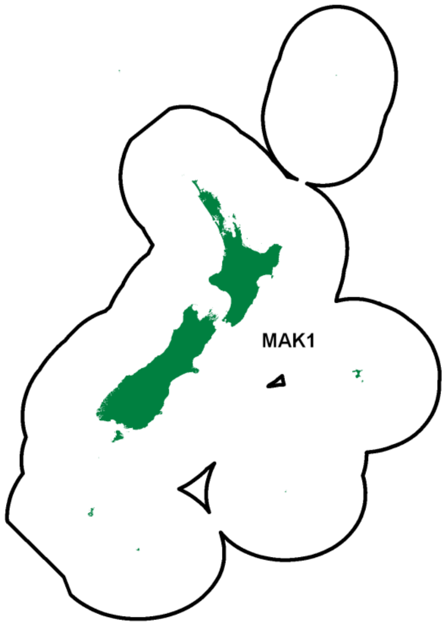
MAKO SHARK (MAK)

(*Isurus oxyrinchus)*
Mako



1. FISHERY SUMMARY

Mako shark were introduced into the QMS on 1 October 2004 under a single QMA, MAK 1, with a TAC of 542 t, a TACC of 406 t and a recreational allowance of 50 t. The TAC was reviewed in 2012 with the reduced allocation and allowances applied from 1 October 2012 in Table 1. The decrease was in response to sustainability concerns that mako shark is considered to be at risk of overfishing internationally because of its low productivity.

Table 1: Recreational and Customary non-commercial allowances, TACC and TAC (all in tonnes) for mako shark.

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
MAK 1	30	10	36	200	276

Mako shark was added to the Third Schedule of the 1996 Fisheries Act with a TAC set under s14 because mako shark is a highly migratory species and it is not possible to estimate MSY for the part of the stock that is found within New Zealand fisheries waters.

The conditions of Schedule 6 releases have been amended for mako, porbeagle, and blue shark. From 1 October 2014, fishers were allowed to return these three species to the sea both alive and dead, although the status must be reported accurately. Those returned to the sea dead are counted against a fisher's ACE and the total allowable catch limit for that species.

Management of the mako shark throughout the western and central Pacific Ocean (WCPO) is the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). Under this regional convention New Zealand is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with those of the Commission.

1.1 Commercial fisheries

Most of the commercial catch of mako sharks is taken by tuna longliners and bottom longliners and they are also incidental bycatch of bottom and mid-water trawlers. Before the introduction of a ban on shark finning that took effect on 1 October 2014, about 25% of mako sharks caught by tuna longliners were processed and the rest were discarded. The TACC was reduced from 400 t to 200 t for the 2012-13 fishing year.

Landings of mako sharks reported on CELR (landed), CLR, LFRR, and MHR forms are shown in Table 2 and Fig. 1. Processors reported 44–319 t on LFRRs during 1997-98 to 2013-14. There was a steady increase in the weight of mako shark landed in the late 1990s, reaching a peak in 2000–01, resulting from a large increase in domestic fishing effort in the tuna longline fishery, and probably also improved reporting. Landings then declined to about one-quarter of the peak landings between 2003-04 and 2012-13. In 2013-14, there was a marked drop in landings to 44 t as a result of the ban on landing shark fins without the associated carcasses.

In addition to catch taken within New Zealand fisheries waters, a small amount (< 1 t in recent years) is taken by New Zealand longline vessels fishing on the high seas.

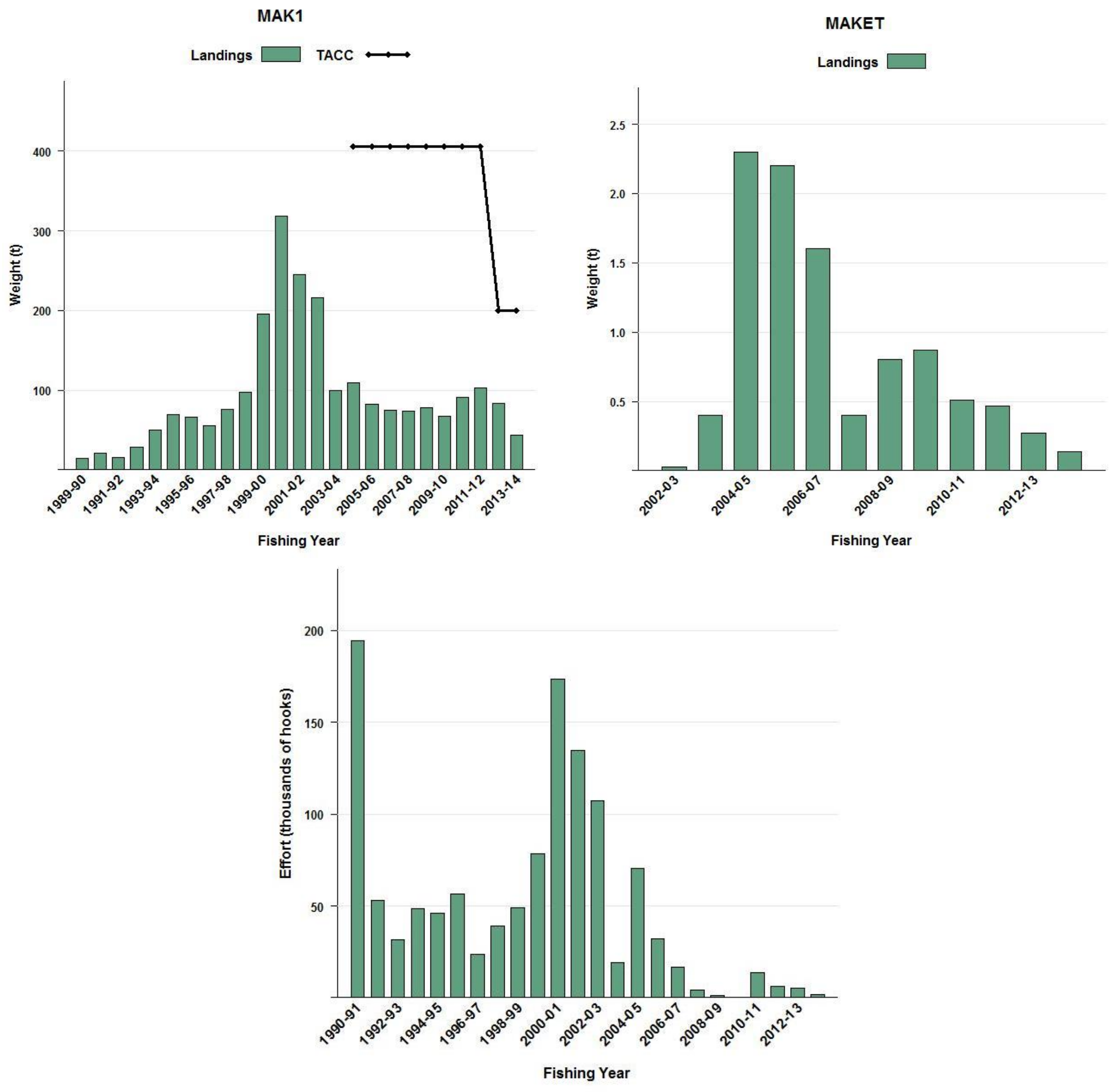


Figure 1: [Top] Mako Shark catch from 1989–90 to 2013–14 within New Zealand waters (MAK 1) and 2002–03 to 2013–14 on the high seas (MAK ET). [Bottom] Fishing effort (number of hooks set) for high seas New Zealand flagged surface longline vessels, from 1990–91 to 2013–14. [Continued on next page].

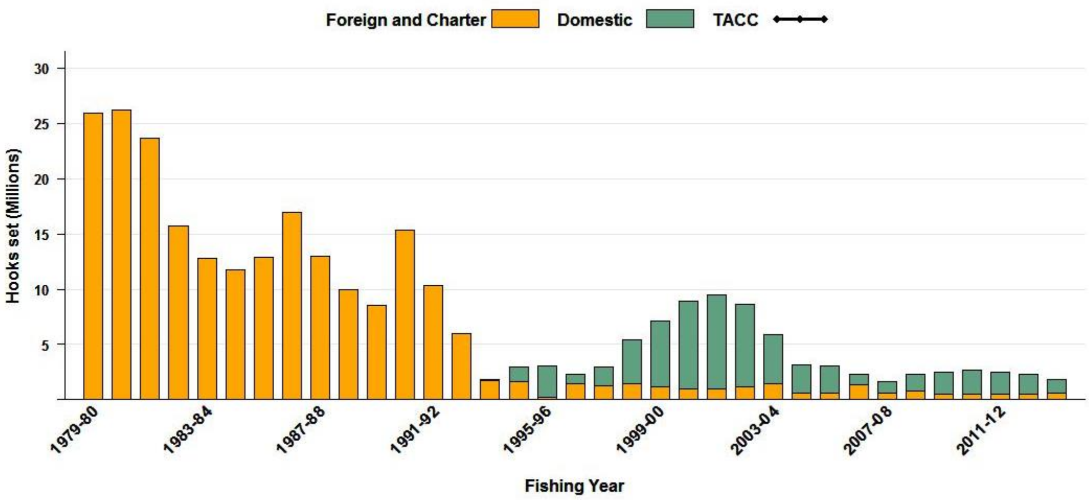


Figure 1 [Continued]: Fishing effort (number of hooks set) for all foreign (including effort by foreign vessels chartered by New Zealand fishing companies) and domestic vessels, from 1979–80 to 2013–14.

Table 2: New Zealand commercial landings (t) of mako sharks reported by fishers (CELRs and CLRs) and processors (LFRRs) by fishing year.

