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Review of commercial fishery interactions and population information for the oceanic whitetip shark, a protected New Zealand species

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Abstract

The oceanic whitetip shark, *Carcharhinus longimanus*, was protected under the Wildlife Act in 2013. This study documents and describes its interactions with commercial fisheries in New Zealand waters, and locates and describes the available population information relevant to assessing the risk to this species. Information on catches was obtained from the literature, commercial catch statistics, and observer records. The catch distribution, seasonality, fishing method, and reported totals are described. Population and biological characteristics are reviewed.

The oceanic whitetip shark is a tropical species that is rarely seen or caught in northern New Zealand. Only 19 observer and two commercial fishery records were located (one of which occurred in both datasets). All records came from surface longlines set in the Kermadec Fisheries Management Area or off the northeastern coast of North Island. Captures around North Island were made in the warmer months of the year whereas captures in the Kermadec FMA were made mainly in the cooler months. Most (84%) of the observed sharks were alive when hauled to the vessel, and about half were processed in some way with the remainder being discarded. Few of the observed sharks were sexed or measured, but those that were comprised equal numbers of males and females, and ranged between 158 and 190 cm fork length.

Given the low commercial reporting rate (1 out of 19 observed sharks) and the low observer coverage of domestic surface longliners, our estimate of the interaction of the surface longline fisheries with oceanic whitetips is substantially under-estimated. Despite that, oceanic whitetips are clearly not caught very often, and are not regarded as a high priority species for research or management.

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Introduction

Nine fish species are currently protected in New Zealand fisheries waters under Schedule 7A of the Wildlife Act: spotted black grouper (*Epinephelus daemelii*) was protected in 1996, white shark (*Carcharodon carcharias*) in 2007, spinetail devilray (*Mobula japanica*), manta ray (*Manta birostris*), whale shark (*Rhincodon typus*), deepwater nurse shark (*Odontaspis ferox*), giant grouper (*Epinephelus lanceolatus*) and basking shark (*Cetorhinus maximus*) in 2010, and oceanic whitetip shark (*Carcharhinus longimanus*) in 2013.

All nine species are considered to have low productivity because of their slow growth rates and low fecundity. They are also actually or potentially caught by fisheries targeting other species in New Zealand and (for migratory species) elsewhere in the Indo-Pacific region. In combination, low productivity and fisheries threats make these species vulnerable to over-exploitation, and possibly even extinction. This risk led to the nine species being declared protected. However, protection does not eliminate fisheries bycatch because these species may be caught unintentionally by various commercial and recreational fishing methods, leading to incidental mortality. It is therefore important to understand the sources and extent of fisheries mortality and the risks these pose for protected species. Armed with such information it may be possible to develop further fisheries management measures or bycatch mitigation techniques for species at significant risk.

Previously, we described the commercial fishery interactions, and the available population information relevant to assessing risk, for eight of the nine protected fish species (Francis & Lyon 2012). In this study, we extend our previous work to the one remaining species, oceanic whitetip shark.

The overall objective of this study was:

To describe population information and the nature and extent of interactions with commercial fishing for oceanic whitetip sharks, to the extent possible from existing information.

The specific objectives were:

1. To review existing information to describe the nature and extent of interactions between commercial fishing and oceanic whitetip sharks
2. To identify information gaps in the understanding of the nature and extent of interactions between commercial fishing and oceanic whitetip sharks, and provide recommendations for further research to address any gaps identified.
3. To review existing information to describe population information relevant to assessing risk from commercial fishing to oceanic whitetip sharks.
4. To identify population information gaps relevant to assessing risk from commercial fishing to oceanic whitetip sharks, and provide recommendations for further research to address any gaps identified.

Methods

Information on the extent of catches of oceanic whitetip sharks in commercial fishing gear around New Zealand was obtained from three main sources: literature, commercial catch statistics, and observer records.

Published and unpublished literature

Oceanic whitetip sharks were first identified in New Zealand waters from two specimens caught by recreational fishers in 1988 and 1990 respectively (Saul & Holdsworth 1992; Francis et al. 1999). Francis et al. (1999) compiled eight further records of oceanic whitetips, six of which were caught by tuna longline vessels off north-eastern North Island and reported by Ministry for Primary Industries (MPI) scientific observers. No other reports are known of oceanic whitetips being caught in New Zealand commercial fisheries.

