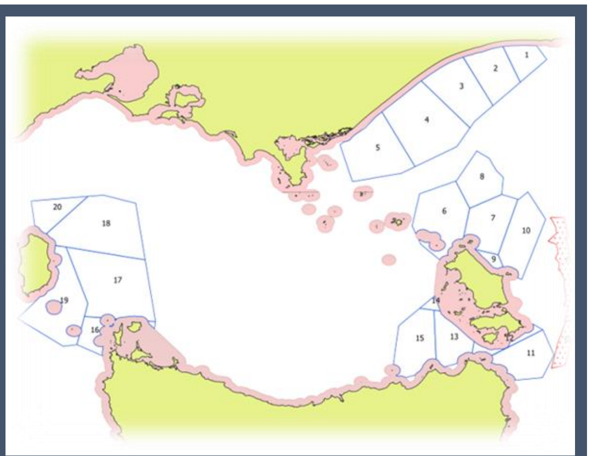
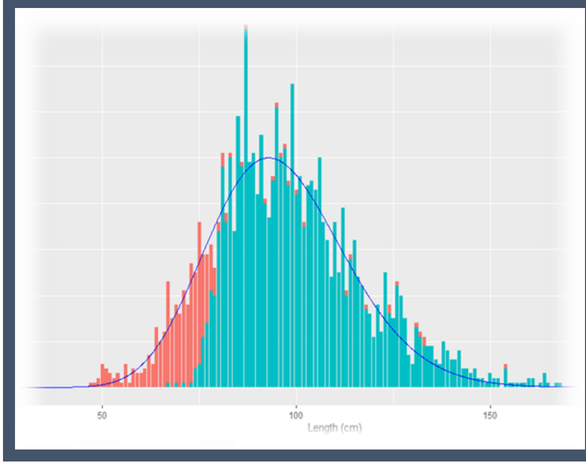
Potential transition of shark gillnet boats to longline fishing in Bass Strait - ecological, cross-sectoral and economic implications





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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

Contents

Tables

Figures

List of Acronyms

AFMA	Australian Fisheries Management Authority
ASL	Australian sea lions
BSCZSF	Bass Strait Central Zone Scallop Fishery
CITES	Convention on International Trade in Endangered Species of Fauna and Flora
CMS	Convention on Migratory Species
CPUE	Catch per unit effort
CTS	Commonwealth trawl sector
DPIPWE	Department of Primary Industry, Parks, Water and Environment (Tasmania)
EPBC Act	*Environment Protection and Biodiversity Conservation* Act (1999)
FRDC	Fisheries Research and Development Corporation
GHAT	Gillnet, Hook and Trap fishery
MAC	Management Advisory Committee
NPV	Net present value
OCS	Offshore constitutional settlement
RAG	Research Advisory Group
SESSF	Southern and eastern scalefish and shark fishery
SHS	Scalefish hook sector
SSIA	Southern Shark Industry Alliance
TAC	Total Allowable Catch
TACC	Total Allowable Commercial Catch
TAP (2,3)	Threat abatement plan (seabirds) as updated
ETP species	Endangered, threatened and protected species
VFA	Victorian Fisheries Authority
WACC	Weighted average cost of capital

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We would particularly like to thank the skipper and crew of the *Candice K* for their support and assistance in conducting the trial. Their knowledge of fishing and professional approach to the project enabled it to proceed without any major issues. We thank the observers Russell Hudson and Mary-Jo Hanly for the long hours, hard work and dedication to on-board sampling of the catch, and data entry and checking after the trip.

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Executive Summary

The gillnet fishery targeting Gummy Shark (*Mustelus antarcticus*), managed under the Southern and Eastern Scalefish and Shark Fishery (SESSF), is concentrated in Bass Strait. Adverse interactions with endangered, threatened or protected species (ETPs) particularly seals and dolphins, has prompted consideration of a change to auto-longlines (that automatically attach bait to hooks).

Longlines have proved to be effective in targeting Gummy Shark in waters off South Australia and, in particular, in reducing interactions with endangered sea lions. However, the ecological and economic implications of changing from gillnets to auto-longlines to fish for shark in Bass Strait were unknown.

Accordingly, the current project involves the evaluation of trials of auto-longlines to target Gummy Shark in Bass Strait. Project objectives were to:

1. Conduct a trial using auto-longlines to target Gummy Shark in SESSF waters in eastern and western Bass Strait.
2. Collect comprehensive information on: longline catch rates; catch composition of all target, bycatch, byproduct and ETP species; and size composition data for major target and byproduct species.
3. Describe potential resource sharing and gear interaction implications for SESSF and other Commonwealth and State fisheries including recreational and Indigenous sectors.
4. Undertake an economic analysis of the viability of gillnet vessels converting to longlines to target Gummy Shark in Bass Strait.
5. Present the results of the longline trials to relevant AFMA RAGs and MACs, VFA, DPIPWE and other stakeholders.

Trials of auto-longlining for Gummy Shark were conducted in Bass Strait with a commercial vessel equipped with a purpose-built Mustad auto-longline system able to set and retrieve ~ 6,000 hooks per day. Three trips were undertaken in specific areas of Commonwealth waters during 2020: two in Autumn/Winter and one in Spring. A total of 120 shots was undertaken with shots focused on likely concentrations of Gummy Shark in Bass Strait (< 183 m depth).

Catch per unit effort of Gummy Shark varied seasonally with catches and catch rates much lower in Spring (10 t catch, 55g/hook) compared with Autumn/Winter (45 t catch, 143 g/hook). Retained catches for auto-longlines were mostly shark (>95%) dominated by Gummy Shark (~50%) and Draughtboard Shark (*Cephaloscyllium isabellum*) (~50%). This proportion differs from gillnets where retained catches for Gummy Shark in Bass Strait varied from 68 to 80% with relatively small catches of Draughtboard Sharks retained (~ 3%). In Autumn/Winter, when trial catches and catch rates were greatest, discards comprised mostly Draughtboard Sharks (66%) with other discards comprising Southern Fiddler Ray (10%), Port Jackson Shark (8%) and Melbourne Skate (8%). For gillnetters fishing in Bass Strait, discards mostly comprised Draughtboard Sharks (~66%), Port Jackson Sharks (~10%) and Elephant Fish (~8%). Auto-longlining was shown to have relatively little impact on bycatch species. Most discards were returned alive. However, many discarded Gummy Shark, including large individuals, were returned dead through shark bites and/or lice damage.

Size selectivity of auto-longlines for Gummy Shark was shown to be similar to gillnets (5-inch mesh) with the retained catch comprising mostly 80-115 cm individuals but larger sharks (particularly females) up to 175 cm in length were also caught by auto-longline.

During the trials, auto-longlines caught relatively small quantities of species of interest to other Commonwealth and State commercial fisheries or to other sectors (recreational and Indigenous). Relatively small catches of School Shark (67 kg retained, 43 kg discarded), Southern Sand Flathead (150 kg retained, 64 kg discarded) and Snapper (1.5 kg retained, 56 kg discarded) were caught during the

trials. Southern Sand Flathead were generally caught in small numbers except for north of Flinders Island and in deeper waters off southern Gippsland. Similarly, small numbers of School Shark were caught in discrete locations including southern King Island, Banks Strait and southern Gippsland. Those small quantities of fish discarded, including species important to State fisheries, were mostly alive when released.

Interaction of auto-longlining and ETPs was generally low throughout the trials. There was one interaction with a Great White Shark (entanglement) and one with an Australian Fur Seal (briefly hooked) but both animals were released unharmed. Similarly, although there were numerous observations of seabirds, there were no recorded interactions reflecting application of stringent mitigation measures for seabirds. This is noteworthy given that shy albatross and short-tailed shearwaters are commonly encountered and vulnerable to longliners.

The cost of converting a gillnet vessel to auto-longlining is about $150,000. An economic analysis based on discounted cash-flow analysis, which forecast revenue and operating cost over a ten-year term, showed that this investment may be worthwhile for an average gillnet operation (fishing > 50 days p.a.) due to higher auto-longline catch rates. These higher catch rates offset the costs of converting to auto-longline and the increase in operating costs (one additional crew member, bait). However, when compared to a full-time gillnet operation (>150 days/year), converting to auto-longline is unattractive at catch rates achieved in the trials, and will only be worthwhile if auto-longline catch rates are at least 15% higher than catch rates which exclude zero catch. The economic analyses were most sensitive to assumptions of catch rate and the landed price of Gummy Shark.

The trials of auto-longlines were limited spatially and temporally. Accordingly, the results of the trials should be treated cautiously when extending the findings to broader areas of Bass Strait and to other times of the year. In particular, catches and catch rates of commercial and bycatch species, and interactions with ETPs may vary from those observed in the trials. Thus, it is recommended that any potential expansion of commercial longline fishing to target Gummy Shark in Bass Strait is contingent on an initial phase of robust monitoring, data collection and analysis, in conjunction with adequate management measures to ensure that there are no adverse ecological impacts or cross-sectoral interactions.

Keywords

Gummy Shark, School Shark, Gillnet, Marine Mammals, Automatic Longline, Bass Strait, Seabird Interaction, Risk Assessment, Economic Evaluation.

Introduction

Shark fishing in southern Australia was first recorded in 1927 (Wilson et al. 2009) with fishers targeting mainly School Shark (*Galeorhinus galeus*) with demersal longlines. Between 1927 and the early 1960s the shark fishery developed due to increased demand for shark meat and vitamin A from shark liver oil. By the early 1970s, monofilament gillnet methods had been introduced and the fishery moved from a primarily demersal longline fishery targeting School Shark to a demersal gillnet fishery targeting Gummy Shark (*Mustelus antarcticus*). The fishery for Gummy shark is part of the Gillnet Trap and Hook (GHAT) sector of the Southern and Eastern Scalefish and Shark fishery (SESSF) managed by the Australian Fisheries Management Authority (AFMA) on behalf of the Commonwealth government.

Several endangered, threatened and protected species (ETPs) are vulnerable to entanglement and drowning in demersal shark gillnets. These include endangered Australian Sea Lions (*Neophoca cinerea*), primarily off South Australia (Goldsworthy et al. 2009, 2010), dolphins (Delphinidae) and Australian and New Zealand Fur Seals (*Arctocephalus pusillus*) off Victoria (Walker et al. 2007). To mitigate the effect of the gillnet fishery on Australian Sea Lion (ASL) populations, AFMA implemented the 2010 Australian Sea Lion Management Strategy (AFMA 2010; DEWHA 2010). The Strategy included formal fisheries closures around all colonies in South Australia, increased independent monitoring of fishing activity, and adaptive management arrangements for further closures to respond to further ASL interactions (AFMA 2011). This resulted in an immediate reduction of targeted Gummy Shark fishing using gillnets in Commonwealth waters off South Australia and a longer-term shift in gillnet fishing to Bass Strait, Victoria.

The shark gillnet fishery operating in Bass Strait does not interact with ASLs, but does interact with other ETP species such as protected dolphins and seals. AMFA implemented the 2017 Gillnet Dolphin Mitigation Strategy (AFMA 2017) prompting concerns that gillnet operators in Bass Strait could face the same restrictions that South Australian vessels encountered after implementation of the ASL Management Strategy. This concern reflects potential management intervention in response to repeated ETP interactions in the absence of practical mitigation measures. Consequently, there was industry support for a trial, similar to that completed in South Australia, to inform a potential transition from gillnet to longline fishing for Gummy shark in Bass Strait.

Following the implementation of AFMA's ASL Management Strategy, FRDC Project 2011/068 successfully trialled the use of auto-longlines to target Gummy Shark off South Australia and collected comprehensive information on the catch rate, catch composition and size composition of all target, bycatch and byproduct species (Knuckey et al. 2014). This work highlighted difficulties for a sector transitioning from one gear type to another. Although targeting the same species, the catch composition (including byproduct and bycatch) of auto-longlines can differ from gillnet gear, as can the size composition of the target catch, thereby impacting on the effectiveness of current management arrangements and the economic viability of the fishery. The different catch levels of byproduct species among gear types have implications for inter-sectoral and inter-jurisdictional management, including Offshore Constitutional Settlement (OCS) arrangements particularly if some species are highly valued by other sectors including recreational, commercial, and Indigenous fishers.

In addition to changing the catches of target, byproduct and bycatch species, different fishing gears can have contrasting ecological impacts on marine habitats and communities, including the impacts on ETPs. In contrast to gillnets, in the temperate waters of the southern hemisphere, including Bass Strait, seabirds are particularly vulnerable to capture by longline fishing methods (e.g., Brothers 1991; Morant et al. 1983; Tomkins 1985; Weimerskirch and Jouventin 1987; Brothers 2000, 2009; Berlincourt et al. 2015). Recognising this, we subcontracted an expert in seabird-fishery interactions, Dr Johanna Pierre (JPEC Ltd[1])

[1] http://jpec.co.nz/

to review the risk profile of seabirds to interactions with longlines in Bass Strait. This review is provided in Appendix 3 and summarised below.

Of the seabirds potentially encountered in Bass Strait, two groups are readily caught on fishing hooks: albatrosses and shearwaters. Within these groups, shy albatross (*Thalassarche cauta*) and short-tailed shearwaters (*Puffinus tenuirostris*) are considered to present the highest risk for interactions with longline fishing gear. Albatrosses mostly feed at the water surface and only dive a few metres. Overall, 35% of Australia's population of shy albatross occur in Bass Strait, making them a high-risk species for interactions with longline vessels fishing in those waters. Shy albatross follow fishing vessels to feed on baits, offal or fish discards, or on fish coming to the surface during line hauling. However, when using best practice measures for seabird interactions, albatross mortality can be effectively avoided.

In contrast to albatrosses, shearwaters are very effective divers that can reach tens of metres underwater (Burger 2001) and are particularly active during the day. Shearwaters are the most difficult birds to avoid catching on longline gear. They often feed together in gregarious flocks (Berlincourt et al. 2015). Most of the Australian shearwater population (75%) live in Bass Strait where they make nests on many of the islands (Berlincourt et al. 2015).

Seven other seabird species are considered at moderate risk of being caught on longline fishing gear in Bass Strait. These birds are less common than shearwaters but remain vulnerable to longliners. These species include Black-browed albatross (*Thalassarche melanophris*), White-capped albatross (*Thalassarche steadi*) Indian yellow-nosed albatross (*Thalassarche carteri*) *Buller's albatross* (*Thalassarche bulleri*), *Campbell albatross* (*Thalassarche impavida*), *Giant petrels* (*Macronectes spp* including Northern giant petrel (*Macronectes halli*, classified as vulnerable) and Southern giant petrel (*Macronectes giganteus*, classified as endangered) (Schumann et al. 2014).

Fisheries interacting with seabirds are responsive to a Threat Abatement Plan (TAP) 2006 (DEH 2006) updated in 2018 (Commonwealth of Australia 2018): i.e., TAP3. In accordance with TAP3, SESSF longline operators are required to keep seabird interaction rates below 0.01 mortalities per 1000 hooks set, equating to one seabird per 100,000 hooks set. When determining interaction rates for the set number of hooks, the auto-longline sector is separated from other hook methods.

Other ETP species potentially at risk from longline fishing include sharks. The sharks most at risk from auto-longline methods are outlined in the Ecological Risk Management Strategy for the Southern and Eastern Scalefish and Shark Fishery (SESSF) (AFMA 2015). The sharks include three species of upper-slope dogfish and a ghost shark, all of which rarely occur in the relatively shallow waters (< 80 m) of Bass Strait. The Grey Skate (*Dipturus canutus*) and Sawtail Catshark (*Figaro boardmani*) are also considered at risk and potentially caught in Bass Strait by longliners.

White Sharks are listed as endangered under Appendix II of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES) and also on Appendices I and II of the Convention on Migratory Species (CMS). The distribution of White Sharks overlaps with the area fished by longliners and some interactions are inevitable. From 1 July 2020 to 30 June 2021, the GHAT fishery of the SESSF recorded interactions with 12 White Sharks, 9 with gillnets, 2 with set longlines and 1 with auto-longline gear[2]. Of those twelve animals all but two were released alive.

The distribution of several other listed shark species overlaps with Bass Strait and could potentially be caught. These include:

- Grey Nurse Shark (*Carcharias taurus* - critically endangered EPBC Act) – the southern boundary of their distribution is commonly listed as southern NSW however some have been reported from Victorian waters.

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[2] https://www.afma.gov.au/sustainability-environment/protected-species-management/protected-species-interaction-reports

- Porbeagle Shark (*Lamna nasus* - migratory species EPBC Act) - – a pelagic, oceanic species that does occasionally get caught inshore. They are commonly reported in interaction reports by the GHAT fishery.
- Shortfin Mako (*Isurus oxyrinchus* - migratory species EPBC Act) – a pelagic, oceanic species that does occasionally get caught inshore. Main threats to this species include catch by industrial pelagic fleets in offshore and in high-seas waters, but they are commonly reported in interaction reports by the GHAT.
- Smooth Hammerhead (*Sphyrna zygaena* – Appendix II CITES) – a coastal and semi-oceanic pelagic shark that occurs on the continental shelf to at least 200 m depth. Main threats to this species include fishing by small-scale pelagic longline, purse seine, and gillnet fisheries, but it is also caught by coastal longlines. No Smooth Hammerheads have been reported by the GHAT fishery in the past two years.
- Common Thresher (*Alopias vulpinus* – Appendix II CITES) – an oceanic and coastal shark which lives to depths of 650 m. Their main threats are catch by industrial pelagic fleets in offshore and in high-seas waters. No Smooth Hammerheads have been reported by the GHAT fishery in the past two years.

Although School Shark are not classified as an ETP species, they have been historically overfished to well below 20% of virgin biomass (Thomson and Punt 2009; Thomson 2012; Patterson et al. 2021), resulting in the closure of the stock to targeted fishing and establishment of a rebuilding strategy (DEWR 2008) updated in 2015 (AFMA 2015). The rebuilding strategy has established: spatial closures to protect pupping and breeding areas; prevention of targeted fishing by setting total allowable catches (TACs) at the minimum incidental bycatch associated with Gummy Shark fishing and a maximum rate of School Shark to Gummy Shark landings; fishing gear restrictions to limit incidental catch; and a minimum size limit of 450 mm. Further to this, the strategy aims to improve knowledge of stock status, including data collection and monitoring.

There are potential cross-sectoral impacts of introducing a new fishing method into waters used by other sectors. Under OCS arrangements, Australian fisheries are managed under multiple jurisdictions. In relation to Bass Strait complicated arrangements dividing the management of fish between Tasmania, Victoria and the Commonwealth exist based on the type of fish or invertebrate, the fishing methods used, where vessels can operate and where the fish is landed. However, under the OCS, some species are managed by particular jurisdictions even though they may be caught in neighbouring jurisdictions. The SESSF recognises this in their management arrangements (e.g., AFMA 2021). The GHAT sector includes Commonwealth waters from the New South Wales/Victorian border, westward to the South Australian/Western Australian border, including the waters around Tasmania. All targeted fishing of sharks is prohibited inside Victorian coastal waters i.e., within 3 nm of the coast. Shark fishing in Tasmanian coastal waters and South Australian coastal waters is managed as part of the SESSF. Permit holders for coastal waters of South Australia or Tasmania can fish out to 3 nm from shore.

Finally, the cost of installing and operating auto-longlines can be considerable and may have significant impact on the economic viability of the fishery. Fishers will consider this in any decision to transition to auto-longlining.

Here, we describe trials of auto-longlines in Bass Strait including comparison of catches of target and non-target species, impacts on ETPs, resource sharing implications, and the economic viability of auto-longlines compared with gillnet gear.

Objectives

1. Conduct a trial using auto-longlines to target Gummy Shark in SESSF waters in eastern and western Bass Strait.
2. Collect comprehensive information on: longline catch rates; catch composition of all target, bycatch, byproduct and ETP species; and size composition of major target and byproduct species.
3. Describe potential resource sharing and gear interaction implications for SESSF and other Commonwealth and State fisheries including recreational and Indigenous sectors.
4. Undertake an economic analysis of the viability of gillnet vessels converting to longlines to target Gummy Shark in Bass Strait.
5. Present the results of the longline trials to relevant AFMA RAGs and MACs, VFA, DPIPWE and other stakeholders.

Methods

Analysis of historical data for the design of longline trials

Commercial fishery catch and effort logbook data were requested from the Australian Fisheries Management Authority (AFMA), the Victorian Fisheries Authority (VFA), and the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE). Information from Commonwealth gillnet and longline fisheries in waters of Bass Strait together with available data from Victoria and Tasmania included the key locations of fishing, catch rates and size composition of Gummy Shark, byproduct catch composition, and ETP interactions. The design of the trial, particularly the seasonal execution and spatial location of auto-longline fishing, was based on this information.

State fishery logbook data were of far less spatial and temporal resolution (based on division of 10’ latitude and 10’ longitude grids) than the Commonwealth logbook data which are reported by latitude and longitude. Once summarised to this level, the State logbook data were of little value to inform the current trial.

There are small regions of Bass Strait in which manually-baited longline effort was applied to catch shark, but this effort was concentrated south of Cape Barron Island and around the Islands to the north of Stanley. Auto-longline effort in depths less than 183m off South Australia, which began subsequent to the study by Knuckey et al. 2014, was not considered as likely to be relevant to operations in Bass Strait. Overall, there was no auto-longline fishing data and relatively little information on manually-baited longline fishing in Bass Strait on which the design of trial longlining could be based.

The historical data on catch composition of target species from the shark gillnet and hook sector were analysed using the recognised SESSF shark zones (Figure 2). In Bass Strait, the greatest catches of Gummy Shark (all methods) have come from north and north-east of Flinders Island, directly off east Gippsland and south of Cape Barron Island. A substantial amount of Gummy Shark was also caught north-east and south of King Island, together with the Islands to the north of Stanley. As the major Commonwealth fishing method targeting Gummy Shark, this catch distribution is well reflected in gillnet fishing effort. The analyses of these Commonwealth logbook data guided the positioning of trial areas. These “hotspot” fishing areas off Lakes Entrance (Area 1), north of Flinders Island (Area 2), south of Flinders Island (Area 3) and northeast of King Island (Area 4) are shown in Figure 1.

To encompass seasonal variation in catches, trials were undertaken during both Autumn/Winter and Spring. Spatial and seasonal representation of trials, were as follows: Autumn – Area 2, Area 4; and Spring – Area 1, Area 3. The four areas were each split into five sub-areas and these 20 sub-areas were used to spatially distribute sampling effort. The project budget allowed for a total of only four nine-day fishing trips within Bass Strait in each of the two seasons, with one day of fishing in each sub-area.

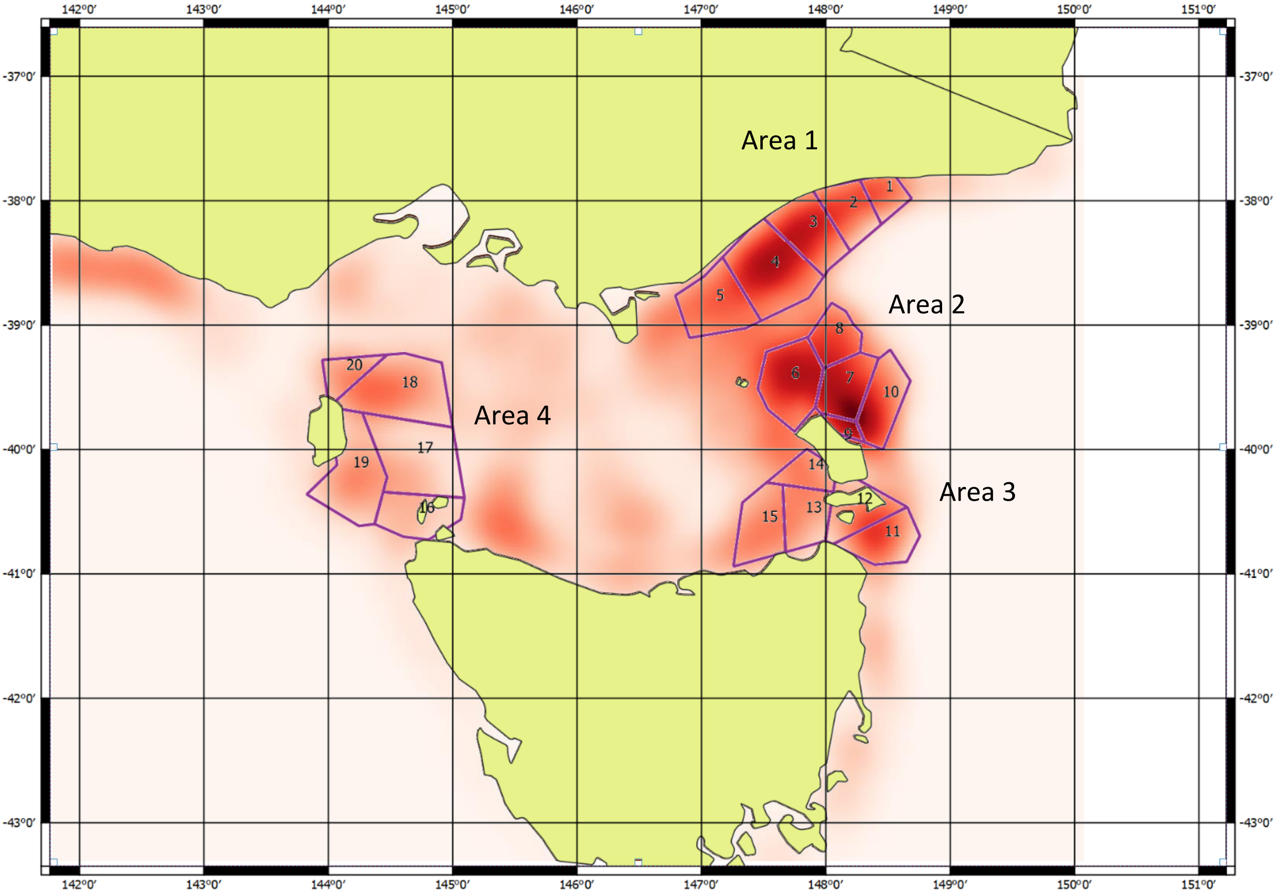

Figure 1. Bass Strait survey areas that cover the main areas of Gummy Shark catch and longline and gillnet effort. Heatmap produced by ABARES.

Figure 2. SESSF Shark research zones.

Auto-longline trials

Vessel Selection

A call for expressions of interest was put out to industry to initiate the vessel-selection process (see Appendix 1). Two longline vessels were subsequently evaluated by an independent panel. Selection criteria were based on the suitability of the vessel for carrying observers and for undertaking the trials, appropriate marine survey and insurance, the owner's involvement in management of the fishery, the skipper's experience in the shark fishery and use of longlines, and the daily charter rate. Accordingly, the *Candice K* was assessed as the most suitable vessel for the trials.

Owned by Southern Sea Eagles P/L as part of the Southern Fisheries Group, the *Candice K* is a 22 m vessel that was fitted out for shark auto-longlining in 2018 (Figure 3). The vessel is surveyed to AMSA Marine Class 3 and has a purpose-built Mustad auto-longline system capable of setting 3,000 hooks per shot in fleets of three 1,500 m lines. Each set can be deployed and retrieved twice per day (800-1,000 hooks per set). The *Candice K* has a holding capacity of 10 t in brine and 15 t in the freezer/ice room. The vessel uses squid and mackerel as bait and has AFMA-approved bird mitigation methods to comply with the seabird threat abatement plan, the vessel's Seabird Management Plan, and permit conditions. During the project the vessel was managed by Mr Kyri Toumazos (SSIA member and SharkRAG member) and skippered by Mr Trevor Smith, a shark fisherman who has worked with Mr Toumazos since 2003 on both gillnet and longline boats targeting Gummy Shark.

Figure 3. Port side view of the dedicated shark longline vessel Candice K.

Data collected

For the purpose of designing longline trials, the area of Bass Strait shown within the black polygon of Figure 4 was considered. Within this polygon, trial fishing was conducted outside State territorial waters and in depths less than 183m according to the Commonwealth division between the current shark and scalefish sectors of the GHAT fishery of the SESSF.

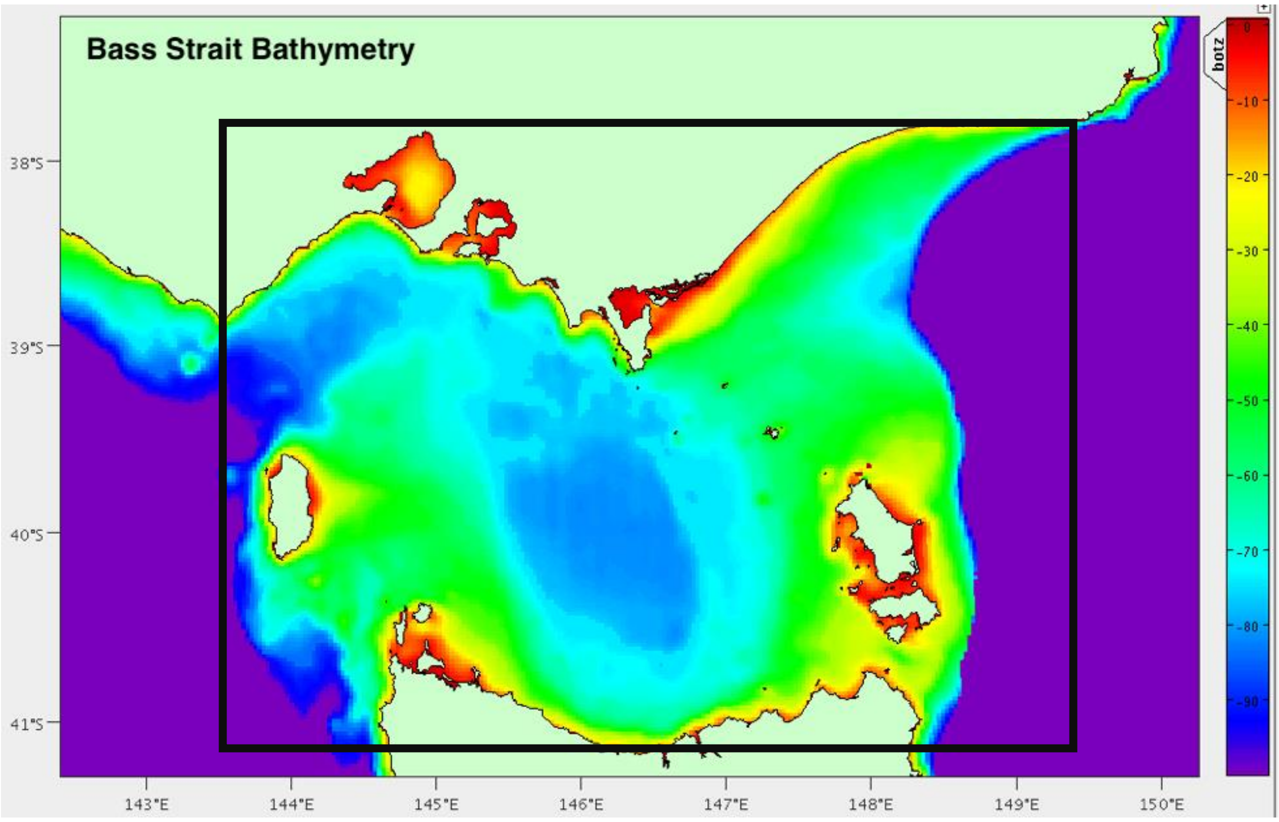

Figure 4. Area and bathymetry of Bass Strait

Two scientific observers were onboard during the trials. Operational data were recorded in the electronic reporting system OLRAC DDL for each trip and shot (Table 1). In accordance with Braccini et al. (2009), where practicable the following information was collected for each individual caught: species, sex, length, total weight, condition and degree of damage of the fish. Some large bycatch species (for example Smooth Stingray) were cut off at the snood or deemed unsafe to handle. Similarly, some commonly-caught small bycatch species (e.g., Spiny Gurnard) presented a safety hazard.. Weights of such species were not measured but were estimated. Interactions and observations with ETP species were also recorded. Observations of the presence of ETP species were made during setting and hauling, and an estimate of their abundance and activity recorded. A Lotek temperature-depth logger was attached to the longline for each set and relevant environmental data recorded.

Life state of released sharks was recorded in accordance with descriptions in Table 2. Descriptions of bloating categories are shown in Table 3.

Table 1. Data fields collected during longline trials.

Component	Data field
Trip	Trip ID, Vessel, Skipper, Observer, Depart Harbour, Start Date, Start Time, Start Latitude, Start Longitude, Return Harbour, End Date, End Time, End Latitude, End Longitude
Set	Management Zone, Start Set Date, Start Set Time, Start Set Latitude, Start Set Longitude, End Set Date, End Set Time, End Set Latitude, End Set Longitude, Set Direction, Set Speed, Valid Set, % Set Hooks Baited
Haul	Start Haul Date, Start Haul Time, Start Haul Latitude, Start Haul Longitude, End Haul Date, End Haul Time, End Haul Latitude, End Haul Longitude, Haul Direction, Haul Speed, Hooks Retrieved, % Haul Hooks Baited, Hooks Lost
Gear	Mainline type, Mainline diameter, Mainline Length, Snood type, Snood diameter, Snood Length, Snood spacing, Hook Type, Hook Gauge, Hook size, Bait Type, Bait size
Environment	Wind Strength (Beaufort), Cloud Type, Cloud Cover, Moon Phase, Wind Speed, Wind Direction, Air Temperature, Swell height, Wave Height, Sea Surface Temperature, Surface Current Speed, Surface Current Direction, Bottom Temperature, Bottom Current Speed, Bottom Current Direction
Biological	Length measurements (rounded up to nearest cm) on target species and major byproduct/bycatch species.
Retained Catch	Species, Process, Length, Length Unit, Length code, Sex, Total Green Weight, Individual Green Weight (subsample), % Carcass Damage.
Discarded Catch	Species, Length, Length Unit, Length code, Sex, Total Green Weight, Life State, Discard Reason, % Carcass Damage.
ETP Interaction	Species, Sex, Weight, ETP Date, ETP Time, ETP Latitude, ETP Longitude, Interaction type, Life State (During setting, an observer will be dedicated to viewing the entry of the baited longline into the water to determine if there are any interactions with seabirds).

Table 2. Description of shark life state categories.

Life State	Description
1	Strong and lively, flopping around on deck, shark can tightly clench jaws, no stiffness
2	Weaker movement but still lively, response if stimulated or provoked, shark can clench jaws no stiffness
3	Intermittent movement, physical activity limited to fin ripples or twitches, little response to stimuli, body appears limp but not in rigor mortis some stiffness
4	Shark in rigor mortis, stiff and lifeless, no physical activity or response to stimuli, jaws hanging open

Table 3. Description of bloating categories.

Bloat stage	Description
1	None
2	Bloating
3	Gut extrusion
4	Exophthalmia – eyes bulging

Interaction with species of concern

Species of concern include ETPs and species managed by States under OCS arrangements.

A Code of Conduct was developed by Johanna Pierre Environmental Consulting before the trials, to reduce the chance of seabird interactions with longline fishing in Bass Strait. This Code of Conduct identified the risk to Bass Strait seabirds by species. It specified risk abatement measures for seabirds, marine mammals and sharks (particularly Porbeagle, Shortfin Mako, and Longfin Mako). The Code also described best practice for reporting ETP interactions and for handling ETP species caught. An "interaction" is defined by AFMA as physical contact with a protected species. This includes collisions, catching, hooking, netting, entangling of a ETP species[3].

