

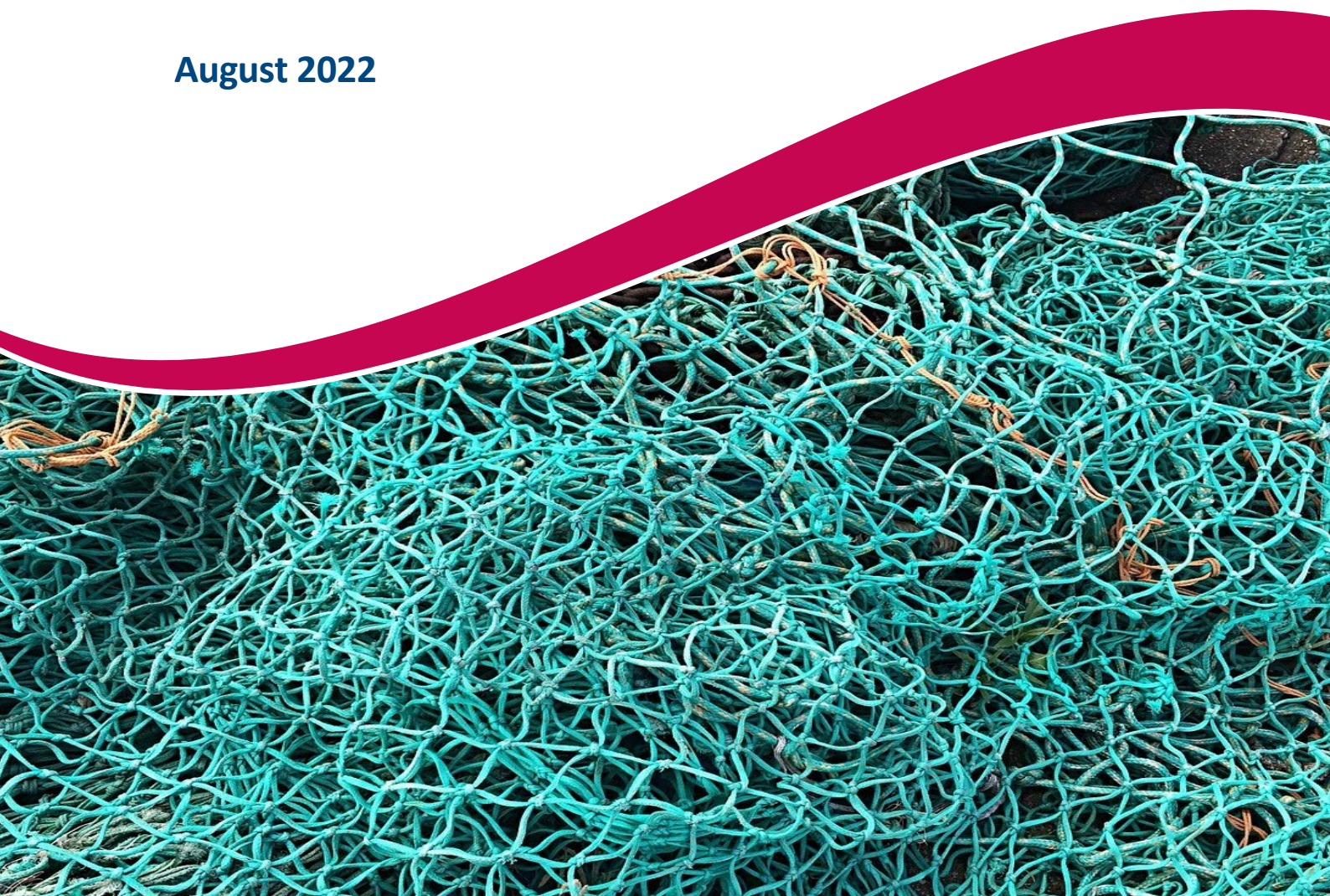


Australian Government

Australian Fisheries Management Authority

Upper-Slope Dogfish Management Strategy

August 2022



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Executive Summary

Four species of upper-slope dogfish have undergone significant decline in south eastern Australia as a result of fishing pressure primarily in the Southern and Eastern Scalefish and Shark Fishery (SESSF): Harrison's dogfish, southern dogfish, endeavour dogfish and greeneye spurdog.

The Upper-Slope Dogfish Management Strategy (the Strategy) forms AFMA's management response to the species' risks identified through its Ecological Risk Assessment (ERA) for the Commonwealth trawl and auto-longline sectors of the Southern and Eastern Scalefish and Shark Fishery (SESSF). The Strategy is also designed to meet *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requirements relating to the conservation dependent status of Harrison's and southern dogfish and Wildlife Trade Operation (WTO) accreditation for the SESSF.

The objective of the Strategy is to stop the decline and support the recovery of Harrison's dogfish and southern dogfish so that their chances of long term survival in nature are maximised. Specifically, to rebuild the populations of Harrison's dogfish and southern dogfish above a limit reference point (B_{LIM}) of B_{25} (25 per cent of unfished biomass), in line with the Commonwealth Fisheries Harvest Strategy Policy (HSP). The rebuilding timeframe is estimated to be 62 years for southern dogfish and 86 years for Harrison's dogfish. In the absence of biomass estimates for these species, a habitat proxy has been used for biomass. Management measures introduced under the Strategy also benefit the survivability of endeavour dogfish and greeneye spurdog.

The Strategy relies on a network of spatial closures supplemented by a range of operational measures including regulated handling practices, 100 per cent monitoring¹, move-on provisions and zero retention of gulper sharks. Performance of the Strategy will be monitored primarily through fishery independent surveys designed to measure the relative index of abundance through time.

The Strategy, was first implemented in 2012 following consultation with the fishing industry, scientists, conservation groups and other stakeholders, to address the decline of these species. The Strategy was reviewed during 2019-21 resulting in no changes to the management measures but with some revision of the text to remove references to transitional arrangements, improve readability and take account of recent research that has informed the update to the monitoring and evaluation section.

¹ This refers to monitoring coverage in area closures where some line fishing is permitted. Outside of these areas, lower levels of monitoring apply.

Introduction

The Upper-Slope Dogfish Management Strategy (the Strategy) outlines management actions to rebuild two species of gulper sharks: Harrison's dogfish (*Centrophorus harrissoni*) and southern dogfish (*C. zeehaani*). The management actions outlined in the Strategy also provide some protection to other dogfish species including endeavour dogfish (*C. moluccensis*) and greeneye spurdog (*Squalus chloroculus*).

Background

Catch restrictions for three species of upper-slope dogfish, Harrison's, southern and endeavour dogfish, have been in place in the Southern and Eastern Scalefish and Shark Fishery (SESSF) since the early 2000's in recognition of stock decline and to prevent targeting of these species. Management was subsequently strengthened via measures outlined in this Strategy between 2009 and 2013, in response to AFMA's ERA process, as well as requirements of the EPBC Act relating to the conservation dependent status of Harrison's dogfish and southern dogfish, and WTO accreditation of the SESSF.

