Conservation Services Programme

DRAFT

Protected Marine Fishes Medium-Term Research Plan

December 2022

Conservation Services Programme

Department of Conservation

1. Purpose

The Conservation Services Programme (CSP) undertakes research to understand and address the effects of commercial fishing on protected marine species in New Zealand fisheries waters (CSP Strategic Statement).

This CSP protected fish medium term research plan (the plan) outlines a rolling five-year research programme to deliver on the protected fish population, mitigation and interaction research component of CSP. It has been developed as part of the work of the CSP Research Advisory Group (CSP RAG) and will be used in the development of CSP Annual Plans and any other relevant delivery mechanisms. Protected fishes include some sharks, rays and teleost species.

Development of the plan has been guided by the objectives of the CSP, Te Mana o te Taiao - Aotearoa New Zealand Biodiversity Strategy 2020, and the National Plan of Action for the Conservation and Management of Sharks 2013 (NPOA-Sharks). It has also been informed by relevant scientific research including Francis & Lyon (2012, 2014), Francis & Sutton (2012), Jones & Francis (2012), Francis (2013), Howard (2015), Francis (2017a, b), Francis & Jones (2017), Parker & Rexer-Huber (2019), Finucci et al. (2021), and qualitative risk assessment and threat classifications for New Zealand sharks and rays (Ford et al. 2018; Duffy et al. 2018; Finucci et al. 2019).

Research falling outside the scope of the CSP, including bycatch of protected species by recreational fishers, is not covered by this plan.

2. CSP objectives

A. *Proven mitigation strategies are in place to avoid or minimise the effects of commercial fishing on protected species across the range of fisheries with known interactions.*

B. *The nature of direct effects of commercial fishing on protected species is described.*

C. *The extent of known direct effects of commercial fishing on protected species is adequately understood.*

D. *The nature and extent of indirect effects of commercial fishing are identified and described for protected species that are at particular risk to such effects.*

E. *Adequate information on population level and susceptibility to fisheries effects exists for protected species populations identified as at medium or higher risk from fisheries.*

3. Protected marine fishes

Marine fishes protected in New Zealand waters are listed in Table 1. Protection under the Wildlife Act 1953 covers the Territorial Sea and Exclusive Economic Zone, joint protection under the Fisheries Act 1996 extends protection to New Zealand vessels fishing on the High Seas.

Prohibitions on retention, trans-shipment, and landing of oceanic whitetip sharks (*Carcharhinus longimanus*) have also been adopted by the following regional fisheries management organisations (RFMOs):

- International Commission for the Conservation of Atlantic Tunas (ICCAT)
- Inter-American Tropical Tuna Commission (IATTC)
- Western and Central Pacific Fisheries Commission (WCPFC).

Cetorhinus maximus, Carcharodon carcharias, Carcharhinus longimanus and *Mobula* spp. are listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Protection of these species under the Wildlife Act 1953 means that CITES export permits or re-export certificates will only be issued for the export of specimens and samples of these species for scientific research or possibly cultural use.

Table 1. Conservation status of protected marine fishes. Alternative common names and synonyms given in brackets.

Common names	Scientific Name	Family	Protecting Legislation	NZTCS Status	Qualifier	IUCN Red List status (Global)
Whale shark	*Rhincodon typus*	Rhincodontidae	Wildlife Act 1953	Migrant	Stable Overseas	Endangered (decreasing population)
Smalltooth sandtiger shark (deepwater nurse shark)	*Odontaspis ferox*	Odontaspididae	Wildlife Act 1953	At Risk – Naturally Uncommon	Threatened Overseas	Vulnerable (decreasing population)
Basking shark	*Cetorhinus maximus*	Cetorhinidae	Wildlife Act 1953 Fisheries Act 1996	Threatened – Nationally Vulnerable		Vulnerable (decreasing population)
Great white shark (white shark, white pointer)	*Carcharodon carcharias*	Lamnidae	Wildlife Act 1953 Fisheries Act 1996	Threatened – Nationally Endangered	Data Poor, Threatened Overseas	Vulnerable (population trend unknown)
Oceanic whitetip shark	*Carcharhinus longimanus*	Carcharhinidae	Wildlife Act 1953 Fisheries Act 1996	Migrant	Stable Overseas	Vulnerable (decreasing population)
Giant manta ray	*Mobula birostris*	Mobulidae	Wildlife Act 1953	Data Deficient	Threatened Overseas	Vulnerable (decreasing population)

Common names	Scientific Name	Family	Protecting Legislation	NZTCS Status	Qualifier	IUCN Red List status (Global)
(Oceanic manta ray)	*(Manta birostris)*					
Spinetailed devil ray	*Mobula mobular* *(M. japanica)*	Mobulidae	Wildlife Act 1953	Data Deficient	Stable Overseas	Near Threatened (population trend unknown)
Spotted black grouper	*Epinephelus daemelii*	Serranidae	Wildlife Act 1953	Not Threatened	Threatened Overseas	Near Threatened (population trend unknown)
Giant grouper (Queensland grouper)	*Epinephelus lanceolatus*	Serranidae	Wildlife Act 1953	Vagrant	Threatened Overseas	Data Deficient (decreasing population)

4. Threat classification and risk assessment

Threat classification

The conservation status of all known New Zealand chimaeras, sharks and rays was reassessed in 2016 (Duffy et al. 2018).

Great white shark (*Carcharodon carcharias*)

This species was classified as Nationally Endangered due to the estimated population size of the East Australian-New Zealand population (Blower et al. 2012; Duffy et al. 2012; Bruce et al. 2018; Hillary et al. 2018). Genetic mark-recapture analyses estimated adult abundance to be between 590 and 750 individuals, and a total population of 5460 (2909–12 802) (Bruce et al. 2018). The mean adult population trend is estimated to have remained stable since the early–mid 2000s (Bruce et al. 2018). The conservation status of this species had previously been assessed as Gradual Decline based upon its low biological productivity and reported levels of bycatch in domestic commercial and recreational fisheries (Hitchmough et al. 2007).

