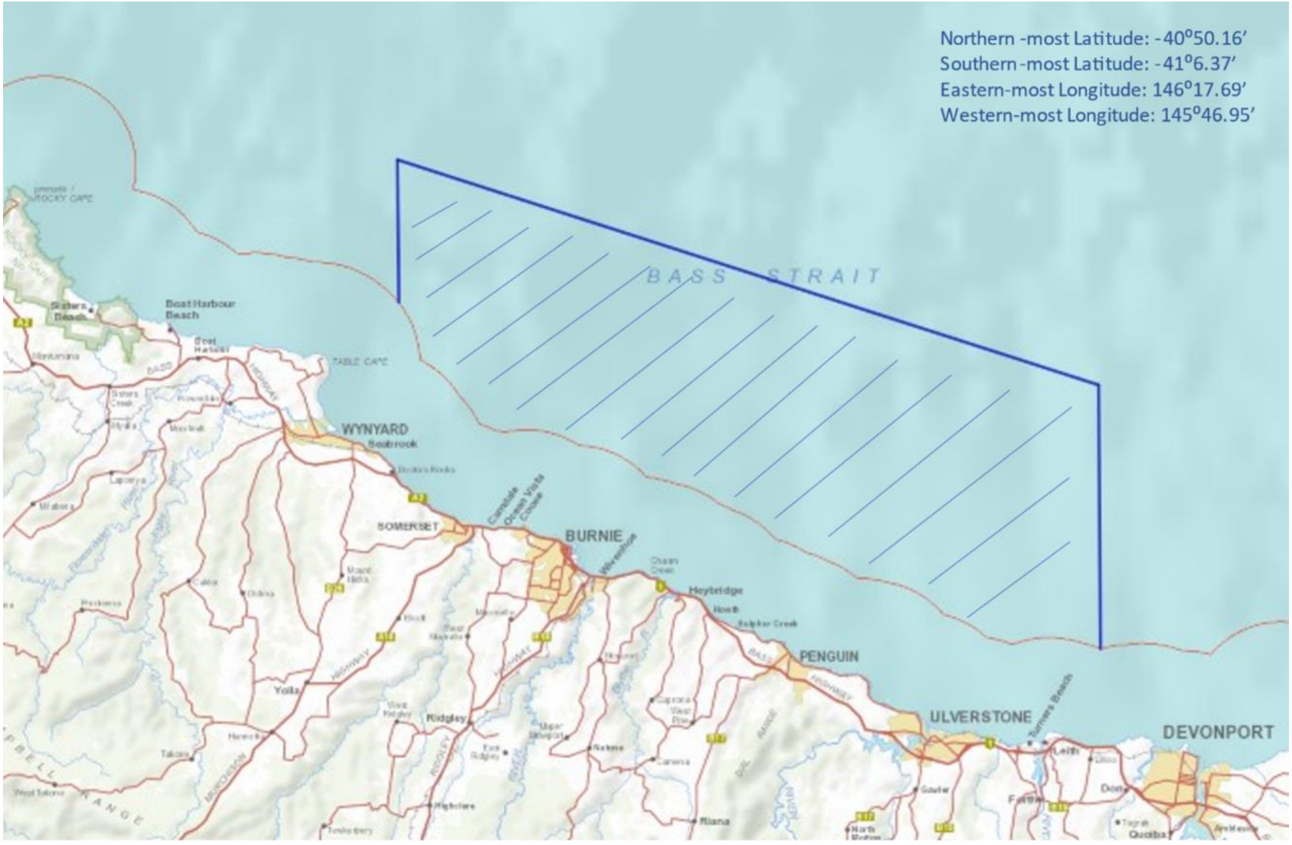
COMMERCIAL FISHING DATA:

Blue Economy CRC fishing data assessment area



Report Prepared by
Atlantis Fisheries Consulting Group

27/07/2022

Version 3.2

ATLANTIS
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EXECUTIVE SUMMARY

Background

The Blue Economy CRC brings together 43 industry, government, and research partners with the aims of supporting the move to high energy offshore aquaculture production and introducing novel approaches and innovation to production systems and operations to decrease production costs.

Blue Economy CRC have engaged Atlantis FCG to report on commercial fishing industry catch and effort in the vicinity of a proposed Blue Economy fishing data assessment area (Figure 1) and to also provide preliminary information on the extent to which that activity may pose a physical threat (risk) to fish farm infrastructure.

The commercial fishing industry is a broad congregation, with management and rights divided initially between state (in this case Tasmanian) and Commonwealth management. In South-East Australia this results in some fisheries being represented by more than one peak body with many represented by both a higher-level and a regional-level association.

Fisheries operating in and around the Blue Economy CRC fishing data assessment area

Atlantis FCG sub-contracts Fishwell Consulting; a leading fisheries consulting firm who specialise in fisheries project design and execution to undertake data requests and interrogate data in order to understand fishing in the Blue Economy fishing data assessment area.

Fisheries agencies have confidentiality policies that restrict making public, data that is comprised of less than five vessels. This is often referred to as the "*five-boat rule*". Given the expected smaller number of Tasmanian vessel believed to be working the area it was hoped that the longer time period would have a greater chance of passing Tasmanian data release confidentiality hurdles. Historical data was therefore obtained for Commonwealth fisheries for the last 10 years and for Tasmanian fisheries for the last 20 years.

Currently, 17 fisheries (see Table 3), managed by the Commonwealth and Tasmanian Governments overlap with the fishing data assessment area. However, data showed that only five of these recorded actual fishing activity in the vicinity of the fishing data fishing data assessment area in recent years.

In the Commonwealth's jurisdiction only the SESSF Shark Fishery (Gillnet and Hook sectors) and Southern Squid Jig Fishery have reported effort in the past 10 years.

Within Tasmania's jurisdiction effort has been recorded in the past 20 years for the Tasmanian Scalefish fishery, Abalone Fishery, and Rock Lobster Fishery.

Permissible fishing methods across these five fisheries are wide ranging and described in detail in the report.

Due to these confidentiality rules, data about the size of the catch from the fishing data assessment area was not available for the Tasmanian Abalone fishery or the Southern Squid Jig fishery.

Catch and effort overlap

These five commercial fisheries registered effort (fishing activity) in the fishing data assessment area (refer Table 1), with a combined average[1] annual catch amount and value[2] of 15t and $123,000.

[1] based on 10 year averages for Commonwealth and 20 year averages for Tasmanian fisheries
[2] using indicative current fish prices

Most of this catch and value was from the Tasmanian Scalefish Fishery. This fishery uses a variety of methods (fishing gears) to target several species. Target species and methods include squid jig (Southern calamari), octopus trap (pale octopus), and fish trap (wrasse sp.), purse seine, beach seine and dip nets. However, after direct communication with fishers in northern Tasmania this report contends that only squid jig, octopus trap and fish trap operate in or near the fishing data assessment area. The remaining methods operate further inshore in shallower water and were therefore not assessed for risk in this report. The report was not able to differentiate between the catch or value of different methods (within this fishery), so the catch and value are for all gear types used in the fishery near the fishing data assessment area. This means that the catch and value that overlaps with the fishing data assessment area is over-estimated to an unknown extent.

The bulk of the remainder of the landed catch was attributable to the Commonwealth managed Gillnet Hook and Trap fishery which targets gummy shark with gillnet and demersal longline.

Remaining activity was from the Commonwealth Southern Squid Jig Fishery which targets Gould's squid (arrow squid) using auto squid jigging apparatus. However, data remains confidential under the "five boat rule".

There appears to also be a small amount of rock lobster fishing using pots by the Tasmanian Rock Lobster Fishery.

Finally, abalone harvesting by divers was present, however, to date most of this activity has been concentrated on shallower more productive grounds further inshore of the research area (pers. comm. J. Harrington, CEO Tas. Commercial Fishers Assoc., June 2022), nevertheless, given the potential for some activity overlap this crayfishing was included in the Risk Assessment.

The data release confidentiality rules, described earlier, mean that although the Commonwealth Southern Squid Jig Fishery and the Tasmanian Rock Lobster Fishery are present there is no data regarding the extent of their catches in the fishing data assessment area. Data not released does not necessarily indicate low catch and/or value, it is possible that a few vessels (<5) from each fishery catch a lot of fish in the fishing data assessment area. This underestimates the catch and value overlapping with the fishing data assessment area to an unknown extent. However, by collating data over a 10[3]-20[4] year period the probability of acquiring insightful data was improved; in this case it appears that the number of Commonwealth licensed squid fishers and Tasmanian cray fishers operating in the fishing data assessment area has indeed been historically low (i.e., <5).

Risk Assessment

Dr John Wakeford was engaged by Atlantis FCG to gauge the potential physical impact that the nine operational fishing gears/methods in the fishing data assessment area may have on Blue Economy CRC infrastructure by providing comparative impulse and pulling force data for each.

The four types of impulses considered were attributable to:

1. fishing vessel collision
2. vessel anchor drop impact
3. vessel anchor drag impact
4. descending fishing gear impact,

[3] For Commonwealth fisheries
[4] For Tasmanian fisheries

Additionally, as a fifth risk factor, pulling force was considered and relates to the pulling force associated with freeing snagged fishing gear.

Input data used in all impulse and pulling force calculations was based on representative vessels, gears, equipment, tackle, and methods used in each fishery.

The output results were all indexed relative to the highest value (given an index value of 1.00) in each category and then summed to give an overall "Risk" score between 0-5, thus enabling the nine fishing methods to be ranked according to the potential damage they may inflict on fish farm infrastructure.

Overall risk scores

The overall Risk scores (refer Table 2) showed great variation across the fishing methods assessed, ranging from 4.54 to 0.30.

It was evident that the larger vessels with more momentum, heavier anchors and utilising bulkier/heavier gear, (namely demersal gillnet), posed the greatest risk of damaging Blue Economy CRC infrastructure. Whereas smaller craft with less momentum, lighter anchors, and less bulky/heavier gears, such as handline and hand gathering posed the least risk.

This outcome was very much governed by three key characteristics; vessel momentum, the mass of the vessel's anchor, and the momentum of the largest fishing gear ballast component.

Of note, squid jigging, despite having relatively lightweight fishing gear (squid jigging lines etc), still registered second overall because of the large maximum pulling force associated with its sea anchor (which was considered to be an integral part of the fishing gear), should that become entangled with farm infrastructure.

Further, there were three distinct natural groupings in overall risk score, namely Ranking 1-5, Ranking 6, and Ranking 7-8, which were largely dictated by the momentum associated with the representative fishing vessels used with that fishing method.

The type of interaction that poses the greatest risk

An analysis of the Impulse results for each fishing vessel/method revealed that Impulses associated with vessel collision (Type 1 - vessel comes to a standstill) were much greater than the other forms of Impulse considered (Type 2-4). In other words, for any given fishing method, vessel collision was the interaction that posed the greatest potential risk to Blue Economy CRC surface infrastructure.

Relative magnitude of impulses and pulling forces

It was apparent from the Impulse and Pulling force results, irrespective of fishing method, that a collision between fishing vessel and fish-farm surface infrastructure represents the greatest form of harm to this proposed activity, and that forces associated with anchor and fishing gear interactions will be at least one or two orders of magnitude less.

Table 1. Fisheries and fishing methods identified as operating in the fishing data assessment area, summary of annual average (timeframe in parenthesis) catch and revenue, total allowable catch (TAC) from 2020-21, total catch 2020/21 and percentage of catch within fishing data assessment area.

				A	B	C	D=C/B	E=A*price
Fishery (ordered by impact on annual average revenue)	**Methods**	**Data**	**Jurisdiction**	**Fishery TAC 2020-21 (tonnes)**	**Fishery catch most recent year (tonnes)**	**Average annual catch in area (tonnes)**	**% of Fishery catch from area**	**Average annual revenue from area (AUD)**
Tasmanian Scalefish Fishery[a]	Squid jig Fish trap Octopus trap Others	Table 9	Tasmanian	NA	293	10.7 (2002–2020)	3.7	$84,699
Shark Gillnet and Shark Hook Sector	Demersal Gillnet Demersal Longline	Table 7	Commonwealth	2,516	2,268	4.1 (2012–2021)	0.2	$37,618
Tasmanian Rock Lobster Fishery	Pot	Table 8	Tasmanian	1050.7	1037	0.014 (2002–2021)	<0.01	$757
Tasmanian Abalone Fishery[b]	Hand harvest	Confidential	Tasmanian	1,018.5[c]	1,011	Confidential	Confidential	Confidential
Southern Squid Jig Fishery	Squid jig	Confidential	Commonwealth	NA[d]	67	Confidential	Confidential	Confidential
TOTALS					**4,676**	**14.8+**		**$123,074+**

[a] *Over 14 fishing methods are permitted in the Tas. Scalefish Fishery, however, those shown are the ones which account for the bulk of the landed catch in the vicinity of the fishing data assessment area*

[b] *The numbers for the Tasmanian Abalone Fishery cannot be reported as less than five vessels have fished in the reporting grids annually and would breach confidentiality rules. However, it is likely that there is a negligible level of catch from within the fishing data assessment area. See section 2.6.1 for further detail.*

[c] *TAC listed is for 2020, data for landed catch is not yet available for 2021. However, of note, the TAC dropped to 833 t in 2021.*

[d] *The Southern Squid Jig Fishery is managed by effort rather than TAC.*

Table 2. Risk score and ranking with impulse and pulling force summary. (note: full results and workings shown in Section 3 and Appendix A)

Fishing method	Risk Ranking	Risk Score (= T1 + T2 + T3 + T4 + PF)	Impulse Type 1 Vessel impact Relative Score [T1]	Impulse Type 2 Anchor drop Relative Score [T2]	Impulse Type 3 Anchor drag Relative Score [T3]	Impulse Type 4 Gear drop impact Relative Score [T4]	Pulling force Snagged gear recovery Relative Score [PF]
Demersal gillnet	**1**	**4.54**	1.00	1.00	1.00	1.00	0.54
Squid jigging	**2**	**4.00**	1.00	1.00	1.00	-	1.00
Craypot	**3**	**3.97**	1.00	1.00	1.00	0.53	0.44
Octopus trap	**4**	**3.74**	1.00	1.00	1.00	0.51	0.23
Demersal longline	**5**	**3.63**	1.00	1.00	1.00	0.40	0.23
Fish trapping	**6**	**2.20**	0.48	0.33	0.44	0.51	0.44
Trolling	**7**	**0.34**	0.19	0.03	0.07	-	0.04
Handline	**7**	**0.34**	0.19	0.03	0.07	0.01	0.04
Hand gathering	**8**	**0.30**	0.19	0.03	0.07	-	-

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GLOSSARY

Abbreviation	Explanation
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
BSCZSF	Commonwealth Bass Strait Central Zone Scallop Fishery
CFA	Commonwealth Fisheries Association
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTS	Commonwealth Trawl Sector
ECDTS	East Coast Deepwater Trawl Sector
GABTS	Great Australian Bight Trawl Sector
GHaT	Gillnet, Hook and Trap
GVP	Gross value of production
RA	Risk Assessment
SESSF	Southern and Eastern Scalefish and Shark Fishery
SETFIA	South East Trawl Fishing Industry Association
SFR	Statutory fishing right
SGSHS	Shark Gillnet and Shark Hook Sector
SHS	Scalefish Hook Sector
SSIA	Southern Shark Industry Alliance
SSJF	Southern Squid Jig Fishery
TAC	Total Allowable Catch
TRLFA	Tasmanian Rock Lobster Fishermen's Association
TSF	Tasmanian Scalefish Fishery
TSIC	Tasmanian Seafood Industry Council

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PROJECT DESCRIPTION

Background

The Blue Economy CRC brings together 43 industry, government, and research partners from ten countries with expertise in aquaculture, marine renewable energy, maritime engineering, environmental assessments and policy and regulation. Their goals include research to support the move to high energy-offshore aquaculture production and decreasing production costs via improved access to high energy and offshore sites through development and adoption of regulatory regimes. To support this the Tasmanian Government recently passed the *Living Marine Resources Management Amendment (Aquaculture Research) Bill 2021* which enables marine aquaculture research in Commonwealth waters off Tasmania's coast. This research is the first step to establishing a framework for delivery of offshore aquaculture, focussed on finfish (i.e salmon farming), but with the view of expanding to seaweed and shellfish.

The study area for offshore aquaculture research that is the focus of this report are the Commonwealth waters of Bass Strait, north of Burnie. Blue Economy CRC have engaged Atlantis FCG to report on catch and effort of both Tasmanian and Commonwealth commercial fishing industry catches in the vicinity of the fishing data assessment area.

The nature of commercial fishing stakeholders

The fishing industry is a broad congregation, divided initially by State or Commonwealth management. Agreements between the Commonwealth and States for how this division occurs are unique, with some States such as NSW divided geographically (i.e., by a line or lines on the water), while other States such as Victoria use both a line on the water and also allocate rights by species (or taxonomic group). This initial management division is then followed by management and rights issued by "fishery". This complication has seen a network of representative peak bodies without formal structural linkages develop. In South-East Australia this sees fisheries represented by more than one peak body. Peak bodies can also be divided into those where stakeholders pay voluntary levies choosing to join or not, and those that are funded through compulsory levies or funded by (State) Government. In a rough order of informal hierarchy, the seafood and fishing industries are divided into a hierarchy of four as follows:

1. Seafood Industry Australia (SIA) is the peak body representing seafood production in Australia, it covers a variety of issues including social licence and media, exporting, shared marine space policy and labelling on behalf of the wildcatch and aquaculture industries. Initially Government funded but now through voluntary levies.
2. Commonwealth Fisheries Association (CFA) represents Commonwealth licenced fishing in Australia working on uniquely Commonwealth issues such as management strategies, cost recovery and Commonwealth Acts. Voluntary levies.

Neither of these two associations are likely to take involvement in regional issues unless they become of national significance. It is possible, perhaps even likely, that the establish a framework for delivery of offshore aquaculture will be of interest to SIA and perhaps CFA because it may become a national precedent.

3. State fisheries are represented by State funded bodies; the relevant association in Tasmania is the Tasmanian Seafood Industry Council (TISC).
4. Other fishery associations operate for both State and Commonwealth fisheries. Associations relevant to the Blue Economy CRC include: the Southern Shark Industry Alliance (SSIA), the Tasmanian Rock lobster Fisherman's Association (TRLFA), and the Tasmanian Abalone Council.

Project area

In order to report on catch and effort of both Tasmanian and Commonwealth commercial fishing industry catches in the vicinity of the research area, a fishing data assessment area, as shown in Figure 1, was provided to Atlantis FCG by Blue Economy CRC and is the basis of the data capture throughout this report.

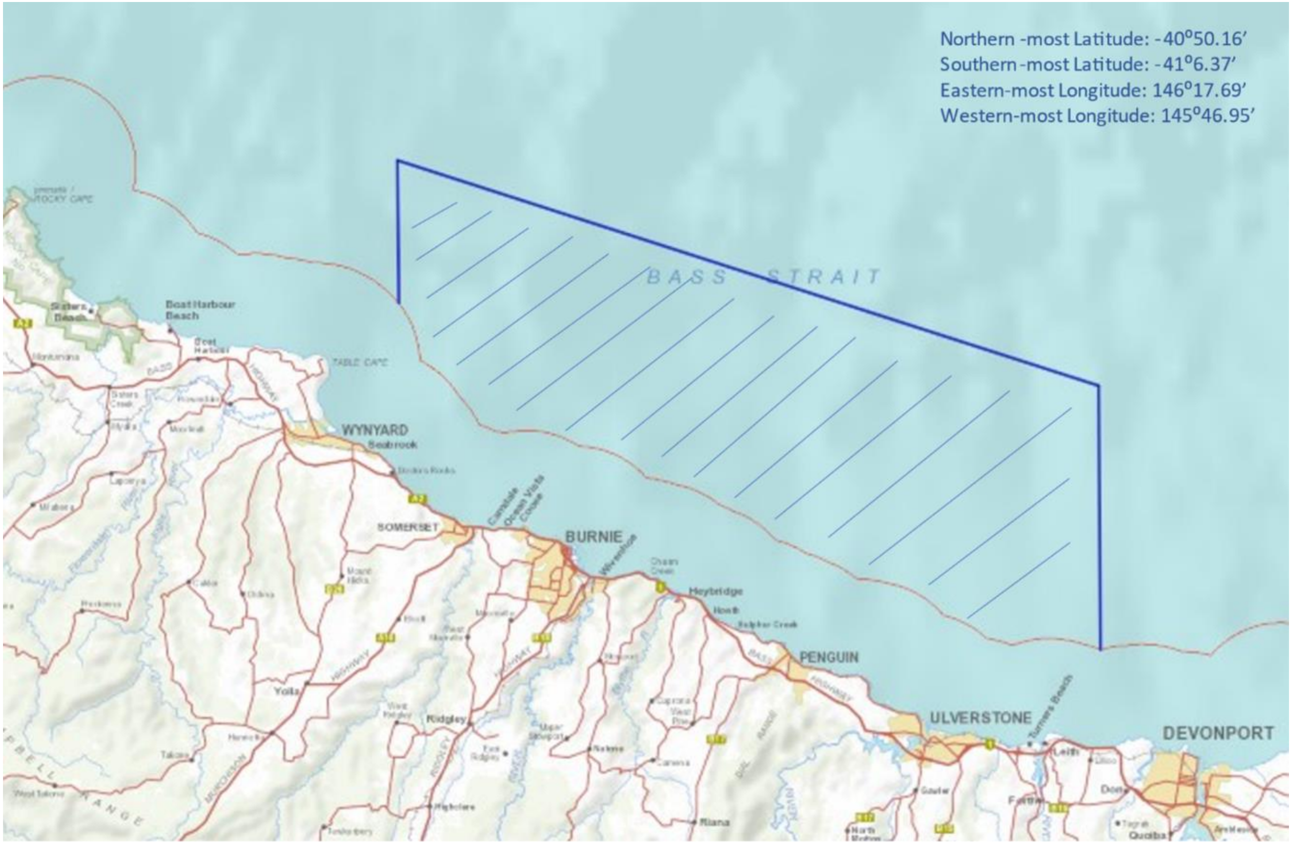


Figure 1. CRC Blue Economy fishing data assessment area.

Scope and deliverables

The client wishes to understand more about the commercial sectors present in the project area (Figure 1).

Therefore, the scope of this project is three deliverables as outlined below;

DELIVERABLE 1: FISHING INDUSTRY STAKEHOLDERS

1.1 To agree a polygon (hereafter referred to as the fishing data assessment area) with the Client (Figure 1)

1.2 To identify all fisheries permitted to work inside the fishing data assessment area

1.3 To provide a comprehensive stakeholder list of associations representing all sectors identified in 1.2.

1.4 To provide some general information about the vessel size, gear types, catches etc about impacted sectors and their fishing methods.

DELIVERABLE 2: FISHING GROUNDS

2.1 Obtain shape file data showing fishery closures, state marine parks, Commonwealth marine parks and PSZs[5].

2.2 Where relevant, to obtain shape file data about the area permitted to be fished by each fishery identified in 1.2

2.3 To draw together commercial fishing data for fisheries identified in 1.2 obtaining data from AFMA and Tasmanian DPI and then to aggregate this detailing in order of potential impact by section; the catch, approximate value, historical catches, catch limits and relative importance of the area for each sector.

2.4 Overlay and present data on a chart in as fine as possible scale, as well as providing in GIS format.

DELIVERABLE 3: FISHING METHOD RISK ASSESMENT

3.1 Comparative and tabulated risk ranking of fishing methods/gears (which are not jurisdictional) relevant to the activity occurring in and around the fishing data assessment area. Report to include Impulse data about anchor drop, anchor drag, vessel impact, and fishing gear impact. Methods explained and supporting information provided.

The scope of work excludes:

1) Consultation with the commercial fishing industry
2) Consideration of capability or training in the fishing method risk assessment
3) Data on the recreational fishery
4) Work on polygons additional to and later than that agreed with the Client at the beginning of the Project in 1.1.
5) Consideration of the nature of finfish aquaculture infrastructure.

[5] Petroleum safety zones

DELIVERABLE 1: FISHING INDUSTRY STAKEHOLDERS

1.1 Area of interest

The area of interest extends from the Tasmanian Coastal Waters limit to 18–27 km offshore covering an area of about 750 km^2 (Figure 1). It is situated north of Burnie in depths of 21–67 m. This area will be referred to as the fishing data assessment area throughout the document.