Commercial catch and effort database (warehou)

The *warehou* database is maintained by MPI. It was searched for all records containing the three-letter species code OWS up to 28 April 2014. Fishers began to record protected fish species on "non-fish bycatch" forms from 1 October 2008 onwards, so these were also searched for OWS. Associated data extracted included date, location, fishing method, fishing gear details, target species, and processed state (if any).

Central Observer Database (COD)

The *COD* database contains data collected by observers on fishing vessels, and is managed by NIWA for MPI. We extracted data up to 6 May 2014 for OWS. We plotted maps of the location data, and summarised observed catches (in number of records) by method, region, month and year.

Data grooming

Commercial captures of protected fish could potentially be recorded in three separate places: a catch-effort landing form, a non-fish bycatch form, and an observer form. We searched for duplicate records among these sources by comparing vessel key (an anonymous code number given to each vessel), date, location, time, species and (if available) weight. There was one duplication of a capture between the observer forms and catch-effort forms. To avoid double-counting, the duplicate record was deleted from the catch-effort landing data and retained in the observer data. No OWS records were found in non-fish bycatch forms.

Results

Interactions with commercial fisheries

Two catch-effort records of OWS were found in *warehou* and 19 observer records of OWS in *COD*. One oceanic whitetip shark record was duplicated between the two databases, and has been omitted from the former in subsequent analyses.

Oceanic whitetip sharks are rarely taken as bycatch around north-eastern New Zealand (Figure 1). All captures were made either in the Kermadec FMA (FMA 10) or off the north-eastern North Island coast between Bay of Islands and Mahia Peninsula (FMAs 1 and 2) (Table 1). All records came from surface longline fisheries, which targeted bigeye tuna (10 records), albacore tuna (5), swordfish (3) or southern bluefin tuna (2). All records consisted of a single shark caught per set. Captures around North Island were made in the warmer months of the year (December−April, N = 12) whereas captures in the Kermadec FMA were made mainly in the cooler months (April−August, N = 8).

Most (84%) of the observed oceanic whitetip sharks were alive when hauled to the vessel, and about half were processed in some way with the remainder being discarded (Table 2). Few of the observed sharks were sexed or measured, but those that were comprised equal numbers of males and females, and ranged between 158 and 190 cm fork length (average 175 cm FL) (Table 2).

Oceanic whitetip sharks are also caught occasionally by recreational fishers off east Northland (Saul & Holdsworth 1992; Francis et al. 1999), and a pregnant female shark was found stranded on Muriwai Beach in May 2013 (C. Duffy, Department of Conservation, & T. Trnski, Auckland Museum, pers. comm.).

Table 1: Commercial and observer records of oceanic whitetip sharks caught by surface longline, classified by fishing year and Fisheries Management Area (FMA).

Fishing year	FMA			
	1	2	10	Total
1996	3			3
1998	1	2		3
2000		1		1
2001		3		3
2003			5	5
2004			1	1
2005	1			1
2007			1	1
2008			1	1
2011	1			1
Total	6	6	8	20