Basking shark (*Cetorhinus maximus*)

This species was assessed as Nationally Vulnerable based upon small estimated global population, published catch estimates and an absence of sightings of surface aggregations at coastal hot spots since the mid–late 1990s (Francis & Duffy 2002; Hoelzel et al. 2006; Francis & Smith 2010; Francis & Lyon 2012). Finucci et al. (2019) found that basking sharks met the IUCN Red List criteria for Vulnerable, noting that the level of estimated commercial catch in New Zealand fisheries is comparable to that which drove the species close to local extinction in British Columbia between 1945 to 1970. Catch per unit effort (CPUE) peaked between 1988–1991 and has been near or at zero since the mid-2000s (Francis & Sutton 2012). Given the species capacity for trans-oceanic movement it is unknown if this reflects a change in fishing gear or practice resulting in decreased interactions with fishing vessels, a change in the distribution of basking sharks or a true decline in abundance (Skomal et al. 2009; Francis, 2017b; Dewar et al. 2018). This apparent decline in abundance is of concern as New Zealand appears to be the Southern Hemisphere hot spot for the species. There are few records of basking shark from the Indian Ocean, and it is considered rare in Australian waters, where it is only known from scattered occurrences (Bray, 2018).

In New Zealand waters, basking sharks are mainly taken in trawl fisheries off east and west coasts of South Island and in the Subantarctic Zone. Historical capture locations were predominantly east of Banks Peninsula, the west coast South Island between Westport and Hokitika, Puysegur, the shelf edge south and east of Stewart Island and the Snares Islands, and around the Auckland Islands (Francis & Duffy 2002; Francis & Smith 2010; Francis & Lyon 2012; Francis & Sutton 2012). Basking sharks caught off the West Coast and in the Subantarctic are mainly mature males, whereas the sharks taken off the east coast South Island are mainly immature male and females less than 7 m total length (Francis & Duffy 2002). High Seas records of basking sharks extend across the South Pacific to South America but Yatsu (1995) reported more were observed at longitudes between 150E and 150W. Yatsu (1995) also reported the capture of several very small juveniles near the Louisville Seamount Chain (37oS, 171oW). One small juvenile less than 3 m total length was seen in New Zealand waters off Cape Kidnappers, Hawke Bay, in 1996 (Clinton Duffy, pers. obs.).

Spinetailed devil ray (*Mobula mobular*)

This species was assessed as Data Deficient reflecting recent evidence of breeding in New Zealand waters, the species' overlap with the skipjack purse seine fishery and the lack of robust, long-term data on bycatch (Duffy et al. 2018; Ford et al. 2015, 2018).

Giant manta ray (*Mobula birostris*)

This species was assessed as Data Deficient reflecting uncertainty around the species' residency in New Zealand waters (Duffy et al. 2018).

Oceanic whitetip shark (*Carcharhinus longimanus*)

Finucci et al. (2019) classified this species as critically endangered based upon significant declines in CPUE and other fishery indicators across the species range (e.g. Young et al. 2018).

Smalltooth sandtiger shark (*Odontaspis ferox*)

This uncommon deep-water species was assessed as At Risk – Naturally Uncommon (Threatened Overseas) (Duffy et al. 2018). Its preferred habitat appears to be deep reefs, oceanic ridges, and sea mounts between 70-900 m depth. Significant declines in abundance of the species in southern Australia have been attributed to bycatch in trawl fisheries (Fergusson et al. 2008).

Whale shark (*Rhincodon typus*)

This species is classified as a Migrant in New Zealand waters (Duffy et al. 2018). Its global IUCN Red List classification is Endangered, Population Trend – Decreasing. Combined abundance data for the Indo-Pacific and Atlantic regions suggests a greater than 50% decline in the global population over the last 75 years (Pierce & Norman 2016).

<u>Giant grouper (*Epinephelus lanceolatus*) and spotted black grouper (*E. daemelii*)</u>

The conservation status of giant grouper and spotted black grouper has not been assessed since 2005. The status of these species is Vagrant (Threatened Overseas) and Not Threatened (Conservation Dependent, Threatened Overseas) respectively. Abundance and size composition of spotted black grouper around mainland New Zealand is poorly documented (Francis et al. 2016). The only breeding population in New Zealand waters is thought to occur around the Kermadec Islands.

Fishery risk assessments

The risk posed to a species by fishing is a product of the biological characteristics of the species (e.g., intrinsic population growth rate) and the extent to which it interacts with fishing activity. Availability or exposure to fishing is a product of spatial and temporal overlap with fisheries and susceptibility to being caught in the various fishing gears (Ford et al. 2015, 2108).

The first qualitative assessment of the risk commercial fishing posed to New Zealand sharks and rays undertaken by Ford et al. (2015) allocated the highest risk scores for protected species to basking shark, great white shark and spinetailed devil ray. Whale shark, oceanic whitetip shark and giant manta ray received the lowest risk scores possible due to either the lack of any confirmed captures in New Zealand waters (whale shark, giant manta ray), or an absence of reported captures in the five years prior to the assessment (oceanic whitetip shark). Basking shark, great white shark and spinetailed devil ray each had an overall Risk Score of 13.5, and smalltooth sandtiger had a Risk Score of 8. Although these risk scores were lower than almost all Quota Management System (QMS) sharks and many non-QMS sharks, basking shark, great white shark, smalltooth sandtiger and spinetail devil ray received consequence scores of 4.0-4.5 indicating a high likelihood of actual, or potential for, unsustainable impacts (Ford et al. 2015). The overall risk and consequence scores for basking shark, great white shark and spinetailed devil ray did not change when the risk assessment was updated in 2017. Smalltooth sandtiger, whale shark, oceanic whitetip shark and giant manta ray were not reassessed in 2017 due to the small size/absence of reported captures in commercial fisheries (Ford et al. 2018).