The conditions of our scientific permit required compliance with the latest 'Threat Abatement Plan for the Incidental Catch (or by-catch) of Seabirds during Oceanic Longline Fishing Operations' (Commonwealth of Australia 2018) to minimise interactions with seabirds and other ETP species particularly sharks (see Appendix 2). Thus, catches of School Shark were closely monitored during auto-longline trials.

The auto-longline trials in Bass Strait did not occur in waters within 3nm of Victoria or Tasmania. Nevertheless, there was potential for interaction with species managed by both of these jurisdictions. Within the SESSF, there are trip limits for Commonwealth catches of state-managed species. For Victoria, these species include Australian Anchovy, Australian Salmon, Blue Sprat, King George Whiting, Australian Sardine (Pilchard), Sprat, Wrasse, Barracouta, Leatherjackets, Snapper, Striped Trumpeter, and Yellowtail

[3] See the AFMA SESSF Management Arrangements Booklet for more information (AFMA 2021).

Kingfish. For Tasmania these species include Australian Anchovy, Australian Salmon/Tommy Ruff, Australian Sardine (Pilchard), Australian Sprat, Banded Morwong, Black Bream, Bluespotted Goatfish, Blue Sprat, Dusky Morwong, Grassy (rock) Flathead, Handfish (Family Brachionichthyidae), King Gar, King George Whiting, Luderick, Magpie Morwong, Mulloway, Sea Sweep, Seahorses, and Pipefish (Family Syngnathidae), Snook, Southern Garfish, Three Finned Blennies (Family Tripterygiidae), Wrasse, Yelloweye Mullet, Yellow-Fin Whiting, Bastard Trumpeter, Blue Groper, Snapper, Striped Trumpeter, and Yellowtail Kingfish. The number and weight of catches of any of these species during longline fishing trials were recorded.

Economic Analysis

Discounted cash flow (DCF) analysis was used to undertake the economic analysis. DCF compares future cash flows (revenue minus operating costs) for two types of gillnet operations to the same operation converted to auto-longline. The two types of gillnet operation used for comparison were:

A. **Average**: the average of annual Gummy Shark catch, trips and fishing days of all gillnet vessels fishing for more than 50 days/year.
B. **Full-time:** the average of annual Gummy Shark catch, trips and fishing days of gillnet vessels fishing more than 150 days/year.

The difference in cash flows (revenue, operating costs and investment) of converting a gillnet operation to auto-longline were discounted over a 10-year period to estimate the net present value (NPV) of the difference under two CPUE scenarios (excluding and including zero catches from trial data).

The discount rate was estimated using a Weighted Average Cost of Capital (WACC) approach, based on the Capital Asset Pricing Model. The WACC incorporates a risk-free interest rate, a market risk premium, a (beta) risk related to the systematic risk of fishing businesses relative to the risk of the market as a whole and a liquidity premium.

The analysis made several revenue and cost assumptions regarding the operations of a gillnet operation compared with a vessel converted to auto-longline fishing. These assumptions were based on information provided industry practitioners, Commonwealth logbook data 2017-2019 and ABAREs data (Bath et al. 2018). Where there was uncertainty about a key cost or revenue assumption (for example annual catches or beach prices) sensitivity analysis was undertaken to estimate the impact on NPV.

The comparative economic analysis of the conversion of a gillnet operation to auto-longline constructed a base case using the following assumptions.

Cost of conversion to auto-longline

A new Mustad Coastal System (such as that on the *Candice-K*) costs A$175,000-250,000 with $A20,000 to install and requires 3-4 crew to operate. Second-hand systems are widely available internationally and cost about $100,000[4] excluding installation costs. A Mustad system can be installed in 5-7 days. The Mustad Select System is newer and probably better suited to the Gummy Shark fishery and currently costs A$300,000-A$340,0001[5] plus A$20,000 installation. The Select system can operate with 3 crew.

It was assumed that vessels would install a second-hand Mustad Coastal System at a cost of $150,000 including installation and that 4 crew (including skipper) would be required to operate the vessel and fishing gear. Conversion would occur in Year 0, before the start of the fishing season.

[4] https://fisheriesassetbrokers.com.au/listings/mustad-auto-line-coastal-system/. Last accessed May 7 2021.

[5] If the vessel already has an existing hydraulic system

Sensitivity analysis explored the impact on the net present value (NPV) of investment in conversion if a new Mustad Select System was installed at a cost of $360,000 including installation. This would require one less crew member to operate reducing operating costs accordingly.

Gillnet operations

Cashflows of two categories of gillnet operation were compared with the same operation when converted to auto-longline:

a) **An Average Operation**: defined as the average of annual Gummy Shark catch, trips and fishing days of all gillnet vessels fishing for more than 50 days/year.
b) A **Full-time Operation:** defined as the average of annual Gummy Shark catch, trips and fishing days of gillnet vessels fishing more than 150 days/year.

Number of trips and fishing days/trip

The number of trips and days with hook sets in the economic analysis for the two categories of gillnet operation were based on logbook data for vessels fishing in Bass Strait 2017-2019 (Table 4). For an auto-longline, it was assumed that the same number of trips and days/trip were undertaken including one day/trip was spent travelling to and from the fishing area.

Table 4. Average number of trips and days/trip per annum (gillnet vessels fishing >50 days p.a. 2017-2019).

Category	Number of Trips	Days/trip
Average: all vessels	19	7
Full-time	28	8

Annual catches of an average and full-time gillnet operation

Annual catches of Gummy Shark and other species for a gillnet operation were based on average catches taken from logbook data for the two categories of gillnet operation over the period 2017-2019. It was also assumed that 20% of annual catches comprised other species (logbook data, Skirtun et al. 2012).

Annual catches (green weight) of a gillnet vessel converted to auto-longline

Annual catches of Gummy shark and Draughtboard shark were estimated using CPUE data from the trials. Bycatch of other species was negligible and excluded from the economic analysis. Accordingly, two CPUE estimates were used to estimate annual catch:

i. Annual CPUE (includes shots with zero catch) all seasons:206g/hook of which 93g/hook is Gummy Shark and 113g/hook is Draughtboard Shark.
ii. Annual CPUE (excludes shots with zero catch) all seasons:264g/hook of which 112g/hook is Gummy Shark and 152 g/hook is Draughtboard Shark.

It was assumed that sets are 3,000 hooks per shot in fleets of three 1,500 m lines. Each set is deployed and retrieved twice per day. Therefore 6,000 hooks were set/fishing day.

To account for improvements in experience and targeting and given that fishing trials were confined to areas defined by research protocols (rather than optimal commercial locations), it was also assumed that between years 2 and 6 of operation, auto-longline catches of Gummy Shark increase by 2.5% p.a. and catches of Draughtboard Shark fall by 10% p.a. Six years was considered to be a reasonable timeframe for improvements in targeting.

Green weight to trunked weight conversion factor

Gummy Sharks are almost always landed trunked (headed and gutted with pectoral fins still attached). However, as the trials recorded all catches as green weight, an adjustment was made to catch weights for Gummy shark and Draughtboard using a conversion factor of green weight: trunked weight of 1: 0.67.[6]

Revenue

Revenue was estimated using an average June 2021 beach price of $11.00/kg for gillnet caught Gummy Shark and an additional $0.50 premium was assumed for line-caught Gummy Shark. The beach price of other bycatch species caught by gillnet was assumed to be $5.00/kg. The beach price of Draughtboard Sharks was assumed to be $1.00/kg as they are sold for bait in the lobster/king crab fishery (they cannot be used for bait for the auto-longline fishery).

Operating Costs

Assumptions underpinning operating costs for gillnetters and auto-longliners are described in Table 5.

Inflation

For this analysis, prices and costs were inflated by 2%.[7]

Terminal Value

Terminal value is the value of an investment beyond an initial forecast period. This was estimated using the mean of the difference in discounted cashflow of a gillnet and auto-longline operation, assuming that there was a reduction in the effectiveness of the auto-longline gear of 25% and a lifetime of the auto-longline gear of twenty years.

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[6] Conversion ratio based on conversion ratio for New Zealand dogfish (*Mustelus lenticulatus).*
https://www.fishserve.co.nz/Media/Default/documents/Fisheries(ConversionFactor)Notice2014.pdf (p.46)
[7] https://www.westpac.com.au/news/in-depth/2021/10/rbas-inflation-target-has-been-too-high-for-too-long/

Table 5. Operating cost assumptions applicable to gillnetters and auto-longliners targeting Gummy Shark in Bass Strait.

Item	Assumptions
Crew costs	A gillnetter will have three crew (including skipper). An auto-longliner will require four crew (including skipper). Crew share is 38% of catch for both methods using a current boat price of $8.50/kg for Gummy Shark, $0.75 for draughtboard sharks and $3.50/kg for other species. Crew provisions are estimated to be $30/person/day.
Bait Costs	Bait is required for the auto-longline operation. Bait are squid and mackerel with hooks using an estimate 30g of bait/hook at a cost of $2.00/kg.
Fuel Costs	Fuel costs are estimated to be 500 litres/day for both methods at a cost of $1.12/litre (30/01/22) excluding GST and fuel rebate.
Quota lease fees	Quota lease fees were estimated to be $2.75/kg for Gummy Shark. Although some operators might own quota (and not have to pay fees), these fees are included as an operational cost, representing a return to the quota owner (irrespective of whether the quota owner is also the vessel operator).
Electronic Monitoring	For all vessels fishing over 50 days, it was assumed that the costs of electronic monitoring are $15,500 installed in Year 1, with replacement required in Year 6.
Annual Licence fees	Gillnet permit fees are $6,012 per year and auto-longline permit fees (in depths <183m) are $5,032 per year. The average of $5,500 for both gear types was used as the annual permit cost for an auto-longline shark permit.
Annual Insurance	Insurance was estimated to be $25,000 (Year 1) for a vessel using either gear.
Annual Repairs and Maintenance	Repairs and Maintenance (excluding gear replacement) were estimated to be $60,000.
Annual Gear Replacement Costs	Gear replacement cost for a gillnetter was estimated to be $40,000. Gear replacement cost for an auto-longliner was estimated to be $230/fishing day equating to an annual cost of $26,200 for an "average" operation and $38,640 for a "full-time" gillnet vessel.
Other Onshore costs	As the comparative analysis focuses on vessels, onshore costs such as freight and packaging have been excluded. Interest and tax have been excluded as there is considerable variability between fishing businesses reflecting their assets and financing arrangements.
Depreciation	Depreciation was excluded as cash flow remains unaffected.

Weighted Average Cost of Capital (WACC)

The discount rate used in the NPV analyses was estimated from the weighted average cost of capital (WACC) to be 7.3%. Parameter estimates and assumptions underpinning the WACC are provided in Table 6.

Table 6. Parameter assumptions WACC

Parameter	Explanation	Estimate
R_e	Post-tax return on equity (before imputation adjustments) calculated using the CAPM as follows: $R_e = R_f + \beta_e(R_m - R_f)$	9.02%
E	Assumed level of equity (E = 1 – D)	100%
V	Sum of assumed debt level plus assumed equity level	100%
t_c	Effective (corporate) tax rate	30%
γ	Value of dividend imputation credits. $\gamma = 1$ when all franking credits can be used and $\gamma = 0$ when none can be used.	1
R_d	Cost of debt	4.2%
D	Assumed level of debt	0
R_f	The expected return from holding a riskless security. Estimated using nominal Commonwealth bonds	1.96%
R_m-R_f	The market risk premium, measured as the difference between expected holdings from a (share) market portfolio and the risk-free rate.	8.0%
β_e	The equity beta (β_e) measures the operational risk associated with the business relative to the market as a whole for a given financial risk based on the gearing level.	0.67
β_a	The asset beta (β_a) measures the operational risk associated with the business, relative to the market as a whole, assuming 100% equity finance. In conjunction with the debt beta (β_e) the asset beta is transformed to an equity beta using levering and de-levering formula.	0.67

Results

2015-2019 catches from the Shark Hook and Shark Gillnet sector

Over the past five years, most Gummy Shark caught by gillnets has come from eastern and western Bass Strait, whereas the catch by manually-baited longline has mostly come from central and eastern South Australia (Figure 5). All auto-longline catch of Gummy Shark has come from South Australia, mostly central South Australia (Figure 5). The frequency of catch weights from auto-longlines, gillnets and manually-baited longlines are shown in Figure 6, Figure 7 and Figure 8 respectively. Although the distribution of catches less than 125 kg/trip by gillnets was similar across zones, Victorian and Tasmanian zones showed a higher frequency of catches greater than 125 kg. Catch frequencies of Gummy Shark by manually-baited demersal longlines are similar between central South Australia and eastern Bass Strait but differ from eastern South Australia, Eastern Tasmania and South Australia/Victoria with smaller proportions of catches 125–250 kg.

From 2015 to 2019, CPUE of manually-baited demersal longline fishing for Gummy Shark in Bass Strait ranged from 200–400 kg per 1,000 hooks, which was generally higher than most regions (Figure 9). In other regions, CPUE of manually-baited longlines was generally around 200g/hook, but this has decreased in the South Australia/Victoria (SA/VIC) zone since 2015 to about 100g/hook and increased to 300g/hook in Western Bass Strait and more than 300g/hook in Eastern Bass Strait (Figure 9. . CPUE by gillnet generally ranges about 20–40 kg per 1,000 m of net (Figure 10). Although CPUE has decreased in the SA/VIC, western Bass Strait, western Tasmania and eastern Tasmania zones, CPUE has remained relatively steady in central SA and eastern Bass Strait (Figure 10).

The size composition of discarded Gummy Shark caught by gillnets differed greatly among regions. The distribution for discarded males from South Australia was bimodal with peaks at about 75 cm and 115 cm, and a trough at 100 cm whereas sizes of male Gummy Shark from Bass Strait peaked at 100 cm (Figure 11). Size distribution of male Gummy Shark from Tasmania differed from that of both Bass Strait and South Australian with a flattened peak over 100–130 cm length (Figure 11). Overall, male Gummy Sharks from Tasmania were larger than those from Bass Strait (Figure 11). Size composition of discarded female Gummy Sharks also differed among regions (Figure 12). Female sharks from Bass Strait followed a bell-shaped curve, and peaked at about 100 cm, whereas those from South Australia peaked at about 70 cm, but sloped in steps with increasing size (Figure 12). The opposite was observed for females from Tasmania where there was a small peak at about 70 cm and then a main peak at about 120 cm (Figure 12).

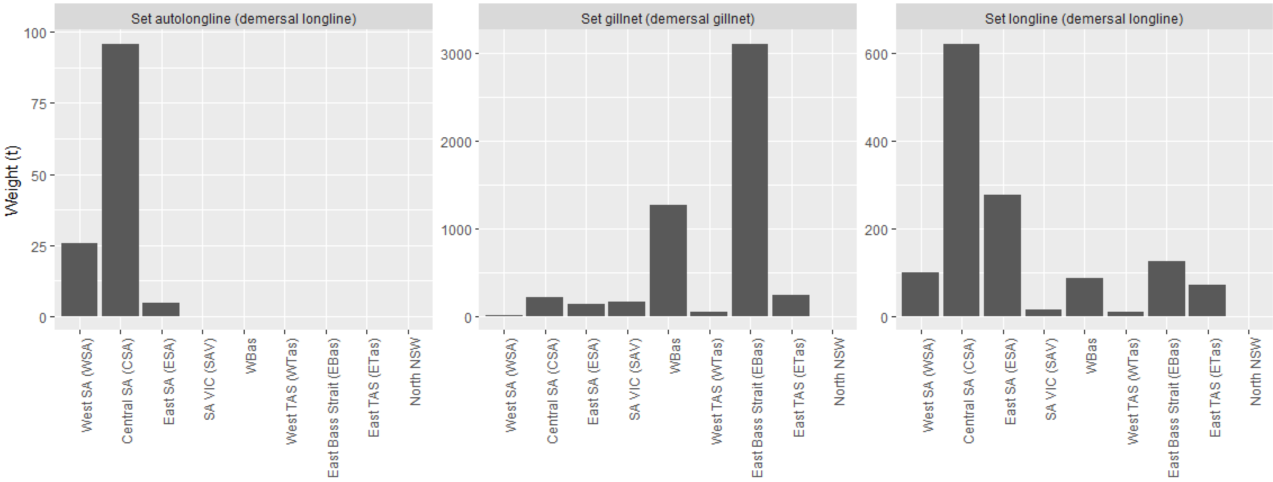

Figure 5. Catch of Gummy Shark by gear type in different areas of the fishery from 2015–2019 shallower than 183 m.

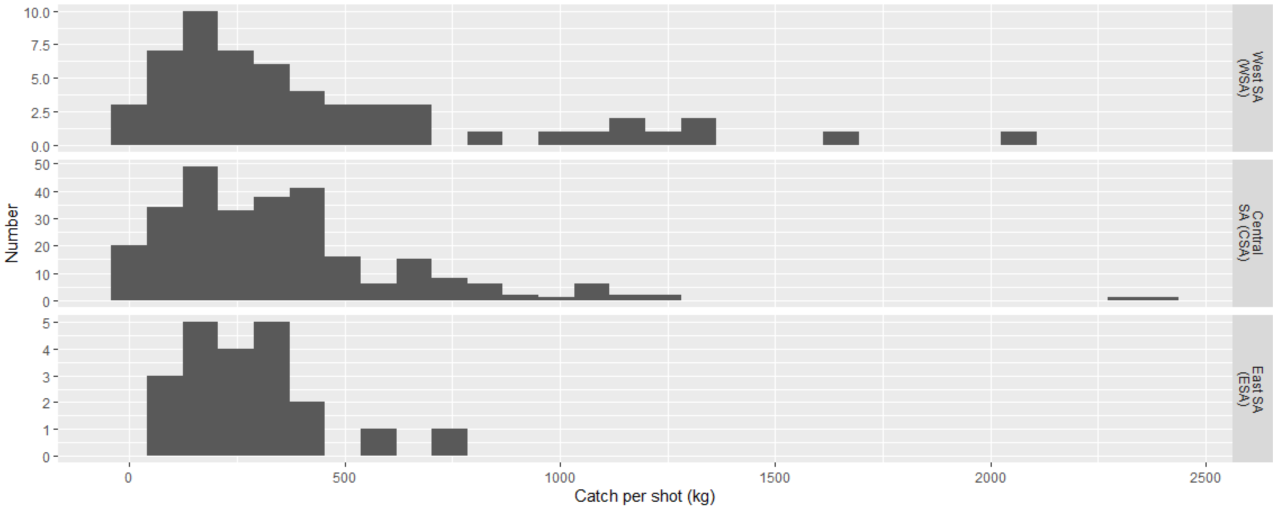

Figure 6. Catch frequency of Gummy Shark by auto longline in different areas of the fishery from 2015–2019 shallower than 183 m.

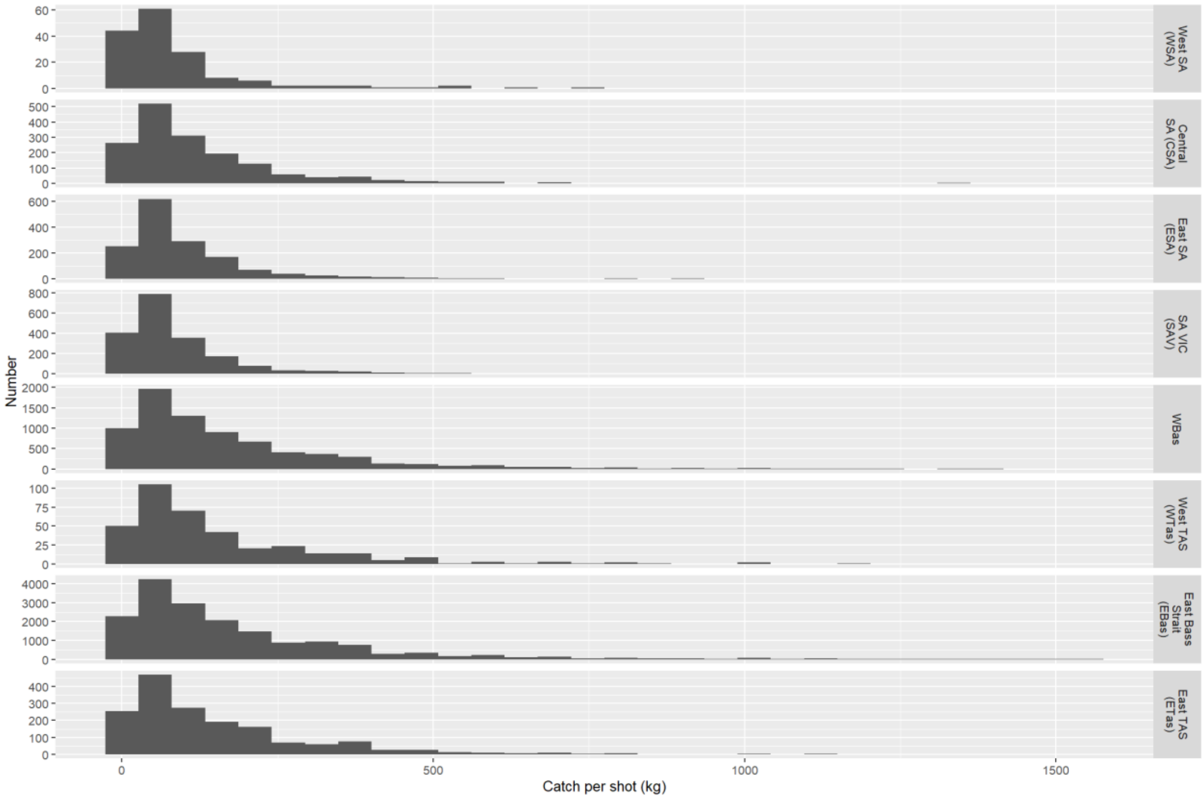

Figure 7. Catch frequency of Gummy Shark by demersal gillnet in different areas of the fishery from 2015–2019 shallower than 183 m. Note that data were filtered for catches < 1,500 kg to increase resolution. This removed about 0.16% of catch records.

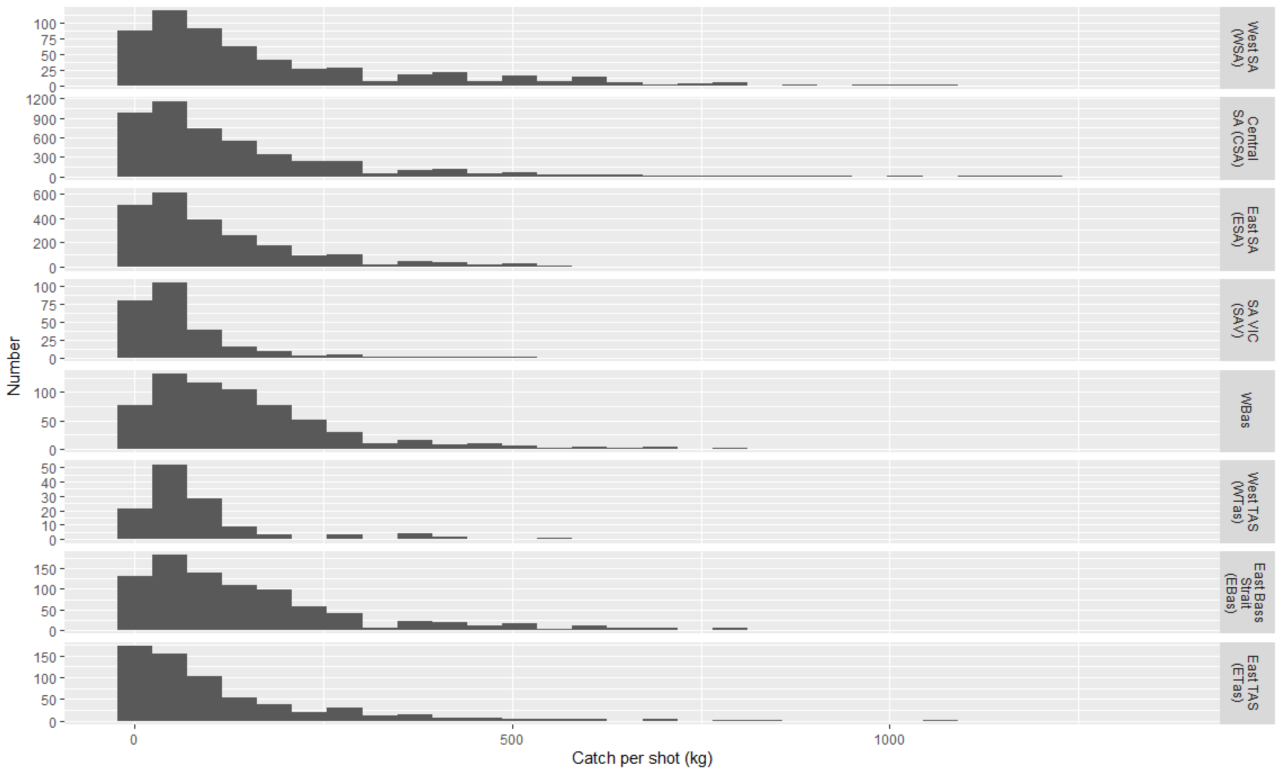

Figure 8. Catch frequency of Gummy Shark by manually-baited longline in different areas of the fishery from 2015–2019 shallower than 183 m.

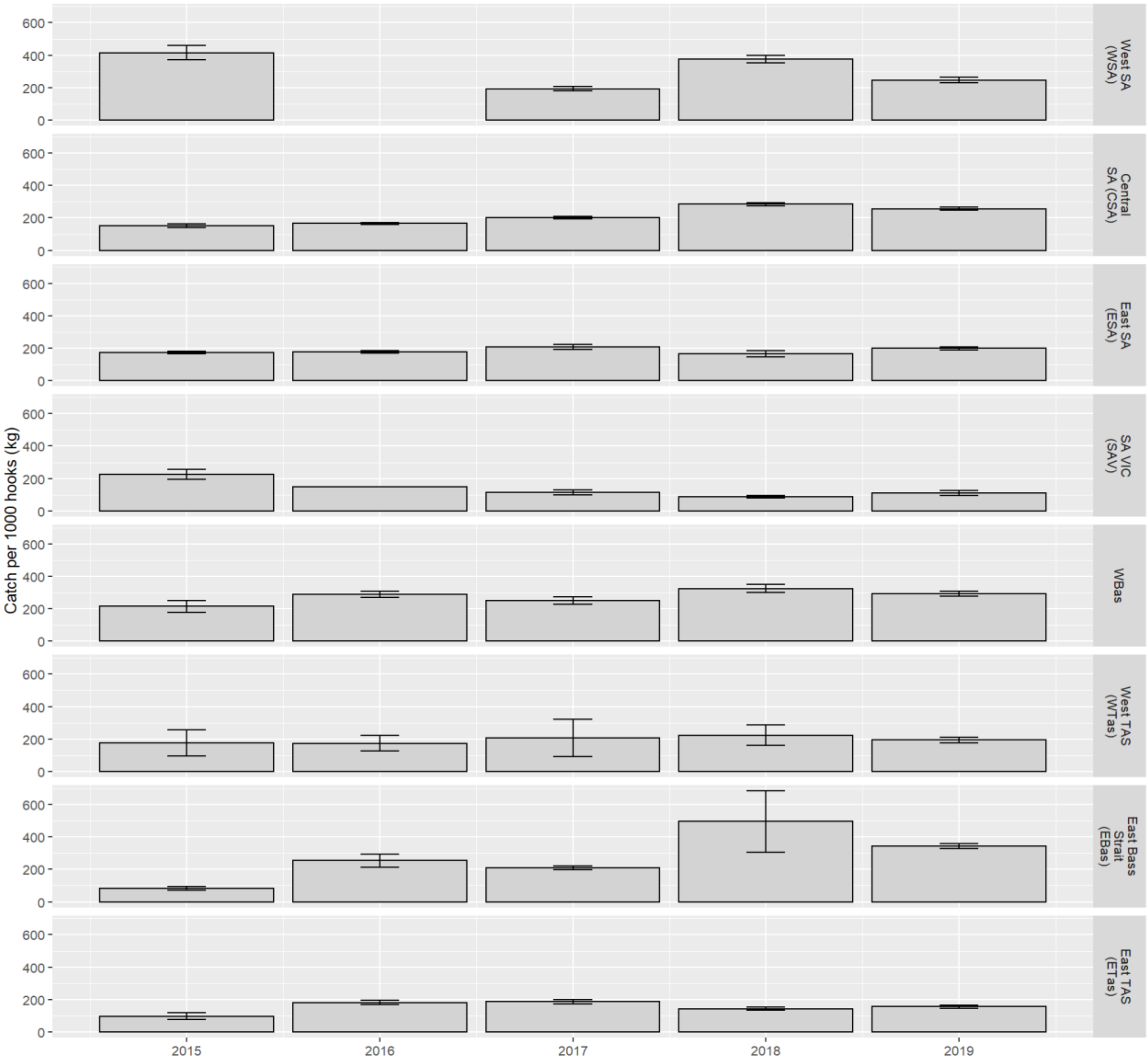

Figure 9. Catch rates of Gummy Shark by manually-baited demersal longline in different areas of the fishery from 2015–2019 shallower than 183 m.

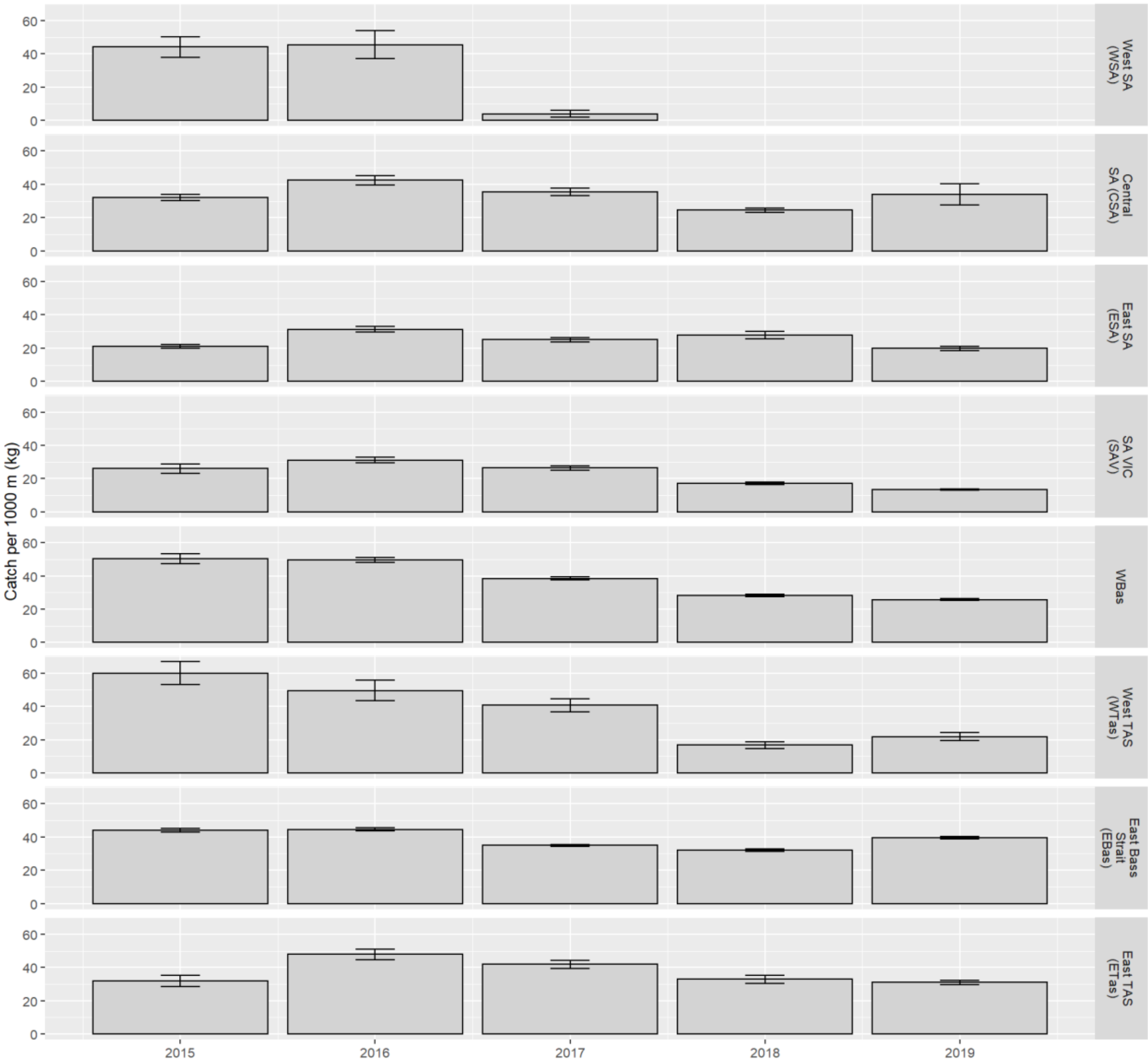

Figure 10. Catch rates of Gummy Shark by demersal gillnet in different areas of the fishery from 2015–2019 shallower than 183 m.

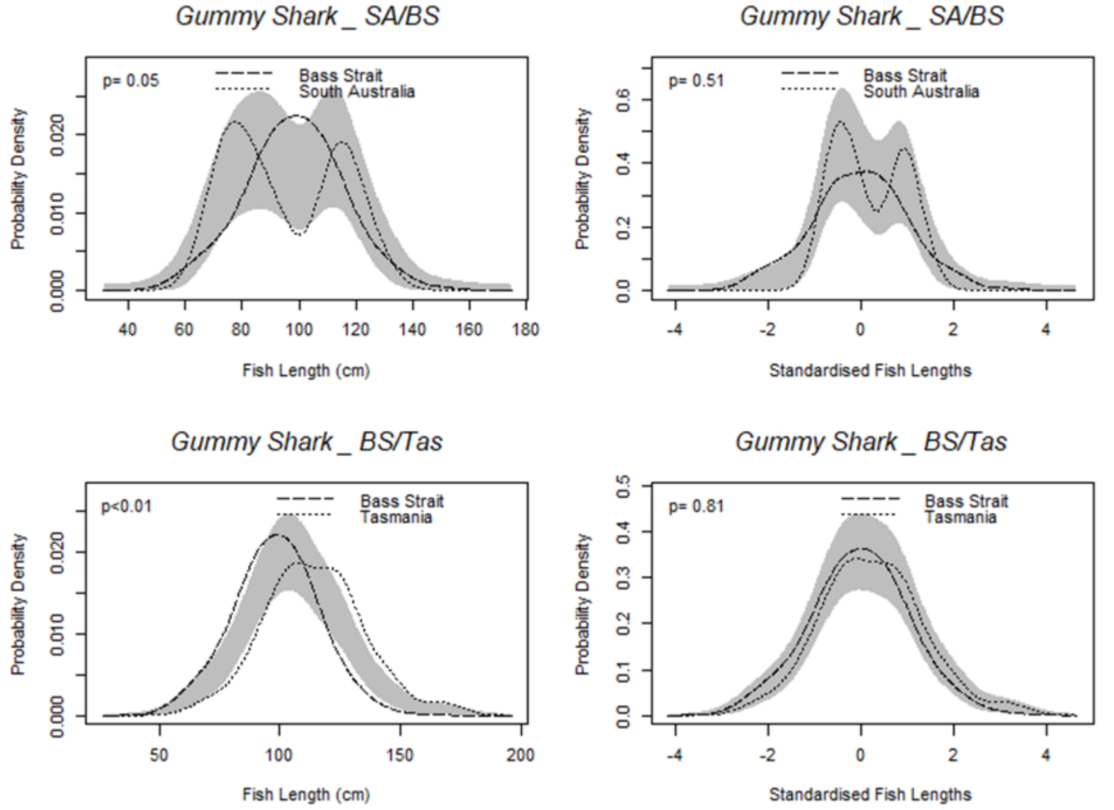

Figure 11. Probability densities for discarded male Gummy Sharks caught by gillnets between adjacent zones for total length and standardised length (from Koopman and Knuckey 2018).