The first iteration of the ERA process for the SESSF identified Harrison's dogfish, southern dogfish and greeneye spurdog as being at potential high risk from fishing in the Commonwealth trawl and the auto-longline sectors. Based on the 2021 ERA for the Commonwealth Trawl Sector (CTS), southern and endeavour dogfish continue to be assessed as potential high risk from fishing. Updated ERAs for auto-longline and manual longline sectors of the SESSF were finalised in 2022 and no risks were identified for the three upperslope dogfish species.

In 2009, Harrison's dogfish and southern dogfish, along with endeavour dogfish were also nominated for listing as threatened species under the EPBC Act. A condition relating to management of Harrison's dogfish, southern dogfish, endeavour dogfish and greeneye spurdog was attached to the February 2010 WTO accreditation of the SESSF.

In July 2011, the Commonwealth Minister with responsibility for the environment portfolio, concluded that endeavour dogfish was not eligible for listing under the EPBC Act and subsequently listed Harrison's and southern dogfish in the category of Conservation Dependent in 2013. This Strategy effectively forms the plan of management required under the EPBC Act for a conservation dependent listing. A condition relating to the management of conservation dependent species more broadly, continues to apply to the WTO accreditation for the SESSF.

Objectives

The Strategy was developed in accordance with the objectives of the *Fisheries Management Act 1991* (FMA) and the Commonwealth Fisheries Harvest Strategy, 2nd ed. (HSP) (Department of Agriculture and Water Resources 2018).

The objective of the Strategy is to promote the recovery of Harrison's dogfish and southern dogfish. Specifically, to rebuild the populations of Harrison's dogfish and southern dogfish above a limit reference point (B_{LIM}) of B_{25} (25 per cent of unfished biomass) within 86 years and 62 years respectively. The Strategy will also help to mitigate the impact of fishing on endeavour dogfish and greeneye spurdog.

The Strategy applies to Commonwealth waters managed by AFMA. New South Wales (NSW), Western Australia (WA) and other jurisdictions are responsible for their own actions in relation to dogfish species.

Reference points

The Upper-Slope Dogfish Scientific Working Group (SWG), established to provide expert scientific advice in relation to the Strategy, determined that the most appropriate figure for B_{MSY} for Harrison's and southern dogfish is 50 per cent (B_{50}), resulting in a limit reference point of B_{25} . Given the multi-species nature of the fishery it may be that the biomass does not reach the target reference point (B_{TARG}) of B_{50} (50 per cent of unfished biomass), consistent with the HSP. These reference points are in excess of the default levels required for commercial species under the HSP in recognition that, in comparison to teleost fishes, these species are long lived and characterised by low biological productivity.

The SWG also agreed that habitat area, weighted by carrying capacity (the ability of the habitat area to support dogfish populations), could be used as a proxy for biomass, given the absence of biomass estimates for these species. Consequently, the closure network was designed by considering the relative contribution of proposed spatial closures to achieving B_{LIM} , with the evaluation based on area (km^2) and pre-fishery carrying capacity (K) of each area. Both of these estimates provide information on the level of protection offered to Harrison's and southern dogfish under the Strategy.

Depletion estimates and pre-fishery carrying capacity

Williams *et al.*, (2012a, Part 4) estimated pre-fishery carrying capacity for Harrison's dogfish and southern dogfish in each habitat segment in the species' core ranges, both directly and indirectly, and estimated depletion (the proportion of carrying capacity remaining) and current biomass values for each segment. The resultant depletion estimates for each stock is:

- Harrison's dogfish 21 per cent (range 11% - 31%)
 - Continental slope stock: 11 per cent (range 4% - 20%)
 - Seamount stock: 75 per cent (range 50% - 100%)
- Southern dogfish 13 per cent (range 7% - 25%)
 - Eastern stock: 11 per cent (range 6% - 19%)
 - Central stock: 16 per cent (range 8% - 33%)
 - Western stock: estimation not possible.

The depletion rates show that both the continental slope stock of Harrison's dogfish and the eastern stock of southern dogfish are substantially depleted south of Sydney. The central stock of southern dogfish, east of Kangaroo Island, is also substantially depleted compared to the western side of this population which has experienced a lower level of depletion (such as in the '60nm

closure'). These results highlighted the need for recovery of these three stocks south of Sydney and east of Kangaroo Island.

Rebuilding timeframes

The life history characteristics of gulper sharks and low levels of depletion mean recovery times for these species are likely to be long (multiple decades). Factors influencing recovery times include the level of depletion at the start of the management strategy; time taken to re-colonise depleted areas; and any ongoing fishing mortality arising during the recovery phase.

Reliably estimating recovery timeframes is data intensive and not currently feasible for these species. In the interim, three mean generation times has been adopted as the most appropriate recovery time period for these species. This compares to the one generation plus ten years recovery period prescribed in the HSP. The HSP setting is not considered appropriate for these species as the calculation of the recovery time in the HSP is based on teleost species for which recruitment processes are much different to those of upper-slope dogfish. The low reproductive rates of dogfish means that stocks below B_{LIM} would be unlikely to recover within the standard HSP timeframe, even with complete protection (SWG, 2012).

Based on estimates of age at maturity of 23 years for female Harrison's dogfish and 14 years for female southern dogfish (Whitely, 2004), and using a standard demographic approach, the mean generation time for Harrison's dogfish is estimated at 28.5 years and 20.5 years for southern dogfish. Using these estimates at three mean generation times, the recovery time to B_{25} is estimated at around 86 years for Harrison's dogfish, and 62 years for southern dogfish (SWG, 2012).

Species description

Biology

Upper-slope species within families Centrophoridae and Squalidae, along with sharks in general, have a slower growth rate, later onset of sexual maturity and lower fecundity than that of bony (teleost) fish species. These life history characteristics place them at higher risk of rapid stock depletion and subsequently, make their recovery protracted once stocks are depleted (Daley *et al.*, 2002; Simpfendorfer and Kyne, 2009).

Harrison's dogfish reach lengths up to 114 cm. Males mature at around 83 cm and females at around 98 cm. Females typically give birth to one to two pups on a reproductive cycle that is likely to be longer than one year (Daley *et al.*, 2002; McLaughlin and Morrissey, 2005). An estimate of mean generation time for Harrison's dogfish has been established as 28.5 years based on dorsal spine bands (Whitely, 2004). Until 2008, the western gulper shark *Centrophorus westraliensis*, that occurs from Shark Bay to Cape Leeuwin in Western Australia, was believed to be conspecific with Harrison's dogfish but has now been formally separated (White *et al* 2008).