1.2 Fisheries permitted in the fishing data assessment area

A number of fisheries, both Commonwealth and Tasmanian managed, overlap with the fishing data assessment area (Table 2). However, for many of these, actual fishing has not occurred in recent years (10 years for Commonwealth, and 20 years for Tasmanian managed).

To account for any possible short-term temporal variation in fishing effort, fisheries which recorded effort in the past 10 years (Commonwealth managed) and 20 years (Tasmanian managed) in/near the fishing data assessment area were deemed as active. The remainder were considered very unlikely to be used in the future, possibly for the unsuitable/access reasons cited above, and therefore only active fisheries were considered in the following report.

Table 3. List of fisheries permitted to fish in the fishing data assessment area

	Commonwealth-managed fisheries	Tasmanian-managed fisheries
Active	SESSF Shark Gillnet and Shark Hook sectors (GHaT)	Abalone Fishery
	Southern Squid Jig Fishery	Rock Lobster Fishery
		Scalefish Fishery
Inactive	Eastern Tuna and Billfish Fishery	Giant Crab Fishery
	Skipjack Tuna Fishery	Commercial Dive Fishery
	Southern Bluefin Tuna Fishery	Mackerel Fishery
	Small Pelagic Fishery	Seaweed Fishery
	SESSF Scalefish Hook sector	Shellfish Fishery
	SESSF Commonwealth Trawl sector	
	Bass Strait Central Zone Scallop Fishery*	

1.3 Fisheries stakeholder list

Table 4 provides a list of key contacts for representative bodies for each fishery identified as active in 1.2.

Table 4. Key contacts for representative bodies for each affected sector.

FISHERIES	REPRESENTATIVE ORGANISATIONS	KEY CONTACT NAME	PHONE NUMBER	KEY CONTACT EMAIL ADDRESS
All Australian wildcatch fisheries and aquaculture	Seafood Industry Australia (SIA)			
All Australian Commonwealth managed fisheries	Commonwealth Fisheries Association (CFA)			
Southern Squid Jig Fishery	No association default to CFA			
Shark Gillnet & Shark Hook Sector (GhaT)	Southern Shark Industry Alliance (SSIA)			
All Tasmanian managed fisheries	Tasmanian Seafood Industry Council (TSIC)			
Tasmanian Rock lobster Fishery	Tasmanian Rock Lobster Fishermen's Association			
Tasmanian Abalone Fishery	Tasmanian Abalone Council			

1.4 General Information on fisheries overlapping with the fishing data assessment area

There are five different fisheries, sectors and sub-sectors with recent (within the last 10–20 years) fishing activity in the fishing data assessment area. These fisheries use at least ten different fishing gears and are managed by two different jurisdictions (regulators); Commonwealth and Tasmania. Table 5 outlines the fisheries, management authority and fishing methods used by each sector.

Table 5. Operation of Commonwealth and Tasmanian managed fisheries who have legally fished within the fishing data assessment area in the past 10 years for Commonwealth fisheries and in the past 20 years for Tasmanian fisheries.

<table>
<tr><th></th><th colspan="3">Fishery</th><th>Fishing methods</th></tr>
<tr><td rowspan="3">Commonwealth-managed</td><td rowspan="2">SESSF</td><td rowspan="2">GHAT</td><td rowspan="2">Shark Gillnet and Shark Hook Sector</td><td>Demersal gillnet</td></tr>
<tr><td>Demersal longline</td></tr>
<tr><td colspan="3">Southern Squid Jig Fishery</td><td>Squid jig</td></tr>
<tr><td rowspan="3">Tasmanian managed</td><td colspan="3">Rock Lobster Fishery</td><td>Rock Lobster Pots</td></tr>
<tr><td colspan="3">Tasmanian Abalone Fishery</td><td>Hand harvest</td></tr>
<tr><td colspan="3">Scalefish Fishery</td><td>Various methods allowed with those of most relevance to the fishing data assessment area being; trap, horizontal demersal longline, demersal gillnet, squid jig, trolling, and handline, with hand collection and purse seine a low possibility</td></tr>
</table>

1.5 Commonwealth fisheries

The Southern and Eastern Scalefish and Shark Fishery (SESSF) extends from Cape Leeuwin in Western Australia to Fraser Island in Queensland and is comprised of five sectors: the Commonwealth Trawl Sector (CTS), Great Australian Bight Trawl Sector (GABTS), East Coast Deepwater Trawl Sector (ECDTS), Gillnet and Shark Hook Sector (SGSHS) and Scalefish Hook Sector (SHS) (Figure 2). Of these only the Shark Gillnet and Shark Hook Sector operate within the fishing data assessment area.

The Australian Fisheries Management Authority (AFMA) manages fisheries to maintain stocks at ecologically sustainable levels, while maximising the net economic returns to the Australian community (DAFF, 2007). The main management measures used in the SESSF include limited entry, gear restrictions, closed areas and Total Allowable Catch (TAC) limits. A limited number of statutory fishing right (SFR) vessel permits exist. One is required on each vessel operating in the fishery. Additionally, any fish species managed under *quota* must be landed against quota SFRs. Annual TACs are set based on outcomes of stock assessments conducted for each quota species. Quota SFRs are converted to tonnes of quota (TAC) each year depending on the annual TAC that is set.

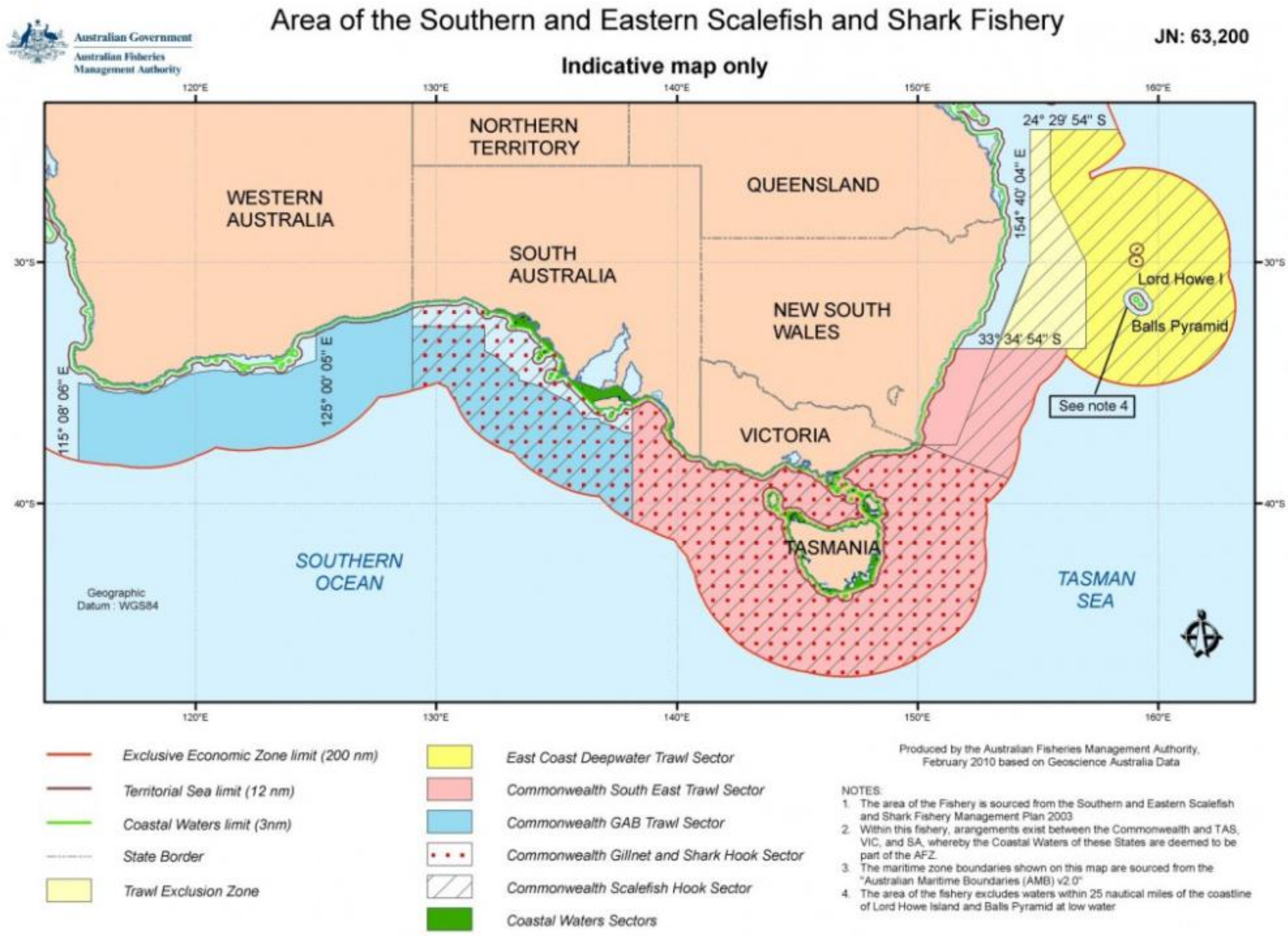


Figure 2. The Commonwealth Shark Gillnet and Shark Hook sectors (dotted) as part of the larger Southern and Eastern Scalefish and Shark Fishery.

1.5.1 Shark Hook and Shark Gillnet Sector

The Shark Hook and Shark Gillnet Sector (SHSGS) includes waters of the Australian Fishing Zone (AFZ) between the New South Wales/Victorian border to the South Australian/West Australian border. Within this sector Demersal gillnet and demersal longline fishing methods are deployed.

1.5.1.1 Demersal gillnet fishing

Demersal gillnets are a passive fishing gear (i.e., they are not towed — the fish have to swim into the gear) comprising of a long panel of diamond shaped mesh held upright in the water column by a series of floats (Figure 3) at regular intervals along the top edge of the netting panel together with ballast (weights or lead beads in the rope lay) along the lower netting edge to keep the net on the sea floor. Anchors affixed at each end of the netting panel also provide some ballast (up to 50kg) and also serve to hold everything in place while the net "soaks" i.e., fishes.

The SHSGS is managed by quota (the sustainable volume of fish that can be taken each year) and as such operators in the sub-sector can use gillnets of an unlimited length (provided video monitoring is present onboard) but most use between 4,000 m and 6,000 m. Many operators divide their maximum legal net length into two or three fleets of nets, which can either be fished together or separately.

Gillnets in the SHSGS are used to catch gummy and school shark and a few other by-product species in the area around the proposed research area. Catch is controlled by quotas set using scientific stock assessments.

Gillnets generally have the headrope set about 1-2 m above the seafloor; note this height is governed by the logrope length at each end of the netting panel plus how much netting materials is present between the upper and lower framelines (i.e., headrope and footrope) The headrope (or floatrope) and footrope (or leadline) is typically a 16 and 14 mm rope respectively, with MBL of 2.5 and 2.1t respectively.. The monofilament netting twine is around 1-2mm in diameter with a breaking strain of 50-200Kgf)

At either end of the gillnet, a marker buoy (floats) on a down-line indicates where the gillnet resides below. The downline is typically 10mm PP rope (MBL 1.1 t) and is attached to a J anchor (up to 50kg) or lead weights via a length of chain (c. 2m in length). Depending on tide and sea conditions and gillnet length, extra intermediate anchors, usually smaller ones, may also be added at intervals along the net.

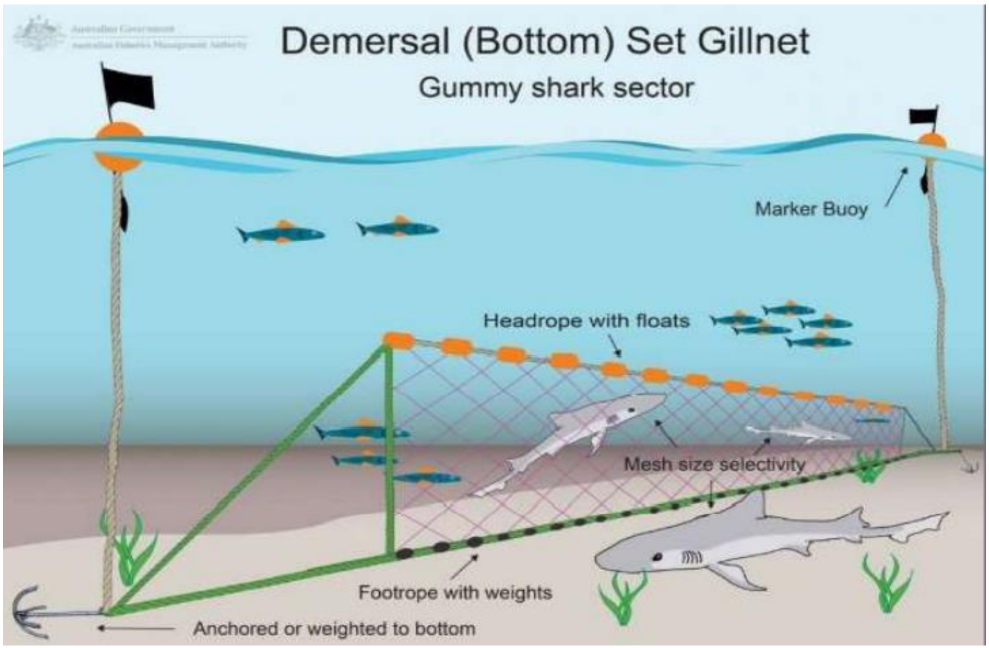


Figure 3. Demersal gillnet method diagram (image source: afma.gov.au)

Gillnets are susceptible to snagging on rough bottom and other structures/obstacles. Like most fishers, gillnetters have known safe areas (clear *grounds*) that they work regularly. Each time a gillnet is set the operator logs the position on both their GPS plotter and the electronic logbook.

Gillnetting is limited by marine parks, fishery closures, unfishable grounds, unproductive grounds and other closures. Currently, gillnetting is not permitted in Commonwealth waters deeper than 183 m (equivalent to 100 fathoms) to protect certain deep-water species.

Shark gillnetters may lay-up at anchor during bad weather or while fishing gear soaks. The type/weight of anchor and the connecting tackle used will vary depending on the vessel, and is a function of AMSA requirements for that size and class of vessel, together with an upward adjustment if deemed necessary to allow for local environmental factors such as bottom type, sea-state and current. A prime example of a medium sized aft wheelhouse shark gillnetter vessel (15m in length) operating from Devonport is shown in Figure 4.

Figure 4. FV Mustelus, Commonwealth shark gillnetter (15m aft wheelhouse) working out of Devonport, Tasmania (Source: MarineTraffic.com courtesy of Nicole Pike).

Figure 5. FV Erin Jay - a Commonwealth shark gillnetter fishing out of Lakes Entrance. Note the large drum on the foredeck to hold the long net. (Source: Erin Jay - www.leftrade.com.au).

1.5.1.2 Horizontal demersal longline fishing

Demersal longlines comprise of a long length of rope (backbone) strewn across the seabed between anchors with hooks on snood attached at regular intervals (refer Figure 6). Fishery regulations recognise two forms of longline, namely demersal autolongline and bottom longline, with the distinction being autolongline has permanently attached snoods/hooks while bottom longline has removable snoods/hooks. Furthermore, as the name implies, autlonglines are configured in such a way that, with the aid of specialised machinery, vast numbers of hooks can be set and recovered each day. Whereas bottom longlining necessitates having crew manually clip snoods on and off the backbone as it is deployed and recovered, making it relatively labour intensive, and fewer hooks are set each day as a result.

Currently, only bottom longlines are used in or around the fishing data assessment area, these are used to catch school and gummy shark that live on or near the sea floor.

When set, the longline can be many kilometres in length (typically 1.5 – 5 km) and may have several thousand hooks. Bottom longline gear consists of a rope mainline with baited hooks spaced every 2 to 5 m on monofilament or braided cord snoods. The mainline is attached at both ends to downlines which have a large buoy on the surface for locating gear, and anchors at the bottom to hold the gear in place. Some vessels use radio beacons to be able to find gear in low visibility or if it drifts in heavy current. Each line is normally left to 'soak' (deployed) for around 6 to 8 hours before being hauled. Hauling is done using hydraulic winches which are fixed to the deck of the boat. The gear can be hauled from either end by retrieving the downline.

Demersal longline gear is relatively light fishing gear. Downlines (ropes connecting floats and the mainline) are generally made of 8 – 10 mm rope with a breaking strain of 0.8 to 1.1 t. Mainlines are thinner (e.g. 7 mm) but are more abrasion resistant. Snoods are usually monofilament with very low breaking strain (approximately 50 kg). Anchors are only large enough to manage onboard by hand (~15–25 kg). The number of anchors used depends on many factors including, currents, sea condition, ground fished, and species targeted. Bottom longline fishing causes very little disturbance to the sea floor and has only a very limited level of bycatch. Gear can become snagged on the bottom and get broken off, although this is not a common occurrence.

Shark longline vessels bear similarity to shark gillnetters, and may lay-up at anchor during bad weather or while fishing gear soaks. The anchor and connecting tackle used will be a function of AMSA requirements for that size and class of vessel, together with an upward adjustment if deemed necessary to allow for local environmental factors such as bottom type, sea-state and current.

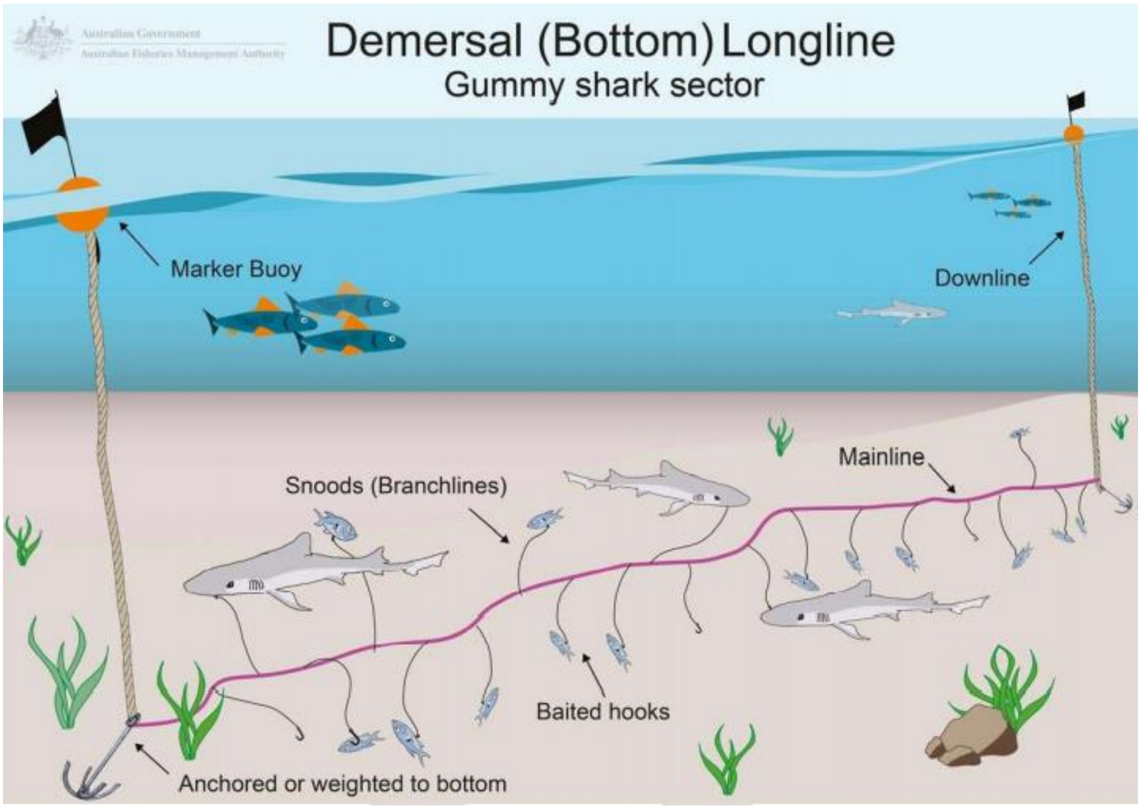


Figure 6. Demersal longline, gummy shark sector, method diagram (image source: afma.gov.au)

1.5.2 Southern squid jig fishery

The Southern Squid Jig Fishery operates in Commonwealth waters off South Australia, Victoria, Tasmania, New South Wales and parts off Queensland (Figure 7), with most of the fishing effort occurring off the south-east of Australia. This fishery targets a single species — Gould's squid — using either hand operated or mechanically powered jigs (Patterson et al., 2021).

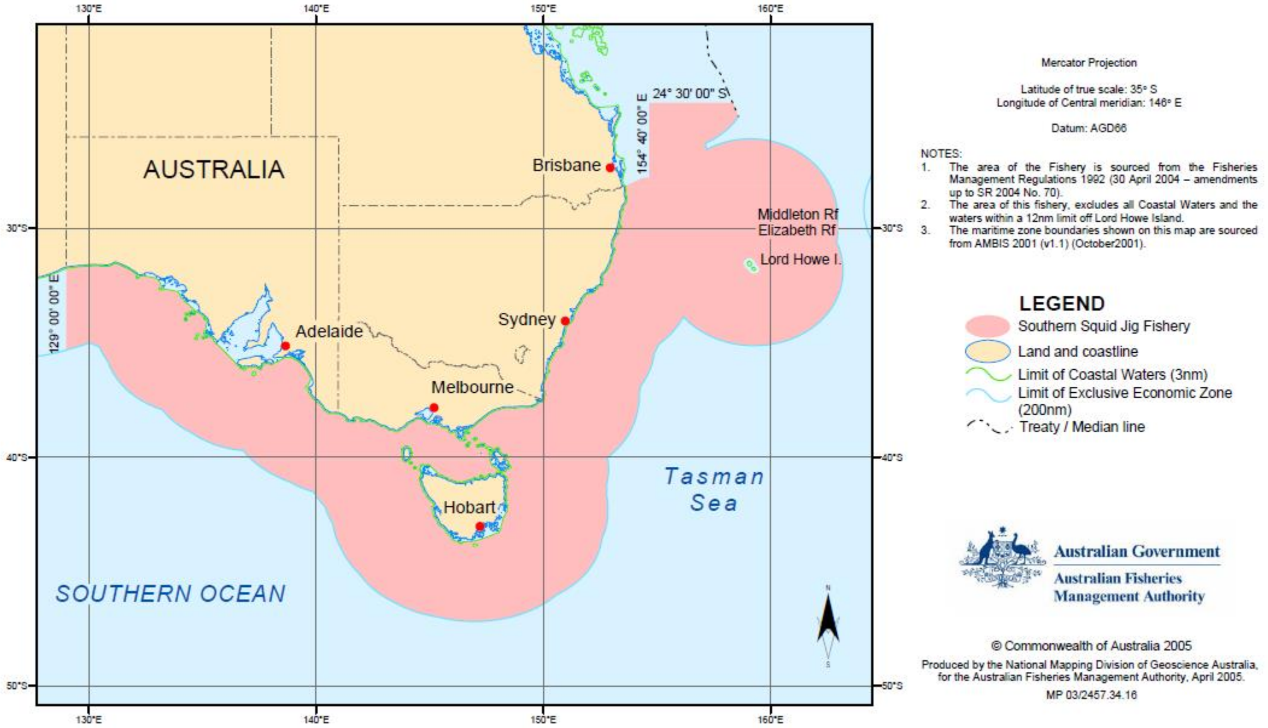


Figure 7. Southern squid jig fishery area

Fisheries operating squid jigging in the fishing data assessment area include; Commonwealth managed Southern Squid Jig Fishery, and the Tasmanian Scalefish Fishery. Squid jigging typically occurs midwater at depths between 50 and 100 m at night using large lights that illuminate the waters around a boat. Once a suitable site has been chosen, it is common for vessels to deploy a drogue or sea anchor to reduce the vessel's drift while fishing. This anchor is often attached to a strong rope (around 22mm PP with a MBL of 4.7t).