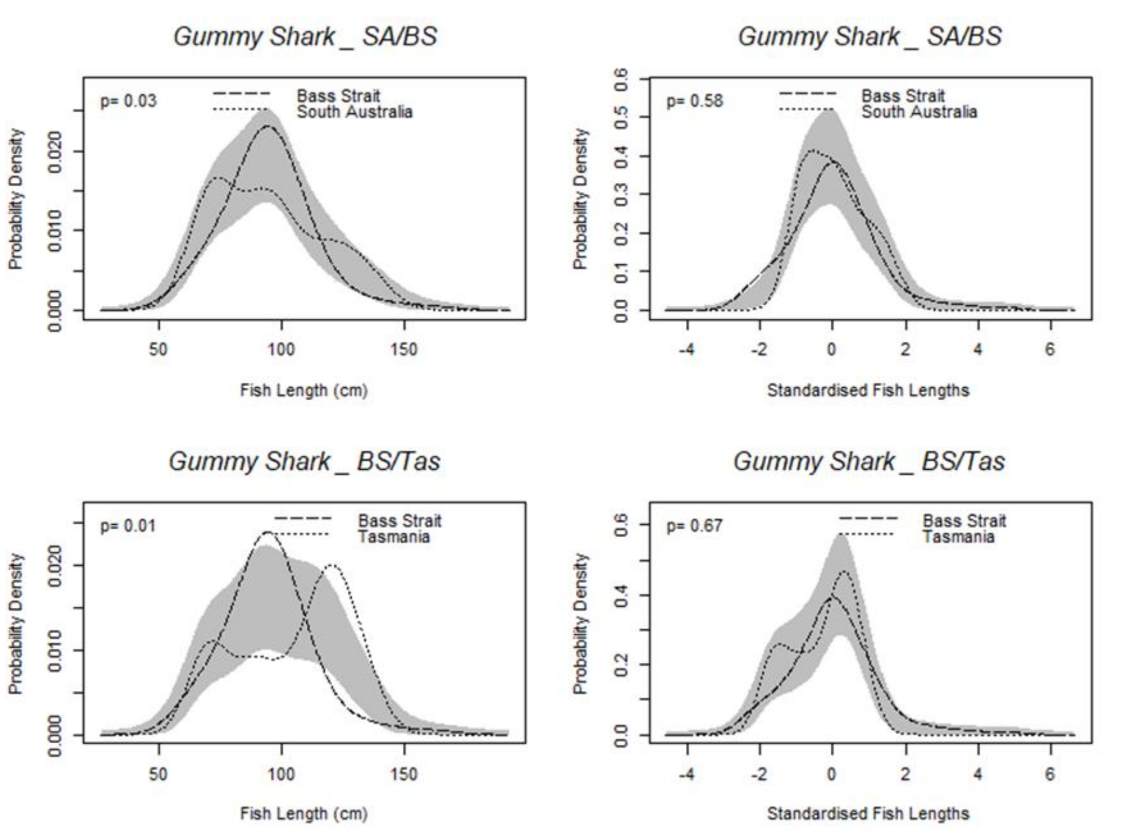

Figure 12. Probability densities for discarded female Gummy Sharks caught by gillnets between adjacent zones for total length and standardised length (from Koopman and Knuckey 2018).

Catch Composition – byproduct and bycatch species

The catch from manually-baited demersal longliners was dominated by Gummy Shark, ranging from 61% of the catch in the SA/VIC zone to 87% in the western Bass Strait zone (Figure 13). School Shark comprised a large component of byproduct species (7%–24% of retained catch) in all zones except for Eastern Bass Strait where it comprised 1% of the retained catch (Figure 13). The catch composition from Eastern Bass Strait also differed in catch composition from most other zones, with Draughtboard Sharks and Skates among the top five species caught (Figure 13). Only small catches of Snapper were recorded (< 3% of the catch) (Figure 13).

More than half the retained catch of gill netters was Gummy Shark (up to 88% in the eastern Tasmania zone) (Figure 15). School Shark was the second largest component of the gillnet catch in most zones except in eastern Bass Strait (~ 2% of the catch) where more Sawshark was caught and in eastern Tasmania where more Elephantfish was caught (Figure 15). As with manually-baited longline, Draughtboard Sharks and Skates were in the top five species landed (Figure 15). Gummy shark dominated the retained catch reported by observers on gillnetters (45% to 80%) but Common Sawshark comprised a relative high proportion of the retained catch off SA/Vic (31%), western Bass Strait (7%) and eastern Bass Strait (5%) (Figure 18). Southern Sawshark comprised 15% of the gillnet catch off Western Bass Strait and Draughtboard Shark comprised 25% of the retained catch off eastern Tasmania (Figure 18). Draughtboard Shark was the main discarded species (65-70%) reported by observers from demersal gillnets (Figure 19). Composition of discards was different in the more western zones, with Port Jackson shark comprising 33% of discards in the SA/Vic zone, Thresher Shark and Bottlenose Dolphin comprising 25% of discards in the eastern SA zone, and Broadnose shark comprising 20% of discards in the central SA zone (Figure 19).

Auto-longlines caught mostly Gummy Shark (72%–96%), with School Shark comprising2%–26% of catch (Figure 14). Snapper comprised less than 1% in all zones (Figure 14). Retained catches reported by observers on auto-longliners were dominated by Gummy Shark comprising 93% and 95% of the catch (Figure 16). Lesser quantities of Broadnose Shark, Snapper, School Shark and Bight Redfish were among the top five species caught (Figure 16). Discarded catch from auto-longliners was dominated by Port Jackson Shark (57%) and Southern Eagle Ray (15%) off central SA, and Thorntail Stingray (33%) and Southern Eagle Ray (27%) off eastern South Australia (Figure 17).

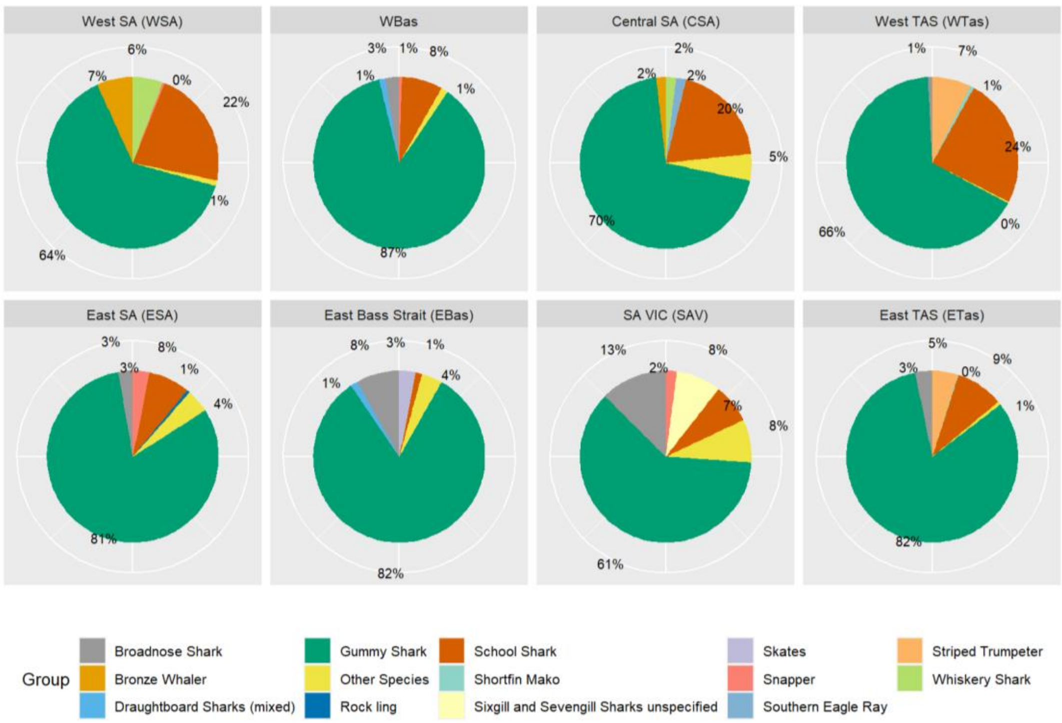

Figure 13. Logbook-recorded retained catch composition by manually-baited demersal longlines shallower than 183 m from 2015–2019.

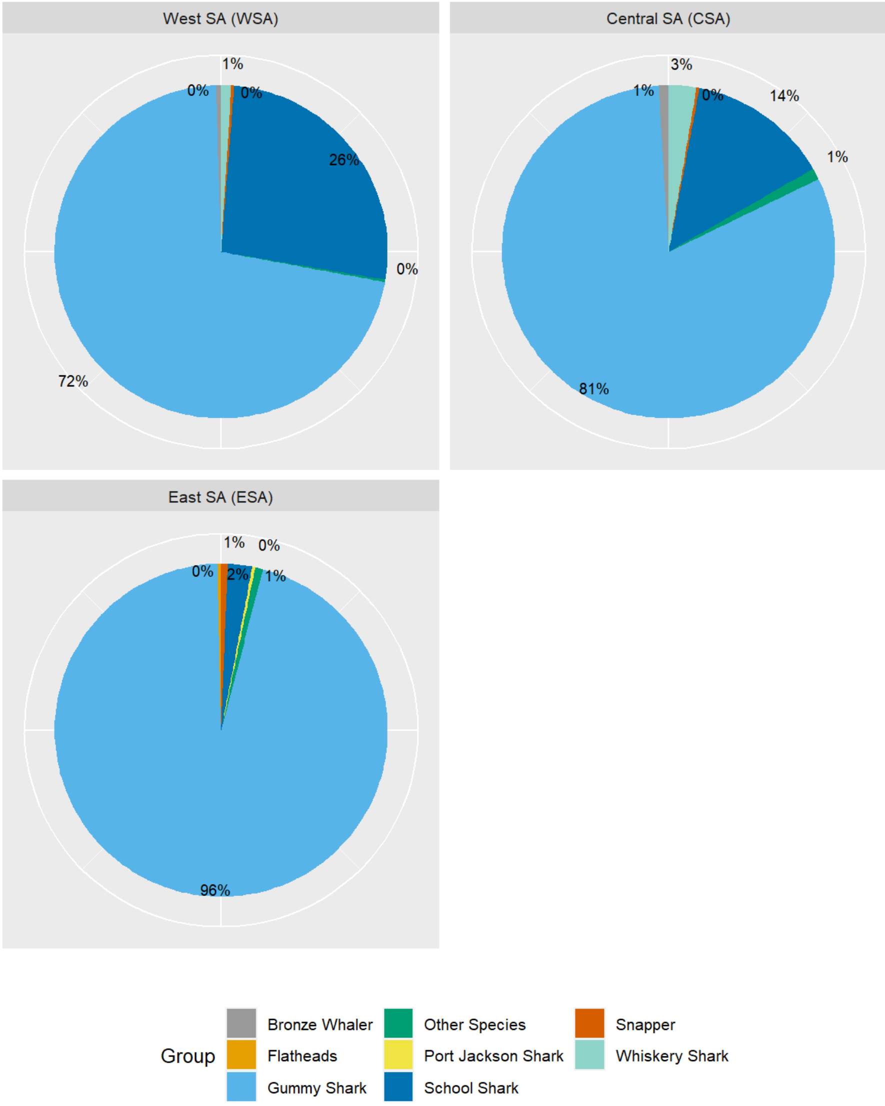

Figure 14. Logbook-recorded retained catch composition of auto-longlines shallower than 183 m from 2015–2019.

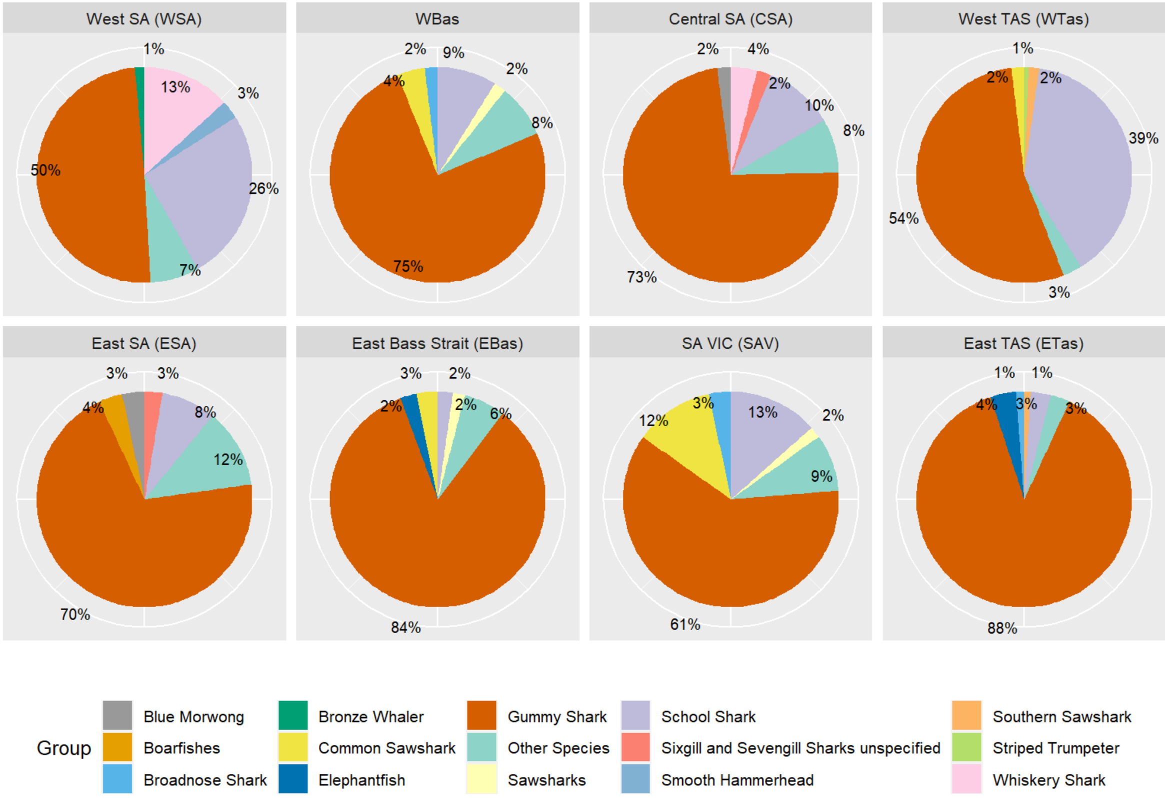

Figure 15. Logbook-recorded retained catch composition of demersal gillnets shallower than 183 m from 2015–2019.

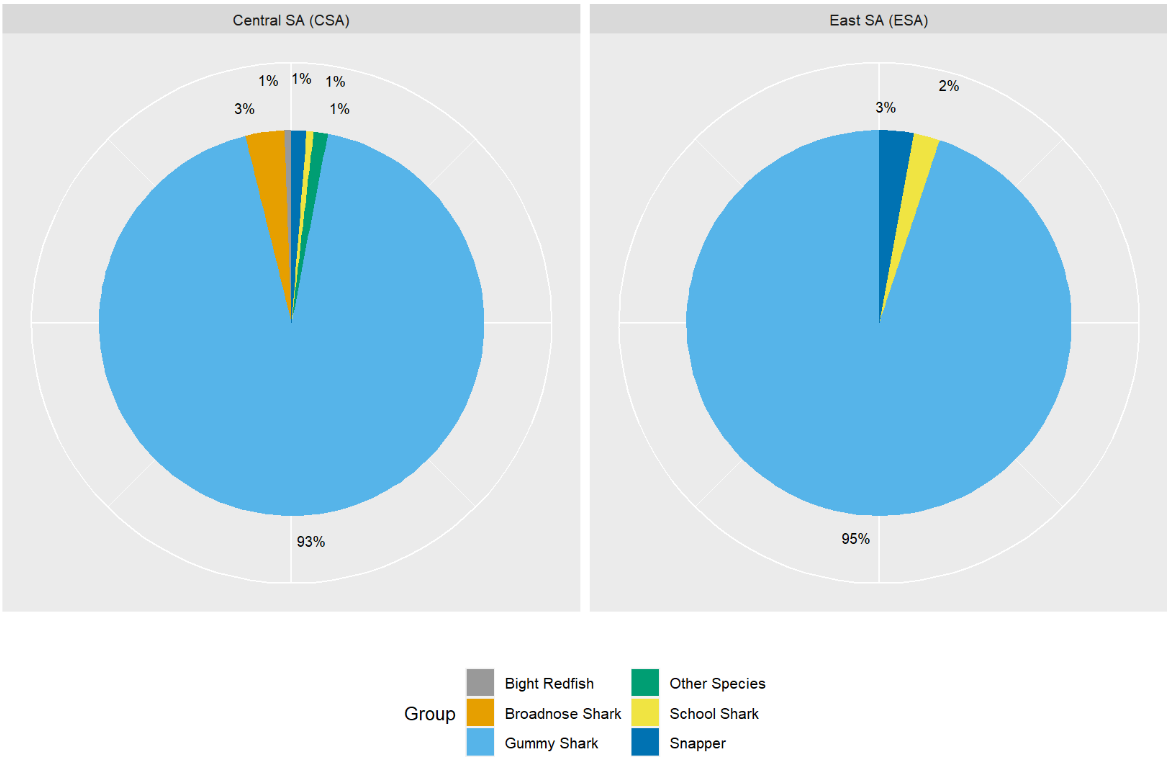

Figure 16. Observer-reported retained catch composition by auto-longlines shallower than 183 m from 2015–2018.

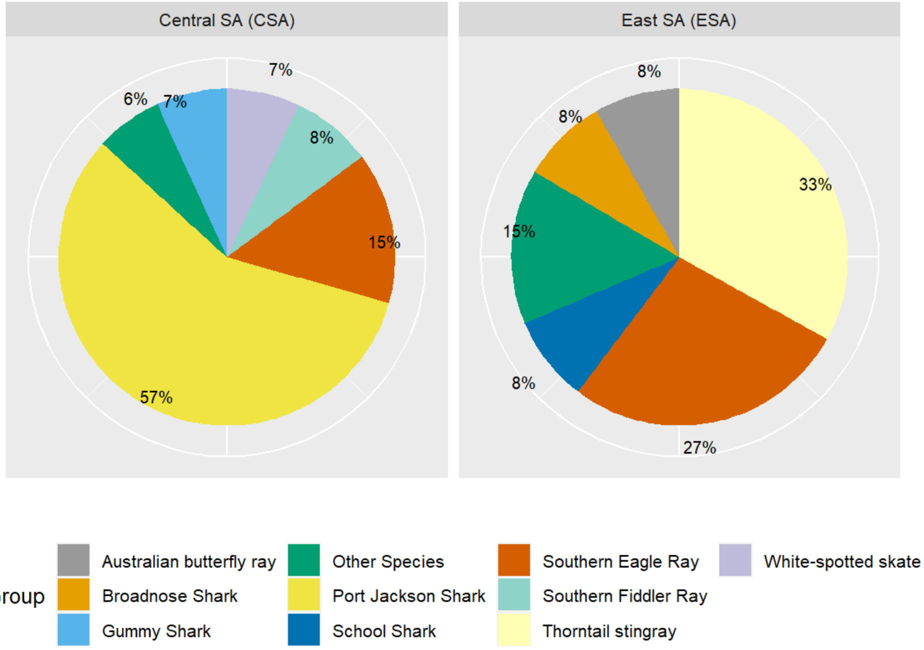

Figure 17. Observer-reported discard catch composition by auto-longlines shallower than 183 m from 2015–2018.

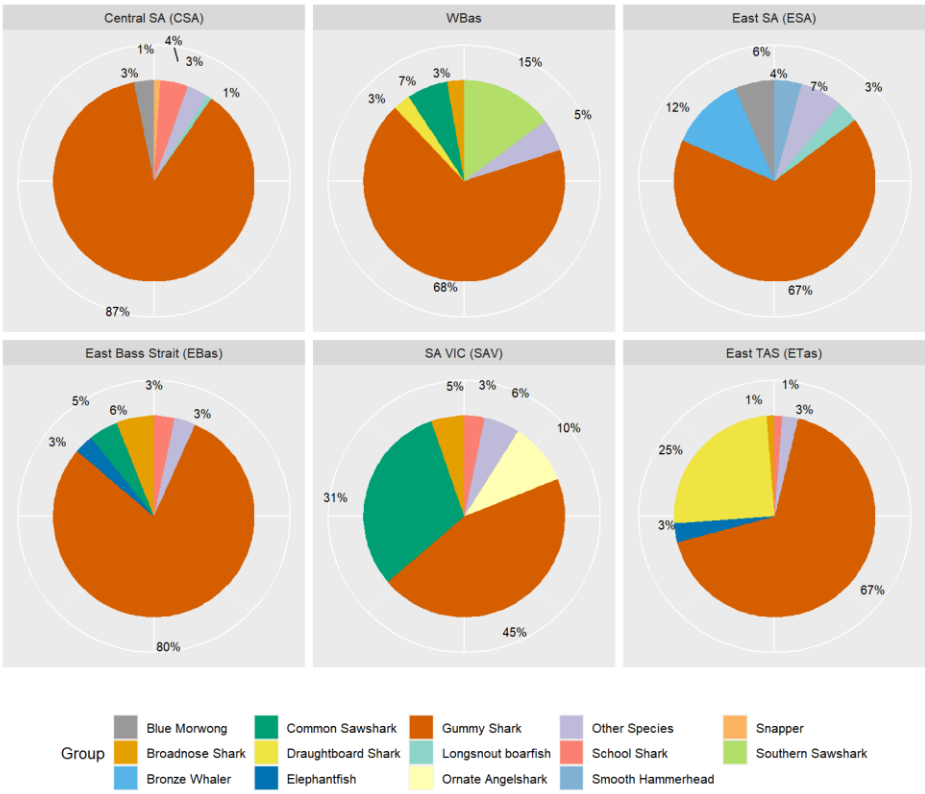

Figure 18. Observer-reported retained catch composition by demersal gillnets shallower than 183 m from 2015–2018.

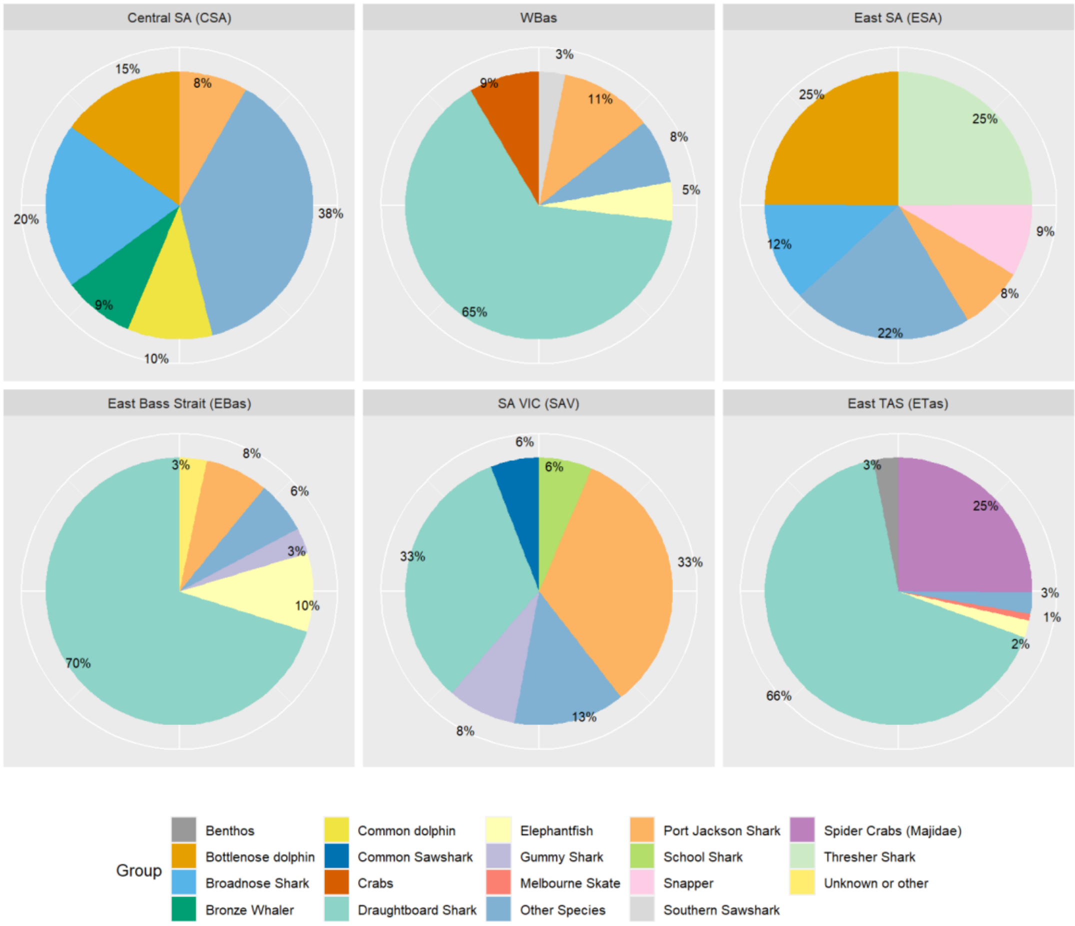

Figure 19. Observer-reported discard composition by demersal gillnets shallower than 183 m from 2015–2018.

ETP species in the trial area

Birds

Copies of the seabird risk profile and the Code of Conduct applied in the trials are shown in Appendix 3 and Appendix 4 respectively.

Fur Seals

Colonies of Australian Fur Seals are much more common in Bass Strait than in South Australia (Figure 20), and they were not observed during trials with auto-longliners targeting Gummy Shark in South Australia in 2011–12. The increased prevalence of Australian Fur Seals in Bass Strait could therefore potentially result in increased interaction and predation rates compared with fishing in South Australia. Although capture of Australian Fur Seals by longlines is a rare event, it does happen [8]. Australian Fur Seals are known to prey on fish catches from the line sector of the GHAT fishery in the SESSF. Gummy Shark caught on longlines are often damaged by predation from lice and sharks. Seals are known to feed on sharks caught by the GHAT (DAFF 2007), and it is likely that they would attack shark catches in a Bass Strait auto-longline fishery.

[8] https://www.afma.gov.au/sites/default/files/q1_2019_protected_species_interactions_final_report.pdf
https://www.afma.gov.au/sites/default/files/q3_2019_final_tep_report_-_final.pdf

Dolphins

During 2011, there was a sharp increase in reported dolphin interactions by shark gillnet fishers in ocean waters off the Coorong in South Australia, east of Kangaroo Island. This led to the first Gillnet Dolphin Mitigation Strategy for the SESSF, including an entire closure of the area to fishing. This Mitigation Strategy was updated in 2019[9], and new measures have been applied for gillnet fishing across the entire SESSF. Dolphins do interact with gillnet fishing in Bass Strait but most interactions (from September 2010 to September 2011) were reported from the Coorong (Parra et al. 2001). It is difficult to determine the likely change in dolphin interaction that might result from a transition to auto-longlines but there is potential for injury or mortality of dolphins due to predation on baited hooks or entanglement.

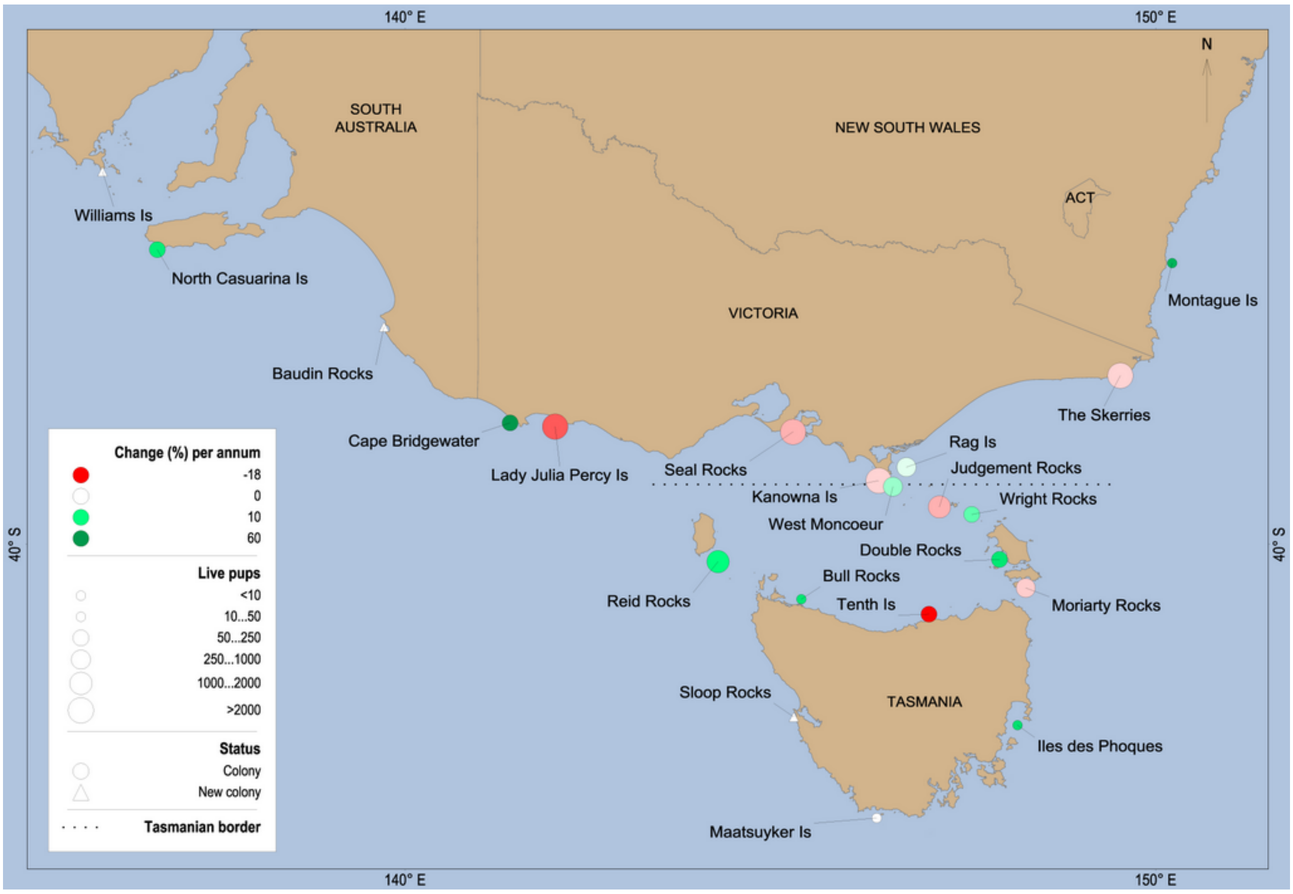

Figure 20. Distribution of Australian Fur Seal colonies in south-east Australia. From McIntosh et al. (2018).

Trial of auto-longline in Bass Strait

Trial shot locations

A summary of the three trips undertaken for auto-longline trials is shown in Table 7 and set details are presented in Figure 21 and in Table 20. A total of 79 shots was undertaken over two trips during Autumn and Winter 2020, and an additional 47 shots were undertaken during spring 2020. In total, 126 shots were undertaken comprising 126,300 hooks set (see Appendix 5). Shots were spread throughout Bass Strait

[9] ttps://www.afma.gov.au/sites/default/files/gillnet_dolphin_mitigation_strategy_updated_aug_2019_accessible.pdf

focussing on areas of relatively high Gummy Shark catches historically recorded in logbooks. Areas included east of King Island north and south of Flinders Island and east Gippsland (Figure 21).

Table 7. Trip details for the spring/summer shark longline trials.

Trip #	Start date	Start time	Port of departure	End date	End time	Port of return	Number of shots	Number of hooks set
1	22-May-2020	16:09	Portland	31-May-2020	19:30	Port Welshpool	41	40,800
2	4-Jun-2020	10:54	Port Welshpool	12-Jun-2020	09:20	Port Welshpool	38	38,100
3	2-Nov-2020	07:27	Portland	14-Nov-2020	06:35	Port Welshpool	47	47,400

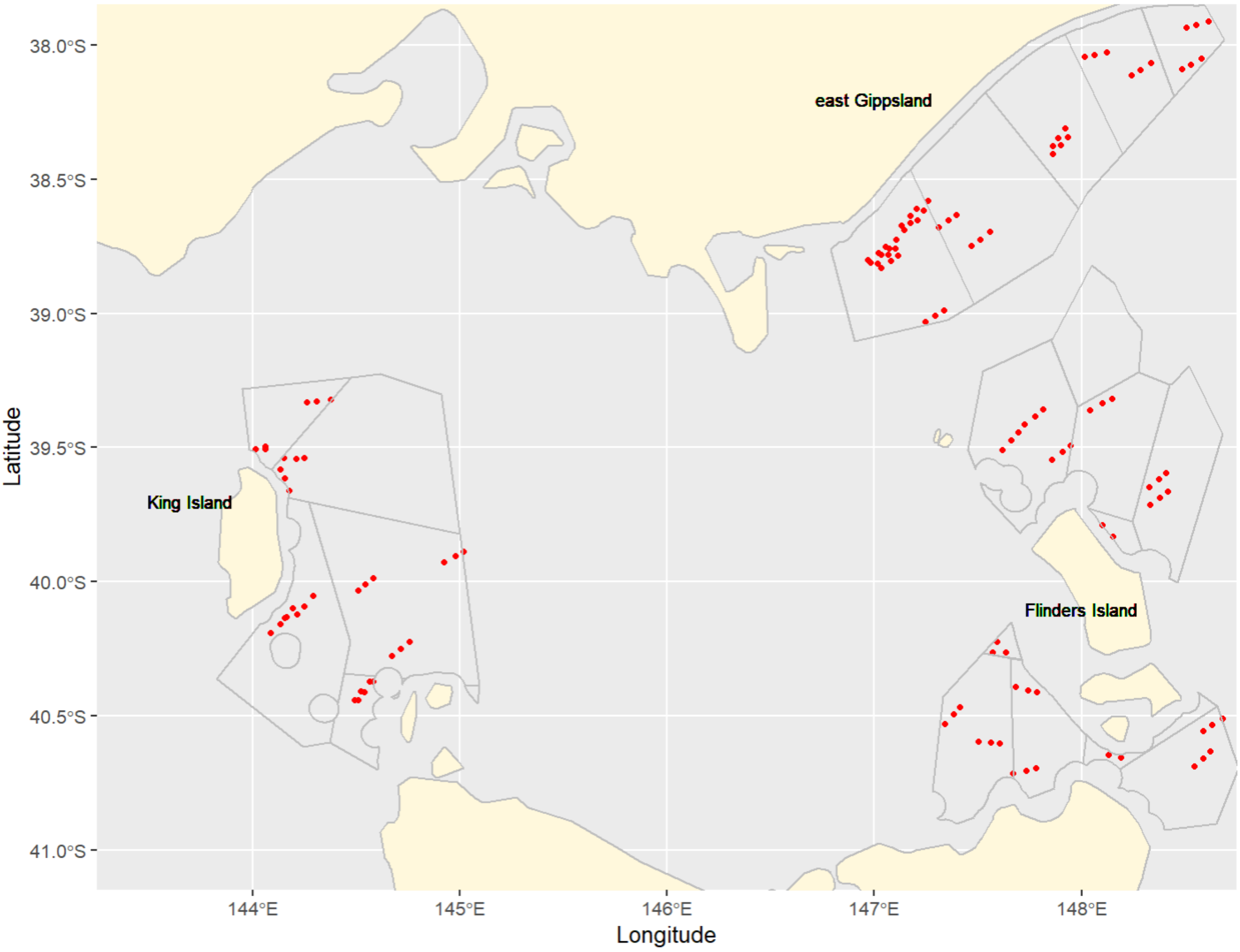

Figure 21. Location of survey shots undertaken.