Southern dogfish reach lengths up to 103 cm. Males mature at around 80 cm and females at around 96 cm. Females invariably give birth up to one pup on a reproductive cycle that is likely to be longer than one year (Daley *et al.* 202: McLaughlin and Morrissey, 2005). An estimate of mean generation time for southern dogfish has been established as 20.5 years based on dorsal spine bands (Whitely, 2004).

Endeavour dogfish reach lengths up to 100 cm. Males mature at about 70 cm and females at around 85 cm. Females typically give birth to two pups on a reproductive cycle that is likely to be longer than one year (Daley *et al.*: McLaughlin and Morrissey, 2005).

Greeneye spurdog reach lengths up to 99 cm (Last and Stevens, 2009). Both males and females mature slowly, and there is evidence of female-biased sexual size dimorphism. Males mature at about 63 cm (~16 years old) and females at about 79 cm (9 – 12 years old) (Last and Stevens 2009; Rochowski *et al.*, 2015). Females have a triennial reproductive cycle, with a gestation period of 31 – 34 months (Rochowski *et al.*, 2015). Each year, a third of females will give birth. The female reproductive cycle is seasonal (birth from September to December) and the males are likely to be in breeding condition year round (Rochowski *et al.*, 2015). Pups are born at 25 cm and litter sizes range from four to 15 embryos (average of nine), with a 1:1 sex ratio (Rochowski *et al.*, 2015).

Distribution

Distributional and depth ranges for Harrison's dogfish and southern dogfish have been established with a high degree of confidence, although some uncertainty remains about the western distributional range endpoint of southern dogfish (Williams *et al.*, 2012a, Part 1).

Range

Harrison's dogfish are distributed in the waters off eastern Australia from southern Queensland to south eastern Tasmania. Their distribution includes seamounts off northern NSW, including Lord Howe Island, and southern Queensland. With the core distribution extending from northern NSW to the south east coast of Tasmania. Core and extra-limital² areas of the species' ranges are identified in Figure 1.

² Extra-limital areas are at the range end-points where abundance is relatively low and/or are areas where the species is represented only by vagrants.



Figure 1: The distribution of Harrison’s dogfish. (1) core continental margin habitat; (2) core seamount habitat; (3 & 4) northern and southern extra-limital distribution on margin; (5) Fraser seamount extra- limital distribution on seamounts. Source: Source: Williams *et al.*, 2012a, Part 1.

Southern dogfish is endemic to southern Australia from Shark Bay in Western Australia to Forster in NSW. The species’ core distribution extends from Port Stephens in NSW to Flinders Island off Tasmania, and from western Bass Strait to south of Ceduna in the eastern Great Australian Bight (GAB), with a gap in distribution over the Ceduna Terrace. However, the distributional status of southern dogfish from the western GAB to Bunbury remains uncertain, largely due to a lack of reliable species-specific identification in commercial catch data in that region (Williams *et al.*, 2012a, Part 2). Core and extra-limital areas of the species’ ranges are identified in Figure 2.



Figure 2: The distribution of southern dogfish. (1) core eastern habitat; (2) core eastern GAB habitat; (3) northeastern extra-limital distribution; (4 & 5) eastern and western Tasmanian extra-limital distribution; (6) eastern GAB extra-limital distribution; (7) southwestern area with insufficient data to determine distributional status; (8 & 9) apparent gaps in distribution off southern Tasmania and Head of Bight. Source: Williams *et al.*, 2012a Part 1.

Endeavour dogfish is more widespread than Harrison’s dogfish and southern dogfish, occurring in the western Indian Ocean off South Africa and western Pacific around the Philippines, Indonesia, Taiwan, Japan and Australia. Within Australia, endeavour dogfish occurs along the west and east coasts but is uncommon off the south coast of Australia.

Greeneye spurdog is restricted to waters of south eastern Australia from Jervis Bay in NSW to Eucla in Western Australia (Last *et al.*, 2009).

Depth range and movement

Research has shown gulper sharks undertake day-night (diel) migrations across their depth range from relatively deep daytime residence depths (to 1000 m), to shallower night time feeding depths (to 200 m) (Williams *et al.* 2012b).

The depth range of Harrison’s dogfish is considered to be 180 to 1000 m, with a core range of 200 to 900 m. For southern dogfish, the depth range is considered to be 180 to 900 m with a core range of 200 to 800 m. (Williams *et al.*, 2012a Part 1). Endeavour dogfish has a range of around 150 to 650 m and a core depth of 200 to 550 m (Williams *et al.*, 2012b). Greeneye spurdog occurs within the depths 216 to 1,360 m (Last *et al.*, 2009).

Information on along-slope movement of gulper sharks has been measured by acoustic tracking and conventional tagging. Acoustic tracking detected most (35-45/59) individual sharks within the ‘60-mile closure’ (off South Australia) in any given month. Of nine conventionally tagged southern dogfish recaptured after four years, seven (75 per cent) had moved 50 km or less (Daly *et al.*, 2012).

Stock structure and separation

Southern dogfish

The currently available information suggests that there are likely to be three distinct stocks of southern dogfish: one along the east coast of Australia down to eastern Tasmania (the eastern stock); one from western Tasmania through the GAB (the central stock); and one from the western GAB to southern Western Australia (western stock). This is based on:

- apparent gaps in the distribution off southern Tasmania, through Bass Strait and Ceduna Terraces demonstrated by the absence of southern dogfish in the records from surveys and commercial fishing in these areas;
- differences in the physical characteristics of the seafloor in the upper-slope area off southern Tasmania and on the Ceduna Terrace; and
- limited along-slope movement of the species based on acoustic tagging data from the CSIRO research in the GAB (SWG, 2012).

There is currently no available information on direct indicators for stock structuring. Genetic samples will be collected as part of the monitoring program for dogfish that may assist in informing the future understanding of southern dogfish stock structure.

Harrisson's dogfish

There is less certainty relating to the stock structure of Harrisson's dogfish. A key uncertainty is the relationship between the populations on the continental margin down the east coast and those on offshore seamounts of northern NSW and southern Queensland, including Lord Howe Island. Based on the available information on stock structure, and noting that there are no specific genetic or tagging studies that directly address stock structure in this species, it is considered that:

- the population of Harrisson's dogfish that occurs on the continental margin is likely to be a separate stock to that which occurs on the offshore seamounts, based on the large distance and substantial break in habitat (deep water) between these two areas; and
- the populations occurring on the offshore seamounts should be considered as a single stock based on the strong sex-bias in the dogfish that occur at some offshore seamounts which would require movement between seamounts for reproduction (SWG, 2012).

Fishing history

The primary threat to upper-slope dogfish in Australian waters is commercial fishing within Commonwealth and State (primarily NSW) managed fisheries. A summary of the areas and percentages of the different populations of Harrisson's and southern dogfishes, by fishery and jurisdiction is provided in Table 2. Complementary management arrangements between the Commonwealth and NSW is paramount to the success of this Strategy.