Year	Total reported	LFRR/MHR
1989–90	11	15
1990–91	15	21
1991–92	17	16
1992–93	24	29
1993–94	44	50
1994–95	63	69
1995–96	67	66
1996–97	51	55
1997–98	86	76
1998–99	93	98
1999–00	148	196
2000–01	295	319
2001–02	242	245
2002–03*	233	216
2003–04*	100	100
2004–05*	107	112
2005–06*	83	84
2006–07*	76	75
2007–08*	72	74
2008–09*	82	78
2009–10*		67
2010–11*		91
2011–12*		103
2012–13*		84
2013–14*		44

*MHR rather than LFRR data.

Catches of mako sharks aboard tuna longliners are concentrated off the west and southwest coast of the South Island, and the northeast coast of the North Island (Figure 2). Most of the mako landings were taken in FMAs 1 and 2.

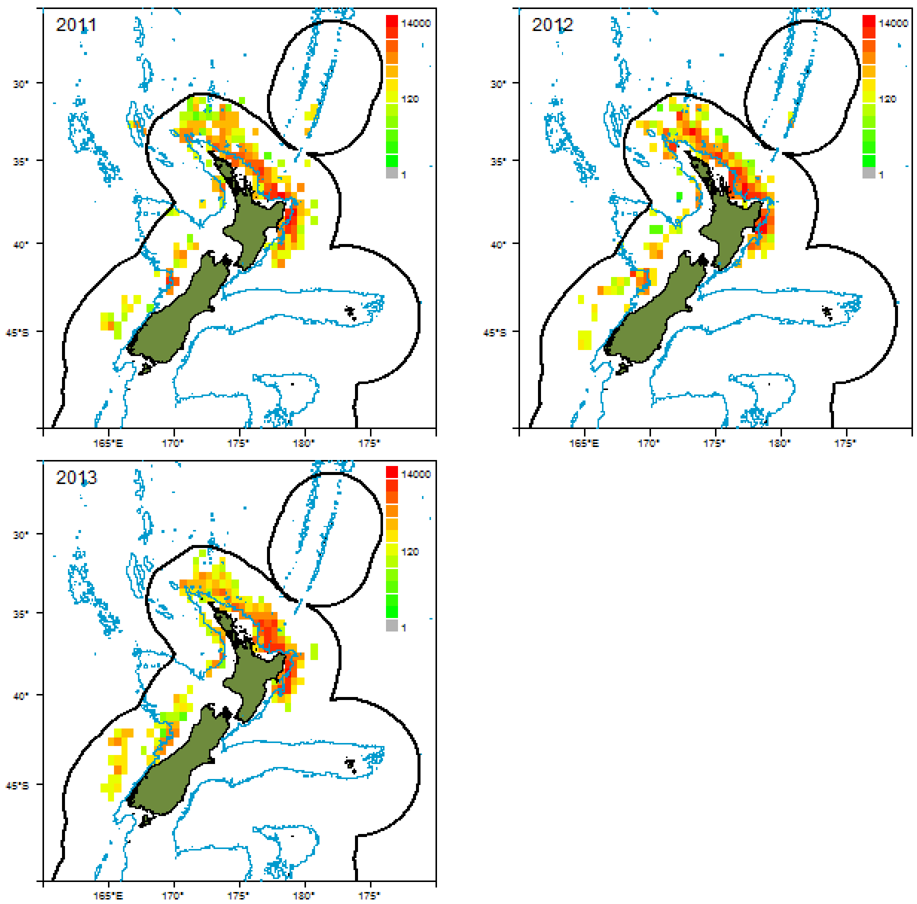


Figure 2: Mako shark catches (kg) by the surface longline fishery in 0.5 degree rectangles by fishing year. Note the log scale used for the colour palette. Depth contour = 1000 m.

The majority of mako shark (55%) are caught in the bigeye tuna target surface longline fishery (Figure 3). Across all longline fisheries mako are in the top ten species by weight (3% of reported catches) (Figure 4). Longline fishing effort is distributed along the east coast of the North Island and the south west coast of the South Island. The west coast South Island fishery predominantly targets southern bluefin tuna, whereas the fishery off the east coast of the North Island targets a range of species including bigeye, swordfish, and southern bluefin tuna (Figure 5).

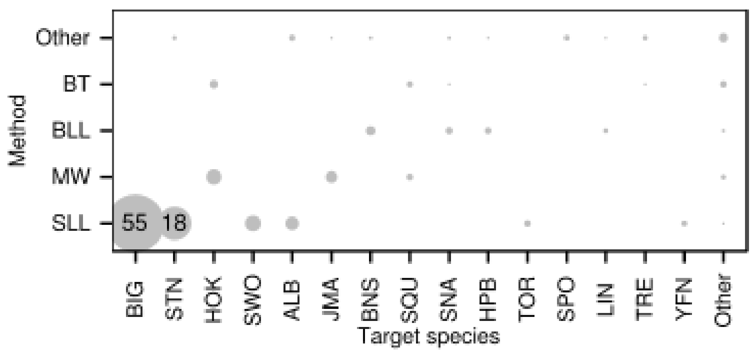


Figure 3: A summary of the proportion of landings of mako shark taken by each target fishery and fishing method for the 2012-13 fishing year. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage. SLL = surface longline, MW = mid-water trawl, BLL = bottom longline, BT = bottom trawl (Bentley et al 2013).

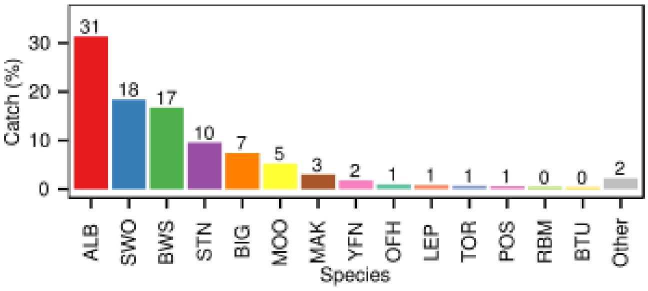


Figure 4: A summary of species composition of the reported surface longline catch for the 2012-13 fishing year. . The percentage by weight of each species is calculated for all surface longline trips (Bentley et al 2013).

Across all fleets in the longline fishery, 73.6% of the mako sharks were alive when brought to the side of the vessel (Table 3). The domestic fleet retains around 19–67% of their mako shark catch, mostly for the fins, while the foreign charter fleet retains most of the mako sharks (94–100%) (mostly for fins) (Table 4).

Table 3: Percentage of mako shark (including discards) that were alive or dead when arriving at the longline vessel and observed during 2006–07 to 2009–10, by fishing year, fleet and region. Small sample sizes (number observed < 20) were omitted. Griggs & Baird (2013).

Year	Fleet	Area	% alive	% dead	Number
2006–07	Australia	North	82.1	17.9	28
	Charter	North	83.0	17.0	276
		South	93.1	6.9	29
	Domestic	North	67.6	32.4	262
	Total		**76.6**	**23.4**	**595**
2007–08	Domestic	North	63.8	36.2	304
	Total		**64.7**	**35.3**	**320**
2008–09	Charter	North	88.6	11.4	44
		South	100.0	0.0	31
	Domestic	North	69.6	30.4	289
	Total		**74.4**	**25.6**	**367**
Year	Fleet	Area	% alive	% dead	Number
2009–10	Domestic	North	76.1	23.9	330
	Total		**75.9**	**24.1**	**348**
Total all strata			73.6	26.4	1 630

Table 4: Percentage of mako shark that were retained, or discarded or lost, when observed on a longline vessel during 2006–07 to 2009–10, by fishing year and fleet. Small sample sizes (number observed < 20) omitted. Griggs & Baird (2013).

Year	Fleet	% retained or finned	% discarded or lost	Number
2006–07	Australia	17.9	82.1	28
	Charter	93.8	6.2	323
	Domestic	37.0	63.0	262
	Total	**66.1**	**33.9**	**613**
2007–08	Domestic	66.6	33.4	305
	Total	**68.2**	**31.8**	**321**

Table 4 [Continued]

Year	Fleet	% retained or finned	% discarded or lost	Number
2008–09	Charter	100.0	0.0	85
	Domestic	58.7	41.3	293
	Total	**68.0**	**32.0**	**378**
2009–10	Domestic	19.1	80.9	350
	Total	21.6	78.4	361
Total all strata		57.3	42.7	1 673

1.2 Recreational fisheries

Historically there was a recreational target fishery for mako sharks and they were highly prized as a sport fish. Most mako sharks are now taken as a bycatch while targeting other species. Reported catch has declined since the mid 1990s. Fishing clubs affiliated to the New Zealand Sports Fishing Council have reported landing 24 mako sharks in 2013–14. In addition recreational fishers tag and release 300 to 530 mako sharks per season. Using NZ Sports Fishing Council records only, it is estimated that 94% of mako sharks caught by recreational fishers associated with sport fishing clubs were tagged and released in 2012-13.

1.3 Customary non-commercial fisheries

There are no estimates of Maori customary catch of mako sharks. Traditionally, mako were highly regarded by Maori for their teeth, which were used for jewellery. Target fishing trips were made, with sharks being caught by flax rope nooses to avoid damaging the precious teeth.

1.4 Illegal catch

There is no known illegal catch of mako sharks.

1.5 Other sources of mortality

Many of the mako sharks caught by tuna longliners (about 75%) are alive when the vessel retrieves the line. It is not known how many of the sharks that are returned to the sea alive under the provisions of Schedule 6 of the Fisheries Act survive. Dead discards are now allowed under Schedule 6 of the Fisheries Act, and these may be under-reported.

2. BIOLOGY

Mako sharks occur worldwide in tropical and warm temperate waters, mainly between latitudes 50°N and 50°S. In the South Pacific, mako are rarely caught south of 40°S in winter–spring (August–November) but in summer–autumn (December–April) they penetrate at least as far as 55°S. Mako sharks occur throughout the New Zealand EEZ (to at least 49°S), but are most abundant in the north, especially during the colder months.