Catch composition

About 26 t of sharks and other species was retained during the gear trials and nearly 30 t was discarded. Retained catch comprised 54% Draughtboard Shark (14.2 t) and 44% Gummy Shark (11.5 t) (Table 8). Main species discarded were Draughtboard Shark (18.2 t, 61% of the discarded catch), Melbourne Skate (2.9 t, 9.8% of the discarded catch) and Southern Fiddler Ray (2.6 t, 8.8% of the discarded catch). Development of a market for Draughtboard Sharks resulted in much more of that species being retained during the Spring trip (a discard rate of only 7.2% compared with 66% during the winter/spring trips). Only 69 kg of School Shark was caught of which just under half was retained, whereas 57.9 kg of Snapper was caught with most of that being released Appendix 6 (Table 21, Table 22). Retained and discarded catches of all species for Winter/Spring and Spring trips are shown in Appendix 6 (Table 21, Table 22).

Catch rates of retained Gummy Shark averaged 111.9 g/hook from the 104 shots in which they were retained (Table 9). Including shots with zero catches reduces the mean catch rate to 93.4g/hook. Discarded Gummy Sharks were caught at 9.2g/hook from 90 shots (Table 9). Retained and discarded Draughtboard Shark were caught at an average of 151.7g/hook, and discards at 162.5g/hook excluding shots with zero catch (Table 9). Catch rates (excluding shots with zero catch) of Gummy Shark were much lower in Spring (55 g/hook) compared with Autumn/Winter (145g/hook).

Distribution of catches of species important to State managed fisheries is shown in Figure 22. Draughtboard Sharks were caught throughout the trials in high numbers. Smallest catches were from north-east Gippsland and in the south of Banks Strait. Only a small amount of Snapper was caught (57.9 kg), mostly from north of King Island, north-west of Hunter Island and in Banks Strait. Gummy Shark was caught consistently throughout the trial area with Gummy Shark retained in 67 of the 79 shots set in Autumn/Winter and 37 of the 47 shots set in Spring. Southern Sand Flathead were caught in small numbers in most of the trial area, except for north of Flinders Island and in deeper waters off southern Gippsland. Small numbers of School Shark were caught over a smaller area than other species, including southern King Island, Banks Strait and southern Gippsland.

Table 8. Retained weight (kg), number and percent composition of the top six retained species by auto-longliners. Catch of all species is shown in Table 21and Table 22 (Appendix 6).

Species	Retained catch (kg)	Percent retained catch	Retained number
Draughtboard Shark	14193.8	54.1%	4392
Gummy Shark	11466.1	43.7%	2553
Broadnose Shark	246.8	0.9%	28
Southern Sand Flathead	150.5	0.6%	191
School Shark	66.7	0.3%	6
Southern Sawshark	34.5	0.1%	21
Other species	61.4	0.2%	89
Total	26219.8		7280

Table 9.Retained and Discarded catch, CPUE and number of shots of Gummy Shark and Draughtboard Shark. Mean CPUE was calculated using only shots in which sharks were caught as well as including shots that caught no retained Gummy Shark or Draughtboard Shark.

Species	Measure	Retained	Discarded
Draughtboard Shark	Catch (kg)	14193.8	18188.6
	Catch (number)	4392	6187
	Mean CPUE (g/hook)	151.67	162.48
	SE CPUE	13.79	19.77
	N	92	112
	Mean CPUE (g/hook) with zero catches	112.53	
	SE CPUE with zero catches	11.84	
Gummy Shark	Catch (kg)	11466.1	827.9
	Catch (number)	2553	725
	Mean CPUE (g/hook)	111.91	9.21
	SE CPUE	10.74	1.14
	N	104	90
	Mean CPUE (g/hook) with zero catches	93.37	
	SE CPUE with zero catches	9.64	

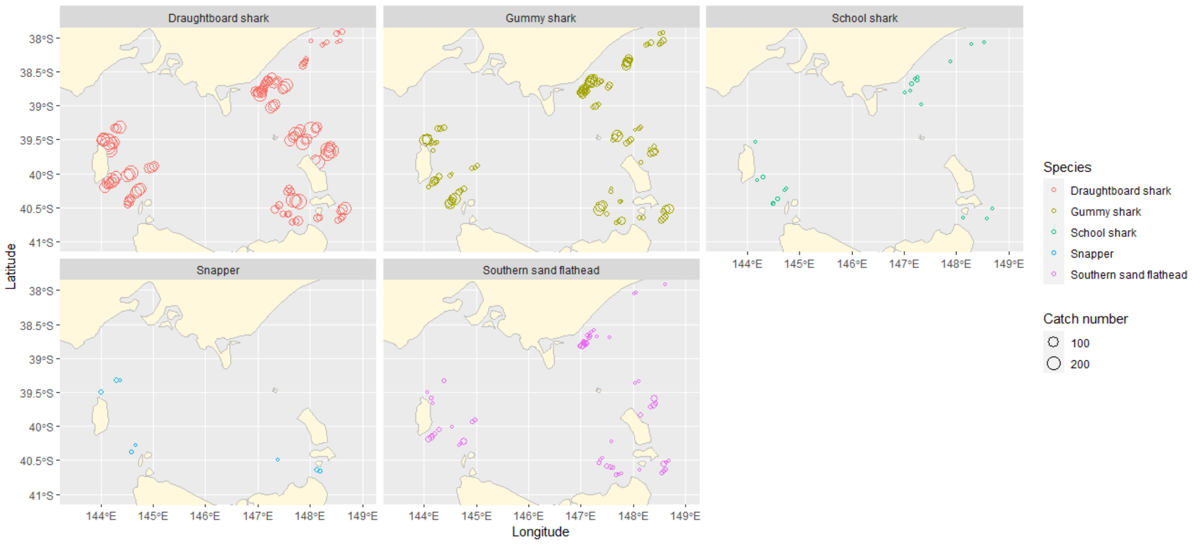

Figure 22. Distribution of catches (numbers caught) of species that were of interest to the States.

Fate of discarded catch

Most discarded Draughtboard Sharks and other large Chondrichthyans (Melbourne Skate, Southern Fiddler Ray, School Shark, Smooth Ray, Port Jackson Sharks) were released in states classified as either strong and lively or weak but lively (Figure 23) see also Appendix 6 (Table 24, Table 25). Many of the discarded Gummy Shark were dead, having been damaged by shark bites, lice or both. Bite damage usually resulted in greater damage to Gummy Sharks than lice, with damage generally greater than 80% (i.e., 80% of the carcass was missing) (Figure 26). Lice damage was mostly less than 20% but significant damage also occurred particularly in Spring (Figure 26).

For most species, discards were observed to swim away when released (Figure 24, see also Appendix 6 Table 26, Table 27). Other than Gummy Shark, most discards were released alive and swam away. Species that were discarded with a high proportion of either just alive or dead were small teleosts including Bearded Rock Cod, Common Gurnard Perch, and Red Cod (see Appendix 6, Table 24, Table 25). However, species that were discarded and floated away (i.e., did not swim away) were Common Gurnard Perch, Red Cod, Bearded Rock Cod and Draughtboard Shark. The most common reason for discarding was being unmarketable (see Appendix 6 Table 28, Table 29).

Level of bloating was recorded for the main teleost species and was commonly observed in Bearded Rock Cod, Common Gurnard Perch and Red Cod (Figure 25). Gut extrusion was observed more frequently during the Spring trip in Common Gurnard Perch, and there was some exophthalmia observed in that species (Figure 25). Bloating and gut extrusion was observed in the few Snapper caught (Figure 25).

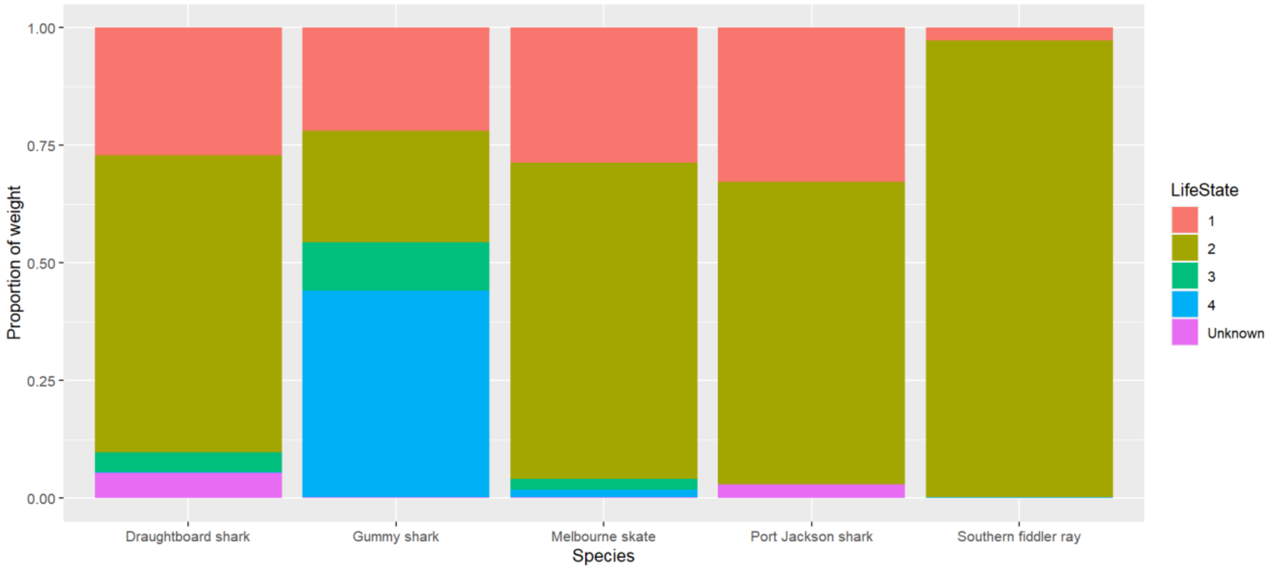

Figure 23. Life state of main discarded species.

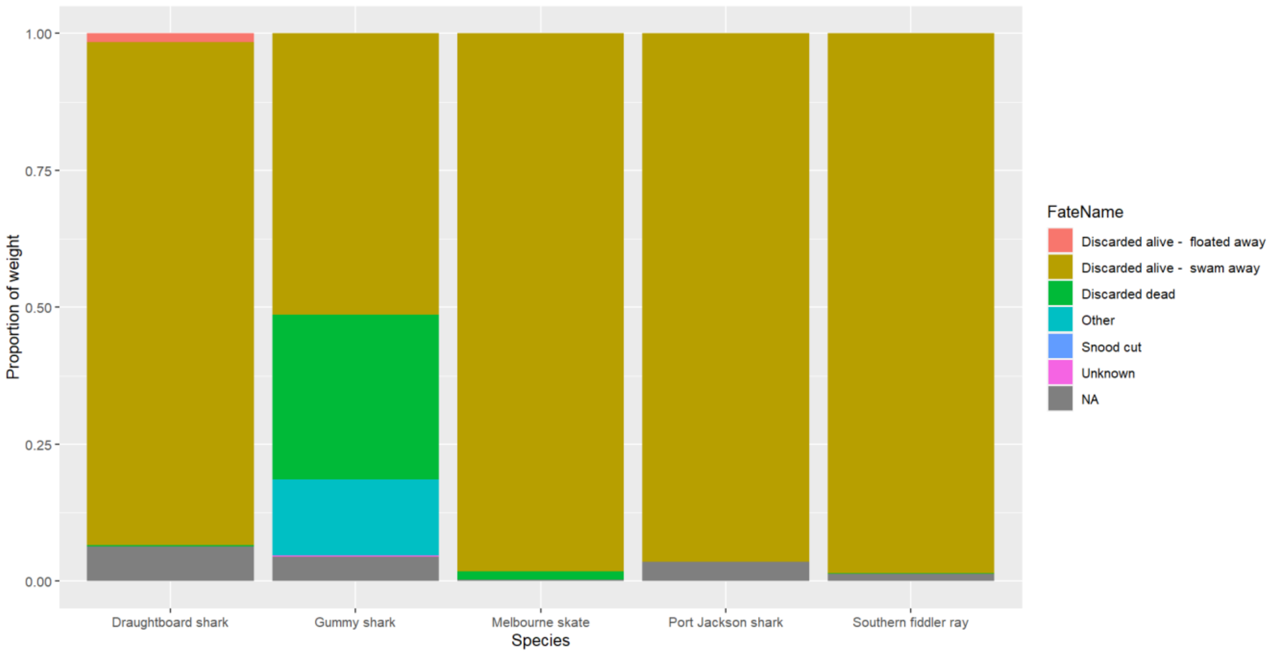

Figure 24. Fate of main discarded species.

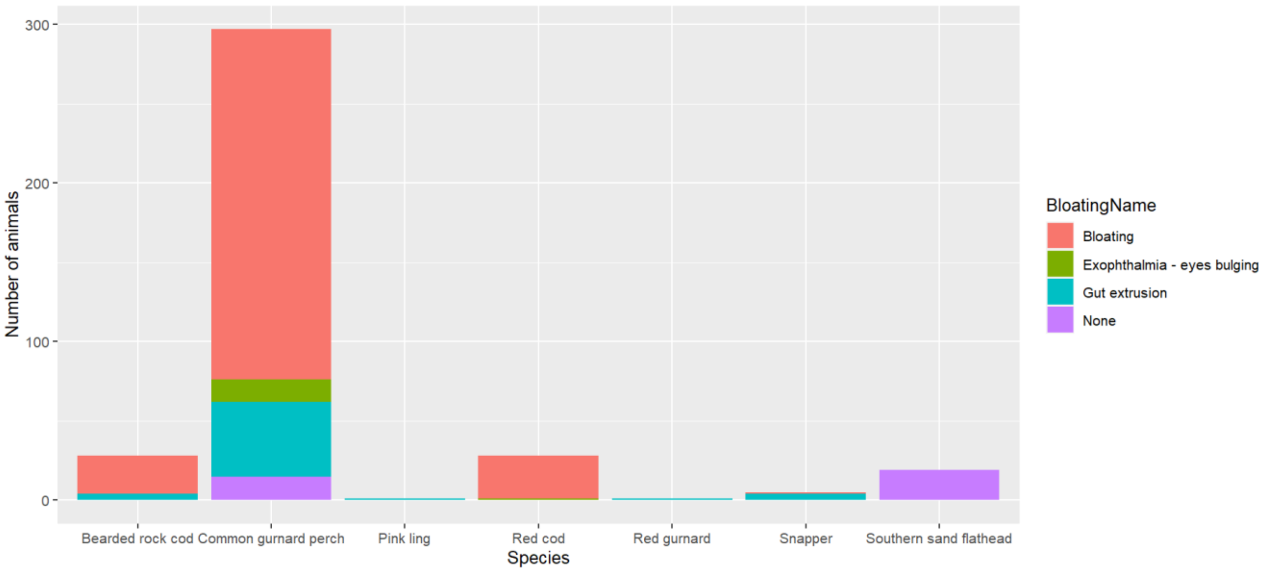

Figure 25. Extent of bloating on main teleosts. Note that Southern Sand Flathead do not have a swim bladder.

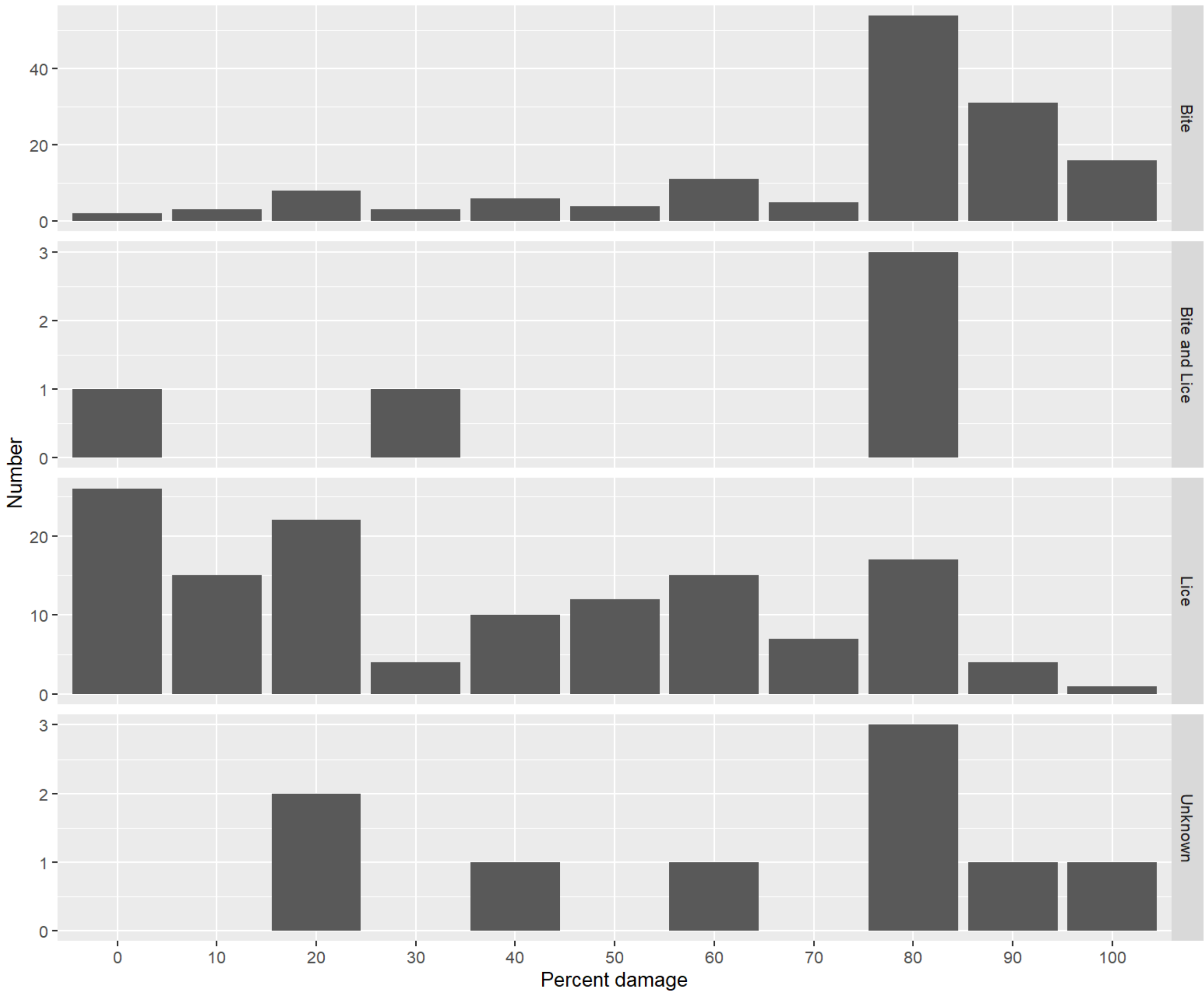

Figure 26. Frequency of percent damage (% of carcass missing) to discarded Gummy Shark by damage type.

Size composition of Gummy Sharks

The size frequency of retained and discarded Gummy Sharks recorded in the auto-longline trials is similar to that recorded for gillnets (Shark Industry Data Collection Program[10] (SIDaC) data) (Figure 28). The SIDaC data show selectivity for various gillnet mesh sizes with current trial data showing similar selectivity to 5-inch mesh.

Discarded Gummy Sharks measured in Autumn/Winter were generally smaller than 77 cm but discards spanned the range of lengths because bite and lice-damaged fish were discarded (Figure 27). Some smaller discarded Gummy Sharks (~ 50 cm) were caught in Spring resulting in a significant difference in length distributions between seasons (KS test: D = 0.28, p<0.001), but otherwise the size frequency of discards was similar to that from Autumn/Winter. The retained catch comprised mostly 80–115 cm fish but size composition was skewed to larger sharks particularly of females reaching nearly 175 cm. Larger fish were caught during Autumn/Winter, particularly in the range 100–120 cm, and the length distributions were significantly different between seasons (KS test: D = 0.29, p<0.001). The sex ratio appeared even in Autumn/Winter samples but was dominated by males in Spring.

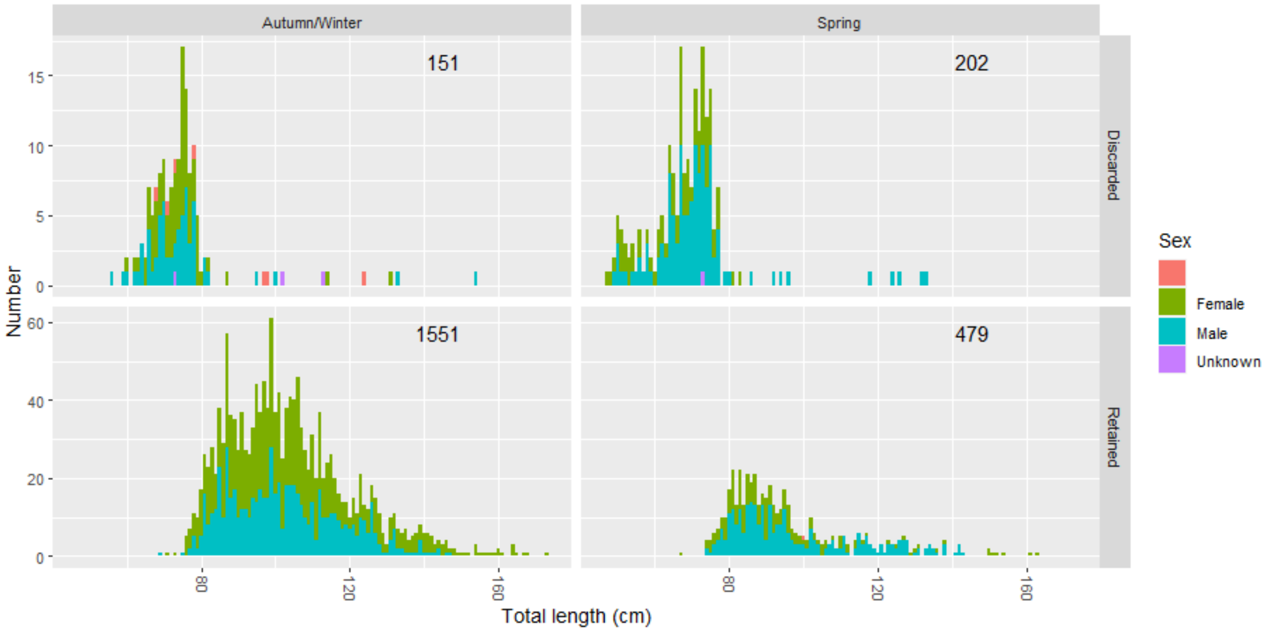

Figure 27. Size frequency (total length, cm) of retained and discarded Gummy Shark by season.

[10] Section 4.4 of Southern and Eastern Scalefish and Shark Fishery Management Arrangements Booklet 2020
https://www.afma.gov.au/sites/default/files/2020_southern_and_eastern_scalefish_and_shark_fishery_management_arrangements_booklet.pdf

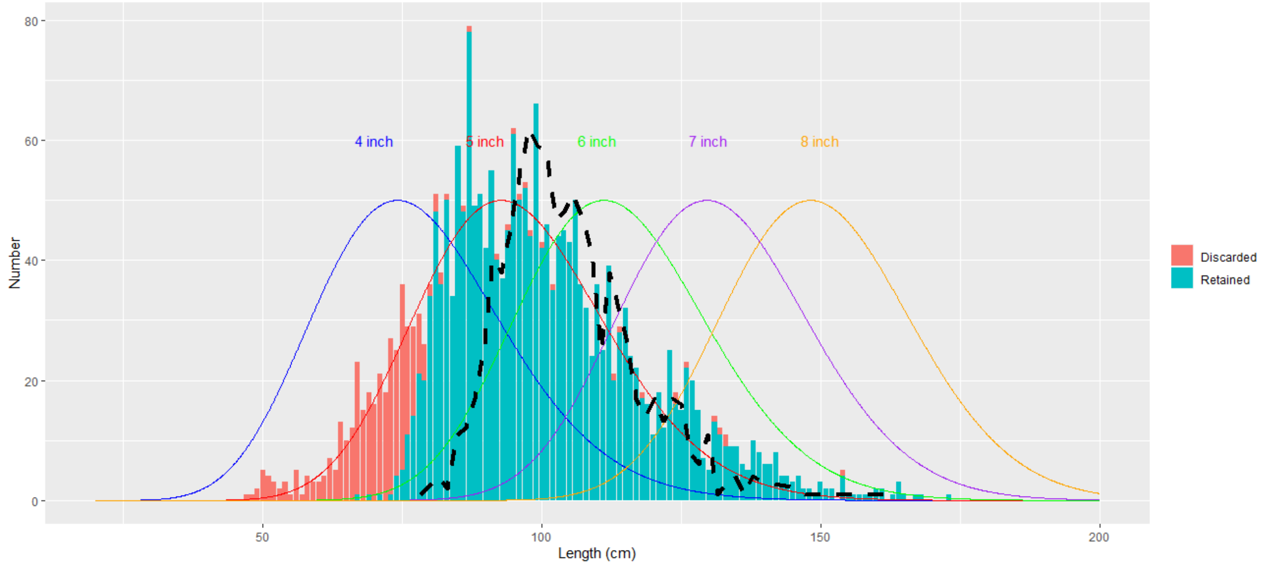

Figure 28. Size frequency of retained and discarded Gummy Shark (red and blue bars), size frequency of landed Gummy Sharks from SIDAC data collected in eastern and western Bass Strait (black dashed) and selectivity curves for 4, 5, 6, 7 and 8 inch mesh nets using selectivity parameters from Table 13 of Braccini et al (2009) for Gummy Sharks from across southern Australia (mainly Bass Strait) during 1973–76 surveys (Kirkwood and Walker 1986).

Size composition of Draughtboard Sharks

Most Draughtboard Shark were retained, particularly individuals > 80 cm in length, resulting in relatively few data to assess size composition of discards (Figure 29). Discarded Draughtboard Sharks spanned a large size range. Some large individuals were discarded because of either bite or lice damage or because of their low market value.

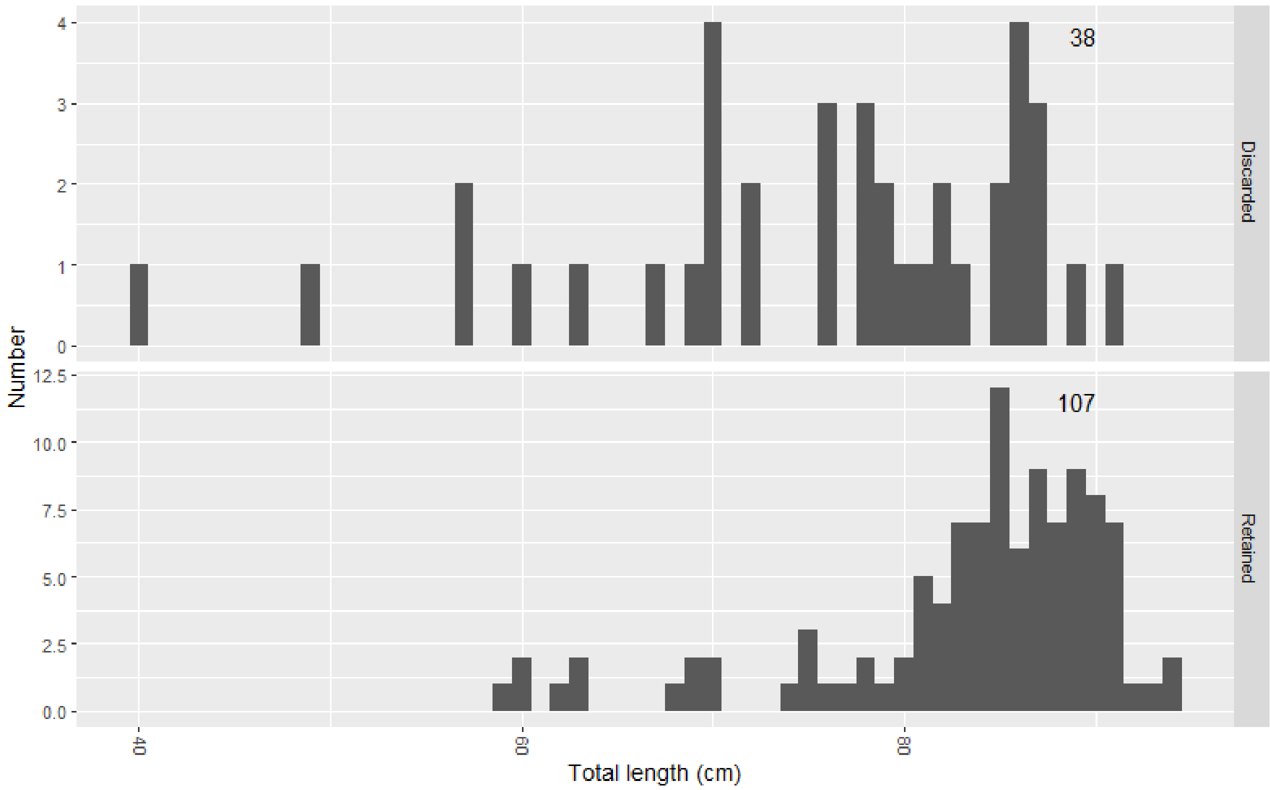

Figure 29. Size frequency (total length, cm) of retained and discarded Draughtboard Shark. Data are percent of total sampled.

ETP Species

During the longline trials, on 31/5/2020 a Great White Shark was tangled around the mainline, having likely fed on nearby hooked Gummy Sharks (many were observed to have bite damage) (Table 10). The shark was about 2.5–3 m long, and once untangled, swam away seemingly unharmed. This interaction occurred off east Gippsland during the daytime. Similarly, off east Gippsland on 11/6/2020, an Australian Fur Seal was briefly hooked in the mouth while attempting to take a shark off the hook (apparent seal bite damage was also observed on sharks caught on nearby hooks) (Table 10). The adult Australian Fur Seal became unhooked without intervention, and swam away vigorously. Both interactions were reported to AFMA through logbooks. There were no interactions with dolphins. No fishing gear was lost during trials.

Seabird observations were regularly made during hauling and setting (Table 11). Shy Albatross was the most common seabird observed during the first and thirds trips, whereas Giant Petrel was the most common during trip two. Shy Albatrosses were most often roaming widely seemingly unattracted to the fishing operation, but some were observed irregularly searching (i.e., not intensively searching). Giant Petrel were unattracted, with some roaming widely or irregularly searching. Most Black-browed Albatross were observed to be disinterested in the fishing operation, roaming widely or irregularly searching. The only species observed intensively searching was Crested Terns.

Table 10. Details of ETP interactions that occurred during the trials. Note there were no interactions recorded during the spring trip.

Species	Australian Fur Seal	Great White Shark
Date	11/6/2020	31/5/2020
Time	12:04 (haul start time)	14:09 (time photo was taken)
Activity	Hauling	Hauling
Approximate latitude	-38˚ 40.31	-38˚ 48.42
Approximate longitude	147˚ 07.90	147˚ 04.45
Set number	33	41
Life status on release	Alive	Alive
Nature of interaction	Tried to take seal off hook. Briefly hooked, dropped off hook and swam away. Likely adult.	Tangled around mainline. Untangled itself and swam away. Many bitten shark and Gummy shark nearby. 2.5-3 m. Photos taken.

Table 11. Species composition (number of birds) of seabirds observed during each of the three trips.

Species	Trip 1	Trip 2	Trip 3
Black-browed Albatross	32	81	3
Crested Tern	6		
Diving Petrel	2		
Giant Petrel	47	338	44
Indian Yellow Nose	2	4	
Mix of Shy and Black Brow Albatrosses	3	36	
Pacific Gull			8
Sea Gull		1	
Short-Tailed Shearwater	1		11
Shy Albatross	277	21	60
Storm Petrel	2		
Westland Petrel			2

Economic analysis

Comparison of economic performance

The difference in cash flow (revenue, operating costs and investment) of a gillnet operation and one converted to auto-longline were discounted over a 10-year period to estimate the NPV using CPUE from trial data under two scenarios (excluding and including shots with zero catches). A negative NPV indicates that the investment in auto-longline would not be attractive. The results (Table 16) are summarised in Table 12 below showing that a conversion from gillnet to auto-longline gear would be attractive for an "average" but not a "full-time" gill-netter (Table 12).

Table 12. NPV: Discounted cash flows of converting a gillnet operation to auto-longline

Operation	Using CPUE including zero catches	Using CPUE excluding zero catches
Average	$188,215	$805,465
Full-time	($1,767,545)	($21,948)

Comparison of an "average" gillnetter to one converted to auto-longline – CPUE trial data including shots with zero catch

Using CPUE data which includes shots with zero catch, the Net Present Value (NPV) of the difference in the cashflow (see Appendix 7 for 10-year cash flow forecasts) of that generated by an "average" gillnetter (fishing > 50 days) compared with one converted to auto-longline is $188,215 (Table 13) at the assumed discount rate of 7.3%. The costs of an additional crew member and bait are offset by higher catch rates and a price premium for line-caught Gummy Shark.

Comparison of an "average" gillnetter to one converted to auto-longline – CPUE trial data excluding shots with zero catch

Using CPUE data which excludes shots with zero catch, the NPV of the difference in the cashflows (see Appendix 7 for 10-year cash flow forecasts) of that generated by an "average" gillnetter (fishing > 50 days) compared with one converted to auto-longline is $805,465 (Table 14). This is substantially higher than the previous comparison where CPUE included shots with zero catch. The costs of conversion would therefore be attractive for an "average" gill-netter at the assumed discount rate of 7.3%. The costs of an additional crew member and bait costs are offset by much higher catch rates (yielding annual catches 13-21 t greater over the 10-year period compared with a gillnet operation) and a price premium for line caught Gummy Shark.

Comparison of a "full-time" gillnetter to one converted to auto-longline – CPUE trial data including shots with zero catch

Using CPUE data which includes shots with zero catch, the difference in the cashflow (see Appendix 7 for 10-year cash flow forecasts) between a "full -time" gillnetter compared with one converted to auto-longline results in a negative NPV of -$1,767,545 (Table 15). Higher catch rates (and therefore higher annual revenues) of a gillnet operation together with the higher operational costs of an auto-longline yields a negative NPV for conversion. Thus, an investment in auto-longline for a full-time gillnetter with a mean annual catch of about 84 t under this CPUE scenario would be unattractive.

Comparison of a "full-time" gillnetter to one converted to auto-longline – CPUE trial data <u>excluding</u> shots with zero catch

Using CPUE data which excludes shots with zero catch (Table 16), the NPV of the difference in the cashflow (see Appendix 7 for 10-year cash flow forecasts) of a "full -time" gillnetter compared with one converted to auto-longline is negative at a discount rate of 7.3%, but only by ~$22k. The revenues from higher catch rates of Gummy Shark by auto-longline are offset by bait and additional crew costs. Investing in auto-longline for these gillnet operations would result in marginal benefit unless auto-longline catch rates increase significantly (or costs significantly reduce).