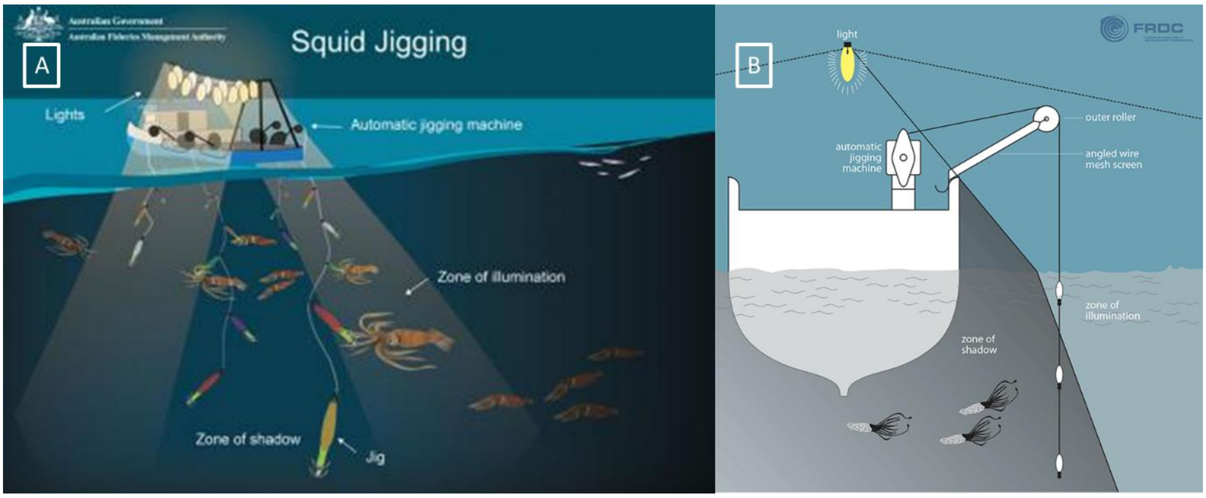


Figure 8. A) A squid jigger with jigging gear deployed (Source: AMSA). B) The important dark and light illumination zone below the squid jigger. Squid hide in the dark zone and pounce on the illuminated jig near the surface (Source: FRDC, ACT).

The light attracts small marine creatures and in turn the squid are attracted to the concentration of these prey species. Squid are also positively phototactic and are attracted to zones of illumination irrespective of weather food items are present. This is where the presentation of substitute food items in the form of squid jigs works to hold squid underneath of the vessel in the shadow zone, where they ambush prey in the adjacent illumination zone (refer Figure 8). Squid jigging, as the words imply, involves erratically raising and lowering a dropline that has a series of jigs in-line, usually with the aid of an elliptical, hand or powered operated, spool. Specialised jigging machines have pre-set jigging cycles and settings, and through the use of barbless hooks and a change in jig orientation as it comes onboard, squid can be removed without any human intervention, hence the term auto-squid jigging gear.

Squid jigs are used in the upper water column and rarely interact with the seafloor. The line used for the squid jig is monofilament with a low breaking strain of 100 – 200 kg. Refer to Figure 10 for squid jigging arrangement and image of squid jigs.

These Commonwealth licensed jig vessels are typically larger and more seaworthy than their inshore (State waters) cousin's vessels (refer to Figure 9 for a typical Commonwealth vessel), and usually opt to anchor on/near the fishing grounds during the day, depending on hold capacity, fish preservation options, and closeness to port, amongst other factors.

Figure 9. FV Del Richey 2, a Commonwealth Southern Squid Jig fishery vessel (20m aft wheelhouse vessel) (Source: Andrew Sullivan)

The anchor and connecting tackle used will be a function of AMSA requirements for that size and class of vessel, together with an upward adjustment if deemed necessary to allow for local environmental factors such as bottom type, sea-state and current.

Figure 10 Deck of an Australian squid jigging vessel showing the multiple jigging machine arrangement showing arrangement of jigging machines (upper pic). A series of colourful squid jigs wound around a jigging machine drum (lower pic). Note the two rows of radially spaced barbless hooks on each jig.

1.6 Tasmanian managed fisheries

1.6.1 Rock lobster fisheries

The Tasmanian Rock Lobster Fishery operates around the Tasmanian coast (Figure 11). The industry in Tasmania is represented by the Tasmanian Rock Lobster Fishermen's Association. Southern Rock Lobster are found to depths of 150 metres, but most catch comes from inshore waters less than 100 metres deep.

Figure 11. Map of Tasmanian Rock Lobster Fishery the division between the Western and Eastern regions, together with the East Coast Stock Rebuilding Zone.

Figure 12. Beehive craypots made from wood/wire (left), and metal, plastic and synthetic netting (right) (Source: images.australialisted.com/nlarge/steel_cray_pots_for_sale_211134 19.jpg).

This fishery is a pot fishery, with the pot designed in the form of cages, made from various materials (wood, wicker, metal rods, wire netting, plastic etc., Figure 12) and weighing about 40 kg. Pot size is regulated and must not be more than 150 cm long by 150 centimetres wide by 120 cm high.

Pots are usually set on rocky/hard bottom, and according to several reliable sources (pers. comm. J. Harrington and M. Hardy June 2002), crayfishing is likely to take place in the deeper waters of the fishing data assessment area where some sandstone shelves are known to exist. In such depths craypots are normally set singularly and marked with a 3-strand 9-14 mm rope (14mm PP MBL 2.1t) and surface buoys. Pots are usually left to soak overnight, although on productive grounds they may be "pulled" at midnight and reset. Pots are hauled onboard using a mechanised rope-hauler, and some vessel may have a simple tipper arrangement for ergonomic and OH&S reasons.

Figure 13. Illustration of a cray boat with pots deployed (Source: AFMA)

Cray boats may opt to anchor on the fishing grounds overnight, depending on hold capacity and options, and closeness to port, amongst other factors. Note that there are nil restrictions on what type of craft are used by licensees in the Tasmanian Rock Lobster fishery, so forward and aft wheelhouse versions can be utilised, with the former sometimes having the extra horsepower needed to exceed 20 knots. The latter group and the steel forward wheelhouse versions tend to be displacement hull types and steam around the 8-9 knot mark. The anchor and connecting tackle used by these craft will be a function of AMSA requirements for that size and class of vessel, together with a possible upward adjustment to cater for environmental factors such as bottom type, sea-state and current.

Figure 14. Two forms of cray boats; forward wheelhouse and planning hull (left), aft wheelhouse and displacement hull (right)

1.6.2 Abalone fisheries

In the Tasmanian Abalone Fishery divers using a hookah breathing apparatus, harvest the abalone from rocky/hard bottom with the aid of hand-held implement (Figure 15).

Boats used in the fishery vary depending on the trip duration amongst other things. The smaller workboats doing short trips (usually day trips) are generally small to medium sized forward wheelhouse workboats (6–8 m in length) with an uncluttered deck. The larger vessels, doing longer trips, possibly equipped with one or more tenders for the actual diving work or harvesting in shallow waters, resemble the displacement hull cray boats described above (Figure 14).

Whilst harvesting abalone the boat is usually moving and following the diver(s) below. Day trips are common and usually take place close to shore in shallow water <20m, although some deeper dives (up to 30m) may be undertaken if deemed worthwhile.

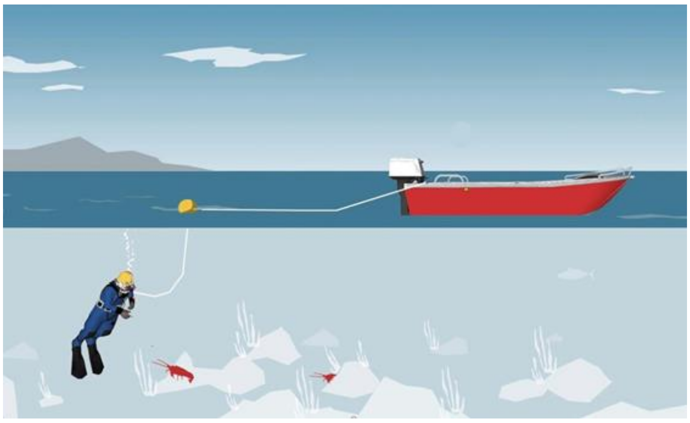


Figure 15. Hand harvesting method illustration. Typically used by the abalone fishery

1.6.3 Tasmanian scalefish fishery

The Tasmanian Scalefish Fishery is a multi-species and multi-gear fishery which operates in the waters surrounding Tasmania. Past catch and effort data (Moore et al 2018; Fraser et al 2021), together with personal communication with industry members and/or those associated with the fishery, indicates the main fishing methods of relevance to be; fish trapping, shark demersal gillnetting, shark bottom longlining, octopus trapping, squid jigging, handlining, and trolling. The fishery also employs purse seining and beach seining, however, these methods are used inshore from the project research area and were therefore not considered further.

1.6.3.1 Shark gillnetting and longlining

In regard to the gillnetting and longlining for shark by Tasmanian licensed vessels, the gear and practices typically resemble that used/followed in the Commonwealth fishery, see descriptions above.

1.6.3.2 Squid jigging

Operators in the Tasmanian squid fishery mainly target Southern calamari, and to a lesser extent Goulds squid, along the northern Tasmanian coastline relatively close to shore. This practice allows licensees to use smaller craft equipped with hand operated jigging machines and handlines, rather than expensive auto jig configurations used on the larger more seaworthy Commonwealth licensed vessels. These smaller Tasmanian licensed vessels are more inclined to do short overnight trips around favourable weather from a nearby port.

1.6.3.3 Fish trapping and handlining

Fish trapping and handline fishing are used regularly in the vicinity of the fishing data assessment area for the live wrasse market, although based on habitat in the region this may occur predominately inshore of the research area. The handlines are relatively simple, resemble vertical droplines and comprise of light tackle (100kg mono attached to 1kg sinker). Apart from the shape of the fish trap, this gear shows a close resemblance to craypot gear in terms of trap weight (c. 30kg), size, haul in rope, and headgear (marker floats).

Vessels engaged in this type of fishing are classified as small to medium sized workboats (6-15m), share many similarities to those engaged in coastal squid jigging, and usually undertake short trips around favourable weather from a nearby port. The larger vessels are favoured by the fish trappers as they require more deck space for trap storage and live fish tanks.

1.6.3.4 Octopus trapping

Only two octopus trapping licenses are currently available (fished across three vessels ranging in length from 14 – 20m, steaming speed around 8-9 knots: pers comm M. Hardy, licensee, June 2022), although exploratory permits for the north east region and east coast are being trialled as well (Moore et al 2018).

The octopus fishing gear shares many similarities with the bottom longline gear, with the key difference being each hook is replaced with a fixed opening container (up to 3L volume, Figure 16). The mainline or "backbone" is typically around 3.5km long and has around 500 traps clipped at regular intervals (c. 6m) along its length. Anchors or weights (approx. 30kg) are placed on the mainline to hold this gear in place on the seafloor. Downlines are attached at each end of the mainline and rise vertically to floats which mark the position of the line.

Figure 16. Left, typical octopus traps with square opening (approx. 20 x 20 cm). Right, octopus fishing gear tangled after likely encounter with other commercial fishing methods.

Vessels engaged in this type of fishing are classified as medium sized workboats (14-20m), and share many similarities to those engaged in squid jigging and fish trapping, and usually undertake short trips around favourable weather from a nearby port.

Figure 17. Two of the three octopus trap vessels, FV Seafarer (left) and FV Masel Hardy (right), operating in the vicinity of the fishing data assessment area.

1.6.3.5 Trolling

Vessels troll in waters along the northern coastline for species such as snook/pike and barracouta. Trolling involves towing a hook disguised as a baitfish near the water's surface at around 1-3m/s (2-6 knots) (Figure 18). Lines (1-2mm mono, 50 – 200kg MBL) are recovered when a predatory fish becomes hooked on the lure.

Vessels engaged in this type of fishing are classified as small to medium sized workboats (6-20m), and usually undertake short trips around favourable weather from a nearby port. Of note, vessels engaged in other forms of fishing may opportunistically troll while in transit.

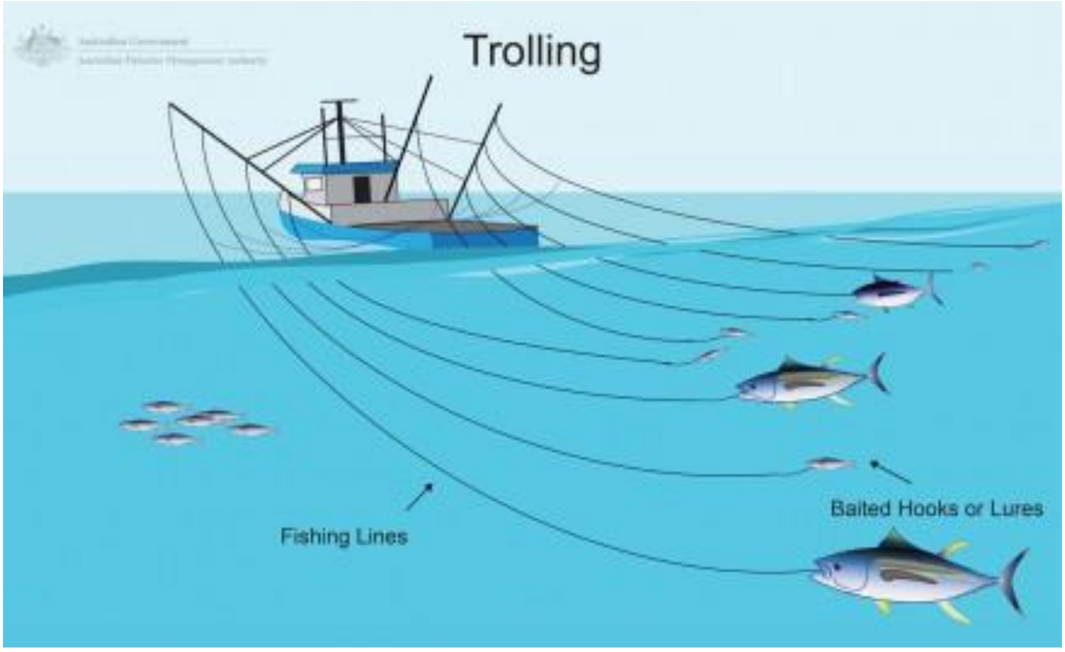


Figure 18. Trolling minor line fishing method diagram (image source: afma.gov.au)

DELIVERABLE 2: FISHING GROUNDS

2.1 Fishery closures and marine parks

2.1.1 Fishery closures

There are two fishery closures that overlap with the fishing data assessment area, Schedule 2 - Bass Strait Trawl Closure (Figure 19) and Schedule 37 – Automatic Longline Shallow Water Closure (Figure 20). The Bass Strait Trawl Closure applies only to Otter Trawl gear, leaving the area open to fishing by Danish seine (note neither fishing gear has been actively used in the fishing data assessment area in the last 10 years). The Automatic Longline Shallow Water Closure prohibits the use of Automatic Longline gear in water shallower than 183 m depth. Both schedules were brought in to protect School Shark and Gummy Shark.

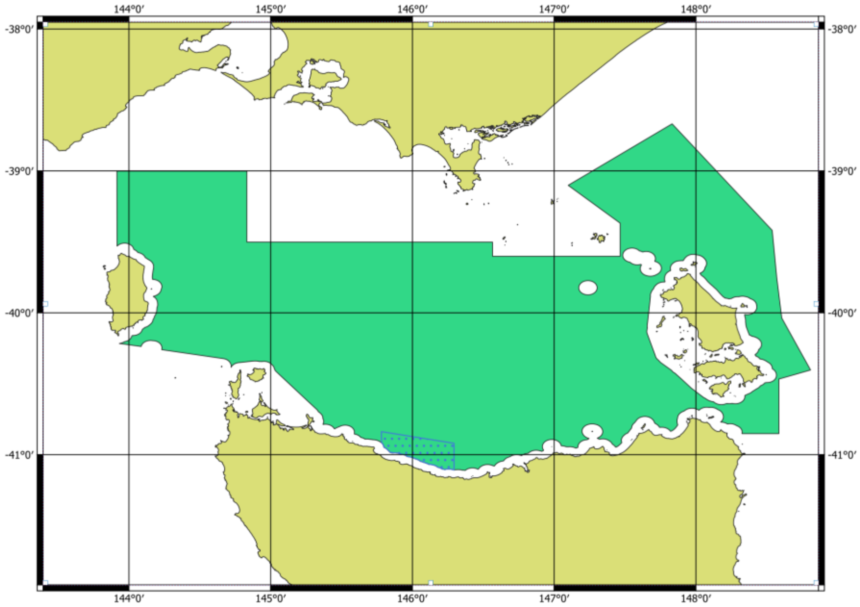


Figure 19. Commonwealth fishery Schedule 2 - Bass Strait Trawl Closure (green) in relation to the fishing data assessment area. This closure only affects otter trawl gear, not Danish seine.

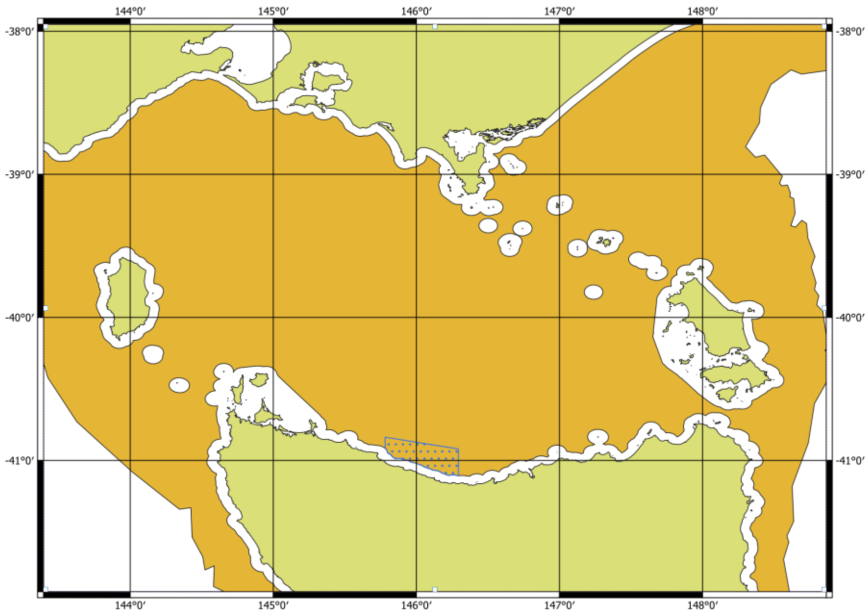


Figure 20. Commonwealth fishery Schedule 37 – Automatic Longline Shallow Water Closure (orange) in relation to the fishing data assessment area. This encompasses waters shallower than 183 m depth.

2.1.2 State marine parks

There are four conservation areas within 30 km of the fishing data assessment area.

The Seagull Islet Conservation Area (Figure 21) is protected the IUCN V level (Protected Landscape/Seascape). The IUCN V level of protection is described as: *A protected area where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values*. (IUCN 2022a)

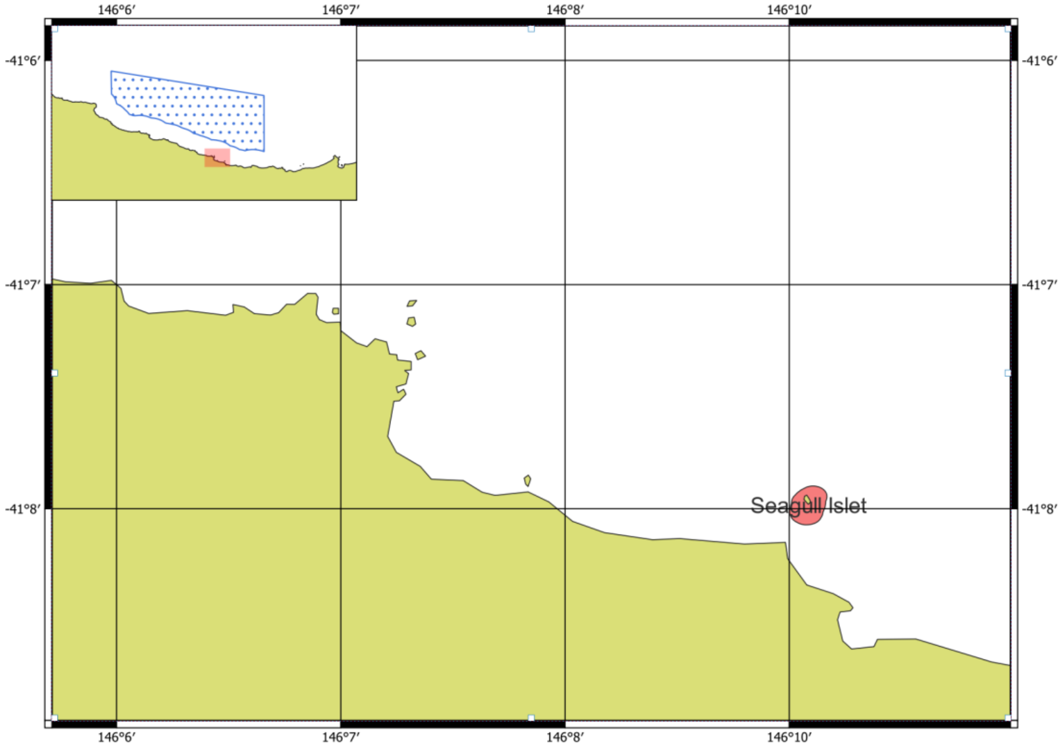


Figure 21.Seagull Islet Conservation Area in relation to the fishing data assessment area.

The Lillico Beach Conservation Area (Figure 22), Wright and Egg Islands Conservation Area (Figure 23) and Pardoe Northdown Conservation Area (Figure 23) are protected a the IUCN VI level (Protected area with sustainable use of natural resources). The IUCN V level of protection is described as: *Protected areas that conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area* (IUCN 2022b).

Little information regarding the conservation values of these areas could be found, but the Lillico Beach is a Conservation Area comprises a pebbly coastal strip and is home to a colony of Little Penguins which breed during September to May.

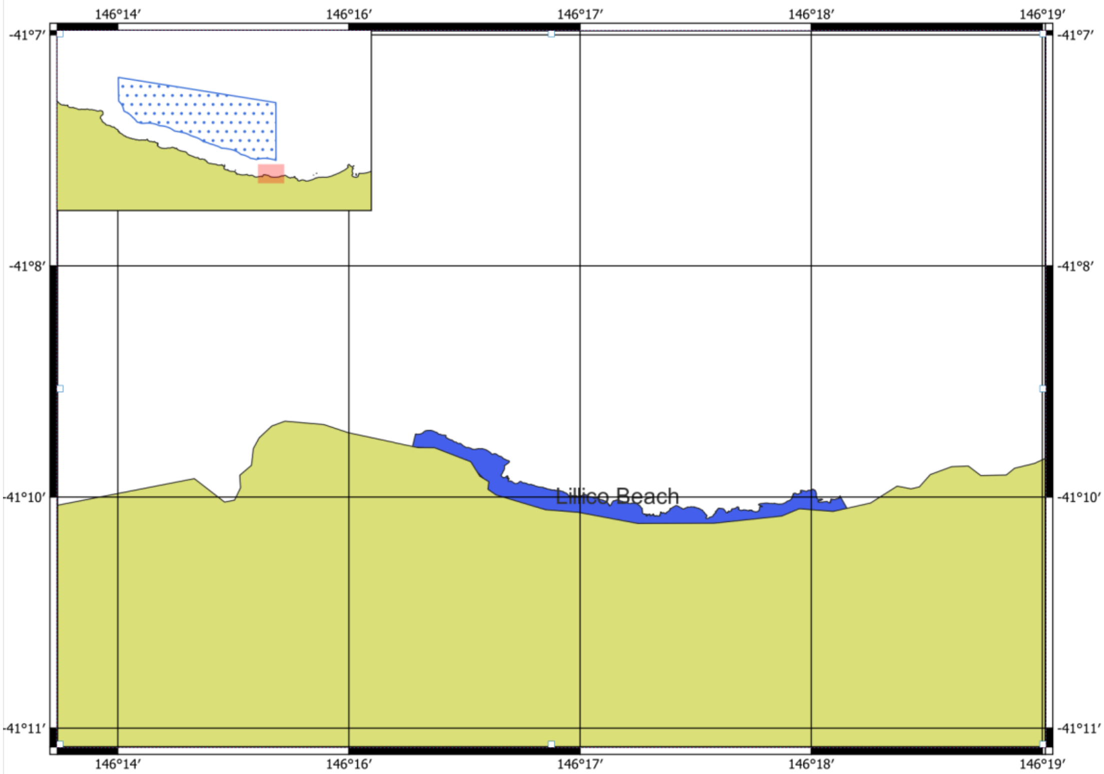


Figure 22. Lillico Beach Conservation Area in relation to the fishing data assessment area.

