28.5°S) and the tip of Cape York Peninsula (approximately 10.5°S) (Fig. 1.1). Consisting of both an East Coast Otter Trawl Fishery (ECOTF) and River and Inshore Beam Trawl Fishery (RIBTF), the ECTF is the largest commercial fishery in Queensland in terms of a) the number of licenced commercial fishers and vessels; b) annual catch weight (approximately 7,500 tonnes); and c) the commercial Gross Value of Production (GVP) (Department of Employment, Economic Development and Innovations [DEEDI], 2011a, 2011b).[1] When both the ECOTF and RIBTF sectors are combined, the annual GVP for the entire ECTF is estimated to be in excess of $91 million (DEEDI, 2011a; 2011b).

The majority of the ECOTF consists of larger vessels operating in inshore and offshore waters (excluding Moreton Bay) under a T1 or T2 fishing endorsement (Fig. 1.1; Appendix A). While operators fish under different endorsements, they are effectively managed as a single entity and for the most part are subject to the same restrictions.

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[1] The Department of Employment, Economic Development and Innovation (DEEDI) and the Department of Agriculture, Fisheries and Forestry (DAFF) are former titles of the Department of Agriculture and Fisheries (DAF).

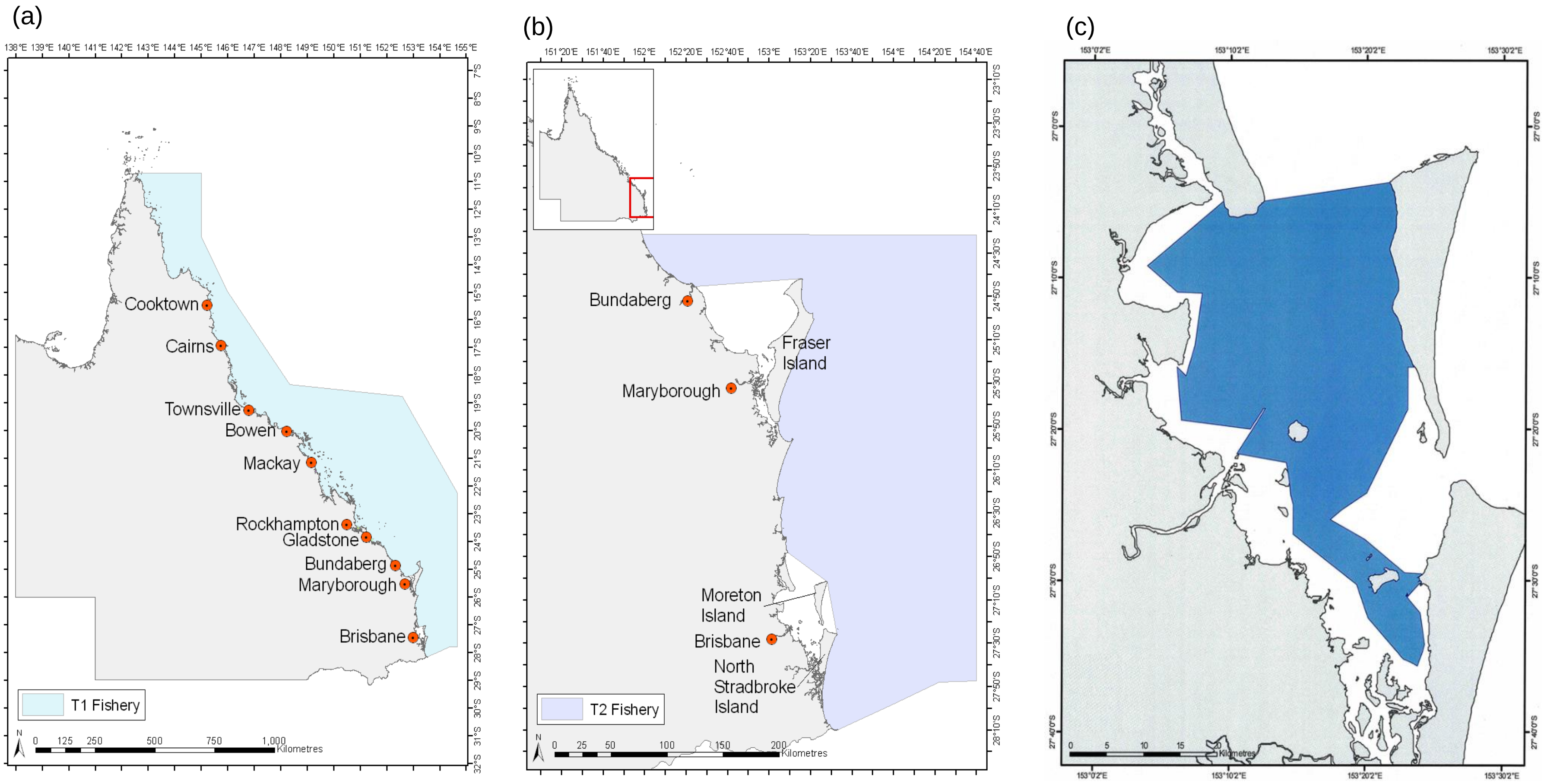

Figure 1.1*. East Coast Otter Trawl Fishery (ECOTF) boundaries for a) the T1 fishery symbol, includes access to Moreton Bay if an operator holds an M1 fishery symbol, b) the T2 fishery symbol, excludes Moreton Bay and c) the boundary of the M1 and M2 fishery.*

In order to conduct finer-scale monitoring and reporting of catch and effort trends, the ECTF (T1 & T2) is frequently subdivided into species-sectors (Fig. 1.2). These subdivisions though are not reflected in the legislation and operators are able to target multiple species within the relevant area of their license endorsement. Target species for the fishery include tropical saucer scallops (*Amusium japonicum balloti*), eastern king prawns (*Melicertus plebejus*), banana prawns (*Fenneropenaeus merguiensis*), red spot king prawns (*Melicertus longistylus*), tiger prawns (*Penaeus* spp.), endeavour prawns (*Metapenaeus* spp.), Moreton Bay bugs (*Thenus* spp.) and squid (*Family Loliginidae / Uroteuthis)* (Fig. 1.2; Appendix A).

As of 31 December 2014, there were 385 T1 fishing endorsements and 19 T2 fishing endorsements in the ECOTF.[2] Based on historical participation rates approximately two thirds of the active T1 and T2 licences fish in waters south of latitude 22°S (Appendix A). Operators fishing in southern Queensland concentrate most of their effort on the shallow water and deep water eastern king prawn sectors. However, other species including tropical saucer scallops, Moreton Bay bugs, banana prawns and tiger prawns are permitted to be harvested in Southern Queensland at varying levels (Fig. 1.2).

In addition to the T1 and T2 areas, otter trawling is permitted within Moreton Bay providing operators hold an M1[3] or M2 fishing endorsement (Fig. 1.1; Appendix A). Moreton Bay (M1, M2) operations are typically smaller with the *Fisheries (East Coast Trawl) Management Plan 2010* placing a 14 m maximum boat length restriction on all M1 or M2 endorsed vessels. M1 and M2 operations have more of a mixed-species catch with greasyback prawns (*Metapenaeus bennettae*), smaller eastern king prawns (*Melicertus plebejus*) and brown tiger prawns (*Penaeus esculentus*) tending to be more prevalent (Courtney *et al*., 2012). In total, there are 47 M1 fishing endorsements and 25 M2 fishing endorsements, which contribute approximately $5 million dollars to the annual ECTF GVP (Courtney *et al*., 2012).[4]

When compared to the ECOTF, the RIBTF (Fig. 1.3) is much smaller with respect to a) the total number of licences, b) the size of vessels and c) reported annual catch. River and inshore beam trawl operators fish in predominantly estuarine and inshore environments and are subject to a nine metre maximum boat length restriction (DEEDI, 2011b) (Appendix A). As the name suggests, beam trawl is the primary apparatus used in the fishery, although some operators are able to use an otter trawl net within the Laguna Bay area. Economically, the RIBTF contributes a similar amount to the overall tonnage and GVP as Moreton Bay (M1 and M2) trawl fishers, approximately 475 tonnes of product and approximately $3.2 million (DEEDI, 2011b).

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[2] *Based on licensing records held by the Department of Agriculture and Fisheries (DAF).*

[3] *License holders wanting to fish under an M1 fishery endorsement must also hold a T1 fishery endorsement.*

[4] *Licence numbers correct as of 31 December 2014 and based on licencing records held by DAF.*

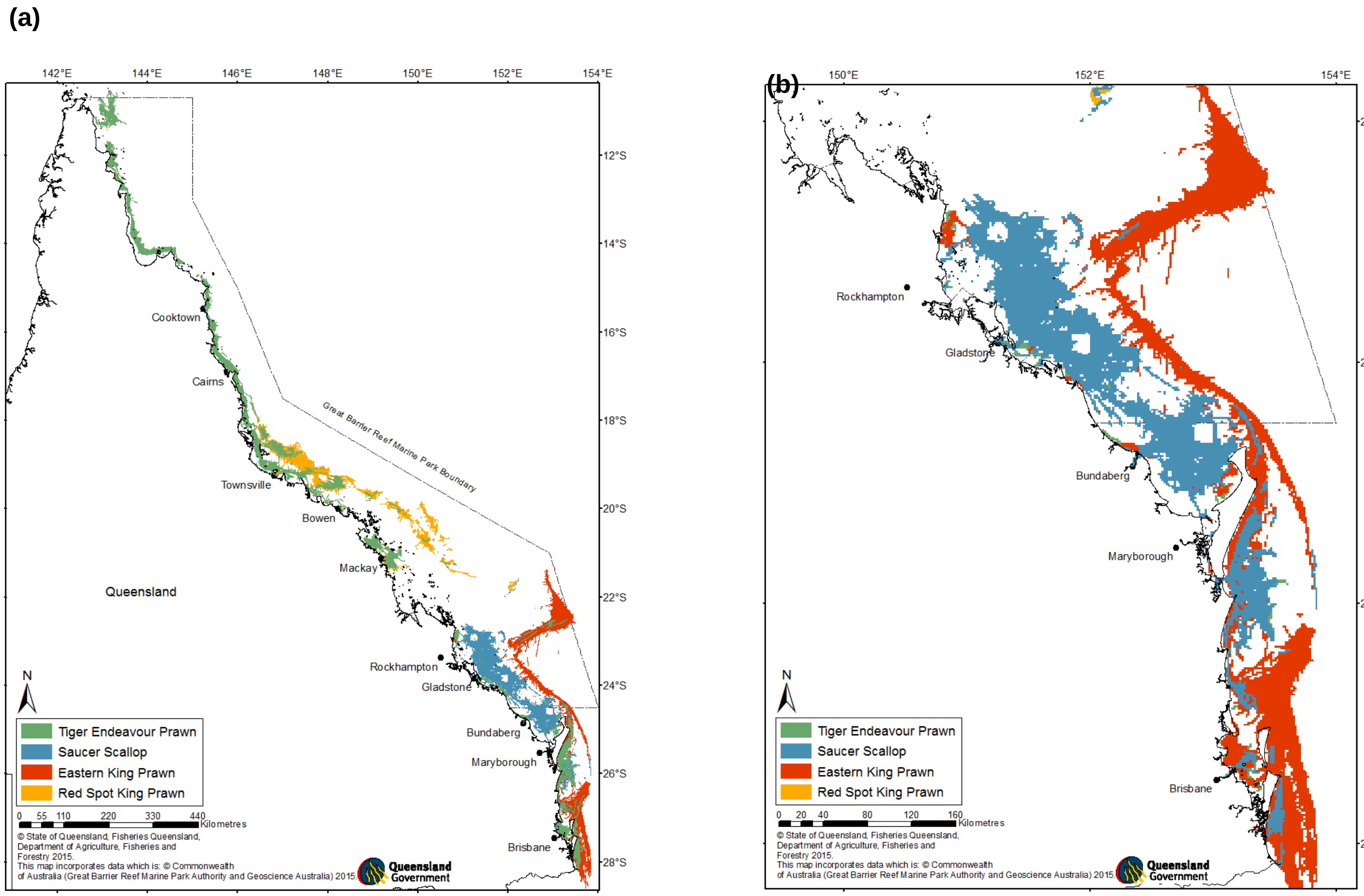

Figure 1.2. *Catch distributions for key species-sectors of the East Coast Otter Trawl Fishery (ECTF) along a) the entire Queensland coastline and b) in Southern Queensland. Boundary of Great Barrier Reef Marine Park (GBRMP) represented by dotted line.*

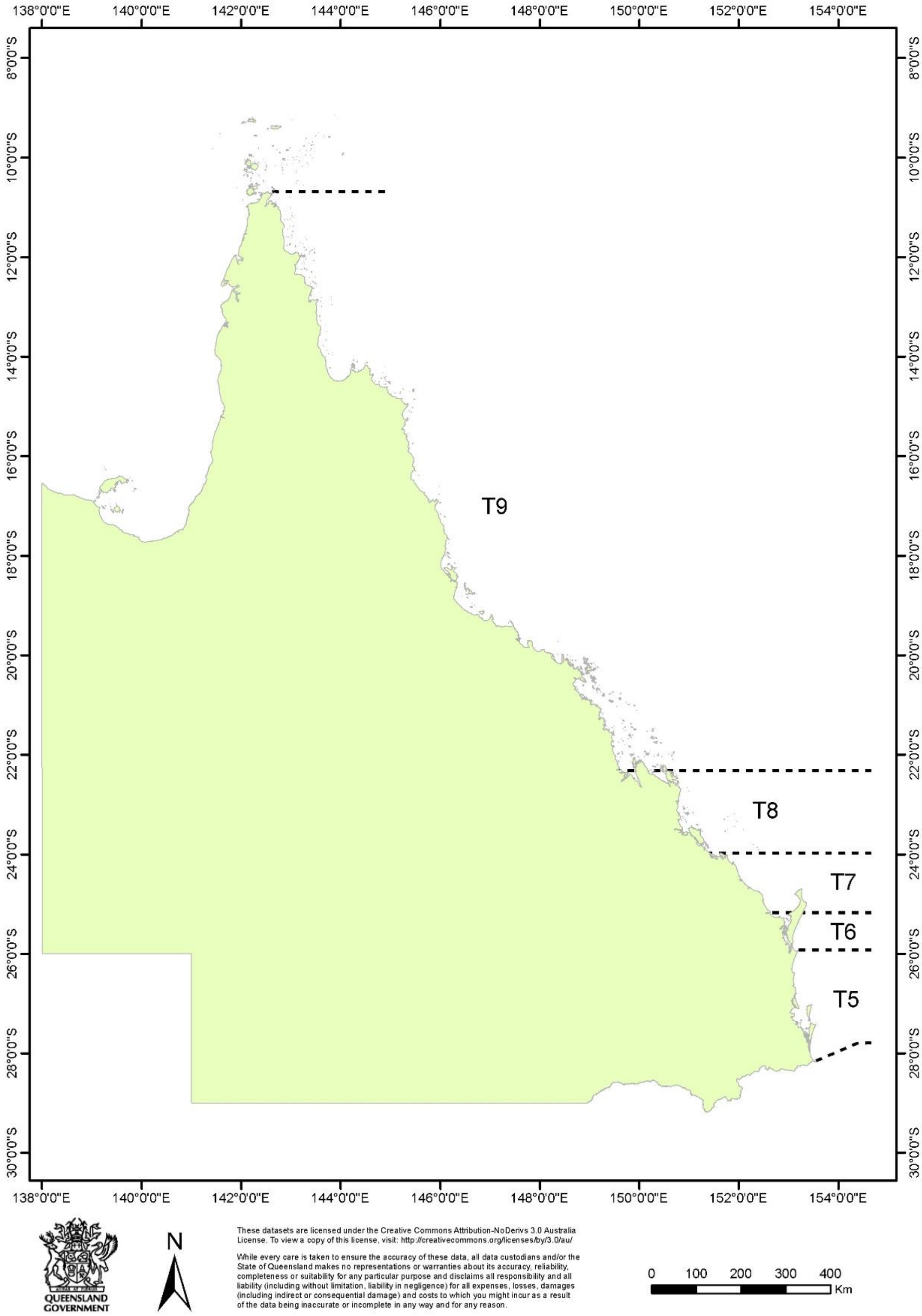

Figure 1.3. *Latitudinal boundaries for each of the respective River and Inshore Beam Trawl Fishery (RIBTF) fishing endorsements (T5 – T9). Note – These areas do not reflect the distribution of RIBTF effort, which is constrained to estuarine/inshore environments.*

Unlike the ECOTF, the RIBTF is subdivided into five regions with fishing endorsements (T5, T6, T7, T8 and T9) used to restrict access to fishing grounds (Fig. 1.3). Of the five specified

RIBTF areas, the T5 and T6 regions are situated south of the Great Barrier Reef Marine Park (GBRMP) with the remaining three regions (T7, T8, and T9) located wholly or partially adjacent to the GBRMP. By region, the T5 fishery has the highest number of endorsements with 36, followed by the T8 fishery (*n* = 27), the T9 fishery (*n* = 20), the T6 fishery (*n* = 5) and the T7 fishery (*n* = 5)[5]. These licences are frequently used as part of a multi-faceted fishing operation with fishers utilizing a range of fishing endorsements as part of their broader business plan *i.e.* beam trawl, crab pots and line (Reid & Campbell, 1999). Operators in the RIBTF are not required to hold additional trawl endorsements *i.e.* a T1 or T2.

The *Fisheries (East Coast Trawl) Management Plan 2010* provides a more detailed explanation of the fishing boundaries for each of the respective trawl fishing endorsements. Broader overviews of the ECOTF and RIBTF are also contained within Appendix A with further information available from the annual reports (DEEDI, 2011a; 2011b) and the *Queensland Fisheries Summary Report* (Department of Agriculture and Fisheries [DAF], 2015). Appendix 2.3 of Pears *et al*. (2012a) also includes a comprehensive overview of the tropical saucer scallops (*Amusium japonicum balloti*), eastern king prawns (*Melicertus plebejus*) and banana prawns (*Fenneropenaeus merguiensis*) species sectors.

1.2 Legislation

The ECTF is principally managed by the State of Queensland through the *Fisheries Act 1994* and the Fisheries Regulation 2008. The ECTF is also subject to a range of provisions outlined in non-fisheries specific legislation including the *Marine Parks (Moreton Bay) Zoning Plan 2008* (State), *Marine Parks (Great Sandy) Zoning Plan 2006* (State), the *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2006* (State), *Great Barrier Reef Marine Park Zoning Plan 2003* (Commonwealth) and the *Great Barrier Reef Marine Park Act 1975* (Commonwealth).[6] However, the broader day-to-day management of the fishery (*i.e.* spatial and temporal closures, boat and gear restrictions etc.) is principally governed through the *Fisheries (East Coast Trawl) Management Plan 2010.*

Implemented in 1999 and last updated in 2010, the *Fisheries (East Coast Trawl) Management Plan 2010* underwent a comprehensive statutory review via the *Department of Agriculture and Forestry* (DAF).[7] The primary objective of the *Fisheries (East Coast Trawl) Management Plan 2010* is to:

> *"… provide for the use, conservation and enhancement of the community's fisheries resources by managing the east coast trawl fishery in a way that seeks to —*
>
> *(a) apply and balance the principles of ecologically sustainable development; and*
>
> *(b) promote ecologically sustainable development.*[8]

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[5] Licence numbers correct as of 31 December 2014 and based on licensing records held by DAF.

[6] More information available in Appendix A.

[7] Review carried out under the formal title for DAF - the Department of Agriculture, Forestry and Fisheries or DAFF.

[8] Section 5 of the Fisheries (East Coast Trawl) Management Plan 2010.

From a management perspective, the *Fisheries (East Coast Trawl) Management Plan 2010* is applied in a manner that is consistent with an *Ecosystem Based Fisheries Management* (EBFM) approach. This approach requires management initiatives involving the ECTF to take into consideration the economic, environmental and social impacts of any proposed changes. From an environmental perspective this includes having due consideration of the level of impact the ECTF has on target species, non-target species and regional ecosystems.

1.3 Principal, Permitted and Bycatch Species

Species that interact with the ECTF can be divided into three key categories: principal species, permitted species and bycatch. Principal species are those that are specifically targeted by ECTF operators and include prawns (eastern king, red spot, tiger, endeavour and banana), scallops (saucer and mud), Moreton Bay bugs (not Balmain) and squid (Appendix A). Permitted species, otherwise referred to as byproduct, are not specifically targeted by ECTF operators but are able to be retained for commercial sale under section 8 of the *Fisheries (East Coast Trawl) Management Plan 2010*. In the ECTF, the list of permitted species includes Balmain bugs, blue swimmer crabs, cuttlefish, mantis shrimp, octopus, pipefish, red champagne lobster, slipper lobster, threadfin bream and the three-spotted crab (Appendix A).

The remainder of the trawl catch can be defined as bycatch or the portion of the trawl catch that is discarded due to their low value, low marketability or where regulations prohibit their retention. Bycatch in the ECTF includes species of conservation concern, undersized principal/permitted species and a wide range of invertebrate and fish species. Detailed lists of the bycatch species encountered in the ECOTF and their frequency of capture can be found in the appendices of Courtney *et al*. (2007). As with principal and permitted species, the *Fisheries (East Coast Trawl) Management Plan 2010* has a range of provisions designed to reduce bycatch in the ECTF; therefore the overall impact of the fishery on regional ecosystems. The most notable of these are provisions mandating the use of bycatch reduction devices (BRD) and turtle excluder devices (TED) in the ECTF.

1.4 Catch monitoring

Monitoring and assessment of trawl catch remains an integral component of the ECTF management regime. In the ECTF, monitoring of catch is principally done through a logbook reporting system. Logbooks are mandatory for all ECTF operators, and provide catch information on all principal and permitted species as well as a number of key species identified as *Species of Conservation Interest*[9] (Appendix B). The ECTF and *Species of Conservation Interest* (SOCI) logbooks, collects information on catch composition, location, weights and release condition.

Information obtained from logbooks has historically been supplemented by projects such as the *Fisheries Observer Program* and ancillary projects such as those undertaken by Pitcher *et al.* (2007) and Courtney *et al.* (2007; 2008; 2010). In 2012, the *Fisheries Observer Program* ceased operations making logbooks the primary source of catch information for the ECTF. This has impacted on the amount of information being collected on species not included in the logbook

[9] 'Species of Conservation Interest' are species that cannot be retained under Queensland legislation i.e. are designated no-take species in the ECTF.

monitoring program and placed added emphasis on alternate projects (small and large) to a) improve the level of information on species compositions and catch rates and b) assess the level of risk associated with trawl fishing. The ecological risk assessment of trawl fishing activities prepared by (Pears *et al.,* 2012a) in the GBRMP, is an example of such a project.

1.5 Objectives

The limited information on catch and effort data makes it difficult to assess long-term catch trends for non-target species that interact with the ECTF. As a consequence, it is difficult to determine if the ECTF is having a significant impact on regional populations and by extension what the appropriate protection measures should be. Given the generally poor selectivity of the trawl nets, it would be unrealistic to monitor the catch of all species that interact with the ECTF. Similarly, implementing individual strategies to address the capture of all non-target species would be unworkable and/or economically inefficient. Accordingly, the primary objective of this study is to assign risk values to a subset of species and marine habitats that interact with the ECTF. These values can then be ranked and compared across or within subgroups to determine key management priorities.

The following is a multi-faceted ecological risk assessment (ERA) for target and non-target species that interact with the ECTF in southern Queensland and RIBTF areas. Designed to augment a previous GBRMP ERA (Pears *et al*., 2012a), the study builds on the results obtained in that study and ensures the entire ECTF has been subject to an ERA process. Using a combination of quantitative and qualitative data, the primary aims of this study were to identify

a) the species and species groupings most at risk due to trawl fishing activities in southern Queensland and RIBTF areas;

b) the key sources of risk; and

c) factors (*e.g.* biology constraints, habitat preferences) that make a species/species complex more susceptible to one or more of the identified sources of risk.

This report also provides a preliminary risk assessment for 10 biophysical strata (*i.e.* proxies for marine habitat types) known to occur in the study area.

The results obtained from the study provide insight into the potential impacts of the ECTF on species, species complexes and marine habitats within the sample area and help inform discussions about the long-term management arrangements for the fishery. Applying a risk-based approach to review the broader impacts of trawl fishing will also ensure that resources and strategies are directed towards areas, species or species assemblages that require the most attention.

2. METHODS

Methodology used to construct the southern Queensland and RIBTF ERA was based on Astles *et al.* (2009) and Pears *et al*. (2012a). Under this methodology, the ERA is developed and analysed in four distinct phases: a) risk context, b) risk identification, c) risk characterisation and d) issues arising. This approach was initially used by Astles *et al*. (2009) to assess risk in the NSW Ocean Trawl Fishery and subsequently adopted by Pears *et al*. (2012a) to construct an ERA for trawl fishing activities within the GBRMP.

As both studies focused on the ECTF, methodology used in the southern Queensland and RIBTF ERA was aligned (where possible) with Pears *et al*. (2012a); although the scope of this study is narrower. For instance, the GBRMP ERA included six groups of species, marine habitats or ecological processes that could interact with or be affected by the ECTF. Otherwise referred to as *ecological components* this included: harvested species, bycatch species, species of conservation concern, marine habitats, species assemblages and ecosystem processes (Pears *et al*., 2012a). Of these, only harvested species, bycatch species, species of conservation concern[10] and marine habitats were included in the southern Queensland and RIBTF ERA. Species assemblages and ecosystem processes were omitted from the analysis due to data inadequacies. A full definition for each ecological component is provided in section 3.3.2 of Pears *et al*. (2012a).

In addition to the above, the GBRMP ERA (Pears *et al*., 2012a) used a two-stage hierarchical approach, which compiles an initial broad-scale risk assessment for each of the ecological components. In the second stage, a more detailed iteration of the assessment is undertaken for key species, species groupings and marine habitats encompassed within each ecological component; referred to herein as *ecological subcomponents*. This differs from the southern Queensland and RIBTF ERA which focused specifically on the production of fine-scale risk assessments for each of the respective ecological subcomponents. It is noted though that the broader ecological component assessments contained within Pears *et al*. (2012a) are largely applicable to otter trawl fishing in southern Queensland and the RIBTF as the issues being addressed are pertinent to the entire ECTF.

As Astles *et al*. (2009) and Pears *et al.* (2012a) provide a comprehensive overview of each stage of the ERA assessment process, only an abridged version will be provided in the current study. Where possible, the terminology, species groupings and definitions used in the southern Queensland and RIBTF ERA were adopted from the GBRMP ERA (Pears *et al*., 2012a). In some instances, it was necessary to make minor changes to account for variances in the amount of available information. These differences are outlined within the relevant method sections.

2.1 Risk Context

The primary objective of the 'risk context' stage of the ERA is to define the broader parameters of the assessment including the risk that is to be analysed (*i.e.* the undesirable event or outcome trying to be avoided), the spatial extent of the analysis and the time frame of the assessment (Astles *et al.,* 2009; Pears *et al*., 2012a). For the purposes of this ERA, 'risk' was defined as:

[10] The 'Species of Conservation Concern" ecological component includes both species protected under legislation as 'no-take' and species that can be retained but are the subject of ongoing conservation concern at a state, national or potentially international scale. As a consequence, this ecological component is broader than the species classified by DAF as 'Species of Conservation Interest' which only includes no-take species; as defined under Fisheries legislation.

> *The "probability (likelihood) of something undesirable happening" that if it were to occur would cause a change in the ecosystem as a result of some behaviour or action*.

An undesirable event was broadly defined as '*a serious or irreversible change*' (*e.g.* a reduction in biomass below a critical level as a percentage of the spawning biomass or a reduced ability to recover from a disturbance or population decline) and was framed in the context of the ecological component being assessed (Astles *et al*., 2009; Pears *et al.,* 2012a). For further information including comprehensive overviews of the definition of risk and understanding risk in a marine ecological context refer to Astles *et al*. (2006; 2009) and Pears *et al*. (2012a) respectively.

The study area for the southern Queensland and RIBTF ERA was defined as all marine waters described within the Queensland *Fisheries (East Coast Trawl) Management Plan 2010* that are not encompassed within the GBRMP. This includes all waters that support otter trawl and beam trawl operations inshore of the 400 m isobath between 24.5º S and 28.2º S *i.e.* waters between the southern limit of the GBRMP and the Queensland – New South Wales border (Fig. 1.1). As RIBTF activities north of 24.5º S are located outside the GBRMP these areas were also included in the analysis. While acknowledging stocks for some species extend into New South Wales, the study area was purposely restrained to those areas encompassed within the Queensland ECTF.

Both ECOTF and RIBTF trawl fishing activities were taken into consideration as part of the ERA process. The ECOTF was defined as a single entity irrespective of the species being targeted (*i.e.* scallops or prawns) and equipment being used. However, differences in fishing practices and methodologies were taken into consideration as part of the risk assessment process. This was done in the context of the ecological subcomponent being assessed (species, species complex or marine habitat), the type of interaction, the extent of the interaction and the relevance of the ecological subcomponent to the ECOTF and RIBTF.

The time frame of the assessment was aligned with Pears *et al*. (2012a) with the southern Queensland and RIBTF ERA considering the potential impacts of trawl fishing and the likelihood of an undesirable event occurring over the next 20 years. This period was identified by Pears *et al*. (2012a) as being a sufficient length of time to examine the risk and consequences of one or more large undesirable events occurring or to evaluate the cumulative impacts of multiple, smaller undesirable events. Taking into consideration this 20 year time frame, the risk context of the whole study can be broadly defined as:

> *The likelihood that current ECTF activities will lead to wide-spread degradation of ecological components resulting in them becoming ecologically unsustainable within the next 20 years.*

Catch and effort data from the 2009 fishing season was used as the basis for all southern Queensland and RIBTF ERA assessments. The 2009 catch and effort data was also used by Pears *et al.* (2012a) as the representative fishing year for the GBRMP ERA, Using 2009 as the baseline year ensured that both ECTF risk assessments utilised the same catch and effort data and provided greater scope with respect to cross-study comparisons.

2.2 Risk Identification

The primary purpose of the risk identification stage was to identify aspects of the ECTF (*i.e.* the sources of risk*)* that have the potential to impact on each of the ecological components (Pears *et al*., 2012a) and the ecological subcomponents that may experience an undesirable event as a result of trawl fishing activities within the sample area.

2.2.1 Sources of risk

The sources of risk relate specifically to fishing activities (otter and beam trawl) that occur within the prescribed study area (described above) under current (2010 – 2015) management arrangements and circumstances. Pears *et al*. (2012a) identified seven trawl fishing activities that have the potential to directly or indirectly affect ecological components within the GBRMP. These included harvesting, discarding, contact without capture, loss of fishing gear, travel to and from fishing grounds, disturbance due to presence in the area, boat maintenance and emissions (Table 2.1).

Table 2.1. *Excerpt from GBRMP ERA (Pears et al., 2012a, section 3.3.2) providing an overview key ECTF activities (sources of risk) including definitions.*

Sources of Risk
***Harvesting*:** capture and retaining of marine resources for sale.
Discarding: returning unwanted catch to the sea (these species are landed on the deck of the boat and then discarded).
Contact without capture: contact of any part of the trawl gear with ecological subcomponents (species, habitats etc.) whilst being towed but which do not result in the ecological components being captured and landed on deck.
Loss of fishing gear: partial or complete loss from the boat of gear including nets, towing cables and otter boards.
Travel to/from grounds: steaming of boat from port to fishing grounds and return.
Disturbance due to presence in the area: other influences of boat on organisms whilst fishing activities take place (*e.g.* underwater sound disturbances).
Boat maintenance and emissions: tasks that involve fuel, oil or other engine and boat-associated products that could be accidentally spilled or leaked into the sea or air.

A review of the sources of risk contained within the GBRMP ERA (Pears *et al*., 2012a) revealed they were all applicable to areas outside the marine park. Therefore, the seven sources of risk identified by Pears *et al*. (2012a) were adopted for the southern Queensland and RIBTF ERA (Table 2.1). These sources of risk were considered in the context of the species, species complex and marine habitat being reviewed with further consideration given to any variations between the ECOTF and RIBTF. No additional sources of risk were identified within the study area. A comprehensive overview of each fishing activity identified by Pears *et al.* (2012a) as a sources of risk and detailed definitions for each have been provided in Table 2.1

2.2.2 Ecological Subcomponents

The subcomponent list for harvest species was compiled from current legislature and included all principal (targeted) and permitted (non-targeted byproduct) species. Given the diversity of prawn trawl bycatch, a preliminary list of all known bycatch species was constructed using a range of pertinent ECTF catch records (*i.e.* the *Fisheries Observer Program*, Courtney *et al*., 2007). This list was subsequently refined using a series of criteria with a species or species complex only included as a bycatch ecological subcomponent if it was or is:

i) a species of significance in the recreational fishing sector;

ii) a species that is retained for sale in another commercial fishery operating in Queensland;

iii) a teleost species that was included in the GBRMP ERA (Pears *et al*., 2012a) whose distribution extends inshore and/or into waters south of the GBRMP;

iv) being considered for inclusion in the ECTF permitted species list;

v) a bycatch species commonly captured in eastern king prawn (*Melicertus plebejus*) or saucer scallop (*Amusium japonicum balloti)* sectors; and/or

vi) frequently caught or is an abundant bycatch species in *Fisheries Observer Program* records from the banana prawn (*Fenneropenaeus merguiensis*) & bay prawn (mixed species) sectors of ECOTF and/or the RIBTF.

While marine turtles, sea snakes, syngnathids (pipefish and seahorses) and chondrichthyans (sharks, skates, rays and chimeras) are classified as bycatch, these formed the basis of the species of conservation concern ecological component. Similarly, principal and permitted species that are landed and subsequently discarded (*i.e.* due to damage or minimum legal size limits) were taken into consideration as part of the harvest species ecological component assessment. As such, none of the above species were included in the bycatch ecological component assessment.

When compared, the marine habitat ecological component assessment differed most from the GBRMP ERA (Pears *et al*., 2012a). Marine habitat subcomponents used by Pears *et al*. (2012a) were based on the *Great Barrier Reef Seabed Biodiversity Survey* (Pitcher *et al*., 2007) which identified and mapped the spatial distributions of nine GBRMP habitats. As an analogous study not been undertaken south of the GBRMP, subcomponents used by Pears *et al*. (2012a) could not be used in the current assessment. As a consequence, the biophysical strata mapped by Kenna & Kirkwood (2008) were used as alternatives to the marine habitat subcomponents used by Pears *et al*. (2012a).

The study by Kenna & Kirkwood (2008) focused specifically on continental shelf waters between the southern tip of the GBR (24°S) and Coffs Harbour (30.5°S) in northern New South Wales. It provided a synthesis of the existing environmental data and categorized the marine habitats in terms of their most obvious physical characteristics *e.g.* muddy-sand seabed, sandy seabed, reef etc. Biophysical strata distributions outlined in Kenna & Kirkwood (2008) enabled a preliminary marine habitat risk assessment to be undertaken for the ECOTF in southern Queensland including Moreton Bay. However, a corresponding assessment could not be undertaken for the beam trawl fishery as the Kenna & Kirkwood (2008) study did not include riverine systems. A full list of the biophysical strata classified and mapped by Kenna & Kirkwood (2008) is provided in section 3.5.

2.3 Risk Characterisation

The purpose of the risk characterisation stage is to provide an estimate of the likelihood that one or more of the identified sources of risk will result in an undesirable event occurring over the next 20 years. Where possible, the risk characterisation stage of the southern Queensland RIBTF ERA was aligned with the GBRMP ERA (Pears *et al*. 2012a). As noted, a number of modifications were required to account for regional variations in trawl fishing activities or to account for differences in the amount of available information.

2.3.1 Assessment Parameters

Likelihood estimates for each ecological subcomponent (species, species grouping or marine habitat) were based on an assessment of their **resilience** capabilities and **fishery impact profile**. The resilience capability is the ability of an ecological subcomponent to resist or recover from disturbance or decline and is principally assessed on intrinsic biological and/or ecological characteristics. Conversely, the fishery impact profile is defined as the pressure exerted on the ecological subcomponent by the ECTF (Pears *et al*., 2012a) in southern Queensland and RIBTF areas.

In order to construct the resilience capability assessment and fishery impact profiles, a series of ecological characteristics (for resilience) and factors of influence (fishery impact profile) were identified (Appendix C). These characteristics and factors of influence represent the constraints (resilience capabilities) of the broader ecological components (*e.g.* life-history limitations) and fishing activities that have the potential to influence regional ecosystems (fishery impact profile). Once identified, a series of decision rules were used to assign each characteristic and factor of influence a score that corresponds with a relative level of risk (Appendix C). These qualitative scores ranged from ‘risk averse’ (A) through to ‘prone to risk’ (P) or ‘risk double prone’ (PP) (Astles *et al*., 2009; Pears *et al*., 2012a) (Appendix D).

Where data deficiencies prevented a score being assigned to a particular characteristic or factor of influence, a proxy value was used. In these instances, proxy values were based on a species from the same taxonomic family/genus or species with similar biological traits. If a suitable proxy could not be found and or no data were available for that particular characteristic, then the ecological subcomponent was assigned the most conservative score available. By default, these decision rules were biased towards the production of more conservative risk assessments for ecological subcomponents with data deficiencies. This in turn reduced the risk of an ecological subcomponent being assigned a risk value lower than the actual level (*i.e.* a type II error) and was consistent with the approach adopted by Pears *et al*. (2012a) for the GBRMP ERA.

As both studies focused on the ECTF, characteristics and decision rules used to assess resilience capabilities and construct the fishery impact profiles in the southern Queensland and RIBTF ERA were based on the GBRMP ERA (Pears *et al*., 2012a). Where possible these characteristics were adopted unchanged, although some modifications/omissions were required to account for regional data deficiencies. These changes mostly relate to the reliance of the GBRMP ERA on the *Great Barrier Reef Seabed Biodiversity Survey* (Pitcher *et al*., 2007) and the absence of an analogous study in southern Queensland or RIBTF areas. Changes to the assessment protocols for the harvest species, bycatch species and species of conservation concern ecological components are as follows:

a) the ‘per cent caught 2009 (without BRD effect)’ characteristic was omitted from the harvest species, bycatch species and species of conservation concern fishery impact profile assessment;

b) the ‘per cent effort exposed 2009’ characteristic was omitted from the harvest species, bycatch species and species of conservation concern fishery impact profile assessment;

c) ‘frequency of capture’ was included as a replacement characteristic for ‘per cent caught 2009 (without BRD effect)’ in the bycatch ecological component fishery impact profile assessment;

d) ‘interaction through life cycle’ was included as a replacement characteristic for ‘per cent effort exposed 2009’ in the bycatch ecological component fishery impact profile assessment; and

e) a ‘depth range’ characteristic was included in the bycatch ecological component resilience capability assessment.

Of the above, the ‘per cent caught 2009 (without BRD effect)’ and ‘per cent effort exposed 2009’ characteristics relate specifically to information contained in *the Great Barrier Reef Seabed Biodiversity Project* (Pitcher *et al*., 2007). This characteristic was not substituted in either the harvest species or species of conservation concern ecological components due to data deficiencies. However, ‘frequency of capture’ was included as a replacement characteristic in the bycatch ecological component based on the strength of data contained in ancillary projects like the *Fisheries Observer Program* and Courtney *et al*. (2007). In addition, a ‘depth range’ characteristic was included for the bycatch ecological component to acknowledge that a) ECTF effort in southern Queensland is dispersed across a wider range of depths and b) the geographical distribution of some bycatch species may be isolated to a particular niche *e.g.* waters <100 m *vs.* waters >300 m.

All characteristics used in the GBRMP ERA to assess the impacts of trawl fishing on marine habitats were adopted for the current ERA. As exploitation percentages were not available for southern Queensland, the 2009 ECTF effort was mapped against the estimated distribution of each biophysical stratum (Kenna & Kirkwood, 2008) using a 1 nm grid pattern. Exposure to trawling estimates was than calculated as the proportion of grids within each stratum where trawl fishing activity had been recorded. While not as precise as the estimates contained within (Pitcher *et al.,* 2007), this approach provided an estimate of the area exposed to trawl fishing.

A full list of the characteristics and decision rules used to assess resilience capabilities and construct the fishery impact profiles for each of the respective ecological components are outlined in Appendix C.

2.3.2 Consultation, Assessment and Scoring

The resilience capabilities and fishery impact profile scores were compiled through a series of workshops. Workshop participants included industry representatives with an intimate knowledge of the operation and marketing aspects of the ECTF, representatives from various government and non-government organizations and scientists with specific knowledge of the species, species complexes or habitats that interact with the ECTF (Appendix E). Many of the workshop participants were involved with the GBRMP ERA (Pears *et al*., 2012a) and had a substantial understanding of the ERA methodology.

Resilience capabilities and fishery impact profile scores were calculated by summing the total number of ‘prone to risk’ scores assigned to a specific ecological subcomponent. Under this system, all ‘risk averse’ (A) scores were given a zero weighting, a ‘prone to risk’ (P) score equalled one and a ‘double risk prone’ (PP) score equalled two. For example, if a resilience capability assessment contained one ‘risk averse’ score, one ‘prone to risk’ (P) score and one ‘double risk prone’ (PP) score, it would have been allocated three ‘P’ scores in total and would therefore have a combined risk score of three. The level of risk associated with a species resilience capabilities or fishery impact profile (Table 2.2) was subsequently determined by comparing this total against a series of thresholds designed to differentiate between a low, intermediate or high risk (Table 2.2).

When the two ECTF ERAs were compared, the ‘P’ thresholds for harvest species and species of conservation concern were identical to those used by Pears *et al.* (2012a) (Table 2.2). However, thresholds for the bycatch and marine habitat ecological components needed to be amended to account for the aforementioned changes in assessment criteria (bycatch) or due to significant differences in the amount of available data (marine habitats). In the bycatch ecological component, the division between the high-intermediate and high risk categories of the fishery impact profile was set lower. Conversely, the two highest thresholds for the marine habitat fishery impact profile assessments were set marginally higher than in the GBRMP ERA (Table 2.2; Pears *et al*., 2012a).

Table 2.2*. Risk thresholds applied for the southern Queensland and RIBTF ERA and GBRMP ERA (Pears et al., 2012a). Threshold scores represent the total number of ‘P’ scores in a single resilience capability or fishery impact profile assessment.*

Risk Level	Resilience	FIP

Ecological Component		Sth ECOTF RIBTF	GBR	Sth ECOTF RIBTF	GBR
Harvested species	Low (L)	>5	>5	0 – 4	0 – 4
	Intermediate-low (I-L)	4 – 5	4 – 5	5 – 6	5 – 6
	Intermediate (I)	3	3	7 – 8	7 – 8
	High-intermediate (H-I)	1 – 2	1 – 2	9 – 10	9 – 10
	High (H)	0	0	>10	>10
Bycatch Species	Low (L)	>4	>4	0	0 – 1
	Intermediate-low (I-L)	3 – 4	3 – 4	1	2
	Intermediate (I)	2	2	2	3
	High-intermediate (H-I)	1	1	3	4
	High (H)	0	0	>3	>4
Species of Conservation Concern	Low (L)	>5	>5	0 – 1	0 – 1
	Intermediate-low (I-L)	4 – 5	4 – 5	2	2
	Intermediate (I)	3	3	3	3
	High-intermediate (H-I)	1 – 2	1 – 2	4	4
	High (H)	0	0	>4	>4
Marine Habitats	Low (L)	>4	>3	0	0
	Intermediate-low (I-L)	3 – 4	3	1	1
	Intermediate (I)	2	2	2	2
	High-intermediate (H-I)	1	1	3 – 4	3
	High (H)	0	0	>4	>3

Once completed, final resilience capability scores and fishery impact profiles were used to assign an overall risk to each ecological subcomponent. Overall risk ratings were graded on a continuum with low risk and high risk situated on the outer extremities (Fig. 2.1). In order to calculate an overall risk rating, final resilience capability scores and fishery impact profiles were cross referenced using a broader risk matrix (Pears *et al*., 2012a) (Fig. 2.1). Under this system, an ecological subcomponent with a high resilience capability score and a low fishery impact profile would have a low overall risk rating. Conversely, ecological subcomponents with a low resilience score and high fishery impact profile would be viewed as being at high risk from trawl fishing activities (Fig. 2.1).