Sensitivity analysis

Sensitivity analysis was undertaken based on changes to the following assumptions selected in consultation with project partners:

i. CPUE for auto-longline increases by 15% compared with trial CPUE.
ii. The beach price of Gummy Shark increases to $15.00/kg with an additional $0.5 premium for line caught.
iii. New markets are developed for Draughtboard Shark resulting in a doubling of their price from Year 6.
iv. The discount rate increases to 10%.
v. The Mustad Select system is installed at a cost of $360,000 reducing crew requirements from 4 to 3 persons for vessels converted to auto-longline.
vi. No price premium for line-caught gummy shark is achieved.
vii. Bait prices increase by 50% from $2/kg to $3/kg.

The sensitivity analysis (Table 17, Table 18) shows that, when compared with the base case, NPV was most affected by a change in CPUE for auto-longline and secondly, by a change in the beach price. For a full-time operation, an increase of 15% in auto-longline CPUE (excluding zero catches) makes a conversion to auto-longline an attractive investment but remains unattractive for one where CPUE includes zero catches.

A recent increase in price of Gummy Shark (attributed to increase in demand as a result of COVID-19 lockdown effects) has resulted in a 36% increase from $11/kg to $15/kg. Including this price into the sensitivity analysis increases revenues for both gillnet and auto-longline operations and results in a positive NPV based on CPUE which excludes zero catches. However, conversion continues to be a poor investment for a full time operation based on a CPUE which includes zero catches. The differential cashflow and terminal value remain negative.

Table 13. Comparison of an "Average" Gillnet operation converted to Auto-longline: Net present value (Australian dollars) of differential cash flow over a 10-year term based on auto-longline CPUE which includes shots with zero catch

		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
a	Annual Cashflow: Average Gillnetter		15,340	28,162	28,725	29,300	29,886	13,706	31,093	31,715	32,350	32,997
b	Annual Cashflow: Average Gillnetter converted to auto-longline		23,180	40,565	45,627	51,557	58,362	53,536	78,554	82,857	87,247	91,724
c	Difference in Annual Cashflow (b-a)		7,840	12,403	16,901	22,257	28,476	39,830	47,460	51,142	54,897	58,728
d	Terminal value of Auto-longline add-on											285,343
e	Auto longline investment	(150,000)										
f	Difference in Cashflow between Gillnetter and Auto-longliner (c+d+e)	(150,000)	7,840	12,403	16,901	22,257	28,476	39,830	47,460	51,142	54,897	344,071
	NPV of difference (NPV of f)	**188,215**										

Table 14. Comparison of an "Average" Gillnet operation converted to Auto-longline: Net present value (Australian dollars) of differential cash flow over a 10-year term based on auto-longline CPUE which excludes shots with zero catch

		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
a	Annual Cashflow: Average Gillnetter		15,340	28,162	28,725	29,300	29,886	13,706	31,093	31,715	32,350	32,997
b	Annual Cashflow: Average Gillnetter converted to auto-longline		89,150	107,460	113,032	119,929	128,127	120,833	148,371	153,898	159,535	165,285
c	Difference in Annual Cashflow (b-a)		73,810	79,298	84,307	90,629	98,241	107,127	117,278	122,183	127,185	132,288
d	Terminal value of Auto-longline add-on											660,952
e	Auto longline investment	(150,000)										
f	Difference in Cashflow between Gillnetter and Auto-longliner (c+d+e)	(150,000)	73,810	79,298	84,307	90,629	98,241	107,127	117,278	122,183	127,185	793,240
	NPV of difference (NPV of f)	**805,465**										

Table 15. Comparison of an "Full-time" Gillnet operation converted to Auto-longline: Net present value of differential cash flow over a 10 year term based on auto-longline CPUE which includes shots with zero catch (Australian dollars)

		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
a	Annual Cashflow: Full-time Gillnetter		240,540	261,161	271,096	281,231	291,568	285,334	312,866	323,836	335,025	346,438
b	Annual Cashflow: Full-time Gillnetter converted to auto-longline		122,985	146,186	156,634	168,616	182,144	180,460	213,922	222,856	231,969	241,265
c	Difference in Annual Cashflow (b-a)		(117,555)	(114,975)	(114,463)	(112,615)	(109,423)	(104,873)	(98,945)	(100,980)	(103,056)	(105,173)
d	Terminal value of Auto-longline add-on											(535,487)
e	Auto longline investment	(150,000)										
f	Difference in Cashflow between Gillnetter and Auto-longliner (c+d+e)	(150,000)	(117,555)	(114,975)	(114,463)	(112,615)	(109,423)	(104,873)	(98,945)	(100,980)	(103,056)	(640,660)
	NPV of difference (NPV of f)	**(1,767,545)**										

Table 16. Comparison of an "Full-time" Gillnet operation converted to Auto-longline: Net present value of differential cash flow (Australian dollars) over a 10-year term based on auto-longline CPUE which excludes shots with zero catch

		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
a	Annual Cashflow: Full-time Gillnetter		240,540	261,161	271,096	281,231	291,568	285,334	312,866	323,836	335,025	346,438
b	Annual Cashflow: Full-time Gillnetter converted to auto-longline		229,225	252,178	263,186	276,474	292,004	292,974	329,702	340,559	351,633	362,929
c	Difference in Annual Cashflow (b-a)		(11,315)	(8,982)	(7,911)	(4,757)	437	7,640	16,836	16,723	16,608	16,491
d	Terminal value of Auto-longline add-on											86,282
e	Auto longline investment	(150,000)										
f	Difference in Cashflow between Gillnetter and Auto-longliner (c+d+e)	(150,000)	(11,315)	(8,982)	(7,911)	(4,757)	437	7,640	16,836	16,723	16,608	102,773
	NPV of difference (NPV of f)	**(21,948)**										

Table 17. Sensitivity Analysis: NPV of differential cash flow from the conversion of an "Average" Gillnet operation to Auto-longline under two CPUE scenarios

SENSITIVITY ANALYSIS		CPUE Scenario 1 includes zero catches	CPUE Scenario 2 excludes zero catches
Differential cash flow		NPV	NPV
	Base Case	**188,215**	**805,465**
i.	CPUE for auto-longliner is 15% higher than trials	676,374	1,303,072
ii.	Increase in the beach price of gummy shark to $15.00/kg with an additional $0.5 premium for line caught	449,616	1,366,104
iii.	New markets developed for draughtboard shark resulting in a doubling of the price of draughtboard sharks from Year 6.	357,226	784,495
iv.	WACC increases to 10%	115,601	638,865
v.	The Mustad Select system is installed at a cost of $360,000 reducing crew requirements from 4 to 3 persons.	31,577	679,273
vi.	No price premium for line caught gummy shark	40,011	527,486
vii.	An increase in the price of bait by 50%	-12,743	604,508

Table 18. Sensitivity Analysis: NPV of differential cash flow from the conversion of a "Full-time" Gillnet operation to Auto-longline under two CPUE scenarios

SENSITIVITY ANALYSIS		CPUE includes zero catches	CPUE excludes zero catches
Differential cash flow		NPV	NPV
	Base Case	**-1,767,545**	**-21,948**
i.	CPUE for auto-longliner is 15% higher than trials	-405,318	1,583,436
ii.	Increase in the beach price of gummy shark to $15.00/kg with an additional $0.5 premium for line caught	-1,864,767	619,522
iii.	New markets developed for draughtboard shark resulting in a doubling of the price of draughtboard sharks from Year 6.	-1,255,753	-$94,989
iv.	WACC increases to 10%	-1,707,046	$85,994
v.	The Mustad Select system is installed at a cost of $360,000 reducing crew requirements from 4 to 3 persons.	-1,863,052	$6,721
vi.	No price premium for line caught gummy shark	-2,201,327	-855,775
vii.	An increase in the price of bait by 50%	-2,368,638	-623,041

Discussion

Trials with an auto-longliner revealed effective targeting of Gummy Shark can be achieved in Bass Strait with relatively low catches of other important commercial species, low interactions with ETPs and other resource users, but a significant bycatch of Draughtboard Sharks.

Although targeting the same species, the potential change from gillnet fishing to auto longline fishing for Gummy Sharks in Bass Strait presents a number of risks which need to be considered. Salient issues are discussed below.

Target species

Averaged across seasons, Gummy Shark catches and catch rates of auto-longliners were similar to historical values for commercial gillnetters operating in similar locations of Bass Strait. However, there is a need for caution when comparing catch rates from a trial to those from commercial fishing. Commercial fishers endeavour to optimise catches and catch rates based on experience and environmental conditions. Longline trials were limited to a few weeks of chartered fishing covering key areas in Bass Strait (east and west) and two different seasons. Unlike commercial operations, trials did not concentrate in areas yielding high catch rates. Rather, the trials functioned to allow evaluation of catch rates, size composition and species composition across the main shark fishing regions in Bass Strait based on historical gillnet information. Thus, the catch rates recorded during trial fishing are likely to be less than commercial rates.

There were differences in the size distribution of Gummy Shark caught by auto-longliners compared with those caught by gillnet. Typically, gillnets show “gauntlet” selectivity, in that the sharks become vulnerable at a certain size i.e., 2-4 year old sub-adults (Prince 2005) with the smaller sharks escaping though the net and larger sharks “bouncing” off the net and not getting gilled. Importantly, this selectivity provides protection for the larger, more fecund adult females (Stevens et al. 1997) and is an important factor in the sustainability of Gummy Shark stocks under current management arrangements. The current trials show that selectivity of auto-longliners is similar to a 5-inch gillnet but longlines yield a greater proportion of larger sharks. Most retained Gummy Shark ranged in length from 80-115 cm but larger individuals, particularly females were also caught. Given the gauntlet-type selectivity of gillnets and the potential protection they offer to larger fecund female Gummy shark, the differing selectivity of autoline hooks is an important component of the stock assessment (Punt et al. 2016) and ultimately the TAC set under the harvest strategy[11]. Therefore, it is recommended that the changed selectivity that would result from a move from gillnets to auto-longlines in Bass Strait needs to be explicitly taken into account in the Gummy Shark stock assessment and in the harvest strategy.

Byproduct and bycatch species: cross-sectoral issues

Draughtboard Shark (*Cephaloscyllium isabellum*) was by far the most common byproduct/bycatch species caught during the longline trial. As markets for this species are undeveloped, most Draughtboard shark would be normally discarded in commercial fishing operations (although some may be retained to explore market opportunities). Other than Draughtboard Shark, trials yielded relatively little bycatch or byproduct from auto-longlines. Only very small quantities of species that are of interest to recreational and Indigenous fishing and other Commonwealth and State managed commercial fisheries were caught (generally < 100 kg). For example, there were very small catches of Snapper (a critically important recreational species) recorded in the longline trials (12 individuals with a total weight ~60kg).

Even so, there are potential cross-sectoral interactions with other commercial fisheries which are discussed below.

[11] https://www.afma.gov.au/sites/default/files/sessf_harvest_strategy_amended_2020.pdf

The **Tasmanian Scalefish Fishery** is a multi-gear, multi-species fishery that operates in waters around Tasmania including Bass Strait (Krueck et al., 2020). Key species include Banded Morwong, Australian Salmon, Bastard Trumpeter, Blue Warehou, Flathead (Sand and Tiger), Southern Calamari, Southern Garfish, Striped Trumpeter and Wrasse. Of those species, only small quantities of flathead were caught during the longline trial. Of the different fishing gears used in this fishery several have the potential to interact with longline gear targeting Gummy Shark but the risk is low. Droplines, fish traps and gillnets are fishing gears that are set and can be left unattended, but are set on the sea floor with weights or an anchor reducing the chance of an interaction with longline gear unless one gear is set on top of the other. Danish seines target whiting and flathead and have the potential to interact with longlines. However, Danish seine fishing off east Gippsland overlaps with gillnet fishing targeting Gummy Sharks with little apparent conflict. The other gears used in the fishery are either used inshore (e.g., beach seine), don't reach the sea floor (e.g., dip-net) or are fishing gears with high mobility and low footprint (e.g. handline) and so are unlikely to interact with an auto-longline fishery for Gummy Sharks.

The **Tasmanian Octopus Fishery** catches Pale Octopus (*Octopus pallidus*), and as bycatch Gloomy Octopus (*Octopus tetricus*) and the Maori Octopus (*Macroctopus maorum*) in waters around Tasmania (Krueck et al., 2021). There is potential for either octopus traps or shark longlines to be set over each other and therefor have some interaction. However, the sole operator of this fishery is in regular contact with other commercial fishers that work in similar areas to exchange information on fishing gear locations to avoid interactions. During this project the octopus fisher and the *Candice K* communicated resulting in no interactions. A small amount (3 kg) of unidentified octopus was caught during the auto-longline trials.

The **Tasmanian Scallop Fishery** (targeting *Pecten fumatus*) can operate in Bass Strait where its jurisdiction covers 3-20 nm offshore. Scallops are usually fished with dredges on known beds within a defined season. Mitigation of interactions between this fishery and an auto-longline fishery for Gummy Shark can easily be achieved by communicating where commercial patches of scallops are found during pre-season biomass surveys. Only small quantities of Commercial Scallops (3.6 kg) and Doughboy Scallops (2.58 kg) were caught during the auto- longline trial.

The **Tasmanian Rock Lobster Fishery** targets Southern Rock Lobster (*Jasus edwardsii*) with baited pots over reef substrata. Most of the catch comes from 0–40 m depth, some catch is taken from as deep as 200 m. Although it is likely that there would be some overlap in areas between the Tasmanian Rock Lobster Fishery and an auto-longline fishery for Gummy Shark, buoyed Rock Lobster pots are highly visible and stationary and so it is unlikely that there would be any conflict between sectors. No Southern Rock Lobsters were caught during the auto-longline trials.

The Commonwealth **SESSF Scalefish Hook sector** (SHS) is another sector of the larger SESSF that primarily targets Pink Ling and Blue-eye Trevalla using demersal longlines (including auto-longline) and droplines. Currently, the use of auto-longline is restricted to waters deeper than 183 m, but expansion of the longline method in Bass Strait would be of concern if significant amounts of SHS target species were caught. Pink Ling and Blue-eye Trevalla inhabit waters deeper than those in Bass Strait, so are very unlikely to be caught by auto- longliners. A small amount of Pink Ling (6.3 kg) but no other species of interest to the SHS were caught during the trial.

The **Commonwealth Trawl Sector** (CTS) is a sector of the SESSF which uses mainly otter-board trawl and Danish seine nets. The fishery catches a large variety of species. There is a large fisheries closure for otter trawling in Bass Strait, but that area is the main focus of the Danish seine fishery targeting flathead and whiting. The auto-longline trial had small catches of several species that are important to the CTS including flathead (225.95 kg), Jackass Morwong (5.3 kg) and Pink Ling (6.3 kg).

The Commonwealth **Bass Strait Central Zone Scallop Fishery** (BSCZSF) operates in the Bass Strait between the Victorian and Tasmanian scallop fisheries from the Victoria/New South Wales border, around southern Australia to the Victoria/South Australia border. The fishery targets Commercial Scallops (*Pecten fumatus*) using scallop dredges. Mitigation of interactions between this fishery and an auto-longline fishery for Gummy

Shark can easily be achieved by communicating where commercial patches of scallops are found during pre-season biomass surveys.

The area of the **Victorian Rock Lobster Fishery** extends along the Victorian coast, out into Commonwealth waters (>3 nm offshore). The fishery targets Southern Rock Lobster (*Jasus edwardsii*) and is divided into two management zones. As for the Tasmanian Rock Lobster Fishery, it is likely that there would be overlap in areas between the Victoria Rock Lobster Fishery and an auto- longline fishery for Gummy Shark. However, Rock Lobster pots are buoyed and highly visible. It is therefore unlikely that there would be any conflict between sectors. No Southern Rock Lobsters were caught during the auto-longline trials.

Victorian Inshore Trawl Fishery had only six active vessels during 2020 (Toby Jeavons, VFA, pers. comm.). It is likely that there would be some overlap in fishing grounds between the Victorian Inshore Trawl Fishery and an auto-longline fishery for Gummy Sharks. Other than Gummy Shark, the auto-longline trial caught the following species which are byproduct species of the Victorian Inshore Trawl Fishery: flathead (225.95 kg), Snapper (57.9 kg) and octopus (3 kg).

The area of the **Victorian Scallop Fishery** extends along the Victorian coast, from the shore to 20 nm out, but most scallop fishing occurs off eastern Victoria (Anon, 2012). The Victorian Scallop Fishery uses scallop dredges to target the Commercial Scallop (*Pecten fumatus*). As for the Tasmanian scallop fishery and the BSCZSF, scallops are usually fished on known beds within a defined season. Mitigation of interactions between this fishery and an auto-longline fishery for Gummy Shark can easily be achieved by communicating where commercial patches of scallops are located.

There is one **Ocean Purse Seine** licence issued in Victoria (Victorian Fisheries Authority 2020). This vessel operates from Lakes Entrance and usually conducts day trips. The fishery targets Australian Salmon, Australian Sardine, Sandy Sprat and Australian Anchovy. The auto-longline trial caught none of those species and it is unlikely that there would be any interaction between Ocean Purse Seine fishery and an auto-longline fishery for Gummy Shark.

The 22 **Victorian Ocean Wrasse Fishery** licence holders (Victorian Fisheries Authority 2020) use hand lines to target Bluethroat Wrasse and Purple Wrasse from reef habitats in relatively shallow water. The auto-longline trial caught no wrasse and it is unlikely that there would be any interaction between Victorian Ocean Wrasse Fishery and an auto-longline fishery for Gummy Shark.

The **Victorian Octopus fisheries** has potential for either octopus traps or shark longlines to be set over each other and therefore have some interaction. During this project there was communication between the project team, octopus fishers and the *Candice K* resulting in no interactions. A small amount (3 kg) of unidentified octopus was caught during the longline trials.

The **Victorian Ocean General Access Licence** authorises the 152 licence holders (Victorian Fisheries Authority, 2020) to carry out fishing activities using a variety of gear types in marine waters other than Port Phillip Bay, Western Port, Gippsland Lakes and any inlet of the sea. This fishery can land fish (mostly Snapper, octopus and Gummy Shark). There is likely to be overlap in area between the Victorian Ocean General and an auto-longline fishery for Gummy Shark with potential for interaction between gears including longlines and mesh nets. The auto-longline trials caught Snapper (57.9 kg) and unidentified octopus (3 kg).

ETP Interactions

A change in fishing method from gillnets to auto-longlines has implications for potential interactions with ETPs particularly seabirds, marine mammals and sharks.

Seabirds

Significant progress has already been made to reduce seabird bycatch in Australia's longline fisheries including bycatch reduction and management measures required in the SESSF (Table 19).

Table 19. Bycatch reduction and management measures for seabirds required in the SESSF.

Bycatch management measure	Auto-longline	Set demersal longline: Scalefish hook and shark hook sectors
Bird scaring (tori) line	Y	
Line weighting	Y	
Night setting - if performance criterion exceeded	Y	
Offal management	Y	Y
Bird exclusion devices	Y	
Observers – on request	Y	Y
Electronic monitoring	Y	Y

Despite all of the potential risks of seabird interactions with auto-longlines set in Bass Strait, no interactions occurred during trials despite seabirds being present in large numbers. This is noteworthy as longline fishing operations have been responsible for many adverse seabird interactions (e.g., Waugh et al. 2008). The low level of interactions observed in the auto-longline trials can be attributed to:

- rigorous project planning;
- the stringent measures to mitigate interactions adopted during the trials, including codes of conduct consistent with the applicable threat abatement plan;
- the professional manner in which fishing was undertaken by the commercial crews; and
- the lack of aggressively-feeding birds around the gear.

Nevertheless, the potentially high risk of seabird interactions to auto-longline fishing in Bass Strait will be an important issue in any future change to auto-longlining. Auto-longlining trials were significantly restricted both spatially and temporally within Bass Strait and it is well established that there are high risk places for seabird interactions with respect to certain areas around Bass Strait islands related to bird colonies, feeding and migration. Similarly, there are high risk seasons for interactions related to the seabird breeding cycle, egg-laying and chick feeding. These seasonal high risks can also be further exacerbated by increased risks associated with lunar cycles (particularly full moon) and diurnal cycles (particularly around dusk). Thus, these cumulative risks to potential seabird interactions with auto-longline fishing in Bass Strait should be fully assessed and mitigation measures put in place if more extensive commercial auto-longline fishing in Bass Strait is to occur. However, there is evidence (including from the present trials) that strict mitigation measures can virtually eliminate seabird interactions with longline fishing even around critically endangered seabird colonies (e.g., Heard and MacDonald Island fishery[12]).

Marine mammals

There were very few interactions with marine mammals during longline trials. The one interaction with an Australian Fur Seal that occurred during this trial was during hauling, when it was briefly hooked while feeding on the catch before dropping off the hook. Marine mammals are known to predate the catch of fish on longlines (e.g., Werner et al. 2015). However, the current trials revealed that lice were responsible

[12] https://fisheries.msc.org/en/fisheries/australia-heard-island-and-mcdonald-islands-toothfish-icefish/@@assessments

for a large proportion of the damage to Gummy Sharks. Furthermore, it was evident from the trials that sharks rather than seals inflicted major damage to caught Gummy Shark, leaving just the head.

In addition to the potential for marine mammals to be captured or "hooked", they can also potentially get entangled in auto- longline marker-buoy ropes (see Hamilton and Baker 2019 for a review). However, there are thousands of buoy ropes from fixed demersal fishing gears (gillnets, rock lobster traps) already deployed throughout Bass Strait with no evidence of adverse entanglements of marine mammals.

Sharks

Unlike those interactions in the GHAT fishery with set longlines and the one auto-longline which involved hooking, the White Shark interaction in the trial was tangled in the mainline after feeding on some of the catch.

The School Shark catch in longline trials was only 0.6% of the retained Gummy Shark catch, whereas the figure for retained and discards combined was 0.9%. However, auto-longline trials were undertaken during only three months of the year, and relative catch rates of School Shark may differ at other times of the year.

Economic viability

The cost of converting a gillnet vessel to auto-longlining is at least $150,000. The discounted cash flow analysis over a ten-year term suggests that conversion to auto-longline by an "average" gillnet operation (fishing > 50 days) would yield a positive return on investment. Superior catch rates of an auto-longline offset the costs of an additional crew member and bait and is helped by the small price premium of $0.50/kg for line-caught Gummy Shark.

However, the analysis showed that the viability of converting a "full-time" gillnet operation (>150 days p.a.) to auto-longline is not attractive given assumed catch rates from auto-longliners. A "full-time" gillnet operation with an average annual catch of at least 84 t of Gummy Shark would therefore find that a $150,000 investment in auto-longline conversion is less financially attractive than the status quo. However, sensitivity analysis suggests that should auto-longline catch rates (excluding shots with zero catch) improve by at least 15%, an investment in auto-longline would become attractive.

Conclusion

Trials of auto-longlines (self-baiting) revealed effective targeting of Gummy Shark could be achieved in Commonwealth waters of Bass Strait. Catches, catch rates, and size composition were similar to those recorded for gillnetters fishing in similar locations. Catches other than Gummy Shark were low except for Draughtboard Sharks which were caught in high numbers. Draughtboard Sharks are usually discarded as they have low market value (although market opportunities present). Other bycatch was mostly sharks, skates and rays with relatively few teleosts caught. In particular, species of interest to State jurisdictions and to other sectors (commercial, recreational and Indigenous) were caught in very small quantities. Such species included School Shark, Snapper, and Southern Sand Flathead. Most bycatch was returned alive although some larger Gummy Shark were damaged by shark-bites and lice, and were discarded dead.

The trials revealed very low interaction with threatened, endangered or protected species and no mortalities. Notably, no interactions with seabirds were recorded despite birds being present around the vessel throughout the trials. Similarly, only one interaction with an Australian Fur Seal and one with a Great White Shark was recorded during the trials.

The economic analysis suggests that investment in converting to auto-longline would be worthwhile for an "average" gillnet operation but less attractive for a "full-time" gillnet operation unless auto-longline catch rates (excluding shots with zero catch) increase by at least 15% compared to those of the trial. However, the very low interaction with ETPS shown by auto-longlines and the ongoing issues with adverse interactions with gillnets may present auto-longlining as an attractive alternative fishing method for some operators targeting Gummy Shark in Bass Strait.

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Recommendations / further development

These trials of the use of auto-longlines to target Gummy Shark in Bass Strait were limited in spatial and temporal coverage. As such, care should be taken in extrapolation of the results to broader time scales and spatial extents within Bass Strait. In particular, the results presented on catches and catch rates of commercial and bycatch species and interactions with threatened, endangered or protected species may differ at other times or in other locations. Seasonal variations and spatial patchiness of habitats and communities and the associated longline catches and interactions have not been fully explored in this study. Accordingly, it is recommended that any potential expansion of commercial auto-longline fishing to target Gummy Shark in Bass Strait is contingent on an initial phase of robust monitoring, data collection and analysis, in conjunction with adequate management measures to ensure that there is no adverse ecological or cross-sectoral impacts.

Extension and adoption

This report will be presented to all relevant AFMA Research Assessment Groups (RAGs) and Management Advisory Committees (MACs) for consideration of the results with respect to the potential use of auto-longlines to target Gummy Shark in Bass Strait. The report will also be presented to relevant fishery managers in Victoria and Tasmania. The peak body representing the Gummy Shark fishery (the SSIA) will present this report to its members.

Appendix 1 – Call for Vessel Expression of Interest

Call for Expressions of Interest
SESSF Shark Longline Trial
- February 2019 -

NEED FOR PROJECT

Shark fishing in southern Australia was first recorded in 1927 and between then and the early 1960s the shark fishery developed with increased demand for shark meat and vitamin A from shark liver oil. By the early 1970s, monofilament gillnet methods had been introduced and the fishery moved from primarily a demersal longline fishery targeting school shark to a demersal gillnet fishery targeting gummy shark.

Following a number of GHaT sector gillnet interactions with threatened Australian sea lions off Sough Australia, AFMA introduced significant gillnet closures (covering 18,500km^2) and costly electronic monitoring (EM) requirements in the west of the fishery. This led to a need to develop other fishing methods. SSIA and Fishwell partnered with a trial vessel and the resultant report led to the development of longline fishing for gummy sharks in that area.

Australian sea lion distribution does not extend to the east of the fishery around Bass Strait, but eastern gillnetters have experience highly variable and seemingly unpredictable interaction rates with common dolphins. Although common dolphins listed as Least Concern (Global Status: IUCN Red List of Threatened Species: 2019.2 list), AFMA's Act sets down that all reasonable steps must be taken to avoid interactions, and continued interactions threaten the social license and brand equity of the fishery. One of the obvious steps to consider is the potential transition from gill net fishing to demersal longline, which largely avoids the capture of marine mammals.

CONCERN OF STAKEHOLDERS – THE ISSUE

A move to demersal longlines, however, raises a number of issues for a variety of stakeholder groups. They include:

- the potential bycatch of conservation-dependent school sharks;
- interactions with other Threatened Endangered and Protected (TEP) species such as seabirds which are subject to a threat abatement plan;
- potentially high catches of fish targeted by neighboring State and Commonwealth fisheries;
- the potential for increase capture of large mature sharks and the implications of their contribution to the recruitment of the fishery; and,
- the economic implications to current gill net vessel operators.

THE SOLUTION

A dedicated research project will provide data to better understand many of these concerns about the use of demersal longlines to target gummy shark in and around Bass Strait. A research project has been developed which aims to collect information to better quantify these implications.

1

EXPRESSION OF INTEREST

Expression of Interest are now being sought from SESSF vessel SFR holders who would like to make a vessel, skipper and crew available to undertake the Eastern Shark Longline Trial. The final charter details will need to be determined after consultation with applicants, but the following outline is provided as a guide.

Please read the details provided below to help you decide whether you would be interested and suitably qualified to be involved in this tender. If you are interested, please contact Ian Knuckey at Fishwell Consulting **only via email** ian@fishwell.com.au. Any question asked, and its answer, will be provided to all applicants (confidentially).

A copy of a sample draft vessel contract is available on request. The contract executed will be via negotiation with the successful applicant.

SURVEY DESIGN

Objectives

1. Conduct a trial using automatic longlines to target gummy shark in SESSF waters in Eastern and Western Bass Strait
2. Collect comprehensive information on longline catch rates and catch composition of all target, bycatch, byproduct and TEP species. Collect length frequency distributions on major target and byproduct species.
3. Describe potential resource sharing and gear interaction implications for SESSF and other Commonwealth and State fisheries
4. Undertake an economic analysis of viability of gillnet vessels converting to longlines to target Gummy Shark in Bass Strait. Construct likely profit and loss statements and net present value return on investment given sensitivities around these catch rates/prices and likely capital investment required.
5. Present the results of the longline trials to relevant AFMA RAGs and MACs, VFA, DPIPWE and other Stakeholders .

Methods

This trial is designed to provide comprehensive information on the catch from demersal longline vessels used by operators to target gummy shark in the SESSF waters adjacent to Victoria. It is not an abundance survey and as such, it does not have a complex random stratified design (i.e. sampling stations) that needs to be repeated in the future. Within the requirements of the survey, skippers will be requested to conduct longline sets with the goal of maximising commercial catches of gummy shark.

The trial will be undertaken in the current SESSF gillnet fishery in waters adjacent to Victoria in waters shallower than 183m.

The trial will be undertaken in two periods in 2020:

1. during late summer and early autumn
2. during winter

The trial will consist of 30 fishing days in total conducted across approximately four trips each of 7-8 days. Two trips will occur in each period. The exact structure and locations of the trips will be determined as part of the project and is negotiable.

2

TENDER DETAILS

Catch / Charter arrangements:

- The vessel conducting The Trial must acquire and maintain a valid AFMA Scientific Permit (with which the Project will assist);
- Proceeds from the sale of all catches taken during the trial will be the property of the Project;
- All landed catches of SESSF quota species taken while conducting the trial will be decremented from the Vessel Owner's individual quota allocation;
    - The quota used on the trial will be leased from the vessel to the project at market prices mutually agreed between the owner and the project.
- All costs to catch and store the fish onboard (including bait and ice) will be borne by the Vessel Owner.
- The unloading, transport, marketing and sale of all catch taken while conducting the trial will be entirely the responsibility of the Vessel Owner;
- All costs for unloading, transport, marketing and sale of all catch taken while conducting the trial will be borne by the Project;
- All charter payments by Fishwell to the Vessel Owner will be made within seven days after the sale of the catch and receipt of a tax invoice from the Vessel Owner.

VESSEL AND GEAR REQUIREMENTS

Vessel requirements

At least one longline vessel will be chartered during the trial.

The charter vessel will comply with all requirements of the SESSF Seabird Threat Abatement Plan currently applied to SESSF longline vessels. Most particularly, this requires the adoption of "proven mitigation measures" including use of at least one bird scaring/streamer line and, where required, night setting and compliance with area/seasonal closures.

To reduce seabird interactions and increase sampling power, maximum set length is 1500 hooks. If practical, sets of 1000 hooks will be used through the trial.

The Vessel must:

1. Be in proper good and workmanlike condition and suitable for use in the trial. Images and description of the vessel are encouraged.
2. Be maintained in Marine Board Survey Class 3 (or equivalent). Please confirm.
3. Have adequate safety gear, safety induction plan, survey requirements and berths to carry up to two Research Personnel in addition to the normal skipper and crew. Please confirm and provide evidence.
4. Have demersal longline gear consisting of either manual longline or auto-longline. Please stipulate which, and indicate the number of hooks that the vessel can, and is likely to, set per day. Note, it is preferable that the longline gear is suitable to set baited hooks of a pattern and size suitable for gummy sharks. Please describe the gear.
5. Have a stabilised 240-volt AC power supply. Please confirm.
6. Have sufficient deck space to process and sort the catch of fish collected during each set. Images are encouraged.

3

7. Have a fish room and sufficient ice/refrigeration to store sufficient amounts of fish. Please explain the vessels capability and hold capacity.
8. Have space in the wheelhouse or other suitable dry area for the Research Personnel to operate a laptop and process data, samples, and record sheets etc. Images are encouraged.
9. Must have sufficient spare gear to allow gear loss during the trial; please stipulate the spares that will be held.
10. Must incorporate at least one bird scaring/streamer line compliant with AFMA's management arrangements. Please explain and provide images if possible.
11. Will preferably be baited with squid as the primary bait and mackerel or other fish species as the secondary bait. Please stipulate.
12. May have de-hooking equipment, but on retrieval, all non-target species will be removed manually from the hooks so that their life-state can be assessed accurately, and they can be release if appropriate. Please confirm.

Skipper and crew requirements

The skipper and crew:

13. Must have demonstrated experience fishing in eastern Bass Strait fishing for gummy shark. Please explain.
14. Must have experience in the use of longline fishing equipment. Please explain.
15. Must have demonstrated experience working with onboard Research Personnel. Please explain.
16. Be willing to take scientific direction during the Charter Term. Please confirm your understanding.

Owner requirements

The owner:

17. Must hold a Statutory Fishing Right for the Commonwealth Gillnet Hook and Trap Sector of the SESSF under the Fishing Management Act 1991. Please confirm.
18. Must acquire and maintain a Scientific Permit under section 33 of the Fisheries Management Act 1991 for the duration of the trial.
19. Must hold adequate quota against which landings of all SESSF quota species can be decremented during the trial. Please stipulate.
20. Must be able to make the vessel, skipper, crew and appropriate Fishing Gear and Equipment available for each Charter Term over the entire period of the trial.
21. Must ensure that the Vessel has appropriate insurance (loss/damage, third party liability, Workcover or equivalent). Please explain and confirm policies.
22. Should have a demonstrated history of active involvement in management / research of the fishery (e.g. participation in AFMA / MACs / RAGs / industry association membership). Please explain.
23. Must ensure that the Research Personnel are provided with a satisfactory standard of accommodation, victualling, medical care and a safe and healthy working environment. Please explain providing images if possible.
24. Must ensure that Research Personnel are given reasonable access to all required areas and facilities of the vessel to collect data, samples, and other information required and have reasonable daily access to the vessel's radio and satellite communication facilities.

COST

25. Please stipulate your daily charter fee (ex GST) and any conditions.

SUBMISSION OF EXPRESSIONS OF INTEREST

If you are interested in participating in the Shark Automatic Longline Trial, please forward your expression that **must address each of the 25 selection criteria** in writing to:

Ian Knuckey
ian@fishwell.com.au

Expressions of interest must be received by close of business **Friday 28 February 2020**.

Only EOIs that address all 27 selection criteria in writing will be assessed.

Images of the vessel and working areas are encouraged.