Basking shark and spinetailed devil ray comprise most reported captures of protected fishes, although the majority of basking shark captures occurred prior to their protection in 2010 (Francis & Duffy 2002; Francis & Smith 2010; Francis & Lyon 2012; Francis & Sutton 2012). Since 2010 almost all reported basking shark captures have been in midwater trawl fisheries, whereas almost all spinetailed devil rays have been taken in the skipjack purse seine fishery (Francis & Lyon 2012; Jones & Francis 2012; Ford et al. 2015, 2018). Most reported captures of great white sharks are in set net and trawl fisheries (Francis & Lyon 2012; Ford et al. 2015, 2018).

Reported commercial catches of spotted black grouper are very small, and there are no confirmed catches of giant grouper (Francis & Lyon 2012).

Non-reporting and misidentification of all protected fishes are known to occur, particularly in fisheries with low observer coverage, meaning the extent to which reported captures reflect the actual catch of most species is unknown (Francis & Lyon 2012; Ford et al. 2015, 2018; Duffy et al. 2018; Finucci et al. 2019).

Whale shark

There is no reported commercial catch in New Zealand. Outside New Zealand waters purse-seines are sometimes set around tuna schools associated with whale sharks and baleen whales. Parties to the Nauru Agreement, a subregional agreement on terms and conditions for tuna purse seine fishing licences in the Western tropical Pacific, adopted a ban on setting on whale sharks in 2010. In January 2014 similar rules were extended to all waters within the Western and Central Pacific Fisheries Convention Area (Clarke 2015). As whale sharks are seldom seen prior to the net being set it is likely that less than one-third of purse-seine interactions are prevented by this measure. Even with improved safe release methods mortality of whale sharks taken in Western and Central Pacific Ocean purse seine fisheries could be as high as 50% (Clarke 2015; Escalle et al. 2016).

Basking shark

Observed raw trawl CPUE has been at or near zero in East Coast and West Coast fisheries since the mid-2000s, whereas in the Southland–Auckland Islands region (SA) it has fluctuated around very low levels. Most (83%) captures reported between 2011–2016 occurred in SA (Francis 2017b). It is not known if the low number of captures since the mid-2000s reflects changed fishing practices, a change in the regional distribution of sharks, or a real decline in abundance. More than half of the reported captures occurred in the arrow squid target trawl fishery. Catch rates were greatest in 200–400 m depth. Capture rates were moderate down to 800 m depth, particularly in the hake fishery. One fishing vessel was responsible for 52% of captures in SA. This is may have been due to a combination of high fishing effort, high headline height and the greater depths fished by that vessel (Francis 2017b).

Headline height and depth appear to be the best predictors of basking shark catches, and thus potentially offer a basis for development of mitigation measures to reduce bycatch. In the SA region, catch rates were greatest when headline heights exceeded 4 m, and when tows were in depths of 200–400 m. Constraining headline heights to less than 4 m and reducing fishing in the preferred depth range of sharks may reduce basking shark captures but other factors, including environmental ones, may be influencing catch rates.

Great white shark

Adult population size is estimated to have been stable, or to have slightly declined since the early–mid 2000s (Bruce et al. 2018). This assessment used population models informed by estimates derived from genetic mark-recapture analyses. Genetic samples were obtained from bycatch, sharks killed in Australian swimmer protection programmes and from living sharks sampled by researchers. This fishery independent approach was necessitated by the absence of robust long-term fishery data sets that could be used to assess trends in abundance. The lack of fishery data for this species is due in part to non-reporting prior to protection under the Wildlife Act in 2007. Levels of non-reporting since 2007 are not known. Juveniles and adults are taken in set net, trawl and demersal longline fisheries (Ford et al. 2015, 2018). There are occasional reports of entanglements in commercial rock lobster and cod pot float lines.

Oceanic whitetip shark

Oceanic white-tip sharks are an infrequent bycatch in surface longline fisheries off northern New Zealand (Francis & Lyon 2014). This species is also taken by tuna purse seine fisheries in tropical and subtropical regions but there is no reported purse seine bycatch in New Zealand (Young et al. 2018).

Smalltooth sandtiger

The smalltooth sandtiger is taken in set net, bottom longline and trawl fisheries. The species' patchy distribution, tendency to aggregate around deep reefs, low natural abundance and low fecundity make it vulnerable to overfishing (Fergusson et al. 2008). A significant decline in abundance of the species off south-east Australia between 1972 and 1997 has been attributed to incidental mortality in outer shelf-upper slope trawl fisheries (Andrew et al. 1997; Fergusson et al. 2008). No robust catch or population trend information is available for this species in New Zealand waters due to non-reporting and high levels of misidentification by fishers and observers (Francis & Lyon 2012). Aggregations of smalltooth sandtiger sharks have been documented at L'Esperance Rock, Kermadec Islands Marine Reserve, and Volkner Rocks, Bay of Plenty. There is an unconfirmed anecdotal report of an aggregation site off Tolaga Bay, East Coast. The only west coast North Island reports are of two juvenile females caught in set nets at about 40 m depth south of New Plymouth. Elsewhere within the New Zealand region the species has been recorded from Norfolk Ridge, Three Kings Islands, Kermadec Ridge, Louisville Ridge, White Island, Gisborne, off Mahia Peninsula and Lachlan Banks (Garrick 1974; Fergusson et al. 2008; Francis & Lyon 2012).

Spinetailed devil ray

Observed and fisher reported catches of spinetailed devil rays are highly variable between years presumably reflecting the influence of environmental factors on their distribution and that of the target species. Levels of mortality in the skipjack purse seine fishery are uncertain for two key reasons. Most bycaught individuals of this species are reported to be released alive however, a study conducted shortly after the species was protected in 2010 found that post-release mortality was high, even of rays in apparently good condition (Jones & Francis 2012; Francis 2013; Francis & Jones 2017). Specimens of near-term embryos have occasionally been collected from purse seines indicating an additional source of mortality is abortion of embryos during capture (Paulin et al. 1982; Stewart 2002).