Mako sharks produce live young around 57–69 cm (average 61 cm) fork length (FL). In New Zealand, male mako sharks mature at about 180-185 cm fork length (Figure 5) and female mako mature at about 275–285 cm FL (Francis and Duffy 2005) (Figure 6). The length of the gestation period is uncertain, but is thought to be 18 months with a resting period between pregnancies leading to a two- or three-year pupping cycle. Only one pregnant female has been recorded from New Zealand, but newborn young are relatively common. Litter size is 4–18 embryos. If the reproductive cycle lasts three years, and mean litter size is 12, mean annual fecundity would be 4 pups per year.

Estimates of mako shark age and growth in New Zealand were derived by counting vertebral growth bands, and assuming that one band is formed each year. This assumption has recently been validated for North Atlantic mako sharks but there is evidence that fast-growing juveniles in California waters deposit two bands peer year. Males and females grow at similar rates until age16 years, after which the relative growth of males declines. In New Zealand, males mature at about 7–9 years and females at 19–21 years. The maximum ages recorded are 29 and 28 years for males and females respectively.

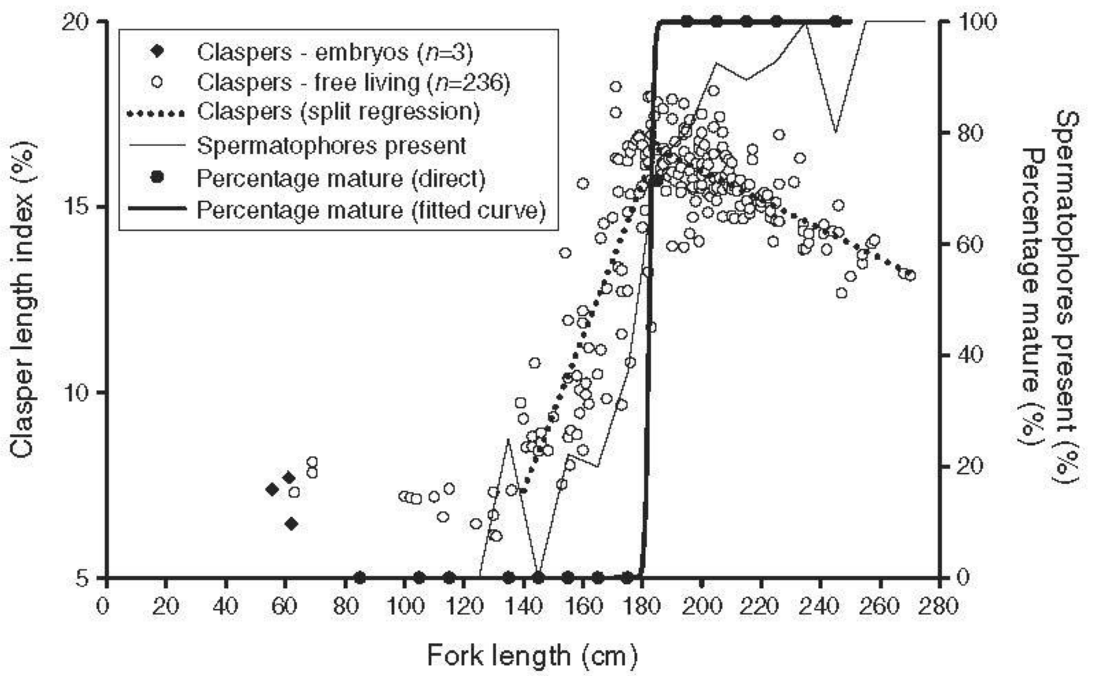


Figure 5: Maturation of male shortfin mako sharks (*Isurus oxyrinchus*): variation in clasper development, presence of spermatophores in the reproductive tract, and direct maturity estimation determined from a suite of maturity indicators (Francis and Duffy 2005).

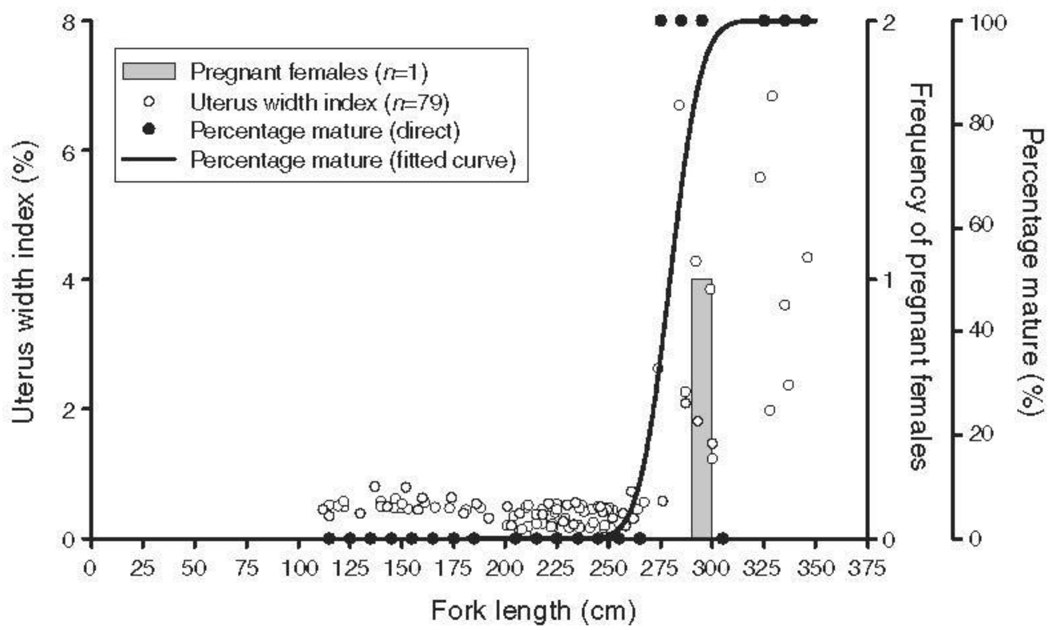


Figure 6: Maturation of female shortfin mako sharks (*Isurus oxyrinchus*): variation in uterus width index, and direct maturity estimation from a suite of maturity indicators. The only pregnant female recorded from New Zealand waters is also indicated (Francis and Duffy 2005).

The longest reliably measured mako appears to be a 351 cm FL female from the Indian Ocean, but it is likely that they reach or exceed 366 cm FL. In New Zealand, mako recruit to commercial fisheries during their first year at about 70 cm FL, and much of the commercial catch is immature. Sharks less than 150 cm FL are rarely caught south of Cook Strait, where most of the catch by tuna longliners consists of sub-adult and adult males.

Mako sharks are active pelagic predators of other sharks and bony fishes, and to a lesser extent squid. As top predators, mako sharks probably associate with their main prey, but little is known of their relationships with other species.

Estimates of biological parameters are given in Table 5.

Table 5: Estimates of biological parameters.

Fishstock	Estimate				Source
1. Natural mortality (M)					
MAK 1	0.10–0.15				Bishop et al (2006)
2. Weight = a(length)^b (Weight in kg, length in cm fork length)					
Both sexes combined	a		b		
MAK 1	2.388×10^{-5}		2.847		Ayers et al (2004)
3. Schnute growth parameters	L_1	L_{10}	κ	γ	
MAK 1 males	100.0	192.1	-	3.40	Bishop et al (2006)
MAK 1 females	99.9	202.9	-0.07	3.67	Bishop et al (2006)
MAK 1 both sexes, less than 16 years	97.1	183.6	-0.03	3.51	M. Francis (unpubl. data)

3. STOCKS AND AREAS

Up to June 2015, 14 831 mako sharks had been tagged and released in New Zealand waters and 370 recaptured. Most of the tagged fish in recent years were small to medium sharks with estimated total weights at 90 kg or less, with a mode at 40 to 50 kg, and they were mainly tagged off east Northland and the west coast of the North Island. Most recaptures have been within 500 km of the release site, with sharks remaining around east Northland or travelling to the Bay of Plenty and the west coast of North Island. However, long distance movements out of the New Zealand EEZ are frequent, with mako sharks travelling to eastern Australia or the western Tasman Sea (1500–2000 km), the tropical islands north of New Zealand (New Caledonia, Fiji, Tonga, Solomon Islands; 1500–2400 km) and to the Marquesas Islands in French Polynesia (4600 km). Electronic tagging of five juvenile mako sharks aged about 4−8 years showed relatively high site fidelity, with all five sharks remaining in the NZ EEZ for many months. Four of the five sharks showed an offshore movement in winter, with three sharks travelling up the Kermadec Ridge and one to Fiji before all returned to New Zealand. This indicates that juvenile mako sharks may undergo seasonal migrations but that they spend much of their life in New Zealand coastal waters. Little is known about the movements of adults, but they appear to travel further afield than juveniles.

Several DNA analyses of mako sharks worldwide have shown that there are distinct stocks in the North Atlantic, South Atlantic, North Pacific, Southwest Pacific and Southeast Pacific (Clarke et al 2015). This is consistent with tagging data that have shown no movements of New Zealand sharks beyond the Southwest Pacific

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2015 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of mako shark but there is no directed fishery for them and the incidental catch sections below reflect the New Zealand longline fishery as a whole and are not specific to this species; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review where the consequences are also discussed (https://www.mpi.govt.nz/document-vault/5008) (Ministry for Primary Industries 2014).

4.1 Role in the ecosystem

Mako sharks (*Isurus oxyrinchus*) are active pelagic predators of other sharks and bony fishes, and to a lesser extent squid (Figure 7 and Figure 8) (Griggs et al 2007).

4.2 Diet

Throughout their life the diet remains dominated by fish with squid making up a small percentage of their gut contents.