5

Appendix 2 – Scientific permit conditions relating to mitigating ETP interactions

Scientific permit conditions relating to mitigating ETP interactions included:

- The holder must not use the nominated boat to fish using auto-longline methods unless a seabird management plan for the boat has been approved by AFMA;
- To avoid interactions with seabirds, the seabird management plan must contain measures:
    - to require the holder to use physical mitigation devices in a particular manner to avoid interactions with seabirds; and
    - to avoid the discharge of biological material during the setting or hauling of fishing gear.
- For each fishing trip the holder must:
    - carry a copy of the AFMA approved seabird management plan on the nominated boat;
    - strictly comply with the measures and requirements contained in the seabird management plan;
    - ensure each member of the crew on board the nominated boat is briefed on the content of the seabird management plan before each fishing trip; and
    - ensure each member of the crew on board the nominated boat complies with the measures and requirements of the seabird management plan.
- At all times while automatic baiting equipment is on board the boat nominated to this Scientific Permit, the holder must ensure:
    - The boat carries on board one or more assembled Tori lines. Each Tori line must be constructed and used in accordance with the following specifications:
        - must be a minimum of 150 metres in length;
        - must be deployed from a position on board the boat and utilise a drogue so that it remains above the water surface for a minimum of 100 metres from the stern of the boat;
        - the streamer pair nearest to the boat is positioned not more than 10 metres (measured horizontally) from the boat;
        - all other streamer pairs are positioned not more than 7 metres apart; and
        - in addition to the minimum length above, all streamers must be maintained to ensure that their lengths are as close to the water surface as possible.
    - The boat carries on board one or more assembled seabird excluder devices (brickle curtain); and
        - the seabird excluder device is used at all times during line hauling.
    - The seabird excluder device must be constructed in order to achieve the following operational characteristics:
        - deterrence of birds flying directly into the area where the line is being hauled; and
        - prevention of birds that are sitting on the surface from swimming into the hauling bay area.
    - When fishing with demersal longlines:
        - all baits used are non-frozen; and
        - prior to longlines entering the water a separate Tori line is deployed at each point where hooks enter the water.
    - If AFMA approves in writing an alternative Tori line, device or system, that written approval is kept on board the nominated boat.
- The holder must not discard processing waste, including offal, from the nominated boat while setting or hauling using auto-longline fishing methods unless an exemption has been provided by AFMA.
- If a seabird mortality occurs during fishing operations on the boat nominated to this Scientific Permit, for the remainder of the trip the holder must only set longline gear at night (i.e. during the hours of darkness between the times of nautical twilight). If AFMA notifies the holder in writing

that the observed mortality rate of seabirds within the 1 September to 30 April season or the 1 May to 31 August season has exceeded 0.01 seabirds per 1,000 hooks on the boat nominated to this Scientific Permit, the holder must only set longlines at night (i.e. during the hours of darkness between the times of nautical twilight) for the remainder of that fishing season.

Appendix 3 – Bass Strait Seabird Risk Profile

JPEC ENVIRONMENTAL CONSULTING

Seabird bycatch risks associated with demersal longline fishing in Bass Strait

April 2020

Seabirds in Bass Strait

Bass Strait is a key breeding and foraging area for a diverse assemblage of seabirds, from albatrosses to penguins. Some species breed on the islands in the Strait, e.g. shy albatross, short-tailed shearwaters, little penguins, terns, and Australasian gannets. Others breed elsewhere and visit Bass Strait to forage. Seabirds occurring in Bass Strait are protected under the Environment Protection and Biodiversity Conservation Act 1999. Some are common and not of conservation concern, while others are classified as Vulnerable or Endangered.

Bycatch risks

Bycatch results from seabirds encountering a fishing operation, and then interacting with the fishing gear. In demersal longline fisheries, seabirds may be caught on hooks (e.g. in the throat or beak, or through a body part such as a wing or foot). Birds may also become entangled with snoods/traces or the longline backbone. Baits and fish waste discharge (e.g. used baits, fish discards, offal from fish processing) attract some seabirds to fishing operations, increasing the likelihood of interactions occurring.

High risk species

Bycatch risk is considered high for two seabird species in Bass Strait: shy albatross and short-tailed shearwater. These seabirds breed in the Strait and are present for most or all of the year. Both species are also attracted to fishing operations and actively forage on baits and fish waste. Shy albatrosses are generally active during the day, and plunge dive in surface waters. Short-tailed shearwaters can dive deeply and are active both at night and during the day, further increasing their susceptibility to being caught on fishing gear.

Moderate risk species

Five species of albatross and two species of giant petrels are regularly present around Bass Strait. They are also attracted to fishing vessels and susceptible to being bycaught. Because they may be regularly encountered and readily bycaught, these seabirds are identified as being of moderate bycatch risk for demersal longline fishing. Albatross are generally active during the day and do not dive beyond the surface layers, which helps reduce bycatch risks. Giant petrels may be active during the day and at night, but they are not proficient divers.

Low risk species

Seabirds may be at low capture risk in Bass Strait for three reasons:

- Seabirds are not attracted to fishing vessels

Many of the seabirds present in Bass Strait are not attracted to fishing operations and are therefore unlikely to interact with demersal longline gear. This group includes some species that commonly occur and breed in the Strait, such as little penguins and common diving petrels. It also includes a number of less commonly occurring species, such as fluttering shearwater. Overall, bycatch risks for these species are low.

- Seabirds attend vessels, but do not interact with fishing gear

Behaviour around fishing vessels can also result in low bycatch risk. For example, though gulls are scavengers and may follow and actively feed around fishing vessels (particularly in coastal areas), they appear to be very seldom caught in fishing gear. Gull bycatch events are therefore considered to be low risk.

- Seabirds are susceptible to bycatch, but present in Bass Strait in low numbers

Some seabird species are only occasionally present in Bass Strait, though they are highly susceptible to being bycaught (e.g. flesh-footed and sooty shearwaters). While these species often follow fishing vessels and can dive deeply for baits and fish waste, bycatch risk is low purely because it is unlikely that a fishing operation in the Strait would encounter them.

Reducing seabird bycatch risks

Effective measures for reducing bycatch risks, including for high risk species, are summarised below. A diverse assemblage of seabirds is present in Bass Strait, including threatened species that may interact with demersal longline fishing operations. However, the same approach is effective in mitigating bycatch risks across the species present. The core of any seabird bycatch mitigation strategy for demersal longline fishing should include:

- Setting lines at night
- Sinking hooks quickly, by ensuring lines are weighted well and float use is minimised
- Using a tori line
- Retaining all fish waste, including discards, offal, and old bait, for discharge when gear is out of the water. If this is not possible, waste must be discharged away from any fishing gear in the water.

This document

In the pages that follow, this document:

- profiles seabirds seen in Bass Strait, including in coastal areas
- summarises key factors that determine the bycatch risk profiles of these species; and,
- sets out key elements of mitigation strategies to reduce seabird bycatch risks associated with demersal longline fishing.

Seabirds in Bass Strait

Commonly occurring species

Shy albatross ***Thalassarche cauta***	**Short-tailed shearwater** ***Ardenna tenuirostris***	**Australasian Gannet** ***Morus serrator***	**Little penguin** ***Eudyptula minor***	**Pacific gull** ***Larus pacificus***	**Silver gull** ***Chroicocephalus novaehollandiae***
					
• Breeds on Albatross Is. in Bass Strait. • 35% of Australia's population occurs in Bass Strait • Wingspan 2.1-2.6 m • Present year round • IUCN: Near Threatened • EPBC Act: Vulnerable, Marine, Migratory	• Breeds on many islands in Bass Strait • 75% of Australia's population occurs in Bass Strait • Wingspan 1 m • Present Sept. – May • IUCN: Least Concern • EPBC Act: Marine, Migratory	• Several breeding colonies around Bass Strait, incl. Black Pyramid Is. • 85% of Australia's population occurs in Bass Strait • Wingspan 1.7-2 m • Present year round • IUCN: Least Concern • EPBC Act: Marine, Migratory	• Breeds on many islands in Bass Strait • 82% of Australia's population is in Bass Strait • Length ~40 cm • Present year round • IUCN: Least Concern • EPBC Act: Marine	• Breeds on many islands in Bass Strait • 82% of Australia's population occurs in Bass Strait • Wingspan 1.3-1.5 m • Present year round • IUCN: Least Concern • EPBC Act: Marine	• Breeds on islands in Bass Strait • 35% of Australia's population occurs in Bass Strait • Wingspan ~95 cm • Present year round • IUCN: Least Concern • EPBC Act: Marine
High bycatch risk	High bycatch risk	Low bycatch risk	Low bycatch risk	Low bycatch risk	Low bycatch risk

Commonly occurring species

White-faced storm petrel ***Pelagodroma marina***	**Fairy prion** ***Pachyptila turtur***	**Black-faced cormorant** ***Phalacrocorax fuscescens***	**Crested tern** ***Sterna bergii***	**White-fronted tern** ***Sterna striata***	**Common diving petrel** ***Pelecanoides urinatrix***
 • Breeds on some islands in Bass Strait • 25% of Australia's population occurs in Bass Strait • Wingspan ~40 cm • Mostly absent in winter. • May be disoriented by lights at sea and land on vessels • IUCN: Least Concern • EPBC Act: Marine	 • Breeds on numerous islands in Bass Strait • 7% of Australia's population occurs in Bass Strait • Wingspan ~55 cm • Present year round • IUCN: Least Concern • EPBC Act: Marine	 • Breeds on numerous islands in Bass Strait • 55% of Australia's population occurs in Bass Strait • Wingspan ~1 m • Present year-round • IUCN: Least Concern • EPBC Act: Marine	 • Breeds on numerous islands in Bass Strait • 13% of Australia's population occurs in Bass Strait • Wingspan ~1 m • Present year round • Mostly coastal • IUCN: Least Concern • EPBC Act: Marine, Migratory	 • Breeds on some islands in eastern Bass Strait • Resident throughout coastal areas of the Strait • Wingspan ~80 cm • Present year round • IUCN: Near Threatened • EPBC Act: Marine	 • Breeds on a number of islands in Bass Strait • 63% of Australia's population occurs in Bass Strait • Wingspan ~40 cm • Present year round • IUCN: Least Concern • EPBC Act: Marine
Low bycatch risk	**Low bycatch risk**	**Low bycatch risk**	**Low bycatch risk**	**Low bycatch risk**	**Low bycatch risk**

Regularly occurring species

Black-browed albatross ***Thalassarche melanophris***	**White-capped albatross** ***Thalassarche steadi***	**Indian yellow-nosed albatross** ***Thalassarche carteri***	**Buller's albatross** ***Thalassarche bulleri***	**Campbell albatross** ***Thalassarche impavida***	**Giant petrels** ***Macronectes spp.***
					
• Forages in Bass Strait • Wingspan 2.1-2.5 m • Present year round • Similar to Campbell albatross (which has a gold eye) • IUCN: Least Concern • EPBC Act: Vulnerable, Marine, Migratory	• Forages in Bass Strait • Wingspan 2.2-2.5 m • Present year round • Looks extremely similar to shy albatross • IUCN: Near threatened • EPBC Act: Vulnerable, Marine, Migratory	• Forages in Bass Strait • Wingspan ~2 m • Present April-Oct. • IUCN: Endangered • EPBC Act: Vulnerable, Marine, Migratory	• Forages in Bass Strait • Wingspan ~2 m • Present Jan.-July • IUCN: Near threatened • EPBC Act: Vulnerable, Marine, Migratory	• Forages in Bass Strait • Wingspan 2.1-2.5 m • Present year round • IUCN: Vulnerable • EPBC Act: Vulnerable, Marine, Migratory	• 2 similar-looking species (northern and southern) • Forages in Bass Strait • Wingspan 1.5-2 m • Present May-Nov. • IUCN: Least Concern • EPBC Act: Marine, migratory Northern giant petrel: Vulnerable Southern giant petrel: Endangered
Moderate bycatch risk	**Moderate bycatch risk**	**Moderate bycatch risk**	**Moderate bycatch risk**	**Moderate bycatch risk**	**Moderate bycatch risk**

Rarely occurring species

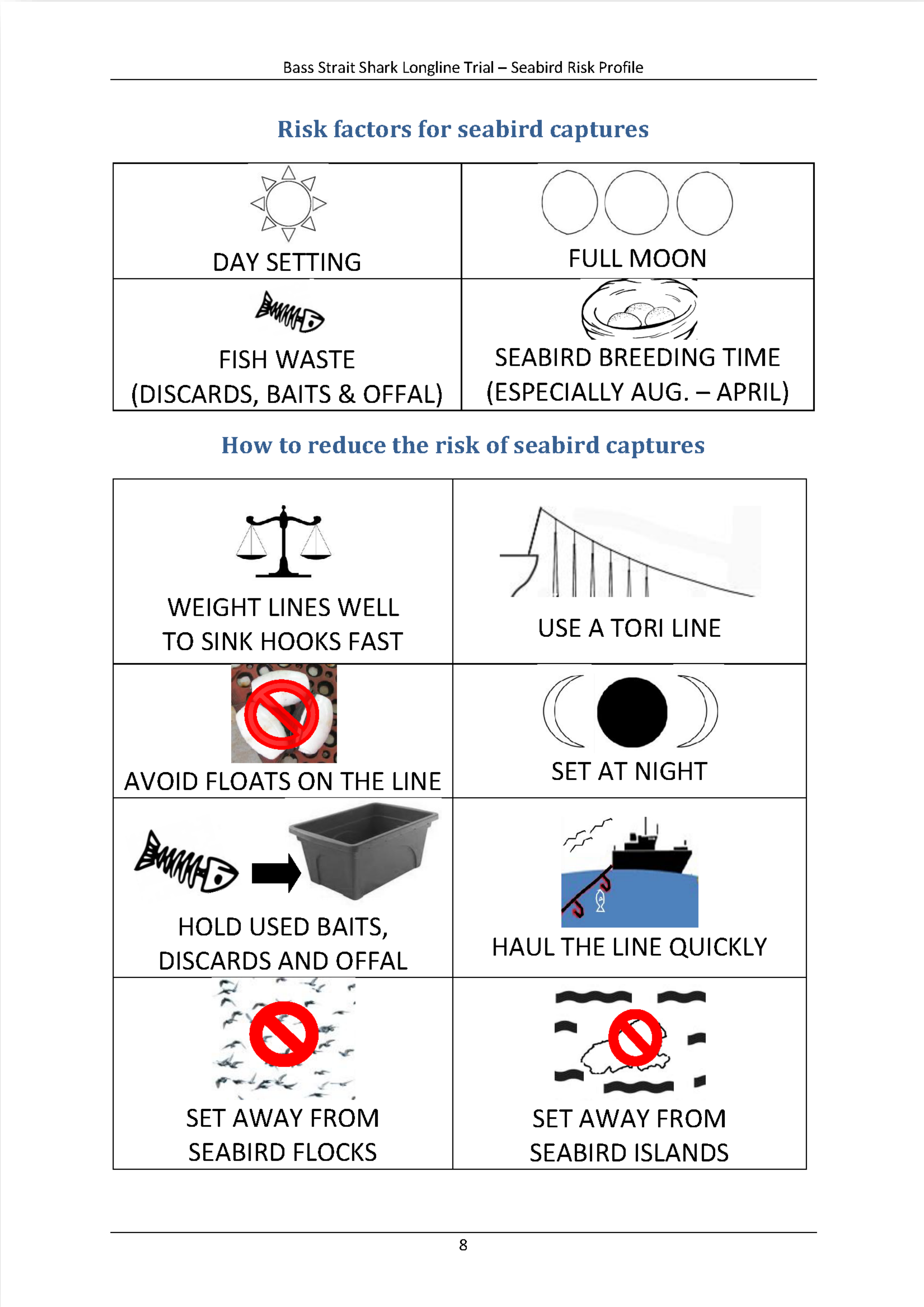
Antipodean albatross ***Diomedea antipodensis***	**Wandering albatross** ***Diomedea exulans***	**Grey-headed albatross** ***Thalassarche chrysostoma***	**Sooty shearwater** ***Ardenna grisea***	**Flesh-footed shearwater** ***Ardenna carneipes***	**Fluttering shearwater** ***Puffinus gavia***
 					
• Forages in Bass Strait • May be difficult to distinguish from wandering albatross • Range of coloration • Wingspan 3 m • IUCN: Endangered • EPBC Act: Vulnerable, Marine, Migratory	• Forages in Bass Strait • May be difficult to distinguish from some Antipodean albatross • Present year round • Wingspan 2.5-3.5 m • IUCN: Vulnerable • EPBC Act: Vulnerable, Marine, Migratory	• Forages in Bass Strait • Wingspan 2.1-2.2 m • Present mostly May – Nov. • IUCN: Endangered • EPBC Act: Endangered, Marine, Migratory	• Forages in Bass Strait • Wingspan ~1 m • Present spring to autumn • IUCN: Near Threatened • EPBC Act: Marine, Migratory	• Forages in Bass Strait • Wingspan ~1.2 m • Present spring to autumn • IUCN: Near Threatened • EPBC Act: Marine, Migratory	• Forages in Bass Strait • Wingspan ~75 cm • Present autumn to spring • Looks similar to Hutton's shearwater • IUCN: Least Concern • EPBC Act: Marine
Low bycatch risk	**Low bycatch risk**	**Low bycatch risk**	**Low bycatch risk**	**Low bycatch risk**	**Low bycatch risk**

Seabird bycatch risk profiles: Demersal longline fishing in Bass Strait

Species	When present				Activity in Bass Strait		When active		Dives		Follows vessels	E	S	Overall Bycatch Risk
	Spring	Summer	Autumn	Winter	Breed	Forage	Day	Night	5 m or less	More than 5 m	Y / N	H	H	High
												M	M	Moderate
												L	L	Low
Shy albatross											Y			
Short-tailed shearwater											Y			
Black-browed albatross											Y			
White-capped albatross											Y			
Indian yellow-nosed albatross											Y			
Buller's albatross											Y			
Campbell albatross											Y			
Northern giant petrel											Y			
Southern giant petrel											Y			
Australasian gannet											ST			
Little penguin											N			
Pacific gull											Y			
Silver gull											Y			
White-faced storm petrel											N			
Fairy prion											N			
Common diving petrel											N			
Sooty shearwater											Y			
Flesh-footed shearwater											Y			
Black-faced cormorant											N			
Crested tern											N			
White-fronted tern											N			
Grey-headed albatross											R			
Wandering albatross											Y			
Fluttering shearwater										?	N			

(ST = Sometimes, R = Rarely, E = Likelihood of encountering the species, S = Inherent susceptibility to bycatch, H = High, M = Medium, L = Low)

7



Bass Strait Shark Longline Trial – Seabird Risk Profile

Risk factors for seabird captures

DAY SETTING	FULL MOON
FISH WASTE (DISCARDS, BAITS & OFFAL)	SEABIRD BREEDING TIME (ESPECIALLY AUG. – APRIL)

How to reduce the risk of seabird captures

WEIGHT LINES WELL TO SINK HOOKS FAST	USE A TORI LINE
AVOID FLOATS ON THE LINE	SET AT NIGHT
HOLD USED BAITS, DISCARDS AND OFFAL	HAUL THE LINE QUICKLY
SET AWAY FROM SEABIRD FLOCKS	SET AWAY FROM SEABIRD ISLANDS

8

Seabird image credits

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- Northern giant petrel: © M.P. Pierre
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- Shy albatross: JJ Harrison, CC-SA-3.0-Unported
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- Wandering albatross: G. Robertson
  (http://www.antarctica.gov.au/about-antarctica/wildlife/animals/flying-birds/wandering-albatross)
- White-capped albatross: © M.P. Pierre
- White-faced storm petrel: BirdLife Australia
  (https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:1f384ad4-0de3-4b8b-9330-f05025c8b392#gallery)
- White-fronted term: Bernard Spragg, NZ
  (https://commons.wikimedia.org/wiki/File:White-fronted_tern_(Sterna_striata)_(26822094987).jpg)

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Appendix 4 – Code of Conduct: Demersal Longline Fishing in Bass Strait

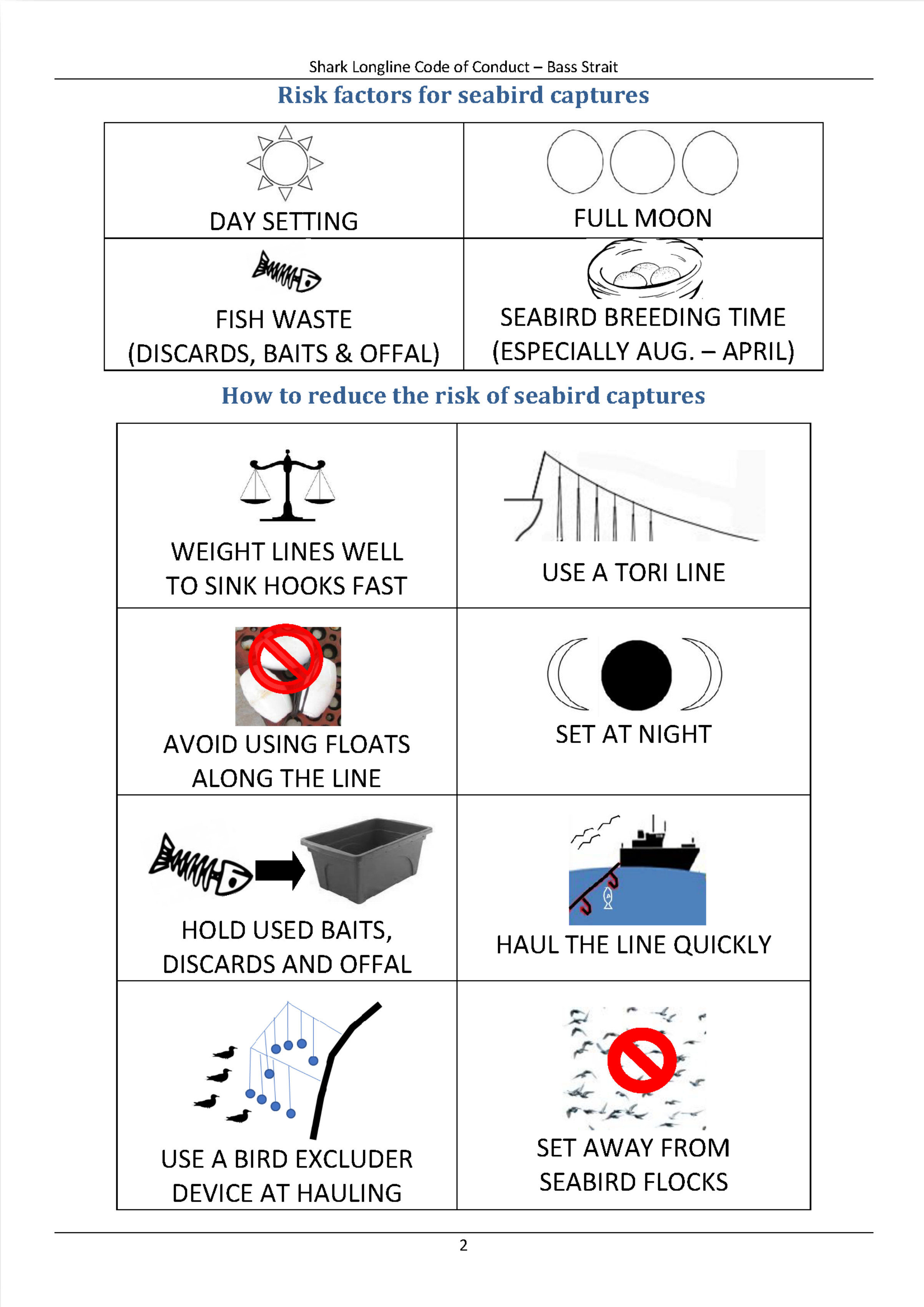
Code of Conduct: Demersal Longline Fishing in Bass Strait

April 2020

Australian Government
Fisheries Research and Development Corporation

fishwell CONSULTING

JPEC ENVIRONMENTAL CONSULTING



Risk factors for seabird captures

DAY SETTING	FULL MOON
FISH WASTE (DISCARDS, BAITS & OFFAL)	SEABIRD BREEDING TIME (ESPECIALLY AUG. – APRIL)

How to reduce the risk of seabird captures

WEIGHT LINES WELL TO SINK HOOKS FAST	USE A TORI LINE
AVOID USING FLOATS ALONG THE LINE	SET AT NIGHT
HOLD USED BAITS, DISCARDS AND OFFAL	HAUL THE LINE QUICKLY
USE A BIRD EXCLUDER DEVICE AT HAULING	SET AWAY FROM SEABIRD FLOCKS

Contents

Introduction

This Code of Conduct focuses on avoiding and managing interactions with seabirds. It also includes information on other Threatened, Endangered, and Protected (TEP) species[1]: marine mammals and some sharks.

An "Interaction" is defined by AFMA as physical contact with a protected species. This includes collisions, catching, hooking, netting, entangling of a TEP species[2].

Species are protected for a variety of reasons. This includes aiding recovery from a population decline, and to ensure their long-term survival. The key legislation for protected species is the Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999.

The EPBC Act protects:

- listed threatened species and ecological communities;
- listed migratory species;
- listed marine species; and,
- all cetaceans (whales and dolphins).

In addition to seabirds being listed in the EPBC Act, seabird interactions in this fishery are subject to the "Threat Abatement Plan for the incidental catch (or bycatch) of seabirds during oceanic fishing operations (2018)"[3], known as the TAP. You'll find more about the TAP later on in this Code.

Globally, best fishing practice requires minimising impacts on non-target species and ocean systems. The measures described in this Code help achieve that. However, beyond minimising environmental damage, the safety of all crew members is the utmost priority. Fishing vessels can be dangerous places to work. Fish responsibly, for your safety and that of your crew, and also for the environment that supports your livelihood.

Shy albatross (Photo: Ed Dunens, CC-2.0)

[1] For a full list of marine TEP species, see: www.environment.gov.au
[2] See the AFMA SESSF Management Arrangements Booklet for more information.
[3] Available at:
http://www.antarctica.gov.au/environment/plants-and-animals/threat-abatement-plan-seabirds

Seabirds in Bass Strait

Bass Strait is home to many species of seabirds. Of the seabirds you will encounter, two groups are readily caught on fishing hooks. These are albatrosses and shearwaters. These groups have different characteristics, which influence their risk of being caught.

Albatrosses

These seabirds mostly feed at the water surface and only dive a few metres at best. They are mostly active during the day. However, they can also be active at nights around full moon. Albatrosses are easy to recognise - they are the largest seabirds you will see.

When using best practice measures for bycatch reduction, albatross bycatch can be extremely effectively avoided.

Note the size differences between albatrosses and the much smaller shearwater (left)[4] and an albatross and gulls (right)[5].

Shearwaters:

This group includes some very effective divers that can reach tens of metres underwater. For example, you are certain to see short-tailed shearwaters in Bass Strait. These birds can dive to more than 70 m. Shearwaters are much smaller than albatrosses and can be active at night as well as during the day. Shearwaters are the most difficult birds to avoid catching on longline gear.

Other birds you will see

When fishing in Bass Strait, you might also see little penguins, storm petrels, diving petrels and fairy prions. These seabirds all breed on islands in the Strait. They are not attracted to fishing vessels. Therefore, they are rarely (if ever) caught in longline fishing gear. If you are fishing closer to the

[4] L: http://whalemike.blogspot.co.nz/2011/02/arrived-in-kaikoura.html; R: Photo: J.J. Harrison
[5] © Callocephallon Photography

coast, you may also see gulls, terns and cormorants. These birds may occasionally be caught on longline gear, but they do not dive deeply to chase baited hooks.

A black-faced cormorant (Photo: JJ Harrison, CC-SA-3.0)

High risk seabird species

In Bass Strait, there are two seabirds at particularly high risk of being bycaught during longline fishing: shy albatross and short-tailed shearwater.

Shy albatross

Shy albatross are mostly only active during the day. However, they may also be active on very bright moonlit nights. This species nests and raises its young on Albatross Island in Bass Strait, and also on islands off southern Tasmania. Overall, 35% of Australia's population of shy albatross occur in Bass Strait. Shy albatross actively follow fishing vessels, waiting for an opportunity to get food. That could be baits, offal or fish discards, or fish coming to the surface during line hauling.

Shy albatross (Photo: JJ Harrison, CC-SA-3.0)

Short-tailed shearwater

Short-tailed shearwaters are active during the day and at night. They are avid vessel-followers and can dive to more than 70 m. They often feed together in gregarious flocks. Short-tailed shearwaters are attracted to fishing vessels because they have learned they can get food. These birds live in Bass Strait in spring, summer and autumn, and make nests on many of the islands in the Strait. In fact, 75% of Australia's population of this seabird lives in Bass Strait.

Short-tailed shearwater (Photo: JJ Harrison, CC-SA-3.0)

Moderate risk seabird species

Seven other seabird species are considered at moderate risk of being caught on longline fishing gear in Bass Strait. These birds are less common than short-tailed shearwaters, but can still be readily bycaught when they are around.

Black-browed albatross ***Thalassarche melanophris***  • Forages in Bass Strait • Wingspan 2.1-2.5 m • Present year round • Similar to Campbell albatross (which has a gold eye) • IUCN: Least Concern • EPBC Act: Vulnerable, Marine, Migratory	**White-capped albatross** ***Thalassarche steadi***  • Forages in Bass Strait • Wingspan 2.2-2.5 m • Present year round • Looks extremely similar to shy albatross • IUCN: Near threatened • EPBC Act: Vulnerable, Marine, Migratory	**Indian yellow-nosed albatross** ***Thalassarche carteri***  • Forages in Bass Strait • Wingspan ~2 m • Present April-Oct. • IUCN: Endangered • EPBC Act: Vulnerable, Marine, Migratory
Buller's albatross ***Thalassarche bulleri***  • Forages in Bass Strait • Wingspan ~2 m • Present Jan.-July • IUCN: Near threatened • EPBC Act: Vulnerable, Marine, Migratory	**Campbell albatross** ***Thalassarche impavida***  • Forages in Bass Strait • Wingspan 2.1-2.5 m • Present year round • IUCN: Vulnerable • EPBC Act: Vulnerable, Marine, Migratory	**Giant petrels** ***Macronectes spp.***  • 2 similar-looking species (northern and southern) • Forages in Bass Strait • Wingspan 1.5-2 m • Present May-Nov. • IUCN: Least Concern • EPBC Act: Marine, migratory Northern giant petrel: Vulnerable Southern giant petrel: Endangered

The Threat Abatement Plan for seabirds

Longline fishing is recognised by the Australian government as a key threat to seabird populations. A threat abatement plan (TAP) was first developed to address this threat in 1998. The TAP was recently updated, in 2018. The ultimate goal of the TAP is that seabird bycatch is reduced to zero in longline fisheries. Significant progress has already been made to reduce seabird bycatch in Australia's longline fisheries.

The TAP sets out requirements for longline fisheries including a performance criterion, and the use of seabird bycatch reduction measures. For the SESSF scalefish hook, shark hook and scalefish automatic longline sectors (and new and developing fisheries), the performance criterion is:

- **0.01 birds caught per 1,000 hooks in each of the demersal longline sectors**.

Bycatch reduction and management measures for seabirds required in the SESSF are set out in the following table, and described in the next section of this Code.

Bycatch management measure	Autolongline	Set demersal longline: Scalefish hook and shark hook sectors
Bird scaring (tori) line	Y	
Line weighting	Y	
Night setting - if performance criterion exceeded	Y	
Offal management	Y	Y
Bird exclusion devices	Y	
Observers – on request	Y	Y
Electronic monitoring	Y	Y

AFMA monitors seabird bycatch and achievement of the performance criterion on an ongoing basis. The TAP sets out next steps if the performance criterion is not met, such as requirements for additional management measures.

Reducing seabird captures: out of bite, out of mind

Seabirds want food – that is why they are around fishing vessels. Birds can be caught on longline hooks during setting and hauling. They may get hooked when trying to eat a bait (e.g., in the beak or the throat) or trying to pull a fish off a hook. They may also get hooked on the body or wing when moving around in the water, especially if feeding aggressively. Further, birds can be entangled in the fishing line.

If birds can't access your gear, your baits will remain on the hooks to fish properly. In addition, you won't catch birds. If birds can get to your hooks, there's a bycatch risk. Think like a bird, and keep your baited hooks out of bite, and out of mind.

The best measures for reducing seabird bycatch in demersal longline fisheries are:

- weighting gear well so hooks sink rapidly, and minimising the use of floats along the line,
- using a tori line,
- holding discards, old baits, and offal onboard until the gear is out of the water,
- setting at night,
- hauling gear quickly,
- keeping birds away from the hauling bay, and,
- not setting or hauling when seabirds are around.

More about seabird bycatch reduction measures required in the SESSF can be found in the SESSF Management Arrangements Booklet.

WEIGHT GEAR WELL TO SINK HOOKS FAST

From a seabird bycatch perspective, a major advantage with demersal longlining is that lines must be weighted to catch your target fish. To reduce bird captures, you need to get the gear below bird diving depths as fast as you can. If you use a tori line, you want the gear to be *at least* 10 m underwater at the end of the tori lines. 15 m deep is better. As mentioned above, some birds can dive much deeper than that. However, getting the gear to 10 m still will reduce your bird capture risks significantly.

- Use as much weight as you can to sink gear as quickly as possible. Weight works best when spread evenly along the line. That way, you won't get parts of the line lofting.
- Use thawed bait, as this sinks faster than frozen bait.
- Set the line slack so weights can sink without tension.
- If you are using external weights, metal weights sink best (rather than concrete or rock).
- Do a Bottle Test. International best practice is to weight bottom longline gear so it sinks at 0.3 m/s. This is cheap and easy to check using a bottle test. (See below).
- At times of heightened risk, add more weights to longlines to increase sink rates.

How to do a bottle test[6]:

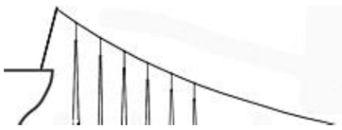
- Use an empty 750 ml water bottle (500 ml to 1 L will work, if that's all you have). Spray paint this a bright colour like yellow or pink, or cover it in reflective tape. This will make it more visible.
- Screw the lid on the bottle. Pull the mouthpiece out so water can enter the bottle once it's in the sea.
- Tie 10 m of line (e.g. monofilament or rope) to the neck of the bottle and attach a clip to the other end of the 10 m length. Wrap the 10 m length around the bottle.
- During setting, attach the clip to the longline backbone midway between two weights and throw the attached bottle overboard.
- Start timing when the backbone enters the water at the point where the bottle is clipped on. Stop timing when the bottle is pulled completely under the water by the sinking backbone.
- Find out the line sink rate:
    - Sink rate = 10 / time to bottle submergence
    - Line sink rate should be close to 0.3 m/s. If it's not, add more weight.

Note: SESSF requirements for the scalefish autolongline sector include only using non-frozen bait. See the SESSF Management Arrangements Booklet.

[6] Source: www.ccamlr.org/sites/drupal.ccamlr.org/files//24-02.pdf

AVOID USING FLOATS

Adding floats makes your gear sink more slowly. Avoid using floats. If you must use floats, consider making the ropes attached to them longer. This allows more rope to unroll before the float slows the sinking speed of the line.



USE A TORI LINE WHEN SETTING

Tori lines (also called streamer lines and bird-scaring lines) are an extremely effective measure to reduce seabird captures. These lines are also cheap and easy to make. They are deployed just before setting and retrieved when setting is completed. They protect the hooks of the longline with a 'barrier curtain' of streamers that moves about in wind or swell.

Ideally, use two tori lines deployed from a bridle system, or one line deployed from each of the port and starboard stern quarters. You will tweak your own tori lines to improve them over time.

Note: SESSF requirements for tori lines are set out in the Management Arrangements Booklet. Tori lines used in the scalefish autolongline sector must:

- Be at least 150 m long
- Have at least 100 m aerial extent – this could be achieved using a combination of a drogue (to provide drag) and adequate deployment height (e.g. using a mounting pole, such that the tori line is 6 to 7 m above the water at the vessel stern)
- Have its first streamers no more than 10 m from the vessel stern
- Have all other streamers no more than 7 m apart (5 m is best practice)
- Ensure streamers reach as close as possible to the sea surface.