Table 2: Habitat areas as a percentage of the stocks of Harrison’s dogfish and southern dogfish by fishery/region

Fisheries/sector/jurisdiction	Harrison’s dogfish			Southern dogfish		
	Total area (km ²)	% Continental slope stock	% Seamounts stock	Total area (km ²)	% East stock	% Central stock
Total core area (km²)		19,674	3,091		11,980	10,156
SESSF (GAB)	n/a			3,732		37
SESSF – ‘west’	n/a			6,424		63
SESSF – ‘east’	8,441	43		6,052	51	
SESSF – CTS ‘east’+ NSW line methods	5,062	26		4,596	38	
NSW Fisheries (all gears)	6,172	31		1,329	11	
SESSF – ‘seamounts’	3,091		100	n/a		

Source: Williams *et al.*, 2012a, Part 3.

Commonwealth fisheries

Historically the gillnet method in the SESSF posed a key threat to these species, while management arrangements implemented since early 2000’s have mitigated against these interactions the hook method of the Gillnet, Hook and Trap (GHAT) Sector and the CTS still are known to interact with these species. Two other Commonwealth fisheries occur within the range of these species. The Coral Sea Fishery (CSF) potentially interacts with the endeavour dogfish, and the Western Deepwater Trawl Fishery (WDTF) potentially interacts with both endeavour dogfish and southern dogfish. However, given the small number of operators and low, sporadic effort in these fisheries, the impact on these species is considered low³. Consequently, this Strategy focuses on reducing the impact of the SESSF on these species.

The SESSF covers nearly half of the waters within the Australian Fishing Zone off mainland Australia and Tasmania, extending from Fraser Island in Queensland and south and west to Cape Leeuwin in Western Australia. It is a multi-species, multi-gear fishery and some sectors of the fishery have operated for more than 85 years. The fishery catches over 80 species of commercial value and is the main provider of fresh fish to the Sydney and Melbourne markets. Major ports include Ulladulla, Eden, Lakes Entrance, Portland and Hobart. The SESSF is managed under the *Southern and Eastern Scalefish and Shark Fishery Management Plan 2003* (the Plan) and is divided into four principal sectors (See Figure 3):

1. CTS which uses predominantly otter trawl and Danish seine methods and some mid-water trawling;
2. East Coast Deepwater Trawl (ECDWT) Sector which uses both demersal and mid-water trawl;
3. GAB Trawl (GABT) Sector which uses predominantly otter trawl with some mid-water trawl; and
4. GHAT Sector which uses primarily scalefish hook and shark hook, shark gillnets and

³ For example, there is typically one to two operators in the WDTF who fish intermittently, and 0 kg of dogfish were reported in the 2019-20, 2020-21 and 2021-22 fishing seasons.

fish traps. Within the GHAT only scalefish hook (including auto-longlines) is now used on the upper-slope areas as shark gillnets and shark hook are restricted to depths shallower than 183 m.

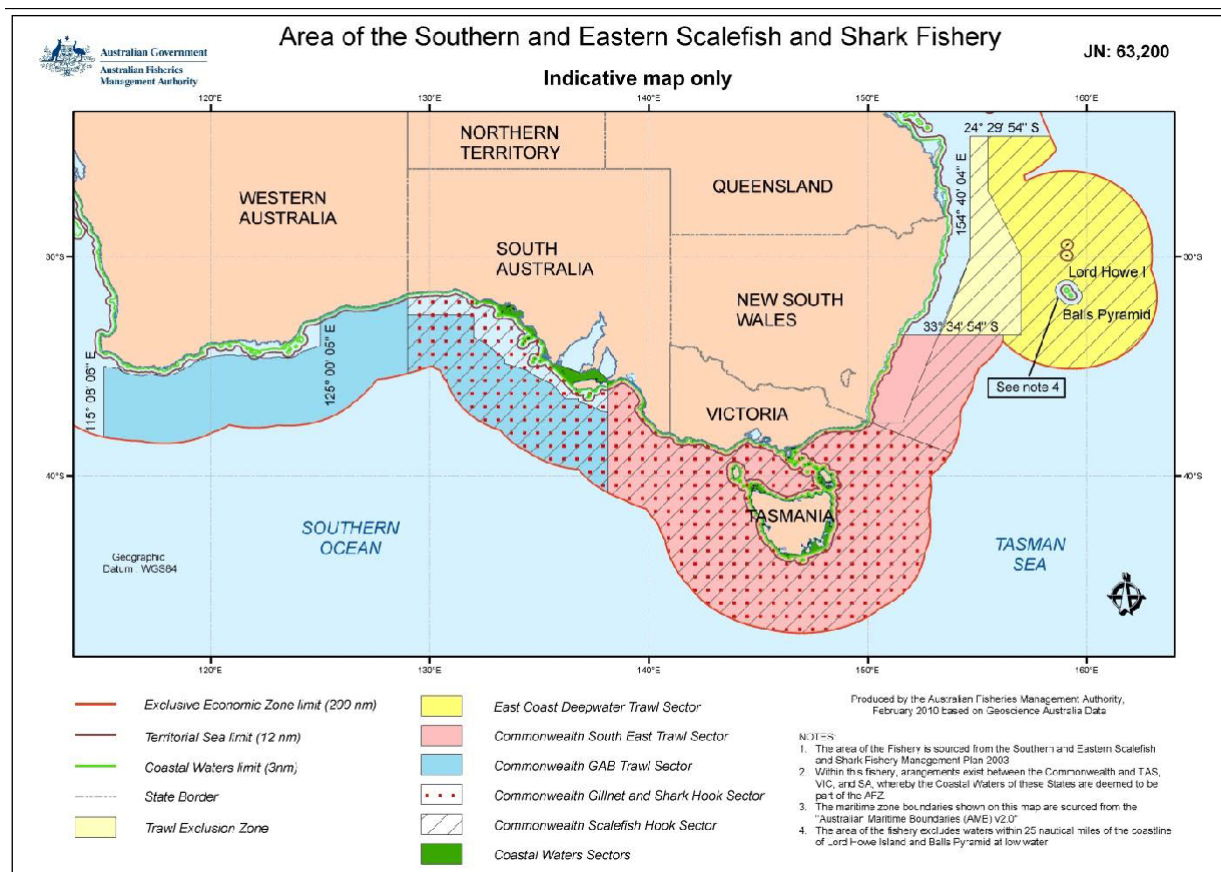


Figure 3: Area of the SESSF and primary sectors.