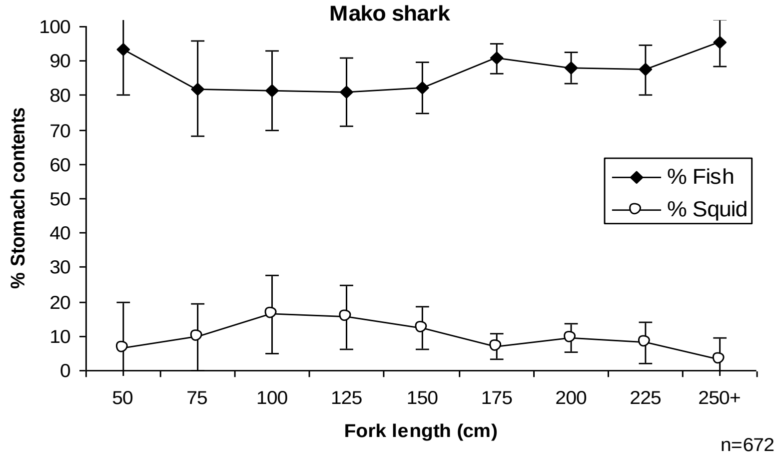


Figure 7: Changes in percentage of fish and squid in stomachs of mako sharks with fork length.

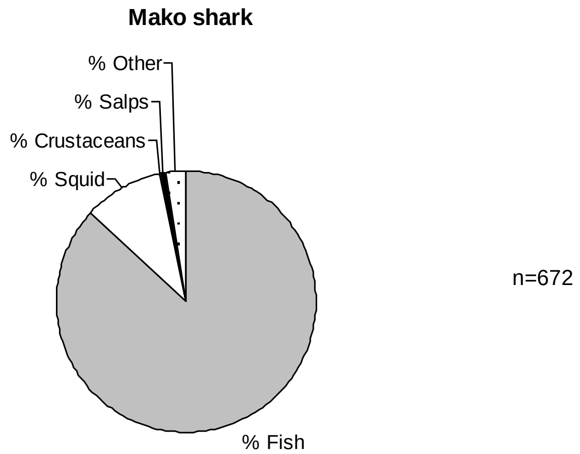


Figure 8: Percentage composition of stomach contents (estimated volumetric) of mako sharks sampled in New Zealand fishery waters.

4.3 Incidental catch (seabirds, sea turtles and mammals)

The protected species, capture estimates presented here include all animals recovered onto the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds caught on a hook but not brought onboard the vessel)[1]

[1] As part of its data reconciliation processes, MPI has identified that less than 2% of observed protected species captures between 2002 and 2015 were not recorded in COD. Steps are being taken to update the database and estimates of protected species captures and associated risks. Accordingly, some estimates of protected species captures or risk in this document may have a small negative bias. Neither Maui nor Hector’s dolphins are affected. Updated estimates will be reviewed by the Aquatic Environment Working Group in the second quarter of 2016.

4.2.1 Seabird bycatch

Between 2002–03 and 2013–14, there were zero observed captures of birds other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish). Seabird capture rates since 2003 are presented in Figure 9. Seabird captures were more frequent off the south west coast of the South Island (Figure 10). Bayesian models of varying complexity dependent on data quality have been used to estimate captures across a range of methods (Richard & Abraham 2014). Observed and estimated seabird captures in surface longline fisheries are provided in Table 7.

Through the 1990s the minimum seabird mitigation requirement for surface longline vessels was the use of a bird scaring device (tori line) but common practice was that vessels set surface longlines primarily at night. In 2007 a notice was implemented under s 11 of the Fisheries Act 1996 to formalise the requirement that surface longline vessels only set during the hours of darkness and use a tori line when setting. This notice was amended in 2008 to add the option of line weighting and tori line use if setting during the day. In 2011 the notices were combined and repromulgated under a new regulation (Regulation 58A of the Fisheries (Commercial Fishing) Regulations 2001) which provides a more flexible regulatory environment under which to set seabird mitigation requirements.

Risk posed by commercial fishing to seabirds has been assessed via a level 2 method which supports much of the NPOA-Seabirds 2013 risk assessment framework (MPI 2013). The method used in the level 2 risk assessment arose initially from an expert workshop hosted by the Ministry of Fisheries in 2008. The overall framework is described in Sharp et al. (2011) and has been variously applied and improved in multiple iterations (Waugh et al. 2009, Richard et al. 2011, Richard and Abraham 2013, Richard et al. 2013 and Richard & Abraham in press). The method applies an "exposure-effects" approach where exposure refers to the number of fatalities is calculated from the overlap of seabirds with fishing effort compared with observed captures to estimate the species vulnerability (capture rates per encounter) to each fishery group. This is then compared to the population's productivity, based on population estimates and biological characteristics to yield estimates of population-level risk.

The 2015 iteration of the seabird risk assessment (Richard & Abraham in press) assessed other surface longline target fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, and swordfish) contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 7). These target fisheries contribute 0.003 of PBR_1 to the risk to Southern Buller's albatross which was assessed to be at very high risk from New Zealand commercial fishing (Richard & Abraham in press).

Table 6: Effort, observed and estimated seabird captures by fishing year for the New Zealand surface longline fishery within the EEZ. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures; the capture rate (captures per thousand hooks); and the mean number of estimated total captures (with 95% confidence interval). Estimates are based on methods described in Thompson et al (2013) are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2013–14 are based on data version 2015003.

Fishing year			Fishing effort	Observed captures	
	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 770 488	2 195 152	20.4	0	0
2003–2004	7 386 484	1 607 304	21.8	1	0.001
2004–2005	3 679 765	783 812	21.3	2	0.003
2005–2006	3 690 869	705 945	19.1	1	0.001
2006–2007	3 739 912	1 040 948	27.8	2	0.002
2007–2008	2 246 139	421 900	18.8	1	0.002

Table 6 [Continued]

Fishing year	Fishing effort			Observed captures	
	All hooks	Observed hooks	% observed	Number	Rate
2008–2009	3 115 633	937 496	30.1	2	0.002
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 188 179	674 572	21.2	4	0.006
2011–2012	3 100 177	728 190	23.5	0	0
2012–2013	2 876 932	560 333	19.5	2	0.004
2013–2014	2 546 764	773 527	30.4	0	0

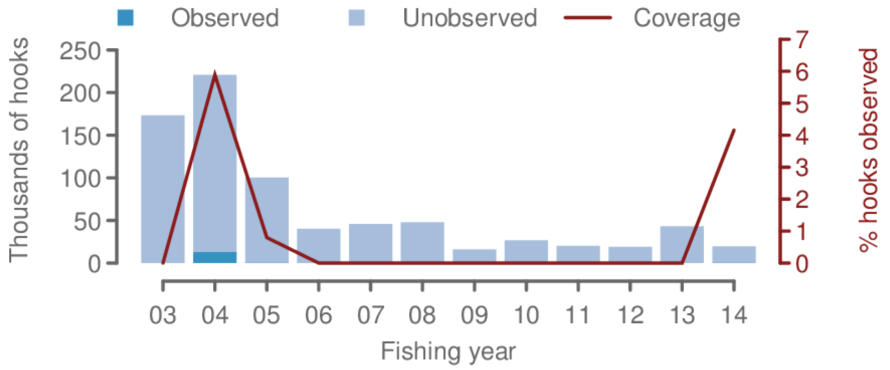


Figure 9: Observed and estimated captures of seabirds in the New Zealand surface longline fisheries from 2002–03 to 2013–14.

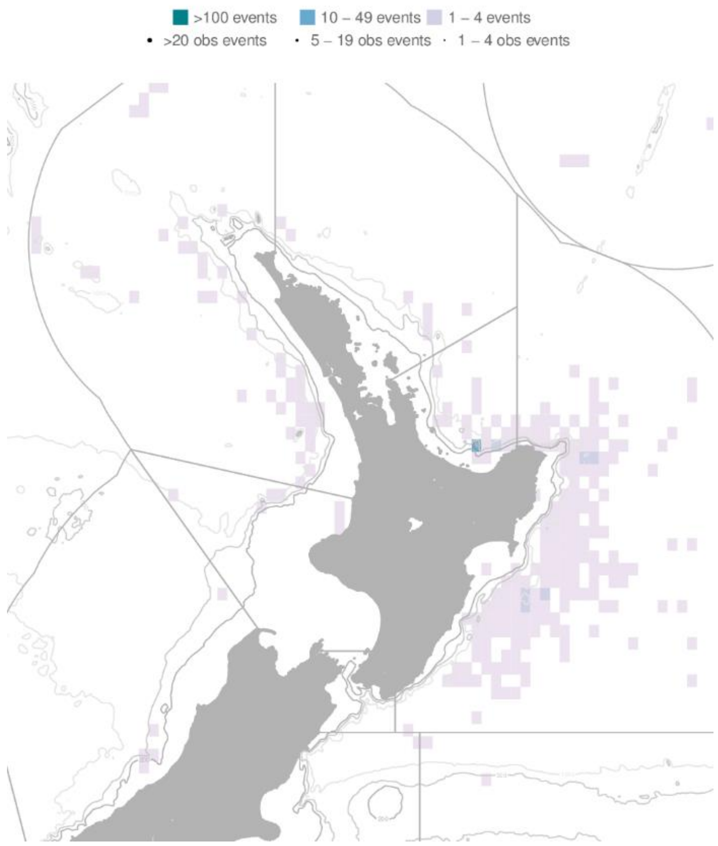


Figure 10: Distribution of fishing effort in the New Zealand surface longline fisheries and observed seabird captures, 2002–03 to 2013–14. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Table 7: Risk ratio of seabirds predicted by the level two risk assessment for the other species target surface longline fisheries (those not targeting albacore tuna, bigeye tuna, southern bluefin tuna, pacific bluefin tuna and swordfish) and all fisheries included in the level two risk assessment, 2006–07 to 2013–14, showing seabird species with risk category of very high or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR_1 (from Richard and Abraham 2014 where full details of the risk assessment approach can be found). PBR_1 applies a recovery factor of 1.0. Typically a recovery factor of 0.1 to 0.5 is applied (based on the state of the population) to allow for recovery from low population sizes as quickly as possible. This should be considered when interpreting these results. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

	Risk ratio				
Species name	OTH target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.000	15.095	0.00	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.000	3.543	0.00	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.003	2.823	0.10	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.000	1.557	0.00	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.000	1.245	0.00	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.000	1.096	0.01	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.000	0.888	0.00	High	Threatened: Nationally Critical
Westland petrel	0.000	0.498	0.00	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.000	0.336	0.13	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.000	0.304	0.00	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable

4.2.2 Sea turtle bycatch

Between 2002–03 and 2013–14, there were 15 observed captures of sea turtles across all surface longline fisheries (Tables 8 and 9, Figure 11). Observer records documented all but one sea turtle as captured and released alive. Sea turtle capture distributions predominantly occur throughout the east coast of the North Island and Kermadec Island fisheries (Figure 12).