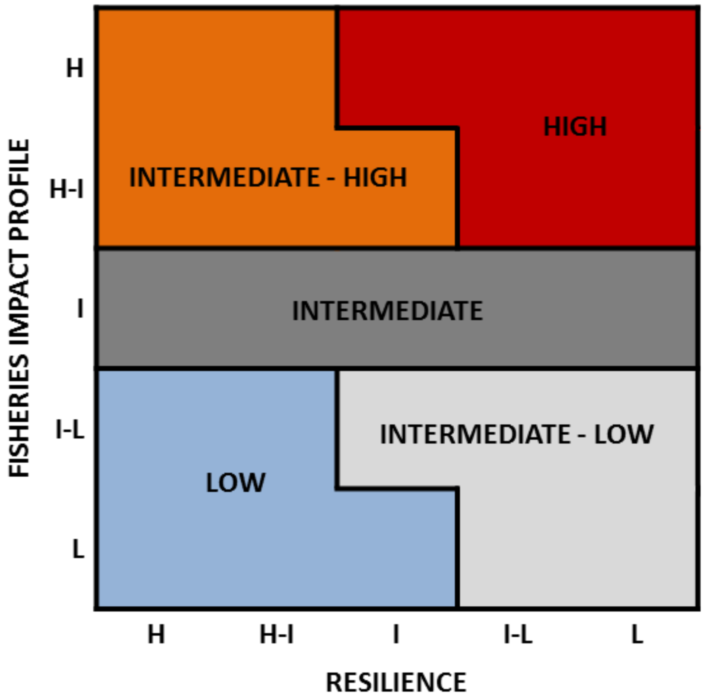

Figure 2.1. *Risk matrix showing the relationship between resilience capabilities and the fishery impact profile. Regions within the framework represent the overall level of risk. Adopted from Astles et al. (2009) and Pears et al. (2012a).*

A full and comprehensive overview of the scoring procedures and risk matrix can be reviewed in section 3.3.3 of Pears *et al.* (2012a) and in Astles *et al*. (2009).

2.4 Issues arising

In the final phase of the ERA, the resilience capability scores, fishery impact profiles and overall risk ratings are reviewed in order to identify the key factors of influence. For the purpose of this analysis, the focus of this section remained within the specific ecological component and, where applicable, within the relevant species subgroup. Accordingly, this section of the assessment focused specifically on factors that affected the overall risk rating of an individual species, species complex or marine habitat (ecological subcomponent) rather than factors that affected the entire study area.

3. RESULTS

3.1 Harvest Species

The harvest species ecological component included all species that are actively targeted by the ECTF operators for commercial sale (principal species) and species that are not targeted by the fishery but can be retained for commercial sale (permitted or byproduct species) under the *Fisheries (East Coast Trawl) Management Plan 2010*.

3.1.1 Risk Context and Risk Identification

'Risk context' for the harvest species ecological component assessment was based on the GBRMP ERA (Pears *et al*., 2012a) to assess:

> *What is the likelihood that ECTF activities in waters outside the GBRMP (including RIBTF areas) will breach a relevant limit reference point or lead to any harvested species or populations within the study area being classified as overfished within the next 20 years?*

The 'risk identification' phase revealed 'harvesting', 'discarding' and 'contact without capture' as key factors of influence for the ECOTF in southern Queensland and the RIBTF (Table 2.1). This assessment was consistent with results obtained by Pears *et al*. (2012a) for ECOTF activities within the GBRMP. The most notable event identified for 'harvesting' related to the overexploitation of stocks including the consequences of growth or recruitment overfishing (Pears *et al*., 2012a).The impacts of discarding primarily relate to the consequences of catching target and byproduct species and then returning them to the water. Consequences of discarding include higher rates of fishing-induced mortality, poor post-release survival and trawl damage (Hill & Wassenberg., 1990; Pears *et al*., 2012a). 'Contact without capture' relates to impacts of fishing gear on animals not actually landed, such as injuries sustained by turtles escaping a trawl net via a TED.

The 'risk identification' phase of the assessment also identified 31 species or species groupings that may be impacted by harvesting, discarding and contact without capture. Fourteen species and one species grouping (Squid, *Family Loliginidae*) were included as principal species (Table 3.1) with the remaining 12 species and four species groupings classified as permitted or byproduct species (Table 3.2). Twelve of the 14 principal species were assessed as part of the GBRMP ERA (Pears *et al*., 2012a). The greasyback prawn (*Metapenaeus bennettae*) and the school prawn (*M. macleayi*) were included in the current analysis due to their prominence in southern Queensland and estuarine catches (Table 3.1). The Asian moon (mud) scallop (*Amusium pleuronectes*) which is a permitted species was not included in the southern Queensland and RIBTF ERA as catch rates within the study area are relatively low. In addition to *A. pleuronectes*, pipefish, which are on the permitted species list, were omitted from the harvest species ecological component analysis as they were assessed as part of the species of conservation concern ecological component (section 3.4). All 16 permitted species included in the southern Queensland and RIBTF ERA have corresponding ecological risk assessments for the GBRMP (Pears *et al*., 2012a).

3.1.2 Risk Characterisation

Resilience capability scores and fishery impact profiles for the harvested species ecological subcomponents were compiled using characteristics and decision rules outlined in Table A9 and A10 (Appendix C). While the number of characteristics used to assess permitted and principal species remained the same, some minor modifications were required to the fishery impact profile assessments (Appendix C: Table A10) to account for different harvesting regimes (*i.e.* targeted *vs.* non-targeted) and the way in which data is collected for these species. These changes were as follows:

- the 'nominal catch trends' characteristic in the principal species assessment was replaced in the permitted species assessment with 'can it be targeted/is it truly incidental catch'; and

- the 'stock assessment adequacy' characteristic in the principal species assessment was replaced in the permitted species assessment with 'biological information adequacy' (Appendix C: Table A9, A10).

The above changes did not have a significant bearing on the final outcomes of the study including the scoring of the fishery impact profile and the overall risk ratings (Table 3.1 – 3.2).

3.1.2.1 Southern Queensland and RIBTF areas

Most of the harvest species ecological subcomponents had resilience capability scores of high-intermediate (45.2%) or high (41.9%) (Table 3.1 – 3.2). Resilience capability scores for the permitted (byproduct) species (*n* = 16) had a broader range with four species identified as having an intermediate or intermediate-low ability to recover from disturbance or decline. These included the red champagne lobster (*Linuparus trigonus*), the slipper lobster species complex (*Scyllarus spp.*), the hammer octopus (*Octopus australis*) and the red-spot night octopus (*Callistoctopus dierythraeus*) (Table 3.2).

The completed fishery impact profiles suggest the ECTF exerts a low to intermediate level of pressure on species harvested within the study area. Of the species assessed, the majority had either an intermediate (*n* = 13, 41.9%) or intermediate-low (*n* = 13, 41.9%) fishery impact profile. Another four (12.9%) were assessed as having a low fishery impact profile (Table 3.1 – 3.2). The notable exception was the Cuttlefish (*Sepia* spp.) species complex, whose final score for the fishery impact profile equated to a high-intermediate level of risk (Table 3.2).

Cross-referencing the resilience capabilities of harvest species with their fishery impact profiles produced overall risk ratings of low to high-intermediate (Table 3.1 – 3.2). In general terms:

- overall risk ratings for principal (target) species were lower than that reported for permitted (byproduct) species;

- the majority of principal species had a low risk due to trawl fishing activities;

- there was an intermediate risk to around half (56.3%) of the permitted species and species groupings due to trawl fishing activities; and

- Cuttlefish (*Sepia* spp.) was the only harvest species ecological subcomponent to register an overall risk rating higher than intermediate (Table 3.1 – 3.2).

Ecological risk assessment summaries for principal and permitted species are detailed in Table 3.1 and 3.2 respectively. Additional information including completed resilience capability scores and fishery impact profiles for each principal (Table A17, A18) and permitted (Table A19, A20) species are provided in Appendix D.

***Table 3.1**. Resilience capability scores, fishery impact profiles (FIP) and overall risk ratings for **principal species** (targeted) retained for sale in the southern Queensland ECOTF and the RIBTF.*

Common Name	Species Name	Resilience	FIP	OVERALL
Tropical saucer scallop	*Amusium japonicum balloti*	H	I	I
Moreton Bay bugs				
– Reef Bug	*Thenus australiensis*	H-I	I	I
– Mud Bug	*Thenus parindicus*	H-I	I	I
Squid spp.	*Family Loliginidae: Uroteuthis (Photololigo)* spp.	H-I	I	I
Brown tiger prawn,	*Penaeus esculentus*	H	I-L	L
Blue-legged king prawn	*Melicertus latisulcatus*	H	I-L	L
Red spot king prawn	*Melicertus longistylus*	H	I-L	L
Black tiger prawn	*Penaeus monodon*	H	I-L	L
Eastern king prawn	*Melicertus plebejus*	H-I	I-L	L
Grooved tiger prawn	*Penaeus semisulcatus*	H	I-L	L
Greasyback (bay) prawn	*Metapenaeus bennettae*	H	I-L	L
Blue endeavour prawn	*Metapenaeus endeavouri*	H	L	L
False endeavour prawn	*Metapenaeus ensis*	H	L	L
School prawn	*Metapenaeus macleayi*	H	I-L	L
White banana prawn	*Fenneropenaeus merguiensis*	H-I	L	L

Table 3.2. *Resilience capability scores, fishery impact profiles (FIP) and overall risk ratings for* ***permitted species*** *(non-targeted byproduct) retained for sale in the southern Queensland ECOTF and the RIBTF.*

Common Name	Species Name	Resilience	FIP	OVERALL
Cuttlefish spp.	*Sepia* spp.	H-I	H-I	H-I
Threadfin bream	*Family Nemipteridae*	H-I	I	I
Mantis shrimp	*Order Stomatopoda; Family Squillidae*	H-I	I	I
Red champagne lobster	*Linuparus trigonus*	I	I	I
Octopus				
– Hammer octopus	*Octopus australis*	I-L	I	I
– Red-spot night octopus	*Callistoctopus dierythraeus*	I	I	I
– Scribbled night octopus	*Callistoctopus graptus*	H-I	I	I
– Plain-spot octopus	*Amphioctopus exannulatus*	H	I	I
– Veined octopus	*Amphioctopus marginatus*	H	I	I
– Southern star-eyed octopus	*Amphioctopus c.f. kagoshimensis*	H-I	I	I
Slipper lobster	*Scyllarus* spp. *(includes: Scyllarus martensii, Scyllarus demani; Scyllarides squammosus)*	I-L	I-L	I-L
Blue swimmer crab	*Portunus pelagicus*	H-I	L	L
Three-spotted/Red-spotted crab	*Portunus sanguinolentus*	H	I-L	L
Deepwater bug (Velvet/Balmain bug)	*Ibacus altricrenatus*	H-I	I-L	L
Shovel-nosed lobster	*Ibacus brucei*	H-I	I-L	L
Smooth bug	*Ibacus chacei*	H-I	I-L	L

3.1.2.2 Comparison with the GBRMP ERA

Of the harvested species included in both ECTF ERAs, five principal species (Table 3.3) and 11 permitted species (Table 3.4) had different overall risk ratings. In the majority of these instances (*n* = 12), overall risk ratings for the GBRMP ERA were lower than that reported in the present study. These differences were in direct response to the ecological subcomponent having a higher fishery impact profile score in the southern Queensland and RIBTF ERA (Table 3.3 – 3.4). On closer inspection:

- the elevated risk assessments for octopus species were largely attributed to an absence of species-specific measures and limited (in comparison) refuge availability;
- discard rates and hence risk for Moreton Bay (mud and reef) bugs were considered to be higher in southern Queensland; and
- the squid species complex (Family *Loliginidae*) and tropical saucer scallop (*Amusium japonicum balloti*) were assigned higher risk scores in the southern Queensland and RIBTF ERA for 'proportion of the fishery taken within the study area' and 'refuge availability' (Appendix D: Table A18, A20).

Of the species with lower overall risk ratings, the observed difference in grooved tiger prawn (*Penaeus semisulcatus*) assessments was largely attributed to this species receiving a 'risk double prone' (PP) score in the GBRMP ERA for 'per cent effort exposed 2009' (Pears *et al*., 2012a). As noted, this characteristic was intimately linked with information contained in (Pitcher *et al*., 2007); therefore was not included in the current analysis. The observed differences in fishery impact profile scores for slipper lobsters (*Scyllarus* spp.) and *Ibacus* species was more operational with the southern Queensland and RIBTF ERA having lower risk scores for 'interaction throughout life', 'marketability' and 'refuge availability' (Appendix D: Table A20). Factors that contributed to this difference included reduced market demand and increased protection due to the species preference for rockier marine habitat environments.

3.1.3 Issues arising

While risk ratings for permitted (byproduct) species tended to be higher, initial risk assessments indicate that species retained for sale in the ECTF are fairly resilient to trawl fishing activities. For instance, all but seven of the biological and ecological parameters used to assess resilience capabilities were assigned a value of 'risk averse' (Appendix D: Table A17, A19). This suggests that the fishery impact profile scores (Appendix D: Table A18, A20) may be a more sensitive indicator when attempting to identify individual areas of concern within the harvest species ecological component or when trying to differentiate between the ecological subcomponents.

When the two sub-fisheries (otter trawl *vs.* beam trawl) are compared, cross-species comparisons indicate that the otter trawl fishery had more of an influence on the fishery impact profiles. The primary reason for this is otter trawl operations interact with a wider array of harvest species and at varying stages of their life history. This contrasts to the RIBTF where the catch composition of the RIBTF is dominated by the greasyback or bay prawn (*Metapenaeus bennettae*), banana prawn (*Fenneropenaeus merguiensis*) and school prawns (*Metapenaeus macleayi*) (DEEDI, 2011b).

Table 3.3. *A comparison of the resilience characteristics and fishery impact profile scores for* ***principal species*** *whose overall risk rating differed between southern Queensland and RIBTF ERA and the GBRMP ERA (Pears et al., 2012a).*

Common Name	Species Name	Southern Queensland and RIBTF ERA			GBRMP		
		Resilience	FIP	OVERALL	Resilience	FIP	OVERALL
Moreton Bay Bugs							
– Reef Bug	*Thenus australiensis*	H-I	I	I	H-I	I-L	L
– Mud Bug	*Thenus parindicus*	H-I	I	I	H-I	I-L	L
Squid spp.	*Family Loliginidae, Uroteuthis (Photololigo) spp.*	H-I	I	I	H-I	L	L
Tropical saucer scallop	*Amusium japonicum balloti*	H	I	I	H	I-L	L
Grooved tiger prawn	*Penaeus semisulcatus*	H	I-L	L	H	I	I
Greasyback (bay) prawn	*Metapenaeus bennettae*	H	I-L	L	Not assessed.		
School prawn	*Metapenaeus macleayi*	H	I-L	L	Not assessed.		

Table 3.4. *A comparison of the resilience characteristics and fishery impact profile scores for* ***permitted species*** *whose overall risk rating differed between southern Queensland and RIBTF ERA and the GBRMP ERA (Pears et al., 2012a).*

Common Name	**Species Name**	**Southern Queensland and RIBTF ERA**			**GBRMP**		
		Resilience	**FIP**	**OVERALL**	**Resilience**	**FIP**	**OVERALL**
Cuttlefish spp.	*Sepia spp.*	H-I	H-I	H-I	H-I	I-L	L
Octopus							
– Hammer octopus	*Octopus australis*	I-L	I	I	I-L	I-L	I-L
– Red-spot night octopus	*Callistoctopus dierythraeus*	I	I	I	I	I-L	I-L
– Scribbled night octopus	*Callistoctopus graptus*	H-I	I	I	H-I	I-L	L
– Plain-spot octopus	*Amphioctopus exannulatus*	H	I	I	H	I-L	L
– Veined octopus	*Amphioctopus marginatus*	H	I	I	H	I-L	L
– Southern star-eyed octopus	*Amphioctopus cf. kagoshimensis*	H-I	I	I	H-I	I-L	L
Slipper lobster	*Scyllarus* spp.	I-L	I-L	I-L	I-L	I	I
Deepwater bug (Velvet/Balmain bug)	*Ibacus altricrenatus*	H-I	I-L	L	H-I	H-I	H-I
Shovel-nosed lobster	*Ibacus brucei*	H-I	I-L	L	H-I	H-I	H-I
Smooth bug	*Ibacus chacei*	H-I	I-L	L	H-I	H-I	H-I

While brown tiger prawns (*Penaeus esculentus*), grooved tiger prawns (*P. semisulcatus*) and eastern king prawns (*Melicertus plebejus*) are also caught by beam trawl operators (Williams, 2002), workshop participants considered this to be a much smaller component of the catch. Similarly, bycatch research (*e.g.* Lupton & Heidenreich, 1999; Hyland, 1988) indicates that the geographical range of a number of the permitted species had limited to no overlap with nearshore and estuarine areas typically fished by beam trawl operators. Given this, workshop participants considered the risk of an undesirable event occurring due to RIBTF activities to be relatively low for the majority of the permitted species. This included the Balmain bugs (*Ibacus* spp.) species complex.

Given the above considerations, the risk that RIBTF activities will cause an undesirable event for one or more of the harvested species is expected to be lower than that presented in Tables 3.1 and 3.2. DAF notes though that RIBTF operations occur along the Queensland coastline (Fig. 1.3) and that catch compositions and therefore the level of risk may vary regionally. For example, the risk that RIBTF activities will cause or contribute to the occurrence of an undesirable event is expected to be more significant in south-east Queensland where there are higher levels of effort (DEEDI, 2011b). This is perhaps most applicable to the T5 fishery which incorporates the Brisbane River; a key source of recruits for the Moreton Bay Trawl Fishery and the wider ECOTF. In comparison, beam trawl effort north of Moreton Bay tends to quite low (Tanimoto *et al*., 2006; *pers. comm*., T. Courtney).

At the whole-of-fishery level, the biggest factor of influence with respect to the fishery impact profiles was the current operating environment of the ECTF. Fishing data (DAFF, 2013a) shows that effort usage and participation rates have steadily declined in both the ECOTF and RIBTF (Appendix A). While a reduction in effort does not necessarily equate to a reduction in regional fishing intensity, it was generally accepted that lower levels of effort would reduce the risk from trawling. The primary reason for this is that lower levels of effort often equates to fewer interactions (overall) and reduced levels of fishing mortality. This factor was ultimately reflected in the scores assigned to characteristics like 'discard rates' for principal species, 'targeting of permitted species' and 'exploitation status'; all of which are characteristics used to construct the fishery impact profile (Appendix D: Table A18, A20).

In addition to the above, workshop participants gave significant weighting to the effectiveness of management arrangements used to control trawl fishing in key areas or during key times of the year.[11] For example, spatial and temporal closures outlined in the *Fisheries Regulation 2008*, the *Fisheries (East Coast Trawl) Management Plan 2010* or in non-fisheries specific legislation such as those defined within the *Marine Parks (Moreton Bay) Zoning Plan 2008* and the *Marine Parks (Great Sandy) Zoning Plan 2006*. The level of protection these closures afford harvest species range from permanent prohibitions on trawl fishing activities through to limited access during key times and seasons. These measures provide harvest species with a level of protection against overexploitation which (again) was accounted for in the fisheries impact profiles.

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[11] *Refers to the ECTF management regime in place at the time of the ERA i.e. 2013, 2014, 2015.*

A high proportion of the closures outlined in the *Fisheries Regulation 2008* and the *Fisheries (East Coast Trawl) Management Plan 2010* were implemented for the specific protection of principal species. In comparison, few of the spatial or temporal closures contained within the *Fisheries Regulation 2008* or the *Fisheries (East Coast Trawl) Management Plan 2010* were implemented to specifically manage the catch of permitted (byproduct) species. This contributed to a high number of permitted species being assigned a score of 'prone to risk' (P) for the 'species-specific measures' and 'refuge availability' characteristics (Appendix D: Table A20). In saying that, closures implemented for the protection of principal species and a number of the wider-scale or non-species specific closures could reduce the level of incidental fishing mortality for permitted species living within these areas *i.e.* the *Southern regional regulated waters* six week closure and those contained within marine parks legislation. Further, a portion of the area encompassed within the southern Queensland and RIBTF ERA spatial definition would not be fished by trawl operators due to environmental factors (*e.g.* hard/non-trawlable substrate) or economic reasons (*e.g.* low levels of commercial product). This would provide all of the harvest species with a degree of protection from trawl fishing activities; albeit varying between regions and species/species complexes.

An absence of biological information, a limited understanding of interaction rates and poor species resolutions were all contributing factors for species with overall risk ratings of intermediate or higher (Total, n = 14; permitted species, n = 10; principal species, n = 4). This was particularly evident in the fishery impact profiles of permitted species where data inadequacies often resulted in more conservative scores being assigned to specific characteristics (Appendix D: Table A20). For example, the 'prone to risk' (P) score assigned to 'exploitation status' and 'refuge availability' for cuttlefish (*Sepia* spp.) was due mostly to an absence of credible data. Similar trends were observed for octopus species where all but one of the species was assigned a 'prone to risk' (P) score for these characteristics (Appendix D: Table A20).

3.1.4 Management considerations

While risk assessments for harvest species were comparatively low, it is important to note that a) effort levels in the 2009 fishing season were below the historical average, b) there is sufficient scope within the *Fisheries (East Coast Trawl) Management Plan 2010* for effort usage to increase and c) none of the harvest species ecological subcomponents are subject to an enforceable harvest strategy. These points are of particular relevance to the ECOTF where operators are able to shift between areas and or target different species during a given season. For example, otter trawl (T1/T2) operations in southern Queensland can access both shallow water and deepwater environments. Alternatively, ECOTF operations situated north of 24.5º S can access fishing grounds in southern Queensland and vice versa. Some examples from a harvest species perspective include T1 and T2 operators shifting their focus from tropical saucer scallops to deepwater eastern king prawns or from red spot king prawns north of 24.5º S to tiger prawns in southern Queensland.

The ability of ECOTF operators to move between regions and species sectors will need to be taken into consideration when determining the applicability of this ERA to future fishing environments. Shifting fishing patterns may result in one or more of the harvested species experiencing increased levels of fishing intensity and an increased rate of fishing mortality. This may occur even if overall effort usage levels in southern Queensland remain the same. For species like the tropical saucer scallop (Campbell *et al*., 2010), harvest strategy evaluations that include reference points has made it easier to assess changes to the risk-level. Future evaluations though would benefit from additional information on harvest limits and a greater understanding of how risk is or may be reduced through large or small-scale effort controls.

As noted, assessments for the harvest species ecological component were generally positive with all but one of the species/species complexes recording an overall risk rating above intermediate (Table 3.1 – 3.2). While the cuttlefish (*Sepia* spp.) species complex had a high to intermediate assessment, closer examination suggests this is a conservative estimate resulting from regional data deficiencies. This inference was partially supported by the GBRMP ERA where more detailed data sets produced lower overall risk ratings for both cuttlefish and octopus (Pears *et al*., 2012a). Despite this, managers will need to consider the possibility that trawl fishing activities pose a higher risk to these species in southern Queensland or RIBTF areas. Additional information would also help to refine future risk assessments.

While data deficiencies were considered to be less of an influence when compared to the bycatch species ecological component, future ERAs for harvest species would benefit from additional information; particularly with respect to the permitted species. The most notable information gaps appear to be catch related and are due, in part, to the current catch monitoring regime (Appendix B) and the need to balance reporting requirements with operational efficiencies *i.e.* industry and management costs. Increasing the level of catch and biological information will improve the accuracy of future ERAs involving harvest species; thus helping to ensure that finite fisheries resources are directed towards the management of species at actual risk from trawl fishing. Improving the accuracy of risk assessments may also facilitate an expansion of the permitted species list and enable greater use of resources often discarded in a dead or moribund state.

Promisingly, Queensland has already implemented a number of initiatives that are designed to improve the accuracy of catch reporting in the ECTF. For example, the Queensland Government developed and distributed a comprehensive Moreton Bay and Balmain bug identification guide in 2009 (Department of Primary Industries [DPI][12], 2009). Designed to improve the accuracy of bug identification in the field, the continued use of this guide may enable bug species to be further delineated in future versions of the ECTF logbook; currently limited to 'sand/mud bugs' and 'Balmain/honey bugs' (Appendix B). If this were to occur, it is anticipated that the level of uncertainty surrounding the bug assessments would decline; therefore improving the accuracy of the overall risk ratings (Table 3.1 – 3.2). In the context of this ERA, any improvement in the available data may result in bug species being assigned a lower score for one or more of the fishery impact profile characteristics *e.g.* 'species level data (identification)' (Appendix D: Table A20).

In addition to improved catch reporting, research has shown that the impact of the ECTF on some harvest species can be reduced through a refinement of provisions relating to BRD usage. Courtney *et al*. (2007, 2008) showed that the mean catch rate of undersized scallops

[12] *Former title of the Department of Fisheries and Agriculture.*

was reduced by 32% when a Square Mesh Codend BRD was used in conjunction with a TED. Importantly, this reduction was achieved without a discernible reduction in the catch of legal-sized scallops (Courtney *et al*., 2008). The same net configuration yielded a 76% reduction in the catch rate of undersized Moreton Bay (reef) bugs (*Thenus australiensis*). However, Courtney *et al*. (2008) noted that this configuration reduced the catch of commercially viable bugs by around 32%. Despite this, Courtney *et al*. (2007) indicated that the benefits outweighed these costs and recommended that the use of a Square Mesh Codend BRD become mandatory in the scallop sector.

Significantly, provisions governing the use of BRDs in the ECTF were reviewed in light of the aforementioned results. As a result of this review, a number of amendments were made to the *Fisheries (East Coast Trawl) Management Plan 2010* to increase the use of more effective BRDs in the ECTF. Coming into effect on 1 March 2015 these amendments, among other things, reduced the number of approved BRDs from eight to five, mandated the use of a Square Mesh Codend in the scallop fishery and introduced regional BRD management arrangements (Appendix F). These amendments were preceded by a number of other initiatives designed to promote the use of more efficient BRDs in the ECTF. This includes a rebate program to encourage and promote the use of a Square Mesh Codend BRD in the scallop and eastern king prawn (EKP) sectors (Roy & Jebreen, 2011). Going forward, these changes and initiatives will help to further reduce the risk posed by trawl fishing activities in southern Queensland.

Changes to the *Fisheries (East Coast Trawl) Management Plan 2010* and initiatives like the Square Mesh Codend rebate scheme (Roy & Jebreen, 2011) will have longer-term benefits for at least two of the principal species: the tropical saucer scallop (*Amusium japonicum balloti*) and Moreton Bay (reef) bug (*Thenus australiensis*). These benefits may extend to species with similar life history traits *i.e.* the Moreton Bay (mud) bug (*T. parindicus*) and Balmain bugs (*Ibacus altricrenatus* and *I. brucei*) and other species on the permitted species list (Appendix D: Table A18, A20). For example, Courtney *et al.* (2014) demonstrated that the use of a Square Mesh Codend in the deepwater eastern king prawn (*Melicertus plebejus*) trawl fishery significantly reduced the catch rates of small (15 – 40 mm mantle length) cuttlefish. From an ERA and stock management perspective, the exclusion of smaller size cohorts will improve post-interaction mortality rates, help to minimize trawl-related injuries, contribute to future recruitment events and reduce catch processing times (Courtney *et al*., 2007; Eayrs, 2007).

3.2 Bycatch Species

The primary focus of the bycatch ecological component ERA was non-targeted species that are caught in the ECTF and subsequently discarded. This aspect of the analysis did not include discarded principal and permitted species, marine turtles, sea snakes, syngnathids and Chondrichthyes as they are all captured under alternate ecological component assessments.

3.2.1 Risk Context and Risk Identification

‘Risk context’ for the bycatch ecological component was again modified from the GBRMP ERA (Pears *et al*., 2012a) with the southern Queensland and RIBTF ERA attempting to address the following question:

> *What is the likelihood that ECTF activities in waters outside the GBRMP (including RIBTF areas) will exceed the ability of a species to renew themselves, such that regional populations of bycatch species are no longer maintained, no longer fulfil their ecosystem role or are excessively depleted within the next 20 years?*

As the majority of the species included in the bycatch ecological component were smaller fish of low or no economic value, discarding and contact without capture (Pears *et al*., 2012a) were identified as the key sources of risk (Table 2.1). The principal concerns being: the proportion of bycatch landed in a dead or moribund state, poor post release survival rates and injuries resulting from interactions with the trawl gear. The sources of risk identified for ECOTF operations in southern Queensland and the RIBTF were consistent with Pears *et al*. (2012a).

A review of catch records and data sources relating to the ECTF identified 59 species that achieved one or more of the criteria prescribed in the materials and methods section (Table 3.5). The majority of this list were teleost ray-finned species (*n* = 58) and included grinners/lizardfish (Order Aulopiformes), herring (Order Clupeiformes), mullet (Order Mugilidae), perch-like fishes *e.g.* bream, silverbiddies, snapper, whiting, barracuda, barramundi goatfish, tailor, scad, trevally, threadfin (Order Perciformes), flatfish and sole (Order Pleuronectiformes) and flathead (Order Scorpaeniformes). One invertebrate species, the painted rocklobster (*Panulirus versicolor*) was included in the analysis due to its importance to both the commercial and recreational fishing sectors. Eight of the 59 bycatch species assessed as part of the southern Queensland and RIBTF ERA had corresponding risk assessments for the GBRMP (Pears *et al*., 2012a).

3.2.2 Risk Characterisation

Characteristics and decision rules used to assess the resilience capabilities and construct fishery impact profiles for the bycatch ecological component are outlined in Table A11 and A12 respectively (Appendix C).

3.2.2.1 Southern Queensland and RIBTF

A high proportion (44.1%) of bycatch species included in the analysis registered resilience capability scores of intermediate-low with only six (10.2%) assessed as having a low ability to recover from disturbance or decline (Table 3.5). Similar trends were observed in the fishery impact profiles with the majority of species allocated to the intermediate (45.8%) or intermediate-low (40.7%) risk categories (Table 3.5). While taxonomic relatedness did not appear to be a significant factor in the final resilience capability scores, the four species with the highest fishery impact profile scores were all *Parupeneus* (Goatfish) species (Table 3.5). The only invertebrate species included in the bycatch ecological component, the painted rocklobster (*P. versicolor*), was one of four assigned a low fishery impact profile score (Table 3.5).

Table 3.5. *Resilience capability scores, fishery impact profiles (FIP) and overall risk ratings for species caught as* ***bycatch*** *by ECTF operators in southern Queensland and RIBTF areas – arranged in order of the level of risk*.

Common Names	Species Name	Resilience	FIP	OVERALL
Goatfish, Yellowspot	*Parupeneus indicus*	I-L	H-I	H
Goatfish, Opalescent	*Parupeneus heptacanthus*	H-I	H-I	H-I
Goatfish, Bicolour	*Parupeneus barberinoides*	I	H-I	H-I
Goatfish, Banded	*Parupeneus multfasciatus*	I	H-I	H-I
Trevally, Whitefin	*Carangoides equula*	H-I	I	I
Tounge Sole, Spotfin	*Cynoglossus maculipinnis*	H-I	I	I
Tounge Sole, Fourline	*Cynoglossus bilineatus*	I-L	I	I
Sole, Tufted	*Brachirus muelleri/Dexillichthys muelleri*	I-L	I	I
Saury, Brushtooth/Largescale	*Saurida grandisquamis/undosquamis*	H-I	I	I
Saury, Threadfin	*Saurida filamentosa*	H-I	I	I
Saury, Longfin	*Saurida longimanus*	H-I	I	I
Saury, Clouded	*Saurida nebulosa*	I	I	I
Thryssa, Hamilton's	*Thryssa hamiltonii*	I	I	I
Thryssa, Longjaw	*Thryssa setirostris*	I	I	I
Silverbiddy, Threadfin	*Gerres filamentosus*	H-I	I	I
Silverbiddy, Blacktip	*Gerres oyena*	I	I	I
Silverbiddy, Longfin	*Pentaprion longimanus*	I-L	I	I
Silverbiddy, Slender	*Gerres oblongus*	I-L	I	I
Herring, Southern	*Herklotsichthys castelnaui*	H-I	I	I
Anchovy, Flase Baelama	*Thryssa encrasicholoides*	H-I	I	I
Threadfin, Australian	*Polydactylus multiradiatus*	I	I	I
Whiting, Stout	*Sillago robusta*	I	I	I

Common Names	Species Name	Resilience	FIP	OVERALL
Whiting, Sand	*Sillago ciliate*	I-L	I	I
Whiting, Trumpeter	*Sillago maculata*	L	I	I
Ponyfish, Whipfin	*Leiognathus leuciscus/Equulites leuciscus*	I-L	I	I
Bream, Pikey	*Acanthopagrus berda*	I-L	I	I
Baracuda, Military	*Sphyraena putnamae*	I-L	I	I
Baracuda, Sharpfin	*Sphyraena acutipinnis*	I-L	I	I
Baracuda, Yellowtail	*Sphyraena flavicauda*	I-L	I	I
Teraglin	*Atractoscion aequidens*	L	I	I
Goatfish, Pennant	*Upeneus filifer*	I-L	I	I
Goatfish, Bluestriped	*Upeneichthys lineatus*	I	I-L	I-L
Goatfish, Goldband	*Upeneus moluccensis*	I	I-L	I-L
Goatfish, Striped	*Upeneus vittatus*	I	I-L	I-L
Goatfish, Bartail (Red Mullet)	*Upeneus tragula*	I	I-L	I-L
Goatfish, Luzon	*Upeneus luzonius*	I	I-L	I-L
Goatfish, Blacksaddle	*Parupeneus spilurus*	I-L	I-L	I-L
Goatfish, Asymmetric (Red Mullet)	*Upeneus asymmetricus*	I-L	I-L	I-L
Rabbitfish, Black	*Siganus fuscescens*	I	I-L	I-L
Lizardfish/Saury, Short-finned/Shortfin	*Saurida argente /tumbil*	I	I-L	I-L
Perch, Pearl	*Glaucosoma scapulare*	I-L	I-L	I-L
Tuskfish, Purple	*Chaerodon cephalotes*	I-L	I-L	I-L
Barramundi	*Lates calcarifer*	I-L	I-L	I-L
Mullet, Sea	*Mugil cephalus*	I-L	I-L	I-L
Flathead, Bartail	*Platycephalus indicus*	I-L	I-L	I-L

Common Names	Species Name	Resilience	FIP	OVERALL
Tailor	*Pomatomus saltatrix*	I-L	I-L	I-L
Snapper, Pink (inside MB)	*Pagrus auratus*	I-L	I-L	I-L
Snapper, Pink (outside MB)	*Pagrus auratus*	I-L	I-L	I-L
Bream, Silver (Tarwhine)	*Rhabdosargus sarba*	I-L	I-L	I-L
Bream, Yellowfin	*Acanthopagrus australis*	I-L	I-L	I-L
Tuskfish, Venus	*Chaerodon venustus*	L	I-L	I-L
Flathead, Dusky	*Platycephalus fuscus*	L	I-L	I-L
Scad, Yellowtail	*Trachurus novaezelandiae*	I-L	L	I-L
Rocklobster, Painted	*Panulirus versicolor*	I-L	L	I-L
Threadfin, King	*Polydactylus macrochir*	L	L	I-L
Mulloway	*Argyrosomus japonicus*	L	L	I-L
Silverbiddy, Common	*Gerres subfasciatus*	H-I	I-L	L
Baracuda, Striped	*Sphyraena obtusata*	H-I	I-L	L
Grinner, Painted	*Trachinocephalus myops*	H-I	I-L	L

Combining the resilience capability scores with the fishery impact profiles produced overall risk ratings of low through to high (Table 3.5). The majority of species from the bycatch ecological component were at an intermediate (45.8%) or intermediate-low (42.4%) risk of experiencing an undesirable event due to trawl fishing activities. Only four species (6.8%) registered an overall risk rating above intermediate (Table 3.5).

Based on the results obtained, the following evaluations could be made with respect to the bycatch species ecological component:

- trawl fishing activities represented a low to intermediate risk for the majority of bycatch species (93.2%);
- at least three species of goatfish (the opalescent goatfish, *Parupeneus heptacanthus*; the bicolour goatfish, *Parupeneus barberinoides*; the banded goatfish, *Parupeneus multfasciatus*) were assessed as having a high-intermediate risk rating; and
- one another species of goatfish, the yellowspot goatfish (*Parupeneus indicus*), was categorised being at high risk.

3.2.2.2 Comparisons with the GBRMP ERA

Of the eight species that were included in both assessments, four had overall risk ratings that differed between the GBRMP ERA (Pears *et al*., 2012a) and southern Queensland and RIBTF ERA (Table 3.6). Cross-comparisons of individual scores indicated that these differences could not be entirely attributed to either the resilience capability assessments or the fishery impact profiles, although all four had higher fishery impact profiles.

Resilience capability scores for the lizardfish complex (*Saurida grandisquamis/S. undosquamis*) and the spotted-fin tongue-sole (*Cynoglossus maculipinnis*) were higher in southern Queensland and RIBTF areas (Table 3.6). The main reason for this is that these two groups were considered to be widespread and highly prolific within the sample area. As a consequence, a score of ‘risk averse’ (A) was assigned to one or more of the following characteristics: habitat association, life history strategy and longevity/natural mortality (Appendix D: Table A21). This contrasts to the GBRMP ERA (Pears *et al*., 2012a) where the two subcomponents were more likely to receive a ‘prone to risk’ (P) score.

In addition to the above, the fishery impact profiles for some bycatch species were directly affected by the changes in methodology *i.e.* observed differences in the scores assigned to replacement characteristics. For example, the southern Queensland and RIBTF ERA used ‘frequency of capture’ as a substitute for ‘per cent caught 2009’ (Pears *et al*., 2012a). In the current study, the lizardfish complex (*Saurida grandisquamis/S. undosquamis*) was assigned a ‘prone to risk’ (P) score for the ‘frequency of capture’. However, the same species complex was assigned a ‘risk averse’ (A) score for ‘per cent caught 2009’ component of the GBRMP ERA (Pears *et al*., 2012a). Given this difference, it is possible that the aforementioned methodological changes contributed to the lizardfish complex (*Saurida grandisquamis/S. undosquamis*) having a higher overall risk rating in southern Queensland (Table 3.6).

Table 3.6. *A comparison of the resilience characteristics and fishery impact profile scores for* ***bycatch species*** *whose overall risk rating differed between southern Queensland and RIBTF ERA and the GBRMP ERA (Pears et al., 2012a).*

Common Name	Species Name	Southern Queensland and RIBTF ERA			GBRMP		
		Resilience	FIP	OVERALL	Resilience	FIP	OVERALL
Tounge Sole, Spotted-fin	*Cynoglossus maculipinnis*	H-I	I	I	I-L	I-L	I-L
Threadfin, Australian	*Polydactylus multiradiatus*	I	I	I	I	I-L	I-L
Lizardfish/Saury, Brushtooth/Largescale (Grey)	*Saurida grandisquamis/undosquamis*	H-I	I	I	I-L	I-L	I-L
Whiting, Trumpeter	*Sillago maculata*	L	I	I	L	I-L	I-L
Silverbiddy, Longfin	*Pentaprion longimanus*	I-L	I	I	I	I	I

Of the three fishery impact profile characteristics included in both studies, ‘survival after capture’, ‘TED/BRD effectiveness’ and ‘refuge availability’ (Appendix D: Table A22), all but one of the southern Queensland and RIBTF ERA scores aligned with the GBRMP ERA (Pears *et al*., 2012a). The notable exception being the spotted-fin tongue-sole (*Cynoglossus maculipinnis*) which was assigned a ‘prone to risk’ (P) score for survival after interaction; compared with a ‘risk averse’ (A) score in the GBRMP ERA (Pears *et al*., 2012a). This again contributed to this species having a higher overall risk rating for southern Queensland and RIBTF areas.

3.2.3 Issues arising

In the southern Queensland and RIBTF ERA, the scope of the bycatch ecological component consisted almost exclusively of teleost species (Table 3.5). This is in contrast to the bycatch ecological component of the GBRMP ERA which included ray-finned fish, seapens, bivalves, crustaceans and gastropods (Pears *et al*., 2012a). In reality, the list of bycatch species that interact with the ECOTF in southern Queensland or the RIBTF would be much larger than that included in the current study (*e.g.* Courtney *et al*., 2007). This includes a diverse range of invertebrate and vertebrate species; some of which were included in the GBRMP ERA (Pears *et al*., 2012a).

By using a shortlisting process, the southern Queensland and RIBTF ERA was able to prioritise what species were included in the final analysis. As the criteria were based on catch data and/or the level of significance to other fisheries (commercial and recreational), the primary objective of the bycatch ERA was developing informed assessments for species with sufficient data sets. This by extension omitted species that have limited interactions with the ECTF and reduced the number of speculative risk assessments. As data deficiencies were addressed in the ERA through conservative risk scores, this process also minimised the number of ecological components with highly conservative but inaccurate risk assessments.

An inherent trade-off with the above approach is that the risk posed by the ECTF in southern Queensland remains unknown for those species that did not meet the inclusion criteria. Further, the shortlisting process may have excluded some bycatch species that are at genuine risk of experiencing an undesirable event *i.e.* rare species for which there were insufficient data to make an assessment (Pears *et al*., 2012a). To this extent, any future ecological risk assessments should review the shortlist of bycatch ecological subcomponents to determine: a) if there is any new and relevant information; and b) if there are additional species including invertebrates that warrant detailed assessment.

Despite the above safeguards, the southern Queensland and RIBTF ERA still includes a number of species with significant gaps in the available information. This was most evident in the fishery impact profiles where characteristics like ‘interaction throughout lifecycle’, ‘survival after interaction’ and ‘refuge availability’ required conservative estimates to be applied with more regularity (Appendix D: Table A22). While proxies were required in the resilience capability assessments, information on teleost life-histories, geographical distributions, habitat associations and natural mortality rates were considered to be more robust. This enabled closely related species to be used as proxies in the resilience capabilities assessments and provided a higher level of confidence in the final results (Appendix D: Table A21). This however was not always the case in the fishery impact profile assessments where data sets for the proxy values were, at times, only marginally better than the subcomponents they were representing (Appendix D: Table 22). This in turn introduces a degree of uncertainty into the final risk ratings.

Of the 59 species included in the bycatch ecological component, six were identified as having a low ability to resist disturbance or recover from decline (Table 3.5). Closer inspection of the resilience capability scores indicates that these findings were influenced more by the limitations of individual species rather than all six having deficiencies in a specific subset of characteristics *i.e.* all having low fecundity levels or reduced distributions. It is noted though that all six had low natural mortality rates and were in a minority of subcomponents assigned a 'prone to risk' (P) score for 'cumulative pressures' (Appendix D: Table A21). Other factors including life-history constraints contributed to species like mulloway (*Argyrosomus japonicus*) and Teraglin (*Atractoscion aequidens*) having low resilience capability scores (Table 3.5; Appendix D: Table A21).

Known geographical distributions and catch records (Reid & Campbell, 1994; Courtney *et al*., 2007) indicate that a number of the bycatch subcomponents interact with both the ECOTF and the RIBTF (Appendix D: Table A21). Of the two sectors, the ECOTF would be responsible for the vast majority of the bycatch interactions. The primary reasons for this are that ECOTF operations utilize larger gear, have longer trawl times and cover a greater range of habitats and water depths (Robins & Courtney, 1998; DEEDI, 2011a, 2011b). While the RIBTF does contribute to the overall discard rate, this for the most part is represented in the catch rates of smaller teleosts including baitfish. An example of which is the common silverbiddy (*Gerres subfasciatus*) which makes up a considerable portion of the total beam trawl catch weight (Hyland, 1988; Robins & Courtney, 1998).

All 32 species with an overall risk rating of intermediate or higher were assigned a 'prone to risk' (P) score for the 'survival after interaction' fishery impact profile characteristic (Appendix D: Table A22). These scores were largely based on industry observations and research showing that a) smaller species are less likely to survive a trawl event and b) a considerable portion of the teleost catch is landed in either a dead or moribund state (*e.g.* Hill & Wassenberg, 1990; Hill & Wassenberg, 2000; Broadhurst *et al*., 2008). A high proportion of these species also received a 'prone to risk' (P) score for 'TED/BRD effectiveness' with smaller teleosts more likely to pass through the bar spacing of a TED. Once caught in the codend of a trawl net, the ability of these species to escape tends to be limited; although research has shown that BRD effectiveness can vary between designs (Courtney *et al*., 2007).

At the species-specific level, the four subcomponents with the highest overall risk ratings (high-intermediate and high) all belong to the Mullidae (goatfish) family (Table 3.5). As the resilience capabilities of these species ranged from intermediate-low to high-intermediate, this result was largely attributed to their fishery impact profiles (Appendix D: Table 22). For example, the four goatfish are smaller species that live a predominantly benthic existence and interact with the ECTF throughout their life-cycle. The ERA assessment phase also indicated that a substantial proportion of their geographical range occurred in areas outside of the GBRMP. As a consequence, these four were assigned a 'prone to risk' (P) score for all of the fishery impact profile characteristics. This is in contrast, to a number of the species with an intermediate overall risk rating which were assigned a lower risk score due to them inhabiting areas not accessible to the trawl fishery and or having life-histories that included a pelagic stage (Appendix D: Table A22).

3.2.4 Management considerations

The complete exclusion of non-targeted species from the total ECTF catch is highly unlikely, even with a range of bycatch mitigation measures in place. This places added importance on studies like the southern Queensland and RIBTF ERA which attempts to quantify the potential impacts of trawl fishing on non-targeted species and helps to identify long-term sustainability risks. To this extent, the bycatch ecological component assessment (Table 3.5) provides a good framework for future iterations of the southern Queensland and RIBTF ERA to build upon. As part of this process, consideration should be given to improving the diversity of the bycatch ecological subcomponents (*i.e.* including additional taxonomic groups and species) and the quality of information used to construct these assessments.

Teleosts were well represented in the current study and have ERAs that can be easily updated when new or relevant information becomes available (Appendix D, Table A21, A22). This is in contrast to the invertebrate subsample (n = 1) which was extremely limited and provided little insight into the risks posed by trawl fishing to this component of the ECTF catch. With this in mind, the next logical step for the southern Queensland and RIBTF ERA would be to increase the number of invertebrates included in the bycatch ecological component (Table 3.5), although any expansion will be highly dependent on data availability.