Spotted black grouper

There have been infrequent commercial captures of spotted black grouper in coastal set net fisheries around the North Island and west coast South Island (Francis & Lyon 2012; Roberts et al. 2015). Reported captures in fisheries operating in water depths greater than about 50 m are likely to be misidentifications of eightbar/convict grouper (*Hyporthodus octofasciatus*). This species suffers barotrauma even when caught at depths as shallow as about 20 m. Post-release survival has not been studied.

5. Information needs

In general, there is a lack of data on the biology, population size and population structure of protected fishes in New Zealand (Table 2) (Francis & Lyon 2012; Ford et. al. 2015, 2018). This section briefly summarises the information required to understand the impacts of commercial fisheries on protected marine fishes. It reflects information needs identified by previous CSP projects and in published scientific literature.

Whale shark

All biological parameters are poorly estimated due to lack of access to specimens (Rowat & Brooks 2012). The species' distribution in New Zealand waters is reasonably well known from documented sightings however movements within New Zealand waters and between New Zealand and other range states are unknown (Duffy 2002; Francis & Lyon 2012).

Smalltooth sandtiger

All biological parameters are poorly estimated or unknown due to lack of access to specimens (Fergusson et al. 2008; Francis & Lyon 2012). Distribution in New Zealand waters is poorly known. Population size structure and trends, movements and stock structure are unknown. Captures in commercial fisheries are poorly documented but are known from Bay of Plenty, including White Island and Volkner Rocks, Hawke Bay, Taranaki and Louisville Ridge (Fergusson et al. 2008; Francis & Lyon 2012; Ford et al. 2015).

Basking shark

Most biological parameters are poorly estimated due to operational difficulties associated with sampling such large animals aboard commercial fishing vessels, and the disappearance of surface schools from coastal waters. Size and age structure, and length at maturity in New Zealand waters are poorly known. Research is required to determine if basking sharks can be aged from their vertebrae. Difficulties include variation in the number of growth bands along the length of the vertebral column and the presence of about seven bands at birth. Other estimates of age and growth are imprecise or speculative and based on untested assumptions (Francis & Lyon 2012). Little is known of reproduction, including size at birth (Francis & Duffy 2002; Francis & Lyon 2012).

Captures of basking sharks off the east and west coasts of South Island and elsewhere in New Zealand waters have dropped to negligible levels. Whether this reflects a change in fishing practices resulting in decreased bycatch, or a serious reduction in the natural population of sharks in those regions is unknown (Francis 2017b). Global population connectivity inferred from genetic and satellite tagging studies appears to be high suggesting the possibility that regional declines in abundance could be due to large scale shifts in distribution (Hoelzel et al. 2006). However, genetic sampling of seasonal aggregations of basking sharks in the Northeast Atlantic has revealed unexpectedly complex population structure with high levels of relatedness within schools, and synchronous movement of groups of related individuals into and out of aggregation sites (Lieber et a. 2020). Genetic sampling of basking sharks undertaken in New Zealand waters to date has been haphazard. A more systematic approach to sampling bycaught sharks and surface schools (if these reappear in coastal waters) is required to understand population structure of basking sharks occurring here, and their relationship to basking sharks elsewhere in the Southern Hemisphere.

Spatial changes in the abundance of planktonic prey appear to be important drivers of basking shark distribution and abundance in other parts of the species' range and may have contributed to the decline in abundance observed here (Sims 2008; MfE & Stats NZ 2019). However, the lack of knowledge of basking shark diet and feeding behaviour in New Zealand makes this possibility difficult to assess. Only two non-quantitative observations of the stomach contents of individual sharks captured in shallow inshore waters have been reported from New Zealand, no stable isotope or fatty acid analyses of New Zealand basking shark tissues have been undertaken, and there is no information on the relationship between prey distribution and foraging behaviour in New Zealand waters.

Research on the environmental drivers of basking shark distribution in New Zealand waters undertaken by the CSP in 2020 suggests suitable basking shark habitat occurs over the upper continental slope around much of New Zealand however, data limitations (i.e. relatively small sample size; presence only; long time span – 121 years; absence of prey distribution models north of 39°S) mean the results may be a better representation of the species' historic rather than contemporary distribution. Satellite tracking data from the Northern Hemisphere also indicate that basking sharks occupy oceanic habitats for prolonged periods during which time they seldom appear at the surface, preferring depths between 200-1000 m (Skomal et al. 2009; Braun et al. 2018; Dewar et al. 2018). The absence of data on movements, depth preferences and diving behaviour in the Southern Hemisphere means it has not been able to assess basking shark use of oceanic habitats in the New Zealand region.

Bycatch outside the New Zealand EEZ, particularly in the jack mackerel fishery within the South Pacific Regional Fishery Management Organisation area, is poorly known.

No biomass estimates or information on trends in basking shark size composition are available.

Great white shark

Size and age at maturity, fecundity and reproductive periodicity are poorly defined due to their relative rarity and operational difficulties associated with sampling such large animals aboard commercial fishing vessels. Long-distance movements and regional connectivity of sub-adult and adult males, and sub-adult females tagged at aggregation sites in central and southern New Zealand are well known. Fine scale habitat use by all size and sex classes remains poorly known. Almost all aspects of the distribution, movements and ecology of mature females in the East Australian-New Zealand population are unknown.

Reconstruction of commercial catches of great white sharks is not possible to a lack of data prior to protection and unknown levels of non-reporting following protection. No information is available on post-release survival of sharks taken as bycatch in commercial fisheries in New Zealand. An attempt to investigate post-release survival in coastal set net fisheries failed due to low encounter rates and operational difficulties getting observers aboard fishing vessels. Safety constraints also make it difficult or impossible for observers to tag large great white sharks landed aboard commercial fishing vessels.

No biomass estimates or information on trends in great white shark size composition are available. Population size and trend has been estimated using genetic data (Bruce et al. 2018; Hillary et al. 2018).

Oceanic whitetip shark

Existing growth models for the SW Pacific lack age estimates for large adults (>2m TL) and juvenile specimens. Collection of material in NZ waters may help improve these.