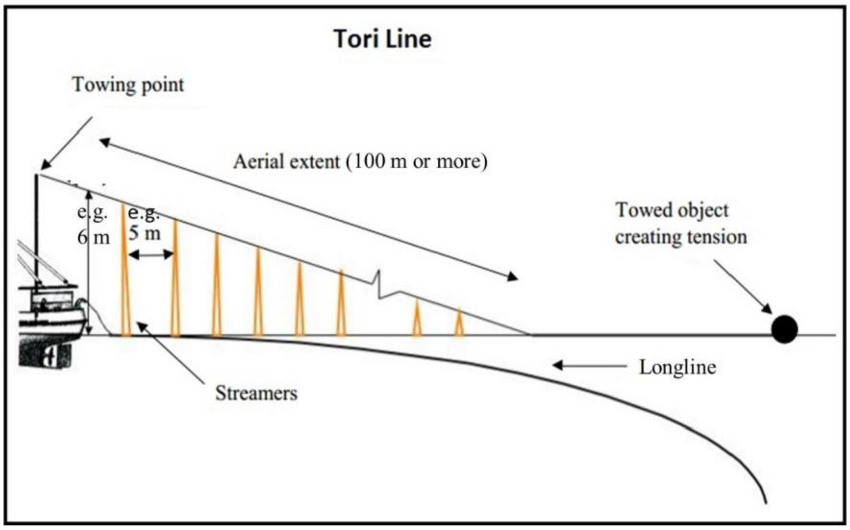
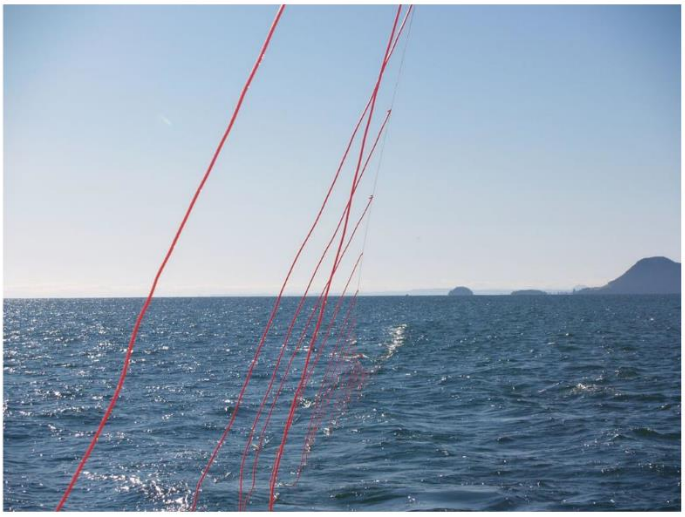


Diagram edited from www.colto.org/seabirds/

Some other tori tips are:

- Incorporate a weak link into the tori line, so you know where the tori line will break if it gets tangled. This could be a loop of weaker rope attached to the towing point, with other weaker length attaching the towed object.
- As a benchmark, aim to protect the sinking longline until it is at a depth of 10 m. If your sink rate is confirmed by your bottle test (above), the line is sinking at 0.3 m/s or more. At that rate[7], your longline will be at 10 m after about 34 seconds. What is your setting speed and how much longline has gone out in 34 seconds?
- Take some spare parts out fishing in case your tori line needs repairs. For example, streamers can break. Carrying a spare made-up tori line is good practice and makes for a quick and simple replacement at sea.
- Onboard, nominate a crew member to take responsibility for deploying the tori line before setting, and retrieving it afterwards.

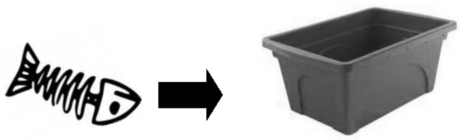
[7] Note that sink rates vary with depth. This approximation is for indicative purposes.



Tori lines are hard to take good photos of…..but this is tori line nirvana - what a tori line should look like in calm conditions.

Tori lines might seem silly and simplistic, but they really do work. Check out the big flock of albatrosses and petrels *behind* the aerial part of tori line in the photo below. This tori line is deployed from a large vessel in the Southern Ocean. The buoy marks the end of the tori line. You can see that on the water under the streamers, there are no birds.

A tori line doing its job: no birds are passing underneath the streamers.



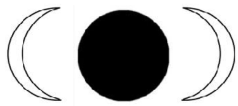
HOLD USED BAITS, DISCARDS AND OFFAL

Seabirds are attracted to anything they can eat that is discharged from vessels. Hold used baits, offal and any discards onboard while setting and hauling. Discharge this waste when setting or hauling is complete. Depending on your catch volume, a simple system of fish bins may achieve this.

Also, remove any hooks from offal before it is discharged. If discharged, these present a danger to seabirds, as well as a waste of money for you.

Note: In the SESSF, there is a requirement for the scalefish automatic longline and demersal longline sectors to hold offal during setting and hauling.

If you are running a small vessel demersal longline operation and really can't meet this requirement, contact AFMA to discuss an exemption: BycatchProgram@afma.gov.au.



SET GEAR AT NIGHT AND TAKE CARE WHEN IT'S BRIGHT

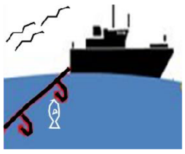
Worldwide, night-setting is one of the most effective ways to reduce seabird captures. This is because many seabirds are not active at night. So, aim to set longlines between nautical dusk and nautical dawn. To minimise bycatch risk, start the set 2 hours after dusk and stop setting an hour or two before dawn.

Albatrosses are generally not active at night. Shearwaters are active at night, but less than during the day. However, keep an eye on moon phases. Albatrosses and shearwaters are all more active during nights around full moon. Take extra care 3 days before and 3 days after full moon.

Note that deck lighting can also illuminate the area astern vessels. This makes it easier for birds to see baits going out. Minimise deck lighting to ensure crew safety, while not unnecessarily attracting seabirds to the vessel. Switch off deck lighting when it is not needed.

Note: In the SESSF, there is a requirement for night-setting in the scalefish automatic longline sector:

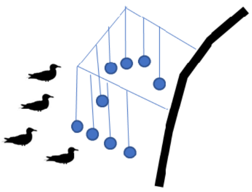
- For the remainder of a trip after a seabird mortality occurs
- For the remainder of a TAP season, when seabird interactions exceed the performance criterion (0.01 interactions per 1,000 hooks).



HAUL THE LONGLINE QUICKLY

The more time hauling takes, the more likely it is seabirds will be attracted to what is going on. Hauling the line quickly gives birds less opportunity to find the vessel and attack the returning hooks.

If you take a break during hauling, run out a length of backbone to sink the hooks well below the surface, so seabirds can't see the returning baits or attached fish. If they can't see the food, they are less likely to forage and dive. Therefore, they are less likely to get hooked or tangled in the gear.



USE A BIRD EXCLUDER DEVICE DURING HAULING

Seabirds may be caught during longline hauling. Birds can see the fish and used baits coming to the surface, and may dive on them or try to eat them on the surface. To reduce the risk of haul bycatch, keeping birds away from the hauling bay is a smart option. Methods include a rope with buoys on it floated on the water, and a 'Brickle curtain' to keep birds out of the hauling bay. The photo below shows a Brickle curtain used on a larger bottom longline vessel[8].

<u>Note</u>: If you're using automatic longline gear to catch scalefish in the SESSF, it is a requirement to use a bird excluder device at hauling. The bird excluder <u>must</u>:

- deter birds flying directly into the area where the line is being hauled, and,
- prevent birds that are sitting on the surface from swimming into the hauling bay area.

If you'd like assistance with design ideas for bird excluder devices, contact AFMA: BycatchProgram@afma.gov.au.

[8] https://www.afma.gov.au/environment-and-research/reducing-bycatch/bycatch-reduction-devices/bird-exclusion-devices

A bird excluder device on an Australian longline vessel.

SET AWAY FROM SEABIRD FLOCKS

It's a no-brainer that you should avoid setting when seabirds are present. If you set into a flock of birds, it's asking for trouble as it is much more likely that some will be caught. However, if you are setting and a flock arrives, you may have to choose – do you risk catching birds by continuing the set, or stop setting and steam away? (You might also decide to wait until the birds disperse).

A flock of shearwaters is a chaotic place. It's no wonder they get tangled and hooked on longlines. Where is the longline amongst these short-tailed shearwaters[9]?

[9] Source: http://oceana.org/en/explore/marine-wildlife/short-tailed-shearwater

SET AWAY FROM SEABIRD ISLANDS

There are many islands in Bass Strait where seabirds (including albatross and shearwaters) breed. If you set lines near seabird islands, you are more likely to catch birds. This is because the birds are concentrated nearby.

Especially high-risk times for breeding seabirds are September to April. Avoid setting around seabird islands during those months.

Marine mammals

On your fishing grounds, you may encounter marine mammals including seals, sea lions and dolphins. All marine mammals are protected. Marine mammals are not at high risk of capture in demersal longline operations compared to seabirds. However, captures and entanglements can still occur.

A hooked New Zealand fur seal (Photo: stuff.co.nz).

DON'T SET IF MARINE MAMMALS
HAVE BEEN SEEN NEARBY

Your best approach is to avoid marine mammal bycatch in the first place. Don't set if you see marine mammals nearby. If you are hauling, be mindful that marine mammals may be around the line underwater. Keep line-cutting gear close at hand in case of a capture. If caught and found alive, marine mammals' best chance of survival is through being freed from the entangling line and hook (if possible). (See below).

Sharks

In the SESSF fishery, there are several TEP shark species to be aware of.

The great white shark occupies a broad depth range from very shallow water to around 1,200 m. Amongst other prey, this legally protected shark feeds on seals and sea lions. It sometimes frequents areas where these animals breed. This species cannot be retained or traded.

Porbeagle, shortfin mako and longfin mako sharks are listed under the EPBC Act. However, these species may be retained and traded when they are dead on landing, as long as the operator is fishing in accordance with the SESSF Management Plan. All live-caught porbeagle and mako sharks must be returned to the sea unharmed.

Silky sharks are also protected. They tend to be pelagic and you probably won't encounter them.

If you do have an interaction with any of these sharks – alive, dead, retained or discarded - it must be reported like other TEP interactions (see the section on Reporting, later in this Code).

As for marine mammals, your best approach is to avoid shark bycatch in the first place.

- If hauling, be mindful that sharks may be around the line underwater. Keep line cutting and de-hooking gear close at hand in case of a capture.
- If caught and found alive, sharks' best chance of survival is through being freed from the gear and released rapidly.

Handling Threatened, Endangered and Protected species

So, you've caught a TEP species. Hopefully the animal will still be alive, and you must handle it carefully to promote survival. Also, TEPs can cause injury if handled inappropriately.

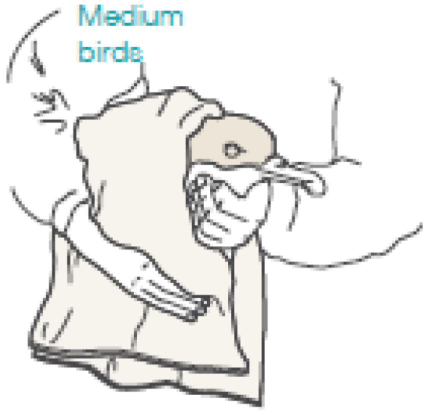
AFMA have produced a bycatch handling guide with more information: www.afma.gov.au/sites/default/files/uploads/2018/04/9853R-AFMA-Handling-Practices-Guide-Tagged.pdf

Seabirds

For seabirds, gloves are very useful for protecting your hands. Your seabird release kit should include scissors, a line-cutter, a towel, bolt-cutters or pliers with a barb-cutting edge, and a net.

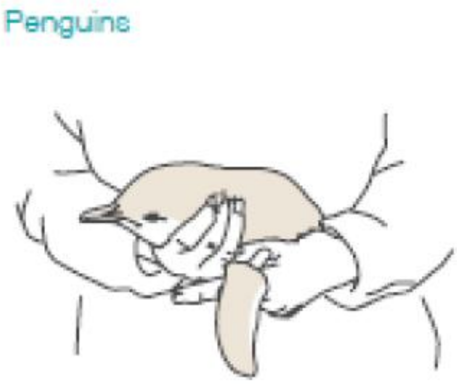
Stop hauling when the bird is within reach. Bring it onboard (scooping it with a net if possible), and hold it like the pictures below[10]. DO NOT hold birds by their wingtips.

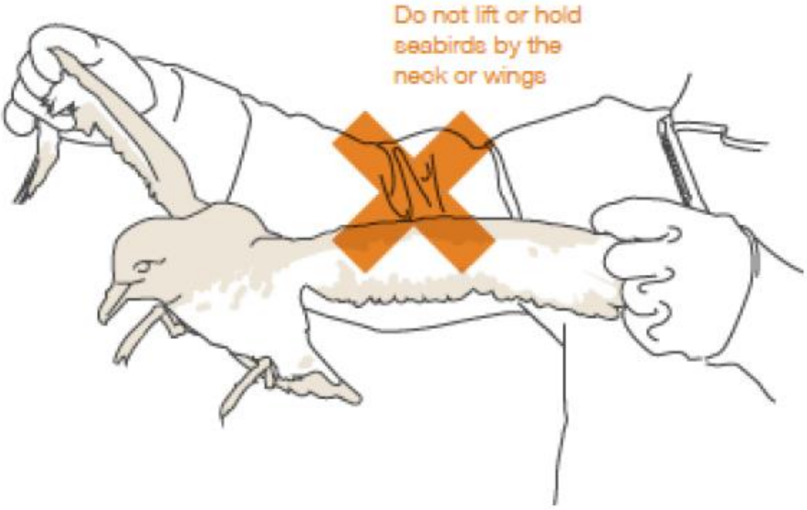
Then, flatten the hook barbs to remove the hook, cut the hook in half, or cut the fishing line off the bird – as shown on the following pages.



[10] https://www.doc.govt.nz/globalassets/documents/conservation/marine-and-coastal/marine-conservation-services/resources/protected-species-handling-guide-20192.pdf


Large
birds


Penguins


Do not lift or hold
seabirds by the
neck or wings


Safe seabird release
reduces injury to the bird & yourself
Release kit
1
Use a landing net to lift the bird on board.
2
Hold small birds between fingers behind the neck.
3
Wrap medium sized birds in towels & cover their eyes if possible.
4
Hold large birds' beaks shut, don't cover nostrils.
5
Cut fishing line. Use pliers to flatten the barb or cut hook with small bolt cutters.
6
Pull the hook back out of the beak.
7
If hook is swallowed cut as close to entry as possible. Fishing line left on bird can tangle in vegetation at nests.
8
If bird is exhausted or waterlogged place in loosely covered box to recover.
9
Release healthy bird onto the water.
Helpful hints
Keep a towel, net & pliers on board
Protect your eyes when handling birds
Approach birds from behind where possible
When holding the bird, make sure the beak is not twisted & nostrils are not covered

Fur seals and sea lions

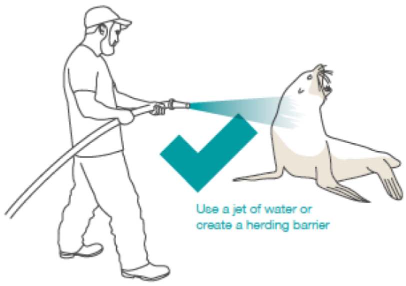
Given the size of seals and sea lions, freeing them from gear in the water is the best option! Carry line-cutting gear can help you do this safely and effectively.

<u>In the water</u>:

- Stop hauling when the animal is in reach
- Cut away the line (and hook if possible) as quickly as you can
- If you can't remove the hook, cut the line as close as possible to the hook.

<u>On the deck</u>:

It is unlikely you will land a fur seal or sea lion on deck in a demersal longline operation. If you do, move slowly around them and take care to avoid their bites. Encourage the animal to leave the vessel using a deck hose or by blocking its movement, for example, with sheets of cardboard or plywood[11].



[11] https://www.afma.gov.au/sites/default/files/uploads/2018/04/9853R-AFMA-Handling-Practices-Guide-Tagged.pdf

Other TEP species

For dolphins, whales, and sharks, use line-cutters and de-hooking gear to free them in the water if possible. If you cannot remove hooks, cut the line as close as possible to the hook. Working quickly and carefully is important to minimise stress on these animals and maximise their chance of survival.

Handling guidance is available here:

- For sharks and rays: www.afma.gov.au/sites/default/files/uploads/2014/11/Shark-Handling-Guide-2016-Update.pdf
- For other TEP species: www.afma.gov.au/sites/default/files/uploads/2018/04/9853R-AFMA-Handling-Practices-Guide-Tagged.pdf

Reporting

By law, all interactions with Threatened, Endangered and Protected Species must be reported. It is *NOT* an offence to have an interaction. It *IS* an offence not to report it.

An interaction includes[12]:

- any physical contact between an individual (person, boat or gear) and the animal, that causes, or may cause death, injury or stress to the animal,
- all catching, hooking, netting, or entangling,
- any injuries or mortalities directly resulting from fishing activities, or,
- any contact or collisions with fishing gear, the wheelhouse, and windows.

To report an interaction on paper, follow the instructions in your Daily Fishing Logbook. Fill in the "Listed Marine and Threatened Species" form in the back of your logbook. Then, submit that form with the relevant logbook page. If you use an e-log, complete your report as required by the type of e-log you use.

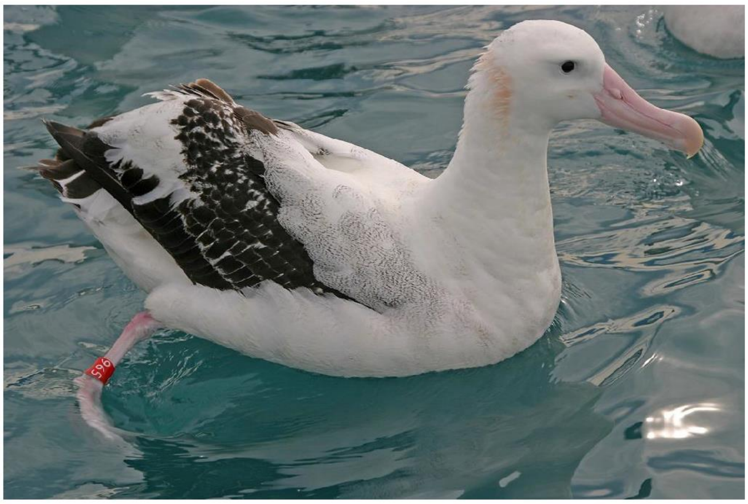
A list of TEP species is included in your logbook. You can get a free protected species identification guide from AFMA's Bycatch and Discards Program team on (02) 6225 5555 or by emailing bycatchprogram@afma.gov.au.

[12] Source: *Southern and Eastern Scalefish and Shark Fishery 2019 Management Arrangements Booklet*

Tagged wildlife

On occasion, you may see or capture tagged animals. Scientists tag animals for many reasons, including to understand animal populations, biology and movements. If you encounter a tagged animal, record as many details of the encounter as possible. Note that the "Listed Marine and Threatened Species" form has a column for band or tag numbers. In addition to the tag number, colours, and shape, record the place, time and date of your encounter, and the appearance of the animal (e.g., size, sex). Take a photo if possible.

If the animal is dead, try to remove the tag and return it. The instructions and an address may be written on the tag. If the animal is alive, record the tag number and details and release the animal as quickly as possible.



A banded albatross. (Photo: Albatross Encounter)

For more information

AFMA. 2019. Southern and Eastern Scalefish and Shark Fishery Management Arrangements Booklet:
https://afma.govcms.gov.au/sites/default/files/sessf_management_arrangements_booklet_2019_final_updated_july_2019.pdf

Appendix 5 – Shot details

Table 20. Details of each shot including time, date, location, number of hooks, length of line and depth.

Trip	Shot number	Start date	Start set time	Start latitude	Start longitude	End latitude	End longitude	Number of hooks	Length of line (m)	End haul time	Mean depth (m)
1	1	23-May-20	15:04	-39.3224	144.3781	-39.3249	144.3211	1200	4800	20:33	58
1	2	23-May-20	15:39	-39.3264	144.3108	-39.3314	144.2707	900	3600	21:45	65
1	3	23-May-20	16:02	-39.3319	144.2638	-39.3355	144.2217	900	3600	23:55	74
1	4	24-May-20	05:00	-39.4972	144.0608	-39.5059	144.0677	1200	4800	16:09	56
1	5	24-May-20	05:31	-39.5066	144.0606	-39.5059	144.0221	900	3600	13:57	56
1	6	24-May-20	05:53	-39.5061	144.0152	-39.5060	143.9714	900	3600	12:15	56
1	7	24-May-20	16:36	-39.5368	144.1522	-39.5414	144.2031	1200	4800	02:00	54
1	8	24-May-20	17:04	-39.5415	144.2088	-39.5398	144.2427	900	3600	23:49	56
1	9	24-May-20	17:24	-39.5394	144.2491	-39.5384	144.2899	900	3600	22:45	56
1	10	25-May-20	04:39	-39.6598	144.1760	-39.6528	144.8250	1200	4800	13:51	41
1	11	25-May-20	05:11	-39.6127	144.1545	-39.5872	144.1358	900	3600	11:48	41
1	12	25-May-20	05:32	-39.5808	144.1320	-39.5503	144.1207	900	3600	10:20	41
1	13	25-May-20	17:28	-40.0970	144.1940	-40.1278	144.1619	1200	4800	01:26	58
1	14	25-May-20	17:59	-40.1341	144.1551	-40.1564	144.1307	900	3600	22:15	58
1	15	26-May-20	04:35	-40.0514	144.2921	-40.0888	144.2529	1200	4800	14:42	44
1	16	26-May-20	05:05	-40.0922	144.2490	-40.1172	144.2202	900	3600	12:22	50
1	17	26-May-20	05:28	-40.1226	144.2145	-40.1509	144.1847	900	3600	10:40	52
1	18	26-May-20	17:39	-39.9853	144.5831	-40.0071	144.5498	900	3600	02:42	45
1	19	26-May-20	18:03	-40.0100	144.5450	-40.0297	144.5146	900	3600	01:06	45
1	20	26-May-20	18:24	-40.0325	144.5105	-40.0546	144.4764	900	3600	23:28	45
1	21	27-May-20	05:42	-40.2243	144.7573	-40.2463	144.7196	900	3600	15:43	56
1	22	27-May-20	6:04	-40.2487	144.7153	-40.2697	144.6808	900	3600	13:47	56
1	23	27-May-20	6:30	-40.2755	144.6712	-40.3049	144.6269	1200	4800	12:15	56
1	24	27-May-20	17:15	-40.3722	144.5821	-40.4048	144.5464	1200	4800	02:45	57
1	25	27-May-20	17:46	-40.4112	144.5405	-40.4361	144.5138	900	3600	01:03	57
1	26	27-May-20	18:10	-40.4414	144.5086	-40.4676	144.4797	900	3600	22:40	57
1	27	28-May-20	04:37	-40.3701	144.5630	-40.4026	144.5276	1200	4800	15:40	62
1	28	28-May-20	05:06	-40.4073	144.5225	-40.4339	144.4964	900	3600	13:08	62
1	29	28-May-20	05:30	-40.4396	144.4910	-40.4682	144.4644	900	3600	11:40	62
1	30	29-May-20	15:50	-39.0297	147.2444	-39.0091	147.2885	1200	4800	01:13	58
1	31	29-May-20	16:18	-39.0069	147.2927	-38.9911	147.3268	900	3600	23:12	58
1	32	29-May-20	16:41	-38.9877	147.3337	-38.9691	147.3709	900	3600	21:39	58
1	33	30-May-20	04:54	-38.6795	147.3103	-38.6556	147.3527	1200	4800	14:21	58
1	34	30-May-20	05:20	-38.6534	147.3568	-38.6351	147.3905	900	3600	12:32	51
1	35	30-May-20	05:41	-38.6326	147.3950	-38.6141	147.4290	900	3600	11:09	51
1	36	30-May-20	16:35	-38.6952	147.5569	-38.7232	147.5122	1200	4800	01:56	57
1	37	30-May-20	17:04	-38.7252	147.5085	-38.7447	147.4764	900	3600	23:49	57
1	38	30-May-20	17:28	-38.7488	147.4697	-38.7691	147.4365	900	3600	22:09	57
1	39	31-May-20	05:50	-38.8317	147.0308	-38.8085	147.0757	1200	4800	13:20	49
1	40	31-May-20	6:17	-38.8052	147.0793	-38.7887	147.1100	900	3600	12:52	49
1	41	31-May-20	6:36	-38.7857	147.1151	-38.7680	147.1485	900	3600	14:56	49

Trip	Shot number	Start date	Start set time	Start latitude	Start longitude	End latitude	End longitude	Number of hooks	Length of line (m)	End haul time	Mean depth (m)
2	1	5-Jun-20	03:35	-39.7138	148.3319	-39.6881	148.3744	1200	4800	15:07	29
2	2	5-Jun-20	04:06	-39.6854	148.3789	-39.6658	148.4104	900	3600	12:47	32
2	3	5-Jun-20	04:28	-39.6621	148.4159	-39.6403	148.4498	900	3600	10:53	32
2	4	5-Jun-20	16:27	-39.6477	148.3241	-39.6199	148.3676	1200	4800	2:21	31
2	5	5-Jun-20	16:58	-39.6173	148.3712	-39.5976	148.4028	900	3600	0:14	32
2	6	5-Jun-20	17:22	-39.5951	148.4061	-39.5755	148.4367	900	3600	22:47	34
2	7	6-Jun-20	04:56	-39.8308	148.1488	-39.8010	148.1124	1200	4800	13:08	17
2	8	6-Jun-20	05:38	-39.7886	148.0986	-39.7703	148.0768	900	3600	11:04	22
2	9	6-Jun-20	16:46	-39.5443	147.8573	-39.5188	147.9014	1200	4800	2:48	43
2	10	6-Jun-20	17:16	-39.5148	147.9085	-39.4945	147.9428	900	3600	0:44	43
2	11	6-Jun-20	17:40	-39.4922	147.9468	-39.4705	147.9809	900	3600	23:18	43
2	12	7-Jun-20	05:06	-39.5080	147.6178	-39.4774	147.6546	1200	4800	15:20	52
2	13	7-Jun-20	05:34	-39.4732	147.6594	-39.4490	147.6875	900	3600	13:28	52
2	14	7-Jun-20	05:59	-39.4434	147.6944	-39.4193	147.7226	900	3600	11:33	52
2	15	7-Jun-20	16:56	-39.4141	147.7257	-39.3862	147.7697	1200	4800	22:48	52
2	16	7-Jun-20	17:25	-39.3821	147.7761	-39.3618	147.8066	900	3600	0:17	53
2	17	7-Jun-20	17:46	-39.3576	147.8136	-39.3359	147.8496	900	3600	2:22	52
2	18	8-Jun-20	04:02	-39.3605	148.0393	-39.3393	148.0926	1200	4800	15:13	48
2	19	8-Jun-20	04:33	-39.3358	148.1008	-39.3205	148.1374	900	3600	13:08	48
2	20	8-Jun-20	04:57	-39.3174	148.1449	-39.3023	148.1803	900	3600	11:29	48
2	21	9-Jun-20	04:01	-38.8122	147.0170	-38.7847	147.0602	1200	4800	10:58	42
2	22	9-Jun-20	04:31	-38.7815	147.0653	-38.7616	147.0967	900	3600	12:25	42
2	23	9-Jun-20	04:54	-38.7588	147.1009	-38.7390	147.1318	900	3600	13:47	42
2	24	9-Jun-20	15:33	-38.8108	146.9832	-38.7841	147.0289	1200	4800	23:01	38
2	25	9-Jun-20	16:03	-38.7808	147.0344	-38.7617	147.0642	900	3600	0:24	38
2	26	9-Jun-20	16:23	-38.7578	147.0705	-38.7363	147.1047	900	3600	1:59	36
2	27	10-Jun-20	04:29	-38.8012	146.9676	-38.7759	147.0158	1200	4800	12:41	32
2	28	10-Jun-20	05:00	-38.7731	147.0204	-38.7541	147.0494	900	3600	13:59	34
2	29	10-Jun-20	05:20	-38.7513	147.0538	-38.7299	147.0877	900	3600	15:28	34
2	30	10-Jun-20	15:43	-38.7242	147.1041	-38.6919	147.1402	1200	4800	1:49	37
2	31	10-Jun-20	16:14	-38.6878	147.1447	-38.6660	147.1692	900	3600	23:31	38
2	32	10-Jun-20	16:35	-38.6613	147.1745	-38.6353	147.2029	900	3600	22:05	39
2	33	11-Jun-20	05:03	-38.6715	147.1317	-38.6399	147.1666	1200	4800	13:51	38
2	34	11-Jun-20	05:29	-38.6357	147.1716	-38.6128	147.1974	900	3600	14:56	38
2	35	11-Jun-20	05:50	-38.6091	147.2017	-38.5837	147.2303	900	3600	11:16	38
2	36	11-Jun-20	15:55	-38.6526	147.2082	-38.6198	147.2335	1200	4800	2:38	40
2	37	11-Jun-20	16:21	-38.6155	147.2365	-38.5859	147.2546	900	3600	0:33	41
2	38	11-Jun-20	16:44	-38.5815	147.2573	-38.5507	147.2733	900	3600	22:46	38
3	1	3-Nov-20	06:47	-40.1917	144.0849	-40.1622	144.1266	1200	4800	15:00	57
3	2	3-Nov-20	07:22	-40.1585	144.1318	-40.1368	144.1567	900	3600	18:25	58
3	3	3-Nov-20	07:43	-40.1318	144.1626	-40.1078	144.1866	900	3600	17:49	57
3	4	4-Nov-20	03:04	-39.9278	144.925	-39.9075	144.9737	1200	4800	13:48	52
3	5	4-Nov-20	03:32	-39.9056	144.9781	-39.8907	145.0140	900	2700	11:53	54

Trip	Shot number	Start date	Start set time	Start latitude	Start longitude	End latitude	End longitude	Number of hooks	Length of line (m)	End haul time	Mean depth (m)
3	6	4-Nov-20	03:55	-39.8887	145.0176	-39.8734	145.0550	900	2700	10:31	54
3	7	5-Nov-20	08:27	-40.5949	147.5003	-40.5999	147.5554	1200	4800	18:13	43
3	8	5-Nov-20	08:55	-40.6000	147.5608	-40.6010	147.6018	900	3600	16:28	43
3	9	5-Nov-20	09:13	-40.6009	147.6038	-40.6011	147.6480	900	3600	15:01	41
3	10	5-Nov-20	20:16	-40.3917	147.6805	-40.4022	147.7345	1200	4800	4:39	39
3	11	5-Nov-20	20:45	-40.4033	147.7405	-40.4105	147.7783	900	2700	2:52	37
3	12	5-Nov-20	21:05	-40.4115	147.7838	-40.4142	147.8250	900	2700	1:29	37
3	13	6-Nov-20	06:25	-40.2637	147.57	-40.2620	147.6260	1200	4800	15:49	49
3	14	6-Nov-20	06:53	-40.2615	147.6325	-40.2591	147.6734	900	3600	14:00	47
3	15	6-Nov-20	16:50	-40.2241	147.5911	-40.2057	147.6427	1200	4800	0:24	48
3	16	7-Nov-20	04:20	-40.5306	147.3417	-40.4980	147.3759	1200	4800	15:37	56
3	17	7-Nov-20	04:50	-40.4934	147.3807	-40.4701	147.4059	900	4800	13:41	56
3	18	7-Nov-20	05:10	-40.4662	147.4107	-40.4420	147.4383	900	3600	12:12	54
3	19	7-Nov-20	18:17	-40.7157	147.6694	-40.7059	147.7246	1200	4800	1:58	37
3	20	7-Nov-20	18:46	-40.7042	147.732	-40.6962	147.7729	900	3600	3:19	38
3	21	7-Nov-20	19:07	-40.6953	147.7789	-40.6873	147.8225	900	3600	4:43	35
3	22	8-Nov-20	06:35	-40.6452	148.131	-40.6542	148.1807	1200	4800	13:36	64
3	23	8-Nov-20	06:58	-40.6553	148.1882	-40.6603	148.2330	900	3600	14:53	53
3	24	8-Nov-20	17:17	-40.6871	148.5415	-40.6597	148.5806	1200	4800	23:05	53
3	25	8-Nov-20	17:45	-40.6569	148.5847	-40.6346	148.6160	900	3600	0:37	55
3	26	8-Nov-20	18:09	-40.6314	148.6204	-40.6108	148.6496	900	3600	2:05	56
3	27	9-Nov-20	03:42	-40.5106	148.6815	-40.5332	148.6333	1200	4800	15:34	48
3	28	9-Nov-20	04:09	-40.5347	148.6291	-40.5524	148.5913	900	3600	13:35	45
3	29	9-Nov-20	04:32	-40.5550	148.5845	-40.5706	148.5507	900	3600	12:00	43
3	30	10-Nov-20	16:50	-37.9100	148.6117	-37.9236	148.5591	1200	4800	2:03	48
3	31	10-Nov-20	17:17	-37.9245	148.5536	-37.9318	148.5120	900	3600	0:17	48
3	32	10-Nov-20	17:39	-37.9341	148.5049	-37.9413	148.4677	900	3600	22:49	50
3	33	11-Nov-20	04:07	-38.0481	148.5784	-38.0698	148.5316	1200	4800	15:27	59
3	34	11-Nov-20	04:37	-38.0718	148.5263	-38.0881	148.4884	900	3600	13:25	59
3	35	11-Nov-20	04:58	-38.0903	148.4829	-38.1058	148.4477	900	3600	12:00	56
3	36	11-Nov-20	17:04	-38.0672	148.3361	-38.0888	148.2902	1200	4800	3:37	56
3	37	11-Nov-20	17:32	-38.0913	148.2845	-38.1080	148.2483	900	3600	1:44	55
3	38	11-Nov-20	17:55	-38.1116	148.2404	-38.1269	148.2073	900	3600	22:43	55
3	39	12-Nov-20	05:11	-38.0274	148.121	-38.0355	148.0666	1200	4800	14:10	49
3	40	12-Nov-20	05:40	-38.0362	148.0617	-38.0423	148.0209	900	3600	12:22	49
3	41	12-Nov-20	06:03	-38.0436	148.015	-38.0493	147.9789	900	3600	10:56	48
3	42	12-Nov-20	17:38	-38.3099	147.9204	-38.3415	147.8911	1200	4800	0:12	58
3	43	12-Nov-20	18:05	-38.3466	147.8872	-38.3730	147.8631	900	3600	1:42	57
3	44	12-Nov-20	18:27	-38.3765	147.8588	-38.3977	147.8323	900	3600	3:07	57
3	45	13-Nov-20	04:37	-38.4039	147.8586	-38.3743	147.8956	1200	4800	15:16	58
3	46	13-Nov-20	05:04	-38.371	147.8995	-38.3464	147.928	900	3600	13:25	59
3	47	13-Nov-20	05:26	-38.343	147.9314	-38.317	147.9554	900	3600	11:55	60

Appendix 6 – Detailed summary of results

Table 21. Number and percent composition of retained and discarded catch from Autumn/Winter trips.