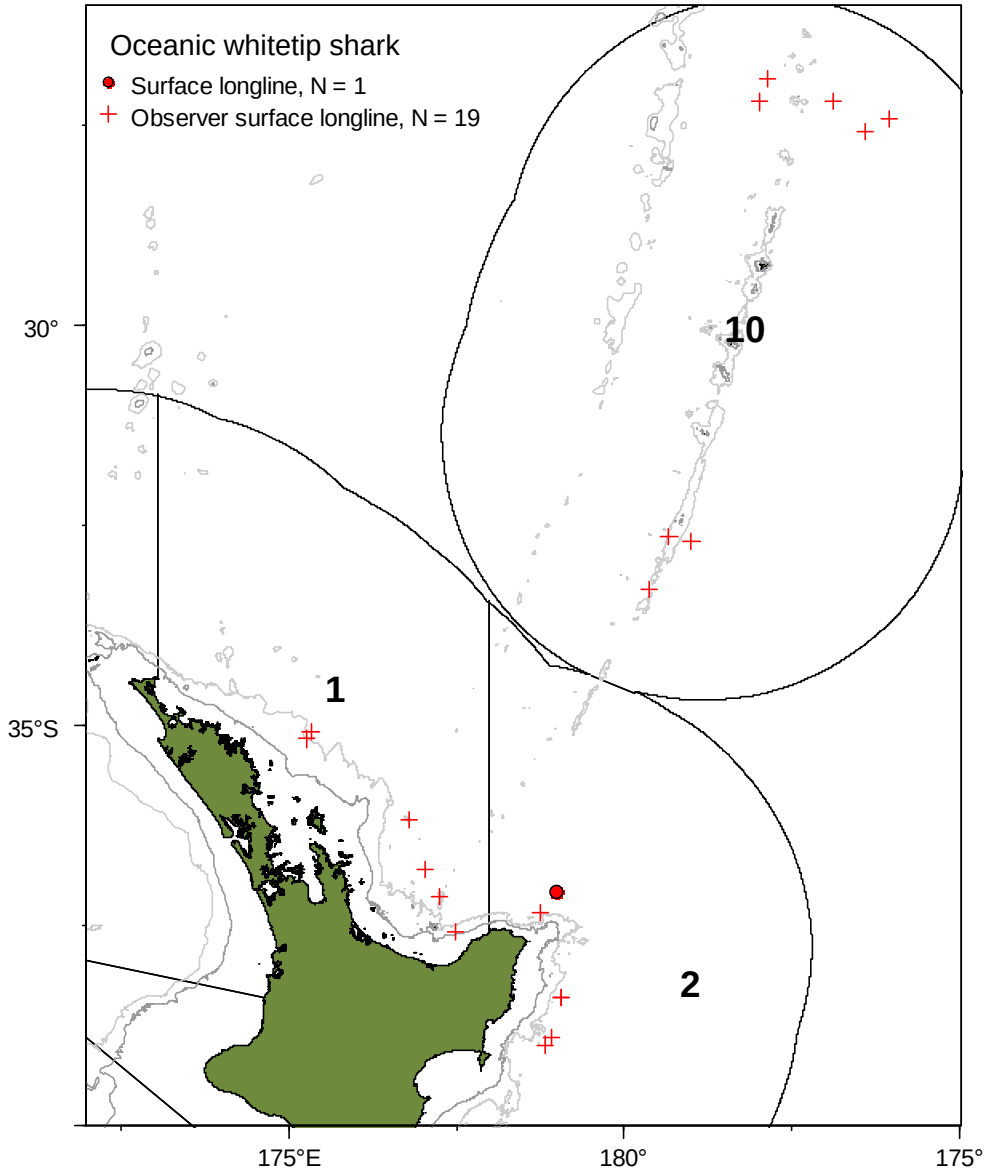

Figure 1: Reported capture locations of oceanic whitetip sharks in commercial (circles) and observer (crosses) data records. Some points represent multiple captures. One commercial record that duplicates an observer record is not shown. The Exclusive Economic Zone and Fisheries Management Areas are shown as black lines. The dark and light grey lines indicate the 250 m and 1,000 m isobaths respectively.

Table 2: Life status, handling and biological data for 19 observed oceanic whitetip sharks

Life status at retrieval	Handling	Fork length (cm)	Weight (kg)	Sex
Alive	Discarded			
Alive	Discarded			
Alive	Finned	176		M
Alive	Retained	167		M
Dead	Discarded			M
Alive	Discarded		80	
Alive	Finned			M
Alive	Discarded			
Alive	Discarded			
Alive	Discarded			
Alive	Discarded			
Alive	Discarded			
Alive	Lost			
Alive	Finned	190		F
Alive	Retained			F
Alive	Finned	158		M
Alive	Retained	170		F
Dead	Retained	190		F
Dead	Retained			F

Information gaps and recommendations

Francis & Lyon (2012) identified three major deficiencies in the analyses of interactions of eight protected fishes with commercial fisheries:

1. Identification of protected species by both observers and fishers has historically been poor.
2. Many captures of protected species are not reported by commercial fishers.
3. Observer coverage of many commercial fisheries has been low or non-existent.

These same deficiencies limit our understanding of the full extent of commercial fishery interactions with oceanic whitetip sharks. Oceanic whitetips have large rounded dorsal and pectoral fins, and several of the fins have white tips (McMillan et al. 2011), making them distinctive and easily identified. However, juvenile sharks shorter than about 110 cm FL have black fin tips instead of white (McMillan et al. 2011), and may not be recognised by fishers and observers. The rarity of oceanic whitetip sharks in New Zealand waters means that fishers seldom encounter them, and this could also hinder recognition. Furthermore, fishers may use the MPI reporting code of OSD (other sharks and dogfish) rather than OWS, thus obscuring the true extent of the commercial catch. The appearance of 19 oceanic whitetip sharks in the observer data but only two in the commercial data confirms that most captures are going undetected. Given the low observer coverage of domestic surface longliners (< 9%

up to 2009−10; (Griggs & Baird 2013)), our estimate of the interaction of the surface longline fisheries with oceanic whitetips is substantially under-estimated. Despite that, oceanic whitetips are clearly not caught very often.