Table 8: Number of observed sea turtle captures in the New Zealand surface longline fisheries, 2002–03 to 2013–14, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	1	4	3	3	11
Green turtle	0	1	0	0	1
Unknown turtle	0	1	0	2	3
Total	1	6	3	5	15

Table 9: Effort and sea turtle captures in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data see Thompson et al (2013).

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2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 188 179	674 572	21.2	4	0.006
2011–2012	3 100 177	728 190	23.5	0	0
2012–2013	2 876 932	560 333	19.5	2	0.004
2013–2014	2 546 764	773 527	30.4	0	0

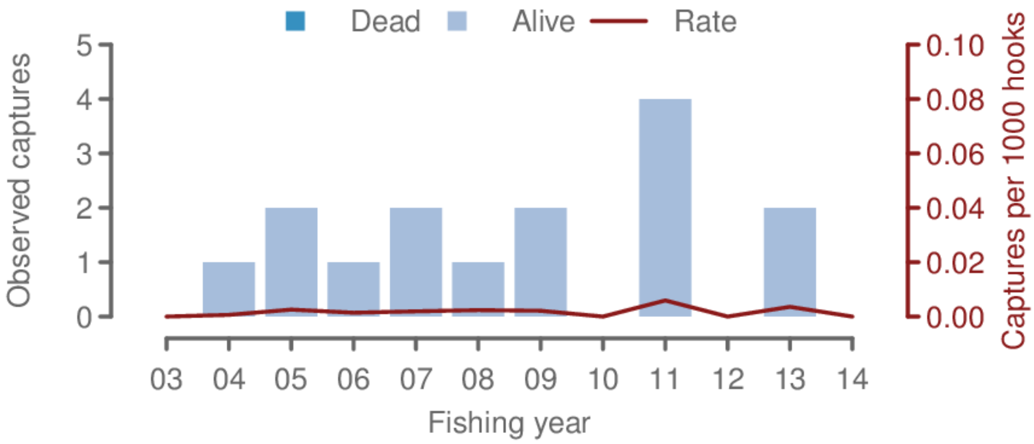


Figure 11: Observed captures of sea turtles in the New Zealand surface longline fisheries from 2002–03 to 2013–14.

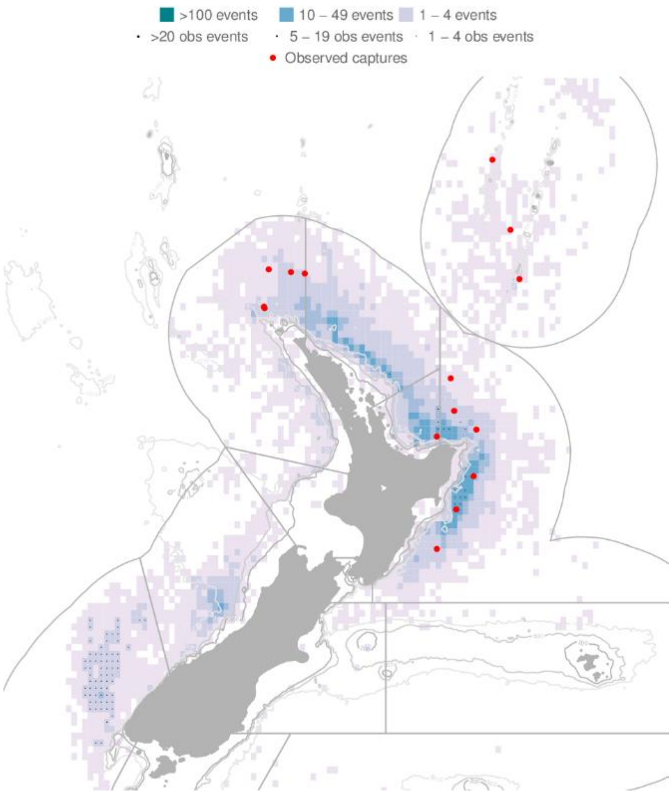


Figure 12: Distribution of fishing effort in the New Zealand surface longline fisheries and observed sea turtle captures, 2002–03 to 2013–14. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3 Marine Mammals

4.2.3.1 Cetaceans

Cetaceans are dispersed throughout New Zealand waters (Perrin et al 2008). The spatial and temporal overlap of commercial fishing grounds and cetacean foraging areas has resulted in cetacean captures in fishing gear (Abraham & Thompson 2009, 2011).

Between 2002–03 and 2013–14, there were seven observed captures of whales and dolphins in surface longline fisheries. Observed captures included 5 unidentified cetaceans and 2 long-finned Pilot whales (Tables 10 and 11, Figure 13) (Thompson et al 2013). All captured animals recorded were documented as being caught and released alive (Thompson et al 2013). Cetacean capture distributions are more frequent off the east coast of the North Island (Figure 14)

Table 10: Number of observed cetacean captures in the New Zealand surface longline fisheries, 2002–03 to 2013–14, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

Species	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	West Coast North Island	West Coast South Island	Total
Long-finned pilot whale	0	1	0	0	0	1	2
Unidentified cetacean	1	1	1	1	1	0	5
Total	1	2	1	1	1	1	7

Table 11: Effort and captures of cetaceans in surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). For more information on the methods used to prepare the data, see Thompson et al (2013).

Fishing year	Fishing effort			Observed captures	
	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	10 770 488	2 195 152	20.4	1	0
2003–2004	7 386 484	1 607 304	21.8	4	0.002
2004–2005	3 679 765	783 812	21.3	1	0.001
2005–2006	3 690 869	705 945	19.1	0	0
2006–2007	3 739 912	1 040 948	27.8	0	0
2007–2008	2 246 139	421 900	18.8	1	0.002
2008–2009	3 115 633	937 496	30.1	0	0
2009–2010	2 995 264	665 883	22.2	0	0
2010–2011	3 188 179	674 572	21.2	0	0
2011–2012	3 100 177	728 190	23.5	0	0
2012–2013	2 876 932	560 333	19.5	0	0
2013–2014	2 546 764	773 527	30.4	0	0

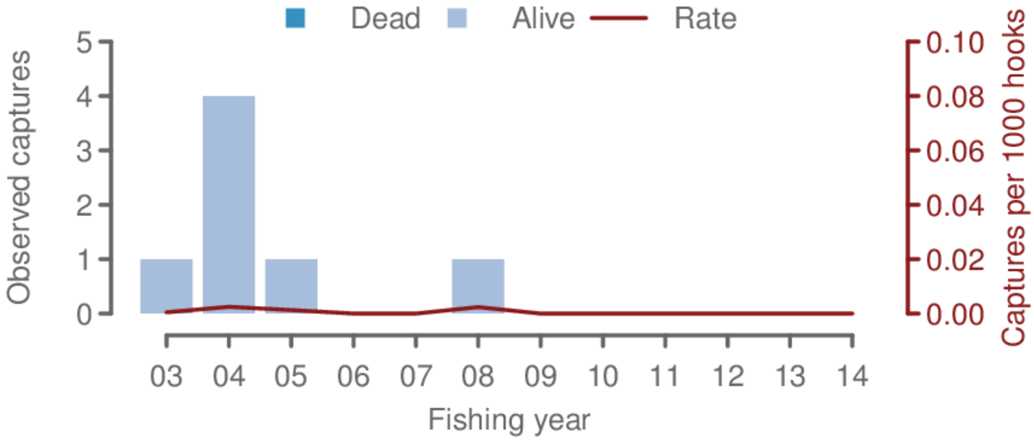


Figure 13: Observed captures of cetaceans in the New Zealand surface longline fisheries from 2002–03 to 2013–14.