While recognising the need to increase the level of information (biological and fisheries related), this may be easier said than done for a high proportion of the bycatch species. This can be partly attributed to the fact that ECTF bycatch often consists of low-profile species with low research priorities or are species of limited or no economic value. In these instances, there is little incentive to investigate the life-history constraints of these species and therefore limited opportunities to improve on current information levels. This issue is compounded by the fact that the *Fisheries Observer Program* ceased operations in 2012. Given the above, early consideration should be given to identifying priority species (invertebrate and vertebrate) for future assessments and avenues within which the level of information on their biology and fisheries interactions can be improved.

With regards to the sources of risk, research has shown that the effectiveness of BRD designs can vary and, in the case of the ECOTF, may be dependent on the species-sector. For example, Courtney *et al*. (2007) demonstrated that the use of a Square Mesh Codend BRD[13] in the tropical saucer scallop (*Amusium japonicum balloti*) sector reduced bycatch rates by as much as 77% (Courtney *et al*., 2007). Significantly, this reduction was achieved without a discernible decline in the catch rates of marketable product. Analogous bycatch reductions using the Square Mesh Codend BRD were observed in the deepwater eastern king prawn (*Melicertus plebejus*) sector and in the Northern Prawn Fishery when a Fisheye BRD was used in conjunction with a TED (Heales *et al*., 2008). As noted by Courtney *et al*. (2007), albeit in the context of using a Square Mesh Codend BRD in the tropical saucer scallop sector, these results

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[13]Used in conjunction with a TED (Courtney et al., 2007).

demonstrate that bycatch levels can be reduced without a significant impact on the catch rates of commercial product.

From an ERA perspective, mandating the use of more efficient BRDs will have benefits for a number of the species included in the current analysis (Table 3.5). These benefits may extend to the four goatfish (Courtney *et al*., 2007) with high and high-intermediate risk ratings which, as small teleost species, are expected to experience higher rates of trawl-induced mortality. It is noted though that the extent of these benefits may be difficult to quantify as all four species have limited catch and mortality rate data. Specifically, it will be difficult to quantify the extent of any decrease in individual catch rates and its potential to reduce the overall risk rating of a particular species. Additionally, bycatch reductions attributed to a particular BRD are often reported at a higher level *i.e.* a proportional reduction in the overall weight (*e.g.* Courtney *et al*., 2007). Reporting of results in this manner is often done out of necessity as quantifying catch rates for a large number of species is inherently difficult. It is for this reason that measuring the success of any proposal to mandate the use of a specific BRD will continue to be done at the whole-of-catch level in the short to medium term.

More long-term, it will be important to consider how changes in the ECTF fishing environment will affect risk assessments for bycatch species. While difficult to quantify, risk assessments for one or more of the bycatch ecological subcomponents may change if effort usage increases in southern Queensland. The extent of this change will ultimately be dependent on the ecological subcomponent, the extent of (any) increases and the duration of the increase *e.g.* sustained and permanent or a temporary pulse. As there is substantial scope for effort usage to increase in the ECTF, this will need to be taken into consideration when assessing trawl-related risks going forward and the relevance/applicability of bycatch assessments contained within this report.

Similarly, some consideration should be given to how changing fishing patterns may alter risk assessments for bycatch species. If for example effort shifts from one species sector to another (*e.g.* from scallops to eastern king prawns) but total effort usage remained the same. If this were to occur, a particular subgroup of bycatch species may be exposed to more intense fishing practices (*i.e.* deepwater species) even if total effort usage rates remain the same. Given this, it will be important to review the results of this analysis in the context of the management arrangements; how effective they are at controlling fishing effort both at a fishery-wide and regional level, and their ability to mitigate the (potential) risks associated with an increase in effort usage in one or more of the species sectors. Unlike the harvest species ecological component, the overwhelming majority of bycatch species will have little data on harvest reference points. This type of data deficiency creates an additional challenge that will be difficult to overcome.

In addition to the above, attempts should be made to quantify the level of protection provided to bycatch species through the current suite of spatial and temporal closures. A likely priority in this process would be species at high risk with further consideration given to the inclusion of species at an intermediate risk (Table 3.5). This again may be difficult to achieve as it requires an understanding of regional distributions through species records (*i.e.* catch records, museum records etc.) and an examination of how well a species' biology (*i.e.* reproductive periods) aligns with the closure period. Despite these difficulties, this type of analysis would help to identify the wider benefits of closures originally introduced to protect harvest species, species of conservation concern or representative areas *i.e.* marine park zones. This type of analysis would also help to identify closures that provide a high level of protection, those that could be improved with marginal changes to boundaries or times and areas that would benefit from additional protection measures.

3.3 Species of Conservation Concern

The species of conservation concern ecological component[14] encompassed a diverse range of species from four distinct groups: marine turtles (Order Testudines); sea snakes (Suborder Serpentes); seahorses and pipefish (Order Syngnathiformes); sharks, skates, rays and chimaeras (Class Chondrichthyes). While not universal, these four groups contain a number of species that have experienced declines in population numbers, have reduced spatial distributions and/or have *k*-selected life history traits that, when compared to other species, make them more susceptible to overexploitation (Environment Australia, 2003; Reynolds *et al*., 2005; White & Kyne, 2010). In some instances, these declines have resulted in protections under international, national and state legislature; thus helping to minimize the level of impact commercial and recreational fishing has on regional populations *e.g.* aspects of the *Fisheries Act 1994*, the *Fisheries (East Coast Trawl) Management Plan 2010*, the *Great Barrier Reef Marine Park Act 1975* and the *Environment Protection and Biodiversity Conservation Act 1999*.

3.3.1 Risk Context and Risk Identification

In the current study, the ERA attempted to address the following question:

> *What is the likelihood that the current activities of the ECTF in waters outside the GBRMP (including RIBTF areas) will exceed the level of interaction which is acceptable for the species of conservation concern within the next 20 years?*

When compared to the other ecological components, the species of conservation concern were exposed to the highest number of risk sources. This was due to the diverse nature of the species included in the analysis and a high level of interspecific variability in locomotive capabilities and habitat preferences. Of the seven sources of risk identified by Pears *et al*. (2012a), the following were all considered to be applicable to this ecological component: discarding, contact without capture, travel to and from grounds and disturbance due to presence in the area (Table 2.1). Harvesting was also identified as a source of risk for syngnathids on the permitted species list; although was not significant for marine turtles, sea snakes and Chondrichthyes. The sources of risk identified for the southern Queensland and RIBTF ERA were consistent with those identified by Pears *et al*. (2013a).

Six marine turtles (Appendix D: Table A23, A24), 11 sea snakes (Appendix D: Table A25, A26) and six syngnathids (Appendix D: Table A27, A28) assessed by Pears *et al*. (2012a) have

[14] The 'Species of Conservation Concern" ecological component includes both species protected under legislation as 'no-take' and species that can be retained but are the subject of ongoing conservation concern at a state, national or potentially international scale. As a consequence, this ecological component is broader than the species classified by DAF as 'Species of Conservation Interest' which only includes no-take species; as defined under Fisheries legislation.

geographical distributions that extend into areas outside of the GBRMP, and were therefore included in the southern Queensland and RIBTF ERA (Table 3.7). The sad seahorse (*Hippocampus tristis*) and Dunker's pipehorse (*Solegnathus dunkeri*) were also included in the analysis as they interact with the ECOTF in southern Queensland (Table 3.8). No other species of marine turtle or sea snake were identified as having the potential to interact with the ECTF in southern Queensland and RIBTF areas.

Table 3.7. *ERA compositions for the species of conservation concern ecological component including the proportion of species with corresponding GBRMP ERA assessments (Pears et al., 2012a).*

Grouping	No. Assessed	Percentage with GBRMP ERA
Marine turtles	6	100.0%
Sea snakes	11	100.0%
Seahorses & pipefish	8	75.0%
Sharks, skates, rays, chimeras.	47	51.1%
Total	**72**	**65.3%**

As the analysis included all waters outside the GBRMP, a preliminary assessment was undertaken to determine which chondrichthyan species have distributions that overlap with the ECTF. This assessment was subsequently refined with 47 species (Appendix D: Table A29, A30) identified as having interacted with or had the potential to interact with the ECOTF in southern Queensland or the RIBTF (Last & Stevens, 2009). For completeness, this list included species whose distributions have only minor overlaps with the ECTF, species that would interact with the fishery infrequently and / or species where minor interactions may be disguised due to misidentifications.

The final list incorporation species from the Orders Carcharhiniformes (ground and whaler sharks; *n* = 9), Orectolobiformes (carpet sharks; *n* = 9), Rajiformes (stingrays, stingarees, skates, sawfishes, butterfly rays; *n* = 28) and Chimaeriformes (Chimaeras; *n* = 1) (Table 3.8). Twenty-four of the 47 species had corresponding risk assessments from the GBRMP ERA (Table 3.7).

3.3.2 Risk Characterisation

Characteristics and decision rules used to assess resilience capabilities and construct fishery impact profiles for all the species of conservation concern are outlined in Tables A13 and A14 respectively (Appendix C).

3.3.2.1 Southern Queensland and RIBTF

Similarities in biological and ecological constraints resulted in all six marine turtles having low resilience capability scores (Table 3.8). A similar trend was observed for the fishery impact profiles with five of the six (83.3%) species falling into the intermediate-low category; the notable exception being the Olive-Ridley turtle (*Lepidochelys olivacea*) (Table 3.8).

The sea snake resilience capability assessment indicated that nine of the 11 species (81.8%) had a low ability to resist or recover from disturbance or decline (Table 3.8). The remaining two species, the olive sea snake (*Aipysurus laevis*) and ornate reef sea snake (*Hydrophis ornatus*), faired marginally better registering resilience capability scores of intermediate-low. The fishery impact profiles were more diverse with sea snake scores ranging from low to high-intermediate. However, only the elegant sea snake (*Hydrophis elegans*) and the spine-bellied sea snake (*Lapemis curtus*) had fishery impact profiles greater than intermediate-low (Table 3.8).

The risk characterisation stage for syngnathids followed a similar pattern to that observed for marine turtles. All but one of the species, the palid pipehorse (*Solegnathus cf. hardwickii*), had an intermediate to low ability to resist disturbance or recover from decline (Table 3.8). Conversely the fishery impact profiles indicated otter trawl activities in southern Queensland and the RIBTF had an intermediate impact on all eight species (Table 3.8).

Twenty-seven (57.5%) chondrichthyan species were assessed as having a low ability to resist or recover from disturbance or decline with a further 16 species (34.0%) registering scores within the intermediate-low risk bracket (Table 3.8). The Australian sharpnose shark (*Rhizoprionodon taylori*) and the egg-laying grey carpetshark (*Chiloscyllium punctatum*) were the only species to register resilience capability scores higher than intermediate-low (Table 3.8). The majority of the chondrichthyan species had fishery impact profile scores of high-intermediate (n = 9), intermediate (n = 14) or intermediate-low (n = 12). Approximately 10% of the species were assessed as having a high fishery impact profile including all four species of skate (Family Rajidae) (Table 3.8).

Based on the assigned resilience capability scores and fishery impact profiles, overall risk ratings for the species of conservation concern ecological component ranged from low through to high (Table 3.8). The following key findings were observed with respect to the ecological subcomponents:

- there is an intermediate-low overall risk for marine turtles inhabiting the study area;
- there is an intermediate overall risk for one or more syngnathid species;
- there is an intermediate or lower risk for the vast majority of sea snake species and many of the chondrichthyan species;
- almost one third (31.9%) of the chondrichthyan species were at high risk of experiencing an undesirable event due to trawl fishing activities; and
- the elegant sea snake (*Hydrophis elegans*) was the only non-chondrichthyan species to record a high overall risk rating.

Table 3.8. *Resilience capability scores, fishery impact profiles (FIP) and overall risk ratings for marine turtles, sea snakes, syngnathids and chondrichthyans included in the* ***species of conservation concern*** *ecological component – arranged by taxonomic Class & Order.*

Common Names	Species Name	Resilience	FIP	OVERALL RISK
	Marine Turtles			
Turtle, Flatback	*Natator depressus*	L	I-L	I-L
Turtle, Green	*Chelonia mydas*	L	I-L	I-L
Turtle, Hawksbill	*Eretmochelys imbricata*	L	I-L	I-L
Turtle, Leatherback	*Dermochelys coriacea*	L	I-L	I-L
Turtle, Loggerhead	*Caretta caretta*	L	I-L	I-L
Turtle, Olive Ridley	*Lepidochelys olivacea*	L	L	I-L
	Sea Snakes			
Sea snake, Elegant	*Hydrophis elegans*	L	H-I	H
Sea snake, Spine-Bellied	*Lapemis curtus*	L	I	I
Sea snake, Dubois'	*Aipysurus duboisii*	L	L	I-L
Sea snake, Spine-Tailed	*Aipysurus eydouxii*	L	I-L	I-L
Sea snake, Olive	*Aipysurus laevis*	I-L	I-L	I-L
Sea snake, Stokes'	*Astrotia stokesii*	L	I-L	I-L
Sea snake, Spectacled	*Hydrophis/Disteira kingii*	L	I-L	I-L
Sea snake, Olive-Headed	*Hydrophis/Disteira major*	L	I-L	I-L
Sea snake, Beaked	*Enhydrina schistosa*	L	L	I-L
Sea snake, Small-Headed	*Hydrophis macdowelli*	L	L	I-L
Sea snake, Ornate Reef	*Hydrophis ornatus*	I-L	L	I-L
	Syngnathids			
Seahorse, Queensland	*Hippocampus queenslandicus*	I-L	I	I
Seahorse, Sad	*Hippocampus tristis*	I-L	I	I
Seahorse, Highcrown	*Hippocampus proceros*	I-L	I	I
Pipefish, Bentstick	*Trachyrhamphus bicoarctatus*	I-L	I	I
Pipefish, Straightstick	*Trachyrhamphus longirostris*	I-L	I	I
Pipefish, Tiger	*Filicampus tigris*	I-L	I	I

Common Names	Species Name	Resilience	FIP	OVERALL RISK
Pipehorse, Pallid	*Solegnathus cf. hardwickii*	I	I	I
Pipehorse, Dunker's	*Solegnathus dunkeri*	I-L	I	I
		Sharks		
Catshark, Grey Spotted	*Asymbolus analis*	I-L	H-I	H
Catshark, Orange Spotted	*Asymbolus rubiginosus*	I-L	H-I	H
Catshark, Sawtail	*Figaro boardmani*	L	H-I	H
Carpetshark, Blue-Grey	*Brachaelurus colcloughi*	L	I	I
Weasel Shark, Australian	*Hemigaleus australiensis*	I-L	I	I
Shark, Sliteye	*Loxodon macrorhinus*	I-L	I	I
Shark, Milk	*Rhizoprionodon acutus*	L	I	I
Shark, Australian Sharpnose.	*Rhizoprionodon taylori*	I	I	I
Shark, Spinner	*Carcharhinus brevipinna*	L	L	I-L
Shark, Whitecheek	*Carcharhinus dussumieri*	L	I-L	I-L
Shark, Zebra	*Stegostoma fasciatum*	L	I-L	I-L
Hornshark, Crested	*Heterodontus galeatus*	I-L	I-L	I-L
Wobbegong, Gulf	*Orectolobus halei*	L	I-L	I-L
Wobbegong, Spotted	*Orectolobus maculatus*	L	I-L	I-L
Wobbegong, Banded	*Orectolobus ornatus*	L	I-L	I-L
Wobbegong, Tasselled	*Eucrossorhinus dasypogon*	I-L	I-L	I-L
Carpetshark, Collar	*Parascyllium collare*	I-L	I-L	I-L
Carpetshark, Grey	*Chiloscyllium punctatum*	H-I	I-L	L
		Batoids and Chimaeras		
Skate, Sydney	*Dipturus australis*	I-L	H	H
Skate, Endeavour	*Dipturus endeavouri*	I-L	H	H
Skate, Blacktip	*Dipturus melanospilus*	I-L	H	H
Skate, Argus	*Dipturus polyommata*	I-L	H	H
Ray, Australian Butterfly	*Gymnura australis*	L	H-I	H
Shovelnose Ray, Eastern	*Aptychotrema rostrata*	I-L	H-I	H
Whipray, Blackspotted	*Himantura astra*	L	H-I	H

Common Names	Species Name	Resilience	FIP	OVERALL RISK
Maskray, Bluespotted	*Neotrygon kuhlii*	I-L	H	H
Maskray, Speckled	*Neotrygon picta*	I-L	H-I	H
Stingaree, Common	*Trygonoptera testacea*	L	H	H
Stingaree, Sandyback	*Urolophus bucculentus*	L	H-I	H
Stingaree, Kapala	*Urolophus kapalensis*	L	H-I	H
Stingaree, Greenback	Urolophus viridis	L	I	I
Stingaree, Patchwork	Urolophus flavomosaicus	L	I	I
Stingaree, Yellowback	*Urolophus sufflavus*	L	I	I
Sawfish, Narrow. S.	*Anoxypristis cuspidata*	L	I	I
Ray, Coffin	*Hypnos monopterygius*	L	I	I
Whipray, Brown	*Himantura toshi*	L	I	I
Stingray, Estuary	*Dasyatis fluviorum*	L	I	I
Ghostshark, Blackfin	*Hydrolagus lemures*	I-L	I	I
Sawfish, Green	*Pristis zijsron*	L	I	I
Torpedo Ray, Short-tail	*Torpedo macneilli*	I-L	I-L	I-L
Eagle Ray, Banded	*Aetomylaeus nichofii*	L	L	I-L
Stingray, Smooth	*Dasyatis brevicaudata*	L	L	I-L
Stingray, Black	*Dasyatis thetidis*	L	L	I-L
Stingray, Cowtail	*Pastinachus astrus*	L	L	I-L
Shovelnose Ray, Giant	*Glaucostegus typus*	L	I-L	I-L
Whipray, Reticulate	*Himantura uarnak*	L	L	I-L
Guitarfish/Wedgefish	*Rhynchobatus australiae/Rhynchobatus palpebratus*	L	I-L	I-L

3.3.2.2 Comparison with GBRMP

As the scoring system for the GBRMP ERA (Pears *et al*., 2012a) and southern Queensland and RIBTF ERA were aligned, direct comparisons could be made between scores assigned to each ecological subcomponent. These comparisons revealed little regional difference between the resilience capability assessments, fishery impact profiles and overall risk ratings of species included in both analyses (Table 3.9). This is best exemplified by the marine turtle (Appendix D: Table A23, A24) and syngnathid (Appendix D: Table A27, A28) subgroups where the risk from trawling in southern Queensland was identical to the GBRMP (Pears *et al*., 2012a). This suggests that risk assessments involving marine turtle and sygnathids were influenced by large-scale factors *i.e.* fishing impacts and management initiatives that apply to the entire ECTF. An example of which would be the introduction of TEDs and the corresponding decline in marine turtle catch rates across the entire ECTF (Robins, 1995; Robins & Myer, 1998; Brewer *et al*., 2006; Pears *et al*., 2012a).

Of the remaining subgroups, four of the 11 sea snakes had overall risk ratings that differed from the GBRMP ERA (Table 3.9). Three of the four sea snakes were deemed to be at lower risk in southern Queensland and RIBTF areas. The fourth species, the spine-bellied sea snake (*Lapemis curtus*), had a higher fishery impact profile and a higher overall risk rating (Table 3.9). Inter-study comparisons revealed that the observed differences in *L. curtus* scores were due to this species having a high level of interaction with inshore and estuarine sectors of the ECTF including in the banana prawn fishery and the RIBTF (Courtney *et al*., 2010). Evidently, this level of interaction was considered to be sufficient to assign *L. curtus* a 'double risk prone' (PP) score against the corresponding fishery impact profile characteristic (Appendix D: Table A26). This is in contrast to the GBRMP ERA (Pears *et al*. 2012a) where *L. curtus* was assigned a 'risk averse' (A) score for the same characteristic. It is noted though that the incidental mortality rates associated with *L. curtus* interactions with the inshore beam and banana prawn sectors tend to be low (*pers. comm.,* T. Courtney). Given this, the PP score assigned to this characteristic for *L. curtus* is considered to be a conservative estimate.

When individual sea snake scores were compared, the GBRMP ERA (Pears *et al*., 2012a) contained a higher number of 'prone to risk' scores (n = 11 *vs.* 8) for the 'survival after interaction' characteristic (Appendix D: Table A26) including a 'double risk prone' (PP) score for the small-headed sea snake (*Hydrophis macdowelli*), the ornate reef sea snake (*H. ornatus*), and the elegant sea snake (*H. elegans*). This differs to the current study where the three aforementioned species were assigned a 'prone to risk' (P) score for the same characteristic (Appendix D: Table A26). This difference can be partly attributed to results obtained by Courtney *et al*. (2010) which showed the red spot king prawn (*Melicertus longistylus*) sector was responsible for 58.9% of the sea snake bycatch and 84.5% of trawl related sea snake mortalities. As this sector operates almost exclusively within the GBRMP (Courtney & Dredge, 1988; Dredge, 1990)**,** the direct impacts of this fishery on sea snake populations in southern Queensland and RIBTF areas was considered to be negligible.

Table 3.9. *A comparison of the resilience characteristics and fishery impact profile scores for* ***sea snakes*** *and* ***chondrichthyan species*** *whose overall risk rating differed between southern Queensland and RIBTF ERA and the GBRMP ERA (Pears et al., 2012a).*

Common name	Species Name	Southern Queensland and RIBTF ERA (current study)			GBRMP ERA		
		Resilience	FIP	OVERALL	Resilience	FIP	OVERALL
Snakes							
Sea snake, Spine-Bellied	*Lapemis curtus*	L	I	I	L	L	I-L
Sea snake, Spectacled	*Hydrophis/Disteira kingii*	L	I-L	I-L	L	I	I
Sea snake, Small-Headed	*Hydrophis macdowelli*	L	L	I-L	L	I	I
Sea snake, Ornate Reef	*Hydrophis ornatus*	I-L	L	I-L	I-L	H-I	H
Batoids and Chimaeras							
Ray, Coffin	*Hypnos monopterygius*	L	I	I	L	H-I	H
Sharks							
Shark, Milk	*Rhizoprionodon acutus*	L	I	I	I-L	I-L	I-L
Shark, Sliteye	*Loxodon macrorhinus*	I-L	I	I	I-L	I-L	I-L

Cross-study comparisons revealed that three of the elasmobranch species had overall risk ratings that differed from the GBRMP ERA (Table 3.9). In these instances, the key sources of inter-study variability were characteristics relating to the 'level of interaction' and 'survival after interaction'. In the case of the milk shark (*Rhizoprionodon acutus*), this species was included in the analysis due to its potential to interact with the ECTF and its presence in trawl catch obtained from research vessels (Jacobsen, 2008). This species was assigned a conservative estimate to both of the above characteristics due to a) the species having a smaller body size when compared to other carcharhinids (whalers) and b) an increased likelihood of it passing through a TED when compared to other carcharhinids (whalers) (Appendix D: Table A31). While acknowledging these scores, catch rates for this species are anticipated to be very low with Courtney *et al*. (2007) and the Fishery Observer Program failing to report a single *R. acutus*. This suggests that the risk of this species experiencing an undesirable event over the next 20 years due to trawl fishing activities is lower than the intermediate rating obtained during the assessment phase of this ERA (Table 3.8).

The sole difference between the ECTF assessments for the two remaining chondrichthyan species, the coffin ray (*Hypnos monopterygius*) and the sliteye shark (*Loxodon macrorhinus*), was the 'survival after interaction' characteristic (Appendix D: Table A30). In the case of *L. macrorhinus*, workshop participants did not consider there to be sufficient information on post-interaction mortality rates to make an informed assessment. As a consequence, the species was assigned a higher risk score than in the GBRMP ERA (Appendix D: Table A30). In comparison, qualitative advice provided as part of the assessment process indicated that post-interaction survival rates for *H. monopterygius* in southern Queensland and northern New South Wales were reasonable (*pers. comm.,* A.M. Frost). Accordingly, *H. monopterygius* was assigned a 'risk averse' (A) score for this characteristic. This resulted in the species having a lower fishery impact profile score and overall risk rating score in the southern Queensland and RIBTF ERA (Table 3.9).

3.3.3 Issues arising

3.3.3.1 Marine Turtles

While all six marine turtles had an intermediate-low overall risk rating, they were all assessed as having a low ability to resist or recover from disturbance or decline (Table 3.8). This is fairly typical for species with *k*-selected life history traits which among other things include longer-lived animals that have delayed maturity and lower levels of fecundity (Reynolds *et al*., 2005; White & Kyne, 2010). Based on these resilience capability scores, the intermediate-low overall risk ratings were largely attributed to a) management arrangements designed to minimize interactions and b) the positive effect these management arrangements had on the fishery impact profile scores (Table 3.8; Appendix D: Table A24). Of these arrangements, the most influential management initiative with respect to the fishery impact profiles of marine turtles was the introduction and use of TEDs in the ECOTF.

Designed to prevent the capture of marine megafauna, the use of TEDs was made mandatory for all ECOTF operations in the early 2000s. Since then, the total number of marine turtles caught and or dying as a direct result of trawl fishing activities has declined dramatically. For example, marine turtle catch rates in the ECOTF prior to 2001 were estimated to be in excess of 5000 (Robins, 1995; Robins & Myer, 1998; Pears *et al*., 2012a); approximately 2% of which died as a result of these interactions (*pers. comm.,* T. Courtney). While incidental mortality rates for the post-TED period are difficult to quantify, data on marine turtle catch and interactions suggests this number is now relatively negligible (DEEDI, 2011a; *pers. comm.,* T. Courtney). Even when the possibility of under-reporting is factored in, the overall impact of the ECOTF on regional marine turtle populations and therefore the risk from trawling has declined markedly.

It is acknowledged that marine turtle interaction rates will be higher than that reported in the logbooks with turtles entering the net but escaping through the TED opening. This type of interaction can result in injuries and therefore has the potential to negatively affect turtle populations. While this type of interaction was taken into consideration as part of the assessment process, post-interaction survival rates for marine turtles escaping through a TED opening were anticipated to be high (*pers. comm.* Southern Queensland and RIBTF ERA workshop participants). As such, the long-term consequences of this type of interaction were not considered sufficient to elevate any of the fishery impact profile scores for marine turtles (Appendix D: Table A24).

Unlike the ECOTF, the use of a TED is not mandatory for all aspects of the RIBTF. Under the current arrangements, RIBTF operators are required to utilise a TED when a) the net is being used in waters other than a river or creek and b) when utilizing an otter trawl net – primarily the Laguna Bay region of the T5 fishery. The primary reason for this is that RIBTF operators are more likely to interact with marine turtles in inshore areas of the ECTF. While beam trawls are not required to have a TED installed while operating in creeks and rivers, there is little overlap between the preferred grounds of the fishery and habitats utilized by marine turtles. In the unlikely event that a marine turtle is caught in the RIBTF (otter or beam) shorter trawl times and a lower (total) catch biomass would help to maintain high post-interaction survival rates. As a consequence interactions between marine turtles and the RIBTF were considered to be negligible when compared to the ECOTF.

3.3.3.2 Sea snakes

Sea snakes as with marine turtles displayed a low capacity to resist or recover from disturbance or decline (Appendix D: Table A25). This however did not translate to an elevated level of risk for most species with only two of the 11 sea snakes recording an overall risk rating greater than intermediate-low (Table 3.8); the elegant sea snake (*Hydrophis elegans*) and the spine-bellied sea snake (*Lapemis curtus*). For *H. elegans*, the high overall risk rating was driven principally by a high interaction rate and relatively poor survivability (Courtney *et al*., 2010) (Appendix D: Table A26). Similarly, *L. curtus* was assigned a ‘double risk prone’ (PP) score for ‘level of interaction’; the highest value assigned to this characteristic for a sea snake species (Appendix D: Table A26). The primary reason for this was that *L. curtus* has comparatively high interaction rates with inshore ECTF sectors including the banana prawn and beam trawl fishery (Courtney *et al*., 2010). Research also indicates that this species interacts to a lesser extent with the inshore tiger and endeavour prawn sector (Courtney *et al*., 2010).

Interspecific comparisons indicate that two of the biggest trawl-related issues for sea snakes in southern areas of the ECOTF and the RIBTF are mortality rates and TED/BRD efficiency (Appendix D: Table A26). With regards to the survival rates, Courtney *et al*. (2010) estimated that some 25.9% of sea snakes caught within trawl nets died either upon capture or in the proceeding hours or days. This was given considerable weighting by workshop participants when assessing the potential impact of trawl fishing on sea snake populations. It is important to note though that the above percentage is for the entire ECTF and that sea snake mortality displays a degree of regional variability (Courtney *et al*., 2010). For example, sea snake mortality rates for otter trawl operations south of 20°S are generally lower than that observed in the red spot king prawn (*Melicertus longistylus*) sector. Further, two of the sectors with the highest sea snake interaction rates, beam trawl and black tiger prawn (brood stock collection), have relatively low rates of mortality due to shortened trawl durations (Courtney *et al*., 2010). Both of these sectors operate in waters outside of the GBRMP suggesting the impact of the RIBTF and ECOTF operations in southern Queensland may be lower than that observed for the entire ECTF.

Sea snakes would yield some benefit from the use of BRDs in the ECOTF with research indicating that the Square Mesh Codend and Fisheye are effective excluders of sea snakes (Courtney *et al*., 2010). At the time that this ERA was developed, ECOTF operators in southern Queensland could still use BRD's that were not optimal for the exclusion of sea snakes. As a consequence, all of the subgroups were assigned a 'prone to risk' score for 'TED/BRD effectiveness' (Appendix D: Table 26). Since this assessment, a number of changes have been made to provisions governing the use of BRDs in the ECTF. These changes include a) reducing the number of approved BRD designs to five, b) mandating the use of a Square Mesh Codend, Fisheye or Bigeye BRD in central Queensland (16°S – 22°S) and c) mandating the use of the Square Mesh Codend in the tropical scallop fishery (Appendix D).

In southern Queensland, ECTF operators can still use five different BRD designs: the Square Mesh Codend, Square Mesh Panel, Fisheye, Bigeye and V-Cut with Bell Codend. Two of these, the Square Mesh Panel and V-Cut with Bell Codend are not optimal for the exclusion of sea snakes. However, mandating the use of more effective BRDs in adjacent areas may promote or increase their use in southern Queensland. As such, changes to the legislation governing the use of BRDs in Queensland may provide sufficient justification (over time) to reduce the risk level assigned to this characteristic for these species.

Outside the use of a BRD in key areas, there are few management initiatives specifically designed to protect sea snakes within the ECTF. Of the management arrangements currently in place, the most notable protections for sea snakes include no-take provisions and monitoring through the *Species of Conservation Interest* (SOCI) logbooks. More broadly, this subgroup would yield benefit from broader spatial and temporal closures including those contained within non-fisheries specific legislation.

3.3.3.3 Syngnathids

When compared to marine turtles and sea snakes, the resilience capabilities of syngnathids had more of a positive effect on the overall level of risk (Appendix D: Table 27). As noted, all but one of the seahorse and pipefish species had an intermediate to low ability to resist or recover from disturbance or decline (Table 3.8). Albeit minimal, this was an improvement on the two previous subgroups which had a low average ability to resist or recover from disturbance or decline (Table 3.8). Characteristics that improved the resilience capabilities of syngnathids included having a higher level of habitat specificity and broad geographical distributions (Appendix D: Table 27). Syngnathids also have a relatively fast growth rate which, while not universal, increases the likelihood that an individual will reach sexual maturity and have an opportunity to reproduce before their capture (Browne *et al*. 2008).

From a habitat perspective, syngnathids tend to congregate at low densities in sessile benthic environments with complex three dimensional structures (Connolly *et al*., 2001; Caldwell & Vincent, 2013). Once settled, syngnathids occupy smaller home ranges (Caldwell & Vincent, 2013) and often inhabit areas not conducive to trawl fishing activities (Vincent *et al*., 2011; Connolly *et al*., 2001). Given this, it is anticipated that regional syngnathid populations experience lower levels of effort when compared to other species of conservation concern. This was reflected in both the resilience capability assessment (*i.e.* 'habitat specificity or ecological niche') and fishery impact profile (*i.e.* the 'level of interaction' and 'interaction throughout life cycle') (Appendix D: Table A27, A28).

While acknowledging the above, the workshop also noted that syngnathids are small species with an elongated morphology; therefore are more likely to pass through the bars of a TED. Once captured, the limited mobility of syngnathids combined with the positioning and configuration of a number of the BRDs means that individuals are unlikely to escape from the codend. This issue was compounded by the fact that smaller bycatch species tend not to survive a trawl event as well as larger species (Connelly *et al*., 2001; Dunning *et al*., 2001; Dunning *et al*., 2003; Stobutzki *et al*., 2002). Syngnathids are no exception to this and in the context of this ERA were assigned a 'double risk prone' (PP) score for the 'survival after interaction' fishery impact profile characteristic (Appendix D: Table A28). This made a significant contribution towards this subgroup having higher fishery impact profiles and overall risk ratings (Table 3.8).

As syngnathids prefer environments with higher water quality and increased water flows, the above results were largely attributed to interactions between this subgroup and the east coast otter trawl fishery. This inference is supported by previous ECTF catch history assessments which show syngnathid-beam trawl interactions to be largely negligible (Stobutzki *et al*., 2000; Dodt, 2005).

3.3.3.4 Sharks and Rays

At 36.2% of the species assessed, Chondrichthyes had the largest proportion of risk assessments in the high category (Table 3.8). Almost all of the high overall risk ratings were assigned to epibenthic species including all four species of skate (Family Rajdae) and three of the six species of stingaree (Family Urolophidae). Three-quarters of the species with high overall risk ratings were benthic batoids with the remaining three being small catsharks from the family Scyliorhinidae (Table 3.8). This is consistent with previous research that has shown benthic batoids to be one of the more abundant chondrichthyan subgroups in prawn trawl bycatch (Stobutzki *et al*., 2002; Kyne *et al*., 2007). There was only an intermediate risk to the populations of the lone chimaerid representative, the blackfin ghostshark (*Hydrolgus lemnures*) (Table 3.8).

Of the species with high overall risk ratings, species with preferences for deeper water environments including the four species of skate, the three catshark (Scyliorhinidae) species and the sandyback stingaree (*Urolophus bucculentus*) would interact exclusively with the ECOTF; primarily the deep-water eastern king prawn (*Melicertus plebejus*) sector (Kyne *et al.,* 2007; Last & Stevens, 2009). Bycatch interactions for the remaining species would be more diverse with shallow-water chondrichthyans interacting with various sectors of the otter and beam trawl fishery. Species that would regularly interact with the shallow water ECOTF sectors in southern Queensland would include, among others, the Australian butterfly ray (*Gymnura australis*), the blue-spotted maskray (*Neotrygon kuhlii*), the black-spotted whipray (*Himantura astra*) and the eastern shovelnose ray (*Aptychotrema rostrata*) (Table 3.8).

For the RIBTF, a high proportion of the elasmobranch (sharks, skates and rays) interactions would occur when fishers are operating in near-shore environments and estuarine waters. As noted, the RIBTF utilises smaller gear, has shorter trawl times and covers less area; therefore the overall impact of this sector is expected to be lower, involve fewer species and result in fewer deaths when compared to the ECOTF. The impact of this sector on the elasmobranch subgroup is further reduced through the use of spatial and temporal closures along the Queensland coastline, as well as the use of TEDs in waters other than a river or creek systems. The impact (and consequences) of beam trawl fishing though may be higher for species like the IUCN listed estuary stingray (*Dasyatis fluviorum*) which is endemic to near-shore, estuarine and riverine habitats along the Queensland coastline (Kyne *et al*., 2003; Last & Stevens, 2009; Pierce & Bennett, 2010).

The rebound potential of chondricthyans was most inhibited by their fecundity levels and life-history strategies. While these limitations were accounted for in all chondrichthyan assessments, it was most notable for batoids; particularly the Dasyatidae (stingrays) and Urolophidae (stingarees) (Appendix D: Table A29). Smaller viviparous species with an average litter size of less than five (Carrier *et al*., 2004; White & Dharmadi, 2007; Last & Stevens, 2009), the majority of these rays were assigned a ‘double risk prone’ (PP) score for both of the above characteristics. Growth rate and longevity estimates also contributed to the majority of species having resilience scores of low or intermediate-low (Appendix D: Table A29). In the context of this ERA, slower growing species often take longer to reach sexual maturity, have elongated population doubling times and are at higher risk of being caught before they are able to reproduce (Stobutzki *et al*., 2002). As a consequence, these species are likely to take longer to rebound or recover after disturbance or decline (Stevens *et al*., 2000).

All 15 shark and ray species at high risk scored poorly across all four fishery impact profile characteristics (Appendix D: Table A30). Of which, the most influential characteristic with regards to the overall risk ratings appeared to be ‘survival after interaction’. For example, eight of the 15 species at high risk were assigned a ‘double risk prone’ (PP) score for this characteristic with the remaining seven species evaluated as being ‘prone to risk’ (P) (Appendix D: Table A30). For the majority of these species, the ‘double risk prone’ (PP) score was intimately linked with the ECOTF where trawl durations are longer and individuals are more likely to sustain significant internal and/or external injuries during the net retrieval process *i.e.* being crushed by the weight of the catch. For comparative purposes, species with lower risk ratings were assigned a mixture of scores ranging from ‘averse to risk’ (A) to ‘prone to risk’ (P): intermediate (8 prone to risk, 6 risk averse), intermediate-low (12 prone to risk, 5 risk averse) or low (1 risk averse).

The above scoring patterns can be partly explained by the need to use proxies for species with no information on mortality and post release survival rates. In these instances, scores assigned to species with missing mortality rate data were aligned with species with similar morphological traits and life-history constraints; irrespective of the sample size. For example, detailed information on skate mortality in the ECTF was only available for the Argus skate (*Dipturus polyommata*). Therefore, it was necessary to use the data for *D. polyommata* as a proxy for the three remaining skate species (Appendix D: Table A30). A similar situation was observed for deepwater stingarees (Family *Urolophidae*), with mortality rate data for the kapala stingaree (*Urolophus kapalensis*) used as a proxy for the sandyback stingaree (*Urolophus bucculentus*) and the patchwork stingaree (*U. flavomosaicus*).

By using proxies, the southern Queensland and RIBTF ERA was able to provide complete assessments for species with lower levels of information. One of the benefits of using proxies is that the study now has a larger number of 'baseline' assessments which can be built upon in future iterations of this ERA. The downside to this approach is that the use of proxies has the potential to mask interspecific differences and as a consequence increases the likelihood that a species complex will be over-represented in a particular risk category. The use of proxies may also extend the influence of more conservative risk assessments and/or estimates based on smaller sample sizes. This in itself provides a credible alternate hypothesis as to why stingarees (Family *Urolophidae*) and skates (Family *Rajidae*) were more prominent in the higher risk category (Table 3.8).

The introduction of TEDs and BRDs has been effective at reducing the capture of some species and the overall impact of the ECTF on regional chondricthyan populations. The greatest beneficiary of these changes has been larger individuals *i.e.* wedgefish (*Rhynchobatus* spp.) and cowtail rays (*Pastinachus astrus*) which the TED excludes from the net before they enter the cod end (Stobutzki *et al*., 2001; Stobutzki *et al*., 2002; Brewer *et al*., 2006). These benefits decline for smaller individuals which are more likely to pass through a TED bar spacing unhindered or, if initially stopped, have sufficient flexibility in their body structure to be forced though the bar spacings (Stobutzki *et al*., 2001; Brewer *et al*., 2006; Kyne *et al*., 2007) (Appendix D: Table A30). This problem is compounded by the fact that within net survival rates tend to be lower for smaller elasmobranch species (Stobutzki *et al*., 2002).

For species like the blackspotted whipray (*Himantura astra*), TED effectiveness will improve as individuals increase in body size; therefore increasing the chances of the TED expelling them from the net (Griffiths *et al*., 2006; Jacobsen & Bennett, 2011). Given this, it is anticipated that the severity of the fishery impact profile for some species will decline with the age and size of the animal. This inference however is not considered to be universal as maximum disc widths and body depths for a number of species are not sufficient for this to become a factor. For example, the six maskray (*Neotrygon* spp.) and stingaree (Urolophidae) species with high overall risk ratings have maximum disc widths of less than 50 cm (Last & Stevens, 2009; Jacobsen & Bennett, 2010) and body depths of around 5 – 8 cm (*pers. obs.,* I. Jacobsen). Similarly, the Australian butterfly ray (*Gymnura australis*) attains a maximum disc width of 100 cm but has a maximum body depth smaller than the maximum space permitted (12 cm) between the vertical bars of a TED (Jacobsen *et al*., 2009). As a consequence, a portion of large, mature *G. australis* will continue to be caught in the codend despite TEDs being used in the nets (Jacobsen, 2008). Once caught, the ability of sharks and rays to escape the trawl net through most BRDs is low (Kyne *et al*., 2007).

While TEDs and BRDs help to reduce the negative effects of an animal interacting with a trawl net, spatial and temporal closures arguably provide the greatest degree of protection. For chondrichthyans, large-scale permanent closures located in inshore environments including within Moreton Bay and Great Sandy Marine Parks will provide the greatest degree of protection from the southern Queensland ECOTF and the RIBTF. Closures covering smaller geographical areas will provide a degree of protection from trawl fishing activities; although the tendency of chondrichthyans to congregate in smaller densities may limit their effectiveness (Walker, 2004). The effectiveness of spatial closures will also decline for species that have wide home ranges and are more likely to forage in environments suited to trawl fishing (*i.e.* the blackspotted whipray, *Himantura astra*; Jacobsen & Bennett, 2011). The principal reason for this is that these species are more likely to move beyond the boundaries of the closure and into areas open to ECTF activities.

In the ECTF, temporal closures are used to limit the impact of trawl fishing on harvested species during key spawning and recruitment events. This approach is less successful for chondricthyan species which tend to mature later and have longer gestation periods. If for example, a similar approach was taken for chondricthyan species, key breeding and parturition sites would need to be closed from trawling for extended periods *i.e.* six months or more (Carrier *et al*., 2004; Last & Stevens, 2009). This is not considered to be a viable option for the ECTF as it would have a significant impact on the long-term economic viability of the fishery.

3.3.4 Management considerations

Risk profiles for the species of conservation concern ecological component were notably mixed (Table 3.8). This is unsurprising given that this ecological component had the highest level of morphological diversity and the widest array of life-history strategies. Overall, the risks of marine turtles and sea snakes experiencing significant declines due to trawling in southern Queensland and RIBTF areas were considered to be relatively low. The situation for chondrichthyans, particularly for elasmobranchs (sharks and rays) was more varied (Appendix D: Table A23 – A30).

Issues relating to changes in effort usage and fishing patterns identified in the harvest and bycatch species ecological component assessments will be applicable to the species of conservation concern. However, the potential consequences of effort increasing in the ECTF fishery (overall or regionally) are likely to be more varied; noting that small changes in regional fishing intensity or fishing mortality may have significant long-term consequences for some of the species included in this ecological component. Further to this, the morphological diversity displayed within the ecological subcomponents may limit the effectiveness of some bycatch mitigation measures used in the ECTF including the use of TEDs and BRDs (discussed below). These factors will need to be taken into consideration when assessing the applicability of the risk assessments to future fishing environments.

3.3.4.1 Marine Turtles

As the distribution of all six marine turtles overlap with a high proportion of the ECTF, interactions between this subgroup and trawl fishers in southern Queensland will continue. In saying that, management arrangements designed to reduce the number of marine turtles dying as a result of trawl interactions are working (Appendix D: Table A24). This was reflected in the scores assigned to each species during the fishery impact profile assessment (Table 3.8). The use of TEDs remains a pivotal component of the *Fisheries (East Coast Trawl) Management Plan 2010* and the design of TEDs undergoes periodic review to ensure they remain efficient, effective and continue to improve. The latest of which resulted in ECOTF TEDs being aligned with those used in the United States of America. Reconfigured as part of the United States of America export accreditation process, these changes ensured that TEDs used in the ECTF are maintained at a standard widely considered to be world's best practice.

In addition to the use of TEDs, the marine turtle subgroup has arguably the most well developed series of species-specific protection measures. This includes dedicated spatial and temporal closures; complementary land-based management initiatives[15]; detailed catch reporting requirements; and handling/release protocols (DAFF, 2013b). Providing these arrangements remain in place and continue to be effective, it is likely that marine turtles will continue to be at low risk from trawling in southern Queensland even if annual levels of fishing effort increase in the future (Appendix A).

In light of the above considerations, it is conceivable that other factors including non-trawl fisheries, the direct and indirect effects of urban development (Chilvers *et al*., 2005; Manson *et al*., 2005), pollution (Leon & Warnken, 2008; Müller *et al*., 2012) and boat-strike (Hazel & Gyuris, 2006) pose more of a threat to regional marine turtle populations in southern Queensland. This is particularly relevant to areas with high-value marine turtle habitats and higher marine turtle population densities such as Moreton Bay in south east Queensland.