Recently, NIWA produced an identification guide to fish species caught by surface fishing, and it includes the oceanic whitetip shark (McMillan et al. 2011). MPI is attempting to phase out generic reporting codes such as OSD, but it may take some time to educate fishers and convert them to using the correct species code of OWS. Continued low observer coverage of domestic surface longliners reduces our ability to independently monitor catches of oceanic whitetip sharks.

Fishers may be inherently wary about reporting the capture of protected species, even though this is a legal requirement. Fishers may not realise that it is not an offence to catch protected fishes as long as the capture was incidental to legal fishing operations. Alternatively, they may wish to hide the extent of fishing mortality on protected species to avoid the possible implementation of fishing restrictions designed to reduce such mortality. Under-reporting of protected species introduces a major bias into estimates of fishery interactions. Measures that might increase the reporting rate of protected species captures should be explored.

Addressing these three deficiencies will not be simple, and may require increased resources as well as greater focussing and prioritisation of existing resources. But even incremental progress in these areas would greatly enhance our knowledge of the interactions between oceanic whitetips and fishing gear.

Population information

Genetic stock structure

No information is available on the genetic population structure of oceanic whitetip sharks, although a worldwide study is currently underway (M. Shivji, Nova Southeastern University, Florida, pers. comm.).

Evidence of the scale of movement and migration from tagging studies

The Cooperative Shark Tagging Program of the U. S. National Marine Fisheries Service (USNMFS) tagged 542 oceanic whitetips in the Atlantic Ocean between 1962 and 1993, but only six sharks were recaptured. The maximum time at liberty was 3.3 years, the maximum distance travelled was 2,270 km, and the maximum estimated speed was 32 km/day (Kohler et al. 1998). A subsequent summary of four tagging programmes, including the USNMFS programme, raised the number of sharks tagged to 723 and the maximum distance travelled to 2,811 km (Kohler & Turner 2001). Although limited, these data indicate that movements occur on a moderate to large scale in the Atlantic Ocean (Bonfil et al. 2008). Recent electronic tagging in the northeastern Pacific has detected linear movements as great as 4,300 km (Musyl et al. 2011).

World distribution and any barriers to movement

The oceanic whitetip shark is one of the most widespread sharks, occurring globally in tropical and subtropical waters between about 30 °N and 35 °S (Last & Stevens 2009; Ebert et al. 2013). It is most abundant near the equator, and declines in numbers poleward (Bonfil et al. 2008). There appear to be spatial differences in the distribution of various size classes and maturity states (Bonfil et al. 2008). Oceanic whitetips also enter warm temperate waters, such as around New Zealand's northern North Island, during summer (Francis et al. 1999). Cold water may act as a barrier to movement between the eastern Pacific Ocean and the Atlantic Ocean, but movement may occur around the Cape of Good Hope between the Indian and Atlantic oceans.

Habitat requirements and constraints

Oceanic whitetip sharks are epipelagic, ranging from the surface to at least 152 m (Bonfil et al. 2008) but spend most of their time in the warmer, isothermal, upper 100 m of the ocean (Musyl et al. 2011). They prefer open ocean waters, and their abundance increases away from continental and insular shelves (Bonfil et al. 2008). These sharks are regularly found where water temperatures are between 18 and 28 °C, with water above 20 °C preferred. Some sharks have been caught at temperatures as low as 15 °C (Compagno 1984; Ebert et al. 2013).

Growth rate

Seki et al. (1998) estimated a von Bertalanffy growth coefficient for Pacific Ocean sharks of 0.103 based on counting annual bands on 225 vertebral centra, with the assumption that one band is laid down each year. Oceanic whitetip growth is considered slow compared with other pelagic sharks, such as blue, mako, and silky sharks (Branstetter 1990). The growth rate does not differ between male and female sharks (Seki et al. 1998).

Longevity

Oceanic whitetip sharks are relatively short-lived compared with many other sharks. The maximum age reported for the Pacific Ocean is 11 years (Seki et al. 1998), although they may live longer (13−17 years) in the equatorial Atlantic Ocean (Lessa et al. 1999b; Bonfil et al. 2008).