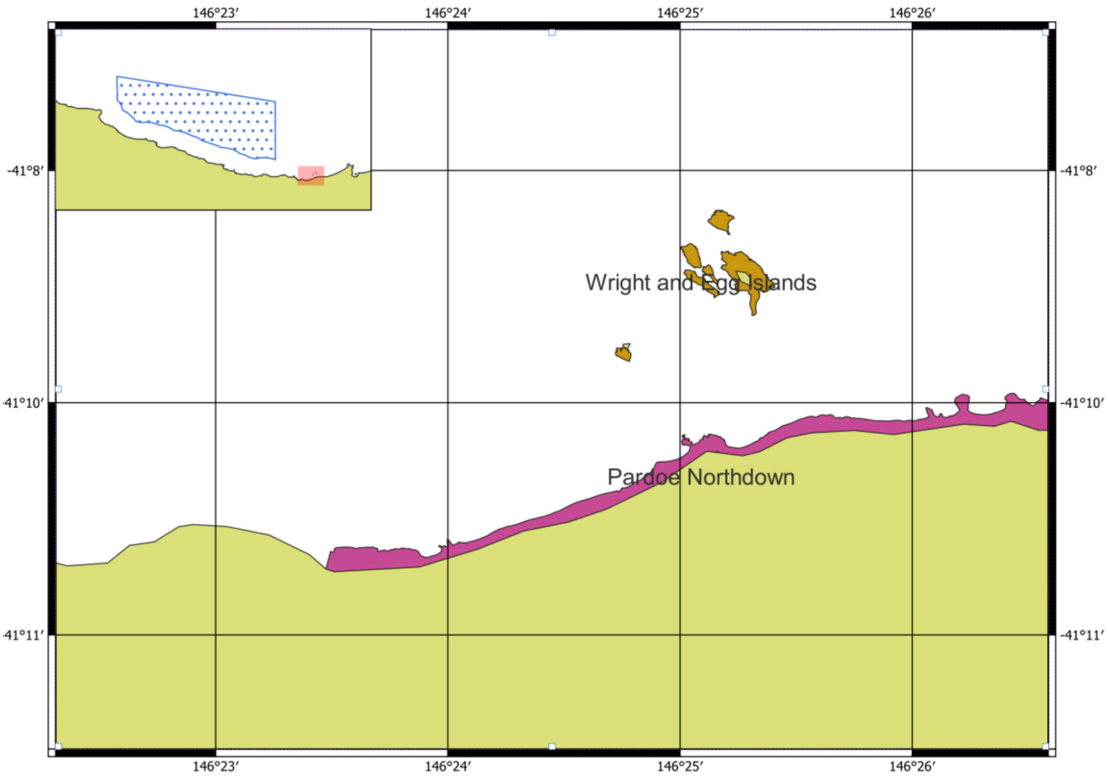


Figure 23.Wright and Egg Islands Conservation Area and Pardoe Northdown Conservation Area in relation to the fishing data assessment area.

2.1.3 Commonwealth marine parks

The nearest Commonwealth marine park is Boags Marine Park which is about 80 km to the north-west of the fishing data assessment area (Figure 24). This is a multi-use zone in 40–80 m of water. Major conservation values include (Director of National Parks, 2013):

- Ecosystems, habitats and communities associated with:
    - the Bass Strait Shelf Province
- Ecosystems, habitats and communities associated with the following sea-floor features:
    - plateau
    - tidal sandwave/sandbank
- Important foraging area for the following seabirds:
    - Shy Albatross, Australasian Gannet, Short-Tailed Shearwater, Fairy Prion, Black-Faced Cormorant, Common Diving Petrel and Little Penguin.

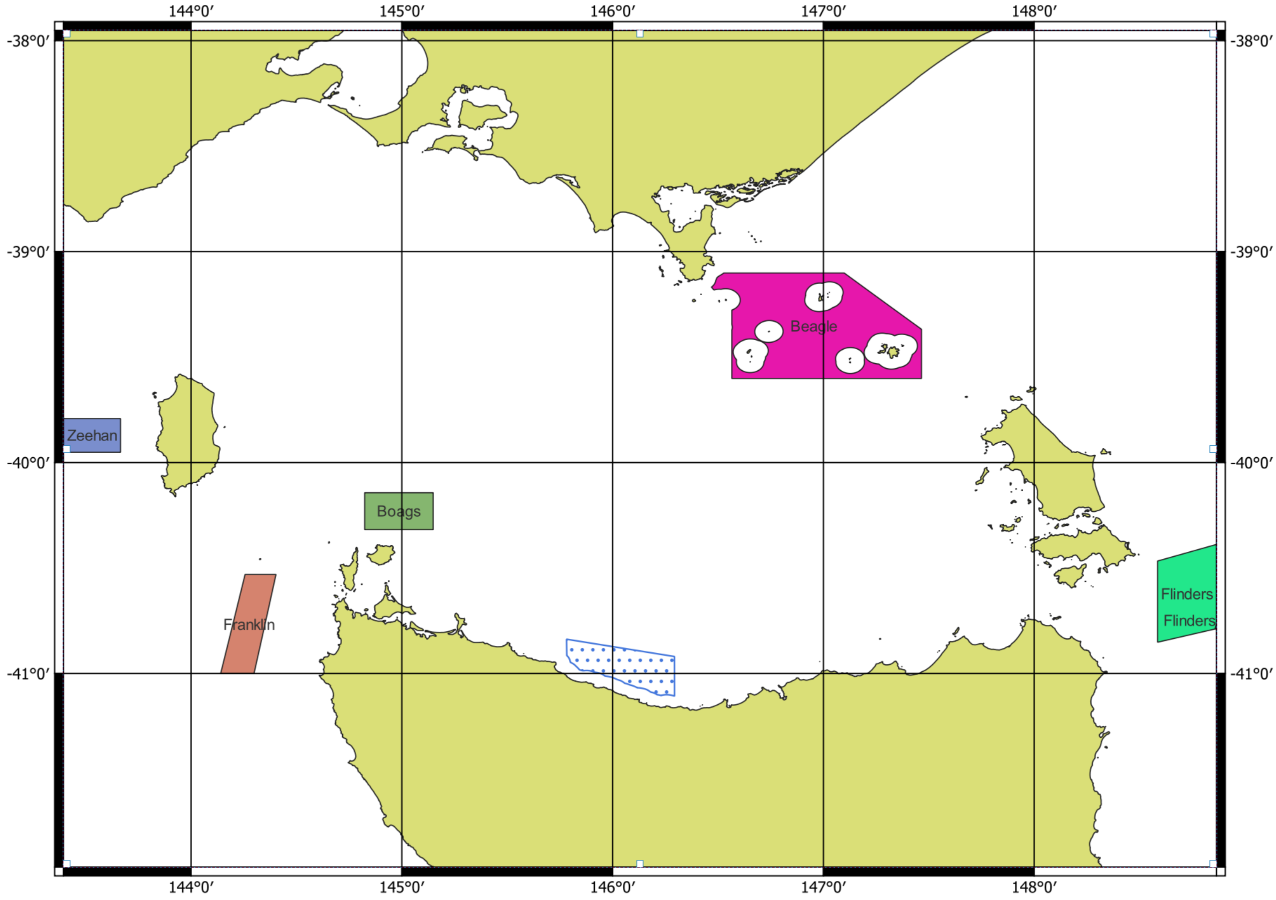


Figure 24. Commonwealth marine parks in relation to the fishing data assessment area.

2.2 Commercial fishing data

2.2.1 Southern and Eastern Scalefish and Shark Fishery (SESSF)

The SESSF gross value of production (GVP) was about $87 million in the 2018–19 financial year but catches have declined significantly from historical levels primarily due to a reduction in fishing effort, largely associated with a 2006 Commonwealth Government-led *Structural Adjustment* which removed 50% of fishing concessions, but also from greatly reduced catches of Orange Roughy and Blue Grenadier (Patterson *et al.*, 2021). Whilst the SESSF is comprised of five sectors: the Commonwealth Trawl Sector (CTS), Great Australian Bight Trawl Sector (GABTS), East Coast Deepwater Trawl Sector (ECDTS), Gillnet and Shark Hook Sector (SGSHS) and Scalefish Hook Sector (SHS). Only the Shark Gillnet and Shark Hook Sector operate within the Blue Economy CRC fishing data assessment area.

More than 100 species are regularly landed in the SESSF but only the main species are managed under quotas. At present, there are 34 fish stocks subject to total allowable catches (TACs, Table 6). Only the four emboldened species are generally found in the vicinity of the fishing data assessment area. The Shark Gillnet and Shark Hook Sector landed 2,268 t of shark during 2020–21 and had a GVP of $18.22 million during 2019–20 (Woodhams and Curtotti, 2021).

Table 6. List of 2021–22 TACs (whole fish unless otherwise stated) for SESSF quota species (AFMA, 2021). Species that are likely to be caught within the fishing data assessment area are in bold.

Species	TAC (t)	Species	TAC (t)
Alfonsino	1,017	Orange Roughy – (GAB)	50
Bight Redfish (GAB)	893	Orange Roughy – (Cascade)	500
Blue Eye Trevalla	421	Orange Roughy – (east)	1,277
Blue Grenadier	12,183	Orange Roughy – (south)	96[6]
Blue Warehou	50	Orange Roughy – (west)	60
Deepwater Flathead (GAB)	1,128	Oreo (smooth Cascade)	150
Deepwater Shark (east)	24	Oreo (smooth other)	90
Deepwater Shark (west)	235	Oreo (basket)	139
Elephant Fish	**114**	Pink Ling	1,121
Flathead	2,333	Redfish	50
Gemfish East	100	Ribaldo	396
Gemfish West	343	Royal Red Prawn	605
Gummy Shark	**1,672**[7]	**Sawshark**	**509**
Jackass Morwong	463	**School Shark**	**194**
John Dory	60	School Whiting	917
Mirror Dory	144	Silver Trevally	197
Ocean Perch	304	Silver Warehou	450

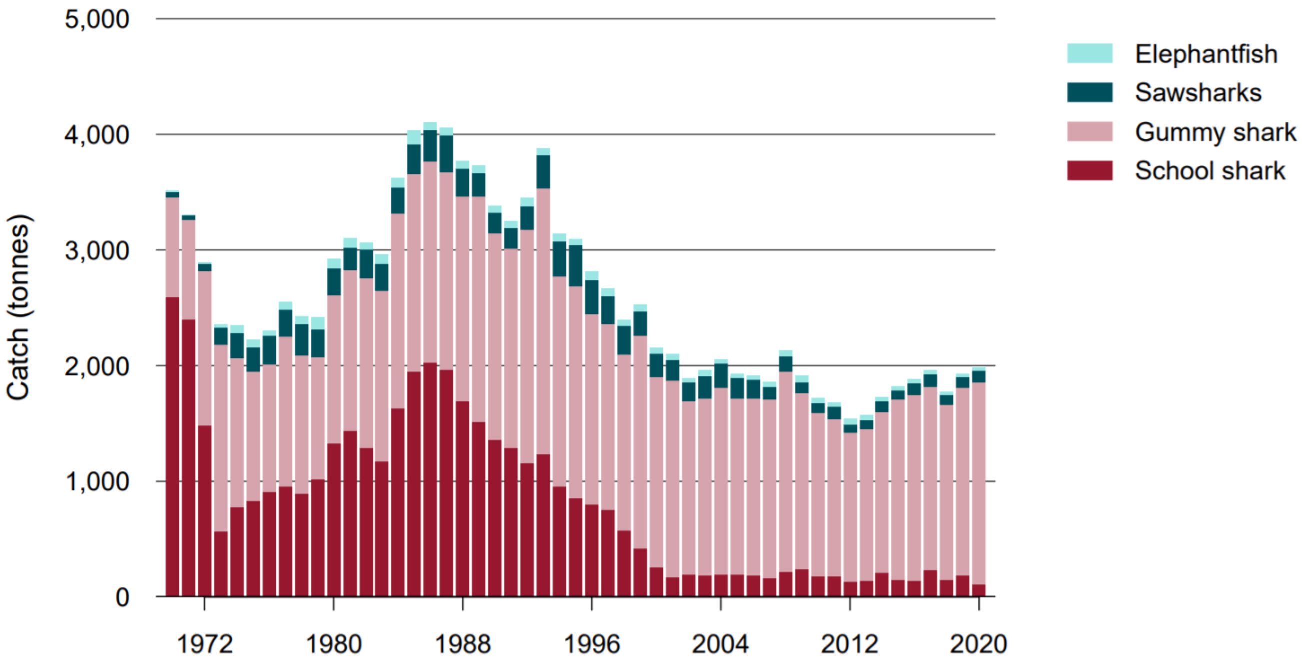
[6] Plus 31 t incidental

[7] Trunk weight

SESSF Shark Gillnet and Shark Hook Sector (SGSHS)

Catch in the SGSHS peaked at more than 4,000 t during 1986, and effort peaked in the following year at more about 120,000 km-lifts (Figure 25). Catch and effort has decreased by more than 50% since, mainly due to declining stocks of School Shark, conservative School Shark management arrangements to promote recovery of that species, and removal of effort through Government-led structural adjustments and closures. Despite this decrease, Gummy Shark landings have increased from 1,288 t in 2012–2013 to 1,695 t in 2020–2021 (Woodhams and Curtotti, 2021).

These SGSHS landed 2,268 t of shark in 2020–2021 and had a GVP of $18.22 million in 2019–20 (Woodhams and Curtotti, 2021). During 2020–2021 there were 31 active shark gillnet and shark hook sector vessels operating gillnets and 38 vessels using demersal longlines (Woodhams and Curtotti, 2021).



Note: **SGSHS** Shark Gillnet and Shark Hook sectors
Source: Multiple sources (1970 to 2015); AFMA catch disposal records (2016 to 2020)

Figure 25. Catch and effort in the Shark Gillnet and Shark Hook Sector since 1970 (Woodhams and Curtotti, 2021).

2.2.1.1 Overlap between Shark Gillnet and Shark Hook Sector grounds and the fishing data assessment area

The Shark Gillnet and Shark Hook Sector targets Gummy Shark using demersal gillnets and demersal longlines (including auto-longlines) and is restricted to waters shallower than 183 m (100 fathoms). Both demersal gillnets and demersal longlines were used in one- degree boxes that overlap with the fishing data assessment area during 2020–21 (Figure 26 & Figure 27), and there has also been historical records of effort in that area.

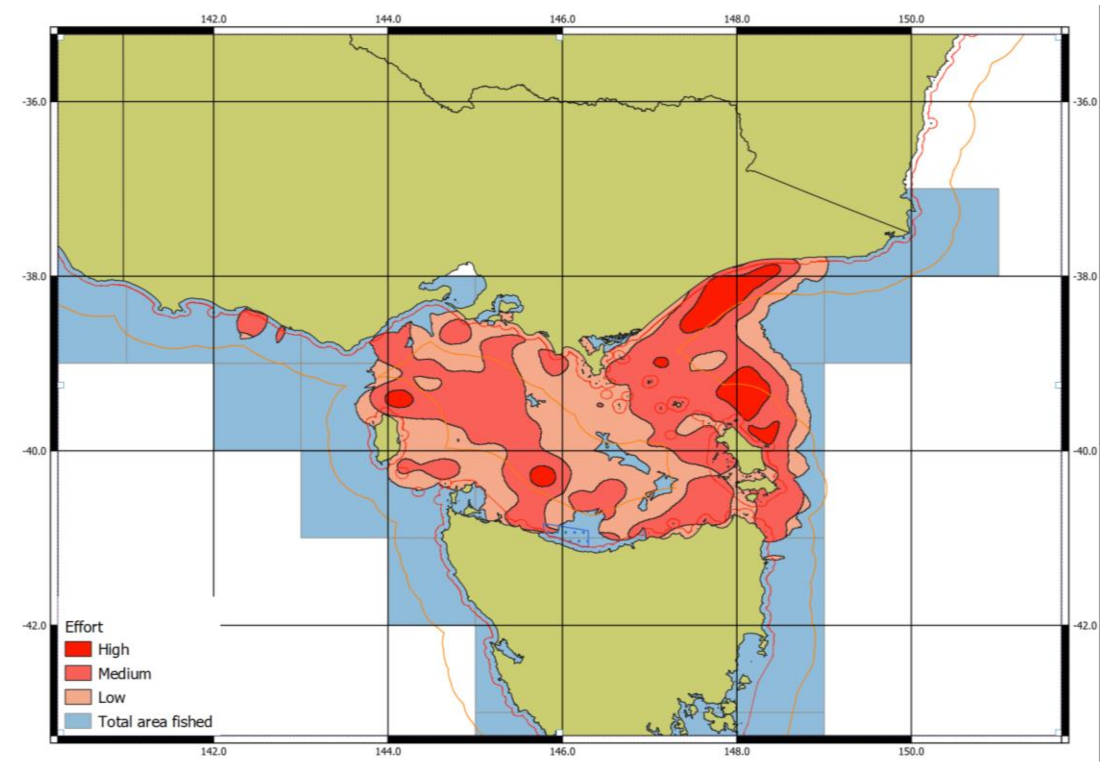


Figure 26. Relative fishing intensity by the Shark Gillnet Sector during 2020–2021 in relation to the fishing data assessment area. Note that effort comprising data of less than 5 vessels has been removed. Data provided by ABARES. Original data source: AFMA

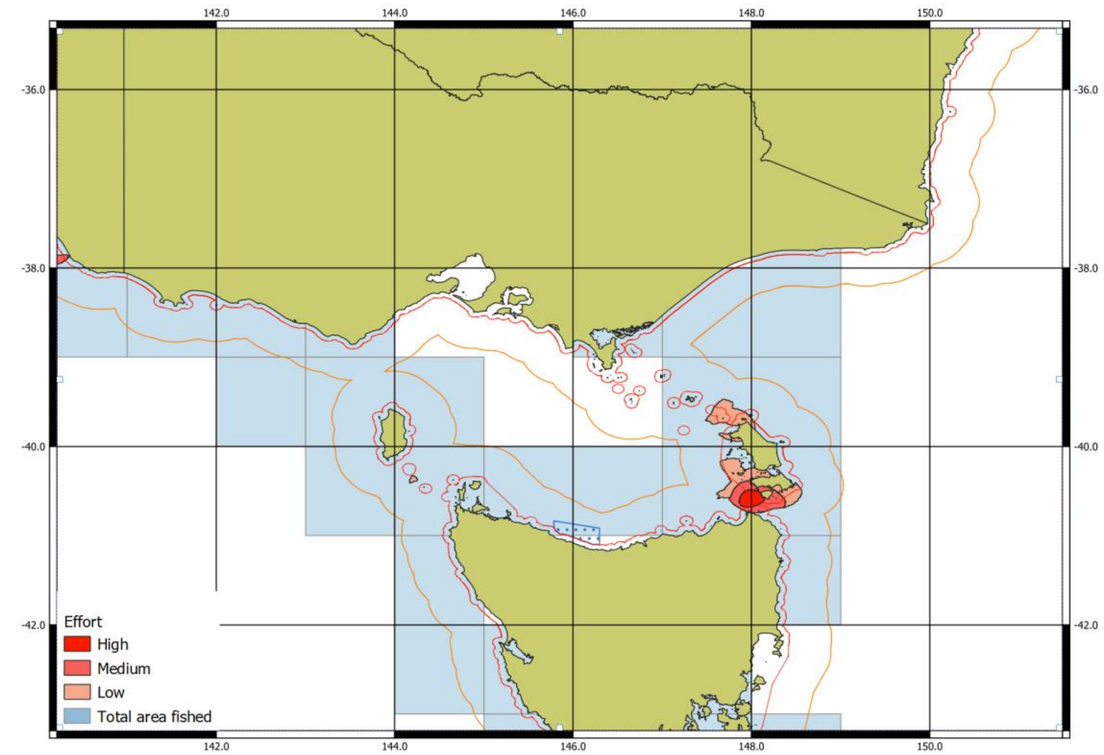


Figure 27. Relative fishing intensity by the Shark Hook Sector during 2020–2021 in relation to the fishing data assessment area. Note that effort comprising data of less than 5 vessels has been removed. Data provided by ABARES. Original data source: AFMA

Less than five vessels reported effort using demersal longline within the fishing data assessment area since 2012, so to maintain confidentiality, data from this vessel was be combined with data from gillnet effort. A summary of catch and effort from the study area by demersal gillnet and demersal longlines combined is shown Table 7. Over 2012 to 2021, a total of 17 different SGSHS vessels fished in the study area. From 463 shots, 41.3 t with an estimated value of $0.38 million was caught. Main species caught were Gummy Shark (17 vessels, 69%), School Shark (8 vessels, 9%) and Elephantfish (12 vessels, 7%) (Table 7 and Figure 28).

SGSHS effort in the fishing data assessment area has decreased since 2012 from just over 70 shots to about 34 in 2018 (Figure 29). Over that time only 5–8 different vessels fished in the fishing data assessment area, and less than 5 vessels has fished that area in any one year since 2019. Catch increased from about 5 t in 2012 to just under 8 t in 2016. Because the catch is dominated by three species, the annual trend in value closely mirrors catch. Annual value from 2012–2018 ranged $20,000 to $80,000.

Table 7. Shark Gillnet and Shark Hook Sector (demersal gillnet and demersal longline) effort, catch, catch value and main species caught within the total AFMA data area from 2012 to 2021. Original data (source: AFMA).