3.3.4.2 Sea Snakes

When compared to marine turtles, the establishment and implementation of bycatch mitigation measures targeted specifically at sea-snakes are less developed. This does not necessarily equate to a species being at high risk from trawling (Table 3.5). However, the absence of a measure analogous to the highly effective TED makes sea snakes more susceptible to a changing fishing environment. If for example, trawl effort were to increase in southern Queensland, it is anticipated that the negative consequences of these interactions would be more pronounced for sea snakes; when compared to marine turtles. This may have a significant effect on fishery impact profile scores obtained in the southern Queensland and RIBTF ERA and therefore the overall risk rating assigned to each sea snake species (Table 3.8).

Efforts are currently being undertaken in the ECOTF to improve the level of information on sea snake bycatch and reduce sea snake mortality. Courtney *et al*. (2010) compiled a detailed assessment of sea snake bycatch in Queensland trawl fisheries that included an evaluation of the effectiveness of two BRDs used in the ECOTF; the Fisheye BRD and the Square Mesh Codend. This study found that nets fitted with a Fisheye BRD and TED reduced sea snake catch rates by 63% compared to a standard diamond mesh codend with a TED installed but no

[15] *Managed under non-fisheries related legislation.*

BRD (Courtney *et al*., 2010). A similar trend was observed in the Northern Prawn Fishery when BRD effectiveness was reviewed in the context of improving sea snake catch and survival rates (Heales *et al*., 2008; Milton *et al*., 2009). On the strength of the Courtney *et al*. (2010) results, Queensland launched a management initiative designed to promote the use of the Fisheye BRD in the ECTF (Roy & Jebreen, 2011) whereby all ECOTF operators were provided with 12 free fisheye BRDs to install in their nets.

The establishment of sea snake-specific management arrangements has also been progressed as part of a broader review of the *Fisheries (East Coast Trawl) Management Plan 2010*. This review has drawn upon resources like Courtney *et al*. (2010) in an attempt to address sea snake bycatch at a whole of fishery and regional level. This is best exemplified by the recent amendments to the *Fisheries (East Coast Trawl) Management Plan 2010* which limits the number of BRD designs that can be used in areas with high sea snake interaction/mortality rates *i.e.* the red spot king prawn (*Melicertus longistylus*) sector where most incidental sea snake mortalities occur (Courtney *et al*., 2010; Appendix F).

While *M. longistylus* are targeted almost solely within the GBRMP, mandating the use of more efficient BRDs in this sector could yield indirect benefits for other areas of the ECTF. For example, fishers targeting *M. longistylus* as part of a multi-sector operation would be more inclined to retain the same trawl gear configuration when fishing for other prawn species. To this extent, restricting BRD use in central Queensland to the Fisheye, Square Mesh Codend and Bigeye (Appendix F) may help to reduce the impact of trawl fishing in other areas of the ECOTF. It is also noted that, a reduction in trawl-related mortalities in the red spot king prawn sector may improve the rebound potential of sea snake populations *i.e.* through the net emigration of adults.

In addition to promoting the use of more efficient BRDs, management authorities are endeavouring to improve both the accuracy of sea snake catch reporting and sea snake handling procedures. An example of which is the publication of an on-line guide to assist fishers in the safe handling and release of sea snakes caught as bycatch in the ECTF (DAFF, 2013c). While a video of this kind will not reduce the level or extent of injuries that snakes may incur from trawling, improvements in handling procedures will assist in minimizing the extent of these injuries once the animal has been landed and released. The potential benefits of this initiative include improved post release survival rates of snakes and a greater awareness by fishers of their interaction with protected species. While it is difficult to determine how successful this campaign has been, the on-line guide has been viewed more than 6,000 times since its original posting in January 2013.

3.3.4.3 Syngnathids

Syngnathids as with chondricthyans will arguably benefit most from the suite of spatial closures used in the ECTF. While these benefits are intimately linked to an absence of fishing pressures, these benefits will be accentuated by the life-history traits of syngnathids. As noted, syngnathids have both limited mobility and restricted home ranges meaning sexually mature adults located within a spatial closure are less likely to move into areas open to trawl fishing (Vincent *et al*., 2011; Caldwell & Vincent, 2013). This is in direct contrast to Chondrichthyes which have larger home ranges and a higher propensity to move in and out of a protected area *i.e.* during peak feeding periods (Kramer & Chapman, 1999; Jacobsen & Bennett, 2011). The weakness of this settlement strategy is that individuals located within a trawl ground will have limited capacity to escape if situated in the path of a trawl track. Given the above, one of the more significant challenges for the ECTF will be to provide some context to the assessments obtained. This would be best achieved by documenting regional syngnathid distributions and the level of overlap with current spatial and temporal closures.

On a more species-specific level, the pallid pipehorse (*Soelgnathus cf. harwickii*) and Dunker's pipehorse (*S. dunkeri*) are somewhat unique in that they are the only species of conservation concern that can be retained for commercial sale. Currently listed as a permitted species, these pipefish are a high value commodity that can attract up to $1500 per kilogram dry weight on the international market (Dodt, 2005). This economic appeal may act as an incentive for fishers to target these species, which if it were to occur, would increase the risk from trawling (Table 3.8). As it was, participants at the workshop considered the risk of trawl operators changing their fishing practices to target pipefish to be a fairly low. This for the most part is due to the fact that it would be difficult to target these species in significant numbers or without risking significant damage to the trawl equipment. This inference is supported by catch data which shows pipefish are retained in relatively low numbers in the ECTF (DEEDI, 2011a). Despite this, trip possession limits[16] should continue to be reviewed in the context of overall catch rates to ensure exploitation does not increase substantially. This will ensure that a balance is maintained between the need to minimize interactions with non-targeted species and utilizing fished resources that would otherwise be returned in a dead or moribund state (Dunning *et al*., 2001; Dunning *et al*., 2003).

In addition to the ongoing monitoring of pipefish catch rates, some consideration will need to be given into the effectiveness of wider syngnathid catch monitoring techniques. Historically, syngnathid catch compositions and catch rates were monitored through both the logbook monitoring program and the *Fisheries Observer Program*. As the *Fisheries Observer Program* ceased operations in 2012, the monitoring of syngnathid catch in southern Queensland now relies heavily on the *Species of Conservation Interest* (SOCI) logbook. From an ERA perspective, the critical aspect of this monitoring will be on how best to account for individuals that are inadvertently discarded without being recorded; that is individuals that are unseen and unnoticed amongst the total catch.

[16] *Currently 50 individuals under the Fisheries Regulations 2008*

3.3.4.4 Sharks and rays

As the broader aim of the ERA was to compare risk across multiple subgroups, decision rules used for the species of conservation concern ecological component needed to accommodate a diverse range of life-history strategies. For example, decision rules used to assess fecundity needed to account for broadcast spawning species, egg laying species and species that give birth to live young (Appendix C: Table A13). Given these types of requirements and the life-history strategies employed by chondrichthyan species, it was always likely that a proportion of the sharks, skates, rays and chimeras would have higher overall risk ratings. In saying that, it is important to remember that this type of analysis is qualitative by design and examines risk over a 20 year period. Therefore overall risk ratings contained within this report may not represent the actual level of risk a species or species complex is exposed to. Further to this, a high risk rating does not automatically equate to a significant decline in a population size or signal a broader sustainability risk.

While the above does not negate the validity of the chondrichthyan risk assessments, it does provide some context with respect to where sharks, skates, rays and chimeras fit into the broader southern Queensland and RIBTF ERA. It also highlights the challenges of applying a single set of decision rules and criteria to a group as diverse as the species of conservation concern ecological component. On this basis, consideration should be given to undertaking a Chondrichthyes-specific ERA where the characteristics and decision rules are based specifically on their life-history traits, geographical distributions and likely interactions with the ECTF. This approach would help to differentiate between individual species and identify species within the complex that are most at risk from the ECOTF in southern Queensland and RIBTF areas. This is in contrast to the current study which attempts to quantify the level of risk trawl fishing poses to chondrichthyans in the context of other species caught by operators in the ECTF.

A secondary challenge for the southern Queensland and RIBTF ERA was obtaining refined risk assessment for chondrichthyan species with limited catch data or where there is a limited understanding of how a species interacts with the ECTF. This was best exemplified by the sandy back stingaree (*Urolophus bucculentus*); a temperate-water species whose geographical range overlaps marginally with the ECOTF (Last & Stevens, 2009). This species was included in the analysis as it would more than likely interact with the deep water eastern king prawn (*Melicertus plebejus*) sector, albeit at very low levels (Last & Stevens, 2009; *pers. comm.,* I. Jacobsen). As *U. bucculentus* is a data-poor species it was assigned conservative scores for a range of resilience capability and fishery impact profile characteristics (Appendix D: Table A29, A30). This resulted in *U. bucculentus* being identified as one of the 15 shark or ray species at 'high' risk. This result though was largely due to the aforementioned data deficiencies and the default approach of the ERA to assign more conservative estimates to parameters with limited or no information (Table 3.8). In reality, the risk to *U. bucculentus* due to trawl fishing activities in southern Queensland would be well below that reported in the current study.

Data deficiencies were identified as a factor of influence in a number of the chondrichthyan assessments and will need to be improved for future iterations of the southern Queensland and RIBTF ERA. Positively, the level of information on chondrichthyan taxonomy and life-histories has increased over time (White & Last, 2012) and will continue to do so over the immediate future. Continued increases in the amount of biological information will help to refine resilience capability assessments and further differentiate between species with respect to the level of risk associated with trawl fishing activities within the sample area. There are however some considerable gaps in the fisheries related data including catch rates, catch distributions and post-interaction mortality rates. Further, the vast majority of chondricthyans that interact with commercial fisheries in Australia have inadequate stock assessments; making it difficult to assess long-term population trends.

The lack of catch data stems, in part, from the fact that the majority of Chondrichthyes are not captured within the current logbook management regime (Appendix B). This means that the majority of catch data for chondrichthyan species is collected through ancillary projects like the *Fisheries Observer Program* and Courtney *et al*. (2007), Kyne (2008) and Jacobsen (2008). As the *Fisheries Observer Program* ceased operations in 2012, this option is not currently available to management authorities. Further, the prospect of the *Fisheries Observer Program* being replaced with an alternate government or industry funded program is considered to be unlikely in the short to medium term. Consequently, increasing the amount of information on chondrichtyan catch and interaction rates for the foreseeable future will rely heavily on targeted projects; the scope of which will be highly dependent on funding availability and critical timeframes. Significantly, projects like the southern Queensland and RIBTF ERA and/or a Chondrichthyes-specific ERA can provide a significant level of guidance to these projects.

While species at high risk could be included in the *Queensland East Coast Trawl Fishery* logbook (Appendix B), there are logistical challenges with this approach. For example, including all elasmobranch species at high risk in the logbooks could a) reduce the efficiency of the program, b) potentially result in the collection of poor-quality data and c) create challenges with respect to the ability of operators to accurately differentiate between elasmobranch species in an active environment. If for example, all 15 species were included in the ECTF logbook, the system could become too unwieldy and place a significant impost on the operational ability of the fleet. Further, back-deck operations at sea are hazardous and therefore it may (at times) be difficult for fishers to safely identify elasmobranchs to the species level. As a consequence, the likelihood of fisher's incorrectly reporting catch (inadvertently or on purpose) could increase as they attempt to balance their operational efficiency with their legislative obligations.

A second alternative would be to include Chondrichthyes in the logbooks at a higher taxonomic level *e.g.* sharks and rays or sharks, skates and rays. This would allow chondrichthyan catch to be reported efficiently and enable broader comparisons to be made between ECTF species-sectors. A more specific approach would be to include a subset of species with easily distinguishable traits *i.e.* stingrays (*Dasyatidae* spp., *Neotrygon* spp.), whiprays (*Himantura* spp.), stingarees (Urolophidae), skates (Rajidae). In the four aforementioned examples, each group has distinct variations in their tail morphology (Last & Stevens, 2009) making them easier to identify in a highly dynamic environment. The drawback to this approach is that it would still represent a significant increase in the reporting requirements for the fishery. Complementary arrangements would also be needed to educate fishers, independently quantify species compositions and identify species not encompassed within each of the respective subgroups. This represents a substantial challenge and would require a significant investment of resources from both management agencies and industry.

In addition to improved catch rate data, future ERAs involving chondricthyans would benefit from increased information on post-interaction mortality rates. This again represents a significant challenge as quantifying total mortality rates (direct and post release) for bycatch species is inherently difficult. Obtaining information on direct mortalities is relatively easy as it only requires an assessment of the life status of an individual once it has been landed on deck. Documenting post release survival rates is more difficult as it depends on the extent of the injuries (internal and external) and requires monitoring of an individual over an extended period of time. While this can be done on a dedicated research vessel, it is more difficult on an active commercial fishing vessel. Despite this, any improvement in the level of information on post release mortality rates is likely to be beneficial with regards to the accuracy of future chondricthyan ERAs.

When compared to post release mortality rates, research into the use of TEDs and BRDs is more advanced. This research indicates that the greatest catch reductions may have already been achieved with the introduction of TEDs and the exclusion of larger Chondrichthyes from the catch (Stobutzki *et al*., 2002; Brewer *et al*., 2006). The results for smaller species has been more mixed (Stobutzki *et al*., 2001; Brewer *et al.*, 2006; Kyne *et al*., 2007) with TED effectiveness unlikely to change for these species until the TED specifications are modified. To this extent, exclusion rates for small to medium sized chondrichthyans may be improved by reducing the size of the TED bar spacings. The success of this proposal though would be dependent on a number of key variables including the effect of the change on chondrichthyan catch rates (if any), the impact on targeted species, the cost of transitioning a fleet over to a new TED design and the effectiveness of a TED design across multiple species sectors. It is for these reasons that any proposal to amend the current TED design would require a significant level of research, testing and consultation before being implemented; a process that is unlikely to be completed over a short period of time.

The likelihood of chondrichthyans escaping a trawl net once they pass through the bars of a TED is considered to be low. Kyne (2008) did show that the probability of capturing chondrichthyans in the tiger/endeavour prawn sector and scallop sector were lower when a net was fitted with a TED and a Fisheye BRD or a Square Mesh Codend; when compared to a standard general mesh net without a TED. This assessment though had a number of notable caveats including an acknowledgment by Kyne (2008) that the majority of this difference could be attributed to the use of a TED.

3.4 Marine Habitat

There was considerable variability in the amount of available information on community structures, species assemblages, seabed substrata and epibenthic coverage within the sample area. For the majority of the sample area, information on regional marine habitats was limited or if present, provided only a fragmented view of the broader picture. When detailed information was available *i.e.* for Moreton Bay, this information was regionally specific and for the most part could not be extrapolated beyond a defined area. As a consequence, it was extremely difficult to identify a set of ecological subcomponents that were applicable to the entire area and the decision rules needed to provide an accurate determination of risk throughout the sample area.

Biophysical strata (Fig 3.1) defined by Kenna & Kirkwood (2008) covers the entire ECOTF sample area and therefore were considered to be most suited to this type of analysis. However, the scope and extent of the analysis was limited by the fact that each stratum was defined by the most prominent physical characteristics (Table 3.10). Given these limitations, the resilience capability scores, fishery impact profiles and overall risk ratings contained within the study are considered to be preliminary in nature. It is noted though that additional information on the broader components of marine environments in southern Queensland was made available for consideration during the assessment phase (Appendix G).

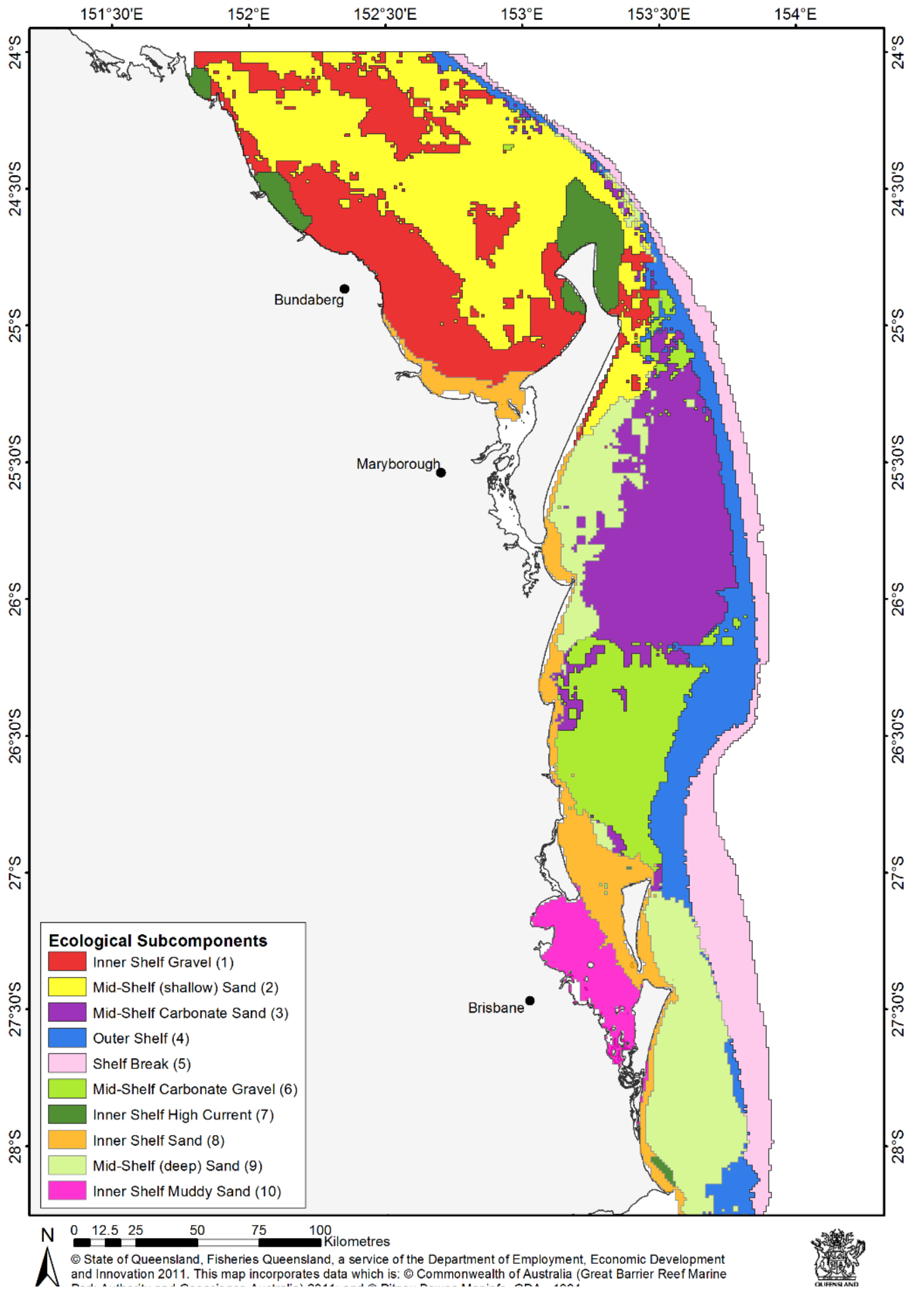

Figure 3.1. *Map of biophysical parameter strata (surrogates) for seabed habitats in the Tweed-Moreton Bioregion (Kenna & Kirkwood, 2008). Additional information and maps located in Appendix G of this report.*

3.4.1 Risk Context and Risk Identification

The purpose of the marine habitat ecological component assessment was to address the following question:

> *What is the likelihood that ECOTF activities will result in serious or irreversible damage to one or more of the 10 biophysical strata (marine habitat type proxies) over the next 20 years?*

Of the seven sources of risk identified by Pears *et al*. (2012a) discarding, contact without capture, loss of fishing gear and boat maintenance and emissions were most likely to lead to serious or irreversible damage (Table 2.1). Of the four identified sources of risk, discarding is arguably the easiest to quantify as it deals with the proportion of the catch that has been retrieved, landed and subsequently discarded. Some of the more significant impacts of discarding include the removal of structural habitat and in the case of living microcosms their translocation into potentially uninhabitable environments. The associated effects of contact without capture, loss of fishing gear and boat maintenance and emissions is harder to quantify as the consequences of these interactions are not readily observed. However, physical damage to seabed assemblages, plants or microhabitats within the immediate area (contact without capture) and pollution including water contamination (loss of fishing gear, boat maintenance) are all likely consequences of this type of interaction.

All 10 biophysical strata identified by Kenna & Kirkwood (2008) were included in the southern Queensland and RIBTF ERA. These strata covered a diverse range of inner, mid and outer shelf environments (Table 3.10) and encompassed a range of water depths, sediment sizes and sediment compositions. Table 3.10 provides an overview of the broader physical characteristics of each stratum along with a summary of the ECTF species sectors they are most likely to interact with. Figure 3.1 provides a spatial representation of the distribution of each biophysical stratum included in the analysis. The characteristics and decision rules used to assess the resilience capabilities of each biophysical strata and the fishery impact profiles are outlined in Table A15 and A16 respectively (Appendix C).

3.4.2 Risk Characterisation

Based on the characteristics and decision rules applied, the majority of biophysical strata have an intermediate ability to resist or recover from disturbance or decline (Table 3.11). Of the 10 biophysical strata assessed, the lowest resilience capability scores were recorded for stratum 7 (inner shelf - high current) and stratum 10 (inner shelf - muddy sand) (Table 3.11). This differential was primarily due to the restrictive nature of their geographical distributions within the sample area (Fig. 3.1; Appendix D: Table A31).

The scores assigned to each of the fishery impact profile characteristics showed some variability between marine habitat ecological subcomponents (Appendix D: Table A32). Of the five characteristics, 'knowledge of spatial distribution of fishing effort' and 'proportion of available habitat impacted by fishing gear' all displayed a level of variability between risk scores (Appendix D: Table A32). This was reflected in the fishery impact profile assessments where the majority of the ecological subcomponents registered risk scores of low through to high-intermediate (Table 3.11).

Table 3.10. *Relative measures of biophysical strata mapped by Kenna & Kirkwood (2008) and used as surrogate* ***marine habitat*** *ecological subcomponents.*

Strata	Habitat Type	Species Sector Interactions*	Estimated Average depth (m)[17]	Relative Average					
				Seabed Slope	Mud Content	Sand Content	Gravel Content	Carbonate Content	Grain Size
1	Inner Shelf Gravel	BUG, SC	20 (0-50)	Low	Low	Mod	High	Low	Large
2	Mid-Shelf Sand (shallow)	BUG, SC	30 (10-50)	Low	Low	High	Low	Low	Medium
3	Mid-Shelf Carbonate Sand	SC	60 (50-70)	Low	Low	High	Low	Mod	Medium
4	Outer Shelf	DWEKP	90 (50-150)	Mod	Low	High	Mod	High	Large
5	Shelf Break	DWEKP	200 (120-290)	High	Low	High	Low	Mod	Medium
6	Mid-Shelf Carbonate Gravel	SWEKP, SC	50 (40-70)	Low	Low	Mod	Mod	High	Large
7	Inner Shelf High Current	SWEKP	10 (0-30)	Low	Low	High	Low	Low	Medium
8	Inner Shelf Sand	SWEKP	10 (0-40)	Mod	Low	High	Low	Low	Medium
9	Mid-Shelf Sand (deep)	SWEKP, DWEKP	50 (10-100)	Mod	Low	High	Low	Low	Medium
10	Inner Shelf Muddy sand	MB**	10 (0-20)	Low	high	High	Low	Mod	Fine

** Abbreviations: BUG, Moreton Bay Bug sector, SC, saucer scallops, DWEKP, deep water eastern king prawn; SWEKP, shallow water eastern king prawn, MB, Moreton Bay*

*** Moreton Bay sector catches incorporates a range of prawn species including tiger and endeavour prawns, eastern king prawns, greasyback and school prawns.*

[17] *Numbers in parenthesis represent the depth range*

Combining the resilience capability assessment scores with the fishery impact profiles produced overall risk ratings of low through to high-intermediate (Table 3.11). Based on the results obtained, the following observations could be made with respect to the level of risk trawl fishing poses to each of the respective ecological subcomponents:

- there is an intermediate risk to half of the marine habitat ecological subcomponents due to trawl fishing activities in southern Queensland; and

- these intermediate risks are in marine habitats where eastern king prawns, scallops and/or Moreton bay bugs are targeted.

Table 3.11. *Risk assessment evaluations for each biophysical stratum (Kenna & Kirkwood, 2008) used as surrogates for* ***marine habitat*** *ecological subcomponents located in southern Queensland.*

	Habitat Type	Species Sector Interactions*	Resilience	FIP	OVERALL
1	Inner Shelf Gravel	BUG, SC	**I**	I	I
2	Mid-Shelf Sand (shallow)	BUG, SC	**I**	H-I	H-I
3	Mid-Shelf Carbonate Sand	SC	**I**	I-L	I-L
4	Outer Shelf	DWEKP	**I**	I	I
5	Shelf Break	DWEKP	**I**	I	I
6	Mid-Shelf Carbonate Gravel	SWEKP, SC	**I**	I	I
7	Inner Shelf High Current	SW EKP	**I-L**	I	I-L
8	Inner Shelf Sand	RIBTF, SWEKP	**I**	L	L
9	Mid-Shelf Sand (deep)	SWEKP, DWEKP	**H-I**	I	I
10	Inner Shelf Muddy sand	RIBTF, MB**	**I-L**	I-L	I-L

** Abbreviations: BUG, Moreton Bay Bug sector, SC, saucer scallops, DWEKP, deep water eastern king prawn; SWEKP, shallow water eastern king prawn, MB, Moreton Bay; RIBTF, river and inshore beam trawl fishery.*

*** Moreton Bay sector catches incorporates a range of prawn species including tiger and endeavour prawns, eastern king prawns, greasyback and school prawns.*

3.4.3 Issues Arising

While the ecological subcomponents did not align with the GBRMP ERA (Pears *et al*., 2012a), the inclusion of the 10 biophysical strata helped provide a more holistic account of the risk trawl fishing poses to regional ecosystems in southern Queensland. With this in mind, final risk assessments contained within this study were subject to a number of notable caveats. For instance, biophysical strata mapped by Kenna & Kirkwood (2008) are principally defined by their broader environmental characteristics *i.e.* water depth, slope gradient and sediment compositions (Table 3.10). Further, strata definitions provided by Kenna & Kirkwood (2008) contained little information on the distribution of key epibenthic assemblages *e.g.* sponge, seagrass and corals. As a consequence, the current study was able to identify strata most at risk over the next 20 years but provided little insight into the long-term reactions of epibenthic assemblages or the long-term effects of trawl fishing within these areas. For example, the impacts of trawl fishing in barren substrates will be different from those experienced by marine habitats with high proportions of sponge and soft corals (Hutchings, 1990; Svane *et al*., 2009; Currie *et al.* 2011).

In addition to an absence of epibenthic coverage data, the biophysical strata mapped by Kenna & Kirkwood (2008) focused principally on areas fished as part of the ECOTF (Fig. 3.1). As a consequence, marine habitats fished by beam trawl operators were not subject to a risk assessment. Of the biophysical strata included in the current analysis, stratum 10 (muddy-sand inner shelf environments) arguably provides the best proxy for areas fished by beam trawl fishers (Table 3.10). By extension, some parallels could be drawn between the risk to stratum 10 and that in areas fished by beam trawl operators (Fig. 3.1). It is noted though that this type of evaluation provides a relatively simplistic account of how beam trawl activities impact regional ecosystems and negates the influence of regional factors including varying levels of fishing intensity, the degree of habitat degradation and the level of urban development.

While strata 7 and 10 were assessed as having lower resilience capabilities, they recorded an overall risk rating of intermediate-low (Table 3.11). This because both strata are afforded a reasonable level of protection from trawl fishing activities. For stratum 10, which is confined almost exclusively to Moreton Bay, the majority of this protection comes in the form of the *Marine Parks (Moreton Bay) Zoning Plan 2008* which protects approximately 54% of the marine park from trawl fishing (Department of Environment and Resource Management, 2010). This area is also subject to fisheries-specific closures suggesting the proportion of stratum 10 protected from trawl fishing is even higher. The sources of protection for stratum 7 have more to do with natural phenomena as marine habitats with high currents are less conducive to trawl fishing activities (*pers. comm.,* D. Roy; Appendix G, Fig. 4). As a consequence, these areas tend to attract a smaller proportion of the trawl fishing effort.

The strata with the highest fishery impact profile scores also had the highest overall risk ratings (Table 3.11). This result was largely attributed to two intimately linked characteristics; 'the proportion of available habitat impacted by fishing gear' and the 'proportion of total habitat which is permanently protected from fishing activities'. For example, strata 2 and 9 have predominantly sandy substrates and are the preferred fishing grounds for tropical saucer scallops (*Amusium japonicum balloti*) and eastern king prawns (*Melicertus plebejus*) respectively. Potential impacts of trawling in these areas include elevated levels of sediment disturbance and sediment re-suspension, reduced habitat stability and increased translocation of more complex three-dimension structures (Fleddum *et al*., 2013; Dannheim *et al*., 2014). Studies also suggest areas subject to longer periods of higher effort may experience a phase shift in species compositions with disturbance-averse species (*i.e.* species *r*-selected life-history traits) becoming more prevalent through time (Pitcher *et al*., 2000; de Juan & Demestre, 2012).

From a management perspective, there was a notable shift in the level of protection afforded to each of the respective stratum through spatial and temporal closures. Inner-shelf environments had the highest level of protection with trawl fishing restricted along the coastline through a complex array of spatial and temporal closures. The level of protection afforded to mid- and outer-shelf strata (Fig. 3.1) tended to be lower with the emphasis shifting from permanent closures to seasonal effort restrictions – the *Southern regional regulated waters* six week closure being the largest seasonal closure in the area. As a consequence, the majority of mid- and outer-shelf regions were assigned a ‘prone to risk’ (P) score for characteristics like ‘proportion of total habitat permanently protected from trawl fishing’ and ‘proportion of available habitat impacted by fishing gear (Appendix D: Table A32).

3.4.4 Management Considerations

In the GBRMP ERA (Pears *et al*. 2012a), the majority of information issues encountered in the southern Queensland and RIBTF were negated by the *Great Barrier Reef Seabed Biodiversity Survey* (Pitcher *et al*., 2007). This study not only identified habitats contained within the GBR but also defined their distribution and provided finer scale assessments of the species assemblages. This information provided Pears *et al*. (2012a) with greater scope to assess the potential impacts of trawl fishing and the risk to marine habitats from trawling.

The accuracy of the southern Queensland and RIBTF ERA would certainly improve if data from a project similar to the *Great Barrier Reef Seabed Biodiversity Survey* (Pitcher *et al*., 2007) were undertaken in the region. However, projects of this magnitude are both very expensive and very resource intensive. As such, the likelihood of replicating the *Great Barrier Reef Seabed Biodiversity Survey* (Pitcher *et al*., 2007) in the southern Queensland and RIBTF areas is unlikely in the short to medium term. Therefore, alternate methods will need to be considered in order to improve the accuracy and scope of future marine habitat ecological component assessments.

As a possible way forward, consideration could be given to reducing the scope of the marine habitat ecological component to regions with higher levels of information. For example, the level of information on seabed strata and epibenthic coverage in Moreton Bay (Environmental Protection Agency, 2009) is comparable to that reported in Pitcher *et al*. (2007). This information could be used to construct a more detailed and accurate risk assessment for targeted areas of the ECTF. This in turn would provide greater opportunities to improve regional management initiatives and target any specific areas of concern.

As inshore environments have the most information on seabed strata and epibenthic coverage, risk assessments involving strata 1, 7, 8 and possibly 9 would arguably benefit most from a refinement of the marine habitat ecological component assessment. However, the extent of this benefit would be highly dependent on the specificity of the regional data, the degree of overlap with areas fished by the ECTF, and its wider applicability. Further, a regional approach may detract from the broader appeal of assessments like the southern Queensland and RIBTF ERA which are designed to assess risk across a large area. The primary reason for this is that regional marine habitat data is often fragmented, has a highly restrictive geographical distribution and/or lacks continuity with respect to the definitions used across studies. This can make it difficult to standardize results across studies and obtain outcomes that are applicable at a whole-of-fishery level.

Despite the above, the southern Queensland and RIBTF ERA provided some useful insight into the risk from trawling and some of the limitations of the current management regime. When compared, subcomponents with lower resilience capability scores and higher fishery impact profiles had either a restricted geographical range or proportionately more area open to trawl fishing activities (Appendix D: Table A31, A32). Significantly, none of the 10 biophysical strata were assigned a 'prone to risk' (P) score for both characteristics (Appendix D: Table A31, A32).

A review of current ECTF closures revealed that most were situated in inner shelf marine habitats (strata 1, 3, 8 and 10) where trawl fishing is restricted through a range of permanent, temporal and seasonal closures. The use of temporal closures tends to decline in the mid-shelf strata, with the number of temporal closures continuing to declines as the fishery progresses further east *i.e.* into the outer shelf (strata 4) and shelf break (strata 5) regions (Fig. 3.1). As a consequence some areas of the mid- and outer shelf strata are more likely to experience a degree of trawl fishing activity throughout the year. This is particularly relevant for biophysical strata east of the *Southern regional regulated waters* which are open to trawl fishing all year round. In acknowledgement of the above, consideration should be given to reviewing the current suite of closures in mid- and outer-shelf regions and, if needed, increasing the level of protection afforded to these areas during key periods.

4. FUTURE CONSIDERATIONS

Under an ideal scenario, future ERAs involving the ECTF would include all areas fished inside and outside of the GBRMP. In the GBRMP ERA, Pears *et al*. (2012a) was able to draw upon more detailed data sets (Pitcher *et al.,* 2007) and provide comprehensive assessments of the potential impacts of trawl fishing within a defined area. This enabled Pears *et al*. (2012a) to address regional fishing pressures and identify more regionally specific management initiatives for the GBRMP. This level of detail would not be achieved (at present) by a fisheries-wide ERA as it would need to accommodate both data rich and data poor areas including regions covered by this ERA. Accordingly, one of the most significant challenges for the ECTF will be to improve information on catch rates, species compositions and marine habitats/assemblages outside of the GBRMP.

This report is considered to be the first step towards determining long-term risk trends for species and habitats interacting with the fishery within the study area, especially those subcomponents which are not targeted by the fishery. This process has already commenced in the GBRMP with risk ratings obtained by Pears *et al*. (2012a) able to be compared to an analogous assessment undertaken in 2005 (Pears *et al*., 2012b). These comparisons revealed that the overall risk of trawl fishing activities for one or more of the ecological subcomponents had not increased during the interim period (Pears *et al*. 2012a). In a number of instances, the risk of an undesirable event occurring in the GBRMP over the next 20 years had even declined. This was particularly evident in the bycatch ecological component where 84.4% of the species with a 2005 ERA had a lower overall risk rating (Pears *et al*., 2012a; 2012b). Of which, the spinycheek grunter (*Terapon puta*) exhibited the greatest degree of variance improving from a high overall risk rating to a low overall risk rating (Pears *et al*., 2012a).

In the current analysis, the vast majority of ecological subcomponents had an intermediate (39.8%) or intermediate-low (35.7%) risk over the next 20 years due to trawl fishing activities (Table 4.1). This was well above that reported for the high-intermediate (2.3%) and high (9.9%) risk categories; the majority of which were reported within the species of conservation concern ecological component (Table 3.8). These proportions were similar to that reported by Pears *et al*. (2012a) for the GBRMP where 2.0% and 9.5% of the overall risk ratings fell within the high-intermediate and high category respectively. The similarity was to be expected given the broader prevalence of otter trawl fishing inside and outside of the GBRMP and the species compositions of both risk assessments; particularly within the species of conservation concern ecological component.

At the ecological subcomponent level, inter-specific comparisons revealed limited variance between results obtained in this study and the GBRMP ERA (Pears *et al*., 2012a). For example, only 17 of the 83 (20.5%) species included in both the current study and Pears *et al*. (2012a) displayed intraspecific differences in overall risk ratings (Table 3.3, 3.6 and 3.9). In a number of these instances, regional variability in the amount of available data was considered to be a significant factor of influence. There are however some notable examples where the observed differences were due to factors other than data discrepancies including the Moreton Bay bug (*Thenus* spp.) complex (Table 3.3) and sea snakes (Table 3.9). It is within these examples that management authorities will arguably gain most benefit from the ERA with respect to the development of regional management initiatives.

Ecological risk assessments constructed as part of the current study were based on management initiatives outlined in the *Fisheries (East Coast Trawl) Management Plan 2010* and catch and effort data from the 2009 fishing season. While representative of the current fishing environment, effort usage in 2009 was lower than the long-term historical average (Appendix A). In the context of this ERA, the reduction in fishing effort was interpreted (by ERA workshop participants) as the fishery exerting less pressure on the ecological subcomponents, fewer interactions with these ecological subcomponents and fewer trawl related mortalities. From an ERA perspective, these assumptions had more of an influence on the fishery impact profiles, which in at least two instances (harvest species and bycatch), were identified as the largest contributor to the overall risk ratings (Table 3.1, 3.5). To this extent, a comparatively low level of effort was considered to be a major factor influencing the risk assessment for many subcomponents in the current study.

Table 4.1. *Summary of the overall risk ratings for each ecological component assessed as part of the southern Queensland and RIBTF ERA.*

Ecological Component	**Overall Risk Rating***				
	L	**I – L**	**I**	**H-I**	**H**

Harvest Species (total)	**16**	**1**	**13**	**1**	**0**
Principal species	*11*	–	*4*	–	–
Permitted species	*5*	*1*	*9*	*1*	–
Bycatch Species	**3**	**25**	**27**	**3**	**1**
Species of Conservation Concern	**1**	**32**	**23**	**0**	**16**
Marine turtles	–	*6*	–	–	–
Sea snakes	–	*9*	*1*	–	*1*
Syngnathids	–	–	*8*	–	–
Chondrichthyes	*1*	*17*	*14*	–	*15*
Marine Habitats	**1**	**3**	**5**	**1**	**0**
Total**	**21**	**61**	**68**	**4**	**17**

** Abbreviations: L, low; I – L, intermediate-low; I, intermediate; H – I, high-intermediate; H, high.*

While effort usage in the ECTF remains at comparatively low levels, there is still significant scope for it to increase over the short to medium term. This is particularly relevant to southern Queensland where a high proportion of the ECOTF effort is targeted at eastern king prawns (*Melicertus plebejus*). If trawl effort were to increase in southern Queensland and RIBTF areas, then overall risk ratings reported herein may rise. The approach adopted here is well suited to an interim review of the ERA results if a) effort usage undertakes a notable shift upwards in the study area and or b) effort in a particular region or fishing sector increases substantially. If a partial update of this ERA were required, consideration should be given to including as a minimum all species in the current study that were deemed to have an overall risk rating of high-intermediate or high.

Irrespective of whether or not future iterations of the current assessment are a partial or full review, investigations should be undertaken into how best to improve the level of information. As noted, data deficiencies played a role in the final risk scores of a number of the ecological subcomponents; namely within the bycatch (Table 3.5) and species of conservation concern (Table 3.8) ecological components. In the context of this ERA, the risk of including species with data deficiencies was offset by assigning conservative resilience capability and fishery impact profile scores. This insured that the risks from trawling were not underestimated due to data deficiencies.

There is arguably greater capacity to improve the accuracy of the resilience capability scores in the short term. The primary reason for this is that the biological data used to construct the resilience capability scores will continue to increase over time. Further, biological studies are more likely to originate from a wider variety of sources (government and non-government) and include both targeted and non-targeted species. The challenge for management authorities is to encourage further research into the biology of key species including those that a) have a comparatively high overall risk, b) have a risk rating that is likely to increase if effort increases and c) that require further biological investigations. As biological studies are (generally) less reliant on complex sampling regimes and less expensive to conduct, this could include smaller scale projects designed to address critical information gaps.

Improving the depth of catch data for species not included in the current reporting regime (Appendix B) will be a more difficult assignment. With the cessation of the *Fisheries Observer Program* the emphasis of catch reporting for the ECTF is now largely limited to targeted/harvest species and those included in the *Species of Conservation Interest* (SOCI) logbook. Therefore, opportunities to expand the level of catch rate information may be limited for a number of the species included in this analysis. This will require further consideration when attempting to identify priority areas and potential opportunities to work in collaboration with both government and non-government organizations. Given the prevalence of elasmobranch species in discussions surrounding fisheries bycatch and long-term population trends, this subgroup arguably has the best opportunity of garnering support for further research within the wider scientific community.

Of the four ecological components included in the analysis, assessments contained within the marine habitat sector were most affected by data deficiencies (Table 3.11; Appendix D: Table A31, A32). Data deficiencies not only limited the scope of the marine habitat assessments but also required a divergence from the subcomponents used by Pears *et al*. (2012a). Ideally, the ecological subcomponents used for the southern Queensland and RIBTF ERA would mirror those used by Pears *et al.* (2012a). This would provide greater opportunities to assess the potential impacts of trawl fishing on regional ecosystems and help to identify the causal effects of any negative consequences. In reality, it is unlikely that future marine habitat ERAs for the southern Queensland ECOTF or RIBTF will have sufficient detail to conduct a study analogous to Pears *et al*. (2012a). The simple reason for this is that the level of information on habitat distributions and compositions is not expected to expand substantially without a significant investment of resources.

Given the comparative shortfall in environmental data for the southern reaches of the ECOTF and RIBTF areas, the structure of subsequent marine habitat ERAs may need to change over time. As noted, one possible option is to refine the scope of the assessment to regions with high levels of environmental data *i.e.* Moreton Bay and Great Sandy Marine Parks. An alternative would be to incorporate these data into the current framework of marine habitat ecological assessment (Kenna & Kirkwood, 2008). Difficulties of this approach include a) how best to standardize the ecological components across regions and b) how best to account for epibenthic variations in biophysical strata with limited information.

5. SUMMARY

One of the benefits of undertaking a multifaceted ERA is that it includes species that are regularly reported on as well as those not captured under the current catch monitoring program. In doing so, this ERA provides a much broader snapshot of the risks associated with trawl fishing activities in regional ecosystems; as opposed to an individual species or stock. From a management perspective, the completion of this ERA provides greater scope to assess the applicability of pre-existing management arrangements and the benefits of any new initiatives to species interacting with the ECTF.

While acknowledging that some of the risk assessments have a high degree of uncertainty, they provide a strong framework for future iterations of the southern Queensland and RIBTF ERA to build upon. Further, each ecological subcomponent now has a detailed risk matrix that includes key information on their resilience capabilities and fishery impact profiles. This will make it easier to incorporate new information, update risk scores for individual characteristics and (where applicable) amend resilience capability scores, fishery impact profiles and overall risk ratings. The significance of this is that any review (partial or full) of the results obtained in the current study will require less time and fewer resources. The challenge going forward will be on how best to improve the accuracy of the assessments (resilience capabilities, fishery impact profiles and overall risk ratings) contained within this study.

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7. APPENDICES TO TECHNICAL REPORT

List of Appendices Supporting the Technical Report

Appendix A. Overview of the East Coast Trawl Fishery (ECTF), East Coast Otter Trawl Fishery (ECOTF) and River and Inshore Beam Trawl Fishery (RIBTF).

The following is an excerpt of additional information made available to stakeholders involved in the Great Barrier Reef Marine Park ERA (Pears *et al*., 2012a) and the southern Queensland and RIBTF ERA. This information was used in part to inform discussions during the assessment phase of the ERA and provide context with respect to the regional (potential) impacts of the fishery on regional ecosystems.

Further information about the fishery including detailed overviews of catch rates and compositions for the ECOTF and the RIBTF can also be obtained through the annual reports (DEEDI, 2011a; DEEDI, 2011b).

List of tables included in Appendix A

List of figures included in Appendix A

Primary References

- Annual Status report 2009 – East Coast Trawl Fishery. Available from: https://www.daf.qld.gov.au/__data/assets/pdf_file/0003/56928/ECOTF-ASR-FINAL.pdf
- Annual Status Report 2008 – River and Inshore Beam Trawl Fishery. Available from: https://www.daf.qld.gov.au/__data/assets/pdf_file/0003/71346/ASR-RIBTF-2008.pdf

EAST COAST OTTER TRAWL FISHERY – AN OVERVIEW

BACKGROUND INFORMATION

The East Coast Trawl Fishery (ECTF) is the largest Queensland fishery by both volume of product caught and economic value (Fig. A1). While the fishery extends along the entire Queensland east coast, it can essentially be divided into three main areas:

- Northern regional regulated waters;
- Southern regional regulated waters; and
- Moreton Bay.

The ECTF comprises nine separate fishery symbols based on regional access rights and includes the:

- T1, Trawl Fishery (Cape York to QLD/NSW border excluding Moreton Bay)
- T2, Trawl fishery (Concessional)
- T5, Beam trawl area 5
- T6, Bean trawl area 6
- T7, Beam trawl area 7
- T8, Beam trawl area 8
- T9, Beam Trawl area 9
- M1, Moreton Bay Trawl
- M2, Moreton Bay Trawl.

Principal target species for the ECTF include:

- Prawns (Eastern King, Red Spot, Tiger, Endeavour, Banana)
- Scallops (Saucer and Mud)
- Bugs
- Squid.

In addition to the above, the fishery also has a number of permitted species which can be retained under varying management requirements. These include:

- Balmain bugs
- Blue Swimmer Crabs
- Cuttlefish
- Mantis Shrimp
- Octopus
- Pipefish

- Red Champagne Lobster
- Slipper Lobster
- Threadfin Bream
- Three-Spotted Crab.