Giant manta ray

Most biological parameters are poorly estimated due to lack of access to specimens. Size, age structure and movements in New Zealand waters and elsewhere in the SW Pacific are unknown.

Spinetailed devil ray

Most biological parameters are poorly estimated due to lack of access to specimens. Size, age structure and reproductive condition in New Zealand waters are poorly known (Duffy & Tindale 2018; Ford et al. 2018). Cuevas-Zimbrón et al. (2013) investigated aging spinetailed devil rays using caudal vertebrae from below the origin of the dorsal fin. While they concluded that it was feasible to age them using this method they noted the need for validation analysis, a larger sample size and better coverage of size classes. Factor's influencing capture, post-release survival and movements are poorly known (Jones & Francis 2012; Francis 2013; Francis & Jones 2017).

Structural change in the purse seine fishery since the last characterisation of fishery interactions with this species has resulted in changes in vessel size and operating practices, including handling and release methods (Francis & Lyon 2012; Jones & Francis 2012). Industry advice is that few devil rays are now landed on deck due to the absence of large vessels in the fishery, with most brailed for direct release or released over the cork-line (Pelco NZ Ltd., February 2021). The influence of these changes on devil ray bycatch and post-release survival is unknown, as are environmental factors influencing spatial and temporal variation in encounter rates with devil rays in New Zealand waters. Although devil rays frequently associate with skipjack tuna and may be caught with them, they are also observed in areas where there do not appear to be commercial quantities of skipjack (Clinton Duffy pers. obs.). Estimating spatial and temporal overlap with the skipjack purse seine fishery will be necessary for improved risk assessment.

Spotted black grouper

All biological parameters are unknown or poorly estimated due to lack of access to specimens. Maximum age is thought to be around 65 years but no specimens approaching maximum reported size have been aged (Francis et al. 2016). Spotted black grouper have very specific habitat requirements (i.e. shallow rock or coral reef systems with caves and overhangs) which limit their distribution. However, little is known of their patterns of habitat use, residency and movements due the rapid, early depletion of populations throughout their range (Francis et al. 2016). Size structure, abundance and population trends in New Zealand waters have not been studied. Francis et al. (2016) conclude further genetic studies would improve understanding of sources of source populations and recruitment processes. Better data commercial catches, and post-release survival is required.

Giant/Queensland grouper

Most biological parameters are unknown or poorly estimated. The lack of life history data prevents estimation of generation length. Spawning behaviour and most aspects of the species' ecology including movements and population connectivity are poorly known (Fennessy et al. 2018).

Table 2. Quality of information available for assessment of the effects of commercial fishing on protected marine fishes in New Zealand waters. Proportion of population in NZ: 1 = Low, 2 = Moderate, 3 = High. Information quality: 0 = none, 1 = poor, 2 = moderate, 3 = good, 4 = excellent, NA = not applicable (modified from Francis & Lyon 2012).

	Stock-Population Unit						Biological information (productivity)					
Species	Proportion of population in NZ	Genetic stock structure	Movements	World distribution	Habitat use	Sum	Growth	Longevity	Maturity	Reproduction	Natural mortality	Sum
Whale shark	1	2	2	3	3	10	1	1	1	1	1	5
Smalltooth sand tiger	2	0	0	2	1	3	0	0	1	1	0	2
Basking shark	3	1	2	3	2	8	1	1	1	1	1	5
Great white shark	3	3	3	3	3	12	2	1	2	1	1	7
Oceanic whitetip shark	1	2	1	3	2	8	3	3	3	3	2	14
Spinetailed devil ray	2	0	1	3	3	7	1	1	2	2	0	6
Giant manta ray	3	1	1	3	2	7	0	1	2	2	0	5
Spotted black grouper	3	1	0	4	3	8	2	2	1	1	2	8
Giant grouper	1	0	0	3	3	6	0	0	1	0	0	1

	Overlap with fisheries in NZ					Response to catch in NZ			
Species	Proportion of population in NZ	Stock distribution	Fishery distribution	Size class reported in catch	Sum	Catch trend	Biomass	Size composition	Sum
Whale shark	1	3	4	none	7	3	NA	NA	3
Smalltooth sand tiger	2	1	1	all	2	1	0	0	1
Basking shark	3	3	2	>4m	5	2	0	0	2
Great white shark	3	3	2	all	5	1	0	0	1
Oceanic whitetip shark	1	3	4	>1.8 m	7	1	0	0	1
Spinetailed devil ray	2	3	3	all	6	2	0	0	2
Giant manta ray	3	2	3	none	5	3	NA	NA	3
Spotted black grouper	3	3	3	all	6	1	0	0	1
Giant grouper	1	3	2	none	5	0	NA	NA	0

6. Proposed research

The following proposed projects address the knowledge gaps identified above and are intended to improve understanding of the actual and potential risks to protected fishes from commercial fishing. Species-specific projects are identified for smalltooth sandtiger, basking shark, great white shark and spinetailed devil ray. Basking shark, great white shark and spinetailed devil ray are the protected elasmobranchs assessed to be a greatest risk from commercial fishing by Ford et al. (2015, 2018), and are caught in larger numbers than all other protected fishes. Great white sharks are also caught in the greatest number of fisheries. Although reported captures of smalltooth sandtiger are very low, this species has shown very little resilience to bycatch in commercial fisheries elsewhere and existing commercial catch data is considered poor (Fergusson et al. 2008; Ford et al. 2015). No species-specific projects are proposed for whale shark, oceanic whitetip shark, giant manta ray, spotted black grouper or giant grouper as these species are either not caught, or caught in negligible numbers by commercial fisheries within New Zealand waters. Understanding the impact of commercial fishing on these species will be primarily achieved through periodic assessments of reported catch, observer reports and other forms of catch monitoring.

The proposed research projects have been developed to wherever possible provide:

- improved identification of protected fishes
- improved collection of biological samples from dead specimens to enable estimation of fishery relevant life history parameters such as size and age at maturity, fecundity, growth rates and maximum age
- better understanding of population structure and connectivity within the New Zealand EEZ and elsewhere within the species' ranges
- improved understanding of spatial and temporal overlap between commercial fisheries and protected fishes
- assessment of post-release survival
- safe release methods that maximise post-release survival.