YEARS INCLUDED	**2012 to 2021**
Number of different vessels	17
Total shots	463
Total catch (t)	41.3 t
Total value	$376,181
Main species caught	Gummy Shark (69%) School Shark (9%) Elephantfish (9%)
Fishing methods used	Demersal Gillnet Demersal Longline

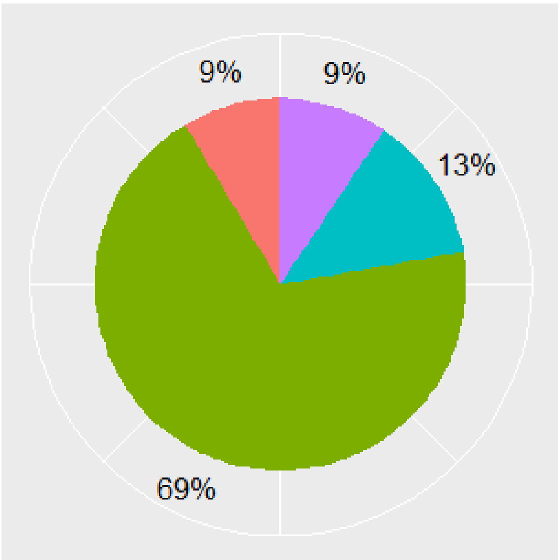


Figure 28. Main species caught in the fishing data assessment area from 2012 to 2021 by the Shark Hook and Shark Gillnet subsectors of the Gillnet, Hook and Trap Fishery. Note the minimum number of vessels that caught any one species shown was 8. Original data source: AFMA

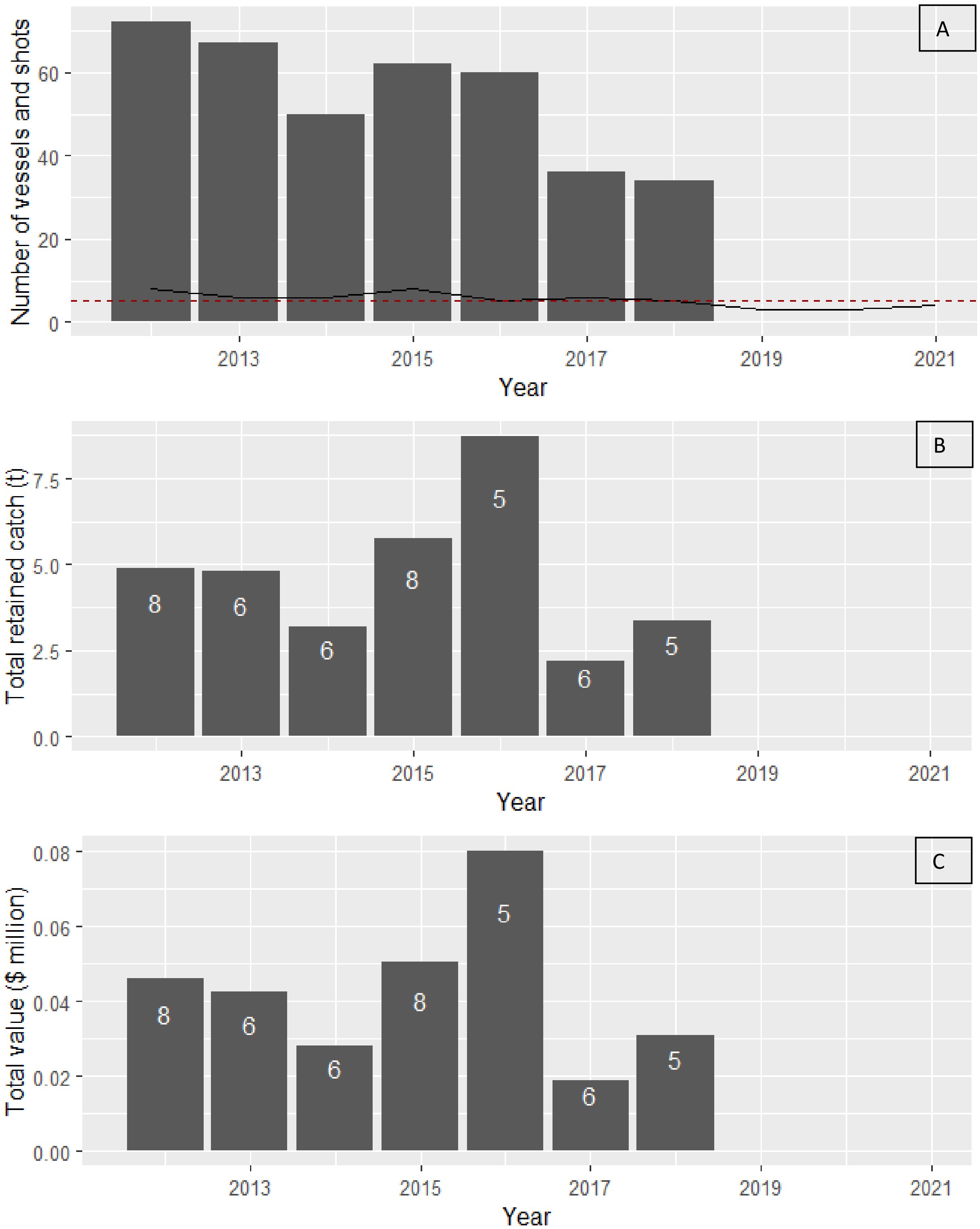
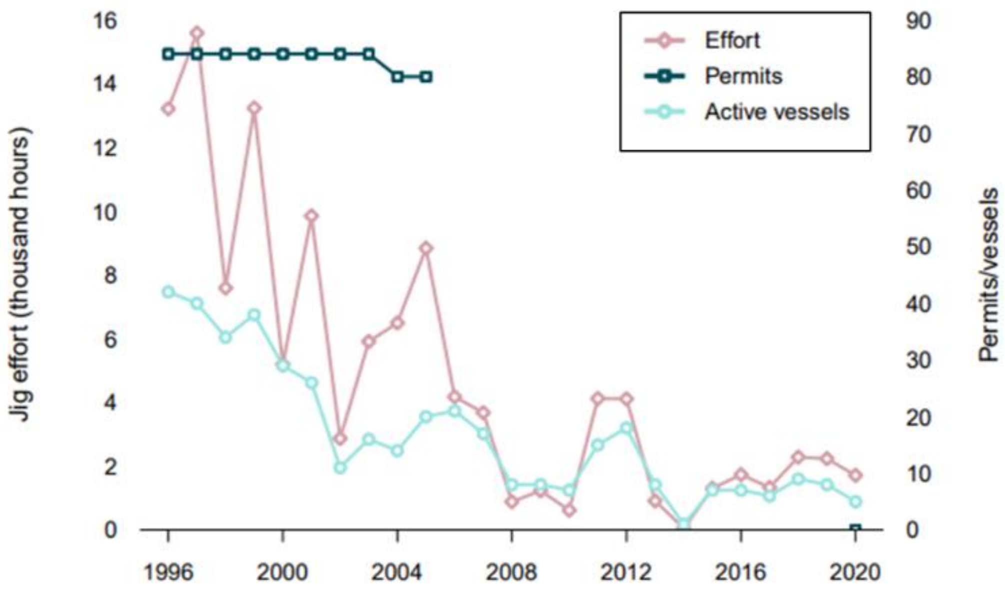


Figure 29. Effort, retained catch and annual value of Shark Gillnet and Shark Hook vessels in the Gillnet, Hook and Trap Fishery during 2012 to 2021. A) Number of vessels with effort represented by the black line and bars representing number of shots, the red line intercepts the y-axis at 5 . B) Annual retained catch within the fishing data assessment area represented by bars. C) Estimated annual values ($ million) landed within the fishing data assessment area in each year. Number of vessels annotated on bars in B and C. Original data source: AFMA

2.3 Southern Squid Jig Fishery

Both fishing effort and the number of vessels participating in the Southern Squid Jig Fishery have declined significantly since 1996 (Figure 30). Poor domestic prices and high fuel costs have resulted in many operators choosing to avoid fishing for squid (Wilson *et al.*, 2009), and consequently, there were only five active vessels out of 36 concessions (95% latency) used during 2020 (Noriega and Steven, 2021). Together they landed 67 t of squid (Figure 31) with a GVP of $0.35 million in that year.



Note: Permits were replaced by gear statutory rights in 2005.

Figure 30. Number of permits, active vessels and fishing effort by the Southern Squid Jig Fishery since 1996 (Noriega and Steven, 2021).

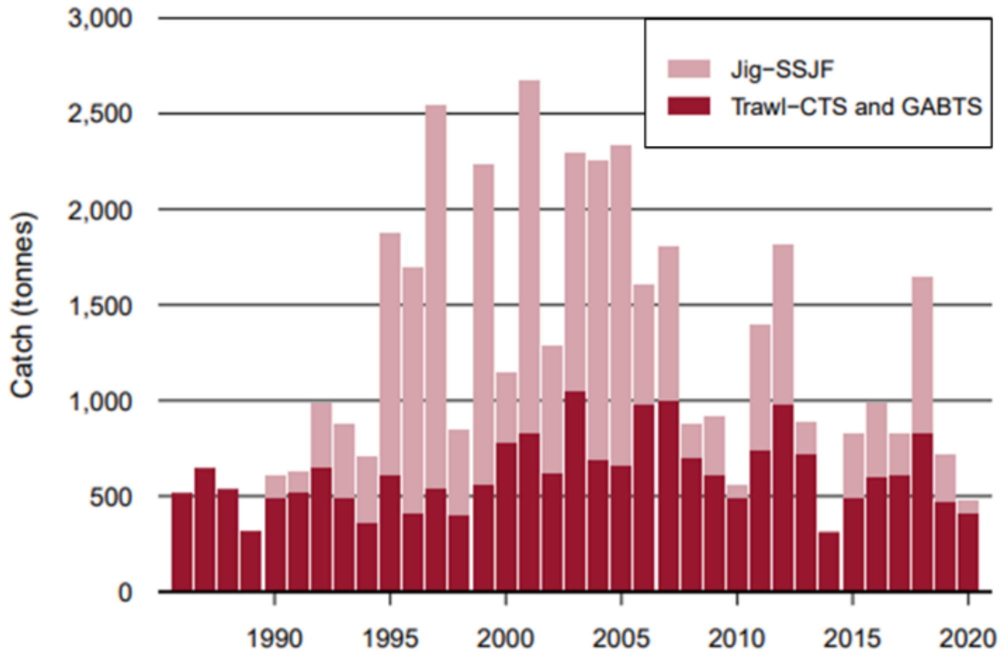


Figure 31. Catch and effort they the Southern Squid Jig Fishery, Commonwealth Trawl Sector and Great Australian Bight Trawl Sector since 1986 (Noriega and Steven, 2021).

2.3.1 Overlap between Southern Squid Jig Fishery and the fishing data assessment area

Less than five vessels fished in the fishing data assessment area over 2012–2021 and so data cannot be presented to maintain confidentiality. Figure 32 shows that recent effort has been recorded in the vicinity of the fishing data assessment area, but during 2020, effort in the fishery was focussed off western Victoria.

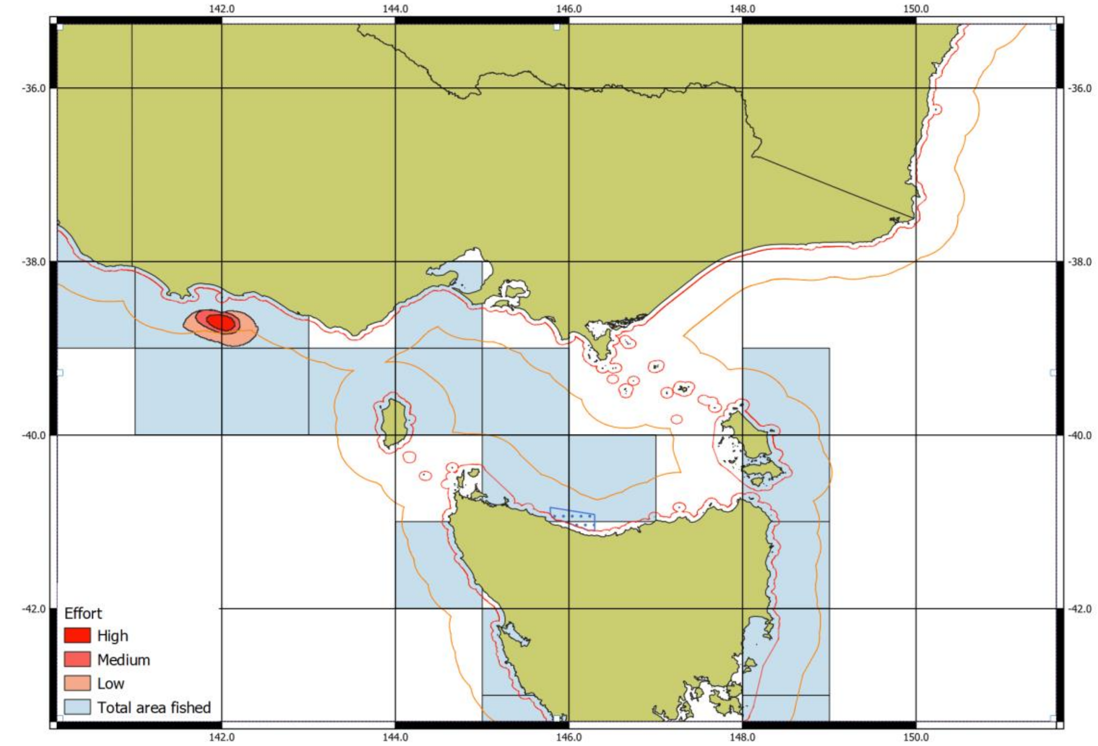


Figure 32. Area fished by the Southern Squid Jig Fishery in relation to the fishing data assessment area during 2020. Note that effort comprising data of less than 5 vessels has been removed. Data provided by ABARES. Original data source: AFMA

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2.5 Tasmanian Rock Lobster Fishery

The TAC for the 2021–22 season is 1,050.7 t, and as of 30 November 2021, 63% of that TAC had been caught. There were less than 200 active fishers during 2016–17 (Hartmann *et al.*, 2019). Annual catch of Southern Rock Lobster has decreased from nearly 1,500 t in 2008–09, to just over 1,000 t during the 2017–18 quota year (Figure 33). Percent of TAC caught dropped to 91% in 2010–11, but has since been about 98% with the exception of the 2019–20 season when the TAC was about 8.5% under caught. Most of the catch comes from 0–40 m depth, some catch is taken from as deep as 200 m (Environment Australia, 2001).

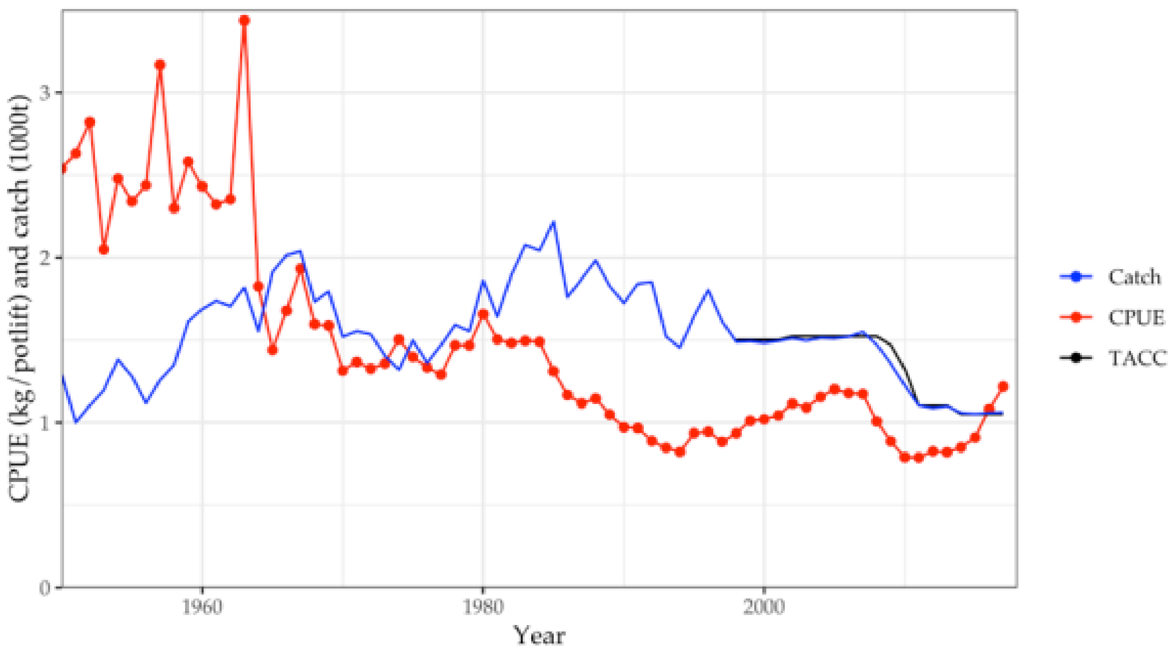

Figure 33. Annual catch, TAC and catch per unit effort (CPUE) of Southern Rock Lobster by the Tasmanian Rock Lobster Fishery since the inception of the ITQ system. From Hartmann et al., (2019)

2.5.1 Overlap between Tasmanian Rock Lobster Fishery and the fishing data assessment area

The fishing data assessment area overlaps the Tasmanian Rock Lobster Fishery reporting grids 4E4, 4F3, 5E2 and 5F1 (Figure 34A), however in assessment reports catches are reported by larger geographic areas, and the fishing data assessment area overlaps with area 5 (Figure 34B). Catch of Southern Rock Lobster in area 5 has decreased from more than 300 t in 2010–11 to 200 t in 2016–17 and 2017–18.

Data provided by Department of Natural Resources and Environment Tasmania for this fishery contained catch number, not weight. Hartmann *et al*. (2013) reported the average weight of Southern Rock Lobster for area 5 from 1970–2011 ranged 1–1.3 kg. We used the middle of this range to convert catch number to catch weight, which was multiplied by the beach price (also provided by Department of Natural Resources and Environment Tasmania) to obtain total value.

From 2002 to 2021 In the reporting grids that overlapped with the fishing data assessment area, six different vessels deployed 542 pots and caught 0.277 t (241 animals) Southern Rock Lobster valued at just over $15,000 (Table 8). Average depth fished was about 21 m.

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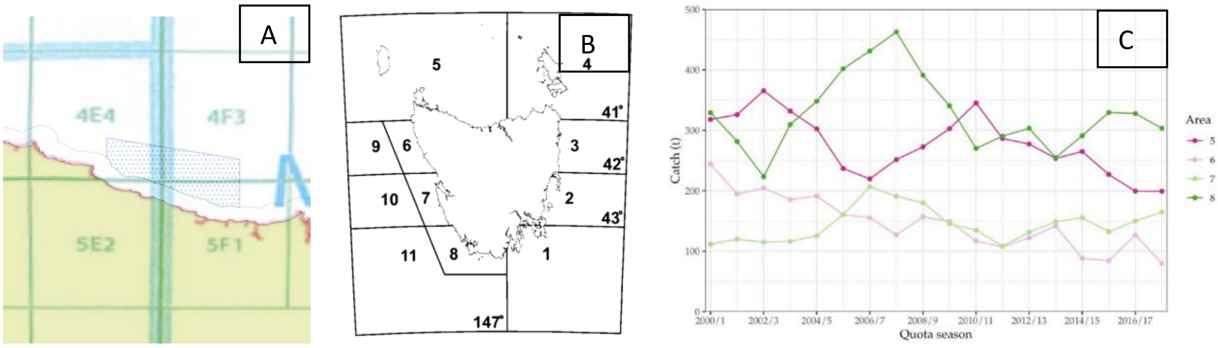

Figure 34. A) Tasmanian Rock Lobster Fishery reporting grids; B) geographical reporting areas used in reporting results of stock assessments (from Hartmann et al., 2019); and annual catch by geographic area (from Hartmann et al., 2019).

Table 8. Tasmanian Rock Lobster Fishery effort, catch, catch value and main species caught within the reporting grids that overlapped with the fishing data assessment area from 2002 to 2021. Original data (source: Department of Natural Resources and Environment Tasmania). Average weight for area 5 from 1970–2011 ranged 1–1.3 kg (Hartmann et al. 2013). We converted number caught to weight using the middle of that range (1.15 kg).

YEARS INCLUDED	2002 to 2021
Number of different vessels	6
Total pots used	542
Total catch (t) (number)	0.277 t (241)
Total value	$15,142
Main species caught	Southern Rock Lobster
Fishing methods used	Pot

2.6 Tasmanian Abalone fishery

From a TAC of 1,018.5 t in 2020, 925.7 t and 85.4 t of Blacklip and Greenlip Abalone, respectively, were landed (Mundy and McAllister, 2021). Catches by the Tasmanian Abalone Fishery reached as high 4,500 t in 1984, dropping to about 2000 t 1989 to 1996 (Figure 35). Annual catches then averaged at around 2,500 t until 2011, after which they steadily declined to about 1,000 t due to declining stocks.

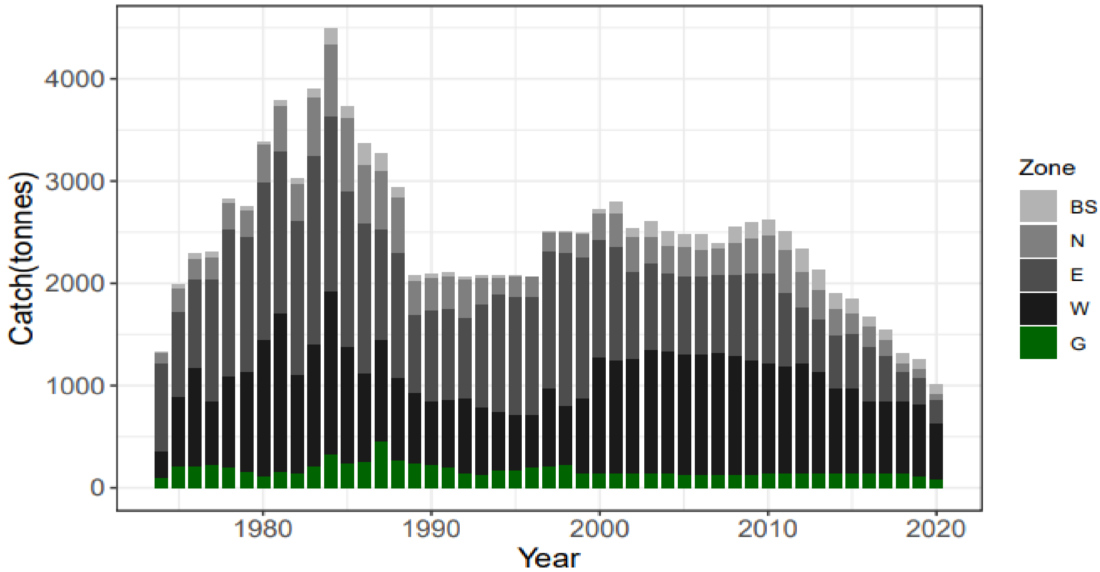

Figure 35. Annual catch of Blacklip ana Greenlip Abalone since 1974 (Mundy and McAllister, 2021).

2.6.1 Overlap between the Tasmanian Abalone Fishery and the fishing data assessment area

The fishing data assessment area overlaps with the Tasmanian Abalone Fishery (greenlip and blacklip) reporting blocks 44 and 45 (Figure 36). Mundy and McAllister (2021) reported catches of Blacklip Abalone in block 45 (they did not report catches for block 44) and Greenlip Abalone for a broader area, all from the Central North Coast (which includes blocks 44 and 45).

Catches of Blacklip Abalone in block 45 have been about 1 t or less from 1992–2020 (Figure 37), while the catch of Greenlip Abalone from the Central North Coast (which stretches across most of the northern Coast of Tasmania) has been less than 10 t per year over the past 20 years (Figure 38). Since 2002, between 1 and 7 divers have fished in either blocks 44 or 45 in any one year. Annual catches cannot be reported to maintain confidentiality, however data provided indicate that block 44 and to a lesser extent block 45 are somewhat important fishing grounds for the Tasmanian Abalone Fishery in some years.

While these blocks overlap the fishing data assessment area, it is unlikely that there is any actual fishing overlap between the Tasmanian Abalone Fishery and the research area because of the depth limitation of divers, who generally don't fish deeper than 30 m.

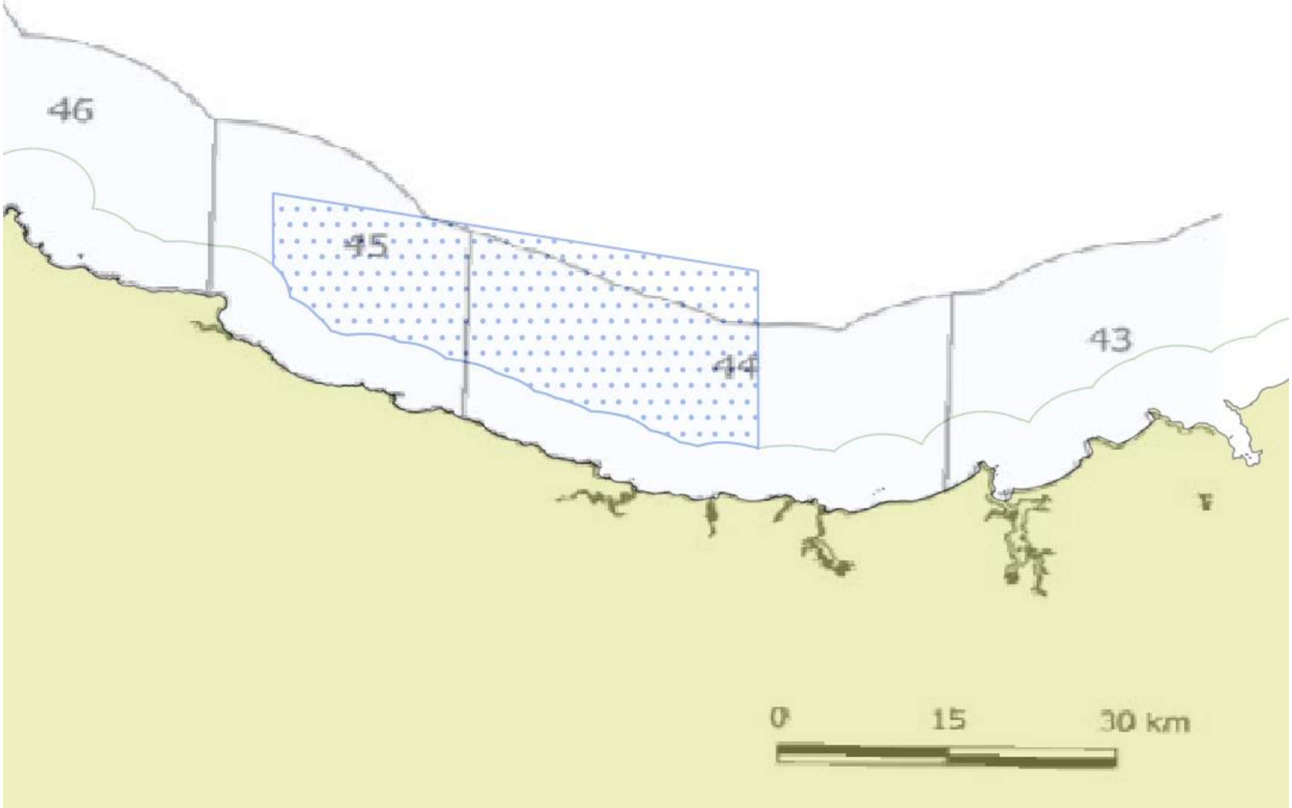

Figure 36. Overlap of the fishing data assessment area and Tasmanian Abalone Fishery reporting grids.