LEGISLATION

The ECTF is principally managed through the:

- *Fisheries Act 1994*;
- Fisheries Regulation 2008; and the
- *Fisheries (East Coast Trawl) Management Plan 2010*.

Provisions[18] relating to trawl activities on the east coast of Queensland are also provided for in the:

- *Marine Parks (Great Barrier Reef Coast) Zoning Plan 2006*;
- *Marine Parks (Great Sandy) Zoning Plan 2006*;
- *Marine Parks (Moreton Bay) Zoning Plan 2008;*
- *Great Barrier Reef Marine Park Act 1975* (Commonwealth);
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth); and
- *Nature Conservation Act 1992*.

KEY MANAGEMENT ARRANGEMENTS

- Limited entry.
- Restrictions on the size of boats which can operate in the fishery, (20 m for T1 & T2; 14 m for M1 & M2; 9 m for T5 – T9).
- 70 hull unit limit for M1, T1, T2.
- Engine restriction of 300 continuous brake kW (maximum).
- Gear restrictions: vessel length, net head rope length and mesh restrictions apply depending on the areas of operation.
- Licence holders only have a certain number of nights they can fish each year in the form of tradeable effort units.
- Effort capped at the 1996 level less 5%.
- Numerous and extensive permanent area closures apply to the fishery, particularly in waters of the Great Barrier Reef World Heritage Area (GBRWHA), Great Sandy and Moreton Bay Marine Parks.

[18] *Please note that the list of legislation with provisions relating to trawl fishing is not exhaustive.*

- Seasonal closures in place during summer and autumn north of 22°S latitude and during spring and summer south of this latitude.
- Daytime and weekend closures apply to trawling in estuaries and some inshore areas (e.g. Moreton Bay) to reduce any interactions with recreational users.
- Mandatory use of turtle exclusion devices (TEDs) and bycatch reduction devices (BRDs).
- A range of by-product harvesting protection arrangements.
- Logbooks, surveillance by fisheries enforcement officers (the Queensland Boating and Fishing Patrol) and remote tracking of otter effort and compliance of fishing operations through satellite VMS.

LICENCE/ENDORSEMENT CONFIGURATION

The following licence summary is based on current records held by Fisheries Queensland (as of 18 August 2010). The data is separated into two different components a) the number of licences currently in the ECOTF and b) the number of individual endorsements covered under the ECTF management plan (Table A1). The discrepancy between the two totals is due to some licences being duel endorsed; principally licences with an M1 symbol which must also have a T1.

Boat length in the ECOTF is effectively restricted to a 20 m limit, however a number of vessels currently operate under grandfather clauses. This clause permits the use of vessels greater than 20 m if a) the boat attached to the licence was greater than 20 m when the new requirement came into effect and b) the licence has not changed during the interim period. Licences that currently operate under a grandfather clause must adhere to the current rules if and when they change the vessel attached to the licence. A breakdown of the type of vessels currently operating in the ECOTF is outlined in Table A2 and Figures A2 – A3.

ECOTF EFFORT USAGE TRENDS & PARTICIPATION RATES

Summary information of effort usage in the ECOTF includes:

a) effort usage for the entire ECOTF represented as proportion of effort available effort units used (Table A3; Fig. A4)

b) effort usage for the entire ECOTF represented as total days fished in the northern and southern regions of the ECOTF between 2001 and 2009 inclusive and days (Table A4; Fig. A5)

c) participation rates in each of the respective northern and southern regional regulated waters including the number of boats accessing each region in a year (Table A5; Fig. A6)

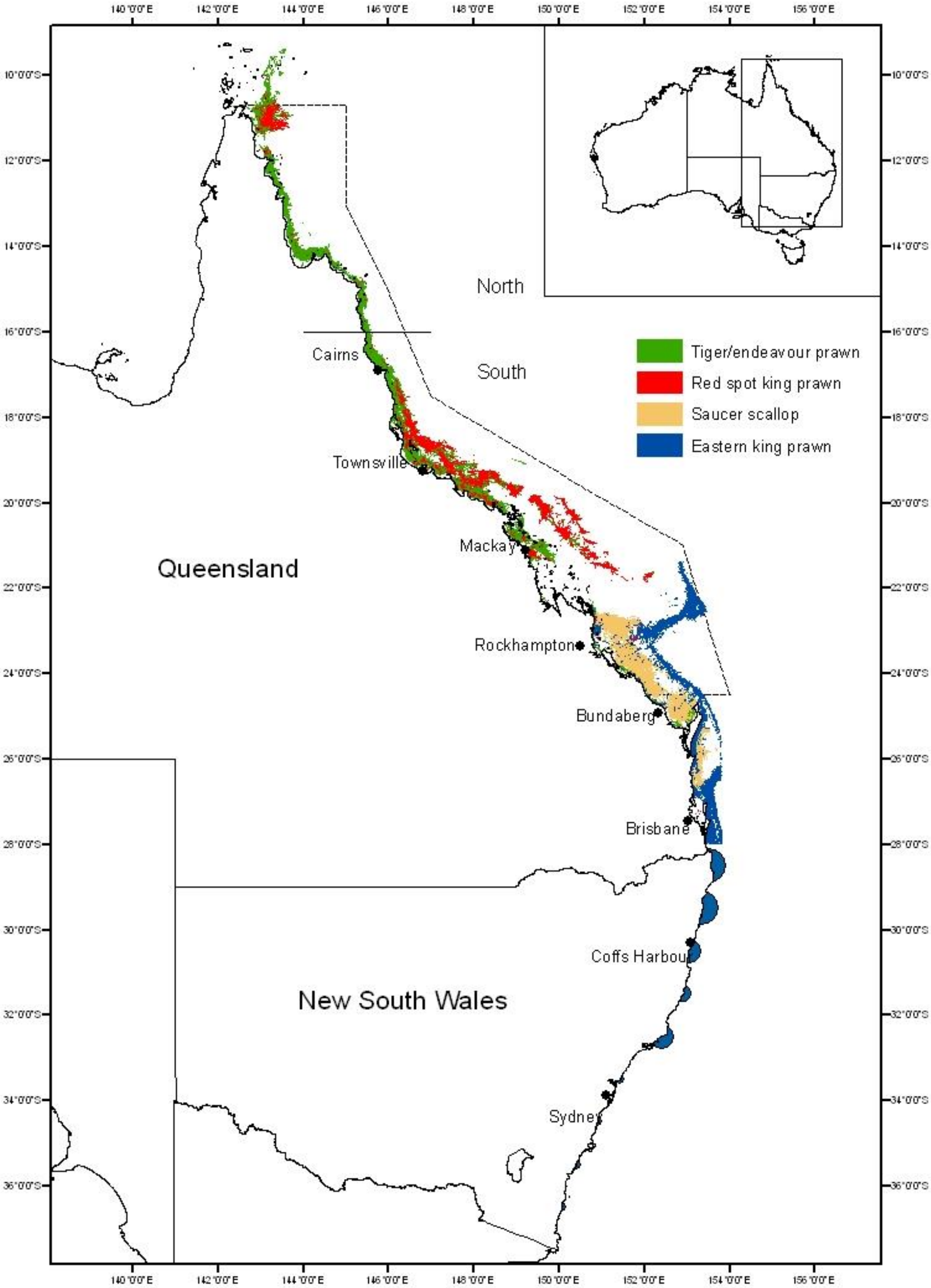

Figure A1. Area of the southern Queensland and River and Inshore Beam Trawl Fishery (RIBTF) ecological risk assessment.

Table A1. Breakdown of licence and endorsement numbers for the ECTF based on Fisheries Queensland records (Correct as of 18 August 2010). * M1 licences also require a T1 symbol, therefore are considered to be duel endorsed licences.

Symbol	Licences	Endorsements
T1	397	397
T2	26	26
M1*	–	42
M2	25	25
T5	49	51
T6	11	11
T7	5	6
T8	28	30
T9	23	23
Total	**564**	**611**

Table A2. Data Summary: boat length frequency comparisons for the all licences with a) a T1, T2 or M2 fishery symbol, b) a T1 or T2 fishery symbol only and c) a M1 or M2 fishery symbol only.

Length (m)	Frequency (No. of Boats)		
	T1, T2, M2	T1 & T2 (only)	M1 & M2 (only)
≤8	6	5	2
8- 9	4	3	2
9 - 10	18	12	10
10 - 11	10	6	9
11 - 12	12	11	9
12 - 13	18	12	10
13 - 14	50	47	23
14 - 15	31	31	2
15 - 16	53	53	-
16 - 17	50	50	-
17 - 18	40	40	-
18 - 19	46	46	-
19 - 20	40	40	-
>20	5	5	-

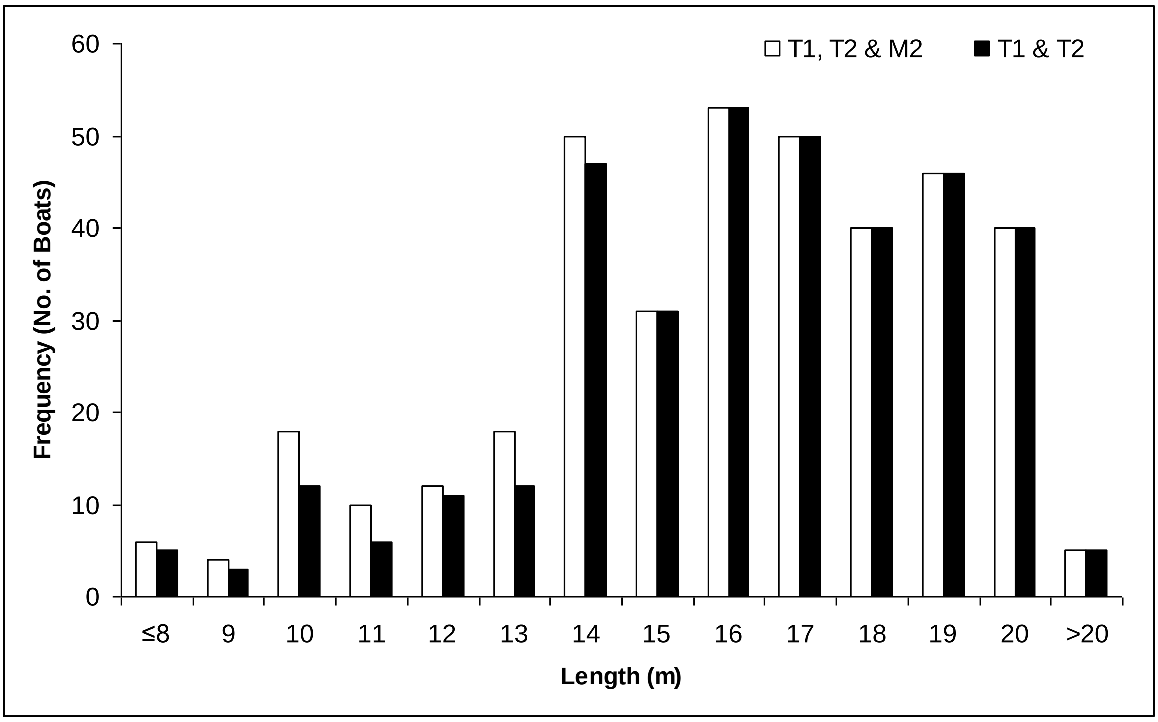

Figure A2. Boat length comparisons for the all licences with a) a T1, T2 or M2 fishery symbol and b) a T1 or T2 fishery symbol only.

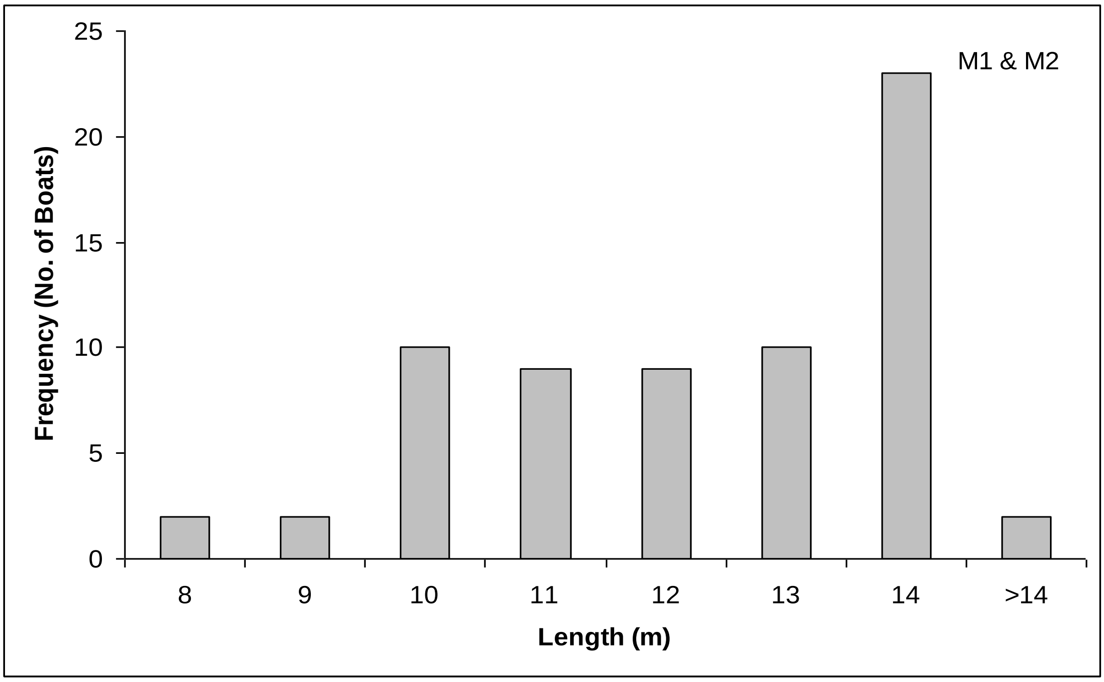

Figure A3. Boat length comparisons for vessels able to operate within Moreton Bay (M1 and M2 fishery symbols).

Effort unit usage for the entire ECOTF was based on data obtained for the 2001 to 2009 seasons (inclusive) and presented as a percentage of the total ECTF unit allocation. Data used to compare days fished in the entire ECTF, northern regional regulated waters and southern regional regulated waters was compiled by Clive Turnbull from the Northern Fisheries Centre. Northern and Southern regions were defined by the – 22° S split with fishing days based on 1990 to 2009 (inclusive) logbook data. Data presented in Table A4 and Figure A5 does not include data on effort usage (days fished) in the beam trawl fishery. Participation rates for the northern and southern regional regulated waters (Table A5, Fig. A6) are represented by the number of licences accessing each region in a given year.

Both participation rates and the total number of days fished/effort used in the ECOTF has shown a general decline between 2000 and 2009 (Table A4; Table A5). This decline has been attributed to a range of issues including increased operating costs, declining or stagnate product prices and various legislative instruments. It is noted thought that effort usage has stabilised in recent years with total effort usage for the ECOTF hovering at around 40,000 annual fishing days.

Overall, the proportion of unused units in the ECTF increased progressively from a low of 10.0 – 11.6% (2001/02) to 43.3% in 2008 (Fig. A4). While the proportion declined slightly in 2009, over a third of the total unit allocation remained unused for the year. This equates to a real term surplus of 1,240,826 units in 2007, 1,290,876 in 2008 and 1,131,924 units in 2009. Regionally the southern reaches of the ECTF (areas south of 22° S) has attracted the majority of the fishing effort. The discrepancy between the northern and southern regions has tended to increase over time. Nowadays, approximately two-thirds of the effort is used in the southern region (Table A5).

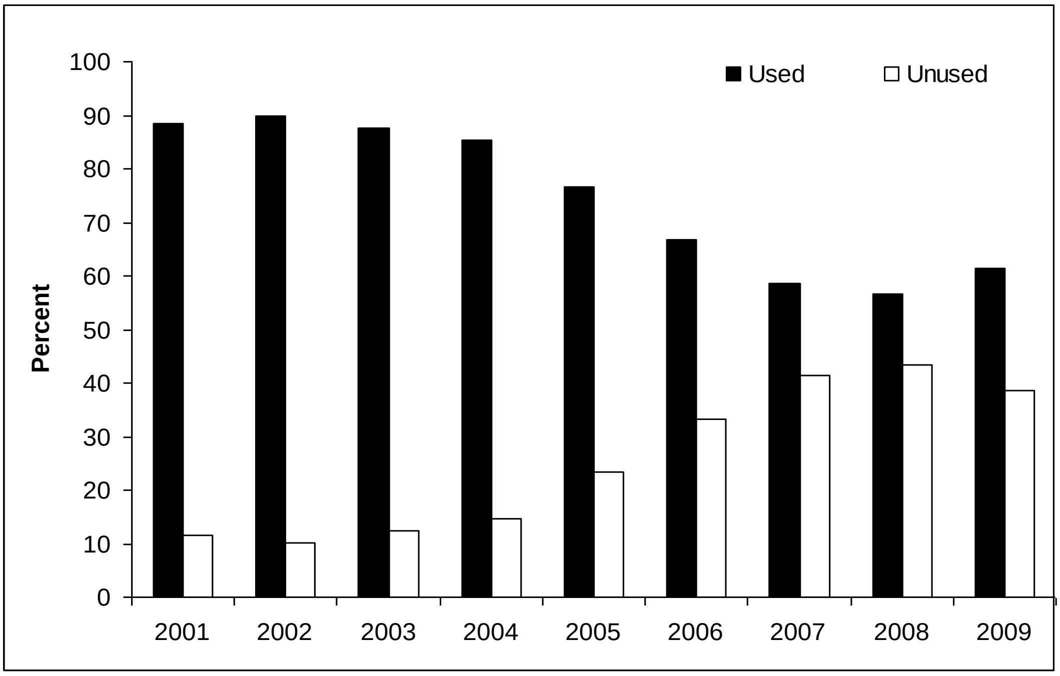

Figure A4. Effort usage for the East Coast Trawl Fishery between 2001 and 2009 represented as a proportion of units used and unused.

Table A3. Data Summary: effort usage for the East Coast Trawl Fishery between 2001 and 2009 represented as a proportion of units used and unused.

Year	Total ECTF	Total Used (x	Total Unused	Used (%)	Unused (%)
2001	2983.3	2636.9	346.4	88.4	11.6
2002	2941.5	2647.1	294.4	90.0	10.0
2003	2925.3	2563.6	361.7	87.6	12.4
2004	2985.4	2548.3	437.2	85.4	14.6
2005	2972.6	2280.1	692.5	76.7	23.3
2006	3007.0	2011.3	995.7	66.9	33.1
2007	3003.5	1762.7	1240.8	58.7	41.3
2008	2978.1	1687.2	1290.9	56.7	43.3
2009	2956.1	1818.2	1137.9	61.5	38.5
2010	2928.8	552.4	2376.4	–	–

Table A4. Data summary: days fished in the entire ECTF, the northern regional regulated waters and southern regional regulated waters represented. * Excludes beam trawl effort.

Year	Total days fished	Days fished: North	Days fished: South	Effort usage split (%)	
				North	South
1990	90,705	36,141	54,564	40%	60%
1991	89,805	37,863	51,942	42%	58%
1992	84,152	31,695	52,457	38%	62%
1993	91,194	36,829	54,365	40%	60%
1994	89,584	40,719	48,865	45%	55%
1995	92,111	37,102	55,009	40%	60%
1996	98,150	42,783	55,367	44%	56%
1997	103,497	44,413	59,084	43%	57%
1998	99,936	41,964	57,972	42%	58%
1999	93,220	39,998	53,222	43%	57%
2000	88,131	40,115	48,016	46%	54%
2001	67,832	25,490	42,342	38%	62%
2002	67,635	29,244	38,391	43%	57%
2003	66,466	27,539	38,927	41%	59%
2004	64,011	24,498	39,513	38%	62%
2005	54,959	20,306	34,653	37%	63%
2006	46,989	15,622	31,367	33%	67%
2007	40,134	10,325	29,809	26%	74%
2008	36,021	10,740	25,281	30%	70%
2009	37,706	10,647	27,059	28%	72%

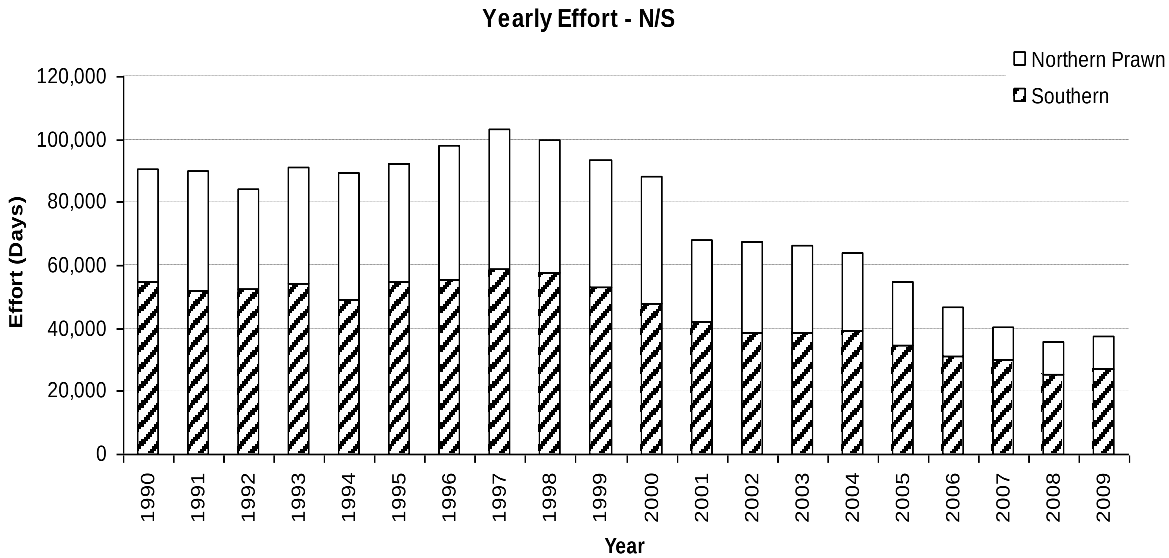

Figure A5. Days fished in the northern regional regulated waters and southern regional regulated waters represented. * Excludes Beam Trawl effort.

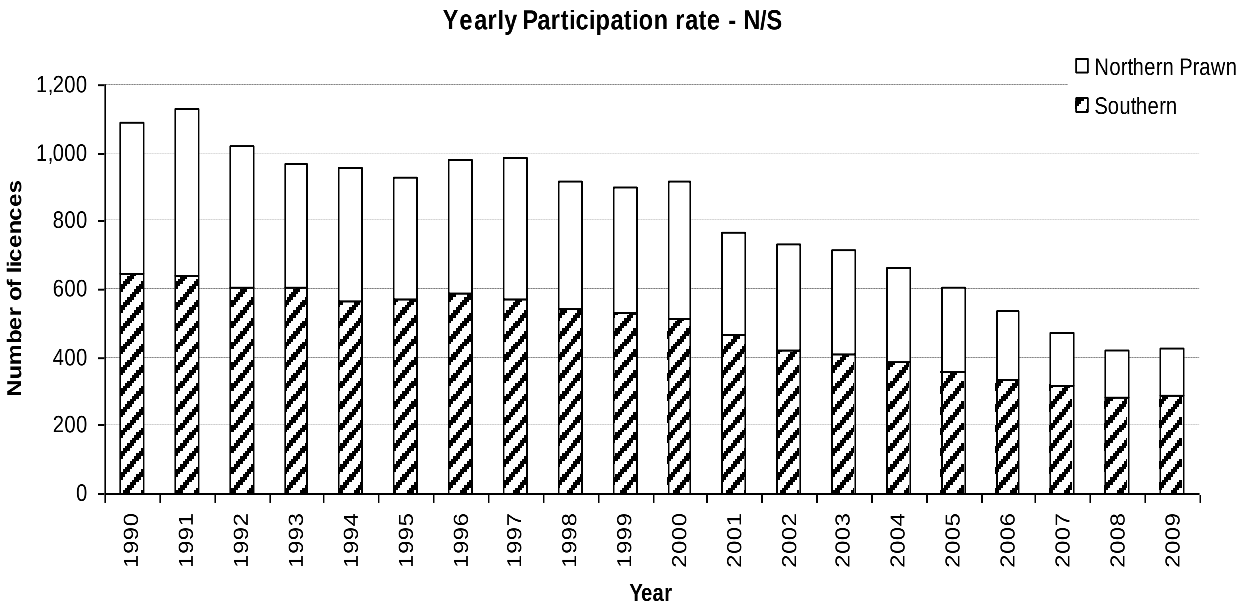

Figure A6. Participation rates for northern and southern regional regulated waters represented as number of licences operating in each of the respective regions. *Excludes Beam Trawl effort.

Table A5. Data summary: participation rates for the entire ECTF, northern regional regulated waters and southern regional regulated waters represented as number of licences. *Excludes Beam Trawl effort.

Year	Total No. Licences	Operating in Nth	Operating in Sth	Licence split (%)	
				Nth	Sth
1990	1091	442	649	41%	59%
1991	1132	489	643	43%	57%
1992	1024	418	606	41%	59%
1993	970	366	604	38%	62%
1994	956	391	565	41%	59%
1995	931	361	570	39%	61%
1996	980	393	587	40%	60%
1997	984	410	574	42%	58%
1998	920	377	543	41%	59%
1999	898	368	530	41%	59%
2000	916	400	516	44%	56%
2001	765	298	467	39%	61%
2002	732	313	419	43%	57%
2003	715	306	409	43%	57%
2004	662	276	386	42%	58%
2005	606	249	357	41%	59%
2006	534	199	335	37%	63%
2007	473	158	315	33%	67%
2008	422	138	284	33%	67%
2009	427	139	288	33%	67%

RIVER AND INSHORE BEAM TRAWL FISHERY – AN OVERVIEW

BACKGROUND INFORMATION

The River and Inshore Beam Trawl Fishery (RIBTF) incorporates rivers and inshore waters of the Queensland east coast between Cape York and the Queensland/NSW border. The RIBTF is subdivided into five regions which are managed under separate fishery symbols, T5, T6, T7, T8 and T9 (Fig. A7). While the fishery operates under different symbols, the same fundamental management rules apply to each of the respective beam trawl sectors.

Species principally targeted in the RIBTF include greasyback prawns (*Metapenaeus bennettae*), school prawns (*M. macleayi*), and banana prawns (*Penaeus merguiensis*). Small amounts of tiger and endeavour prawns, squid and bugs may be retained, along with byproduct species such as blue swimmer crabs. Approximately 5% of the trawl harvest is taken by beam trawl each year.

KEY MANAGEMENT ARRANGEMENTS (also refer to the RIBTF annual report 2008)

- Restrictions on the size of boats that can operate in the fishery (9 m).
- Gear restrictions (beam length and otter trawl headrope length in some areas): net head rope length and mesh restrictions apply depending on the areas of operation.
- Numerous and extensive permanent area closures apply to the fishery, particularly in waters of the GBRWHA, Woongarra, Hervey Bay, Great Sandy Straits and Moreton Bay Marine Parks.
- Daytime and weekend closures apply to trawling in estuaries and some inshore areas (e.g. Moreton Bay) to reduce any interactions with recreational users.
- Mandatory use of bycatch reduction devices (BRDs), and turtle exclusion devices (TEDs) in areas other than a river or creek.
- a range of by-product harvesting protection arrangements.

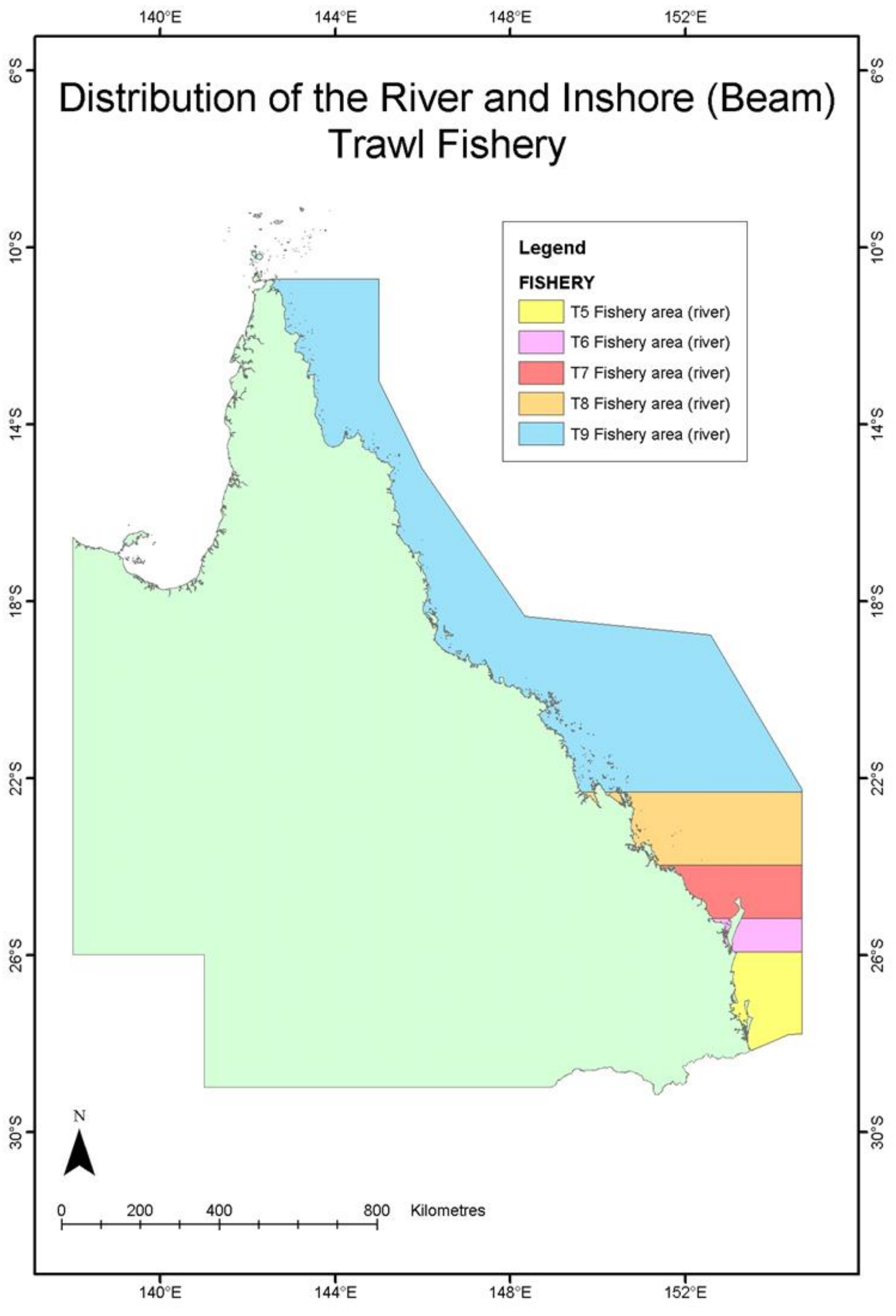

Figure A7. River and Inshore Beam Trawl Fishery (RIBTF) areas of the East Coast Trawl Fishery (ECTF).

DATA SUMMARY RIBTF

The following information was compiled using logbook data from the 2001 – 2009 and includes total number of days fished in the entire RIBTF, catch rates, CPUE and participation rates. It does not however, differentiate between each of the respective sectors. Summary information of effort usage in the RIBTF includes:

a) effort usage and total harvest for the entire RIBTF (Table A6; Fig. A8)

b) monthly effort usage trends for the entire RIBTF (Fig. A9)

c) CPUE and participation rates for the entire RIBTF (Table A7; Fig. A10)

d) within year comparisons of average participation rates, average days fished and average catch (Table A8; Fig. A11)

Baseline catch and effort data has been reported as total yearly catch (kg), total days fished, monthly effort trends, catch per unit effort (CPUE, annual and average monthly trends), number of boats accessing the sector (on average) per month and average monthly CPUE.

CATCH AND EFFORT

Table A6. Data summary: catch (prawn) and effort for the RIBTF between 2001 and 2009 including proportion of total ECTF days used in the sector.

Fishing year	Total harvest (t)	Total effort (days) in the sector
1999	367.9	7031
2000	390.0	6586
2001	416.9	8051
2002	552.2	7652
2003	384.0	6657
2004	387.9	6012
2005	373.2	5841
2006	421.1	6013
2007	411.2	5545
2008	367.9	7031
2009	390.0	6586

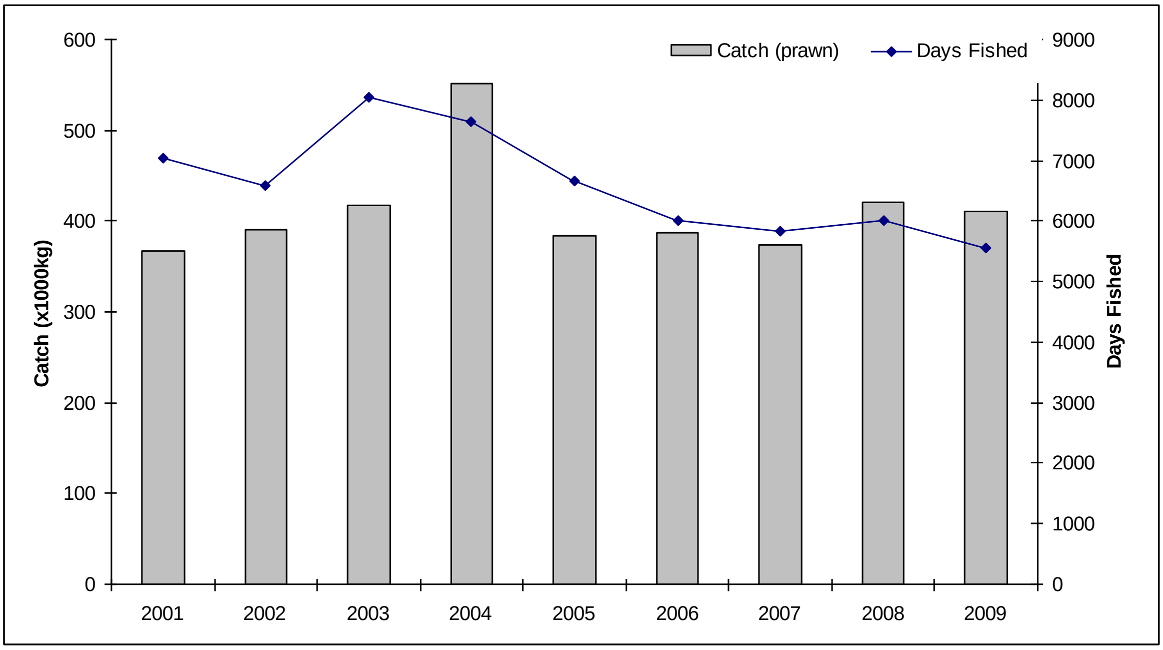

Figure A8. Catch (prawn) and effort trends for the RIBTF represented in kg (x1,000) and days fished respectively.

<u>MONTHLY EFFORT TRENDS (RIBTF)</u>

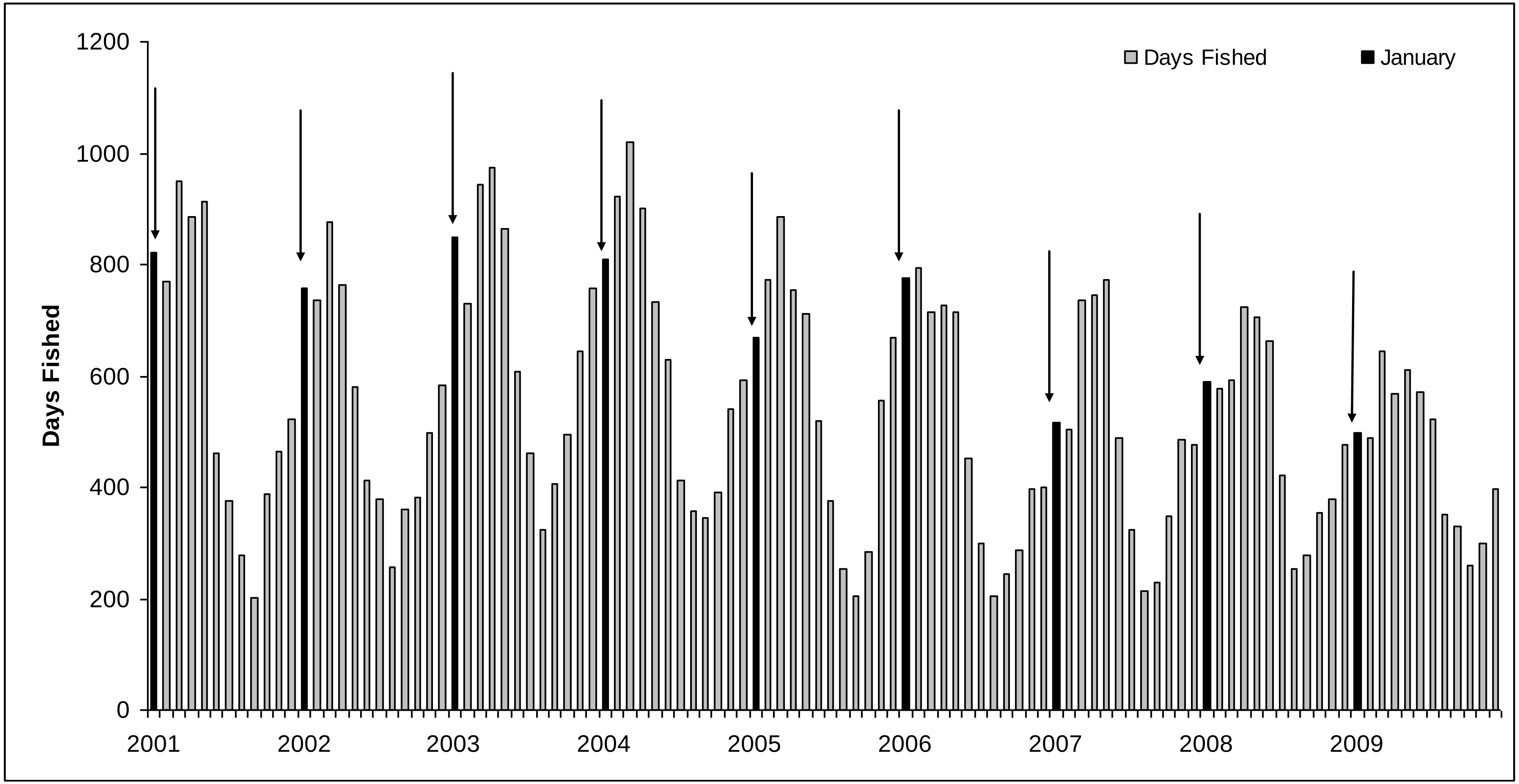

Figure A9. Monthly effort usage trends for RIBTF between 2001 and 2009 (arrow denotes the start of Calendar year).

CPUE and Participation Rates

Table A7. Data summary: yearly prawn CPUE and boat usage trends for the RIBTF. Minimum and maximum no of boats represents the minimum and maximum number of boats fishing in the sector for a given month. Please note that this does not represent the total number of boats accessing the sector during the year.

Year	Mean daily nominal CPUE (kg/day)	Min. Monthly boat No	Max. No. Boats
2001	52.3	23 (Dec)	69 (Mar)
2002	59.2	29 (Aug)	70 (May)
2003	51.8	36 (Aug)	78 (Apr)
2004	72.2	38 (Aug)	85 (Mar)
2005	57.7	27 (Sept)	73 (Mar)
2006	64.5	25 (Aug)	67 (Feb)
2007	63.9	23 (Sep)	61 (Mar)
2008	70.0	32 (Aug)	64 (May)
2009	74.2	27 (Oct/Nov)	62 (Mar)

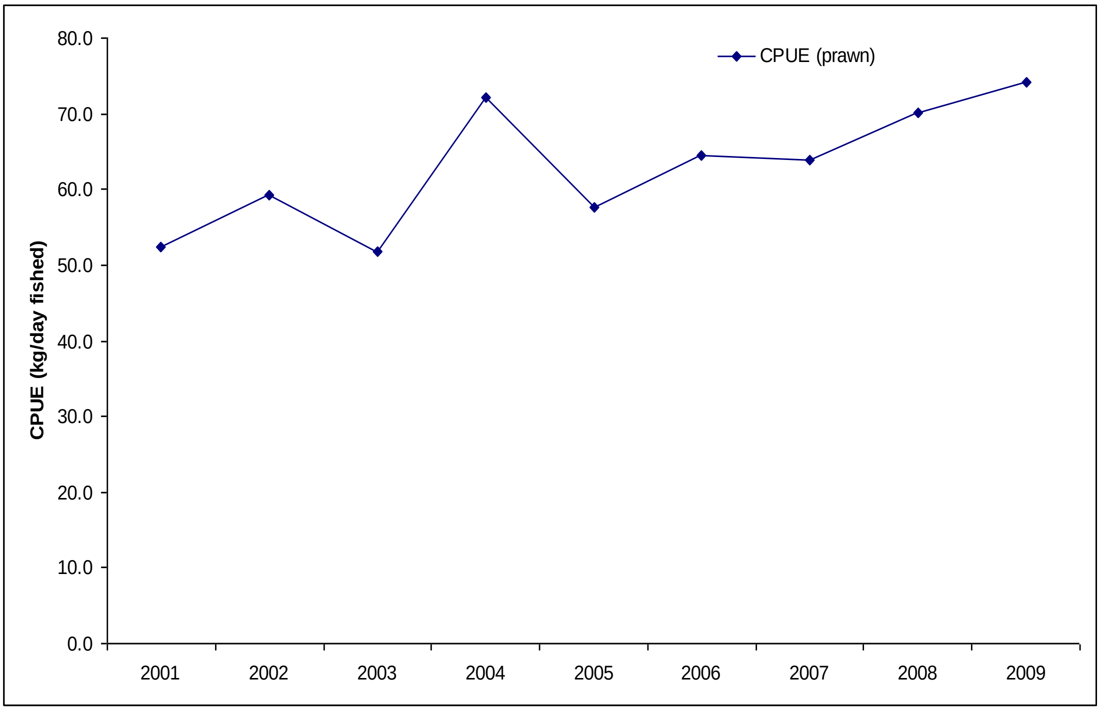

Figure A10. Average catch per unit effort (CPUE, kg/day fished) for the RIBTF between 2001 and 2009.

Table A8. Data summary: within year (monthly) comparisons for the RIBTF between 2001 and 2009.

Month	Av. No. Boats	Ave. Days Fished	Ave. Catch (t)	Ave. CPUE (kg/day)
January	56.8	698.1	47.1	67.5
February	61.2	699.7	38.2	54.6
March	68.2	818.2	41.3	50.4
April	65.2	782.9	52.8	67.4
May	59.2	733.7	41.6	56.7
June	47.2	533.9	42.0	78.7
July	38.4	397.0	40.0	100.7
August	31.4	276.7	21.6	77.9
September	31.7	289.2	25.2	87.0
October	36.6	354.0	16.9	47.8
November	39.8	473.8	19.4	40.9
December	56.8	698.1	25.2	46.6

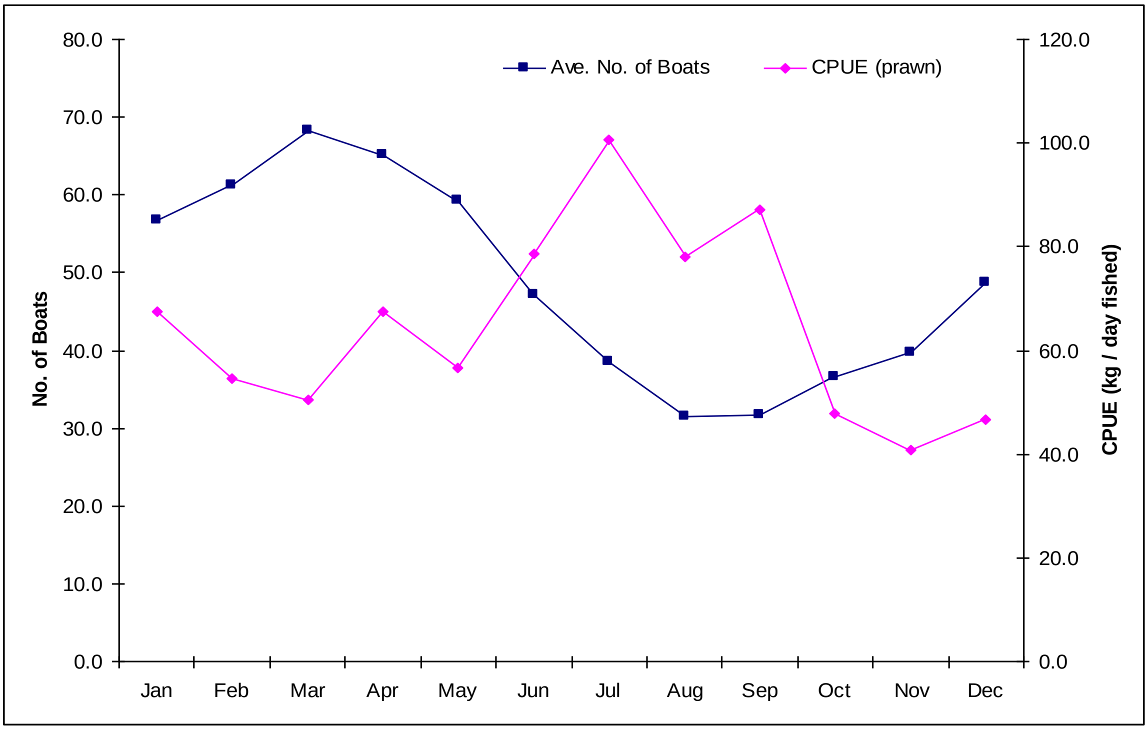

Figure A11. Average monthly CPUE (kg/day fished) and participation (average number of boats) rates for the RIBTF between 2001 and 2009.