Length and age at maturity

Both sexes of oceanic whitetip sharks reach sexual maturity at about 4−5 years (170−200 cm total length) in the Pacific and 6−7 years in the Atlantic (Seki et al. 1998; Lessa et al. 1999a; 1999b; Bonfil et al. 2008; Tambourgi et al. 2013).

Fecundity and reproductive rate

Oceanic whitetips are viviparous, giving birth to live young after a 9–12 month gestation period (Bonfil et al. 2008). Females apparently reproduce every second year (i.e., they have a resting year between pregnancies) (Tambourgi et al. 2013). Litter size ranges from 1 to 14, with a mode at 5 and a mean of 6.2, and is weakly correlated with maternal length (Seki et al. 1998; Tambourgi et al. 2013). Size at birth is about 55−75 cm total length in the Pacific Ocean (Seki et al. 1998). Pupping and nursery areas are thought to exist in the central

Pacific between 0 º and 15 ºN (Bonfil et al. 2008). In the South Pacific parturition occurs in spring−summer (Stevens 1984; Bonfil et al. 2008).

Natural mortality rate

A longevity of 11 years suggests a high natural mortality rate of 0.42, whereas a longevity of 17 years suggests a moderate rate of 0.25 (Hoenig 1983). Demographic studies of oceanic whitetips have used a maximum age estimate of 22 years, which would suggest a natural mortality rate of about 0.19, but that longevity is not based on empirical data (Smith et al. 1998; Cortés 2008; Smith et al. 2008). Since mortality is quite sensitive to maximum age, under-estimation of the latter could generate mortality values that are too high. Better estimates of both parameters are required, though this has become difficult because oceanic whitetips are considered to be overfished through most of their range (Rice & Harley 2012) and the maximum age of sharks in the population has probably declined.

Productivity

The productivity of oceanic whitetips from the western Pacific is estimated to lie near the mid−upper end of the range of other pelagic sharks (Smith et al. 1998; Cortés 2008; Smith et al. 2008).

Spatial and temporal distribution of species

Oceanic whitetip sharks are known only from around the northern North Island and the Kermadec FMA, but they may rarely penetrate further south. The timing of North Island and Kermadec records suggests they may migrate seasonally into New Zealand waters from tropical areas to the north.

Distribution of relevant fisheries

The surface longline fishery in north-eastern North Island and in the Kermadec FMA is the only fishery in New Zealand waters that interacts with oceanic whitetip sharks.

Vulnerable components of population (size and sex composition)

Sharks of both sexes, and a range of sizes (adolescents to adults) are caught by surface longline fisheries.

Trends in catches and population biomass

No information is available on trends in oceanic whitetip shark biomass in New Zealand waters. Catches are rare and the abundance of the species in New Zealand may respond to inter-annual variations in water temperature. In the Pacific Ocean as a whole, which probably supports the stock from which New Zealand sharks are derived, oceanic whitetip catch rates on tuna longlines declined by 90% between 1996 and 2009 (17% per year, 95% CI 14−20%) (Clarke et al. 2012). Purse seine catch rates in the central Pacific Ocean declined at a similar rate over the same period (Clarke et al. 2012). Rice & Harley (2012) concluded that the stock is overfished. Catch rates of oceanic whitetip sharks in the Atlantic Ocean have also declined dramatically as a result of fishing (Baum et al. 2003; Baum & Myers 2004; Bonfil et al. 2008). These studies show that the oceanic whitetip shark has been heavily impacted by fishing in most parts of its range.

Trends in size composition

From 1995 to 2010, the length of female oceanic whitetips caught in the Pacific Ocean longline fishery declined significantly in their core tropical habitat. In the purse-seine fishery the lengths of males and females declined in only one region over the same period (Clarke et al. 2012). All the oceanic whitetips sampled by observers from the west and central Pacific Ocean purse-seine fisheries since 2000 were immature (Clarke et al. 2012).

Information gaps and recommendations

The oceanic whitetip shark is a tropical species that is rarely seen in northern New Zealand, and only occasionally caught in New Zealand surface longline fisheries. It is therefore not regarded as a high priority species for research or management in New Zealand. Nevertheless, New Zealand as a range state should participate in regional international efforts, especially through the Western and Central Pacific Fisheries Commission, to study and manage this species. All of the tuna Regional Fisheries Management Organisations worldwide have banned the retention of oceanic whitetip sharks in tuna fisheries, but there will be an ongoing need to undertake stock assessments and research into the extent and mitigation of bycatch.

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