Of the SESSF sectors, the CTS and auto-longline sector of the GHAT remain the most likely to interact with upper-slope dogfish as key fishing grounds and methods overlap with the habitat of these species. However, taxonomic confusion that was not clarified until 2008 (White *et al.*, 2008), the similarity of different species and more recently with the implementation of no-take rules and handling practices, accurate catch data from fishing operations on dogfish remains a challenge. The historic data that is available includes a larger species assemblage than Harrison’s dogfish, southern dogfish, endeavour dogfish and greeneye spurdog (Wilson *et al.*, 2009). For example, catches of Harrison’s, southern and endeavour dogfish were typically recorded as ‘endeavour dogfish’. Similarly, catches of greeneye spurdog have been recorded along with numerous other species under the generic category ‘dogfish’.

Historically, upper-slope dogfish of the genus *Centrophorus* were targeted by some operators in the CTS and shark sector of the GHAT as these have the highest liver squalene (oil) content relative to other dogfish species (Daley *et al.*, 2002). The annual catch recorded under the generic category of ‘dogfish’, which included *Centrophorus* and *Squalus* spp., among other species, peaked in the SESSF at around 500 t in 1992 (Daley *et al.*, 2002, Walker and Gason, 2005). After this time, catches of upper-slope species declined and operators increasingly began to target mid-slope species (Daley *et al.*, 2002). Further reductions in effort

through the Australian Governments 'Securing our Fishing Future' package saw effort reduced by almost 50 per cent in the CTS and hence reduced the fishing pressure on upper-slope dogfish.

Since the late 1990s, upper-slope dogfish have been taken as incidental bycatch in the SESSF, primarily in the CTS and the auto-longline sector of the GHAT. Trip limits of 150 kg for Harrison's dogfish, southern dogfish and endeavour dogfish (as a group) were implemented in the SESSF in 2002/03. This trip limit was subsequently revised in May 2010 to include greeneye spurdog, and reduced to a 15 kg daily limit or 90 kg in total for trips exceeding six days in length. The combined landed catch for all gulper sharks (upper-slope dogfish from the family Centrophoridae but interpreted to mainly represent Harrison's, southern and endeavour dogfishes) in the SESSF was less than 4.5 t in 2011. In 2010, catch disposal records indicated that approximately 3 t of gulper sharks had been landed and observer reports indicate that a further 0.5 t was discarded (Woodhams *et al.*, 2011). Trip limits were subsequently removed with the implementation of the Strategy, making Harrison's, southern and endeavour dogfishes and greeneye spurdog no take.

State fisheries

New South Wales

Around 31 per cent of the continental slope stock of Harrison's dogfish and 11 per cent of the east stock of southern dogfish overlap with the area of NSW fisheries (Table 2). Significant catches of *Centrophorus* species have been taken in the NSW Ocean Trap and Line Fishery and the Ocean Trawl Fishery. Annual catches from these fisheries peaked at around 250 t in 1992/93 (Scandol *et al.*, 2008). As in the SESSF, these catches have not been identified to species level and are likely to contain significant catches of species other than Harrison's dogfish, endeavour dogfish and southern dogfish.

The NSW Government has in place a complementary strategy to assist with the rebuilding of Harrison's dogfish and southern dogfish populations. The NSW strategy protects 25.8 per cent of area weighted by carrying capacity (26.8 per cent unweighted) for Harrison's dogfish and 21.5 per cent of area weighted by carrying capacity (21.7 per cent unweighted) for the eastern stock of southern dogfish.

Western Australia

As summarised in Wilson *et al.* 2009, a lack of accurate species identification in historical catch data and changes in taxonomy means that the extent of the commercial catch of southern dogfish during the 1990s in Western Australia is uncertain. White *et al.* (2008) confirmed that southern dogfish exist in the western GAB, however, its abundance in this area is not known (Daley *et al.*, 2002; White *et al.*, 2012a Part 2).

Status of Resource

Dogfish, and deepwater sharks in general, have been described by the International Union for Conservation of Nature (IUCN) Shark Specialist Group as being more vulnerable to over-exploitation than perhaps any other marine species group. In Australian waters, while fishers' logbook data and market data indicate clear

declines for deepwater dogfish, accurate data on individual species is limited for a range of reasons. These include: taxonomic confusion, difficulty in fishers identifying different species, and catches being reported under generic categories such as 'dogfish' or 'endeavour dogfish'. Consequently, methods for assessing the status of individual species are also limited.

To date, the primary source of data that demonstrates significant declines to the species level for upper-slope dogfish is from the fishery independent trawl surveys undertaken by the NSW FRV Kapala over a 20-year period. Trawling was undertaken on the upper-slope habitat (200 to 650 m depth) off NSW using the same boat (FRV Kapala), trawl gear and similar sampling protocols in 1976/77 (during the early years of commercial exploitation) and again in 1996/97. This research provided an analysis of the relative abundances of 15 species (or species groups) of sharks (including dogfish) and rays on the NSW upper-slope from the two survey periods between 1976 and 1997. The results described changes in relative abundance after 20 years of trawling on previously lightly unexploited stocks (Graham *et al.*, 2001) based on a dramatic decline in the catch rate of dogfish (*Centrophorus* spp. and *Squalus* spp.):

- In the 1976/1977 surveys the mean catch per unit effort for *Centrophorus* was reported as 139 kg/hr (126.3 kg/hr for Harrison's dogfish and southern dogfish combined and 12.3 kg/hr for endeavour dogfish). For greeneye dogsharks (*Squalus* spp.) a catch rate of 45.2 kg/hr was reported.
- In the 1996-97 surveys, catch per unit effort for *Centrophorus* spp. was reported as 0.6 kg/hr (0.4 kg/hr and 0.2 kg/hr for Harrison's dogfish, southern dogfish and endeavour dogfish respectively). This equates to declines in the relative abundances from the upper-slope of NSW between 1976/77 and 1996/97 of between 98.4–99.7 per cent.
- Similarly, the reported catch rate for greeneye dogsharks (*Squalus* spp.) in 1996-97 was 1.9 kg/hr, a decline of 95.8 per cent since 1976-77.

Wilson *et al.* (2009) conducted a review of all available information on upper-slope dogfish caught in the area of the SESSF, including the Kapala surveys and other relevant studies. This review confirmed previous reports of a decline greater than 90 per cent in upper slope dogfish, in particular in Harrison's dogfish, endeavour dogfish, southern dogfish and greeneye dogsharks, over the past few decades.

Based primarily on the results of the Kapala surveys, the IUCN (2020) has listed Harrison's dogfish and southern dogfish as endangered, endeavour dogfish as Vulnerable, and greeneye spurdog as Endangered.

While targeted by some operators in the SESSF until the late 1990's, upper-slope dogfish are now a relatively minor bycatch species in Commonwealth fisheries. Consequently, there is currently no quantitative stock assessment for upper-slope dogfish species. Nonetheless, the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), in its annual status report on Commonwealth fisheries, has assessed gulper sharks (upper-slope), which includes Harrison's and southern dogfishes, as overfished and subject to overfishing since 2005 when they were first included in the status reports. Since the Strategy was implemented, their overfishing status has been 'uncertain' (Patterson *et al.*, 2020).