Species	Retained catch		Discarded catch	
	Retained catch (kg)	Percent retained catch	Discarded catch (kg)	Percent discarded catch
Gummy Shark	9428.1	50.0%	446.4	2%
Draughtboard Shark	9158.8	48.0%	17799.0	66%
Broadnose Shark	246.8	1.0%	73.5	0.3%
Southern Sand Flathead	92.4	0.5%	58.0	0.2%
School Shark	31.7	0.2%	37.3	0.1%
Southern Sawshark	11.2	0.1%	19.8	0.1%
Jackass Morwong	4.5	0.02%	0.8	0.003%
Southern Bluespotted Flathead	3.8	0.02%		
Pink Ling	3.5	0.02%	2.8	0.01%
Common Gurnard Perch	2.2	0.01%	222.0	0.83%
Common Sawshark	2.2	0.01%	2.7	0.01%
Tiger Flathead	1.9	0.01%		
Snapper	1.5	0.01%	28.5	0.1%
Red Gurnard	1.2	0.01%	1.0	0.004%
Red Cod	1.0	0.01%	94.2	0.4%
Hard Coral	1.0	0.01%	11.4	0.04%
Flathead (U)	0.9	0.005%	0.4	0.001%
Toothy Flathead	0.3	0.002%		
Southern Fiddler Ray			2618.6	9.8%
Melbourne Skate			2187.5	8.2%
Port Jackson Shark			2036.7	7.6%
Sandyback Stingaree			256.4	1.0%
Smooth Stingray			230.0	0.9%
Eleven-Arm Seastar			160.2	0.6%
Sponge (U)			159.5	0.6%
Bearded Rock Cod			96.1	0.4%
Spikey Dogfish			63.9	0.2%
Ascidian (U)			54.4	0.2%
Gulf Catshark			21.7	0.1%
Longnose Skate			18.6	0.1%
Shell			18.1	0.1%
Orange Spotted Catshark			15.9	0.1%
Substrate - Rock			9.8	0.04%
Southern Eagle Ray			5.0	0.02%
Hydroid (U)			4.2	0.02%
Spider Crab (U)			4.0	0.01%
Octopus (U)			3.0	0.01%
Western Shovelnose Ray			2.9	0.01%
Stingaree & Giant Stingaree (U)			2.8	0.01%
Whitespotted Dogfish			2.8	0.01%
Commercial Scallop			2.7	0.01%
Soft Coral (U)			2.4	0.01%
Thornback Skate			2.2	0.01%
Doughboy Scallop			1.9	0.01%
Seastar (U)			1.9	0.01%
Brown Algae			1.0	0.004%
Razor Clams			0.9	0.003%
Elephantfish			0.8	0.003%
Dog Whelk			0.6	0.002%
Whelk 1			0.5	0.002%
Hermit Crab (U)			0.2	0.001%
Rock Cod			0.2	0.001%
Crab (U)			0.1	0.0004%
Seapen (U)			0.1	0.0004%
Velvet Leatherjacket			0.05	0.0002%

Table 22. Number and percent composition of retained and discarded catch from the Spring trip.

Species	Retained catch		Discarded catch	
	Retained catch (kg)	Percent retained catch	Discarded catch (kg)	Percent discarded catch
Draughtboard Shark	5035.0	70.0%	389.6	13.0%
Gummy Shark	2038.0	28.0%	381.5	12.0%
Southern Sand Flathead	58.1	1.0%	5.7	0.2%
School Shark	35.0	0.5%	5.8	0.2%
Southern Sawshark	23.3	0.3%	1.9	0.1%
Melbourne Skate	8.0	0.1%	729.0	24.0%
Common Gurnard Perch	7.4	0.1%	144.8	5.0%
Red Gurnard	4.5	0.1%		
Tiger Flathead	4.1	0.1%	0.3	0.01%
Common Sawshark	2.9	0.04%		
Orange Spotted Catshark	2.8	0.04%	13.9	0.5%
Hard Coral	2.0	0.03%	46.9	2.0%
Bluespotted Flathead	1.3	0.02%		
Bearded Rock Cod	1.0	0.01%	11.1	0.4%
Commercial Scallop	0.9	0.01%		
Spikey Dogfish	0.8	0.01%	2.3	0.1%
Sponge (U)	0.6	0.01%	52.4	2.0%
Ascidian (U)	0.5	0.01%	53.7	2.0%
Spider Crab (U)	0.5	0.01%		
Flathead (U)	0.1	0.001%	0.25	0.01%
Port Jackson Shark			472.0	15.0%
Broadnose Shark			378.3	12.0%
Smooth Stingray			128.0	4.0%
Sandyback Stingaree			98.5	3.0%
Eleven-Arm Seastar			38.5	1.0%
Snapper			27.9	1.0%
Southern Fiddler Ray			21.0	1.0%
Shell			20.12	1.0%
Red Cod			7.3	0.2%
Reef Ocean Perch			5.7	0.2%
Elephantfish			4.9	0.2%
Algae - Undifferentiated			4.3	0.1%
Stony Coral			2.8	0.1%
Longnose Skate			2.5	0.1%
Oysters			1.5	0.05%
Hermit Crab (U)			1.4	0.05%
Australian Tulip Shell			1.1	0.04%
Sergeant Baker			1.0	0.03%
Dog Whelk			0.7	0.02%
Doughboy Scallop			0.68	0.02%
Mixed Fish			0.5	0.02%
Gulf Catshark			0.4	0.01%
Razor Clams			0.4	0.01%
Barred Grubfish			0.05	0.002%
Brittlestars (U)			0.05	0.002%

Table 23. Retained and Discarded catch, CPUE and number of shots of main retained species other than Gummy Shark and Draughtboard Shark.

Species	Measure	Retained		Discarded	
		Autumn / Winter	Spring	Autumn / Winter	Spring
School Shark	Catch (kg)	31.7	35.0	37.3	5.8
	Catch (number)	3.0	3.0	17.0	3.0
	Mean CPUE (kg per 1000 hooks)	13.2	9.8	3.1	2.1
	SE CPUE	1.5	5.4	1.3	0.7
	N	2.0	3.0	13.0	3.0
Southern Sand Flathead	Catch (kg)	92.4	58.1	58.0	5.7
	Catch (number)	106.0	85.0	76.0	16.0
	Mean CPUE (kg per 1000 hooks)	3.4	2.7	4.2	0.5
	SE CPUE	1.5	0.6	2.4	0.1
	N	28.0	21	15.0	11.0
Southern Sawshark	Catch (kg)	11.2	23.3	19.8	1.9
	Catch (number)	6.0	15	16.0	3.0
	Mean CPUE (kg per 1000 hooks)	1.9	3.6	1.7	1.1
	SE CPUE	0.2	1.0	0.3	0.6
	N	6.0	7.0	12.0	2.0

Table 24. Life state of discarded animals from the Autumn/Winter trips. For descriptions of each life state category see Table 2.

Species	Strong and lively		Weak but lively		Just alive		Dead		Not recorded	
	n	kg	n	kg	n	kg	n	kg	n	kg
Ascidian (U)									40	54.4
Bearded Rock Cod	3	2.0	12	17.1	31	39.3	34	36.5	1	1.2
Broadnose Shark	8	30.3	1	18			6	25.2		
Brown Algae									1	1.0
Commercial Scallop			7	0.7	1	0.1			19	1.9
Common Gurnard Perch	126	41.8	268	82.5	151	49.5	140	39.6	32	8.6
Common Sawshark	1	0.8					3	1.9		
Crab (U)									1	0.1
Dog Whelk									3	0.6
Doughboy Scallop					8	0.4			13	1.5
Draughtboard Shark	1425	4568.0	3865	11492.2	250	750	19	29.9	319	958.9
Elephantfish							1	0.8		
Eleven-Arm Seastar	18	6.0	31	9.5	25	8.6			378	136.1
Flathead (U)	1	0.2	1	0.2						
Gulf Catshark	9	2.9	54	15.5	5	1.5	3	0.6	6	1.2
Gummy Shark	59	93.4	65	102	11	16.3	182	234.7	1	0.0
Hard Coral									14	11.4
Hermit Crab (U)			1	0.2						
Hydroid (U)									7	4.2
Jackass Morwong							1	0.8		
Longnose Skate	1	0.6	8	12.4	3	4.4	1	1.2		
Melbourne Skate	19	181.0	172	1937.5	3	23	6	46	0	0
Octopus (U)	1	3.0								
Orange Spotted Catshark	25	11.8	10	2	3	0.9	6	1.2		
Pink Ling			2	1.8					1	1.0
Port Jackson Shark	92	386.4	511	1610.3					8	40.0
Razor Clams									3	0.9
Red Cod	8	4.1	15	13.2	42	41.7	61	35.2		
Red Gurnard							1	1		
Rock Cod							0	0.2		
Sandyback Stingaree	11	44.4	47	183.5	13	19			2	9.5
School Shark	5	15.9	3	12.5	4	2.2	5	6.7	0	0.0
Seapen (U)	1	0.1								
Seastar (U)									8	1.9
Shell									11	18.1
Smooth Stingray	15	93	18	115			2	7	2	15.0
Snapper	3	7.9	7	13.1	4	2.4	3	2.4	1	2.7
Soft Coral (U)									5	2.4
Southern Eagle Ray			1	5						
Southern Fiddler Ray	8	49.1	670	2565.5			2	4		
Southern Sand Flathead	48	43	11	6.3			17	8.7	0	0
Southern Sawshark	8	8.9	5	7.4	2	2.3	1	1.2		
Spider Crab (U)	1	0.5	1	0.8	5	2.1	1	0.6		
Spikey Dogfish	18	16.6	45	39.2	6	3.3	9	3.2	2	1.6
Sponge (U)									139	159.5
Stingaree & Giant Stingaree (U)			2	2.8						
Substrate - Rock									3	9.8
Thornback Skate			1	1.2			1	1		
Velvet Leatherjacket							1	0.05		
Western Shovelnose Ray					1	2.9				
Whelk 1			1	0.2					2	0.3
Whitespotted Dogfish			1	2.8						

Table 25. Life state of discarded animals from the Spring trip. For descriptions of each life state category see Table 2.

Species	**Strong and lively**		**Weak but lively**		**Just alive**			**Dead**				**Not recorded**
	n	**kg**	**n**	**kg**	**n**	**kg**		**n**	**kg**		**n**	**kg**
Algae - Undifferentiated												4.3
Ascidian (U)					1	1.35					136	52.4
Australian Tulip Shell											12	1.1
Barred Grubfish					0	0.05						
Bearded Rock Cod	1	0.4						8	10.7			
Brittlestars (U)											1	0.05
Broadnose Shark	34	290.5	6	18.5	5	29.0		5	25.3		1	15.0
Common Gurnard Perch	84	31.7	142	56.3	43	18.6		68	24.0		34	14.2
Dog Whelk											2	0.7
Doughboy Scallop											7	0.7
Draughtboard Shark	294	362.3			1	3.0		5	8.5		9	15.8
Elephantfish					1	4.0		2	0.9			
Eleven-Arm Seastar	1	1.2									116	37.3
Flathead (U)								0	0.25			
Gulf Catshark					2	0.4						
Gummy Shark	82	88.6	72	94.1	50	67.9		124	129.5		79	1.4
Hard Coral											0	46.9
Hermit Crab (U)											5	1.4
Longnose Skate			2	2.5								
Melbourne Skate	67	655	3	21.0	3	46.0					1	7.0
Mixed Fish								1	0.5			
Orange Spotted Catshark	66	8.2			2	0.3					42	5.4
Oysters											7	1.5
Port Jackson Shark	101	434.2	2	4.8							8	33
Razor Clams											3	0.4
Red Cod	2	0.6			2	1.8		10	4.9			
Reef Ocean Perch	6	4.9	1	0.1	1	0.7						
Sandyback Stingaree	13	67	2	7.0	2	17.0		1	7.5			
School Shark	1	2.5	1	2.7				1	0.6			
Sergeant Baker	2	1.0										
Shell												20.1
Smooth Stingray	14	112			1	16.0						
Snapper	7	18.1	1	4.0	2	3.5		2	2.3			
Southern Fiddler Ray	5	21										
Southern Sand Flathead	7	1.7	1	0.2				7	3.65		1	0.15
Southern Sawshark	1	0.5	1	1.0				1	0.4			
Spikey Dogfish	2	1.3			1	1						
Sponge (U)	1	0.5									1	51.9
Stony Coral												2.8
Tiger Flathead	1	0.3										

Table 26. Fate of discarded animals from the Autumn/Winter trips.

Species	Discarded alive floated away		Discarded dead		Discarded alive swam away		Snood cut		Lost off hook		Eaten		Not recorded / unknown	
	n	kg	n	kg	n	kg	n	kg	n	kg	n	kg	n	kg
Ascidian (U)													40	54.4
Bearded Rock Cod	30	44.7	42	44.2	7	4							2	3.2
Broadnose Shark	1	6	6	25.2	8	42.3								
Brown Algae													1	1
Commercial Scallop					12	1.2							15	1.5
Common Gurnard Perch	190	61.1	234	69.35	261	82.9							32	8.6
Common Sawshark			3	1.9	1	0.8								
Crab (U)													1	0.1
Dog Whelk													3	0.6
Doughboy Scallop					17	1.4							4	0.5
Draughtboard Shark	97	291	18	29.2	5388	16359.7	1	0.7			1	1	373	1117.4
Elephantfish			1	0.8										
Eleven-Arm Seastar					351	122.9							101	37.3
Flathead (U)					2	0.4								
Gulf Catshark			3	0.6	74	21.1								
Gummy Shark	1	0	182	232.9	128	206.6							7	6.9
Hard Coral													14	11.4
Hermit Crab (U)					1	0.2								
Hydroid (U)													7	4.2
Jackass Morwong			1	0.8										
Longnose Skate	2	2.4	1	1.2	10	15								
Melbourne Skate			6	46	194	2141.5								
Octopus (U)					1	3								
Orange Spotted Catshark			6	1.2	38	14.7								
Pink Ling	1	1.2	1	0.6									1	1
Port Jackson Shark					591	1960.7							20	76
Razor Clams													3	0.9
Red Cod	18	15.6	91	68.2	12	7.4	4	2.7					1	0.3
Red Gurnard			1	1										
Rock Cod			0	0.2										
Sandyback Stingaree	2	5.5			63	236.4							8	14.5
School Shark			5	6.7	12	30.6								
Seapen (U)					1	0.1								
Seastar (U)													8	1.9
Shell													11	18.1
Smooth Stingray			2	7	33	208							2	15
Snapper	1	1.5	3	2.4	13	21.9							1	2.7
Soft Coral (U)													5	2.4
Southern Eagle Ray					1	5								
Southern Fiddler Ray			2	4	667	2581.6							11	33
Southern Sand Flathead	1	0.5	17	8.7	56	48	2	0.8						
Southern Sawshark			1	1.2	15	18.6								
Spider Crab (U)			1	0.6	7	3.4								
Spikey Dogfish	1	1.1	9	3.8	68	57.5			1	0.5			1	1
Sponge (U)					0	6.7							139	152.8
Stingaree & Giant Stingaree (U)					2	2.8								
Substrate - Rock													3	9.8
Thornback Skate			1	1	1	1.2								
Velvet Leatherjacket			1	0.05										
Western Shovelnose Ray					1	2.9								
Whelk 1					1	0.2							2	0.3
Whitespotted Dogfish					1	2.8								

Table 27. Fate of discarded animals from the Spring trip.

Species	Discarded alive floated away		Discarded dead		Discarded alive swam away		Snood cut		Lost off hook		Eaten		Retained parts		Not recorded / unknown	
	n	kg	n	kg	n	kg	n	kg	n	kg	n	kg	n	kg	n	kg
Algae - Undifferentiated																4.3
Ascidian (U)	11	3.2													126	50.5
Australian Tulip Shell															12	1.1
Barred Grubfish															0	0.05
Bearded Rock Cod					1	0.4							8	10.7		
Brittlestars (U)															1	0.05
Broadnose Shark			3	16.8	42	324.2	1	5							5	32.3
Common Gurnard Perch	0	30.8	53	19.5	100	41					1	0.4	107	40.85	33	12.3
Dog Whelk															2	0.7
Doughboy Scallop					1	0.2									6	0.5
Draughtboard Shark			1	0.5	287	350.6	1	0.3					4	8	16	30.2
Elephantfish													2	0.9	1	4
Eleven-Arm Seastar					4	1.9									113	36.6
Flathead (U)			0	0.3												
Gulf Catshark															2	0.4
Gummy Shark			12	14.7	226	217.2							114	113.6	55	36
Hard Coral															0	46.9
Hermit Crab (U)															5	1.4
Longnose Skate					2	2.5										
Melbourne Skate					73	722									1	7
Mixed Fish																
Orange Spotted Catshark					70	9									40	4.9
Oysters															7	1.5
Port Jackson Shark					110	459									1	13
Razor Clams															3	0.4
Red Cod					1	0.3					3	0.9	10	6.1		
Reef Ocean Perch					8	5.7										
Sandyback Stingaree					17	91							1	7.5	0	0
School Shark					2	5.2							1	0.6		
Sergeant Baker					2	1										
Shell															0	20.12
Smooth Stingray					15	128										
Snapper	1	2.7			8	18.9					1	4	2	2.3		
Southern Fiddler Ray					5	21										
Southern Sand Flathead			2	2	7	1.55	1	0.3			1	0.2	5	1.65		
Southern Sawshark					2	1.5							1	0.4		
Spikey Dogfish					3	2.3										
Sponge (U)															2	52.4
Stony Coral															0	2.8
Tiger Flathead					1	0.3										

Table 28. Weight of discarded catch by discard reason from the Autumn/Winter trips.

	Weight of discarded catch (kg)								
Species	Unmarketable	Inedible	Lost	Undersize	Trip limit	Bite	Bite / Lice	Lice	Unknown
Ascidian (U)	54.4								
Bearded Rock Cod	82		6.2			7.1	0.8		
Broadnose Shark	21.3		26.0	15.6		4.6		6	
Brown Algae	1								
Commercial Scallop	2.7								
Common Gurnard Perch	217					1.85		2.5	0.6
Common Sawshark				0.8		1.5	0.2	0.2	
Crab (U)	0.1								
Dog Whelk	0.6								
Doughboy Scallop	1.9								
Draughtboard Shark	17659.1		0	110.6		24.9		4.4	
Elephantfish						0.8			
Eleven-Arm Seastar	160.2								
Flathead (U)	0.4								
Gulf Catshark	21.3		0.3					0.1	
Gummy Shark			13.3	216.7		156	1.3	40.8	18.3
Hard Coral	11.4								
Hermit Crab (U)	0.2								
Hydroid (U)	4.2								
Jackass Morwong						0.8			
Longnose Skate	18.6								
Melbourne Skate	2133.5	8				12		34	
Octopus (U)	3								
Orange Spotted Catshark	15.9								
Pink Ling	2.8								
Port Jackson Shark	2032.5			4.2					
Razor Clams	0.9								
Red Cod	90.3		0.4			1	1.4	1.1	
Red Gurnard						1			
Rock Cod	0.2								
Sandyback Stingaree	256.4								
School Shark	32.2			0.4		4.4		0.3	
Seapen (U)	0.1								
Seastar (U)	1.9								
Shell	18.1								
Smooth Stingray	227							3	
Snapper	5.1		1.6		21.8	0			
Soft Coral (U)	2.4								
Southern Eagle Ray	5								
Southern Fiddler Ray	2617.6							1	
Southern Sand Flathead	57.9							0.1	
Southern Sawshark	18.6			1.2					
Spider Crab (U)	4								
Spikey Dogfish	63.3							0.6	
Sponge (U)	159.5								
Stingaree & Giant Stingaree (U)	2.8								
Substrate - Rock	9.8								
Thornback Skate	2.2								
Velvet Leatherjacket						0.05			
Western Shovelnose Ray	2.9								
Whelk 1	0.5								
Whitespotted Dogfish	2.8								

Table 29. Weight of discarded catch by discard reason from the Spring trips.

	Weight of discarded catch (kg)						
Species	Unmarketable	Undersize	Trip limit	Bite	Bite / Lice	Lice	Unknown
Algae - Undifferentiated	4.3						
Ascidian (U)	53.7						
Australian Tulip Shell	1.1						
Barred Grubfish	0.05						
Bearded Rock Cod	11.1						
Brittlestars (U)	0.05						
Broadnose Shark	374.8					3.5	
Common Gurnard Perch	136.5			1.9	0.35	6.05	
Dog Whelk	0.7						
Doughboy Scallop	0.68						
Draughtboard Shark	381.1			7		1.5	
Elephantfish	4			0.9			
Eleven-Arm Seastar	38.5						
Flathead (U)						0.25	
Gulf Catshark	0.4						
Gummy Shark		223		46.1	31.2	48.9	32.3
Hard Coral	46.9						
Hermit Crab (U)	1.4						
Longnose Skate	2.5						
Melbourne Skate	729						
Mixed Fish	0.5						
Orange Spotted Catshark	9.1	4.8					
Oysters	1.5						
Port Jackson Shark	472						
Razor Clams	0.4						
Red Cod	7			0.3			
Reef Ocean Perch	5.7						
Sandyback Stingaree	91				7.5		
School Shark	5.2					0.6	
Sergeant Baker	1						
Shell	20.12						
Smooth Stingray	128						
Snapper	25.6			2.3			
Southern Fiddler Ray	21						
Southern Sand Flathead	1.75	0.3		1.35		2.3	
Southern Sawshark	1.5			0.4			
Spikey Dogfish	2.3						
Sponge (U)	51.9		0.5				
Stony Coral	2.8						
Tiger Flathead	0.3						

Appendix 7 – Discounted cash flow analyses

"Average" Operation: Estimated ten year cash flow for a gillnet vessel

Gillnet- Average	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Annual catches										
Gummy Shark (mt)	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0
Other species(mt)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Revenues										
Gummy Shark	$418,000	$426,360	$434,887	$443,585	$452,457	$461,506	$470,736	$480,151	$489,754	$499,549
Other species	$50,000	$51,000	$52,020	$53,060	$54,122	$55,204	$56,308	$57,434	$58,583	$59,755
Total revenues from fishing	**$468,000**	**$477,360**	**$486,907**	**$496,645**	**$506,578**	**$516,710**	**$527,044**	**$537,585**	**$548,337**	**$559,303**
Operating Costs										
Fuel	$66,500	$67,830	$69,187	$70,570	$71,982	$73,421	$74,890	$76,388	$77,915	$79,474
Crew Food	$11,970	$12,209	$12,454	$12,703	$12,957	$13,216	$13,480	$13,750	$14,025	$14,305
Crew Share	$123,690	$129,458	$132,048	$134,689	$137,382	$140,130	$142,933	$145,791	$148,707	$151,681
Electronic monitoring	$15,500					$16,778				
Licence Fees	$5,500	$5,610	$5,722	$5,837	$5,953	$6,072	$6,194	$6,318	$6,444	$6,573
Quota costs	$104,500	$106,590	$108,722	$110,896	$113,114	$115,376	$117,684	$120,038	$122,438	$124,887
Gear replacement	$40,000	$40,800	$41,616	$42,448	$43,297	$44,163	$45,046	$45,947	$46,866	$47,804
Repairs and Maintenance	$60,000	$61,200	$62,424	$63,672	$64,946	$66,245	$67,570	$68,921	$70,300	$71,706
Insurance	$25,000	$25,500	$26,010	$26,530	$27,061	$27,602	$28,154	$28,717	$29,291	$29,877
Total operating costs	**$452,660**	**$449,198**	**$458,182**	**$467,345**	**$476,692**	**$503,004**	**$495,951**	**$505,870**	**$515,987**	**$526,307**
Cash flow	**$15,340**	**$28,162**	**$28,725**	**$29,300**	**$29,886**	**$13,706**	**$31,093**	**$31,715**	**$32,350**	**$32,997**

"Average" Operation: Estimated ten year cash flow for a gillnet vessel converted to auto-longline CPUE includes zero catch

Auto-longline: Average	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Annual Catches										
Gummy Shark (mt)	**42**	**43.05**	**44.13**	**45.23**	**46.36**	**47.52**	**48.71**	**48.71**	**48.71**	**48.71**
Other species (mt)	**52**	**46.80**	**42.12**	**37.91**	**34.12**	**34.97**	**31.47**	**31.47**	**31.47**	**31.47**
Revenues										
Gummy Shark	$483,000	$504,977	$527,953	$551,975	$577,090	$603,347	$630,800	$643,416	$656,284	$669,409
Other species	$52,000	$47,736	$43,822	$40,228	$36,930	$38,610	$35,444	$36,153	$36,876	$37,613
Total revenues from fishing	**$535,000**	**$552,713**	**$571,775**	**$592,203**	**$614,019**	**$641,957**	**$666,243**	**$679,568**	**$693,160**	**$707,023**
Operating Costs										
Bait	$41,040	$41,861	$42,698	$43,552	$44,423	$45,311	$46,218	$47,142	$48,085	$49,047
Fuel	$66,500	$67,830	$69,187	$70,570	$71,982	$73,421	$74,890	$76,388	$77,915	$79,474
Crew Food	$15,960	$16,279	$16,605	$16,937	$17,276	$17,621	$17,974	$18,333	$18,700	$19,074
Crew Share	$140,600	$146,367	$152,449	$158,855	$165,595	$173,130	$180,540	$184,150	$187,833	$191,590
Electronic monitoring	$15,500					$16,778				
Licence fees	$5,500	$5,610	$5,722	$5,837	$5,953	$6,072	$6,194	$6,318	$6,444	$6,573
Quota costs	$115,500	$120,755	$123,774	$126,868	$130,040	$133,291	$136,623	$136,623	$136,623	$136,623
Gear replacement	$26,220	$26,744	$27,279	$27,825	$28,381	$28,949	$29,528	$30,119	$30,721	$31,335
Repairs and Maintenance	$60,000	$61,200	$62,424	$63,672	$64,946	$66,245	$67,570	$68,921	$70,300	$71,706
Insurance	$25,000	$25,500	$26,010	$26,530	$27,061	$27,602	$28,154	$28,717	$29,291	$29,877
Total operating costs	**$511,820**	**$512,147**	**$526,148**	**$540,646**	**$555,657**	**$588,421**	**$587,690**	**$596,711**	**$605,913**	**$615,299**
Cash flow	**$23,180**	**$40,565**	**$45,627**	**$51,557**	**$58,362**	**$53,536**	**$78,554**	**$82,857**	**$87,247**	**$91,724**

"Average" Operation: Estimated ten year cash flow for a gillnet vessel converted to auto-longline CPUE excludes zero catch

Auto-longline: Average	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Annual Catches										
Gummy Shark (mt)	**51**	**52.28**	**53.58**	**54.92**	**56.29**	**57.70**	**59.14**	**59.14**	**59.14**	**59.14**
Other species (mt)	**70**	**63.00**	**56.70**	**51.03**	**45.93**	**41.33**	**37.20**	**37.20**	**37.20**	**37.20**
Revenues										
Gummy Shark	$586,500	$613,186	$641,086	$670,255	$700,752	$732,636	$765,971	$781,290	$796,916	$812,854
Other species	$70,000	$64,260	$57,834	$52,051	$46,846	$42,161	$37,945	$37,945	$37,945	$37,945
Total revenues from fishing	**$656,500**	**$677,446**	**$698,920**	**$722,306**	**$747,597**	**$774,797**	**$803,916**	**$819,235**	**$834,861**	**$850,799**
Operating Costs										
Bait	$41,040	$41,861	$42,698	$43,552	$44,423	$45,311	$46,218	$47,142	$48,085	$49,047
Fuel	$66,500	$67,830	$69,187	$70,570	$71,982	$73,421	$74,890	$76,388	$77,915	$79,474
Crew Food	$15,960	$16,279	$16,605	$16,937	$17,276	$17,621	$17,974	$18,333	$18,700	$19,074
Crew Share	$171,380	$178,330	$185,666	$193,399	$201,543	$210,111	$219,118	$223,500	$227,970	$232,530
Electronic monitoring	$15,500					$16,778				
Licence fees	$5,500	$5,610	$5,722	$5,837	$5,953	$6,072	$6,194	$6,318	$6,444	$6,573
Quota costs	$140,250	$146,631	$150,297	$154,055	$157,906	$161,854	$165,900	$165,900	$165,900	$165,900
Gear replacement	$26,220	$26,744	$27,279	$27,825	$28,381	$28,949	$29,528	$30,119	$30,721	$31,335
Repairs and Maintenance	$60,000	$61,200	$62,424	$63,672	$64,946	$66,245	$67,570	$68,921	$70,300	$71,706
Insurance	$25,000	$25,500	$26,010	$26,530	$27,061	$27,602	$28,154	$28,717	$29,291	$29,877
Total operating costs	**$567,350**	**$569,986**	**$585,888**	**$602,377**	**$619,470**	**$653,964**	**$655,545**	**$665,337**	**$675,326**	**$685,515**
Cash flow	**$89,150**	**$107,460**	**$113,032**	**$119,929**	**$128,127**	**$120,833**	**$148,371**	**$153,898**	**$159,535**	**$165,285**

“Full-time” Operation: Estimated ten year cash flow for a gillnet vessel

Gillnet: Full-time	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Annual catches										
Gummy Shark (mt)	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0
Other species(mt)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
Revenues										
Gummy Shark	$924,000	$942,480	$961,330	$980,556	$1,000,167	$1,020,171	$1,040,574	$1,061,386	$1,082,613	$1,104,266
Other species	$105,000	$107,100	$109,242	$111,427	$113,655	$115,928	$118,247	$120,612	$123,024	$125,485
Total revenues from fishing	**$1,029,000**	**$1,049,580**	**$1,070,572**	**$1,091,983**	**$1,113,823**	**$1,136,099**	**$1,158,821**	**$1,181,998**	**$1,205,638**	**$1,229,750**
Operating Costs										
Fuel	$112,000	$114,240	$116,525	$118,855	$121,232	$123,657	$126,130	$128,653	$131,226	$133,850
Crew Food	$20,160	$20,563	$20,974	$21,394	$21,822	$22,258	$22,703	$23,158	$23,621	$24,093
Crew Share	$279,300	$284,886	$290,584	$296,395	$302,323	$308,370	$314,537	$320,828	$327,244	$333,789
Electronic monitoring	$15,500					$16,778				
Licence Fees	$5,500	$5,610	$5,722	$5,837	$5,953	$6,072	$6,194	$6,318	$6,444	$6,573
Quota costs	$231,000	$235,620	$235,620	$235,620	$235,620	$235,620	$235,620	$235,620	$235,620	$235,620
Gear replacement	$40,000	$40,800	$41,616	$42,448	$43,297	$44,163	$45,046	$45,947	$46,866	$47,804
Repairs and Maintenance	$60,000	$61,200	$62,424	$63,672	$64,946	$66,245	$67,570	$68,921	$70,300	$71,706
Insurance	$25,000	$25,500	$26,010	$26,530	$27,061	$27,602	$28,154	$28,717	$29,291	$29,877
Total operating costs	**$788,460**	**$788,419**	**$799,475**	**$810,752**	**$822,255**	**$850,765**	**$845,955**	**$858,162**	**$870,613**	**$883,312**
Cash flow	**$240,540**	**$261,161**	**$271,096**	**$281,231**	**$291,568**	**$285,334**	**$312,866**	**$323,836**	**$335,025**	**$346,438**

"Full-time" Operation: Estimated ten year cash flow for a gillnet vessel converted to auto-longline CPUE <u>includes</u> zero catch

Auto-longline: Full-time	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Annual catches										
Gummy Shark (mt)	73.0	74.8	76.7	78.6	80.6	82.6	84.7	84.7	84.7	84.7
Other species(mt)	89.0	80.1	72.1	64.9	58.4	52.6	47.3	47.3	47.3	47.3
Revenues										
Gummy Shark	$839,500	$877,697	$917,632	$959,385	$1,003,037	$1,048,675	$1,096,390	$1,118,317	$1,140,684	$1,163,497
Other species	$89,000	$81,702	$75,002	$68,852	$63,206	$58,023	$53,266	$54,331	$55,417	$56,526
Total revenues from fishing	**$928,500**	**$959,399**	**$992,635**	**$1,028,237**	**$1,066,243**	**$1,106,698**	**$1,149,655**	**$1,172,648**	**$1,196,101**	**$1,220,023**
Operating Costs										
Bait	$70,560	$71,971	$73,411	$74,879	$76,376	$77,904	$79,462	$81,051	$82,672	$84,326
Fuel	$112,000	$114,240	$116,525	$118,855	$121,232	$123,657	$126,130	$128,653	$131,226	$133,850
Crew Food	$26,880	$27,418	$27,966	$28,525	$29,096	$29,678	$30,271	$30,877	$31,494	$32,124
Crew Share	$244,245	$254,280	$264,860	$276,003	$287,727	$300,053	$313,003	$319,263	$325,648	$332,161
Electronic monitoring	$15,500					$16,778				
Licence Fees	$5,500	$5,610	$5,722	$5,837	$5,953	$6,072	$6,194	$6,318	$6,444	$6,573
Quota costs	$200,750	$205,769	$210,913	$216,186	$221,590	$227,130	$232,808	$232,808	$232,808	$232,808
Gear replacement	$45,080	$45,982	$46,901	$47,839	$48,796	$49,772	$50,767	$51,783	$52,818	$53,875
Repairs and Maintenance	$60,000	$61,200	$62,424	$63,672	$64,946	$66,245	$67,570	$68,921	$70,300	$71,706
Insurance	$25,000	$26,744	$27,279	$27,825	$28,381	$28,949	$29,528	$30,119	$30,721	$31,335
Total operating costs	**$805,515**	**$813,214**	**$836,001**	**$859,621**	**$884,099**	**$926,238**	**$935,734**	**$949,792**	**$964,132**	**$978,758**
Cash flow	**$122,985**	**$146,186**	**$156,634**	**$168,616**	**$182,144**	**$180,460**	**$213,922**	**$222,856**	**$231,969**	**$241,265**

"Full-time" Operation:Estimated ten year cash flow for a gillnet vessel converted to auto-longline CPUE <u>excludes</u> zero catch

Auto-longline: Full-time	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Annual catches										
Gummy Shark (mt)	87.0	89.2	91.4	93.7	96.0	98.4	100.9	100.9	100.9	100.9
Other species(mt)	121.000	108.900	98.010	88.209	79.388	71.449	64.304	64.304	64.304	64.304
Revenues										
Gummy Shark	$1,000,500	$1,046,023	$1,093,617	$1,143,376	$1,195,400	$1,249,791	$1,306,656	$1,332,789	$1,359,445	$1,386,634
Other species	$121,000	$108,900	$98,010	$88,209	$79,388	$71,449	$64,304	$64,304	$64,304	$64,304
Total revenues from fishing	**$1,121,500**	**$1,154,923**	**$1,191,627**	**$1,231,585**	**$1,274,788**	**$1,321,240**	**$1,370,961**	**$1,397,094**	**$1,423,749**	**$1,450,938**
Operating Costs										
Bait	$70,560	$71,971	$73,411	$74,879	$76,376	$77,904	$79,462	$81,051	$82,672	$84,326
Fuel	$112,000	$114,240	$116,525	$118,855	$121,232	$123,657	$126,130	$128,653	$131,226	$133,850
Crew Food	$26,880	$27,418	$27,966	$28,525	$29,096	$29,678	$30,271	$30,877	$31,494	$32,124
Crew Share	$292,505	$304,348	$316,851	$330,032	$343,915	$358,522	$373,880	$381,357	$388,984	$396,764
Electronic monitoring	$15,500					$16,778				
Licence Fees	$5,500	$5,610	$5,722	$5,837	$5,953	$6,072	$6,194	$6,318	$6,444	$6,573
Quota costs	$239,250	$245,231	$251,362	$257,646	$264,087	$270,689	$277,457	$277,457	$277,457	$277,457
Gear replacement	$45,080	$45,982	$46,901	$47,839	$48,796	$49,772	$50,767	$51,783	$52,818	$53,875
Repairs and Maintenance	$60,000	$61,200	$62,424	$63,672	$64,946	$66,245	$67,570	$68,921	$70,300	$71,706
Insurance	$25,000	$26,744	$27,279	$27,825	$28,381	$28,949	$29,528	$30,119	$30,721	$31,335
Total operating costs	**$892,275**	**$902,744**	**$928,441**	**$955,111**	**$982,784**	**$1,028,266**	**$1,041,259**	**$1,056,535**	**$1,072,116**	**$1,088,009**
Cash flow	**229,225**	**252,178**	**263,186**	**276,474**	**292,004**	**292,974**	**329,702**	**340,559**	**351,633**	**362,929**