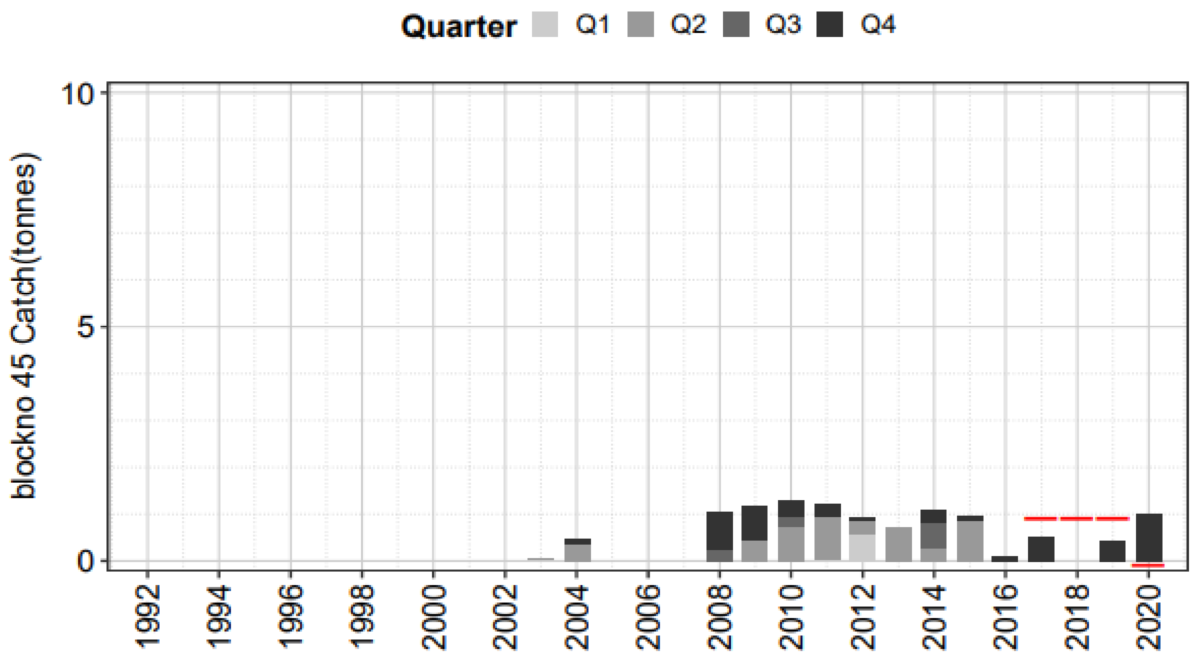

Figure 37. Annual catch of Blacklip Abalone since 1992 in block 45 (from Mundy and McAllister, 2021). Note that Mundy and McAllister (2021) did not include a figure for block 44.

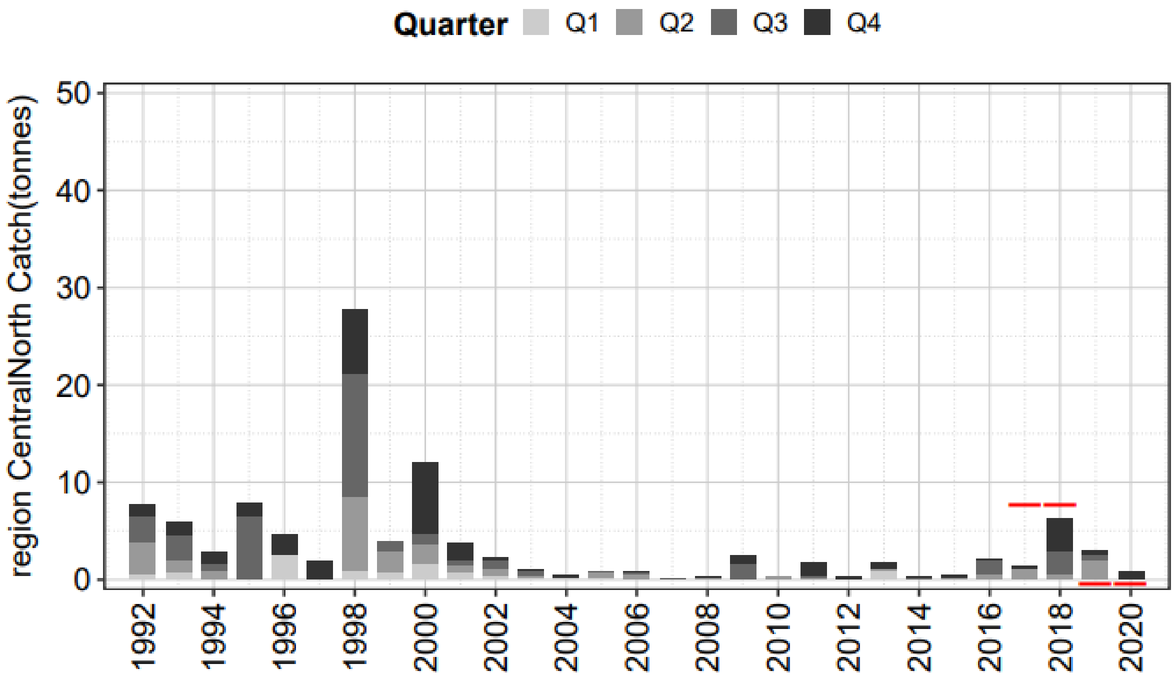

Figure 38. Annual catch of Greenlip Abalone since 1992 from the Central North Coast (from Mundy and McAllister, 2021).

2.7 Tasmanian Scalefish Fishery

More than 90 different species are reported in the TAS Scalefish Fishery catch logbook. Catch of scalefish has been declining since the late 1990s from about 1,300 t to 178 t in 2019–20 (Fraser, *et al.*, 2021). Catch of cephalopods (mostly Southern Calamari and Gould's Squid) has fluctuated annually being as high as 1,140 t in 2012–13 and as low as 27 t in 1996–97. Annual catch of small pelagics has also fluctuated largely from year to year. In 2008–09, 1,456 t of small pelagics (mostly Jack Mackerel and Redbait) was landed, while in 2018–19 only 0.4 t was landed, these numbers are likely Danish seine, since there is no state licenced trawling. Shark catch has decreased from 1,221 t in 1995–96 to less than 20 t since 2007–08.

2.7.1 Overlap between TAS Scalefish Fishery and the fishing data assessment area

From 2002 to 2020, 52 different fishing vessels recorded effort from the reporting grids that overlapped with the fishing data assessment area (Table 9). They recorded 2,934 days of fishing and caught 202.7 t of fish valued at $1,609,280. Main species caught were Southern Calamari (38%), Gould's Squid (13%), Bluethroat Wrasse (12%) and Snook (12%) (Figure 43). Fishing gears that caught the most fish were hand squid jig, handline and troll.

Table 9. Tasmanian Scalefish Fishery effort, catch, catch value and main species caught within the reporting grids that overlapped with the fishing data assessment area from 2002 to 2020. Original data (source: Department of Natural Resources and Environment Tasmania). The latest date in the data is 9/29/2020, and it is unclear if no fishing has occurred since, or if later data was not available. Note the minimum number of vessels that caught any one species shown was 7.

YEARS INCLUDED	2002 to 2020
Number of different vessels	52
Total days fished	2,934
Total catch (t) (number)	202.7 t
Total value	$1,609,280
Main species caught	Southern Calamari (38%) Gould's Squid (13%) Bluethroat Wrasse (12%) Snook (12%)
Fishing methods used	Hand squid jig, Handline, Troll

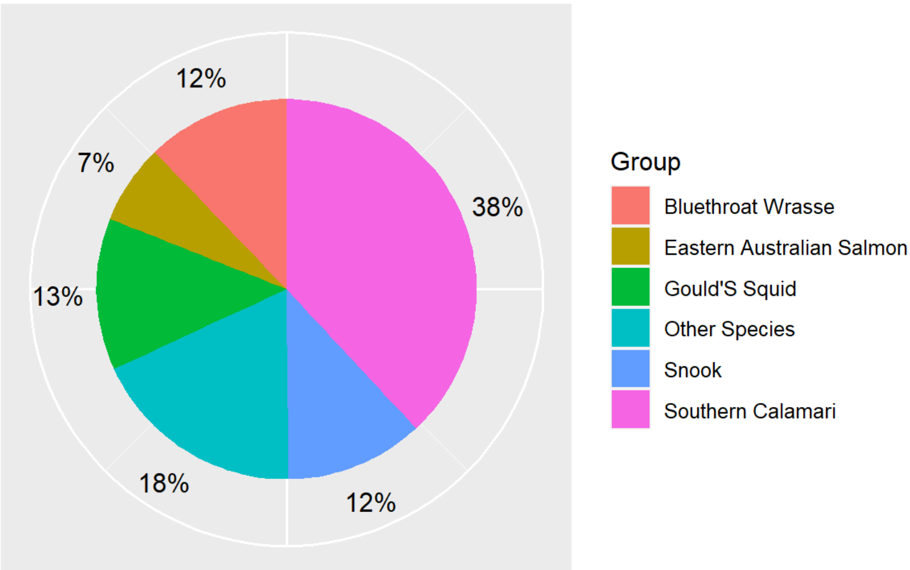

Figure 39. Main species caught in the fishing data assessment area from 2002 to 2020 by the Tasmanian Scalefish Fishery. Note the minimum number of vessels that caught any one species shown was 7. Original data source: Department of Natural Resources and Environment Tasmania

From 2002 to 2005 less than 5 vessel reported effort in the fishing data assessment area, and in 2006 no boats reported effort. Effort and number of vessels fishing increased from 2007 to peak in 2019 at nearly 400 days and 20 vessels. Catch and catch value have also generally increased over that time from about 1 t to more than 20 t and from less than $10,000 to more than $200,000. Compared to other areas around Tasmania, the fishing data assessment area and surrounds is a relative important area for catches of Southern Calamari, Gould's Squid, wrasse and Snook (Figure 41, Figure 42, Figure 43 and Figure 44).

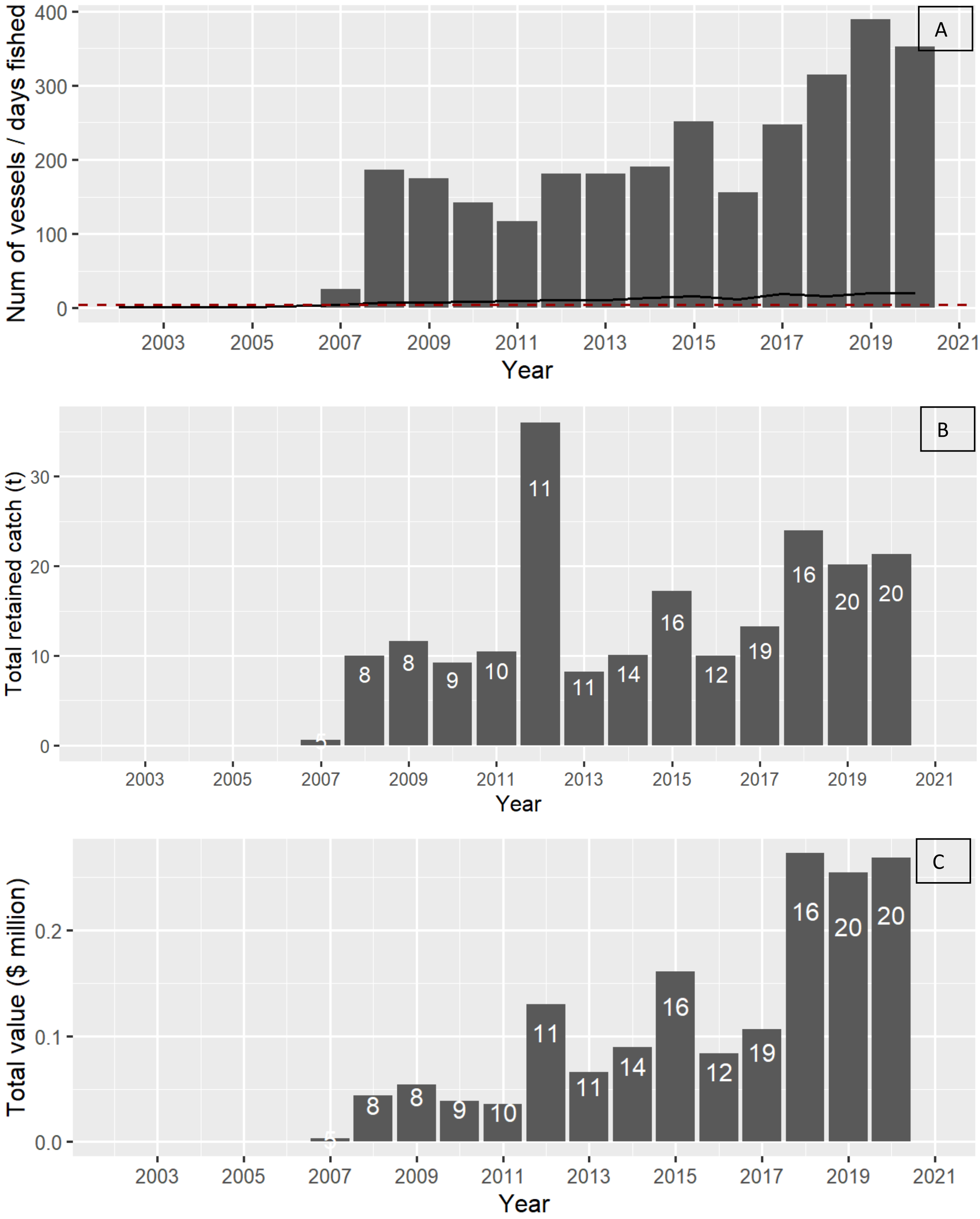

Figure 40. Effort, retained catch and annual value by the Tasmanian Scalefish Fishery during 2002 to 2020. A) Number of vessels which recorded effort represented by the black line and bars representing number of shots, the horizontal red line intercepts the y-axis at 5 . B) Annual retained catch within the fishing data assessment area represented by bars. C) Estimated annual values ($ million) of fish landed within the fishing data assessment area in each year. Number of vessels annotated on bars in B and C. Original data source: Department of Natural Resources and Environment Tasmania

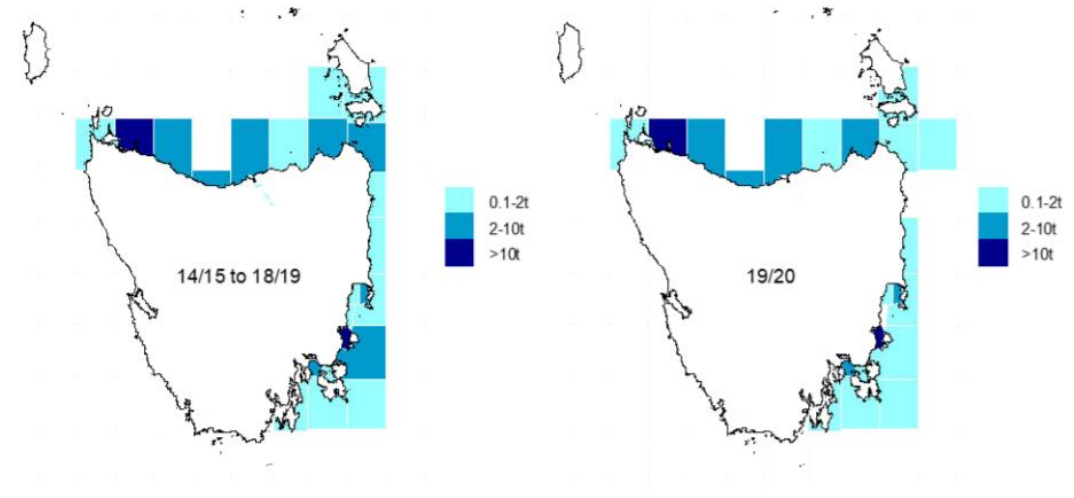

Figure 41. Catch of Southern Calamari from 2014–15 to 2018–19 (left) and 2019–20 (right). From Fraser et al., 2021.

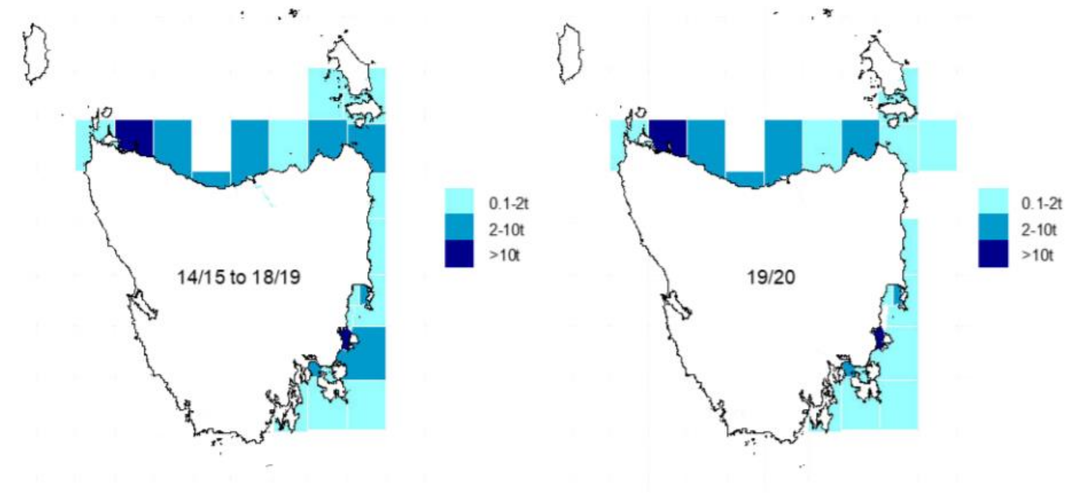

Figure 42. Catch of Gould's Squid from 2014–15 to 2018–19 (left) and 2019–20 (right). Data includes Australian Fisheries Management Authority (AFMA) catch in Tasmanian state waters. From Fraser et al., 2021.

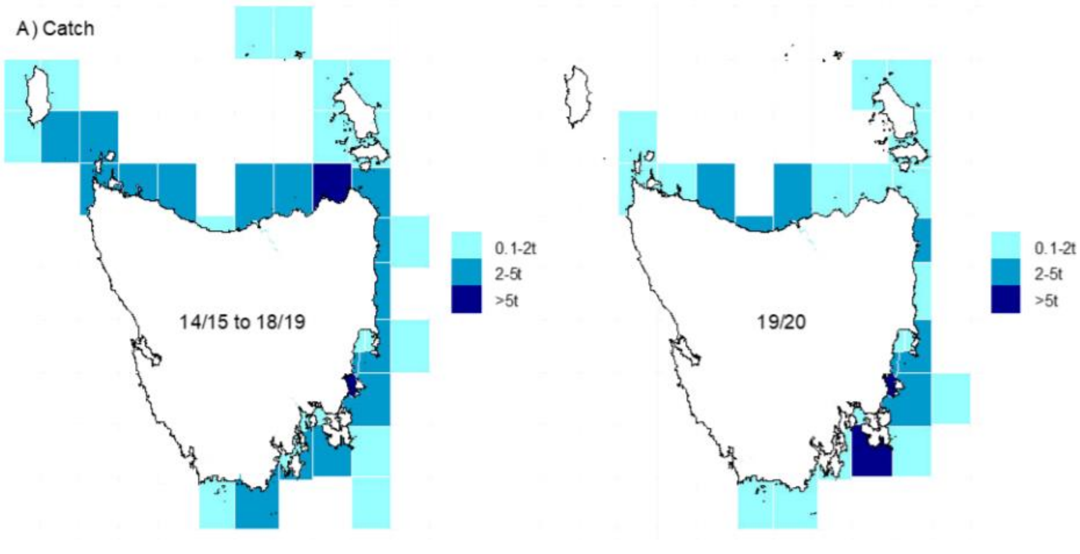

Figure 43. Catch of wrasse from 2014–15 to 2018–19 (left) and 2019–20 (right). From Fraser et al., 2021.

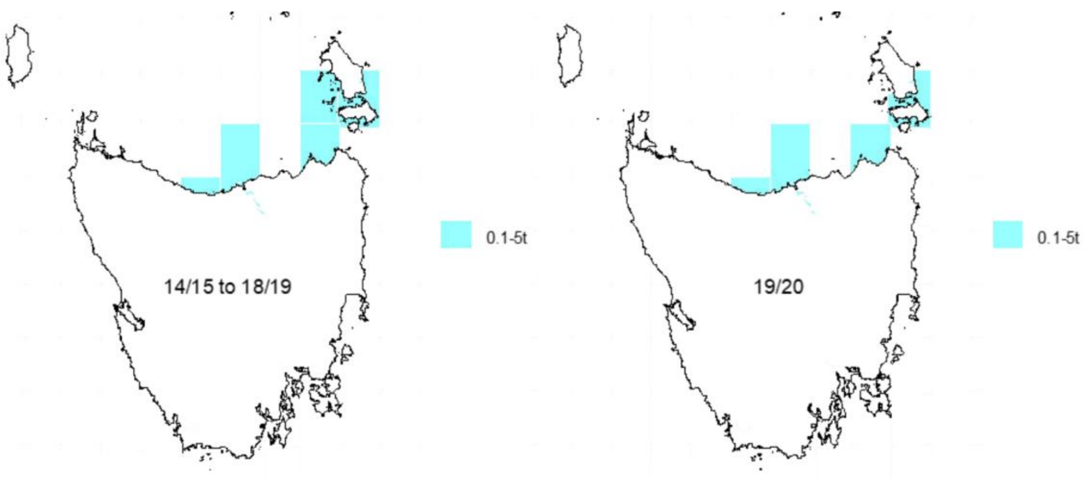

Figure 44. Catch of Snook from 2014–15 to 2018–19 (left) and 2019–20 (right). From Fraser et al., 2021.

DELIVERABLE 3: FISHING METHOD RISK ASSESMENT

The results for the risk ranking of fishing methods (which are not jurisdictional) are presented in Table 10. These Risk scores were are based on four types of impulse attributable to:

1. Fishing vessel impact,
2. Vessel anchor drop impact,
3. Vessel anchor drag impact,
4. Descending fishing gear impact, and a Pulling force associated with snagged gear recovery.

Table 10. Risk ranking results for nine fishing methods (which are not jurisdictional) operating in the vicinity of the fishing data assessment area. The Risk Score was based on four types of impulse associated with vessel, equipment and fishing gear impacts and a pulling force associated with snagged gear recovery.