Actions to achieve objectives

Prior to the development of specific management for dogfish, it should be noted that a range of management arrangements were implemented that are likely to have had a positive impact on upper-slope dogfish, either directly or indirectly. These include general area closures, depth closures of mid-slope habitat, establishment of marine reserves such as the Great Australian Bight Marine Park, and fleet structural adjustment programmes that removed fishing effort across the SESSF.

More specifically, the Strategy relies on a network of spatial closures supplemented by a range of operational measures including regulated handling practices, 100 per cent monitoring⁴, move-on provisions and no retention of gulper sharks. A full list of closures and the rules that apply is provided in Appendix B.

Outside area closures, ten per cent of electronic monitoring footage is reviewed across the GHAT Sector, with 100 per cent review of gillnet footage for Threatened, Endangered and Protected (TEP) species in the Australian sea lion management zones. There are 230-250 days of human observer coverage in a given year in the CTS, which equates to approximately three to four per cent of effort. Observer coverage in the GAB Trawl Sector ranges between one and four per cent of effort. Observer and electronic monitoring programs collect information to inform a range of data needs across the sectors.

Area closures

Harrison's dogfish (continental slope stock) and Southern dogfish (eastern and central stocks)

The closure network was designed with the primary purpose of including 25 per cent of the habitat (or carrying capacity where it could be determined) as a proxy for the equivalent limit reference point, 25 per cent of unfished biomass - the rebuilding objective of the Strategy for each species. Site selection focused on the continental slope stock of Harrison's dogfish and the east and central stocks of southern dogfish. For detail on the methodology for developing the closure network see Williams *et al.* (2013).

The closure network protects 25 per cent of the core habitat (weighted by carrying capacity) of continental slope stock of Harrison's dogfish, 16.2 per cent of the east stock of southern dogfish and 24.3 per cent of the central stock of southern dogfish, in AFMA-managed waters. The core habitat area (not weighted by carrying capacity) protected by the network for each stock is 25 per cent for Harrison's dogfish, 25.9 per cent for eastern southern dogfish, and 20.1 per cent for central southern dogfish. Area closures and the proportion each contributes to the protection of core habitat (weighted by carrying capacity) for each stock is outlined in Appendix A.

While 25 per cent of the core habitat for eastern southern dogfish is protected by the network, it contributes only 16.2 per cent once weighted for carrying capacity. This is due to one of the criteria for closure site selection being based on whether it contains a viable population for rebuilding. Hence while some areas may

⁴ This refers to monitoring coverage in area closures where some line fishing is permitted. Outside of these areas, lower levels of monitoring apply.

have provided higher protection of habitat, they were determined to not hold viable populations for rebuilding (Williams *et al.* 2012a and 2012b).

Note that some closures continue to allow line fishing. Where this is the case, 100 per cent monitoring (electronic or observer), interaction limits and move-on provisions apply. These areas are Murray Dogfish closure, Murray Commonwealth Marine Reserve and the Freycinet Commonwealth Marine Reserve.

In addition, to the closure network, it is worth noting that a further 8.6 per cent of central southern dogfish core habitat area is outside of the GAB Trawl Sector boundary and is not included in the protection figures. While this area does not cover the entire depth range of the species it is effectively closed to trawl methods and offers protection to this stock.

Southern dogfish – western stock

Specific closures were not developed for the western stock of southern dogfish as the risk to these stocks is considered low given the type and limited extent of fishing in that area, as well a large network of marine protected areas. Further, insufficient data because of limited fishing effort, catch and research prevented core habitat protection figures being calculated.

Harrison's dogfish – seamount stock

In relation to the seamount stock of Harrison's dogfish, the depletion rate analysis suggests that the stock is healthy and the aim of this Strategy is to maintain the seamount stock above B_{LIM} and around B_{TARG} , in line with the HSP. Protection is afforded to this stock via closure of the Barcoo and Taupo seamounts, Derwent Hunter Seamount, Queensland Guyot and Britannia Guyot. Note that these areas are included in the Temperate East Marine Park network and AFMA applies additional restrictions on top of the marine park zones. A full list of all closures and complementary arrangements that apply are outline in Appendix B.

Economic impact of closures

As with any closure of fishing grounds, there is an economic impact on the fishing industry. In designing the network, AFMA focused on selecting sites of core habitat areas, combined with areas of least fishing effort, with a view to maximising opportunities for recovery of the species while minimising the economic impact on operators. The closures implemented under this Strategy represent 0.26 per cent of the total SESSF area.

Complementary management arrangements

The Closure Network is complemented by a range of operational measures including:

- fishing and handling practices apply across the SESSF to reduce the potential for interactions with upper-slope dogfish (e.g. through restrictions on soak time for the hydraulic hand reel method) and to minimise post-release mortality (all line fishing methods must not allow dogfish to go through the de-hooker);
- 100% monitoring through AFMA approved methods (electronic monitoring or observer) when fishing in closures to ensure compliance with operational management measures e.g. arrangements to minimise post-release mortality and interaction limits. Closures which allow limited fishing methods and are subject to

100% monitoring include the:

- Murray Dogfish closure
 - Murray Commonwealth Marine Reserve
 - Freycinet Commonwealth Marine Reserve
 - Taupo and Barcoo Seamount closures
 - Queensland and Britannia Seamount closures; and,
 - Option to access the Flinder's Research Zone closure, between 200 and 300 m, during daylight hours only.
- in the closures described above, a 12 month ban on fishing in that particular area when a boat interacts with three individual upper-slope dogfish (of the species Harrison's, southern or endeavour or any combination of those);
 - zero retention of gulper sharks across the whole SESSF to remove any incentive to target the species; and
 - monitoring outside closures areas:
 - ten per cent review of electronic monitoring footage in the GHAT Sector;
 - 100 per cent review of gillnet footage for TEP species in the Australian sea lion management zones;
 - integrated scientific monitoring program in the CTS covers three to four per cent of effort;
 - AFMA observer program in the GAB Trawl Sector covers one to four per cent of effort.

A summary of all closures and any complementary rules that apply are summarised in **Appendix B**.

These measures are supported by an auto-longline Code of Practice (SETFIA, 2006) related to handling of dogfish and education programmes for fishers aimed at improving identification and reporting of dogfish.

Compliance

AFMA has a dedicated compliance program that includes the compulsory use of Vessel Monitoring Systems (satellite location monitoring) and a variety of other tools. Penalties for fishing infringements can be very high and can include the loss of fishing concessions and boats. Consequently, fisheries management actions including quotas and fishery closures can be effectively enforced and existing prosecutions provide a strong deterrent to illegal activity. AFMA also undertakes annual compliance risk assessments of each fishery prior to determining its domestic compliance program for each year. Compliance resources are then apportioned across the fisheries in accordance with those risk assessments.