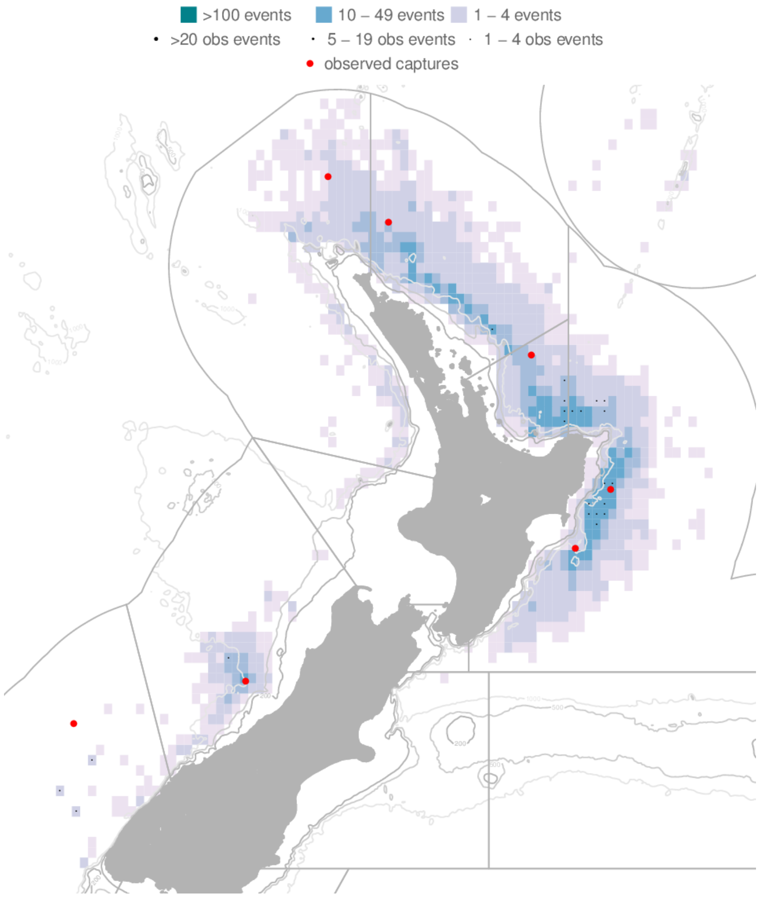


Figure 14: Distribution of fishing effort in the New Zealand surface longline fisheries and observed cetacean captures, 2002–03 to 2013–14. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, especially in waters south of about 40º S to Macquarie Island. The spatial and temporal overlap of commercial fishing grounds and New Zealand fur seal foraging areas has resulted in New Zealand fur seal captures in fishing gear (Mattlin 1987, Rowe 2009). Most fisheries with observed captures occur in waters over or close to the continental shelf, which slopes steeply to deeper waters relatively close to shore, and thus rookeries and haulouts, around much of the South Island and offshore islands. Captures on longlines occur when the fur seals attempt to feed on the bait and fish catch during hauling. Most New Zealand fur seals are released alive, typically with a hook and short snood or trace still attached.

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Capture rates in 2011–12 and 2013-14 were higher than they were in the early 2000s (Figures 16 and 17). While fur seal captures have occurred throughout the range of this fishery most New Zealand captures have occurred off the Southwest coast of the South Island (Figure 18). Between 2002–03 and 2013–14, there were 323 observed captures of New Zealand fur seal in surface longline fisheries (Tables 12 and 13).

Table 12: Number of observed New Zealand fur seal captures in the New Zealand surface longline fisheries, 2002–03 to 2013–14, by species and area. Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures.

	Bay of Plenty	East Coast North Island	Fiordland	Northland and Hauraki	Stewart Snares Shelf	West Coast North Island	West Coast South Island	Total
New Zealand fur seal	16	33	228	4	4	2	36	323

Table 13: Effort and captures of New Zealand fur seal in the New Zealand surface longline fisheries by fishing year. For each fishing year, the table gives the total number of hooks; the number of observed hooks; observer coverage (the percentage of hooks that were observed); the number of observed captures (both dead and alive); and the capture rate (captures per thousand hooks). Data from Thompson et al (2013), retrieved from http://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2012–13 and preliminary estimates for 2013–14 are based on data version 2015003.

Fishing year	Fishing effort			Observed captures		Estimated captures	
	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	10 772 188	2 195 152	20.4	56	0.026	299	199–428
2003–2004	7 386 484	1 607 304	21.8	40	0.025	134	90–188
2004–2005	3 679 765	783 812	21.3	20	0.026	66	38–99
2005–2006	3 690 869	705 945	19.1	12	0.017	47	23–79
2006–2007	3 739 912	1 040 948	27.8	10	0.010	32	14–55
2007–2008	2 246 139	421 900	18.8	10	0.024	40	19–68
2008–2009	3 115 633	937 496	30.1	22	0.023	53	29–81
2009–2010	2 995 264	665 883	22.2	19	0.029	77	43–121
2010–2011	3 188 179	674 572	21.2	17	0.025	64	35–101
2011–2012	3 100 177	728 190	23.5	40	0.055	140	92–198
2012–2013	2 876 932	560 333	19.5	21	0.037	110	65–171
2013–2014	2 546 764	773 527	30.4	56	0.072	103	88-121

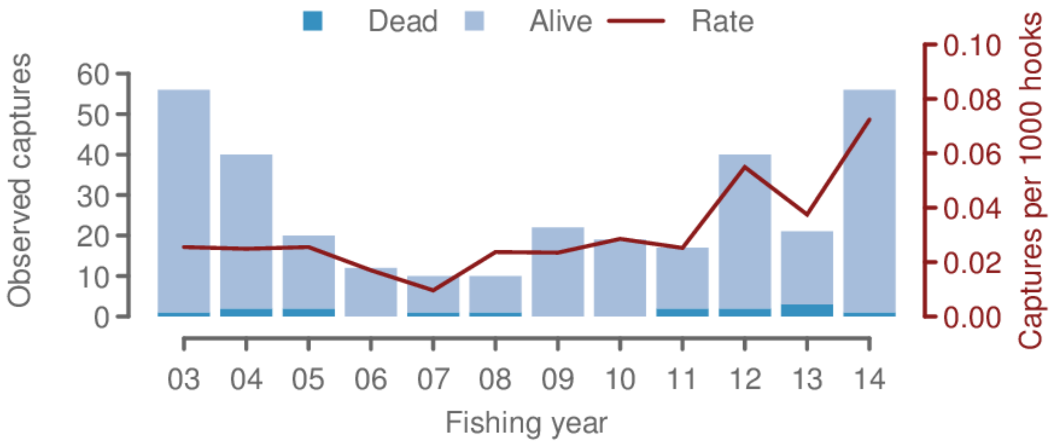


Figure 15: Observed captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2013–14.

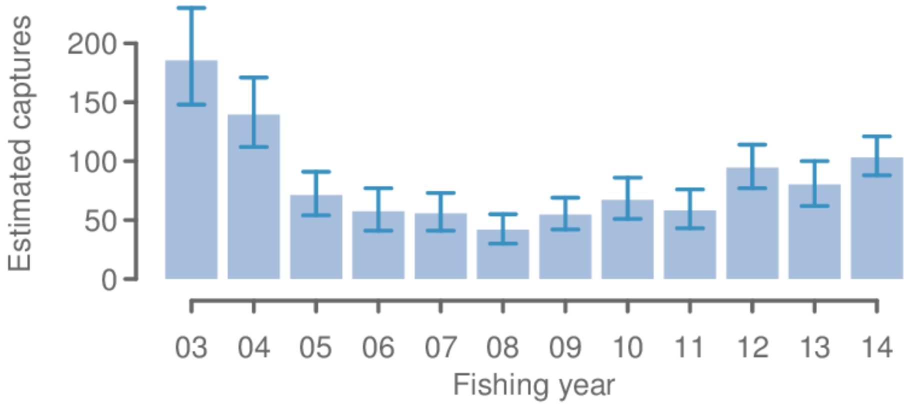


Figure 16: Estimated captures of New Zealand fur seal in the New Zealand surface longline fisheries from 2002–03 to 2013–14.

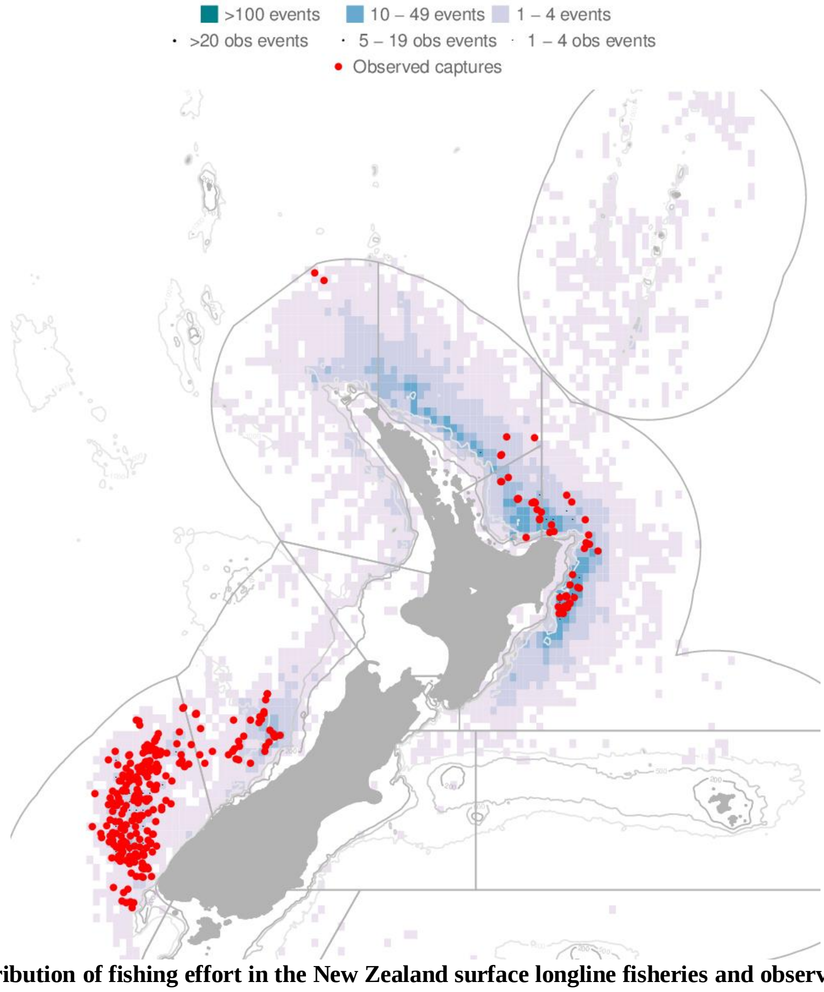


Figure 17: Distribution of fishing effort in the New Zealand surface longline fisheries and observed New Zealand fur seal captures, 2002–03 to 2013–14. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing is only shown if the effort could be assigned a latitude and longitude, and if there were three or more vessels fishing within a cell. In this case, 89.4% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.3 Incidental fish bycatch

Observer records indicate that a wide range of species are landed by the longline fleets in New Zealand fishery waters. Blue sharks are the most commonly landed species (by number), followed by Ray's bream (Table 14).