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- Annual Status report 2009 – East Coast Trawl Fishery. Available from: https://www.daf.qld.gov.au/__data/assets/pdf_file/0006/72294/East-Coast-TF-ASR-08.pdf

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Appendix B. Commercial Logbooks applicable to the *East Coast Trawl Fishery.*

Commercial Logbook – Queensland East Coast Trawl Fishery

Queensland Government

Species of Conservation Interest

(SOCI02 Version 02)

Boat Mark	Skipper's Name	Commercial Fisher Licence#	Logbook No.	Page No.

Date of interaction	Location of interaction		Fishing Method Code (see instructions page)	Species Codes (see instructions page)	Release Condition			Tag or band details
	Latitude (or grid)	Longitude (or site)			Number Dead	Number Alive	Number Injured	

Comments

I certify that the information I have provided on this form is a true and accurate record of the interactions with the species of conservation interest listed in this logbook.

Signature : .... Date : ....

Logbook – Species of Conservation Interest

Fisheries Act 1994

OT10 (Version 10)

QUEENSLAND EAST COAST TRAWL FISHERY LOGBOOK

Boat Mark	Commercial Fisher's Name	Commercial Fisher's Licence Number	Endorsement: (Please specify) EC OTTER TRAWL ☐ T...... ☐ M...... BEAM TRAWL ☐ T......	Logbook No.	Page No.

Boat Activity Code
0... Fishing 1... Searching 2... Steaming 3... Not fishing

LOGBOOKS MUST BE FILLED IN AT THE END OF EACH DAY AND ARE TO BE RETURNED TO THE LOGBOOK SECTION WITHIN 15 DAYS OF THE END OF EACH MONTH.

IF NOT TRAWL FISHING FOR AN EXTENDED PERIOD PLEASE SPECIFY ..../......../........ to ..../......../........

NOTE: NO SPECIES MAY BE RETAINED BY TRAWL OTHER THAN THOSE SPECIFIED BELOW

Date				Position of Maximum Catch		Effort					King Prawns										Number of Baskets				Bugs							Record in numbers						
Day	Month	Year	←	Latitude (or Grid)	Longitude (or Site)	Trawl Gear Code (from Gear Description Form)	Time shot away	Number of shots	Total hours trawled	Depth (metres)	Eastern King Prawns (kg)	Red Spot King Prawns (kg)	Blue Leg King Prawns (kg)	Tiger Prawns (kg)	Endeavour Prawns (kg)	Banana Prawns (kg)	Greasy Prawns (kg)	Bay Prawns (kg)	School Prawns (kg)	Coral Prawns (kg)	Saucer Scallops	Mud Scallops	Discarded Scallops	Squid (kg)	Sand / Mud Bugs	Balmain / Honey Bugs (kg)	Barking Crayfish (kg)	Cuttlefish (kg)	Octopus (kg)	Pinkies (kg)	Mantis Shrimp (kg)	Slipper Lobster (number)	Blue Swimmer Crabs (number)	Three Spot (red spot) Crabs (number)	Duncker's Pipehorse (number)	Pallid Pipehorse (number)	Penaeus monodon (number)	Did you have any interactions with species of conservation interest?
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Comments:

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I certify that the information I have provided on this form is a true and accurate record of fishing activities and that interactions with species of conservation interest have been reported in the SOCI logbook. The weights provided in this logbook are estimates.

Commercial Fisher's Signature

Date

Appendix C. Characteristics and Decision Rules.

The following provides an overview of the characteristics and decision rules used to construct resilience capability scores and fishery impact profiles for each ecological component.

List of tables included in Appendix C – Characteristics and Decision Rules

Table A9. Characteristics and decision rules used to assess the **resilience capabilities** for the **harvest species** (principal and permitted) ecological component.

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
Life history.	**Fecundity.**	Indicative of a species' ability to produce recruits.	High fecundity e.g. > 50,000 eggs per annum.	Moderate fecundity e.g. < 50,000 eggs per annum &/or large eggs (≥ 2mm) or > 10 pups per annum.	Low fecundity e.g. < 10 pups per annum.	Astles et al. (2009); Pears et al. (2012a).
	Life history strategy.	Indicative of a species' ability to maintain viable population sizes or to rebuild regional populations after depletion.	Good ability to maintain/rebuild population *e.g.* pelagic eggs; &/or rapid turnover; &/or long spawning durations.	Moderate ability to maintain/rebuild population *e.g.* demersal eggs; &/or egg cases or parental care; &/or slow turnover &/or short spawning period.	Poor ability to maintain/rebuild population *e.g.* live bearing species or < one reproduction event per year.	Astles *et al*. (2009); Pears *et al.* (2012a).
Distribution & abundance.	**Geographic distribution.**	The distribution of a species provides an indication of its potential to find refuge from fishing activities &/or other negative impacts.	Widespread in the study area & adjacent jurisdictions.	Restricted range within the study area or range has contracted significantly.	–	Astles *et al*. (2009); Pears *et al.* (2012a).
	Habitat specificity or	Indicates how vulnerable a species	Generalist *i.e.* generalist taxa	Specialist *i.e*. has narrow habitat	–	Pears *et al.* (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
	ecological niche.	is to regional impacts with generalist taxa considered to be less vulnerable due to elevated potential to find refuge from fishing activities/negative impacts.	associated with a range of niches, or has a broad habitat requirements or, if narrow habitat requirement, covers a large area of the available habitat.	requirements and restricted habitat &/or a specialist taxa with limited or defined ecological niche.		
Demography.	**Growth rate.**	Indicative of how quickly a species reaches adult size & therefore its ability to escape during more vulnerable developmental stages.	Reaches adult size within 2 years.	Reaches adult size in greater than 2 years.	–	Characteristic was used by Pears *et al*. (2009) for the GBRMP and was originally modified from Astles *et al.* (2009) to suit regional requirements.
	Longevity.	Indicative of population turnover & the productivity of a species.	Short-medium (<20 years).	Long (20 to 50+ years).	–	Undertaken in accordance with Pears *et al*. (2012a) with longevity and natural mortality combined and assessed as a single entity.
	Natural mortality.	Rate of mortality for individuals from the stock due to natural causes (relates to a species capacity to	High natural mortality (≥1 per annum).	Low natural mortality (< 1 per annum) or where data is unavailable.	–	

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
		withstand exploitation).				
Cumulative pressures.	**Other pressures.**	Degree of susceptibility to non-ECTF pressures throughout the species range *e.g.* water quality, habitat loss, climate change.	Has little effect on species or effect is unknown.	Will have a significant effect on a species/species complex.	–	Pears *et al*. (2012a).

Table A10. Characteristics and decision rules used to construct the **fishery impact profiles** for the **harvest species** (principal and permitted) ecological component.

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
How much is caught?	***Principal*: Nominal catch rate (CPUE) trends.**	*Principal*: used as an index of abundance with changes in catch rate indicative of (potential) changes in abundance.	*Principal*: Performance Measurement System not triggered,	*Principal*: Performance Measurement System triggered,	–	Characteristic was used by Pears *et al*. (2009) for the GBRMP and was originally modified from Astles *et al.* (2009) to suit regional requirements.
	***Permitted*: Can it be targeted/is it truly incidental catch?**	*Permitted*: used to indicate degree of fishing effort directed at species.	*Permitted*: species is not targeted by fishery (truly incidental).	*Permitted*: species could be targeted by ECTF operators.	–	
	Discard rate (i.e. estimated % discarded of total number of individuals caught for species).	Indicates level of commercial species landed on deck but not retained for any reason including regulated fish (*i.e.* undersize/egg bearing individuals) and/or unmarketable catch.	Less than 10% of total catch discarded.	More than 10% or the total catch discarded.	–	Astles *et al*. (2009); Pears *et al.* (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
	***Principal*: Stock assessment adequacy.**	*Principal*: indicates if a stock assessment has been completed in the last 5 years and if it was based on a sufficient level of information.	*Principal*: Adequate assessment in the last five years.	*Principal*: Inadequate assessment in the last five years.	–	Characteristic was used by Pears *et al*. (2009) for the GBRMP and was originally modified from Astles *et al.* (2009) to suit regional requirements.
	***Permitted*: Biological information adequacy.**	*Permitted*: indicates if management measures are based on sufficient biological information.	*Permitted*: Adequate biological information.	*Permitted*: Inadequate biological information.	–	
	Exploitation status.	Indicates whether there is evidence of growth or recruitment overfishing.	Not fully utilised or sustainably fished.	Uncertain or no assessment made.	Overfished.	Astles *et al*. (2009); Pears *et al.* (2012a).
How is it fished?	**Interaction throughout life cycle.**	Indicates whether the species interacts with the fishery at all stages of its life cycle.	Only a limited selection of life stages interacts with the ECTF.	All or most life stages interact with the ECTF.	–	Pears *et al.* (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
	Species specific measures.	Indicates adequacy of any species specific measures to protect reproductive function and prevent overfishing (e.g. size limits, catch limits, compliance effectiveness, and relevant fishery closures).	ECTF has a range of measures in place that are well matched to the species.	No species specific measures in place or limited overlap between management arrangements and the life cycle of the species.	–	Characteristic was used by Pears *et al*. (2009) for the GBRMP and was originally modified from Astles *et al.* (2009) to suit regional requirements.
	TED/BRD effectiveness.	Indicates whether or not TEDs/BRDs are effective at reducing unwanted/unmarketable catch including discard of 'regulated fish' (*e.g.* undersize/egg bearing individuals), and/or unmarketable catch.	TED/BRDs used in the ECTF are effective at precluding unwanted/unmarketable catch of the species.	TED/BRDs are ineffective in precluding unwanted/unmarketable catch of the species.	–	Astles *et al*. (2009); Pears *et al.* (2012a).
Pressure from this fishery.	**Proportion of total catch**	Indicative of the level of fishing being	Less than or equal to 50% of estimated	Over 50% of estimated catch of	–	Analogous characteristic used

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
	taken south of GBR (ECOTF) or in areas of the RIBTF.	exerted by the ECTF in the study area compared to all other relevant fishing sectors including other commercial fisheries, recreational & Indigenous fishing.	catch of the species is taken south of the GBR or in areas of the RIBTF.	the species is taken south of the GBR or in areas of the RIBTF.		by both Astles *et al*. (2009) and Pears *et al.* (2012a).
What is caught?	**Species level data (identification problems).**	Indicates whether species of the same taxa are differentiated in available data. If not differentiated then the resilience and fishery impact profiles cannot be determined at a species level and/or the species management optimised.	No identification problems - data available at the species level.	Species identification difficult and/or data generally not available at the species level.	–	Characteristic was used by Pears *et al*. (2009) for the GBRMP and was originally modified from Astles *et al.* (2009) to suit regional requirements.
	Marketability.	Surrogate for the economic value of a species; therefore a proxy for likely pressure on a	Low or moderate demand species.	Species in high demand.	–	Astles *et al*. (2009); Pears *et al.* (2012a)

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
		species (*e.g.* likelihood of it being targeted/retained in areas where it occurs)				
Where is it fished?	**Refuge availability.**	Indicates whether a species has available places to escape fishing mortality.	Substantial refuge areas protecting from otter trawl operations south of the GBRMP and/or from the RIBTF *e.g.* equal to or greater than 20% protection provided by Marine Park zoning plan.	Few refuge areas protecting from otter trawl operations south of the GBRMP and/or from the RIBTF (*e.g.* equivalent to < 20% protection provided by the GBRMP zoning plan) or protection level currently uncertain.	–	Analogous characteristic used by both Astles *et al*. (2009) and Pears *et al.* (2012a).

Table A11. Characteristics and decision rules used to assess the **resilience capabilities** of species included in the **bycatch** ecological component.

Category	**Character**	**Reasons for use**	**Risk averse (A)**	**Prone to risk (P)**	**Risk double prone (PP)**	**Previous ERA usage**
Biological characteristics.	**Life history strategy.**	Indication of a species' ability to maintain viable population sizes or to rebuild populations after depletion.	Good ability to maintain/rebuild population *e.g.* pelagic eggs; &/or rapid turnover; &/or long spawning durations.	Moderate ability to maintain/rebuild population *e.g.* demersal eggs; &/or egg cases or parental care; &/or slow turnover &/or short spawning period.	Poor ability to maintain/rebuild population *e.g.* live bearing species or < one reproduction event per year.	Astles *et al*. (2009); Pears *et al.* (2012a).
	Mode of life (pelagic/demersal).	Indicates its vulnerability to being caught by a demersal prawn trawler in the ECTF.	Pelagic	Demersal or benthic or unknown	–	Astles *et al*. (2009); Pears *et al.* (2012a).
	Habitat Association.	Indicates its vulnerability to being caught by occupying habitats typically trawled by ECTF operators.	Habitat not usually trawled in the ECTF or habitat trawled but larger area of available habitat.	Habitat trawled with small area of available habitat	–	Astles *et al*. (2009); Pears *et al.* (2012a).
	Depth range.	Indicates its scope to avoid being caught	Large depth range giving relatively low probability of encountering an ECTF trawl net.	Small depth range giving relatively high probability of encountering an ECTF trawl net.	–	Character used in NSW (Astles *et al*. 2009) but not by Pears *et al*. (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
	Natural mortality.	Rate of mortality for individuals from the stock due to natural causes (relates to a species capacity to withstand exploitation).	High natural mortality (≥1 per annum).	Low natural mortality (< 1 per annum) or where data is unavailable.		Pears *et al*. (2012a).
Distribution & abundance.	**Geographic distribution.**	The distribution of a species provides an indication of its potential to find refuge from fishing activities &/or other negative impacts.	Widespread in the study area & adjacent jurisdictions.	Restricted range within the study area or range has contracted significantly.		NSW (Astles *et al*. 2009) identified this as a factor but did not use due to a lack of data. Characteristic used by Pears *et al*. (2012a) for the GBR.
Cumulative pressures.	**Other pressures.**	Degree of susceptibility to non-ECTF pressures throughout the species range *e.g.* water quality,	Has little effect on species or effect is unknown.	Will have a significant effect on a species/species complex.	–	Pears *et al*. (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
		habitat loss, climate change.				

Table A12. Characteristics and decision rules used to construct the **fishery impact profiles** of species included in the **bycatch** ecological component.

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
How much is caught?	**Frequency of capture (otter trawl), % weight of bycatch (beam trawl)**	Provides a relative indication of the fishing pressure exerted on the species or species complex.	Not common, occurring in ≤ 25% of samples.	Relatively frequent, occurring in ≥ 25% of samples.	–	Replacement characteristic, not used in Astles *et al*. (2009) or Pears *et al*. (2012a).
	Survival after capture.	Indicates how well individuals survive after being trawled, handled on deck & returned to the water.	Moderate: reasonably chance of survival, experiences a moderate level of trauma.	Low: trawl trauma from handling on deck, barotrauma or predation from marine predators when returned to the water.	–	Astles *et al*. (2009); Pears *et al.* (2012a).
How is it fished?	**Interaction throughout life cycle.**	Indicates whether the species interacts with the fishery at all stages of its life cycle.	Only a limited selection of life stages interacts with the ECTF.	All or most life stages interact with the ECTF.	–	Pears *et al*. (2012a).
	TED/BRD effectiveness.	Indicates whether TEDs/BRDs currently in use are effective at preventing capture during trawling.	Best practice TEDS and BRDS used by most of the fleet and likely to be effective at precluding the species, or trawl	Best practice TEDS and BRDS not used by most of the fleet and/or TEDs and BRDs in use considered to be	–	NSW (Astles *et al*. 2009) identified this as a factor but did not use due to a lack of data. Characteristic used

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
			catchability negligible so characteristic not applicable.	ineffective at precluding the species.		by Pears *et al*. (2012a) for the GBR.
Where is it fished?	**Refuge availability**	Indicates whether a species has available places to escape fishing mortality.	Substantial refuge areas protecting from otter trawl operations south of the GBRMP and/or from the RIBTF *e.g.* equal to or greater than 20% protection provided by Marine Park zoning plan.	Few refuge areas protecting from otter trawl operations south of the GBRMP and/or from the RIBTF (*e.g.* equivalent to < 20% protection provided by the GBRMP zoning plan) or protection level currently uncertain.	–	Analogous characteristic used by both Astles *et al*. (2009) and Pears *et al.* (2012a).

Table A13. Characteristics and decision rules used to assess the **resilience capabilities** of species included in the **species of conservation concern** ecological component.

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
Life history.	**Fecundity.**	Indicative of a species' ability to produce recruits.	High fecundity e.g. > 50,000 eggs per annum.	Moderate fecundity e.g. < 50,000 eggs per annum &/or large eggs (≥ 2mm) or > 10 pups per annum.	Low fecundity e.g. < 10 pups per annum.	Astles et al. (2009); Pears et al. (2012a).
	Life history strategy.	Indicative of a species' ability to maintain viable population sizes or to rebuild regional populations after depletion.	Good ability to maintain/rebuild population *e.g.* pelagic eggs; &/or rapid turnover; &/or long spawning durations.	Moderate ability to maintain/rebuild population *e.g.* demersal eggs; &/or egg cases or parental care; &/or slow turnover &/or short spawning period.	Poor ability to maintain/rebuild population *e.g.* live bearing species or < one reproduction event per year.	Astles *et al*. (2009); Pears *et al.* (2012a).
Distribution & abundance.	**Geographic distribution.**	The distribution of a species provides an indication of its potential to find refuge from fishing activities &/or other negative impacts.	Widespread in the study area & adjacent jurisdictions.	Restricted range within the study area or range has contracted significantly.	–	Astles *et al*. (2009); Pears *et al.* (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
	Habitat specificity or ecological niche.	Indicates how vulnerable a species is to regional impacts with generalist taxa considered to be less vulnerable due to elevated potential to find refuge from fishing activities/negative impacts.	Generalist *i.e.* generalist taxa associated with a range of niches, or has a broad habitat requirements or, if narrow habitat requirement, covers a large area of the available habitat.	Specialist *i.e*. has narrow habitat requirements and restricted habitat &/or a specialist taxa with limited or defined ecological niche.	–	Pears *et al.* (2012a).
	Population size/trend and/or current abundance (throughout the species range).	Indicates the species prevalence and trend (recovery/decline) where available of the species.	Large or medium sized population, and/or a relatively common species.	Large and declining population; or small population size, with trend increasing/stable or unknown and/or uncommon.	Severely depleted or small declining population.	Characteristic was used by Pears *et al*. (2009) for the GBRMP and was originally modified from Astles *et al.* (2009) to suit regional requirements.
Demography.	**Growth rate/Age at maturity.**	Indicative of how quickly a species reaches adult size & therefore its ability to escape during more vulnerable	Reaches adult size within 2 years.	Reaches adult size in greater than 2 years.	–	Characteristic was used by Pears *et al*. (2009) for the GBRMP and was originally modified from Astles *et al.* (2009) to suit

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
		developmental stages.				regional requirements.
	Longevity	Indicative of population turnover & the productivity of a species.	Short-medium (<20 years).	Long (20 to 50+ years).	–	Undertaken in accordance with Pears *et al*. (2012a) with longevity and natural mortality combined and assessed as a single entity.
	Natural mortality	Rate of mortality for individuals from the stock due to natural causes (relates to a species capacity to withstand exploitation).	High natural mortality (≥1 per annum).	Low natural mortality (< 1 per annum) or where data is unavailable.	–	
Cumulative pressures	**Other pressures**	Degree of susceptibility to non-ECTF pressures throughout the species range *e.g.* water quality, habitat loss, climate change.	Has little effect on species or effect is unknown.	Will have a significant effect on a species/species complex.	–	Pears *et al*. (2012a).

Table A14. Characteristics and decision rules used to construct the **fishery impact profiles** of species included in the **species of conservation** concern ecological component.

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
Interaction with the fishery.	**Level of Interaction.**	Interaction with the fishery is based on the overlap between the species and the area in which the fishery operates (geographical and habitat), and where data are available, the frequency of the interaction.	Some contact with the ECTF in southern QLD and RIBTF areas (including the influence of noise and light, capture), but number of individuals encountered or affected is small enough that it has a negligible impact on the species.	Contact with a moderate number of individuals or relatively infrequent contact with the ECTF in southern QLD and RIBTF areas.	Contact with a significant number of individuals, or relatively frequent contact with the ECTF in southern QLD and RIBTF areas	Astles *et al*. (2009); Pears *et al.* (2012a).
	Survival after interaction.	Indicates how well they survive after any interaction with trawling. E.g. Survival after being trawled & handled on deck & returned to the water, or survival after interaction with another trawling activity.	Good survival *e.g.* Some contact with the ECTF in southern QLD and RIBTF areas but the effects of such encounters on individuals are negligible (based on survey information or other observations).	Moderate survival *e.g.* interaction could affect the growth or longer term survival of those individuals.	Low survival *e.g.* *i*nteraction is likely to result in death of the individuals, disruption of breeding, etc.	Pears *et al.* (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
What is caught?	**Interaction throughout life cycle**	Indicates whether the species interacts with the fishery at all stages of its life cycle.	Only a limited selection of life stages interacts with the ECTF.	All or most life stages interact with the ECTF.	–	Pears *et al*. (2012a).
	TED/BRD effectiveness	Indicates whether TEDs/BRDs currently in use are effective at preventing capture during trawling.	Best practice TEDS and BRDS used by most of the fleet and likely to be effective at precluding the species, or trawl catchability negligible so characteristic not applicable.	Best practice TEDS and BRDS not used by most of the fleet and/or TEDs and BRDs in use considered to be ineffective at precluding the species.	–	NSW (Astles *et al*. 2009) identified this as a factor but did not use due to a lack of data. Characteristic used by Pears *et al*. (2012a) for the GBR.

Table A15. Characteristics and decision rules used to assess the **resilience capabilities** for the biophysical strata (Kenna & Kirkwood, 2008) included in the **marine habitat** ecological component assessment.

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
Distribution and abundance.	**Geographic distribution in area of interest.**	Extent and distribution of an assemblage gives an indication of the potential risk from stochastic events (physical, chemical, ecological).	Widely distributed and occupying a large area within southern Queensland ECOTF grounds (*i.e.* > 5000 km sq.).	Large but restricted area that is restricted to southern Queensland including ECOTF grounds; or small area (<5000 km sq.) that is widely distributed throughout southern Queensland trawl grounds.	Small, restricted area (< 5,000 sq. km) located within ECOTF grounds of southern Queensland.	Pears *et al*. (2012a).
Regrowth or recolonisation.	**Recovery rate.**	Indicates capacity of key structural elements to recover after damage and/or recolonise the depleted area, and hence for habitat type to recover after disturbance.	Fast/rapid ability to recover.	Medium ability to recover from disturbance.	Slow recovery from disturbance.	Analogous characteristic used by both Astles *et al*. (2009) and Pears *et al.* (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
Resistance	**Impact of trawling on key structural elements**	Indication of the physical and biological properties of habitats to withstand impact of disturbance.	High resistance capabilities.	Medium resistance capabilities.	Low resistance capabilities.	Analogous characteristic used by both Astles *et al*. (2009) and Pears *et al.* (2012a).
Cumulative pressures	**Other pressures in the East Coast Trawl Fishery area (ex. GBR Otter Trawl)**	Degree of susceptibility to non-ECTF pressures throughout the species range *e.g.* water quality, habitat loss, climate change.	Has little effect on species or effect is unknown.	Will have a significant effect on a species/species complex.	–	Pears *et al*. (2012a).

Table A16. Characteristics and decision rules used to construct the **fishery impact profiles** of the biophysical strata (Kenna & Kirkwood, 2008) included in the **marine habitat** ecological component assessment.

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
Do we know where the habitats are?	**Knowledge of spatial distribution of habitat types.**	Basic knowledge of spatial habitat distributions is needed for risk analysis of fishery-wide impacts on habitat.	Distribution of habitats is well known	Distribution of habitats uncertain or data deficient.	–	Astles *et al*. (2009); Pears *et al.* (2012a).
Where does fishing occur?	**Knowledge of the spatial distribution of fishing effort.**	Knowledge of where the fishery-related impact is occurring is needed for risk analysis of fishery-wide impacts on habitats.	Detained knowledge of the distribution of fishing effort within the habitat.	Distribution of effort within a habitat uncertain or data deficient.	–	Astles *et al*. (2009); Pears *et al.* (2012a
What overlap is there between the area in which the fishery operates and the distribution of habitat types?	**Proportion of available**	Gives indication of	Low - ≤ 25 per cent of	Medium - >25 per	High - > 50 per	Characteristic was used by

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
	habitat impacted by fishing gear (%effort exposed, 2009).	overlap of habitat type with current trawling effort, taking into account intensity and is an indicator of impact size on different habitat types *i.e.* fishing effort may be concentrated on preferred subareas within a broader habitat type.	the defined habitat is impacted by trawl fishing.	cent but ≤ 50 per cent of the defined habitat is impacted by trawl fishing.	cent of the defined habitat is impacted by trawl fishing.	Pears *et al*. (2009) for the GBRMP and was originally modified from Astles *et al.* (2009) to suit regional requirements.
……………………………………………………………………..Do habitats have adequate protection (refuge) from fishing impacts?	**Proportion of total habitat permanently protected from fishing activity.**	An indicator of the level of protection a habitat has from the impacts of fishing.	Substantial refuge areas protecting from otter trawl operations south of the	Few refuge areas protecting from otter trawl operations south of the GBRMP	–	Analogous characteristic used by both Astles *et al*. (2009) and Pears *et al.* (2012a).

Category	Character	Reasons for use	Risk averse (A)	Prone to risk (P)	Risk double prone (PP)	Previous ERA usage
			GBRMP and/or from the RIBTF *e.g.* equal to or greater than 20% protection provided by Marine Park zoning plan.	and/or from the RIBTF (*e.g.* equivalent to < 20% protection provided by the GBRMP zoning plan) or protection level currently uncertain.		
Is the use of 'high-impact' fishing gear currently permitted in the fishery?	**Impacts caused by different gear types used in the fishery.**	An assessment of the need to exclude or modify certain gear types from the fishery.	High-impact gear is excluded or not used in the fishery within the habitat type.	High-impact gear permitted to be used in the fishery within the habitat type.		

Appendix D. Ecological risk assessments.

This section also provides a completed resilience capability score and **fishery** impact profile for each subcomponent included in the analysis. These scores were subsequently used to assign an overall risk rating to each ecological subcomponent.

List of tables included in Appendix D – Completed ERA

Table A17. Summary of the **resilience capability** scores for all **principal species** included in **the harvest species** ecological component assessment.

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity / ecological niche	Growth rate	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Brown tiger prawn	*Penaeus esculentus*	A	A	A	A	A	A	A	H
Grooved tiger prawn	*Penaeus semisulcatus*	A	A	A	A	A	A	A	H
Black tiger prawn	*Penaeus monodon*	A	A	A	A	A	A	A	H
Blue endeavour prawn	*Metapenaeus endeavouri*	A	A	A	A	A	A	A	H
False endeavour prawn	*Metapenaeus ensis*	A	A	A	A	A	A	A	H
Greasyback (Bay) Prawn	*Metapenaeus bennettae*	A	A	A	A	A	A	A	H
Eastern king prawn	*Melicertus plebejus*	A	A	A	A	A	A	P	H-I
Red spot king prawn	*Melicertus longistylus*	A	A	A	A	A	A	A	H
Blue-legged king prawn	*Melicertus latisulcatus*	A	A	A	A	A	A	A	H
White banana prawn	*Penaeus/Fenneropenaeus merguiensis*	A	A	A	P	A	A	A	H-I
School prawn	*Metapenaeus macleayi*	A	A	A	A	A	A	A	H
Moreton Bay bugs									
– Reef bug	*Thenus australiensis*	P	P	A	A	A	A	A	H-I
– Mud bug	*Thenus parindicus*	P	P	A	A	A	A	A	H-I
Squid spp.	*Family Loliginidae Uroteuthis (Photololigo) spp.*	P	A	A	A	A	A	A	H-I

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity / ecological niche	Growth rate	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Tropical saucer scallop	*Amusium japonicum balloti*	A	A	A	A	A	A	A	H

Table A18. Summary of the **fishery impact profile** scores for all **principal species** included in the **harvest species** ecological component assessment.

Common Name	Species Name	Nominal catch rate (CPUE) trends	Discard rate*	Stock assessment adequacy	Exploitation status	Interaction throughout life cycle	Species specific measures	TED / BRD effectiveness	Proportion of total catch taken south of GBR (ECOTF) or in areas of the RIBTF	Species level data (identification)	Marketability	Refuge availability	Fishery Impact Profile level
Brown tiger prawn	*Penaeus esculentus*	A	A	P	P	P	A	A	P	P	P	A	I-L
Grooved tiger prawn	*Penaeus semisulcatus*	A	A	P	P	P	A	A	P	P	P	A	I-L
Black tiger prawn	*Penaeus monodon*	A	A	P	P	P	A	A	P	P	P	A	I-L
Blue endeavour prawn	*Metapenaeus endeavouri*	A	A	P	A	P	A	A	P	P	A	A	L
False endeavour prawn	*Metapenaeus ensis*	A	A	P	A	P	A	A	P	P	A	A	L
Greasyback (Bay) Prawn	*Metapenaeus bennettae*	A	A	P	P	P	A	A	P	P	A	A	I-L
Eastern king prawn	*Melicertus plebejus*	A	A	A	P	P	A	A	P	A	P	P	I-L
Red spot king prawn	*Melicertus longistylus*	A	A	P	P	A	A	A	P	P	P	A	I-L
Blue-legged king prawn	*Melicertus latisulcatus*	A	A	P	P	A	A	A	P	P	P	A	I-L
White banana prawn	*Penaeus / Fenneropenaeus merguiensis*	A	A	A	A	P	A	A	P	A	A	A	L
School prawn	*Metapenaeus macleayi*	A	P	P	P	P	A	A	P	A	P	A	I-L
Moreton Bay bugs													
- Reef bug	*Thenus australiensis*	A	P	P	P	A	A	P	P	P	P	A	I
- Mud bug	*Thenus parindicus*	A	P	P	P	A	A	P	P	P	P	A	I

Common Name	Species Name	Nominal catch rate (CPUE) trends	Discard rate*	Stock assessment adequacy	Exploitation status	Interaction throughout life cycle	Species specific measures	TED / BRD effectiveness	Proportion of total catch taken south of GBR (ECOTF) or in areas of the RIBTF	Species level data (identification)	Marketability	Refuge availability	Fishery Impact Profile level
Squid spp.	*Family Loliginidae* *Uroteuthis (Photololigo)* spp.	P	A	P	P	A	A	A	P	P	P	P	I
Tropical saucer scallop	*Amusium japonicum balloti*	A	P	A	P	P	A	P	P	A	P	P	I

* *Estimated percent discarded of total number of individuals caught from a particular species or species grouping.*

Table A19. Summary of the **resilience capability** scores for all **permitted species** included in the **harvest species** ecological component assessment.

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity / ecological niche	Growth rate	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Threadfin bream	*Family Nemipteridae*	P	A	A	A	A	A	A	H-I
Mantis shrimp	*Family Squillidae, order Stomatopoda*	P	P	A	A	A	A	A	H-I
Blue swimmer crab	*Portunus pelagicus*	A	A	A	A	A	A	A	H-I
Three-spotted/Red-spotted crab	*Portunus sanguinolentus*	A	A	A	A	A	A	A	H
Red champagne lobster	*Linuparus trigonus*	A	P	A	A	P	P	P	I
Slipper lobster	*Scyllarus* spp. *(includes Scyllarus martensii, Scyllarides squammosus, Scyllarus demani)*	P	P	A	A	P	P	P	I-L
Deepwater bug (Velvet Balmain)	*Ibacus altricrenatus*	P	P	A	A	A	A	A	H-I
Bug/Lobster, Shovel-Nosed (Bug, Honey Balmain)	*Ibacus brucei*	P	P	A	A	A	A	A	H-I
Bug, Smooth (Bug, Garlic Balmain)	*Ibacus chacei*	P	P	A	A	A	A	A	H-I
Cuttlefish spp.	*Sepia spp.*	P	A	A	A	A	A	A	H-I
Octopus									
- Hammer octopus	*Octopus australis*	P	P	P	P	A	A	A	I-L
- Red-spot night octopus	*Callistoctopus dierythraeus*	P	P	A	P	A	A	A	I
- Scribbled night octopus	*Callistoctopus graptus*	P	P	A	A	A	A	A	H-I
- Plain-spot octopus	*Amphioctopus exannulatus*	A	A	A	A	A	A	A	H

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity / ecological niche	Growth rate	Longevity / Natural Mortality	Cumulative pressures	Resilience level
- Veined octopus	*Amphioctopus marginatus*	A	A	A	A	A	A	A	H
- Southern star-eyed octopus	*Amphioctopus cf. kagoshimensis*	A	A	P	A	A	A	A	H-I

Table A20. Summary of the **fishery impact profile** scores for all **permitted species** included in the **harvest species** ecological component assessment.

Common Name	Species Name	Can it be targeted / is it truly incidental	Discard rate*	Biological information adequacy	Exploitation status	Interaction throughout life cycle	Species specific measures	TED / BRD effectiveness	Proportion of total catch taken south of GBR (ECOTF) or in areas of the RIBTF	Species level data (identification)	Marketability	Refuge availability	Fishery Impact Profile level
Threadfin Bream spp.	*Family Nemipteridae*	A	P	P	P	P	A	P	P	P	A	A	I
Mantis Shrimp spp.	*Family Squillidae, order Stomatopoda*	A	P	P	P	P	A	P	P	P	A	P	I
Crab, Blue Swimmer	*Portunus pelagicus*	A	P	A	A	P	A	P	A	A	A	A	L
Crab, Three-spotted/Red-spotted	*Portunus sanguinolentus*	A	P	P	P	A	A	P	P	A	A	A	I-L
Lobster, Red Champagne (Crayfish, Barking)	*Linuparus trigonus*	A	P	P	P	P	A	P	P	A	P	P	I
Lobster, Slipper	*Scyllarus* spp. *(includes Scyllarus martensii, Scyllarides squammosus, Scyllarus demani)*	A	A	P	P	A	A	P	P	P	A	P	I-L
Bug, Deepwater (Velvet Balmain)	*Ibacus altricrenatus*	A	P	P	P	A	A	P	P	P	A	A	I-L
Bug/Lobster, Shovel-Nosed (Bug, Honey Balmain)	*Ibacus brucei*	A	P	P	P	A	A	P	P	P	A	A	I-L
Bug, Smooth (Bug, Garlic Balmain)	*Ibacus chacei*	A	P	P	P	A	A	P	P	P	A	A	I-L
Cuttlefish spp.	*Sepia* spp.	A	P	A	P	P	P	P	P	P	P	P	H-I
Octopus													
- Hammer octopus	*Octopus australis*	A	A	P	P	A	P	A	P	P	P	P	I

Common Name	Species Name	Can it be targeted / is it truly incidental	Discard rate*	Biological information adequacy	Exploitation status	Interaction throughout life cycle	Species specific measures	TED / BRD effectiveness	Proportion of total catch taken south of GBR (ECOTF) or in areas of the RIBTF	Species level data (identification)	Marketability	Refuge availability	Fishery Impact Profile level
- Red-spot night octopus	*Callistoctopus dierythraeus*	A	A	P	P	A	P	A	P	P	P	P	I
- Scribbled night octopus	*Callistoctopus graptus*	A	A	P	P	A	P	A	P	P	P	P	I
- Plain-spot octopus	*Amphioctopus exannulatus*	A	A	P	P	A	P	A	P	P	P	P	I
- Veined octopus	*Amphioctopus marginatus*	A	A	P	P	A	P	A	P	P	P	P	I
- Southern star-eyed octopus	*Amphioctopus cf. kagoshimensis*	A	A	P	P	A	P	A	P	P	P	P	I

** Estimated percent discarded of total number of individuals caught from a particular species or species grouping.*

Table A21. Summary of the **resilience capability** scores for all species included in the **bycatch** ecological component assessment.

Common Names	Species Name	Life history strategy	Mode of life (pelagic / demersal)	Habitat association	Depth range	Longevity / Natural Mortality	Geographic distribution	Cumulative pressures	Resilience level
Rabbitfish, Black	*Siganus fuscescens*	A	P	A	A	A	A	P	I
Baracuda, Striped	*Sphyraena obtusata*	A	A	A	A	P	A	A	H-I
Baracuda, Military	Sphyraena putnamae	P	A	P	P	P	A	A	I-L
Baracuda, Sharpfin	*Sphyraena acutipinnis*	P	A	P	A	P	A	A	I-L
Baracuda, Yellowtail	*Sphyraena flavicauda*	P	A	P	P	P	A	A	I-L
Sole, Tufted	*Brachirus muelleri/Dexillichthys muelleri*	A	P	P	A	P	A	A	I-L
Tounge Sole, Spotfin	*Cynoglossus maculipinnis*	A	P	A	A	A	A	A	H-I
Tounge Sole, Fourline	*Cynoglossus bilineatus*	P	P	A	A	P	A	A	I-L
Flathead, Dusky	*Platycephalus fuscus*	P	P	A	P	P	A	P	L
Flathead, Bartail	*Platycephalus indicus*	A	P	A	P	P	A	A	I-L
Ponyfish, Whipfin	*Leiognathus leuciscus/Equulites leuciscus*	A	P	P	A	A	A	P	I-L
Silverbiddy, Longfin	*Pentaprion longimanus*	A	P	P	A	P	A	A	I-L
Silverbiddy, Blacktip	*Gerres oyena*	A	P	A	P	A	A	A	I
Silverbiddy, Threadfin	*Gerres filamentosus*	A	P	A	A	A	A	A	H-I
Silverbiddy, Slender	*Gerres oblongus*	A	P	A	P	P	A	A	I-L
Silverbiddy, Common	*Gerres subfasciatus*	A	P	A	A	A	A	A	H-I

Common Names	Species Name	Life history strategy	Mode of life (pelagic / demersal)	Habitat association	Depth range	Longevity / Natural Mortality	Geographic distribution	Cumulative pressures	Resilience level
Threadfin, Australian	*Polydactylus multiradiatus*	A	P	P	A	A	A	A	I
Threadfin, King	*Polydactylus macrochir*	P	P	A	P	P	A	P	L
Trevally, Whitefin	*Carangoides equula*	A	A	A	A	P	A	A	H-I
Perch, Pearl	*Glaucosoma scapulare*	P	P	A	A	P	A	P	I-L
Snapper, Pink (inside MB)	*Pagrus auratus*	A	P	A	A	P	P	P	I-L
Snapper, Pink (outside MB)	*Pagrus auratus*	A	P	A	A	P	P	P	I-L
Bream, Silver (Tarwhine)	*Rhabdosargus sarba*	P	P	A	A	P	A	P	I-L
Bream, Yellowfin	*Acanthopagrus australis*	P	P	A	A	P	A	P	I-L
Bream, Pikey	*Acanthopagrus berda*	P	P	A	A	P	A	P	I-L
Tuskfish, Venus	*Chaerodon venustus*	P	P	A	A	P	P	P	L
Tuskfish, Purple	*Chaerodon cephalotes*	PP	P	A	A	A	A	P	I-L
Teraglin	*Atractoscion aequidens*	PP	A	P	A	P	A	P	L
Mulloway	*Argyrosomus japonicus*	PP	A	P	A	P	A	P	L
Barramundi	*Lates calcarifer*	P	P	A	A	P	A	P	I-L
Lizardfish/Saury, Short-finned/Shortfin	*Saurida argentea/tumbil*	A	P	P	A	A	A	A	I
Lizardfish/Saury, Brushtooth/Largescale (Grey)	*Saurida grandisquamis/undosquamis*	A	P	A	A	A	A	A	H-I
Saury, Threadfin	*Saurida filamentosa*	A	P	A	A	A	A	A	H-I

Common Names	Species Name	Life history strategy	Mode of life (pelagic / demersal)	Habitat association	Depth range	Longevity / Natural Mortality	Geographic distribution	Cumulative pressures	Resilience level
Saury, Longfin	*Saurida longimanus*	A	P	A	A	A	A	A	H-I
Saury, Clouded	*Saurida nebulosa*	A	P	A	P	A	A	A	I
Grinner, Painted	*Trachinocephalus myops*	A	P	A	A	A	A	A	H-I
Whiting, Stout	*Sillago robusta*	A	P	A	A	P	A	A	I
Whiting, Trumpeter	*Sillago maculata*	A	P	P	P	P	A	P	L
Whiting, Sand	*Sillago ciliata*	P	P	A	A	P	A	P	I-L
Scad, Yellowtail	*Trachurus novaezelandiae*	P	A	A	A	P	A	P	I-L
Tailor	*Pomatomus saltatrix*	P	A	A	A	P	A	P	I-L
Goatfish, Asymmetric (Red Mullet)	*Upeneus asymmetricus*	A	P	P	A	P	A	A	I-L
Goatfish, Bicolour	*Parupeneus barberinoides*	A	P	A	A	P	A	A	I
Goatfish, Opalescent	*Parupeneus heptacanthus*	A	P	A	A	A	A	A	H-I
Goatfish, Yellowspot	*Parupeneus indicus*	A	P	A	P	P	A	A	I-L
Goatfish, Banded	*Parupeneus multfasciatus*	A	P	A	A	P	A	A	I
Goatfish, Blacksaddle	*Parupeneus spilurus*	P	P	A	A	P	A	A	I-L
Goatfish, Bluestriped	*Upeneichthys lineatus*	A	P	A	A	P	A	A	I
Goatfish, Luzon	*Upeneus luzonius*	A	P	P	A	A	A	A	I
Goatfish, Pennant	*Upeneus filifer*	A	P	P	A	P	A	A	I-L
Goatfish, Goldband	*Upeneus moluccensis*	A	P	P	A	A	A	A	I

Common Names	Species Name	Life history strategy	Mode of life (pelagic / demersal)	Habitat association	Depth range	Longevity / Natural Mortality	Geographic distribution	Cumulative pressures	Resilience level
Goatfish, Striped	*Upeneus vittatus*	A	P	P	A	A	A	A	I
Goatfish, Bartail (Red Mullet)	*Upeneus tragula*	A	P	P	A	A	A	A	I
Mullet, Sea	*Mugil cephalus*	A	A	P	P	P	A	P	I-L
Herring, Southern	*Herklotsichthys castelnaui*	A	A	A	A	P	A	A	H-I
Thryssa, Hamilton's	*Thryssa hamiltonii*	A	A	P	P	A	A	A	I
Thryssa, Longjaw	*Thryssa setirostris*	A	A	P	P	A	A	A	I
Anchovy, Flase Baelama	*Thryssa encrasicholoides*	A	A	P	A	A	A	A	H-I
Rocklobster, Painted	*Panulirus versicolor*	A	P	A	P	P	A	P	I-L

Table A22. Summary of the **fishery impact profile** scores for all species included in the **bycatch** ecological component assessment.