Commonwealth Marine Reserves

At the time AFMA was developing fishery specific management arrangements for upper-slope dogfish, the then Department of Sustainability, Environment, Water, Population and Communities was engaged in marine bioregional planning processes, with a number of Commonwealth Marine Reserve (CMR) boundaries

still to be established. While these reserves were not designed as fisheries management tools they may provide supplementary protection for upper-slope dogfish species. The boundaries and zoning of these marine reserves have since been finalised however new figures relating to the protection they afford dogfish have not been calculated. AFMA may consider the need to review the Strategy in light of the protection CMR provide dogfish in the future.

Regulation

The management measures outlined in the Strategy are given effect through the following pieces of legislation:

- area closures and trigger limits are given effect via a closure direction under S 41A(2) of the *Fisheries Management Act 1991* (FMA); and
- zero retention of dogfish⁵, handling practices (including the prohibition on allowing dogfish to pass through the de-hooker), and monitoring requirements are given effect through conditions placed on an operator's statutory fishing concession or permit, consistent with sections 22 and 32 of the FMA.

⁵ Noting this condition currently applies to more than the four species considered in the Strategy.

Monitoring and evaluation

This section has been directly informed by the outcomes of the project *Research to support the upper slope dogfish management strategy: options for monitoring the recovery of Southern Dogfish and Harrison's Dogfish*, completed in November 2018 (Williams *et al.* 2018), and built on earlier advice from the SESSF Resource Advisory Group (SESSFRAG). More detail is provided in the Upper Slope Dogfish Research and Monitoring Plan (the Plan) that outlines the priorities for data collection and how that information will be gathered in order to assess the performance of the Strategy. The Plan also provides a summary of research projects underway and a list of recently completed research projects.

Performance indicators

An increase in the relative abundance is considered as the best indicator of recovery and consequently, this is the key priority for monitoring to assess the performance of the Strategy. However, relative abundance of dogfish is expected to be measured most reliably within closures where there is no fishing (Williams *et al.* 2018) and consequently, requires fishery independent surveys. This is because logbook reporting is confounded by challenges in identifying species rapidly under the current handling practices required by the Strategy. For example, dogfish are required to be cut off the line as close to the water as possible by hook operators to maximise their chance of survival but this reduces the opportunity for accurate identification. Further, increases in abundance is expected to be higher within closures and therefore more readily detectable at this stage of population recovery.

Williams *et al.* (2018) identified another five prospective indicators of recovery that may, with time provide a measure of recovery:

- Area of occupancy ('distribution')⁶
- Size (age) composition⁷
- Sex composition⁸
- Catch and distribution in commercial bycatch⁹
- Genetic measures of connectivity and stock structure¹⁰

⁶ An expanding distribution would be an indicator of stock recovery.

⁷ An increasing size and presence of juveniles would be an indicator of stock recovery.

⁸ Observing separate male and female populations coming together to breed would be an indicator of stock recovery.

⁹ Increasing and expanding bycatch distribution would be an indicator of stock recovery.

¹⁰ Increasing complexity in population genetic structure would be an indicator of stock recovery.

Monitoring

Fishery Independent Survey

A Fishery Independent Survey (FIS), following the survey design of 'Option 1a' identified by Williams *et al.* (2018) is the highest priority for measuring performance of the Strategy in the next five years. The survey is based on the use of six reference sites across the SESSF using the auto-longline method with suitable fishing/handling practices to measure relative abundance. This methodology also provides the opportunity to collect data to support a level of monitoring of the other agreed indicators.

An initial survey commenced in 2022 and is expected to be repeated between five to ten years.

Fishery Dependent Data

Fishery dependent data will continue to be collected via fishers' logbooks with routine monitoring of commercial fishing activity by on-board observers and electronic monitoring. This will be supported by ongoing education of fishers to improve species identification and reporting. However, as outlined above, logbook reporting will continue to be confounded by challenges in identifying species rapidly under the current handling practices required by the Strategy.

Five-year review

AFMA will report annually on the performance of the Strategy against its objectives to the Department of Agriculture, Water and the Environment (DAWE).

The management strategy will be reviewed every five years.

Consultation

AFMA's broad-based consultative framework, including through the South East Management Advisory Committee (SEMAC), Slope Resource Assessment Group and other scientific experts, the fishing industry, conservation groups and the public, underpinned the development of the initial Strategy. The review of the Strategy in 2021 included consultation with relevant scientific experts, the public, GAB Resource Assessment Group, GAB Management Advisory Committee, SESSFRAG and SEMAC.

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Appendix A Core habitat

Protection of core habitat (carrying capacity weighted) in Commonwealth managed waters area under the closure network (per cent) for Harrison's dogfish (continental slope stock) and southern dogfish (eastern and central stock).

Closures	Harrison's dogfish	Southern dogfish	
	Continental slope	East	Central
Harrison's Gulper closure	1.70	1.01	
*Babel Island closure	<i>Inc. in Extended Flinders Research Zone closure</i>	<i>Inc. in Extended Flinders Research Zone closure</i>	
*Cape Barren closure	<i>Inc. in Extended Flinders Research Zone closure</i>	<i>Inc. in Extended Flinders Research Zone closure</i>	
St Helens Hill closure	0.64¹		
700 m closures	10.21¹	12.57¹	5.69¹
Area 1			5.26
Area 2			0.43
Area 3	0.71		
*Area 4	<i>Inc. in Extended Flinders Research Zone closure</i>	<i>Inc. in Extended Flinders Research Zone closure</i>	
Area 5	0.23	0.24	
Area 6	0.38	0.59	
Area 7	6.40	9.83	
Area 8	1.01	0.77	
Area 9	<i>Inc. in Extended Endeavour Dogfish Closure</i>	<i>Inc. in Extended Endeavour Dogfish Closure</i>	
Sydney Cable North	2.16	1.66	
Sydney Cable South	2.49	1.91	
60 mile closure (GAB and shark hook)			8.17
Current Endeavour Dogfish closure	4.92	3.78	
Current Port MacDonnell closure			0.75
Racetrack/Hamburger Orange Roughy closure			0.46
Kangaroo Hill closure			4.67
*Extended Flinders Research Zone closure	6.85	3.56	



*Extension to Endeavour Dogfish Closure off Sydney	7.08	5.44	
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	Continental slope	East	Central
*Extension to Port MacDonnell Closure			1.59
* Murray Dogfish closure (GABT and CTS)			7.54¹
Existing Commonwealth Marine Reserves (2013)	0.65¹	0	6.27²
Total	35.22	28.79	35.14³
Total across depth range²	25.00	16.22⁴	24.31

¹ Closures apply for trawl gears only while still allowing line fishing. However due to the complementary management arrangements for line fishing, AFMA considers these closures will provide equivalent protection to the species. The 700 m closures apply to trawl gear only, however it should also be noted that historically line fishing does not occur deeper than 600m.