Table 14: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2010 to 2014. Also provided is the percentage of these species retained (2013 data only) and the percentage of fish that were alive when discarded, N/A (none discarded).

Species	2011	2012	2013	2014	% retained (2014)	discards % alive (2014)
Blue shark	53 432	132 925	158 736	80 118	16.2	89.2
Lancetfish	37 305	7 866	19 172	21 002	0.3	24.4
Porbeagle shark	9 929	7 019	9 805	5 061	30.6	70.7
Rays bream	18 453	19 918	13 568	4 591	96.1	7.4
Mako shark	9 770	3 902	3 981	4 506	30.3	68.8
Sunfish	3 773	3 265	1 937	1 981	2.4	80.0
Moonfish	3 418	2 363	2 470	1 655	96.6	87.5
Dealfish	223	372	237	910	0.4	24.9
Butterfly tuna	909	713	1 030	699	77.3	3.4
Pelagic stingray	4 090	712	1 199	684	0.0	93.5
Escolar	6 602	2 181	2 088	656	88.6	0.0
Deepwater dogfish	548	647	743	600	1.2	80.9
Oilfish	1 747	509	386	518	82.1	40.0
Rudderfish	338	491	362	327	10.7	83.3
Thresher shark	349	246	256	261	28.6	80.0
Big scale pomfret	139	108	67	164	74.5	75.0
Striped marlin	175	124	182	151	0.0	94.3
School shark	49	477	21	119	72.0	78.6
Skipjack tuna	255	123	240	90	80.0	0.0

4.4 Benthic interactions

N/A

4.5 Key environmental and ecosystem information gaps

Cryptic mortality is unknown at present.

Observer coverage in the New Zealand fleet has historically not been spatially or temporally representative of the fishing effort. However in 2013 the observer effort was re-structured to rectify this by planning observer deployment to correspond with recent spatial and temporal trends in fishing effort.

5. STOCK ASSESSMENT

With the establishment of the WCPFC in 2004, future stock assessments of the western and central Pacific Ocean stock of mako shark will be reviewed by the WCPFC. There is currently a shark research plan that has been developed within the context of the Western and Central Pacific Fisheries Commission but mako sharks will not be a focus of that plan in the near future.

There have been no stock assessments of mako sharks in New Zealand, or elsewhere in the world. No estimates of yield are possible with the currently available data. Indicator analyses (Figure 19 and 20) suggest that mako shark populations in the New Zealand EEZ have not been declining under recent fishing pressure, and may have been increasing since 2005 (Table 15, Francis et al.

2014). These changes are presumably in response to a decline in SLL fishing effort since 2002 (Griggs & Baird 2013), and declines in annual landings since a peak in 2000-01 for mako sharks. Observer data from 1995 suggest that mako sharks may have undergone a down-then-up trajectory. The quality of observer data and model fits means these interpretations are uncertain. The stock status of mako sharks may be recovering. Conclusive determinations of stock status will require regional (i.e. South Pacific) stock assessments.

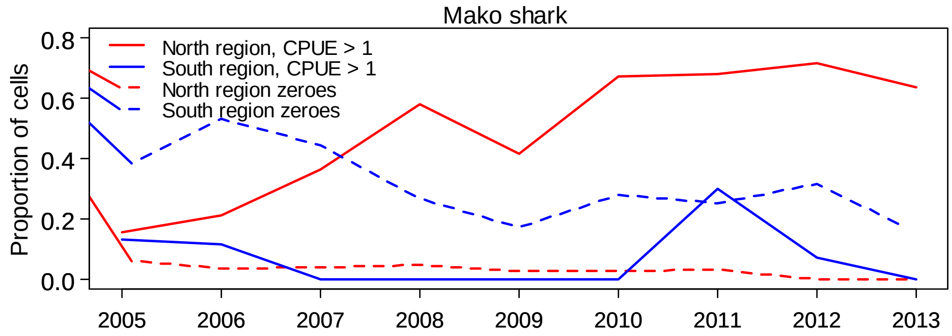


Figure 18. Mako shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 1 per 1000 hooks, and proportions of rectangles having zero catches, for North and South regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs. Source: Francis et al. (2014). North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.

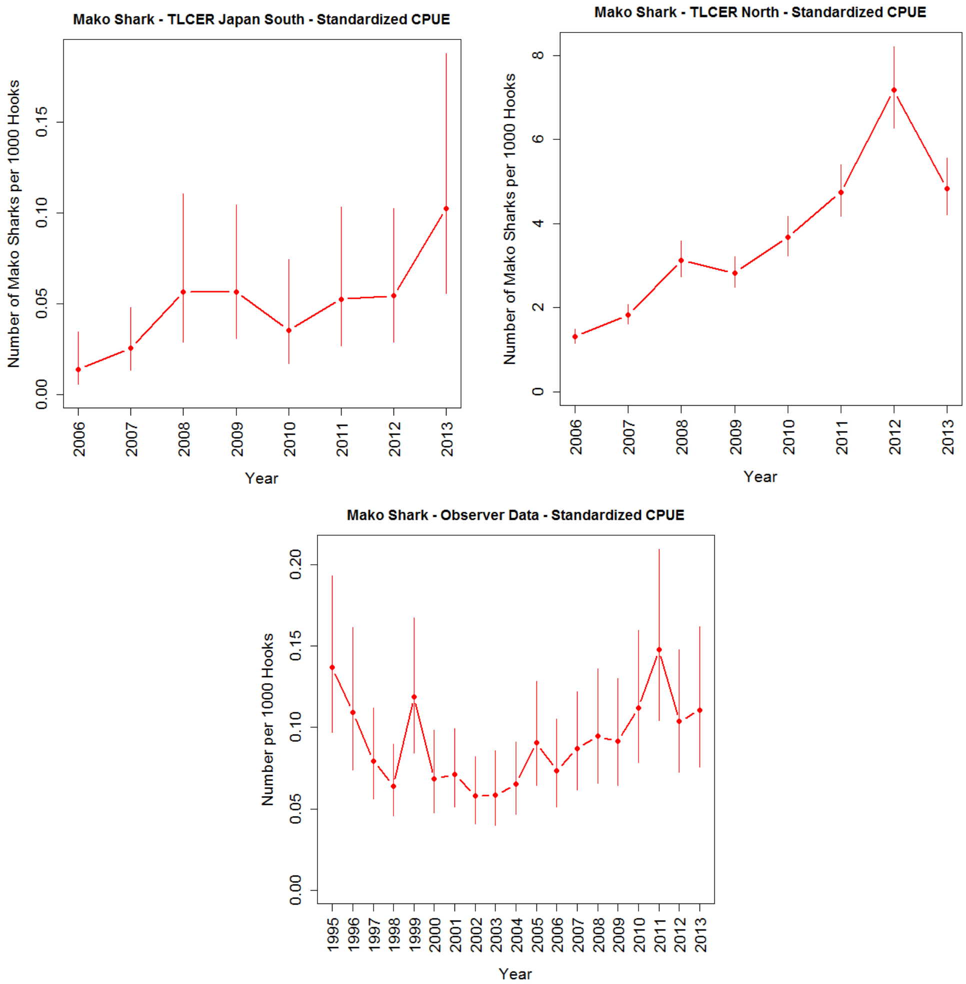


Figure 19. Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand).

Table 15: Summary of trends identified in abundance indicators since the 2005 fishing year based on both TLCER and observer data sets. The CPUE-Obs indicator was calculated for both North and South regions combined. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7. For the CPUE-TLCER indicator in South region, only the Japan dataset indicator is shown (the TLCER Domestic South dataset was small and probably unrepresentative). Green cells show indicators that suggest positive trends in stock size. Note that a downward trend in 'proportion-zeroes' is considered a positive stock trend. NA = indicator not applicable because of small sample size. Source: Francis et al. (2014).

		North region			South region		
Indicator class	Indicator	Blue	Porbeagle	Mako	Blue	Porbeagle	Mako
Distribution	High-CPUE	Up	Up	Up	Up	Up	NA
Distribution	Proportion-zeroes	Nil	Down	Down	Nil	Nil	Down
Catch composition	GM index total catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index total catch - Obs	Up (all species)			Nil (all species)		
Catch composition	GM index HMS shark catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index HMS shark catch - Obs	Up (all species)			Nil (all species)		
Standardised CPUE	CPUE - TLCER	Up	Nil	Up	Up	Nil	Nil
Standardised CPUE	CPUE - Obs	Up	Nil	Nil	Up	Nil	Nil
Sex ratio	Proportion males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Females	Nil	Nil	Nil	Nil	Nil	NA

Compared with a wide range of shark species, the productivity of mako sharks is very low. Females have a high age-at-maturity, moderately high longevity (and therefore low natural mortality rate) and low annual fecundity. The low fecundity is cause for serious concern, as the ability of the population to replace sharks removed by fishing is very limited.

Observer records show that few mako sharks were observed in the South and there were no discernible difference between males and females (Figure 21). There were more males than females, especially in South region (FMAs 5 and 7). With mean length of maturity of 182.5 cm FL for males and 280 cm fork length for females (Francis & Duffy 2005), most mako sharks were immature (85.1% of males and 100.0% of females, overall) (Griggs & Baird 2013).