Prioritisation of projects considered:

- species risk assessments and threat classification
- existing information and information gaps
- the frequency of fishery interactions
- potential synergies with other research projects
- the potential to leverage additional resources from other programmes
- legal and logistic constraints (e.g. animal ethics, health and safety, retention of protected species, size and encounter rates)

- the need for periodic review to ensure ongoing relevance of data and sample collection.

Observer Programme

As well as providing independent information on catch, effort and fishing practices fishery observers play an important role in documenting protected species interactions with fisheries, the efficacy of mitigation measures, obtaining data and samples from live and dead specimens, and assisting with tagging studies.

Improving understanding of life history characteristics of protected fishes informs assessments of their conservation status and the effects of commercial fishing on them. Knowledge of life history parameters for most protected fishes is poor (Francis & Lyon 2012; 2014). Collection of data and biological samples from bycaught animals is often the only means of estimating characteristics such as growth and longevity, size at sexual maturity, litter size and gestation period (Francis & Lyon 2012). Data and samples that should be routinely collected from live protected species landed during commercial fishing operations includes length (total, fork and standard/precaudal length), sex and maturity (where this can be determined externally) and a fin clip for genetic analyses. In the case of sharks and rays the number, size and sex of any aborted embryos should be recorded. Wherever possible dead specimens should be retained and returned to shore for research. Specimens returned to the water or released alive should be tagged, either with conventional plastic streamer tags or electronic tags. All suspected protected species should be photographed to confirm identification.

The degree of post-release mortality of protected fishes in commercial fisheries is not well understood. Some fishery-species interactions have a higher incidence of live release than others, however individuals assessed as alive and in good condition at release may be subject to high levels of post-release mortality due to internal injuries or species-specific physiological responses to capture (Gallagher et al. 2014; Campana et al. 2016). For example, Francis & Jones (2014) found that spinetailed devil rays assessed by observers as in good condition upon release suffered high (75%) post-release mortality. At present estimates of post-release mortality are only available for a relatively small sample of spinetailed devil rays released from skipjack tuna purse seines that were tagged with Survival Pop-up Archival Tags (sPATs) (Jones & Francis 2012; Francis 2013; Francis & Jones 2017). In addition to increasing the sample size of devil rays tagged with sPATS, post-release survival of basking shark, great white shark and smalltooth sandtiger should be investigated using this technology (Francis 2017a, 2019; Francis & Jones 2017).

Low observer coverage in inshore fisheries means understanding of protected species interactions with these fisheries is limited. Increased observer coverage or the implementation of effective electronic monitoring technologies in these fishers should be a priority, particularly in South Island trawl and set net fisheries where there appear to be ongoing issues of non-reporting captures of basking shark and great white shark, and west coast of North Island where levels of observer coverage are low or lacking (Francis 2017a; Parker & Rexer-Huber 2019).

A prerequisite for accurate reporting of protected fish bycatch is accurate species level identification. Ongoing review of identifications, observer training and review of observer photographs of protected species is required to maintain and improve data quality (Weaver 2019).

Smalltooth sandtiger

The main problems with existing fishery data are misidentification and non-reporting, meaning knowledge of the actual bycatch in New Zealand fisheries is limited. Confirmed captures have been documented in set net and trawl fisheries around the upper North Island and on Louisville Ridge. Observer briefings should prioritise identification of this species and the need retain dead specimens for research or collect life history data and genetic samples from specimens that cannot be retained. This species is a priority for post-release survival and satellite tagging studies. To increase the chances of success satellite tags should be issued to fishery observers and/or fishers operating in areas where the species is known to aggregate.

Basking shark

Targeted research on basking sharks in New Zealand waters has proved difficult. The limited availability of specimens, the low chance of encountering one on a trip and the difficulty of working on a large animal during a commercial fishery operation all hinder the collection of biological data. The disappearance of large surface aggregations of basking sharks in coastal waters has also meant fishery independent research on distribution, abundance, size and sex structure, genetic population structure and foraging and reproductive behaviour has become impractical.

The following research activities are considered achievable given these constraints:

1. Ongoing collection of tissue samples (primarily fin clips) for genetic research on global and regional stock structure, and potentially close-kin mark-recapture estimates of population size (Bravington et al. 2016; Francis & Ritchie 2016; Francis 2019). Priority should be given to investigating the feasibility of undertaking a close-kin mark-recapture estimate of the size of the New Zealand population using existing archived tissue samples.

2. White muscle and liver samples should be collected from dead specimens for stable isotope analysis of feeding ecology. Wherever possible a representative sample of stomach contents should be collected, and stomach fullness estimated.

3. Shark length should be measured (subject to safety considerations for live sharks) or estimated, and sex determined, for all sharks caught in commercial fisheries. Length estimates have been obtained for about 60% of observed sharks but these have rarely been sexed. Differences in size, sex and maturity have been found between the main regions where fishery interactions occur, and it is important to monitor for any changes in these indicators (Francis & Duffy 2002). Commercial vessels should be requested to report this data.

4. Small juvenile basking sharks (≤ 2.5 m) are virtually unknown in the scientific literature. Dead juveniles should be retained for scientific study.

5. Whenever possible vertebral samples should be collected from dead specimens, including beach cast carcasses, for research on aging and ontogenetic changes in habitat use using stable isotopes. Data on reproductive status should be collected at the same time.

6. Should surface aggregations reappear in coastal waters every effort should be made to deploy popup satellite tags on free-swimming sharks to study long-distance movements, depth and temperature preferences and diel and seasonal patterns of habitat use. Length and sex composition of surface schools should be documented, and biopsy samples taken for research on genetic population structure and trophic ecology. In the interim the feasibility of satellite tagging sharks caught during commercial fishing operations should be reassessed.