² Closures across the depth range of the species need to be considered as the only closures providing 100 per cent protection to the stocks. Other closures will provide some level of protection but is hard to quantify.

³ A further 8.6 per cent protection is offered to this stock by the Great Australian Bight Trawl sector area of waters not covering some shallow areas of the core habitat of the southern dogfish central stock.

⁴ The closures do not rank as high for the eastern stock of southern dogfish as they are positioned close to the edges of their core distribution, therefore not scoring a high carrying capacity. However, the proposed closures have been chosen in areas where there are known populations of southern dogfish, increasing the likelihood of rebuilding in these areas. Whilst there may be areas with a higher carrying capacity for eastern southern dogfish, the populations in these areas are not sufficient to support any rebuilding.



Appendix B Complete list of closures and complementary measures

Spatial Closure	Southern and Eastern Scalefish & Shark Fishery and Small Pelagic Fishery (Closures) Direction 2021	Details	Complementary management arrangements where fishing is permitted inside closures
Harrison's Gulper closure	Schedule 12 Gulper shark Closure – Harrison's Dogfish	Closed to all fishing methods	Not applicable as fishing is not permitted
Babel Island closure	Schedule 39 Flinders Research Zone Closure	Closed to all fishing methods	If night time closures are negotiated in the future, all fishing will be subject to 100 per cent monitoring by an approved AFMA method
Cape Barren closure	Schedule 39 Flinders Research Zone Closure	Closed to all fishing methods	If night time closures are negotiated in the future, all fishing will be subject to 100 per cent monitoring by an approved AFMA method
St Helens Hill			No longer a closure. Fishing for orange roughy permitted, monitoring may be required. Risk of catching dogfish while fishing for roughy is low. Line fishing does not occur in this area as it is too deep.
700 m closures	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
<i>Area 1</i>	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
<i>Area 2</i>	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
<i>Area 3</i>	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
<i>*Area 4</i>	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
<i>Area 5</i>	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	



Spatial Closure	Southern and Eastern Scalefish & Shark Fishery and Small Pelagic Fishery (Closures) Direction 2021	Details	Complementary management arrangements where fishing is permitted inside closures
Area 6	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
Area 7	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
Area 8	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
Area 9	Schedule 13 South East Trawl Deep Water Closure	Closed to trawl fishing	
Sydney Cable North	Schedule 11 Gulper Shark Closure – Endeavour Dogfish	Closed to all fishing methods	Not applicable as fishing is not permitted
Sydney Cable South	Schedule 11 Gulper Shark Closure – Endeavour Dogfish	Closed to all fishing methods	Not applicable as fishing is not permitted
60 mile closure (GAB and shark hook)	Schedule 10 Commonwealth Gulper Shark Closure – Southern Dogfish	Closed to hook and trawl fishing	
Current Endeavour Dogfish closure	Schedule 11 Gulper Shark Closure – Endeavour Dogfish	Closed to all fishing methods	Not applicable as fishing is not permitted
Current Port MacDonnell closure	Schedule 32 Port MacDonnell Closure	Closed to all fishing methods	Not applicable as fishing is not permitted
Racetrack/Hamburger Orange Roughy closure	Schedule 26 GAB Orange Roughy Zone – Racetrack/Hamburger	Closed to trawl fishing	Re-opening to targeted orange roughy fishing in 2021 deeper than 700m initially under a scientific permit and potentially commercial fishing in the future. Impact on dogfish strategy considered low impact given little overlap of habitat and low risk of interaction.
Kangaroo Hill closure	Schedule 27 GAB Orange Roughy Zone – Kangaroo Island Hill	Closed to trawl fishing	Re-opening to targeted orange roughy fishing in 2021 deeper than 700m initially under a scientific permit and potentially commercial fishing in the future. Impact on dogfish strategy considered low impact given little overlap of habitat and low risk of interaction.



Spatial Closure	Southern and Eastern Scalefish & Shark Fishery and Small Pelagic Fishery (Closures) Direction 2021	Details	Complementary management arrangements where fishing is permitted inside closures
Extended Flinders Research Zone closure	Schedule 39 Flinders Research Zone Closure	Closed to all fishing methods	If night time closures are negotiated in the future, all fishing will be subject to 100 per cent monitoring by an approved AFMA method
Extension to Endeavour Dogfish Closure off Sydney	Schedule 11 Gulper Shark Closure – Endeavour Dogfish	Closed to all fishing methods	Not applicable as fishing is not permitted
Extension to Port MacDonnell Closure	Schedule 32 Port MacDonnell Closure	Closed to all fishing methods	Not applicable as fishing is not permitted
Murray Dogfish closure (GABT and CTS)	Schedule 33 Murray Dogfish Closure	Closed to trawl fishing	Boat interaction limit of three gulper sharks which if reached the holder is excluded from fishing in that area for 12 months 100 % monitoring via observers or EM (hydraulic hand reel method excluded). Hydraulic Hand Reel restricted to Maximum soak time of 90 minutes and no more than 25 hooks per line.
Existing Commonwealth Marine Reserves (July 2013)		Closed to all fishing methods in Sanctuary Zones, Marine National Park Zones, Recreational Use Zones and Special Purpose Zones. Activity is allowed in accordance with a class approval from the Director of National Parks in Habitat Protection Zones and Multiple Use Zones.	Murray Commonwealth Marine Reserve Closures and Freycinet Commonwealth Marine Reserve Closures closed to trawling and require 100 % monitoring via observers or EM for other methods (hydraulic hand reel method excluded). Hydraulic Hand Reel restricted to Maximum soak time of 90 minutes and no more than 25 hooks per line.
Barcoo & Taupo Seamounts	Schedule 29 Barcoo and Taupo Seamounts	Closed to trawl fishing (AFMA) Closed to demersal longline and auto-longline (CMR) Minor line (includes Hydraulic Hand Reel) and dropline permitted.	Boat interaction limit of three gulper sharks which if reached the concession holder is excluded from fishing in that area for 12 months 100 % monitoring via observers or EM (hydraulic hand reel method excluded). Hydraulic Hand Reel restricted to Maximum soak time of 90 minutes and no more than 25 hooks per line.



Spatial Closure	Southern and Eastern Scalefish & Shark Fishery and Small Pelagic Fishery (Closures) Direction 2021	Details	Complementary management arrangements where fishing is permitted inside closures
Derwent Hunter Seamount	Schedule 31 Derwent Hunter Seamount Closure	Closed to all fishing methods	Not applicable as fishing is not permitted
Queensland & Britannia Seamounts	Schedule 30 Queensland and Britannia Seamounts Closure	Only hydraulic hand reel permitted.	Hydraulic Hand Reel restricted to Maximum soak time of 90 minutes and no more than 25 hooks per line.