Common Names	Species Name	Frequency of capture (otter trawl), % weight of bycatch (beam trawl)	Survival after capture	Interaction through life cycle	TED/BRD effectiveness	Refuge availability **	Fishery Impact Profile level
Rabbitfish, Black	*Siganus fuscescens*	A	P	A	P	A	I-L
Baracuda, Striped	*Sphyraena obtusata*	A	P	A	P	A	I-L
Baracuda, Military	Sphyraena putnamae	A	P	A	P	P	I
Baracuda, Sharpfin	*Sphyraena acutipinnis*	A	P	A	P	P	I
Baracuda, Yellowtail	*Sphyraena flavicauda*	A	P	A	P	P	I
Sole, Tufted	*Brachirus muelleri/Dexillichthys muelleri*	A	P	P	P	A	I
Tounge Sole, Spotfin	*Cynoglossus maculipinnis*	A	P	P	P	A	I
Tounge Sole, Fourline	*Cynoglossus bilineatus*	A	P	P	P	A	I
Flathead, Dusky	*Platycephalus fuscus*	A	P	A	P	A	I-L
Flathead, Bartail	*Platycephalus indicus*	A	P	A	P	A	I-L
Ponyfish, Whipfin	*Leiognathus leuciscus/Equulites leuciscus*	A	P	A	P	P	I
Silverbiddy, Longfin	*Pentaprion longimanus*	A	P	A	P	P	I
Silverbiddy, Blacktip	*Gerres oyena*	A	P	A	P	P	I
Silverbiddy, Threadfin	*Gerres filamentosus*	A	P	A	P	P	I

Common Names	Species Name	Frequency of capture (otter trawl), % weight of bycatch (beam trawl)	Survival after capture	Interaction through life cycle	TED/BRD effectiveness	Refuge availability **	Fishery Impact Profile level
Silverbiddy, Slender	*Gerres oblongus*	A	P	A	P	P	I
Silverbiddy, Common	*Gerres subfasciatus*	A	P	A	P	A	I-L
Threadfin, Australian	*Polydactylus multiradiatus*	A	P	P	P	A	I
Threadfin, King	*Polydactylus macrochir*	A	A	A	P	A	L
Trevally, Whitefin	*Carangoides equula*	P	P	A	P	A	I
Perch, Pearl	*Glaucosoma scapulare*	A	P	A	P	A	I-L
Snapper, Pink (inside MB)	*Pagrus auratus*	A	P	A	P	A	I-L
Snapper, Pink (outside MB)	*Pagrus auratus*	A	P	A	P	A	I-L
Bream, Silver (Tarwhine)	*Rhabdosargus sarba*	A	A	A	P	P	I-L
Bream, Yellowfin	*Acanthopagrus australis*	A	A	P	P	A	I-L
Bream, Pikey	*Acanthopagrus berda*	A	P	P	P	A	I
Tuskfish, Venus	*Chaerodon venustus*	A	P	A	P	A	I-L
Tuskfish, Purple	*Chaerodon cephalotes*	A	P	A	P	A	I-L
Teraglin	*Atractoscion aequidens*	A	P	P	P	A	I
Mulloway	*Argyrosomus japonicus*	A	P	A	A	A	L
Barramundi	*Lates calcarifer*	A	P	A	P	A	I-L

Common Names	Species Name	Frequency of capture (otter trawl), % weight of bycatch (beam trawl)	Survival after capture	Interaction through life cycle	TED/BRD effectiveness	Refuge availability **	Fishery Impact Profile level
Lizardfish/Saury, Short-finned/Shortfin	*Saurida argentea/tumbil*	A	P	P	A	A	I-L
Lizardfish/Saury, Brushtooth/Largescale (Grey)	*Saurida grandisquamis/undosquamis*	P	P	A	P	A	I
Saury, Threadfin	*Saurida filamentosa*	P	P	A	P	A	I
Saury, Longfin	*Saurida longimanus*	A	P	P	A	P	I
Saury, Clouded	*Saurida nebulosa*	A	P	P	A	P	I
Grinner, Painted	*Trachinocephalus myops*	P	P	A	A	A	I-L
Whiting, Stout	*Sillago robusta*	P	P	A	P	A	I
Whiting, Trumpeter	*Sillago maculata*	A	P	P	P	A	I
Whiting, Sand	*Sillago ciliata*	A	P	P	P	A	I
Scad, Yellowtail	*Trachurus novaezelandiae*	A	P	A	A	A	L
Tailor	*Pomatomus saltatrix*	A	P	A	P	A	I-L
Goatfish, Asymmetric (Red Mullet)	*Upeneus asymmetricus*	A	P	A	P	A	I-L
Goatfish, Bicolour	*Parupeneus barberinoides*	A	P	P	P	P	H-I
Goatfish, Opalescent	*Parupeneus heptacanthus*	A	P	P	P	P	H-I
Goatfish, Yellowspot	*Parupeneus indicus*	A	P	P	P	P	H-I

Common Names	Species Name	Frequency of capture (otter trawl), % weight of bycatch (beam trawl)	Survival after capture	Interaction through life cycle	TED/BRD effectiveness	Refuge availability **	Fishery Impact Profile level
Goatfish, Banded	*Parupeneus multfasciatus*	A	P	P	P	P	H-I
Goatfish, Blacksaddle	*Parupeneus spilurus*	A	P	A	P	A	I-L
Goatfish, Bluestriped	*Upeneichthys lineatus*	A	P	A	P	A	I-L
Goatfish, Luzon	*Upeneus luzonius*	A	P	A	P	A	I-L
Goatfish, Pennant	*Upeneus filifer*	A	P	P	P	A	I
Goatfish, Goldband	*Upeneus moluccensis*	A	P	A	P	A	I-L
Goatfish, Striped	*Upeneus vittatus*	A	P	A	P	A	I-L
Goatfish, Bartail (Red Mullet)	*Upeneus tragula*	A	P	A	P	A	I-L
Mullet, Sea	*Mugil cephalus*	A	P	A	P	A	I-L
Herring, Southern	*Herklotsichthys castelnaui*	A	P	P	P	A	I
Thryssa, Hamilton's	*Thryssa hamiltonii*	A	P	P	P	A	I
Thryssa, Longjaw	*Thryssa setirostris*	A	P	P	P	A	I
Anchovy, Flase Baelama	*Thryssa encrasicholoides*	A	P	P	P	A	I
Rocklobster, Painted	*Panulirus versicolor*	A	A	A	P	A	L

*** Takes into account overlap with depth and spatial distribution of the ECOTF and RIBTF.*

Table A23. Summary of the **resilience capability** scores for **marine turtle** species included in the **species of conservation concern** ecological component assessment.

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity or ecological niche	Population size or trend	Growth rate / Age at maturity	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Turtle, Flatback	*Natator depressus*	P	PP	A	A	P	P	P	P	L
Turtle, Green	*Chelonia mydas*	P	PP	A	A	P	P	P	P	L
Turtle, Hawksbill	*Eretmochelys imbricata*	P	PP	A	A	P	P	P	P	L
Turtle, Leatherback	*Dermochelys coriacea*	P	PP	A	A	PP	P	P	P	L
Turtle, Loggerhead	*Caretta caretta*	P	PP	A	A	P	P	P	P	L
Turtle, Olive Ridley	*Lepidochelys olivacea*	P	PP	A	A	A	P	P	P	L

Table A24. Summary of the **fishery impact profile** scores for **marine turtle** species included in the **species of conservation concern** ecological component assessment.

Common Name	Species Name	Level of interaction	Survival after interaction	Interaction throughout lifecycle	TED / BRD effectiveness	Fishery Impact Profile level
Turtle, Flatback	*Natator depressus*	P	A	P	A	I-L
Turtle, Green	*Chelonia mydas*	P	A	P	A	I-L
Turtle, Hawksbill	*Eretmochelys imbricata*	P	A	P	A	I-L
Turtle, Leatherback	*Dermochelys coriacea*	A	A	P	P	I-L
Turtle, Loggerhead	*Caretta caretta*	P	A	P	A	I-L
Turtle, Olive Ridley	*Lepidochelys olivacea*	A	A	P	A	L

Table A25. Summary of the **resilience capability** scores for **sea snake** species included in the **species of conservation concern** ecological component assessment.

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity or ecological niche	Population size or trend	Growth rate / Age at maturity	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Sea snake, Dubois'	*Aipysurus duboisii*	PP	PP	A	P	A	A	P	A	L
Sea snake, Spine-Tailed	*Aipysurus eydouxii*	PP	PP	A	P	A	A	P	A	L
Sea snake, Olive	*Aipysurus laevis*	PP	PP	A	A	A	A	P	A	I-L
Sea snake, Stokes'	*Astrotia stokesii*	PP	PP	P	P	P	A	P	A	L
Sea snake, Spectacled	*Hydrophis/Disteira kingii*	PP	PP	P	P	P	A	P	A	L
Sea snake, Olive-Headed	*Hydrophis/Disteira major*	PP	PP	A	P	P	A	P	A	L
Sea snake, Beaked	*Enhydrina schistosa*	P	PP	A	P	P	A	P	P	L
Sea snake, Small-Headed	*Hydrophis macdowelli*	PP	PP	A	P	A	A	P	A	L
Sea snake, Ornate Reef	*Hydrophis ornatus*	PP	PP	A	A	A	A	P	A	I-L
Sea snake, Elegant	*Hydrophis elegans*	P	PP	A	P	A	A	P	P	L
Sea snake, Spine-Bellied	*Lapemis curtus*	PP	PP	A	A	A	A	P	P	L

Table A26. Summary of the **fishery impact profile** scores for **sea snake** species included in the **species of conservation concern** ecological component assessment.

Common Name	Species Name	Level of interaction	Survival after interaction	Interaction throughout life cycle	TED / BRD effectiveness	Fishery Impact Profile level
Sea snake, Dubois'	*Aipysurus duboisii*	A	A	A	P	L
Sea snake, Spine-Tailed	*Aipysurus eydouxii*	P	A	A	P	I-L
Sea snake, Olive	*Aipysurus laevis*	A	P	A	P	I-L
Sea snake, Stokes'	*Astrotia stokesii*	A	P	A	P	I-L
Sea snake, Spectacled	*Hydrophis/Disteira kingii*	A	P	A	P	I-L
Sea snake, Olive-Headed	*Hydrophis/Disteira major*	A	P	A	P	I-L
Sea snake, Beaked	*Enhydrina schistosa*	P	A	A	P	L
Sea snake, Small-Headed	*Hydrophis macdowelli*	A	P	A	A	L
Sea snake, Ornate Reef	*Hydrophis ornatus*	A	P	A	A	L
Sea snake, Elegant	*Hydrophis elegans*	P	PP	A	P	H-I
Sea snake, Spine-Bellied	*Lapemis curtus*	PP	A	A	P	I

Table A27. Summary of the **resilience capability** scores for **syngnathid (seahorses and pipefish)** species included in the **species of conservation concern** ecological component assessment**.**

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity or ecological niche	Population size or trend	Growth rate / Age at maturity	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Seahorse, Queensland	*Hippocampus queenslandicus*	P	P	A	A	P	A	P	P	I-L
Seahorse, Sad	*Hippocampus tristis*	P	P	P	A	P	A	P	A	I-L
Seahorse, Highcrown	*Hippocampus proceros*	P	P	A	A	P	A	P	P	I-L
Pipefish, Bentstick	*Trachyrhamphus bicoarctatus*	P	P	A	A	P	A	P	A	I-L
Pipefish, Straightstick	*Trachyrhamphus longirostris*	P	P	A	A	P	A	P	P	I-L
Pipefish, Tiger	*Filicampus tigris*	P	P	A	A	P	A	P	P	I-L
Pipehorse, Pallid	*Solegnathus cf. hardwickii*	P	P	A	A	A	A	P	A	I
Pipehorse, Dunker's	*Solegnathus dunkeri*	P	P	A	A	P	A	P	A	I-L

Table A28. Summary of the **fishery impact profile** scores for **syngnathid (seahorses and pipefish)** species included in the **species of conservation concern** ecological component assessment.

Common Name	Species Name	Level of interaction	Survival after interaction	Interaction throughout lifecycle	TED / BRD effectiveness	Fishery Impact Profile level
Seahorse, Queensland	*Hippocampus queenslandicus*	A	PP	A	P	I
Seahorse, Sad	*Hippocampus tristis*	A	PP	A	P	I
Seahorse, Highcrown	*Hippocampus proceros*	A	PP	A	P	I
Pipefish, Bentstick	*Trachyrhamphus bicoarctatus*	A	PP	A	P	I
Pipefish, Straightstick	*Trachyrhamphus longirostris*	A	PP	A	P	I
Pipefish, Tiger	*Filicampus tigris*	A	PP	A	P	I
Pipehorse, Pallid	*Solegnathus cf. hardwickii*	A	PP	A	P	I
Pipehorse, Dunker's	*Solegnathus dunkeri*	A	PP	A	P	I

Table A29. Summary of the **resilience capability** scores for all **chondricthyans (shark, skates, rays, chimeras)** included in the **species of conservation concern** ecological component assessment.

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity or ecological niche	Population size or trend	Growth rate / Age at maturity	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Eagle Ray, Banded	*Aetomylaeus nichofii*	PP	PP	A	A	P	P	P	A	L
Sawfish, Narrow. S.	*Anoxypristis cuspidata*	P	PP	A	P	P	P	P	P	L
Shovelnose Ray, Eastern	*Aptychotrema rostrata*	P	P	A	A	A	P	P	P	I-L
Catshark, Grey Spotted	*Asymbolus analis*	P	P	A	P	P	P	A	A	I-L
Catshark, Orange Spotted	*Asymbolus rubiginosus*	P	P	A	P	P	P	A	A	I-L
Carpetshark, Blue-Grey	*Brachaelurus colcloughi*	PP	PP	P	A	P	P	P	P	L
Shark, Spinner	*Carcharhinus brevipinna*	P	PP	A	A	P	P	P	P	L
Shark, Whitecheek	*Carcharhinus dussumieri*	PP	PP	A	A	P	P	P	P	L
Carpetshark, Grey	*Chiloscyllium punctatum*	P	P	A	A	A	A	A	A	H-I
Stingray, Smooth	*Dasyatis brevicaudata*	PP	PP	A	A	A	P	P	A	L
Stingray, Estuary	*Dasyatis fluviorum*	PP	PP	A	P	P	P	P	P	L
Stingray, Black	*Dasyatis thetidis*	PP	PP	A	A	A	P	P	A	L
Skate, Sydney	*Dipturus australis*	P	P	A	A	P	P	P	A	I-L
Skate, Endeavour	*Dipturus endeavouri*	P	P	A	A	P	P	P	A	I-L

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity or ecological niche	Population size or trend	Growth rate / Age at maturity	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Blacktip Skate	*Dipturus melanospilus*	P	P	A	A	P	P	P	A	I-L
Skate, Argus	*Dipturus polyommata*	P	P	A	A	P	P	P	A	I-L
Wobbegong, Tasselled	*Eucrossorhinus dasypogon*	P	PP	A	A	A	P	P	A	I-L
Catshark, Sawtail	*Figaro boardmani*	P	P	A	P	P	P	P	A	L
Shovelnose Ray, Giant	*Glaucostegus typus*	P	PP	A	A	P	P	P	P	L
Australian Butterfly Ray	*Gymnura australis*	PP	PP	A	A	A	P	P	A	L
Weasel Shark, Australian	*Hemigaleus australiensis*	P	PP	A	A	A	P	P	A	I-L
Hornshark, Crested	*Heterodontus galeatus*	P	P	A	A	P	P	P	A	I-L
Whipray, Blackspotted	*Himantura astra*	PP	PP	A	A	A	P	P	A	L
Whipray, Brown	*Himantura toshi*	PP	PP	A	A	A	P	P	A	L
Whipray, Reticulate	*Himantura uarnak*	PP	PP	A	A	A	P	P	A	L
Ghostshark, Blackfin	*Hydrolagus lemures*	P	P	A	A	A	P	P	P	I-L
Ray, Coffin	*Hypnos monopterygius*	PP	PP	A	A	P	P	P	A	L
Shark, Sliteye	*Loxodon macrorhinus*	PP	PP	A	A	A	A	P	A	I-L
Maskray, Bluespotted	*Neotrygon kuhlii*	PP	PP	A	A	A	P	A	A	I-L
Maskray, Speckled	*Neotrygon picta*	PP	PP	A	A	A	P	A	A	I-L

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity or ecological niche	Population size or trend	Growth rate / Age at maturity	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Wobbegong, Gulf	*Orectolobus halei*	P	PP	A	A	P	P	P	P	L
Wobbegong, Spotted	*Orectolobus maculatus*	P	PP	A	A	A	P	P	P	L
Wobbegong, Banded	*Orectolobus ornatus*	P	PP	A	A	A	P	P	P	L
Carpetshark, Collar	*Parascyllium collare*	P	P	A	A	P	P	P	A	I-L
Stingray, Cowtail	*Pastinachus astrus*	PP	PP	A	A	P	P	P	P	L
Sawfish, Green	*Pristis zijsron*	P	PP	P	P	PP	P	P	P	L
Shark, Milk	*Rhizoprionodon acutus*	PP	PP	A	A	A	P	A	P	L
Shark, Australian Sharpnose.	*Rhizoprionodon taylori*	P	P	A	A	A	A	A	P	I
Guitarfish/Wedgefish	*Rhynchobatus australiae/Rhynchobatus palpebratus*	P	PP	A	A	A	P	P	P	L
Shark, Zebra	*Stegostoma fasciatum*	PP	PP	A	A	P	P	P	A	L
Torpedo Ray, Short-tail	*Torpedo macneilli*	P	PP	A	A	P	P	A	A	I-L
Stingaree, Common	*Trygonoptera testacea*	PP	PP	A	A	P	P	A	A	L
Stingaree, Sandyback	*Urolophus bucculentus*	PP	PP	A	A	P	P	A	A	L
Stingaree, Patchwork	*Urolophus flavomosaicus*	PP	PP	P	A	P	P	A	A	L
Stingaree, Kapala	*Urolophus kapalensis*	PP	PP	A	A	P	P	A	A	L

Common Name	Species Name	Fecundity	Life history strategy	Geographic distribution	Habitat specificity or ecological niche	Population size or trend	Growth rate / Age at maturity	Longevity / Natural Mortality	Cumulative pressures	Resilience level
Stingaree, Yellowback	*Urolophus sufflavus*	PP	PP	A	A	P	P	A	A	L
Stingaree, Greenback	*Urolophus viridis*	PP	PP	A	A	P	P	A	A	L

Table A30. Summary of the **fishery impact profile** scores all **chondricthyans (shark, skates, rays, chimeras)** included in the **species of conservation concern** ecological component assessment.

Common Name	Species Name	Level of interaction	Survival after interaction	Interaction throughout lifecycle	TED / BRD effectiveness	Fishery Impact Profile level
Eagle Ray, Banded	*Aetomylaeus nichofii*	A	P	A	A	L
Sawfish, Narrow. S.	*Anoxypristis cuspidata*	P	P	A	P	I
Shovelnose Ray, Eastern	*Aptychotrema rostrata*	PP	P	P	A	H-I
Catshark, Grey Spotted	*Asymbolus analis*	P	P	P	P	H-I
Catshark, Orange Spotted	*Asymbolus rubiginosus*	P	P	P	P	H-I
Carpetshark, Blue-Grey	*Brachaelurus colcloughi*	P	A	P	P	I
Shark, Spinner	*Carcharhinus brevipinna*	A	A	A	P	L
Shark, Whitecheek	*Carcharhinus dussumieri*	P	A	A	P	I-L
Carpetshark, Grey	*Chiloscyllium punctatum*	A	A	P	P	I-L
Stingray, Smooth	*Dasyatis brevicaudata*	A	A	A	A	L
Stingray, Estuary	*Dasyatis fluviorum*	P	A	P	P	I
Stingray, Black	*Dasyatis thetidis*	A	A	A	A	L
Skate, Sydney	*Dipturus australis*	P	PP	P	P	H
Skate, Endeavour	*Dipturus endeavouri*	P	PP	P	P	H

Common Name	Species Name	Level of interaction	Survival after interaction	Interaction throughout lifecycle	TED / BRD effectiveness	Fishery Impact Profile level
Blacktip Skate	*Dipturus melanospilus*	P	PP	P	P	H
Skate, Argus	*Dipturus polyommata*	P	PP	P	P	H
Wobbegong, Tasselled	*Eucrossorhinus dasypogon*	A	A	P	P	I-L
Catshark, Sawtail	*Figaro boardmani*	P	P	P	P	H-I
Shovelnose Ray, Giant	*Glaucostegus typus*	P	A	P	A	I-L
Australian Butterfly Ray	*Gymnura australis*	P	P	P	P	H-I
Weasel Shark, Australian	*Hemigaleus australiensis*	A	P	P	P	I
Hornshark, Crested	*Heterodontus galeatus*	A	A	P	P	I-L
Whipray, Blackspotted	*Himantura astra*	P	P	P	P	H-I
Whipray, Brown	*Himantura toshi*	A	P	P	P	I
Whipray, Reticulate	*Himantura uarnak*	A	A	A	P	L
Ghostshark, Blackfin	*Hydrolagus lemures*	A	P	P	P	I
Ray, Coffin	*Hypnos monopterygius*	P	A	P	P	I
Shark, Sliteye	*Loxodon macrorhinus*	A	P	P	P	I
Maskray, Bluespotted	*Neotrygon kuhlii*	P	PP	P	P	H
Maskray, Speckled	*Neotrygon picta*	A	PP	P	P	H-I

Common Name	Species Name	Level of interaction	Survival after interaction	Interaction throughout lifecycle	TED / BRD effectiveness	Fishery Impact Profile level
Wobbegong, Gulf	*Orectolobus halei*	A	A	p	P	I-L
Wobbegong, Spotted	*Orectolobus maculatus*	A	A	P	P	I-L
Wobbegong, Banded	*Orectolobus ornatus*	A	A	P	P	I-L
Carpetshark, Collar	*Parascyllium collare*	A	A	P	P	I-L
Stingray, Cowtail	*Pastinachus astrus*	A	A	A	A	L
Sawfish, Green	*Pristis zijsron*	P	A	P	P	I
Shark, Milk	*Rhizoprionodon acutus*	P	A	P	P	I
Shark, Australian Sharpnose.	*Rhizoprionodon taylori*	P	A	P	P	I
Guitarfish / Wedgefish	*Rhynchobatus australiae/Rhynchobatus palpebratus*	P	A	P	A	I-L
Shark, Zebra	*Stegostoma fasciatum*	A	A	P	P	I-L
Torpedo Ray, Short-tail	*Torpedo macneilli*	A	A	P	P	I-L
Stingaree, Common	*Trygonoptera testacea*	P	PP	P	P	H
Stingaree, Sandyback	*Urolophus bucculentus*	A	PP	P	P	H-I
Stingaree, Patchwork	*Urolophus flavomosaicus*	A	P	P	P	I
Stingaree, Kapala	*Urolophus kapalensis*	P	P	P	P	H-I

Common Name	Species Name	Level of interaction	Survival after interaction	Interaction throughout lifecycle	TED / BRD effectiveness	Fishery Impact Profile level
Stingaree, Yellowback	*Urolophus sufflavus*	A	P	P	P	I
Stingaree, Greenback	*Urolophus viridis*	A	P	P	P	I

Table A31. Summary of the **resilience capability** scores for the biophysical strata (Kenna & Kirkwood, 2008) included in the **marine habitat** ecological component assessment.

Biophysical Strata	Geographic distribution in area of interest	Impact of trawling on key structural elements	Ability of substrates to recover after being disturbed	Cumulative pressures	Resilience level
Inner Shelf Gravel – strata 1	A	P	A	P	I
Mid-Shelf Sand (shallow) – strata 2	A	P	A	P	I
Mid-Shelf Carbonate Sand – strata 3	A	P	P	A	I
Outer Shelf – strata 4	A	P	P	A	I
Shelf Break – strata 5	A	P	P	A	I
Mid-Shelf Carbonate Gravel – strata 6	A	P	P	A	I
Inner Shelf High Current – strata 7	PP	P	A	A	I-L
Inner Shelf Sand – strata 8	A	P	A	P	I
Mid-Shelf Sand (deep) – strata 9	A	P	A	A	H-I
Inner Shelf Muddy sand – strata 10	PP	P	A	P	I-L

Table A32. Summary of the **fishery impact profile** scores the biophysical strata (Kenna & Kirkwood, 2008) included in the **marine habitat** ecological component assessment.

Biophysical Strata	Knowledge of spatial distribution of habitat types	Knowledge of spatial distribution of fishing effort	Proportion of available habitat impacted by fishing gear (%effort exposed 2009)	Proportion of total habitat permanently protected from fishing activity	Impacts caused by different gear types used in the fishery	Fishery Impact Profile level
Inner Shelf Gravel – strata 1	P	A	A	P	A	I
Mid-Shelf Sand (shallow) – strata 2	P	A	P	P	A	H-I
Mid-Shelf Carbonate Sand – strata 3	P	A	A	A	A	I-L
Outer Shelf – strata 4	P	A	A	P	A	I
Shelf Break – strata 5	P	A	A	P	A	I
Mid-Shelf Carbonate Gravel – strata 6	P	A	A	P	A	I
Inner Shelf High Current – strata 7	P	A	A	P	A	I
Inner Shelf Sand – strata 8	A	A	A	A	A	L
Mid-Shelf Sand (deep) – strata 9	P	A	P	A	A	I
Inner Shelf Muddy sand – strata 10	A	A	P	A	A	I-L

Appendix E. ERA workshop participants.

The following is a list of people who were involved in the ERA process including industry representatives with an intimate knowledge of the operation and marketing aspects of the ECTF, representatives from various government and non-government organizations and scientists with specific knowledge of the methodology, species, species complexes or habitats that interact with the ECTF representatives from various government and non-government organizations and scientists.

Name	Organisation/Affiliation	Expertise
Sandy Morison	Consultant	Fisheries & risk assessment process
Rachel Pears	GBRMPA	GBR sustainable use & ecosystem-based management; GBRMP ERA
Karen Astles	NSW Fisheries	Ecological risk assessment processes
Darren Hale	NSW Fisheries	Fisheries management
Steve Murphy	Trawl Industry	Fishing practices of the various species-sectors
Richard Taylor	Trawl Industry	Fishing practices of the various species-sectors
Geoff Tilton	Trawl Industry	Fishing practices of the various species-sectors
Barry Clarke	Trawl Industry	Fishing practices of the various species-sectors
David Robertson	Trawl Industry	Fishing practices of the various species-sectors
Bernie Wilson	Trawl Industry	RIBTF
Sian Breen	WWF	Conservation, ecosystem assessment
Jim Higgs	DERM	Queensland environment & marine resources
Eddie Jebreen	DAFF	Trawl fishery management
Ian Jacobsen	DAFF	Fishery management, Chondricthyans
Darren Roy	DAFF	Trawl fishery management
Inoni Harris	DAFF	Trawl legislation
Tony Courtney	Agri-Science Queensland, DAFF	Trawl by-catch (composition, reduction measures), principal & permitted species.

Malcolm Dunning	DAFF	Fisheries assessment & monitoring
Clive Turnbull	DAFF	Fisheries management & harvest species.
Brad Zeller	DAFF	Trawl fishery sustainability reporting & risk assessment
Anna Garland	DAFF	Fisheries reporting & data assessment
Nadia Engstrom	DAFF	Fisheries reporting & data assessment
Paul Higgenbottom	Trawl Industry	Fishing practices & marketing
Trin Zahmel	DAFF	Fisheries assessment & monitoring
Kate Yeomans	DAFF	Fisheries assessment & monitoring
Nadia Engstrom	DAFF	Fisheries assessment & monitoring
Michelle Winning	DAFF	Fisheries assessment & monitoring
San McCulloch	DAFF	Fisheries Observer Program

Appendix F. Changes to provisions governing the use of bycatch reduction devices (BRD) in the East Coast Trawl Fishery (coming into effect 1 March 2015). Distributed by the Department of Agriculture, Fisheries and Forestry, November 2014.

Department of Agriculture, Fisheries and Forestry

Changes to the Fisheries (East Coast Trawl) Management Plan 2010

From 1 March 2015, new rules will apply to the use of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) to reduce the level of interactions with protected species including sea snakes.

Bycatch reduction devices

There will be five approved bycatch reduction device types however, not all will be able to be used in all areas of the fishery.

Approved BRDs

- Square mesh codend (northern area, central area, shallow area, deepwater net area and scallop designs)
- Square Mesh Panel (modified design)
- Fisheye
- Bigeye
- V Cut with Bell codend

Non Approved BRDs

- Half round Square mesh codend
- Radial Escape Section
- Popeye Fish Excluder

BRD usage

Fishers must now use approved BRD types when fishing with prawn nets in certain areas of the fishery. However, when using Scallop nets, only a Scallop Square Mesh Codend is approved for use as a BRD.

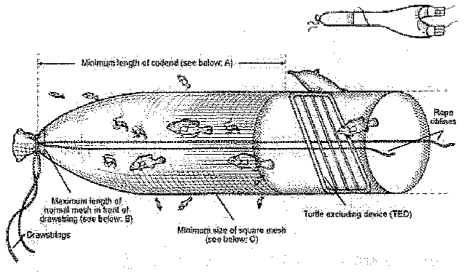
Fishery area	Approved BRD options
Northern Area (north of 16 degrees)	Square mesh codend (Northern area), fisheye, bigeye, square mesh panel and V Cut with bell codend.
Central Area (16-22 degrees)	Square mesh codend (Central area), fisheye, bigeye.
Shallow area (south of 22 degrees and outside of the deepwater net area)	Square mesh codend (Shallow area), fisheye, bigeye, square mesh panel, V Cut with bell codend.
Deepwater Net Area	Square mesh codend (deepwater net area), fisheye, bigeye, square mesh panel.
Scallop Nets (anywhere)	Scallop Square Mesh Codend
Beam Trawl	Square mesh codend, fisheye, bigeye, square mesh panel, V Cut with bell codend.

Great state. Great opportunity.
And a plan for the future.

Queensland Government

BRD design

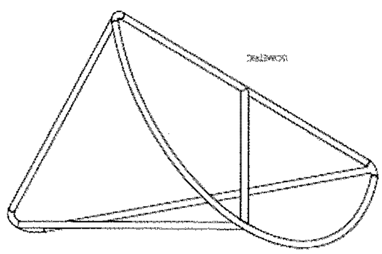
Square mesh codend BRD



Fishery Area	Min Square Mesh Size	Length	Circumference	Max Diamond mesh to drawstrings
Northern/Central Area (prawn nets)	50mm	50 bars	80 bars	25 meshes
Shallow area (prawn nets)	38mm	50 bars	80 bars	25 meshes
Deepwater Net Area (prawn nets)	45mm	50 bars	80 bars	25 meshes
Scallop nets	88mm	33 bars	50 bars	15 meshes
Beam	31mm	50 bars	100 bars	25 meshes

- The **shallow area** square mesh codend must have an additional 300mm x 300mm panel installed made of square mesh of at least 45mm.
- Knotted netting requires 4 evenly spaced belly ropes made of at least 12mm rope. Knotless or double strand net does not require belly ropes.

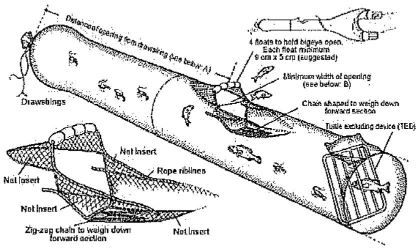
Fisheye BRD



- Rigid frame with semicircular section at least 350mm wide by 150mm high attached to a triangular shaped frame. (230mm x 100mm for beam trawl nets)
- Opening must be divided in half by a rigid bar to prevent opening from crushing.
- Opening installed no more than 66 meshes from codend drawstrings. (80 meshes for beam trawl nets)
- Apex of the triangular section must be installed pointing towards the opening of the net
- Additional strengthening bars may be used.

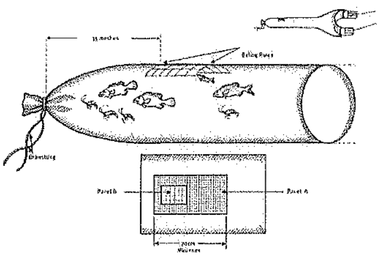
Changes to the Fisheries (East Coast Trawl) Management Plan 2010 Version 1, 25 November 2014

Bigeye BRD



- The opening must be in the top of the net and measure at least 350mm across. (230mm for beam trawl nets)
- Opening must be installed within 66 meshes of codend drawstrings. (80 meshes for beam trawl nets)
- During trawling the opening has a weighted forward section and a buoyed rear section with at least two 50mm x 90mm floats attached.
- The edges of the opening do not overlap by more than 200mm.

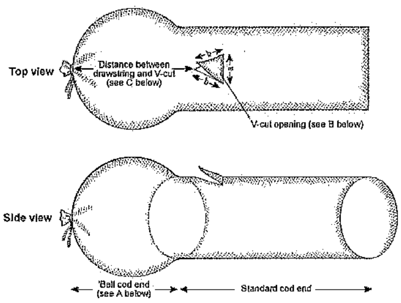
Square mesh panel BRD



This BRD is made up of an inner and outer panel of different sized square mesh at a set distance from the drawstring. This design is the same as the square mesh panel used in the NSW Ocean Trawl fishery.

	Outer panel		Inner panel	
	Otter trawl nets	Beam Trawl Nets	Otter Trawl nets	Beam Trawl Nets
Maximum distance of rear edge from drawstrings	35 meshes	60 meshes	40 meshes	65 meshes
Minimum Mesh Size	45mm	40mm	55mm	50mm
Minimum Length	700mm	600mm	300mm	300mm
Minimum Width	550mm	450mm	250mm	200mm

V Cut with Bell Codend



- No changes to current design.

Turtle excluder device design

The online TED guide contains the changes made to the TED legislation. The guide can be viewed at http://www.business.qld.gov.au by searching for "turtle excluder devices".

The TED changes are:

- Allowing the use of scallop mesh up to 90mm for TED flaps in scallop nets only.
- Allowing the use of accelerator funnels with TEDs.

Crab bag use and design

Crab bags will be able to be used by fishers. The use of these will be optional, however if used must meet the following requirements:

The crab bag's entire circumference is a mesh size of at least 88mm and no more than 50 meshes. Also the crab bag must be installed inside the net's cod end and no more than 50 meshes from the cod end drawstrings.

Definition of trawl nets "in use"

Changing the definition of when trawl nets are "in use" to include trawl nets that are rigged for fishing. This change will allow more compliance activities to be completed in port, at anchor and under safer working conditions, instead of having to occur while boats are fishing.

The definition of using a trawl net now includes having the net rigged for fishing. An example of rigged for fishing includes having a cod end and ground chains attached. This means any net with a cod end and ground chain attached on-board a trawler must also have a compliant TED and BRD installed.

Changes to the Fisheries (East Coast Trawl) Management Plan 2010 Version 1, 25 November 2014

Appendix G. Supplementary material - marine habitat ecological assessment.

The following is an abbreviated summary of the available marine habitat data compiled by Brad Zeller. This information informed discussions surrounding the marine habitat ecological component assessment. This information, among other things, provided context with respect to some of the environmental variables that influenced each biophysical strata and benthic assemblages likely to be encountered along the Queensland coastline.

MARINE HABITAT ASSESSMENT

ADDITIONAL DATA AND INFORMATION

Brad Zeller

Department of Agriculture, Fisheries and Forestry

For the purposes of this risk assessment, the spatial arrangements of covariate strata mapped by Kenna & Kirkwood (2008) were selected as surrogates for the distribution of shelf seabed habitats within the study area (Fig. 1). These strata were mapped as a broader evaluation of the seabed biodiversity of an area defined as the *Tweed-Moreton Bioregion* (TMB) which covers 42,712 km^2 of shelf from Baffle Creek to Coffs Harbour, NSW. While not exact, the TMB covers approximately the same area of seafloor as the shelf area captured within the Central Eastern Biotone (ibid.) and the Central Eastern Shelf Transition (CEST), under the National Benthic Marine Bioregionalisation of Australia program [Fig. 2 (Heap *et al*., 2005)].

While some of the Kenna & Kirkwood (2008) strata extend south of the study area to Coffs Harbour, New South Wales (Department of Environment and Heritage [DEH], 2006), trawl mediated risk to seabed habitats were not assessed beyond the southern boundary of the ECOTF. It is noted though that at least half of the ten strata mapped by Kenna & Kirkwood (2008) extends southward into the operational area of the New South Wales Otter Trawl Fishery; indicating that the results of the assessment may be generalized to similar seabed habitats occurring in far northern New South Wales.

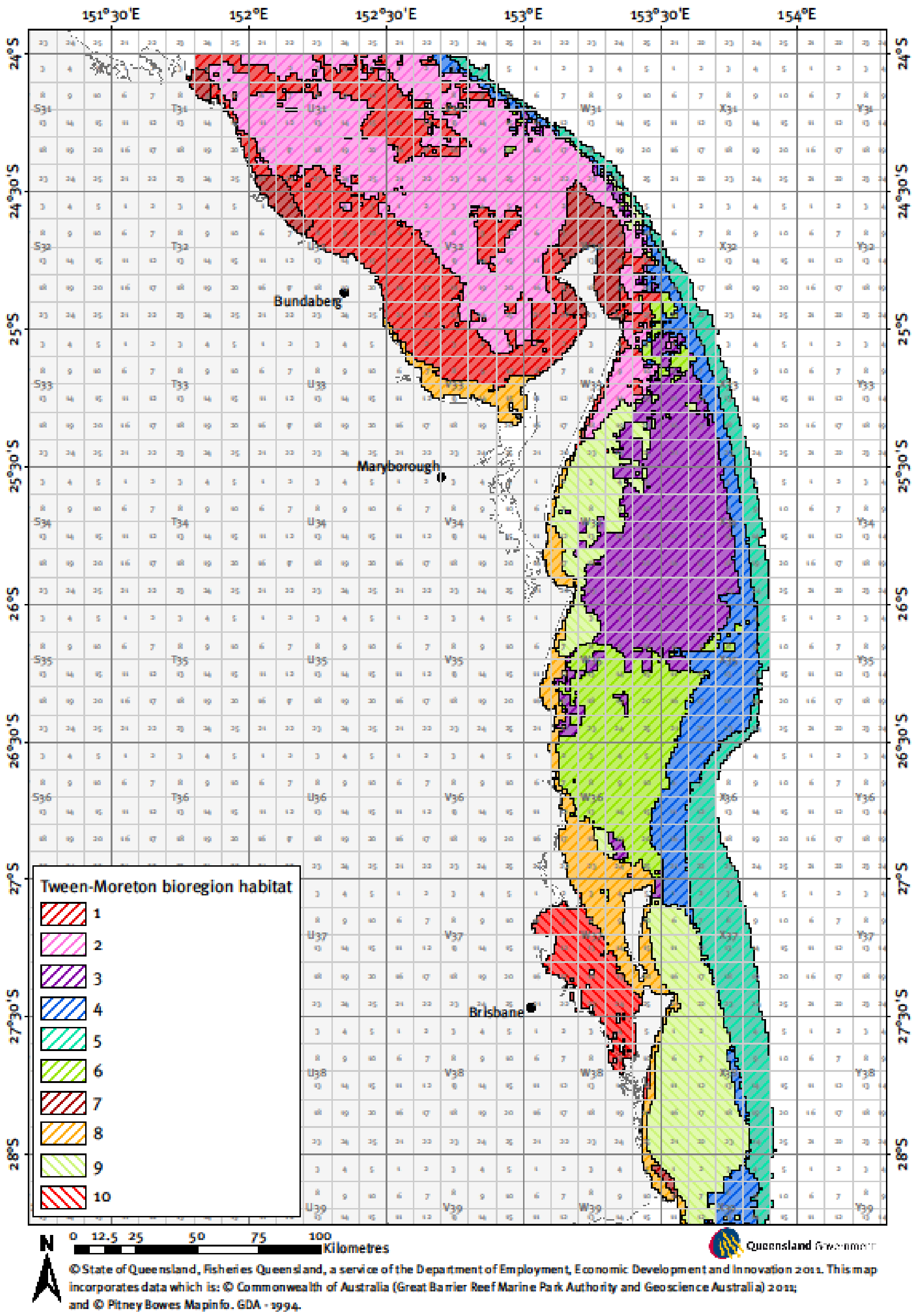


Figure 1. Map of biophysical parameter strata (surrogates) for seabed habitats in the Tweed-Moreton Bioregion (Kenna & Kirkwood 2008).[19]

[19] *Refer to Table 1 for a qualitative description of the relative levels of the main parameters defining the ten seabed strata identified in this map*

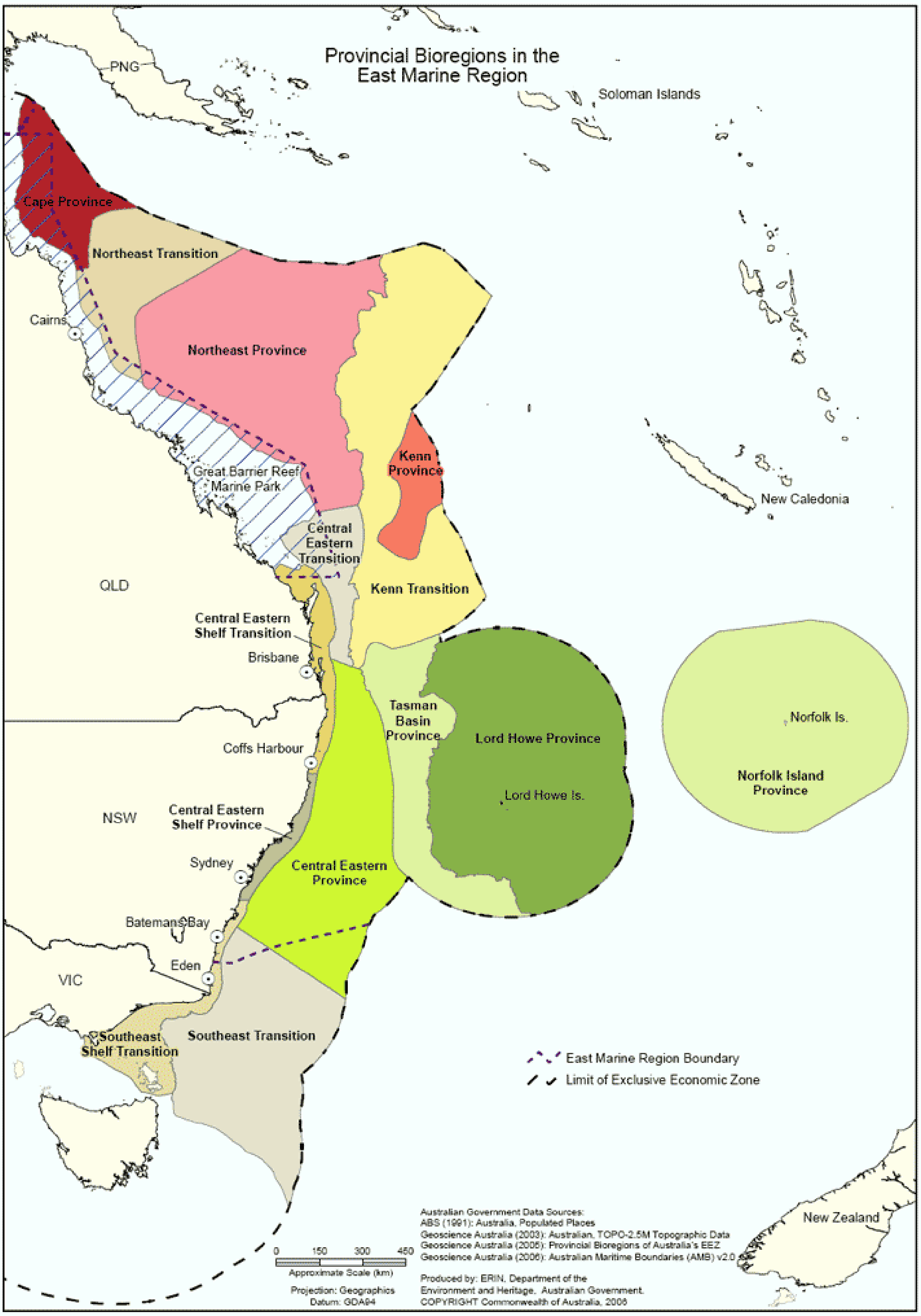


Figure 2. Location of the East Marine Region and associated bioregions including the Central Eastern Biotone (ibid.) and the Central Eastern Shelf Transition (CEST).. Source: SEWPAC, http://www.environment.gov.au/coasts/mbp/east/bioregions.html. [Accessed 28 March 2013]

The spatial arrangement of the covariate strata defined by Kenna & Kirkwood (2008) describes in some detail the physical character of the shelf seabed within the area of the TMN/CEST.

Relevant physical covariates that have been included in a working model of benthic habitat types at a sub-regional scale (Table 1):

- seabed depth and slope;
- near-bed current shear stress;
- proportion of mud, sand, gravel and carbonate in sediments; and
- sediment grain size.

These measures provide a relative measure of the broader configuration of each of the respective biophysical strata included in the southern Queensland and RIBTF ERA.

Bathome level determinants of seabed biota

Bathomes are variably referred to as biomes, environmental regions or environmental zones. Bathomic (bathome) subdivisions used in the southern Queensland and RIBTF effectively revolve around:

a) the inner shelf which consists of the coastline and nearshore marine waters; and
b) the sublittoral shelf which includes both the mid- and outer shelf.

The Inner Shelf

Hervey Bay and Sunshine Coast nearshore habitats are shallow (12 – 25 m deep), have sediments very low in carbonate, water that is very low in nitrate and phosphate with temperatures at the seabed averaging 24.2–24.4°C and range of 5.1–5.7°C (Ellis & Pitcher, 2010). Natural processes shape the coastline and inner shelf and determine the nature of estuarine and marine seabed habitats. The seabed of inshore habitats exposed to strong ocean and tidal currents are subject to scouring, sediment transport and support specialized biota adapted to increased current stress (Stratum 7 of Fig. 1; Table 1). Freshwater floods have short term residual impacts on the inshore seabed and may change sediment composition, the substrate profile and smother or remove sedentary benthos, causing depletion of ecologically dependent species (Healthy Waterways, 2011), including species taken in the ECTF. Cyclones increase rainfall, wind and ocean swells generating physical disturbance to the coastline and inner shelf seabed.

Table 1. Relative measures of physical seabed habitat surrogates classified and mapped by Kenna & Kirkwood (2008).