7. Given known problems with age estimates obtained from vertebrae consideration should be given to developing an alternative aging methodology, potentially epigenetic aging (Parrott & Bertucci 2019). This is likely to require the use of model species such as mako and/or porbeagle sharks to determine if it is possible to develop an accurate alternative aging method for lamniforme sharks.

Great white shark

Long-distance movements of sub-adult and adult male, and sub-adult female white sharks aggregating at pinniped colonies at Chatham Islands and Foveaux Strait (Ruapuke, Titi Islands) are well known. Residency of white sharks at Titi Islands has also been studied using an acoustic array. Gaps in knowledge of the species' spatial ecology include details of fine scale habitat use in coastal waters, and movements of juveniles (<3m TL) and adult females (>4.5 m TL).

Tagging white sharks with dorsal fin-mounted satellite tags (SPLASH and SPOT5 tags) at Stewart Island and in Kaipara and Manukau Harbours has provided little or no information on fine scale habitat use. Once white sharks arrive in coastal foraging areas they become bottom orientated and spend much less time at the surface, greatly limiting the frequency and accuracy of position fixes obtained. The department, in collaboration with Conservation International, is currently investigating the use of tethered Wildlife Computers SPLASH10-321A tags to overcome this problem. If this trial is unsuccessful the only methods available for studying fine scale habitat use in this species involve the deployment of large arrays of acoustic receivers, and/or active tracking of acoustically tagged sharks. Both approaches are expensive and time consuming but could provide useful information on overlap with fisheries. Initial results from the SPLASH10-321A trial should be available in 2021.

Francis (2017a) identified the following research priorities regarding bycatch in set net fisheries:

(i) identification of areas where overlap with fisheries is high, and
(ii) investigation of post-release mortality.

With respect to the post-release mortality study he noted the low encounter rate was likely to mean that the duration would have to be 3-5 years to ensure sufficient data was obtained.

Size and age at maturity and reproductive periodicity are poorly defined due to lack of access to specimens. The large size of sub-adult and mature white sharks (females mature between 4.0-5.2 m TL and c. 800-1650 kg) means it can be difficult, expensive and potentially dangerous for fishers to retain and land carcasses of sharks that die in their gear. Wherever possible, data on length, sex, reproductive condition and vertebral samples should be collected from dead great white sharks of all sizes.

Spinetailed devil ray

Spinetailed devil rays are primarily taken as bycatch in the skipjack tuna purse seine fishery. A review of fishery interactions and investigation of post-release mortality conducted shortly after the species was protected documented regular, sometimes large catches and high mortality (Jones & Francis 2012; Francis 2013; Francis & Jones 2017). However, changes to the purse seine fleet and operational practice that have occurred since then mean it is likely that encounter rates and mortality of spinetailed devil rays have changed. Research is required to understand temporal and spatial overlap of the population with the skipjack purse seine fishery, the factors influencing bycatch (e.g. vessel size, net type and size, fishing practices, environmental drivers, climate phenomena) and how bycatch has varied over time. Research is also required to determine if current handling and release practices (i.e. direct release by brailing or over the cork-line) improve post-release survival. If possible, post-release survival of rays handled according to the operational procedure for large purse seine vessels should also be assessed (Sanford Ltd. et al. 2019). To maximise data obtained on movements, habitat preferences and diving behaviour investigation of post-release survival should involve tagging released rays with standard pop-off archival satellite tags (PAT) as well as survival tags (sPAT). A representative number of free-swimming spinetailed devil rays should also be tagged with PATs as controls for released rays and to allow determination of recovery times for released rays. A limited trial will be conducted in 2022 to determine if it is possible for free divers to tag free-swimming spinetailed devil rays.

As age, growth and reproductive parameters of spinetailed devil rays are poorly known and dead specimens should either be retained for scientific research, or data on size (disc width, disc length), sex and reproductive condition should be collected at sea. A section of the vertebral column should be collected for aging by removing the tail from the ray just in front of the dorsal fin. The dorsal fin should be left attached so the location of vertebrae used in aging studies can be determined relative to its origin and/or insertion. Priority should be given to obtaining vertebral samples from spinetailed devil rays approaching maximum size (i.e. 3.1 m disc width). All rays sampled for aging and post-release survival studies should be photographed to confirm species identification. It is possible that more than one spinetailed devil ray species occurs off northern New Zealand, and small manta rays could be misidentified as spinetailed devil rays. All aborted embryos should be retained for research.

Table 3. Proposed CSP research response over the next 5 years: INT= Interactions with fisheries, includes observing commercial fisheries and collection of biological data and samples by fishery observers; POP=Population abundance and trends, includes estimation of life history parameters used to assess resilience to fishing; MIT= Mitigation methods; SURV= Post-release survival; LIVE= Live release methods; TRACK= Tracking and habitat use, includes estimation of overlap with fisheries; GEN= Genetic population structure.

Species	Research	2021/22	2022/23	2023/24	2024/25	2025/26
Basking shark	INT POP MIT SURV LIVE TRACK GEN					
Deepwater nurse shark	INT POP MIT SURV LIVE TRACK GEN					
Oceanic whitetip shark	INT POP MIT SURV LIVE TRACK GEN					
Whale shark	INT POP MIT SURV LIVE TRACK GEN					
Great white shark	INT POP MIT SURV LIVE TRACK GEN					
Manta ray	INT POP MIT SURV LIVE TRACK GEN					
Spinetailed devil ray	INT POP MIT SURV LIVE TRACK GEN					
Giant grouper	INT POP MIT SURV LIVE TRACK GEN					
Spotted black grouper	INT POP MIT SURV LIVE TRACK GEN					

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Appendix 1. Goals and objectives of the NPOA-Sharks 2013