Fishing method	Risk Ranking	Risk Score (= T1 + T2 + T3 + T4 + PF)	Impulse Type 1 Vessel impact		Impulse Type 2 Anchor drop		Impulse Type 3 Anchor drag		Impulse Type 4 Gear drop impact		Pulling force Snagged gear recovery	
			Impulse (KN.s)	Relative Score [T1]	Impulse (N.s)	Relative Score [T2]	Impulse (N.s)	Relative Score [T3]	Impulse (N.s)	Relative Score [T4]	Max. (KN)	Relative Score [PF]
Demersal gillnet	**1**	**4.54**	639	1.00	257	1.00	130	1.00	72	1.00	25	0.54
Squid jigging	**2**	**4.00**	639	1.00	257	1.00	130	1.00	-	-	46	1.00
Craypot	**3**	**3.97**	639	1.00	257	1.00	130	1.00	38	0.53	20	0.44
Octopus trap	**4**	**3.74**	639	1.00	257	1.00	130	1.00	36	0.51	11	0.23
Demersal longline	**5**	**3.63**	639	1.00	257	1.00	130	1.00	29	0.40	11	0.23
Fish trapping	**6**	**2.20**	306	0.48	86	0.33	57	0.44	36	0.51	20	0.44
Trolling	**7**	**0.34**	123	0.19	8	0.03	9	0.07	-	-	2	0.04
Handline	**7**	**0.34**	123	0.19	8	0.03	9	0.07	0.4	0.01	2	0.04
Hand gathering	**8**	**0.30**	123	0.19	8	0.03	9	0.07	-	-	-	-

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3.1 Risk Review Methodology

The methodology followed is summarised below, for a full explanation of methodology see Appendix A:

1. Present the commercial fisheries and associated fishing methods that overlap with the CRC Blue Economy fishing data assessment area
2. Explain why Impulse is an appropriate parameter to assess the danger/risk in this situation
3. Categorise the various Impulse situations associated with specific types of interactions
4. Present the simplifications, assumptions and approximations used in the analysis
5. Assemble the necessary data (mass, velocity change and interaction duration) on vessel, gear, and anchor, for Impulse or Pulling force determination
6. Complete the Impulse or Pulling force calculations and present the results in an appropriate format
7. Discuss the findings and formulate conclusions

3.1.1 Commercial fishing methods overlapping with the fishing data assessment area

The results from the earlier sections (i.e., Deliverables 1 & 2) identified that five fisheries and at least nine fishing methods operate in the vicinity of the proposed Blue Economy CRC project area (the fishing data assessment area). Of these fishing methods, nine were included in the risk assessment based on proximity to the fishing data assessment area i.e., they would pose a real risk to farm infrastructure, either surface or sub-surface. Methods omitted, such as beach seine, purse seine, dip net, and spear, are used in the Tasmanian Scalefish Fishery, but are considered to be inshore methods and therefore very unlikely to interact with any farm infrastructure at the proposed site.

The nine fishing methods covered in the RA, together with the key representative vessel data for each method are presented below:

- Demersal gillnet; typical vessel length 20m capable of 5 m/s
- Demersal longline; typical vessel length 20m capable of 5 m/s
- Squid jigging; typical commonwealth sector vessel used as representative vessel, 20m aft wheelhouse vessel, capable of 5 m/s
- Craypot; representative vessel of 20m displacement hull form, capable of 5 m/s
- Octopus trap; typical vessel length of 20m, capable of 5 m/s
- Fish trapping; representative vessel of 15m displacement hull vessel capable of 5m/s
- Trolling; dedicated multi-hull trolling vessel used as representative vessel, length 8m, maximum speed 10m/s
- Handline; representative handlining vessel of 8m in length and capable of 10m/s
- Hand gathering; representative vessel 8m in length and capable of 10 m/s

3.1.2 Impulse Theory

To assess the potential physical impact that commercial fishing vessels, their fishing gear, as well as their anchor(s), may have on the Blue Economy CRC infrastructure, the magnitude of the Impulse associated with each interaction (i.e., collision) was determined.

Impulse was seen an appropriate quantity to use in this instance since it contains the key variables governing the forces that may be produced (i.e., the body's mass and velocity) and is relatively simple to calculate. It provides a simple means to show in a relative context the different degree of severity associated with each interaction.

3.1.3 Impulse categories and Pulling Force definition

In relation to potential interactions between commercial fishing vessel/gear and Blue Economy CRC infrastructure, a total of four different situations capable of causing a change in momentum (i.e., Impulse) were identified:

1. fishing vessel collision
2. Impulse type 2 – vessel anchor drop impact
3. Impulse type 3 – vessel anchor drag impact
4. Impulse type 4 – descending fishing gear impact

Also considered in addition to the four forms of Impulse was a pulling force, the latter being associated with an operator trying to free up snagged fishing gear.

3.1.4 Impulse Interaction Assumptions and Approximations

To facilitate the Impulse calculation process certain assumptions and approximations were made regarding the interactions involving fishing vessels, fishing gear and anchor systems. These assumptions and approximations are presented in Appendix D.

3.2 Results and Discussion

The Impulse and Pulling Force results, together with the Risk score and Ranking, are presented in Table 10 above for each of the relevant fishing methods. Note the order of fishing methods is in descending order, with higher Risk scores and therefore Rankings at the top.

3.2.1 High risk fishing methods

Evidently, the larger vessels with more momentum, heavier anchors and utilising bulkier/heavier gear, namely demersal gillnet, posed the greatest risk of damaging Blue Economy CRC infrastructure. Whereas smaller craft with less momentum, lighter anchors, and less bulky/heavier gears, such as handline and hand gathering posed the least risk. This outcome was very much governed by these three key characteristics, namely; vessel momentum, the mass of the vessel's anchor, and the momentum of the largest fishing gear ballast component.

3.2.2 Relative Risk score variation

The Risk scores showed great variation across the fishing methods assessed, with the risk scores ranging from 4.54 to 0.30 (Table 10). As stated above, the risk posed to fish farm infrastructure was heavily tied to the vessel size and speed, as well as the weight and momentum of the main equipment/gear components it deploys. Noteworthy was that squid jigging, despite having relatively lightweight fishing gear (squid jigging lines etc), still registered second overall because of the large maximum pulling force (46 KN) associated with its sea anchor (which was considered to be an integral part of the fishing gear), should that become entangled with farm infrastructure. Also noteworthy was the three distinct groupings in overall risk score, namely Ranking 1-5, Ranking 6, and Ranking 7-8, which was largely dictated by the momentum associated with the representative fishing vessels used with that fishing method.

3.2.3 The type of interaction that poses the greatest risk

An analysis of the Impulse results for each fishing vessel/method revealed that Impulses associated with vessel collision (Type 1 - vessel comes to a standstill) were much greater than the other forms of Impulse considered (Type 2-4). In other words, for any given fishing method, vessel collision was the interaction that posed the greatest potential risk to Blue Economy CRC surface infrastructure.

The vessel induced Impulses also showed considerable variation across the nine fishing methods under consideration (639 to 123KN.s), and this variation was primarily attributable to the variation in vessel size, with the representative vessels for the five highest ranked fishing methods having a displacement of 128 t and registering an Impulse of 639 KN.s, whereas the smaller vessels ranked 7 and 8^{th} with a 12t displacement registering an Impulse of only 123 KN.s (i.e., about 19% of the horizontal longliner Impulse).

3.2.4 Pulling forces

The Pulling Force results (refer Table 10, far right column) showed that squid jigging with the stronger connecting rope and tackle between vessel and gear (in this case the sea anchor), had the greatest potential to damage Blue Economy CRC infrastructure should the fishing gear become snagged, with the maximum tensile force predicted to reach about 46 kN. Vessels using other fishing gears with lighter connecting ropes to the vessel showed a substantial step-down in maximum pulling force, registering 25KN or 2.5tF (about 54% of the fouled sea anchor) or less (down to 2KN (4%)).

3.2.5 Relative magnitude of impulses and pulling forces

It was apparent from the Impulse and Pulling force results, irrespective of fishing method, that a collision between fishing vessel and fish-farm surface infrastructure represents the greatest form of harm to this proposed activity, and that forces associated with anchor and fishing gear interactions will be at least one or two orders of magnitude less.

REFERENCES

Anon. Fishing Line Diameters, Mels-Place http://www.mels-place.com/Mels-Place.com-2016-Fishing-Line-Diameter-Comparison.pdf

AFMA. (2021). Southern and Eastern Scalefish and Shark Fishery Management Arrangements Booklet 2021. Commonwealth of Australia, 2021.

Director of National Parks. (2013). South-east Commonwealth Marine Reserves Network management plan 2013-23, Director of National Parks, Canberra.

Emery, T., Woodhams, J. and Curtotti, R. (2021). Commonwealth Trawl and Scalefish Hook Sectors. In: Patterson, H, Bromhead, D, Galeano, D, Larcombe, J, Woodhams, J and Curtotti, R. (2021). Fishery status reports 2021, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/vahf-ng93.

Environment Australia. (2001). Assessment of the Tasmanian Rock Lobster Fishery against the Guidelines for the ecologically sustainable management of fisheries for the purposes of Part 13 and Part 13A of the Environment Protection and Biodiversity Conservation Act 1999. Environment Australia, Canberra ACT. https://webarchive.nla.gov.au/awa/20191115120433/http://www.environment.gov.au/marine/fisheries/tas/rock-lobster/assessment-report-2001

Fraser, K., Hartmann, K. and Krueck, N. (2021). Tasmanian Scalefish Assessment 2019–20. Institute for Marine and Antarctic Studies, University of Tasmania, Hobart.

Hartmann, K., Gardner, C., Hobday, D. (2013). Tasmanian Rock Lobster Fishery 2011/12. The Institute for Marine and Antarctic Studies, University of Tasmania, Hobart.

Hartmann, K., Gardner, C., León, R. and Rizzari, J. (2019). Fishery Assessment Report Tasmanian Rock Lobster Fishery 2017/18. The Institute for Marine and Antarctic Studies, University of Tasmania, Hobart.

IUCN (2022a). Category V: Protected Landscape/Seascape, viewed on 16 May 2022, < https://www.iucn.org/theme/protected-areas/about/protected-areas-categories/category-v-protected-landscapeseascape>

IUCN (2022b). Category VI: Protected area with sustainable use of natural resources, viewed on 16 May 2022, https://www.iucn.org/theme/protected-areas/about/protected-areas-categories/category-vi-protected-area-sustainable-use-natural-resources

Moore, B., Lyle, J. and Hartmann, K. (2018). Tasmanian Scalefish Fishery Assessment 2017/18. Institute for Marine and Antarctic Studies, University of Tasmania, Hobart.

Mundy, C. and McAllister, J. (2021). Tasmanian Abalone Fishery Assessment 2020. Institute for Marine and Antarctic Studies. June 2021.

Noriega, R and Steven, AH. (2021) Southern Squid Jig Fishery. In: Patterson, H, Bromhead, D, Galeano, D, Larcombe, J, Woodhams, J and Curtotti, R. (2021). Fishery status reports 2021, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/vahf-ng93.

Patterson, H., Bromhead, D., Galeano, D., Larcombe, J., Woodhams, J, and Curtotti, R. (2021). Fishery status reports 2021, Australian Bureau of Agricultural and Resource Economics and Sciences. Canberra. CC BY 4.0. https://doi.org/10.25814/vahf-ng93.

Wilson, D., Curtotti, R., Gegg, G., Phillips, K. (2009). Fishery Status Reports 2008: status of fish stocks and fisheries managed by the Australian Government. Canberra, Bureau of Rural Sciences and Australian Bureau of Agricultural and Resource Economics.

Woodhams, J. and Curtotti, R. (2021). Shark Gillnet and Shark Hook sectors. In: Patterson, H, Bromhead, D, Galeano, D, Larcombe, J, Woodhams, J and Curtotti, R. (2021). Fishery status reports 2021, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/vahf-ng93.

APPENDIX A – RISK REVIEW METHODOLOGY

The methodology followed is outlined below:

1. Present the commercial fisheries and associated fishing methods that overlap with the BECRC infrastructure
2. Explain why Impulse is an appropriate parameter to assess the danger/risk in this situation
3. Categorise the various Impulse situations associated with specific types of interactions
4. Present the simplifications, assumptions and approximations used in the analysis
5. Assemble the necessary data (mass, velocity change and interaction duration) on vessel, gear, and anchor, for Impulse determination
6. Complete the Impulse calculations and present the results in an appropriate format
7. Discuss the findings and formulate conclusions

Impulse Theory

To assess the potential physical impact that commercial fishing vessels, their fishing gear, as well as their anchor(s), may have on BE CRC infrastructure in the fishing data assessment area, the magnitude of the Impulse associated with each interaction (i.e., collision) was determined.

Impulse was seen an appropriate quantity to use in this instance since it contains the key variables governing the forces that may be produced (i.e., the body's mass and velocity) and is relatively simple to calculate. It provides a simple means to show in a relative context the different degree of severity associated with each interaction.

The Impulse-Momentum theorem states that a body's momentum change is proportional to the impulse applied to it (Elert 1998).

The change in momentum (Δp) is determined with equation [1].

$$\text{Change in momentum } (\Delta p) = M \times \Delta v \quad [1]$$

The key variables being mass (M) of the body involved in the interaction and the change in velocity (Δv) of that body during the interaction period. Note: the subscript M_v, M_g, and M_a was used for vessel, fishing gear or anchor respectively.

The impulse (J) is determined with equation [2].

$$\text{Impulse } (J) = F \times \Delta t \quad [2]$$

The key variables in this case are average net force (F) and the duration that this force acts (Δt).

The units for Δp and J are therefore $kg.m.sec^{-1}$ and N.s

Note that both Δp and J are vector quantities due to the presence of the Δv and F vector quantities in equations [1] and [2] respectively, and since these equations are dimensionally similar, it is possible to equate the RHS of equation [1] and [2] to show the key variables of this Impulse-Momentum relationship.

$$F \times \Delta t = M \times \Delta v \quad [3]$$

Noting that if the data for the three key variables, namely Δt, M, and Δv , are available then the Impulse (J), as well as the average net force (F) responsible for the change in momentum, can be determined.

Impulse categories and calculation methodology

In relation to interactions between commercial fishing vessel/gear and Blue Ecology CRC infrastructure, a total of four different situations capable of causing a change in momentum (i.e., Impulse) were identified:

1. Impulse type 1 – vessel only collision
2. Impulse type 2 – vessel anchor drop impact
3. Impulse type 3 – vessel anchor drag impact
4. Impulse type 4 – descending fishing gear component collision

Impulse type 1 – vessel only collision

This interaction was about gauging the maximum Impulse that a vessel may impart to Blue Ecology CRC surface structure should a collision occur. To simplify the calculation, all vessels were assumed to be travelling at constant velocity (v) prior to the collision, and subsequently came to a standstill over the same distance (i.e., 1m) and time period (t) (i.e., 1 second).

By making the change in momentum occur over the same time period, the resultant net average force (refer Equation [3]) was kept relative between vessels. Noting that this may not always be the case due to differences in vessel construction, operator reaction time, collision characteristics, amongst other things.

Impulse type 2 – vessel anchor drop impact

This interaction was concerned with determining the maximum Impulse that an anchor deployed from a fishing vessel may impart to BE CRC infrastructure on the seabed (e.g., submarine cable or mooring). The key variables in this case were anchor mass (M_a), the velocity of the descending anchor (v) and the deceleration period (t) (i.e., to determine the average net force).

For this assessment every anchor was assumed to reach a terminal velocity prior to impact and to have a similar deceleration period of one second, with the magnitude of the velocity governed by the anchor's mass (M_a), drag coefficient (CD) and projected area (A).

$$\text{Terminal velocity} = [(M_a \times g)/(CD \times 0.5 \times p_w \times A)]^{0.5} \quad [4]$$

where

g = gravitational constant i.e., 9.81 $m.s^{-2}$

p_w = mass density of seawater at 1025 $Kg.m^{-3}$

To simplify the analysis each anchor was assumed to be of the stockless type (since admiralty 'stock' type anchors are rarely used nowadays) and geometrically similar despite the possible variation in design (refer Fig. 5.), with a similar drag coefficient of 0.9 based on a stockless anchor (Woo & Na 2014). According to Woo & Na (2014), the influence of Reynolds number and initial velocity on this drag coefficient was negligible, which supports the above simplification.

The projected area used was based on two circular cross-sectional rods of similar dimensions (length /diameter = 4) and aligned so that the two rods intersect at 90° to form a T-shaped anchor. The anchor was assumed to descend as an inverted T through the water i.e., the projected area was equivalent to the product of a single rod's length and diameter. To find the key variable in this instance, namely the rod diameter (d), the volume (V) was firstly found using the required mass (Ma) and equation [5], and then the rod diameter was found using the rearranged form of equation [6]. Lastly, the projected area (A) was deduced using equation [7], that being the area of a single horizontal rod at 90° to the relative flow.

$$Ma = V \times p_s \qquad [5]$$

where p_s = mass density of steel at 7400 $Kg.m^{-3}$

$$V_{rods} = 2 \times L \times (\pi \cdot d^2)/4$$

or in this case where L = 4d

$$= 2 \times 4d \times (\pi \cdot d^2)/4 \qquad [6]$$

Rearranging to find d

$$d = (V_{rods}/2\pi)^{1/3}$$

$$A_{rod} = L \times d$$

or in this case where L = 4d

$$= 5d \qquad [7]$$

Anchor mass requirement for a given vessel can be determined with the Equipment Number, Holding Power and Anchor Mass formulas provided by National Standard for Commercial Vessels Part C, Design and Construction, Subsection 7D – Anchoring Systems (refer Appendix B).

Alternatively, Tables provided for each Class of vessel can be used (refer Appendix B). Commercial fishing vessels fall under Class 3. For the area of interest, the category would be mostly C, making most of the commercial fishing vessels in this area a Class 3C vessel, or 3C restricted vessel if venturing further offshore.

For this investigation, a nominal anchor mass was assigned to each type of fishing vessel based on its assigned length and by using data in Tables prescribed by AMSA (refer Appendix D) to generate the following relationship between vessel length and anchor mass; $M_a = 0.0247x\ L^{2.8597}$

Note, in the derivation of this formula the corresponding height for each vessel was assumed to be 1/5th of the vessel's length (i.e., a L:H ratio of 5:1 was used).

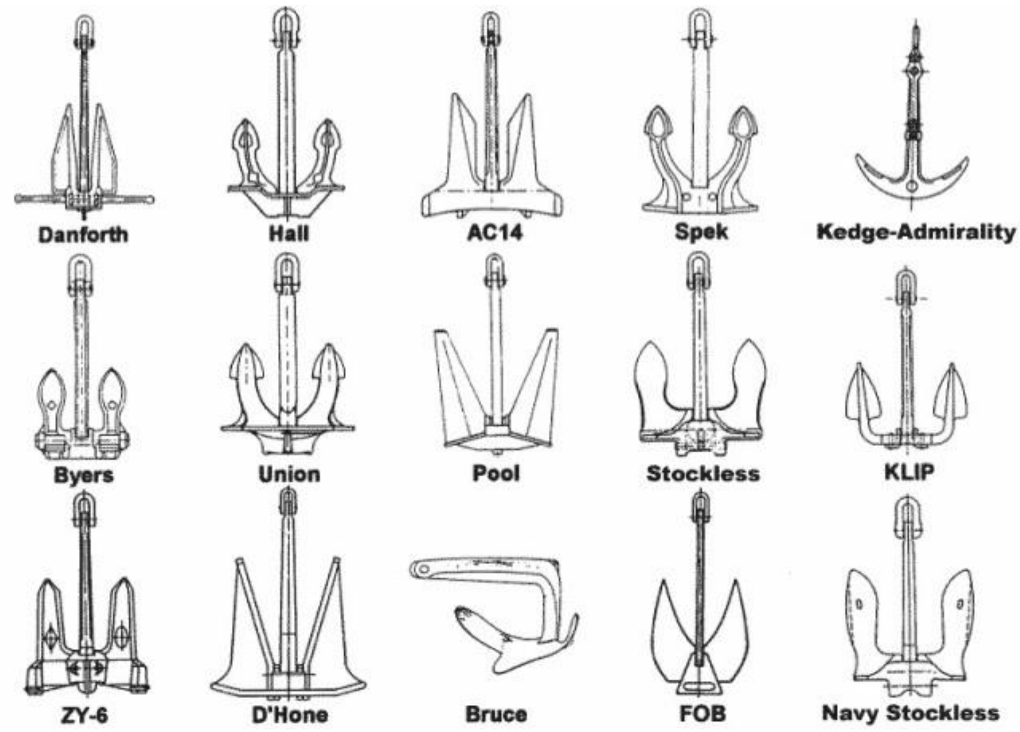


Figure 45 Types of Stockless anchor (source: www.gratitudesailingnw.com/sailing-lessons.html)

Impulse type 3 – vessel anchor drag impact

This interaction was about gauging the maximum Impulse that a dragging anchor may impart to BE CRC infrastructure on the seabed (e.g., a pipeline). For this assessment, all anchors were assumed to be dragging at similar constant velocity (v) prior to the collision, and subsequently came to a standstill over the same distance and time period (t). By making the change in momentum (mass x velocity) occur over the same time period, the resultant average net force caused by the impulse was kept relative to differences in anchor mass (M_a) (refer equation [3]). Noting that for various reasons, such as how much the farm component may shift during the interaction, this may not always be the case in reality.

To assign a representative anchor drag speed to this situation tidal current data from nearby environmental current meters in 47 and 70m water depth (refer Appendix E) was analysed together with wind speed data from the Bureau of Meteorology. Tidal current was found to be reasonably low, whereas surface generated current from wind coupled with the drag this wind imposes on the above water portion of a vessel could at times be very high. So much so that most craft would be making for sheltered waters, which was not far away in this case. With this in mind an anchor drag speed of 1 m/s was assigned to all fishing methods for unfavourable environmental conditions.

Impulse type 4 – descending fishing gear component collision

This interaction was about gauging how much of an Impulse a descending fishing gear component may produce when it collides with BECRC infrastructure and comes to a standstill, for example when a cray pot eventually reaches the seabed and strikes a length of cable located there.

For this assessment every anchor/fishing gear component was assumed to have a similar deceleration period and to reach a terminal velocity prior to impact, with the magnitude of the velocity governed by the anchor's/gear's mass (M_a or M_g), drag coefficient (CD) and projected area (A).

$$\text{Terminal velocity} = [(Ma \times g)/(CD \times 0.5 \times p_w \times A)]^{0.5} \quad [4]$$

where

g = gravitational constant i.e. 9.81 $m.s^{-2}$

p = mass density of seawater at 1025 $Kg.m^{-3}$

For anchors and ballast the same drag coefficient value of 0.9 was used. The terminal velocity and projected area were then found using the same approach and assigning a representative steel mass for the fishing gear in question. For a craypot, a terminal velocity of 0.95 m/s was used based on experimental data gathered in a flume tank (Wakeford 2000).

The assigned masses to anchors and other gear components can be seen in Table 11 below.

Table 11. Input data and calculation results for the various Impulses and Pulling force against each fishing method.

		Type 1 Impulse Vessel			Type 2 Impulse Anchor drop			Type 3 Impulse Anchor drag			Type 4 Impulse Gear drop impact			Pulling force			
FISHING METHOD	**Vessel representative length**	Displacment max. (t)	Transit speed max. (m/s)	Impulse (KN.s) and **RELATIVE SCORE**	Anchor mass (kg)	Descent velocity (m/s)	Impulse (N.s) and **RELATIVE SCORE**	Anchor mass (kg)	Drag speed max. (m/s)	Impulse (N.s) and **RELATIVE SCORE**	Gear componennt mass (kg)	Descent velocity (m/s)	Impulse (N.s) and **RELATIVE SCORE**	PP or PA diameter (mm)	Fishing gear minimum breaking load (MBL) (KN)	F/Vessel Maximum Pulling Force (KN) and **RELATIVE SCORE**	**Risk Score** (Rel. Imp. Type 1 + 2 + 3 + 4 + Rel. Pulling force) [**Ranking**]
Demersal Gillnet	20	128	5	639 **1.00**	130	1.98	257 **1.00**	130	1	130 **1.00**	50	1.44	72 **1.00**	16 PP	24.8	25 **0.54**	**4.54** **(1)**
Squid jigging	20	128	5	639 **1.00**	130	1.98	257 **1.00**	130	1	130 **1.00**				22 PP	46	46 **1.00**	**4.00** **(2)**
Craypot	20	128	5	639 **1.00**	130	1.98	257 **1.00**	130	1	130 **1.00**	40	0.95	38 **0.53**	14 PP	20.4	20 **0.44**	**3.97** **(3)**
Octopus trap	20	128	5	639 **1.00**	130	1.98	257 **1.00**	130	1	130 **1.00**	30	1.22	36 **0.51**	10 PP	10.8	11 **0.23**	**3.74** **(4)**
Demersal longline	20	128	5	639 **1.00**	130	1.98	257 **1.00**	130	1	130 **1.00**	25	1.14	29 **0.40**	10 PP	10.8	11 **0.23**	**3.63** **(5)**
Fish Trapping	15	61	5	306 **0.48**	57	1.51	86 **0.33**	57	1	57 **0.44**	30	1.22	36 **0.51**	14 PP	20.4	20 **0.44**	**2.20** **(6)**
Trolling	8	12	10	123 **0.19**	9	0.83	8 **0.03**	9	1	9 **0.07**				2 PA	1.75	2 **0.04**	**0.34** **(7)**
Handline	8	12	10	123 **0.19**	9	0.83	8 **0.03**	9	1	9 **0.07**	1	0.39	0.4 **0.01**	2 PA	1,75	2 **0.04**	**0.34** **(7)**
Hand gathering	8	12	10	123 **0.19**	9	0.83	8 **0.03**	9	1	9 **0.07**							**0.30** **(8)**

Dropline fishing gear was also assigned similar parameters. The deceleration distance and period were assumed to be similar for all gears (1 second) to simplify the situation and to make the results relative.