Strata Number	Habitat Type	Estimated Average depth and range (m)	Average seabed slope	Near Bed Shear Stress	Relative Average Mud Content	Relative Average Sand Content	Relative Average Gravel Content	Relative Average Carbonate Content	Relative Average Grain Size
1	Inner Shelf Gravel	20 (0-50)	Low	Low	Low	Moderate	High	Low	Large
2	Mid-Shelf Sand (shallow)	30 (10-50)	Low	Low	Low	High	Low	Low	Medium
3	Mid-Shelf Carbonate Sand	60 (50-70)	Low	Low	Low	High	Low	Moderate	Medium
4	Outer Shelf	90 (50-150)	Moderate	Low	Low	High	Moderate	High	Large
5	Shelf Break	200 (120-290)	High	Low	Low	High	Low	Moderate	Medium
6	Mid-Shelf Carbonate Gravel	50 (40-70)	Low	Low	Low	Moderate	Moderate	High	Large
7	Inner Shelf High Current	10 (0-30)	Low	High	Low	High	Low	Low	Medium
8	Inner Shelf Sand	10 (0-40)	Moderate	Moderate	Low	High	Low	Low	Medium
9	Mid-Shelf Sand (deep)	50 (10-100)	Moderate	Low	Low	High	Low	Low	Medium
10	Inner Shelf Muddy sand	10 (0-20)	Low	Low	High	High	Low	Moderate	Fine

Inshore marine and estuarine habitats within the study area support beam trawling and otter trawling for banana, greasyback and school prawns and act as nursery areas for prawn species taken by offshore otter trawling (notably eastern king prawns and tiger prawns). Because of their close proximity to major human population centres and shipping ports, coastal habitats are more frequently and intensively impacted than those offshore. Trawling is but one of a number of habitat disturbances associated with human activity in the coastal zone.

Inner Shelf Biotypes

The physical environment, seabed and biota of inshore marine and estuarine areas within the study area are broadly described at the primary and secondary biotype levels (Table 2). Five sub-regions have been selected based on coastal geomorphology, and habitat homogeneity and continuity. Locations of major human population centres are included as a pressure and modifier of habitats that support trawl fishery resources.

Colosseum Inlet to Hervey Bay

The coastline from Colosseum Inlet to Bustard Head supports an extensive network of estuarine channels, bars and deltas supporting seagrass, and mangrove communities that act as important prawn habitat (DNPRSR, 2012). From Bustard Head to Burrum Heads the coastline is more open to south-easterly swells (Short, 2000) with sandy beaches punctuated by fringing rock and coral reef and mangrove lined estuaries (notably the Kolan River and Burnett River), some with seasonal seagrass cover (Lupton, 1993). Tidal barrages on the Kolan and Burnett Rivers have limited freshwater inflow through their estuaries and reduced tidal influence upstream (Lupton & Heidenreich, 1999). However, both river estuaries support significant areas of coastal wetland of high value to local prawn fisheries (Bruinsma & Danaher, 2000) and together with adjacent estuaries (*e.g.* Baffle Creek to the north and Elliott River to the south), act as important juvenile habitat for several major commercial prawn species (Lupton & Heidenreich, 1999).

Table 2. Spatial scales of biodiversity used in this assessment – as defined under the National Benthic Marine Bioregionalisation of Australia (Heap *et al*., 2005) program and adapted from Last *et al*. (2010).

Bioregionalisation Unit (Example)	**Spatial scale**	**Ecological Significance**	**Typical biotic units**	**Relevance to this assessment**	**Information Sources**
Province - *East Marine Region*	Macro scale (>10,000 km^2)	Local endemism	Biogeographic assemblages	Not relevant to this assessment.	–
Biotone - *Equivalent to the Tweed Morton Bioregion (TMB)/the Central Eastern Shelf Transition (CEST)*	Macro scale (>10,000 km^2)	Tropical/temperate biota overlap More specious than adjacent Provinces (e.g. SE Queensland – N New South Wales is an area of peak species richness for marine sponges on the Australian shelf: Hooper & Ekins, 2004)	Biogeographic assemblages	ECTF trawls spatially potentially overlap distributions of tropical and warm temperate taxa	A comprehensive inventory of seabed communities of the southern Qld shelf has not been documented (IMCRA Technical Group, 1998)
Bathome – *Inner, mid- and outer shelf, continental slope*	Macro scale (>10,000 km^2)	Depth range of biota may be wide (eurybathic) or confined to the shelf (stenobathic)	Communities	Stenobathic shelf biota may be more susceptible to trawl capture than eurybathic taxa which may also inhabit the intertidal zone or the continental slope where trawling does not occur	Seabed communities of the southern Qld sublittoral shelf are not well documented.

Geomorphic – *Estuaries, sand banks, drowned shorelines and terraces*	Meso scale (1,000 – 10,000 km^2)	Surrogates for distinctive biotic assemblages associated with a geomorphic feature	Biological assemblages	The littoral shelf (intertidal banks and beaches) are generally not trawled. Only geomorphic features of the sublittoral shelf that are of low relief (i.e. < 2 m high) are trawlable. A prominent terrace or nick point at 105 m forms a gently sloping, slightly convex surface with a gradient of up to 4°.	Astles *et al*. (2009) define geomorphic features >2 m height as resistant to trawling The submarine terrace at 105 m marks the intersection between the mid- and outer shelves (Marshall, 1978)
Primary Biotype - *Hard grounds*.	Local-scale (100 – 1,000 km^2)	Biota associated with soft v hard substrates and topography	Physical habitats	Determinant of benthic community composition but trawlers avoid reefs and hard grounds minimising exposure of reef attached biota to trawl related impact	Banks and rough ground adjacent to submarine terraces are distributed across the shelf throughout the study area. Carbonate platforms make up the “hard grounds” on the outer shelf adjacent to Fraser Island and the Cooloola Coast (Boyd *et al*., 2004; Marshall *et al*., 1998)
Secondary Biotype - *Mud, sand, gravel and/or calcareous sediment*.	Local-scale (100 – 1,000 km^2)	Biota associated with seabed sediment particle size	Seagrass meadows, calcareous algae beds, kelp beds, sponge gardens	Determinant of benthic community composition relevant to trawling	Inner shelf habitats: seagrass meadows in southern Hervey Bay (Lee Long *et al.*, 1992), Great Sandy Strait (Lennon &

					Luck, 1990), and in Moreton Bay and estuaries from the Noosa River to Tallebudgera Creek (Hyland *et al*., 1989). Sublittoral shelf habitat: physical habitat (Kenna & Kirkwood, 2008); rhodoliths (Marshall & Davies 1978); coralline algae.
Biological Facies – *Halophila* meadows, *Ecklonia* beds; *Halimeda* beds; *Ircinia* gardens.	Micro scale (<1 km)	Patches of a macrobenthic biota adapted to specific local physical & biological conditions	Dominant species	Indicator taxa act as surrogates for the biological assemblage to which they belong	Courtney *et al*. (2007); Barker *et al*. (2004); Stevens & Connolly (2005).

The nearshore edges of Hervey Bay are typically sand and gravel sediments, low in carbonate and subject to increased currents (Strata 7 and 8 in Fig. 1; Table 1). The average seabed water temperature in Hervey Bay exceeds 24.3 °C (Kenna & Kirkwood, 2008). Water depths vary from 12 – 25 m and nitrate and phosphate concentrations in the water are very low (Ellis & Pitcher, 2010). The Hervey Bay seabed is mainly covered with sand with higher gravel content in the shallower sections (Table 1). Structural seabed biota in Hervey Bay includes seagrass, brown algae, sponges and soft coral (Barker *et al*., 2004; Courtney *et al*., 2007). Banana prawns, greasyback prawns and king prawns inhabit estuaries in this sub-region (Lupton, 1993; Lupton & Heidenreich 1999). The main species targeted by beam trawling are banana prawns within the Burnett River estuary and its shallow (<5 m deep) muddy subtidal delta which extends 3 km offshore (Boyd *et al*., 2004) and the Kolan River estuary near Bundaberg and saucer scallops in central Hervey Bay (Fig. 3). Banana prawns are also targeted by otter trawling in shallow inshore waters adjacent to the Burnett River estuary. Otter trawlers also target saucer scallops off Bustard Head, at the northern boundary of the study area and in central Hervey Bay (Fig. 4). Bundaberg and Hervey Bay are major population centres of 69,500 and 61,700 people,[20] providing port and processing infrastructure for the fishery.

Fraser Island to Tin Can Bay

Nearshore seabed habitats adjacent to more than 100 km of sandy beach and rocky headlands along the exposed shores of northern and eastern Fraser Island from Break Sea Spit to Wide Bay Bar are subject to high seabed current stress (Strata 7 and 8 in Fig. 1 and Table 1) generated by easterly winds, ocean swells and tides (Short, 2000) and the East Australian Current which sweeps across the shelf is this area (Marshall *et al*., 1998). School prawns are captured by otter trawling Within the Great Sandy Strait and Tin Can Bay are sheltered estuarine waterways supporting extensive saltmarsh, mangrove and seagrass communities supporting tiger, banana, school and greasyback prawns (Morton and Healy 1992). The Strait itself is closed to trawling by a Marine Park. Consequently benthic habitats are not subject to trawl impacts within its boundaries, but banana, greasyback and school prawns are target species for beam trawlers in the adjacent Mary River estuary (Fig. 3). School and tiger prawns are also taken by otter trawlers adjacent to southern Fraser Island and the Wide Bay Bar (Fig. 4). Maryborough situated on the Mary River is a major population centre of 28,500, while the Townships of Tin Can Bay and Rainbow Beach have a collective population of 26,000.[21]

Wide Bay to Caloundra

The inner shelf seabed of the Cooloola Coast and Sunshine Coast is moderately steep, shallow and sandy and subject to a moderate seabed current stress (Strata 8 in Fig. 1; Table 1). The Noosa, Maroochy and Mooloolah River estuaries support mangrove and seagrass dominated habitat and beam trawling targeting banana and school prawns (Fig. 3). Sunshine coast stream catchments support a population of 255,000.[22]

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[20] *Australian Bureau of Statistics, 2012.*

[21] *Australian Bureau of Statistics, 2012.*

[22] *Australian Bureau of Statistics, 2012.*

Moreton Bay

In general Moreton Bay is very shallow (2 – 11 m), with water low in nitrate, high in silicate and a variable range in temperature at the seabed (Ellis & Pitcher, 2010). Extensive mangrove and seagrass habitats fringe the western shores of Moreton Bay where sediments are fine, relatively high in mud and moderate in carbonate content, and have low exposure to current stress. Northern and eastern Moreton Bay sediments are coarser, sandy and subject to greater current stress (Fig. 1, Table 1). Benthic habitats of Moreton Bay have been classified and mapped by Stevens & Connolly (2004). Most of the habitat areas that support living structural components of the seabed that have low resilience to trawling are inaccessible to trawlers within closures of the Moreton Bay Marine Park.

The State Capital city of Brisbane lies along the western shore of Moreton Bay and in 2011 had an estimated population of 2.74 million.[23]

Cape Moreton to Point Danger

Wave dominated shorelines predominate in this area of extensive sandy beaches and major rocky headlands of Cape Moreton, Point Lookout and Point Danger. Inshore oceanic habitats of Moreton Island and North and South Stradbroke Islands and the Gold Coast are subject to increased seabed current stress (Table 1). The City of the Gold Coast lies adjacent to the southern part of this area with a resident population of 536,500 in 2011.

The Sublittoral Shelf

Pitcher (2002) identified the environmental factors that influence the distribution and abundance of sublittoral shelf seabed habitats (and their related biotic assemblages) in the GBR as:

- percentage of mud in the sediments
- force of water currents (benthic stress)
- turbidity
- depth
- nutrients.

A qualitative description of these and other physical factors relevant to habitat characterisation of the inner, mid- and outer sublittoral shelf is provided below.

[23] *Australian Bureau of Statistics, 2012.*

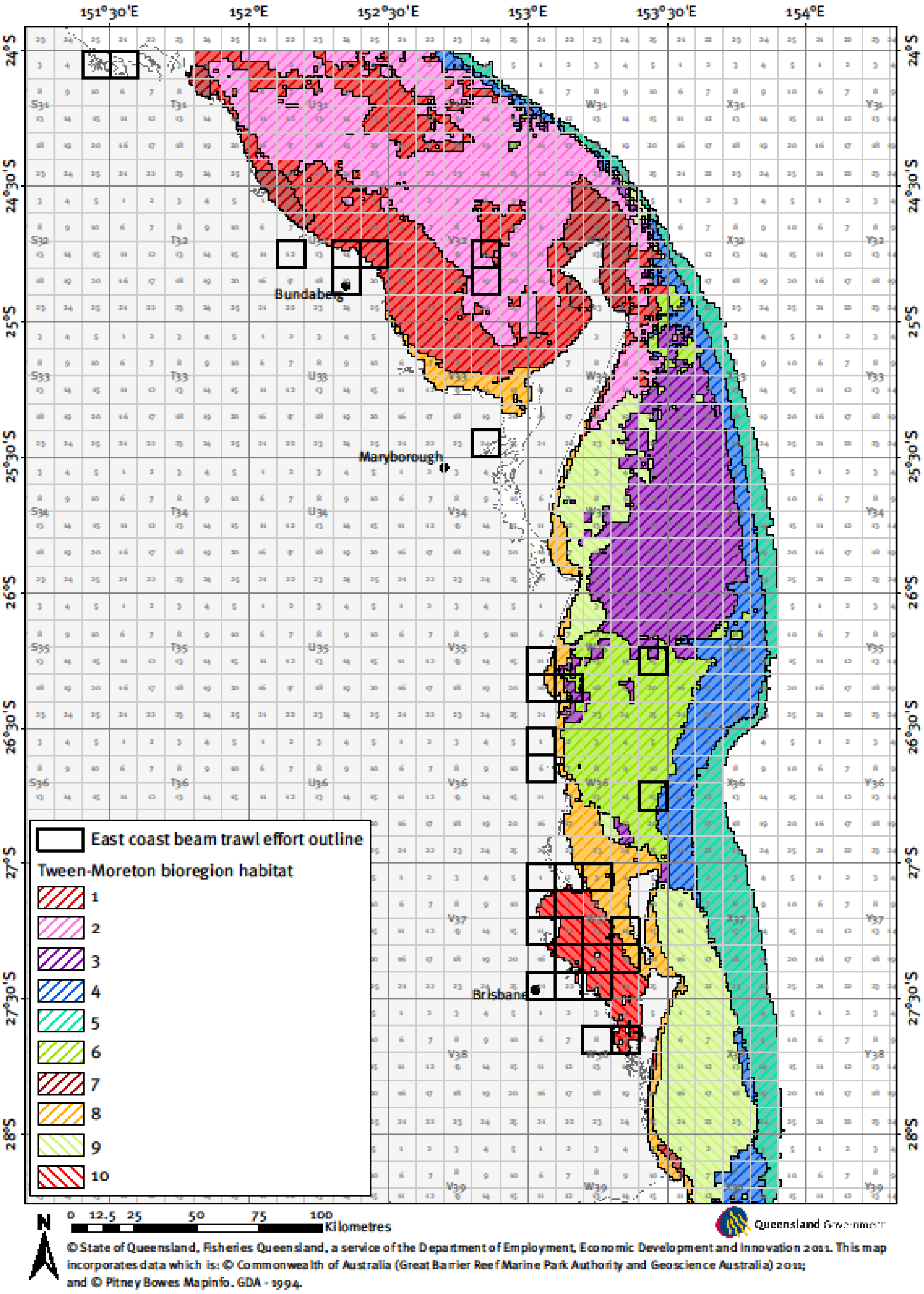

Figure 3. Map outlining beam trawl effort applied to seabed habitats in the Tweed-Moreton Bioregion in 2009.[24] Biophysical strata from Kenna & Kirkwood (2008).

[24] *Effort data sourced from commercial fishery logbooks*

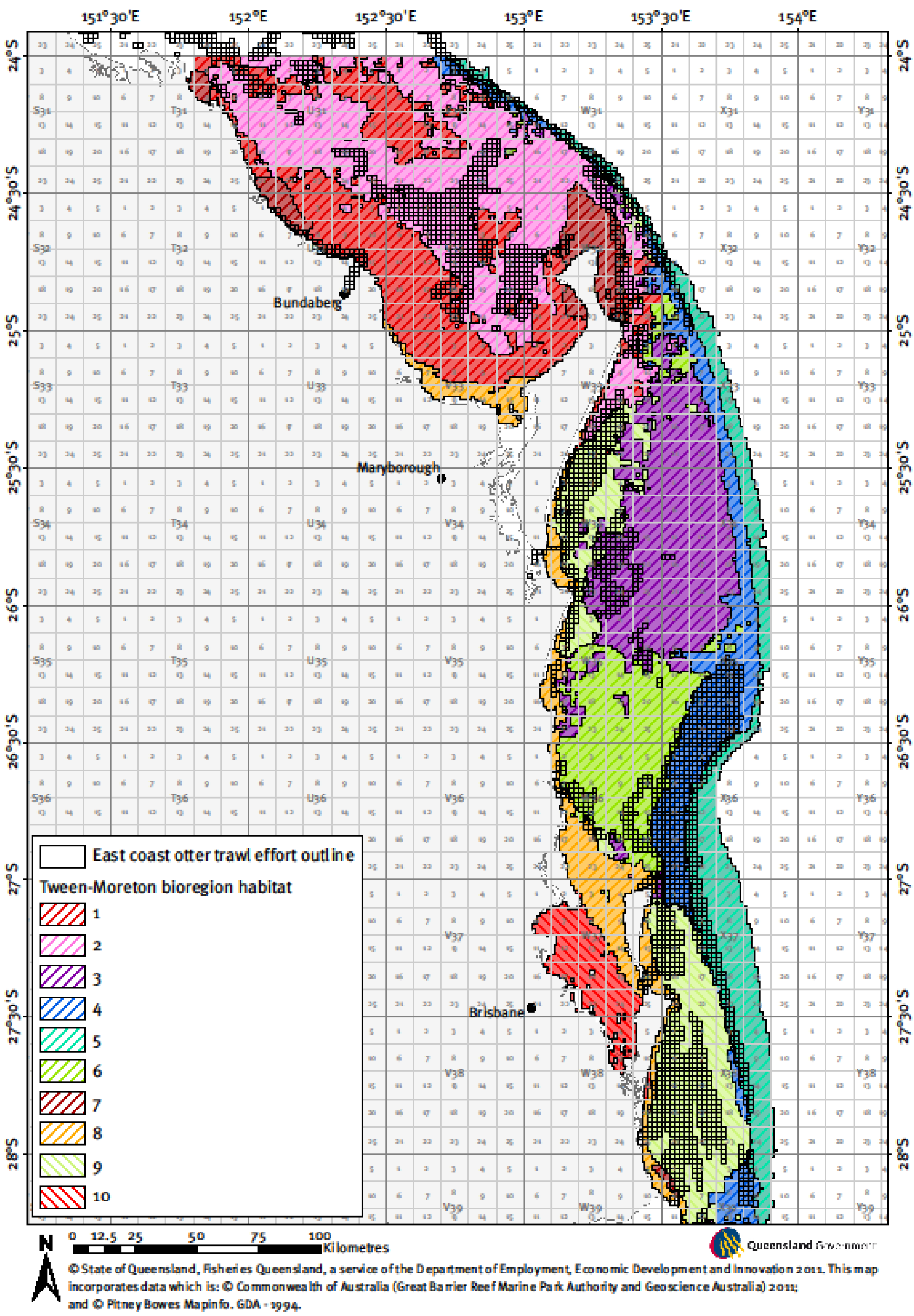

Figure 4. Map outlining otter trawl effort applied to seabed habitats in the Tweed-Moreton Bioregion in 2009.[25] Biophysical strata from Kenna & Kirkwood (2008).

[25] *Effort data sourced from commercial fishery logbooks*

Inner Shelf

From Breaksea Spit to Point Danger the inner shelf ranges in depth from 44 – 59 m. Sediments are moderate to high in carbonate offshore from Indian Head, Fraser Island to Cape Moreton, but sandier further south. Water is low in nitrate and phosphate and water temperature at the seabed often varies by as much as 5.0°C (Ellis & Pitcher, 2010). The most influential physical variable for predicted assemblages of marine fauna on the mid-shelf seabed is variation in water temperature at the seabed (ibid.).

Mid shelf

The mid shelf varies in depth from 57 – 86 m. At the seabed, average water oxygen is low but stable, average water temperature is 18.5 – 19.8 °C, and average water silicate concentration is low (Ellis & Pitcher 2010). The most influential physical variable for predicted assemblages of marine fauna on the mid-shelf seabed is average water temperature (ibid.).

Outer shelf

The outer shelf varies in depth from 137 – 235 m. At the seabed, average oxygen in the water is very low and stable and water temperature is also stable. Benthic irradiance (loosely defined as a measure of light penetration) is stable (Ellis & Pitcher 2010). The most influential physical variable for predicted assemblages of marine fauna on the outer shelf seabed is average water oxygen concentration (ibid.).

Slope

The most influential physical variables for predicted assemblages of marine fauna is depth of the slope seabed (275 –3 57 m), relatively high nitrate and phosphate concentrations, very low average water temperature at the seabed and stable but very low benthic irradiance (Ellis & Pitcher 2010). Two canyons occur on the slope offshore of Coolangatta (Keene *et al*., 2008).

Sublittoral Shelf Biotypes

An inventory of seabed habitats at the biotype level (Table 2) describes the broad-scale physical and biological properties salient to assessment of trawl capture related risk. This is facilitated by dividing the study area into four latitudinal sub-regions:

- Northern (Southern GBRMP boundary to Sandy Cape),
- Northern Central (Sandy Cape to Noosa Head)
- Southern Central (Noosa Head to Cape Moreton)
- Southern (Cape Moreton to Point Danger).

Each sub-region highlights known locations where structural benthic biota components co-occur with the physical habitat types mapped in Figure 2.

Northern sub-region

At the northern boundary of the study area (i.e. the southern boundary of the GBRMP at 24.5°S), the shelf is at its widest, up to 130 km offshore from Bundaberg (Keene *et al*., 2008).

The shelf break is relatively narrow (~10 km) in this area (Fig. 1). Seabed habitats are characterized by: sandy sediments low in mud, gravel and carbonate; increasing bottom shear stress with distance offshore reaching a peak in the vicinity of Breaksea Spit/Sandy Cape; shallow (<50 m) water low in turbidity and increasingly variable dissolved nitrogen and phosphorus concentrations with distance offshore (Pitcher *et al*., 2007). At this latitude an estimated 45% of the inner to mid-shelf seabed is unvegetated, while seagrass and algal (*Halimeda and Caulerpa*) beds cover 40% of the seabed. Seagrass on the outer shelf is sparser, while algal beds persist (Pears *et al*., 2012). Epifauna consisting of relatively small amounts of sponge, gorgonians, alcyonarians and sea whips (*Gorgonacea*) are also present on the inner to mid-shelf seabed (ibid.). In Hervey Bay, algae, alcyonarians and sponges inhabit the seabed where trawling occurs (Barker *et al*., 2004).

Northern central sub-region

Between Sandy Cape and Noosa Head, the shelf width is at its greatest (80 km in the vicinity of Double Island Point). The shelf break in this area is also wider than further north (Fig. 2). Shelf seabed habitats in this section are the most diverse of the study area characterized by: sandy sediments inshore; carbonate sand and reefs on the mid- to outer shelf and an increased incidence of gravelly sediments south from Double Island Point (Fig. 2; Table 1). Seagrass, sponges, gorgonians and kelp (*Ecklonia radiata*) have been recovered from research trawls on the outer shelf at the latitude of Noosa Head approximately 26° 23´ S (Table 2).

Southern Central sub-region

Between Noosa Head and Cape Moreton the shelf narrows, about 30 km in the vicinity of Cape Moreton (Fig. 3). Shelf seabed habitats are generally sandy sediments inshore; carbonate sand, reefs and gravel patches on the mid shelf (Fig. 2; Table 1). Major structural components of benthos inhabiting the mid-outer shelf in the southern ECTF area include sponges, kelp, gorgonians, stony coral, soft coral, sea pens and zoanthids subsampled during otter trawl bycatch research in the eastern king prawn fishery (Courtney *et al*., 2007).

Information on the extent of their spatial distributions is limited to point data mainly within the area bounded by 26 deg 43 min S, 153 deg 28 min E; 26 deg 16 min S, 153 deg 48 min E, 27 deg 41 min S, 153 deg 48 min E and; 28 deg S, 153 deg 34 min E and 27 deg 11 min S, 153 deg 28 min E. This area forms only a small part of the Tweed Moreton Bioregion, but covers the main otter trawl fishing grounds between Noosa Head and Point Danger (Fig. 1).

Cape Moreton to Point Danger

Seaward of Cape Moreton the shelf is 30 km wide. Its width increases to 50 km off Point Danger (Fig. 2). Shelf seabed habitats are generally sand and sandy mud inside Moreton Bay and sand on the mid shelf (Fig. 2; Table 1). Major structural components of benthos inhabiting the mid-outer shelf in the southern ECTF area include sponges, macroalgae, gorgonians, stony coral, soft coral, sea pens and zoanthids subsampled during otter trawl bycatch research in the eastern king prawn fishery (Courtney *et al*., 2007).

Littoral Shelf Biotypes

The physical environment, seabed and biota of inshore marine and estuarine areas within the study area are broadly described at the primary and secondary biotype levels (Table 2). Five sub-regions have been selected based on coastal geomorphology, and habitat homogeneity and continuity. Locations of major human population centres are included as a pressure and modifier of habitats that support trawl fishery resources.

Hervey Bay

The coastline from Bustard Head to Burrum Heads is open sandy beaches punctuated by fringing rock and coral reef and mangrove lined estuaries, some with seasonal seagrass cover (Lupton, 1993). Nearshore benthic habitats of Hervey Bay typically have sand and gravel sediments low in carbonate and subject to increased currents (Table 1). The average water temperature at the seabed exceeds 24.3 °C (Kenna & Kirkwood, 2008). Water depths vary from 12 – 25 m and nitrate and phosphate concentrations in the water are very low (Ellis & Pitcher, 2010). Banana prawns, greasyback prawns and king prawns inhabit estuaries in this sub-region (Lupton, 1993; Lupton & Heidenreich, 1999). The main species targeted is banana prawns within the Burnett River estuary by beam trawling and in shallow inshore waters adjacent to the Burnett River estuary by otter trawling. Bundaberg and Hervey Bay are major population centres of 69,500 and 61,700 people.[26]

Fraser Island to Tin Can Bay

Nearshore seabed habitats adjacent to more than 100 hundred kilometres of sandy beach and rocky headlands along the exposed shores of northern and eastern Fraser Island from Break Sea Spit to Wide Bay Bar are subject to increased seabed current stress (Table 1) generated by easterly winds, ocean swells and tides and the edge of the East Australian Current which meanders across the shelf is this area. Within the Great Sandy Strait and Tin Can Bay are sheltered estuarine waterways supporting extensive saltmarsh, mangrove and seagrass communities supporting tiger, banana, school and greasyback prawns (Morton & Healy, 1992). The Strait itself is closed to trawling by a Marine Park. Consequently benthic habitats are not subject to trawl impacts within its boundaries, but banana, greasyback and school prawns are target species for beam trawlers in the adjacent Mary River estuary. School and tiger prawns are also taken by otter trawlers adjacent to southern Fraser Island and the Wide Bay Bar. Maryborough situated on the Mary River is a major population centre of 28,500, while the Townships of Tin Can Bay and Rainbow Beach have a collective population of 26,000.[27]

Wide Bay to Caloundra

The nearshore seabed of the Cooloola Coast and Sunshine Coast is shallow and sandy and subject to a moderate seabed current stress (Table 1). The Noosa, Maroochy and Mooloolah River estuaries support mangrove and seagrass dominated habitat and beam trawling targeting

[26] *Australian Bureau of Statistics, 2012.*

[27] *Australian Bureau of Statistics, 2012.*

banana and school prawns. Sunshine coast stream catchments support a population of 255,000.[28]

Moreton Bay

In general Moreton Bay is very shallow (2–11 m), with water low in nitrate, high in silicate and a variable range in temperature at the seabed (Ellis & Pitcher, 2010). Extensive mangrove and seagrass habitats fringe the western shores of Moreton Bay where sediments are fine, relatively high in mud and moderate in carbonate content, and have low exposure to current stress. Northern and eastern Moreton Bay sediments are coarser, sandy and subject to greater current stress (Table 1). Refer to Stevens & Connolly (2004) for more information on the benthic habitats of Moreton Bay.

Most of the habitat areas within Moreton Bay a) support living structural components of the seabed that have low resilience to trawling and/or b) are inaccessible to trawlers due to Moreton Bay Marine Park closures. The State Capital city of Brisbane lies along the western shore of Moreton Bay which has an estimated population of around 2.74 million.[29]

Cape Moreton to Point Danger

Wave dominated shorelines predominate in this area of extensive sandy beaches and major rocky headlands of Cape Moreton, Point Lookout and Point Danger. Inshore oceanic habitats of Moreton Island and North and South Stradbroke Islands and the Gold Coast are subject to increased seabed current stress (Table 1). The City of the Gold Coast lies adjacent to the southern part of this area with a resident population of 536,500 in 2011.

Biological Facies

At the level of biological facies, dominant species act as surrogates for the benthic biota adapted to local conditions (Table 2). Information on their distribution is generally good within Moreton Bay, but patchy elsewhere on the littoral shelf. On the sublittoral shelf the available information is neither detailed nor comprehensive and instead relies upon research data from a variety of recent studies (*e.g.* Marshall *et al.,* 1998, Hooper & Ekins, 2004; Cairns, 2004; Barker *et al*., 2004; Stevens & Connolly, 2005; Courtney *et al*., 2007)

Shelf Benthos

Geomorphology and sediment types are primary determinants of the distribution of benthic organisms in the CEST (DEWHA, 2007). While it has been established that more southerly areas of shelf habitat within the TMB have similar physical properties to those located further north as confirmed by the first IMCRA classification of marine geomorphological and sediment characteristics of the shelf between Fraser Island and Coffs Harbour (IMCRA Technical Group, 1998), north-south connectivity appears not to extend to biotic communities of the shelf. The ECTF south of the GBR is recognized as a major tropical/temperate divide within the East Marine Region located on the continental shelf between Fraser Island and Coffs Harbour. The

[28] *Australian Bureau of Statistics, 2012.*

[29] *Australian Bureau of Statistics, 2012.*

area being a transition zone for benthic communities such that the occurrence of tropical benthic species ranges from approaching 100% at the northern tip of Fraser Island, to almost 0% at Coffs Harbour; while the occurrence of temperate benthic species ranges from approaching 100% at Coffs Harbour, to almost 0% at the northern tip of Fraser Island (DEWHA, 2007). A major difference between the CEST benthos and benthos of the shelf adjacent to the southern GBR is a diminished capability of corals to build reefs. This is limited by lower seawater temperatures, reduced day length during winter and available calcium carbonate for skeleton formation (DEWHA, 2007).

A comparison of species identified from research trawl samples (Courtney *et al*., 2007; Graham, 2007), indicate there are broad similarities in the epibenthos taken as trawl bycatch in southern Queensland and northern NSW.

Systematic sampling of the shelf seabed by benthic sled yielded a large amount of information on the distribution; composition and abundance of benthic communities within the GBRMP (see Pitcher *et al*., 2007). However, there is a paucity of such data within the study area. These have been sourced from the otter trawl bycatch research sampling of Courtney *et al*. (2007) in the eastern king prawn sector of the ECTF. From the data that do exist, only qualitative descriptions and locations of structural components of sedentary seabed biota are possible.

Sponges

Hooper & Ekins (2004) state that some environmental variables have been linked to community heterogeneity at a sub-regional level, among them light, depth, substrate quality, local reef geomorphology water quality, flow regimes, food particle size availability, and larval recruitment and survival. However, the effect of environmental variables on the species composition of sponges and other sedentary benthic biota and their distribution within and among the habitats considered in this assessment, is not well understood.

Where sponges are documented in Australia, they exhibit very patchy spatial distributions at both small and large scales. At times they form the dominant structural benthic component of a community whereas in an adjacent area they may be practically absent (Hooper, 2007). Hooper (2007) has noted that sponge community structure is determined by a number of processes including:

- terrestrial impacts (e.g. freshwater input, turbidity, sedimentation, light penetration, nutrient levels, food particle size availability)
- geomorphology (e.g. microhabitat availability, type of substrate, aspect of the seabed, exposure to waves and currents, depth)
- small scale random events (e.g. patterns and timing of arrival and survival of larvae and asexually produced propagules, effects of severe storm events on fragmentation and dispersal)
- larger scale biogeographic events (e.g. historical changes to physical barriers and current patterns, climate change impacts, presence or absence of carbonate platforms versus other substrata, etc.

Analysis of species richness shows a peak (possible biodiversity 'hotspot') in tropical or subtropical sponge faunas at the Southeast Queensland – northern New South Wales biogeographic transition zone (with a peak in the Moreton Bay region) (Hooper & Ekins, 2004).

While a classification of benthic community types within Moreton Bay supports this, sponge density appears to be lower on the mid-shelf but increases on the outer shelf. For example, Courtney *et al*. (2007) reported only 3% of eastern king prawn trawl bycatch samples from depths <91 m contained sponges compared to 26% containing sponges in samples from depths >91 m. In addition, only two taxa of sponge were identified to genus level (*Ircinia* and *Stelletta*). This is perhaps not surprising as in the main, prawn trawl nets are designed to pass at a low level above the seabed rather than scraping the bottom in a manner akin to benthic sampling gear (*e.g.* a towed benthic sled). Sled gear is more suited to sampling sponges and other epibenthos and where it has been used specifically for that purpose; it has been successful in obtaining representative data of seabed communities.[30]

Courtney *et al*. (2007) found *Stelletta* well offshore in relatively deep water of the outer shelf. The slope of the seabed in this area increases with distance from the shore compared to the relatively flat mid-shelf. Sediments are generally gravelly sand with relatively high carbonate content (Habitat 4 in Table 1). *Ircinia* was only sampled at one location on the shelf break offshore from Point Lookout (Table 2). The slope of outer shelf increases further in the shelf break area where the seabed is mainly sand with moderate carbonate content (Habitat 5 in Table 1).

Sponges are also a significant component of the benthos in Hervey Bay scallop trawling.

Macroalgae

Two taxa of brown macroalga were identified (*Ecklonia radiata* and *Sargassum sp*.) in eastern king prawn bycatch samples reported by Courtney *et al*. (2007). *Ecklonia radiata* was widely distributed in depths of 31 – 155 m offshore from Noosa Head to the Jumpinpin Bar[31], but was present at higher densities at inshore sites. The sediments supporting *Ecklonia* growth appear to be gravelly sand with relatively high carbonate content on the outer shelf and sand on the mid-shelf (Habitats 4 & 9 in Table 1). *Sargassum* was only reported inshore near Indian Head, Fraser Island at a depth of 34 m, over a predominantly sand and gravel seabed with relatively low carbonate content (Habitat 1 in Table 1).

Hard Corals

As reef structures are few within the study area, hard corals are less significant than those contributing to the GBR, but by their structural complexity & metabolic processes still provide shelter and food for a wide range of invertebrates and fishes (Wallace & Muir, 2007). Where suitable conditions exist (*e.g.* submerged rock platforms), diverse coral communities may flourish. Flinders Reef, near Cape Moreton, supports at least 119 coral species (Veron, 1993; Harrison *et al*., 1998). But at other (e.g. locations coral diversity on rocky substrate are much

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[30] See epibenthos sampling procedures in Pitcher et al., 2007

[31] Ecklonia radiata is a common macroalgae of the shelf in NSW m depth in the subtidal zone.

lower approximately 50 km north of Flinders Reef A single site was sampled at Flinders Reef. Of all subtropical sites where *S. hystrix* are recorded, only one was not sampled. This was the Gneering Shoals, a low-diversity coral community growing on, which is known to have only sporadic occurrences of *S. hystrix* (Harriott & Banks, 1995). Colonial and solitary forms are known to occur in a number of shelf habitats. Colonial substrate attached forms include staghorn coral *Acropora* spp*.* a component of the benthos on the Hervey Bay saucer scallop trawl grounds (Barker *et al*., 2004) and *Astrangia woodsi* reported from central Moreton Bay, 5 nm west of Tangalooma in 18 m of water (Cairns, 2004).

Solitary forms occur from shallow coastal waters to deeper water on the outer shelf and include: mushroom coral species *Fungia* sp. - a component of the benthos on the deepwater eastern king prawn trawl grounds (Courtney *et al*., 2007) and a variety; *Truncatoflabellum martensii* collected from the outer shelf, 20 nm ESE of Caloundra at a depth of 139 m (Cairns, 2004); *Balanophyllia bairdiana* and *Endopachys grayi* collected from the outer mid shelf NE of Cape Moreton at a depth of 115 – 124 m (ibid); *Heteropsammia moretonensis* collected in the Pearl Channel in Northern Moreton Bay at a depth of 11 m (ibid); and *Trochocyathus* spp. collected from the mid shelf, 10 nm south east of Point Lookout, North Stradbroke Island at depths of 75 – 81 m and on the outer shelf 14 nm east of Jumpinpin Bar at a depth of 86 m (ibid). Asexual reproduction, by regeneration of accidentally broken fragments, is also possible in many colonial coral species (Wallace & Muir, 2007). This implies that disturbance by trawling need not necessarily lead to mortality of the whole colony.

Soft Corals

Soft corals (Family Alcyonacea) are a group of anthozoans that lack the massive solid exoskeleton of hard corals (Fabricius & Alderslade, 2001). Tree coral (*Dendronephthya* spp.) is a common component of the benthos in scallop trawl areas of Hervey Bay (Barker *et al*., 2004).

Gorgonians

Unidentified gorgonian specimens were recovered at two locations (Table 2) in depths ranging from 91 – 108 m in eastern king prawn bycatch samples reported by Courtney *et al*. 2007 (Appendices 1 and 5). Seabed sediment is mainly moderately high carbonate sand at the mid-shelf location where gorgonians were sampled and gravelly sand high in carbonate at the outer shelf location (Habitats 3 and 4 in Table 1).

Sea Pens & Zoanthids

Sea pens were also present in shallower EKP bycatch samples (Courtney *et al*., 2007). *Sphenopus marsupialis* is zoanthid consisting of a robust solitary polyp living on sublittoral sandy substrata, not on coral reefs and may be attached to stones or sea grass blades when small.

Inshore and Estuarine Benthos

The diversity of structural biota is limited by wave action in shallow inshore waters adjacent to ocean beaches. However the tide-dominated systems of Hervey Bay, Great Sandy Straits, Tin Can Bay and Moreton Bay provide adequate protection from ocean swells to consolidate benthic sediments that support highly productive seagrass and mangrove communities inhabited by a rich diversity of crustacean, mollusc and fish species including those harvested in the southern ECTF.

Data supporting the existence of sedentary biota providing subtidal 3-D structure in estuaries within the study area have been sourced from otter trawl bycatch research sampling in the banana prawn otter trawl sector and from Hyland *et al* (1998) in the bay/banana prawn beam trawl sector of the ECTF. Additional relative abundance data have been sourced from bycatch samples from the Southern Section of the study area.

Off southern Queensland quartz sand continues to form a narrow inner shelf belt with carbonate dominating the mid-and outer-shelf (Fig. 5). Carbonate forms >90% of the sediment on the modern biothermal accumulations known as Gardner and Barwon Banks where red algae is a common component (Marshall & Davies, 1978; Marshall, 1980; Marshall *et al*., 1998). The coralline algae are encrusting and have bound other skeletal fragments to form banks and hardgrounds (Marshall, 1980). The mid-to outer-shelf sediments offshore from Fraser Island are sands, gravels and crusts consisting of coralline algae, hermatypic corals, large benthic foraminifers, bryozoans, Halimeda, molluscs and algal rhodoliths up to pebble-sized (Marshall *et al*., 1998). Seafloor photographs in Marshall *et al*. (1998) show living corals on Gardner Bank and rhodolith gravel blanketing the sediment surface on the outer shelf off Fraser Island. The East Australian Current sweeps the seabed here and the rhodoliths are moved by southerly flowing bottom currents with speeds of up to 1.34 ms^{-1} in water depths of 40 – 140 m (Harris *et al*., 2005). A limestone platform underlies the present day sediments on Gardner Bank and outcrops where it forms the shelf edge. Barwon Bank hosts few corals and lacks Halimeda but has abundant bryozoans, barnacles, benthic foraminifers, serpulid encrustations and pelecypods to form a temperate reef.

North of Fraser Island, in Hervey Bay, the shelf is underlain by a lithified (limestone) tropical carbonate platform covered by a thin veneer of migrating quartz sand dunes (Marshall, 1977, Boyd *et al*., 2004). A multibeam image of Stingray Shoal shows it to be roughly circular, approximately 1000 m across at the top (17 m water depth) and rising steeply from the sand dunes which surround its base in 35-40 m of water (Boyd *et al*., 2004). It is composed of coral and coralline algae, some living. Shoreward (west) of these outer-shelf dunes are poorly-sorted fine to coarse sands with some gravel and shell particles, which form the seabed in Hervey Bay (20 m water depth). Their composition of feldspar and rock fragments show them to from the local rivers and reworked Pleistocene shore ridges (Boyd *et al*., 2004).

The interpolated sediment maps give an interpretation of possible regional distribution of sediment properties. Areas with the highest sand (50-100% sand) and lowest mud (<50% mud) content are predicted to occur on the inner-to mid-shelf (Fig. 1) except offshore of Hervey Bay where large variations of gravel (10-90%) and sand (0-100%) content occur.

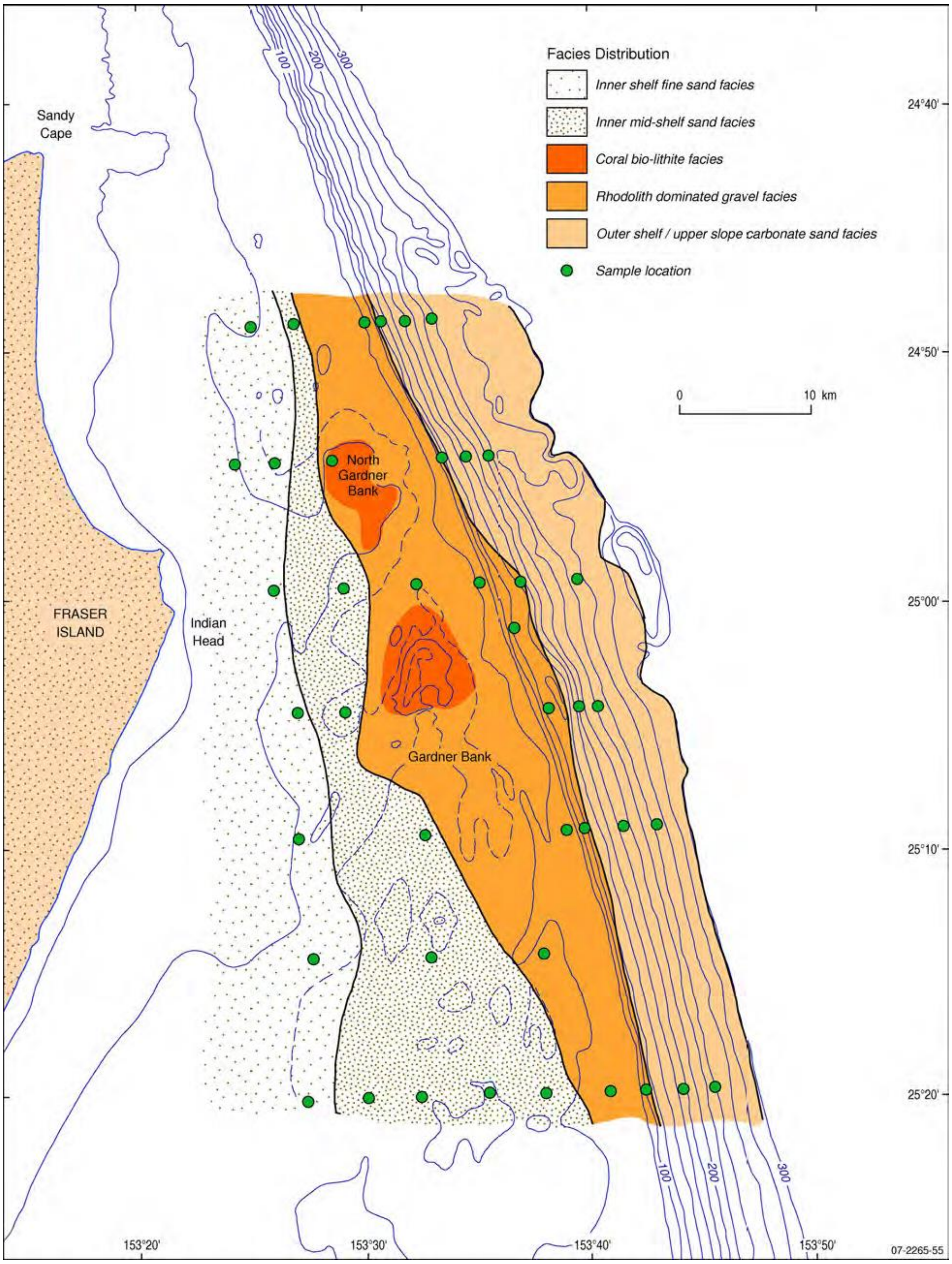

Figure 5. Bathymetric map offshore of Fraser Island showing the distribution of sedimentary facies on the shelf and upper slope around North Gardner Bank and Gardner Bank. (Marshall *et al*., 1998).

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