A data informed qualitative risk assessment was completed on all chondrichthyans (sharks, skates, rays and chimaeras) at the New Zealand scale in 2014 (Ford et al. 2015). Mako sharks had a risk score of 15 and were ranked second equal lowest risk of the eleven QMS chondrichthyan species. Data were described as 'exist and sound' for the purposes of the assessment and the risk score was achieved by consensus of the expert panel, but with low confidence. This low confidence was due to the fact that no data was available on adult stock size.

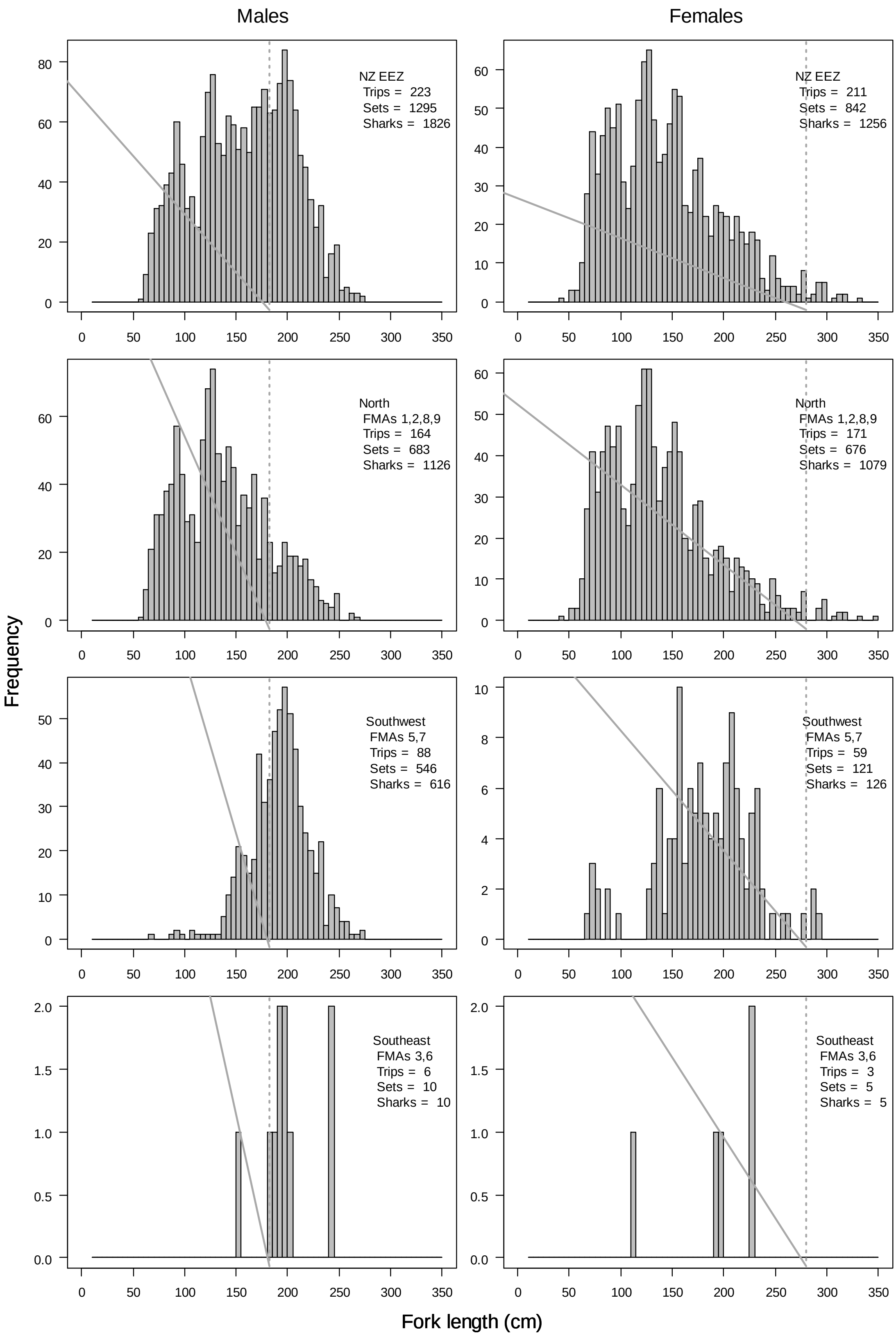


Figure 20: Length-frequency distributions of male and female mako sharks measured by observers aboard surface longline vessels between 1993 and 2012 for the New Zealand EEZ, and North, Southwest and Southeast regions. The dashed vertical lines indicate the median length at maturity. Francis (2013).

6. STATUS OF THE STOCK

Stock structure assumptions

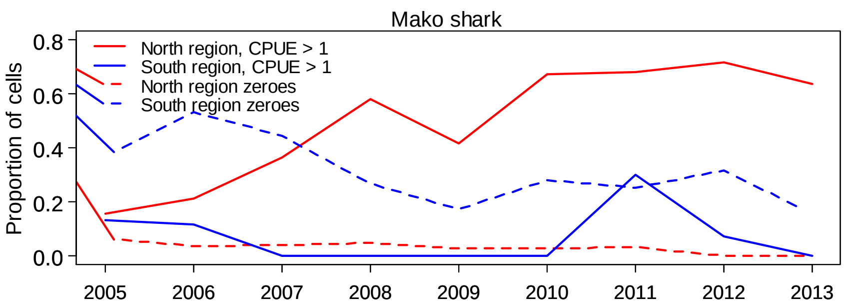
MAK 1 is assumed to be part of the wider South Western Pacific Ocean stock. However, there is no stock assessment for this wider stock. The results below are from indicator analyses of the New Zealand component of that stock only.

Stock Status	
Year of Most Recent Assessment	2014
Assessment Runs Presented	Indictor analyses for NZ EEZ only
Reference Points	Target: Not established Soft Limit: Not established but HSS default of 20% SB_0 assumed Hard Limit: Not established but HSS default of 10% SB_0 assumed Overfishing threshold: F_{MSY}
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Status in relation to Overfishing	Unknown

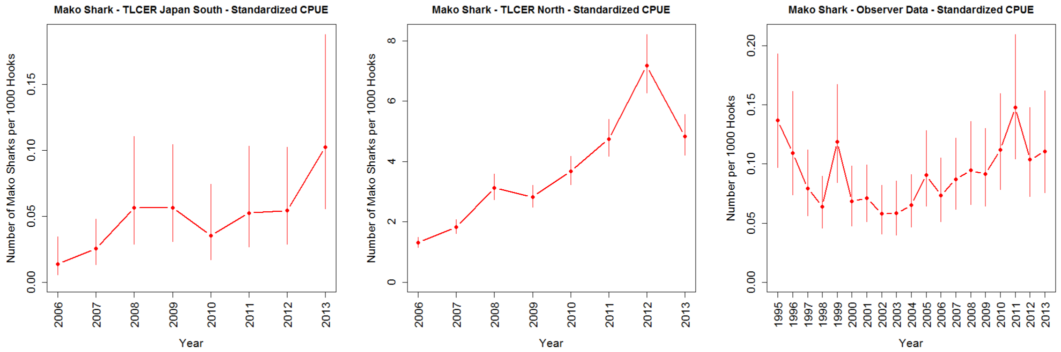
Historical Stock Status Trajectory and Current Status

Summary of trends identified in abundance indicators since the 2005 fishing year based on both TLCER and observer data sets. North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.

		North region			South region		
Indicator class	Indicator	Blue	Porbeagle	Mako	Blue	Porbeagle	Mako
Distribution	High-CPUE	Up	Up	Up	Up	Up	NA
Distribution	Proportion-zeroes	Nil	Down	Down	Nil	Nil	Down
Catch composition	GM index total catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index total catch - Obs	Up (all species)			Nil (all species)		
Catch composition	GM index HMS shark catch - TLCER	Up (all species)			Up (all species)		
Catch composition	GM index HMS shark catch - Obs	Up (all species)			Nil (all species)		
Standardised CPUE	CPUE - TLCER	Up	Nil	Up	Up	Nil	Nil
Standardised CPUE	CPUE - Obs	Up	Nil	Nil	Up	Nil	Nil
Sex ratio	Proportion males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Males	Nil	Nil	Nil	Nil	Nil	NA
Size composition	Median length - Females	Nil	Nil	Nil	Nil	Nil	NA



Mako shark distribution indicators. Proportions of 0.5 degree rectangles having CPUE greater than 1 per 1000 hooks, and proportions of rectangles having zero catches, for North and South regions by fishing year, based on estimated catches (processed and discarded combined) reported on TLCERs. Source: Francis et al. (2014). North region comprises Fisheries Management Areas (FMAs) 1, 2, 8, and 9, and South region comprises FMAs 5 and 7.



Standardised CPUE indices for commercial TLCER (Japan South and North) and observer datasets (all New Zealand).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Appears to be increasing
Recent Trend in Fishing Intensity or Proxy	Appears to be decreasing
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Catches in New Zealand increased from the early 1980s to a peak in the early 2000s but have declined from highs of 319 t to 67-103 t in between 2005-06 and 2012-13, and 44 t in 2013-14. This decline in catch coincides with a decline in longline fishing effort, and for the last year, a ban on shark finning.

Projections and Prognosis		
Stock Projections or Prognosis	The stock is likely to increase if effort remains at current levels	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown	
Assessment Methodology and Evaluation		
Assessment Type	Level 2- Partial Quantitative Stock Assessment: Standardised CPUE indices and other fishery indicators	
Assessment Method	Indicator analyses	
Assessment Dates	Latest assessment: 2014	Next assessment: Unknown
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Distribution - Species composition - Size and sex ratio - Catch per unit effort	1 – High quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	Catch recording before 2005 may not be accurate	
Qualifying Comments		
-		

Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 25ºS. Seabird bycatch mitigation measures are required in the New Zealand and Australian EEZ's and through the WCPFC Conservation and Management Measure CMM2007-04. Sea turtles are also incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure CMM2008-03.

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