Goal	Five-year objectives
Biodiversity and long-term viability of shark populations 1. Maintain the biodiversity and long-term viability of New Zealand shark populations based on a risk assessment framework with assessment of stock status, measures to ensure any mortality is at appropriate levels, and protection of critical habitat.	**Objective 1.1** Develop and implement a risk assessment framework to identify the nature and extent of risks to shark populations. **Objective 1.2** Systematically review management categories and protection status to ensure they are appropriate to the status of individual shark species. **Objective 1.3** For shark species managed under the QMS, undertake an assessment to determine the stock size in relation to B_{MSY} or other accepted management targets and on that basis review catch limits to maintain the stock at or above these targets. **Objective 1.4** Mortality of all sharks from fishing is at or below a level that allows for the maintenance at, or recovery to, a favourable stock and/or conservation status giving priority to protected species and high risk species. **Objective 1.5** Identify and conserve habitats critical to shark populations. **Objective 1.6** Ensure adequate monitoring and data collection for all sectors (including commercial, recreational and customary fishers and non-extractive users)) and that all users actively contribute to the management and conservation of shark populations.
Utilisation, waste reduction and the elimination of shark finning 2. Encourage the full use of dead sharks, minimise unutilised incidental catches of sharks, and eliminate shark finning[1] in New Zealand	**Objective 2.1** Review and implement best practice mitigation methods, as required, in all New Zealand fisheries (commercial and non-commercial). **Objective 2.2** Minimise waste by promoting the live release of bycaught shark species, and develop and implement best practice guidelines for handling and release of live sharks. **Objective 2.3** Develop and implement best practice guidelines for non-commercial fishing and handling of sharks. **Objective 2.4** Eliminate shark finning in New Zealand fisheries by 1 October 2016.

[1] Shark finning is defined for the purpose of this NPOA as the removal of the fins from a shark (Class Chondricthyes – excluding Batoidea (rays and skates)) and the disposal of the remainder of the shark at sea. As such, removal of the fins from a shark where the trunk is also retained for processing is not defined as 'shark finning'.

Goal	Five-year objectives
Domestic engagement and partnerships 3. All commercial, recreational and customary fishers, non-extractive users, Maori, and interested members of the New Zealand public know about the need to conserve and sustainably manage shark populations and what New Zealand is doing to achieve this.	**Objective 3.1** Capture and reflect, through meaningful engagement, the social and cultural significance of sharks, including their customary significance to Maori, in their conservation and management. **Objective 3.2** Communication and information sharing between government agencies and stakeholders is effective, with strategies developed and implemented to promote the conservation and sustainable management of shark populations. **Objective 3.3** Encourage compliance with regulations, implementation of best practice (including catch avoidance and correct handling), and cooperation with ongoing research among commercial and non-commercial stakeholders. In particular, encourage reporting of any illegal practices (especially live finning) that may be observed.
Non-fishing threats 4. New Zealand's non-fishing anthropogenic effects do not adversely affect long-term viability of shark populations and environmental effects on shark populations are taken into account	**Objective 4.1** Non-fishing anthropogenic and environmental threats to shark populations are understood and, where appropriate, managed.
International engagement 5. New Zealand actively engages internationally to promote the conservation of sharks, the management of fisheries that impact upon them, and the long-term sustainable utilisation of sharks.	**Objective 5.1** New Zealand ensures that it meets its international obligations and receives positive recognition for its efforts in the conservation, protection and management of sharks through active engagement in international conservation and management agreements relevant to sharks. **Objective 5.2** New Zealand actively investigates and decides whether to become a signatory to the Convention on Migratory Species (CMS) Memorandum of Understanding on the Conservation of Migratory Sharks (MoU) in advance of the next Meeting of Signatories in 2015. **Objective 5.3** New Zealand collaborates with neighbouring countries to better understand the population dynamics of highly migratory sharks, protected sharks and any other shark species of special interest. **Objective 5.4** New Zealand proactively contributes to and advocates for improved data collection and information sharing of commercial catches and incidental bycatch of sharks within relevant Regional Fisheries Management Organisations (RFMOs). **Objective 5.5** New Zealand encourages fishing countries, coastal States, and other regional organisations to develop and implement best practice Plans of Action for conserving and managing sharks, where they have not already done so.
Research and information 6. Continuously improve the information available to conserve sharks and manage fisheries that impact on sharks, with prioritisation guided by the risk assessment framework.	**Objective 6.1** Ensure information collection systems and processes are sufficient to inform management of shark populations **Objective 6.2** Undertake a research programme, guided by the risk assessment framework, to increase understanding of and improve the management of shark populations. **Objective 6.3** Implement research to inform the development of recovery plans appropriate to protected species

Appendix 2. Relative ranking of protected shark species according to risk from fisheries bycatch from Ford et al. (2015)

Relative ranking of protected shark species according to risk from fisheries bycatch, based on the reviewed Level 1 Qualitative Risk Assessments in (a) 2016 and (b) 2017. For the COMPONENTS OF RISK higher numbers indicate greater intensity or consequence of impact. For RISK longer bars and larger numbers indicate higher risk, and for CONFIDENCE more ticks indicate higher confidence in the data, or greater consensus and a cross indicates a lack of consensus (Two ticks in the consensus column indicate full consensus). Where species scored identical risk scores they are presented so that higher consequences are reported first and then in alphabetical order (after Ford et. al., 2018).

(a) 2015 Qualitative (Level 1) risk assessment

PROTECTED SPECIES RISK

COMPONENTS OF RISK		RISK	CONFIDENCE	
Intensity	Consequence		Data	Consensus
3	4.5	13.5 - Basking shark	✓✓	✓
3	4.5	13.5 - Spinetail devil ray	✓	✓
3	4	12 - Great white shark	✓✓	✓
2	4	8 - Smalltoothed sandtiger	✓	✓
1	1	1 - Whale shark	✓✓✓	✓✓
1	1	1 - Oceanic whitetip shark	✓✓✓	✓✓
1	1	1 - Manta ray	✓✓	✓✓

(b) 2017 Qualitative (Level 1) risk assessment

PROTECTED SPECIES RISK

COMPONENTS OF RISK		RISK	CONFIDENCE	
Intensity	Consequence		Data	Consensus
3	4.5	13.5 – Basking shark	✓✓	✓
3	4.5	13.5 – Spinetail devil ray	✓	✓
3	4	12 – Great white shark	✓✓	✓