Table 12 Fishing related input data for each type of impulse.

Impulse category	Interaction			
	Details	**Mass (or weight) (kg)**	**Vel. Change ($m.s^{-1}$)**	**Period (sec)**
Type 1	vessel only collision	vessel mass derived with W = 0.0602 x L $^{2.5572}$	5 or 10m/s	1
Type 2	vessel anchor drop impact	Anchor mass derived from AMSA Table (refer App. C) and vessel length	Terminal velocity derived using eq. [4]	1
Type 3	vessel anchor drag impact	Anchor mass derived from AMSA Table (refer App. C) and vessel length	1 m/s	1
Type 4	descending fishing gear component collision	Gear anchor/ballast 25kg Lobster pot 15kg	Terminal velocity for anchors derived using eq. [4]. Lobster pot 0.95 m/s	1

Pulling Force and Calculation Methodology

Pulling force to free snagged gear

When fishing gear becomes entangled/snagged on a seabed obstacle, the vessel will at some stage attempt to release it by applying a pulling force (via the connecting ropes between vessel and fishing gear) in an attempt to recover it.

On most occasions a vessel with snagged fishing gear will draw itself closer to the snag on the premise that the additional uplift will pull the gear free. Under certain circumstances (undercut obstacles like large rocks or vehicles) the vessel may opt to circle the snag and try pulling in a different direction. If these measures fail then the vessel will move progressively closer to directly overhead and use a combination of thrust, winch haul force, and vessel buoyancy to apply more of a load. Understandably, this procedure heightens the risk level. However, if the breaking load of the fishing gear and connecting tackle is relatively low, then the gear will normally fail without jeopardising vessel stability to any great extent. Whereas with some trawlers, especially the smaller vessels towing relatively large gear, the risk of capsizing is very real. Under certain circumstances it may be prudent for the vessel to cut the gear free (i.e., cut the wire(s)) to release the vessel, and then return later and use a grapple (similar to an anchor) to recover the gear. Grappling lost fishing gear usually involves towing a modified form of anchor across the seabed to reconnect the vessel to some part of the gear, and then applying a pulling force to drag it free of the snag. The pulling procedure followed is similar to what is adopted when the gear is snagged whilst fishing, with the difference being that the grapple is often pulled in the opposite direction to when the gear became snagged. For these pulling situations, the minimum breaking load (MBL) of the connecting rope between vessel and fishing gear equates to the maximum applied pulling force, and from a worst case scenario perspective, this force may well be applied from directly overhead if pulling initially at shallower angles proves unsuccessful. To reflect this situation, the maximum pulling force for each fishing method was based on the MBL of the connecting rope (synthetic rope or twine) between vessel and gear. In the case of squid jiggers, the gear analysed was the large sea anchor that is deployed from the bow to reduce vessel drift and improve stability. MBL values for typical connecting rope(s) on each type of fishing gear used in the relevant area are presented in Table 13.

Table 13 Maximum pulling force associated with snagged fishing gear based on the MBL of the main connecting rope/cable between vessel and fishing gear. Note: the pulling force represented by the tensile load in the connecting rope/cable may be a combination of winch power, propeller thrust and vessel buoyancy.

Fishing Method	Connecting rope/cable details	Connecting rope M.B.L. t (KN)
Gillnet	16mm PP rope	2.5 (24.8)
Horizontal longline	10mm PP	1.1 (10.8)
Squid jigging	22mm PP rope	4.7 (46.0)
Octopus trap	10mm PP	1.1 (10.8)
Lobster pot	14mm PP rope	2.1 (20.4)
Lobster pot	14mm PP rope	2.1 (20.4)
Trolling	2mm PA twine	0.18 (1.75)
Handline	2mm PA twine	0.18 (1.75)

Impulse Interaction Assumptions and Approximations

To facilitate the Impulse calculation process certain assumptions and approximations were made regarding the interactions involving fishing vessels, fishing gear and anchor systems. These assumptions and approximations are presented below, together with a reference #. Note: some of these assumptions and approximations were presented and discussed in earlier sections.

A#1 Constant velocity assumption – vessel, gear or anchor was travelling at uniform velocity (speed and direction) just prior to the interaction taking place.

A#2 Vessel anchor drag velocity assumption – under severe environmental conditions whereby vessel anchor(s) drag across the seabed, the resultant velocity was 1m/s.

A#3 Maximal change in velocity assumption – whenever vessel/gear had an interaction with BE CRC infrastructure, a maximal change in velocity would transpire i.e., the body would always come to a standstill

A#4 Interaction period assumption – the interaction period was constant for each of the various types of interaction identified.

A#5 Anchor design assumption – every anchor was of the stockless type, and was T-shaped and made from cylindrical bar. The stock to cross-bar ratio was constant (4:1) between anchors, and the diameter of the rod was kept in proportion to the anchor size (i.e., every anchor despite the size was geometrically similar).

A#6 Anchor mass assumption – Using the AMSA table provided in Appendix D the following relationship between anchor mass Ma and vessel length (L) was derived $Ma = 0.0247x\ L^{2.8597}$. Note: this formula was derived from a line of best (LOB) fit for plotted data obtained from the table, and this LOB fit had a correlation coefficient of 0.9994.

A#7 Anchor material assumption – every anchor was made of steel

A#8 Anchor dimensional assumption – based on the design, mass and material assumptions, it was possible to manipulate the anchor size (stock and cross-member lengths, and rod diameter) to acquire a given volume necessary to meet a total anchor mass target.

A#9 Anchor orientation assumption - every anchor descended with the stock vertical so that the projected area was equivalent to the product of the cross-bar's length and diameter.

A#10 Anchor terminal velocity assumption - every anchor reached a terminal velocity prior to impact.

A#11 Anchor drag coefficient assumption - a representative drag coefficient for every anchor descending was 0.9. i.e., based on a stockless anchor (Woo & Na 2014).

A#12 Reynolds number effect on anchor drag coefficient assumption – due to the relatively high Reynolds numbers associated with each anchor descending through the water, it was reasonable to assume the drag coefficient was independent of Reynolds number (Woo & Na 2014).

A#13 Fishing vessel loading condition assumption – all vessels had a similar loading condition based on a departing port condition (i.e., fluid tanks full, hold empty, full array of fishing gear and supplies onboard). Note: this assumption ensured each vessel was at, or very close to, its maximum displacement i.e., mass

A#14 Fishing vessel prismatic coefficient similarity assumption – all vessels were geometrically similar (i.e., shared a similar length to breadth to depth ratio) despite differences in overall length.

A#15 Steel Fishing vessel assumption - all vessels were made from steel, even though in some fisheries wood and composite materials were evident.

A#16 Vessel length to weight relationship assumption - All vessels were made from steel, and because they were "geosims", a vessel weight (W) to length (L) relationship existed; represented by $W = 0.0602 \times L^{2.5572}$ Note: this expression was based on data from nine steel trawlers ranging between 22.5 and 39.9m LOA and with a displacement range of 141 and 670t, respectively.

A#17 Vessel displacement mono hullform assumption – all vessels had displacement mono hullforms, even though in some fisheries multi-hull designs were present.

A#18 Vessel uniform transit speed assumption – all vessels were assumed to have a transit speed of 5 m/s (i.e., c. 10 knots) or 10m/s (trolling, handline, hand gathering), irrespective of size.

A#19 scenario where a vessel tows with a relatively strong tidal current (evident in this

A#19 Uniform vessel length to height ratio assumption – every vessel was geometrically similar and shared a length to height ratio of 5:1.

APPENDIX B – DETERMINANTION OF ANCHOR MASS

Determination of Anchor Mass for Australian Commercial Vessels

3.2 EQUIPMENT NUMBER

Equipment number is a function of displacement, frontal area and profile area
It shall be calculated by the following equation:

$EN = \{(\Delta^{2/3}. f_h) + 2(B.a + \Sigma b.h.\cos\theta_f) + 0.1(A_h + A_{ss} . \cos\theta_p)\} f_o$ .... (3.1)

where

- EN = equipment number
- Δ = vessel displacement, in tonnes
- B = moulded breadth, in metres
- a = Freeboard, in metres
- b = breadth of deckhouse tier if greater than B/4, in metres
- h = height of deckhouse tier if greater than B/4, in metres
- A1 | A_h = the hull profile above waterline, in square metres
- A_{ss} = superstructure profile area, in square metres
- θ_f = slope of superstructure front to the vertical, in degrees
- θ_p = slope of superstructure side to the vertical, in degrees
- f_h = factor for hull type:
  - 1.0 for monohulls
  - 1.26 for catamarans
  - 1.33 for trimarans
- f_o = factor for operational area:
  - 1.0 for area A, B and C
  - 0.8 for area D
  - 0.54 for area E

3.3 HOLDING POWER

The holding power (force) of an anchor is related to the equipment number by the following equation:

$P_h = 3\,(0.002\,EN^2 + 2.3\,EN + 9) \times 9.81$ .... (3.2)

where

- P_h = holding power (force), in newtons
- EN = equipment number

3.4 ANCHOR MASS

The required anchor mass is related to the anchor holding power by the following equation:

$M_a = P_h/(F_t \times 9.81)$ .... (3.3)

where

- M_a = required anchor mass, in kilograms
- P_h = holding power (force), in newtons
- F_t = factor for anchor type:
  - 3.00 for standard anchors
  - 4.29 for high holding power anchors
  - 5.45 for super high holding power anchors

Regulations concerning anchor shackle strength and permissible anchor cable types

CHAPTER 4 REQUIREMENT FOR COMPONENTS

4.1 ANCHOR SHACKLE

The anchor shackle provides the link between the anchor and the anchor cable. The basic requirements of the anchor shackle are:

The strength of the anchor shackle shall be equal to or more than that of the anchor cable it is connected to.

NOTE: As the shape of the anchor shackle is inherently weaker than stud-link anchor cable this will require a larger diameter for the shackle leg and pin.

The proof load for the anchor shackle shall be greater than the certified holding power of the anchor it is connected to.

4.2 ANCHOR CABLE

4.2.1 Cable type

A1 The anchor cable shall be of stud-link chain, short-link chain, wire rope or fibre rope, subject to the requirements of this Chapter.

4.2.2 Design requirements

The anchor cable shall be designed such that the following applies:

a) It provides a connection between the anchor and the vessel of sufficient length so that the anchor is able to provide maximum holding power.
b) It provides a measure of elasticity to reduce the response loads on the vessel and anchor caused by the variation in the applied loads on the vessel due to wind, wave and current forces.

To satisfy the design requirements, the anchor cable shall have a working strength greater than the holding power of the anchor to be used. The anchor cable shall be able to absorb the design accelerations without exceeding the holding power of the anchor. This may be achieved by the use of mass, the elastic properties of the anchor cable, cable length or some combination of these characteristics.

4.2.3 Steel chain

The diameter of the chain shall be as per Clause 3.5 or Table 4.1.

Chain shall be manufactured, tested and certified in accordance with one of the following:

a) ISO 1704 or equivalent National or International Standard.
b) AS 2321 or equivalent National or International Standard.
c) recognised organisation.

4.2.4 Steel wire rope

It is permitted to replace chain by steel wire rope where the equivalent anchor mass does not exceed that of a 130 kg standard anchor and the breaking load of the steel wire rope is at least equal to that of chain cable. The minimum length of chain at the end of wire rope shall be as per Table 4.1.

Wire ropes shall be manufactured, tested and certified in accordance with one of the following:

a) AS 3569 or equivalent National or International Standard.

NOTE: For information on the operation and maintenance of steel wire ropes, refer to AS 2759.

b) The requirements of a recognised organisation.

4.2.5 Fibre rope

Fibre rope is allowed for any anchor excepting anchors on vessels operating in A, B and C Class waters where the equivalent anchor mass exceeds that of a 130 kg standard anchor. The minimum breaking load of the fibre rope shall be equal to or more than that of a chain cable. The rope shall be in good condition, free from sunlight damage, abrasions, and hockles. The minimum length of chain at the end of fibre rope shall be as per Table 4.1.

NOTE: For guidance, rope diameters are given in Table 4.1.

The fibre ropes shall be manufactured as per AS 4142.2 or equivalent National or International Standard and tested as per AS 4143.1 or equivalent National or International Standard.

NOTE: For information on care and safe usage of fibre ropes, refer to AS 4142.1.

Fibre ropes that have been certified by a recognised organisation shall be deemed to comply with this National Standard.

Table 4.1 – Dimensions of anchor cable

Cable material	Standard anchor mass Kg	Short-link chain	Manila	Poly-propelene	Nylon	Poly-ethylene	+ Chain length
		Diameter mm					
Chain, wire rope or fibre rope	Under 8	8	14	12	10	14	3 m chain of table size shackled between rope and anchor
	8 – 13	8	16	12	10	14	
	13 – 18	8	18	14	11	16	
	18 – 25	8	20	16	12	18	
Chain, wire rope or fibre rope	25 – 32	10	24	16	14	20	6 m chain of table size shackled between rope and anchor
	32 – 38	10	24	18	14	22	
	38 – 44	10	24	22	16	24	
	44 – 51	13	30	24	18	28	
	51 – 76	14	34	28	20	32	
	76 – 89	14	38	32	22	36	
	89 – 100	15	40	34	24	36	
	100 – 130	15	48	40	30	44	
Fibre rope permitted for vessels operating in partially smooth water and smooth water	130 – 178	16					9 m chain of table size shackled between rope and anchor
	178 – 226	17					
	226 – 274	19					
	274 – 322	20					
	322 – 370	21					
	370 – 432	21					

4.2.6 Windlass, capstan or winch

Mechanical lifting devices shall be fitted if the combined mass of anchor and one third of the cable exceeds the local Occupational Health and Safety (OHS) requirements for manual lifting. Cable stoppers, claws or similar fastenings shall be provided as necessary between the windlass or capstan and the hawse pipe. The windlass or capstan shall be designed for immediate dropping of the anchor and shall have an efficient brake.

Means shall be provided to secure the cable at the required length. The means shall be of strength sufficient to withstand loads not less than the breaking strength of the cable, including shock loading.

The bitter end of the cable shall be permanently secured to the vessel by an attachment of strength sufficient to withstand loads not less than the breaking strength of the cable.

APPENDIX C – AMSA VESSEL CLASS AND SURVEY CATEGORY

Vessel use	Indicated by
Passenger vessel (13 or more passengers)	1
Non-passenger vessel (up to 12 passengers)	2
Fishing vessel	3
Hire and drive vessel used by the hirer only for recreational purposes	4

Operational area	Indicated by
Unlimited domestic operations (no longer available to domestic commercial vessels). Vessels operating in A waters must be Australian regulated vessels under the *Navigation Act 2012*.	A
Extended offshore operations (beyond 200 nautical miles from the baseline of the Australian mainland, Tasmania, a recognised island but within the exclusive economic zone)	B Extended
Offshore operations (within 200 nautical miles from the baseline of the Australian mainland, Tasmania, a recognised island but within the exclusive economic zone)	B
Restricted offshore operations (within 30 nautical miles from the baseline of the Australian mainland, Tasmania, a recognised island; within 50 nautical miles of the baseline of Queensland, within the Great Barrier Reef Region or the Torres Strait Zone; whilst remaining within the exclusive economic zone)	C
Restricted offshore operations—specified areas	C Restricted
Partially smooth water operations	D
Smooth water operations	E

APPENDIX D – ANCHOR MASS IN KG FOR CLASS A AND B VESSELS

L \ H	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
3														
4			8	11										
5		8	12	13.5	16									
6	8	11	14	16	18.5	21								
7	10	13	16	18.5	21	24	26							
8	12	15	18.5	21	24.5	27	31	35						
9	14	17	21	24	28	32	36	41	46					
10	16	19	23.5	27	32	37	42	47	52	59				
11	18	22	26	31	37	42	48	54	61	67.5	75			
12	20	24.5	29	35	41	48	54	62	69.5	77	87	96		
13	22	27	33	40	46.5	53.5	62	70	80.5	90	99.5	110	121	
14	24	30.5	37.5	45	52	61	70	81	91	102	113	125	138	148
15	27	35	42	50	59	69	79	91	102	115	128	141	154	168
16	31	39	47	56	66	77	90	102	115	129	142	156	171	186
17	35	43	52	63	74	87	100	114	129	143	158	174	190	206
18	39	48	58	70	83	97	111	127	142	158	175	191	210	226
19	43	53	65	78	93	108	124	140	156	175	192	211	228	246
20	48	59	72	87.5	103	120	137	154	173	191	211	229	248	268
21	53	66	80	97	114	132	149	169	189	208	228	248	270	291
22	59	73	90	107	126	145	164	185	206	226	247	270	292	318
23	65	82	100	118	138	158	180	201	223	244	268	291	318	347
24	72	90	109	130	150	172	195	218	240	264	289	318	344	388

Above == 1 anchor required

Below == 2 anchors required

H is height in metres

L is measured length in metres

Figure 46 Anchor mass in Kg for Class A vessels

L \ H	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
3														
4			7	10										
5		7	10	12	14									
6	7	10	12	13	15	18								
7	9	11	14	16	18	20	22.5							
8	10	12.5	15	17.5	20	22.5	25	30						
9	12	15	17.5	20	22.5	27.5	30	35	40					
10	14	17	20	22.5	27.5	30	35	40	45	50				
11	15	20	22.5	25	30	35	40	45	50	55	60			
12	17	20	25	30	35	40	45	50	57.5	65	72.5	80		
13	20	25	30	35	40	45	50	60	67.5	75	82.5	90	100	
14	20	25	32.5	37.5	45	50	57.5	67.5	75	85	95	105	115	125
15	22.5	30	35	42.5	50	57.5	65	75	85	95	110	120	130	140
16	25	32.5	40	47.5	55	65	75	85	97.5	110	120	130	140	155
17	30	37.5	45	52.5	62.5	72.5	85	95	110	120	130	145	160	175
18	32.5	40	50	60	70	80	92.5	105	120	130	145	160	175	190
19	35	45	55	65	77.5	90	105	120	130	145	160	175	190	205
20	40	50	60	72.5	85	100	115	130	145	160	175	190	205	225
21	45	55	67.5	80	95	110	125	140	160	175	190	210	225	245
22	50	60	75	90	105	120	135	155	175	190	205	225	245	265
23	55	70	85	100	115	130	150	170	190	205	225	245	265	290
24	60	75	90	110	125	145	165	180	200	220	240	260	285	320

Above == 1 anchor required

Below == 2 anchors required

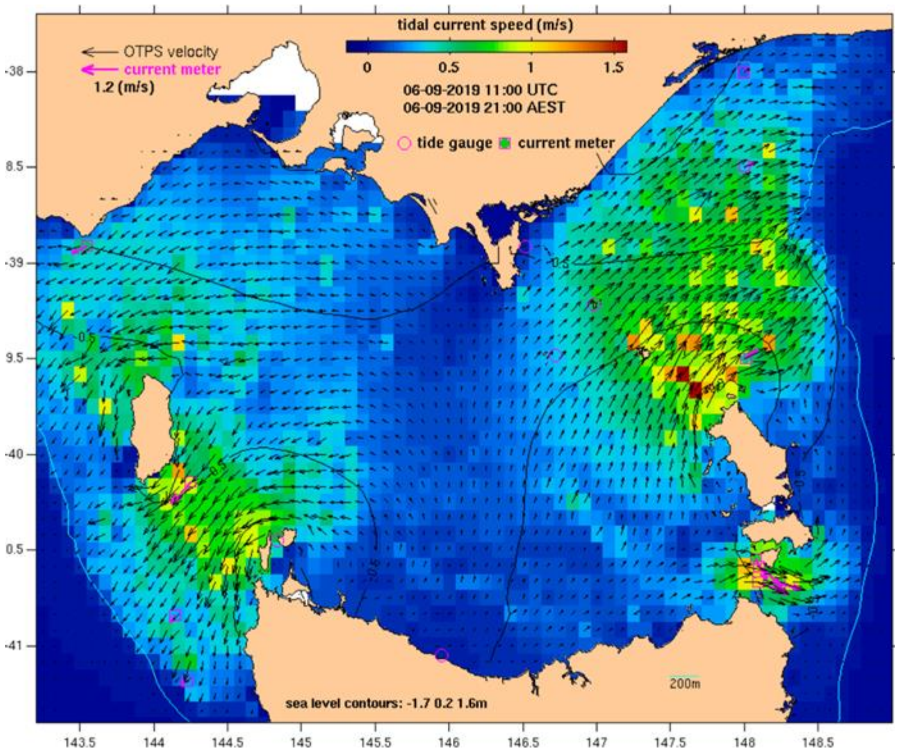
H is height in metres

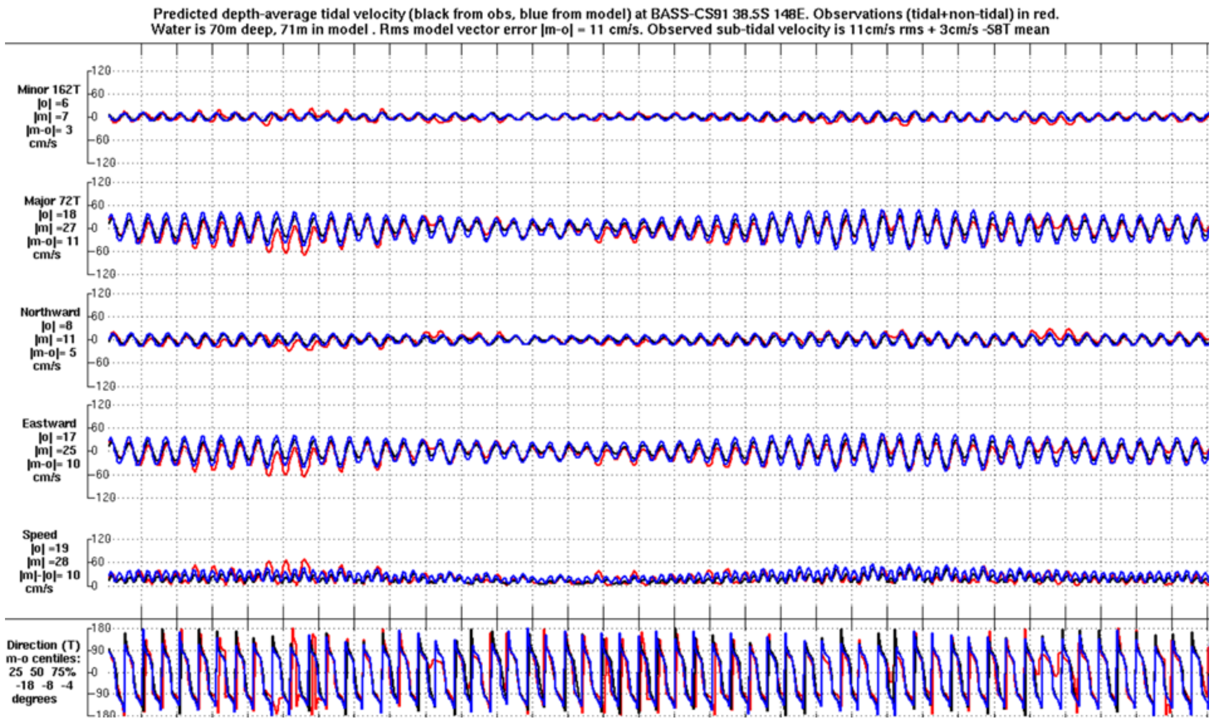
L is measured length in metres

Figure 47 Anchor mass in Kg for Class B vessels

APPENDIX E – TIDAL CURRENT DATA

Taken from CSIRO current meters coupled with computational modelling.





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