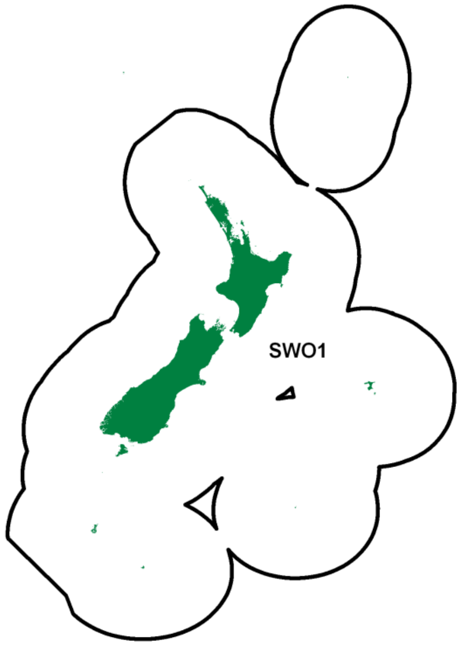
SWORDFISH (SWO)

(*Xiphias gladius*)



1. FISHERY SUMMARY

Swordfish were introduced into the QMS on 1 October 2004 under a single QMA, SWO 1, with allowances, TACC, and TAC in Table 1.

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

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
SWO 1	20	10	4	885	919

Swordfish were added to the Third Schedule of the 1996 Fisheries Act with a TAC set under s14 because swordfish 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.

Swordfish were also added to the Sixth Schedule of the 1996 Fisheries Act with the provision that:

> "A commercial fisher may return any swordfish to the waters from which it was taken from if –
> (a) that swordfish is likely to survive on return; and
> (b) the return takes place as soon as practicable after the swordfish is taken; and
> (c) that swordfish has a lower jaw to fork length of less than 1.25m."

Management of swordfish throughout the western and central Pacific Ocean (WCPO) is the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). At its sixth annual meeting (2009) the WCPFC passed a Conservation and Management Measure (CMM) (this is a binding measure that all parties must abide by) relating to conservation and management of swordfish in the southwest Pacific Ocean (www.wcpfc.int/). This measure restricts the number of vessels fishing for swordfish and sets catch limits in the convention area south of 20 degrees south.

1.1 Commercial fisheries

Annual swordfish catches throughout the Pacific have been increasing, with catches in the Western and Central Pacific increasing to 20 000 t in 2012 (Williams and Terawasi 2013). The swordfish catch from the southwest Pacific has averaged about 12% of the Pacific Ocean total in recent years. In New Zealand, swordfish are caught throughout the year in oceanic waters, primarily by pelagic longlines in areas where the bottom depth exceeds 1000 m.

Swordfish are either targeted or caught in the tuna longline fishery as a bycatch when targeting bigeye and to a lesser extent when targeting southern bluefin tuna. Swordfish can be caught in most FMAs and adjacent high seas areas although most catches are from waters north of 40ºS. Swordfish catch by domestic vessels increased rapidly from 1994–95 to peak at 1100 t in 2000–01. Since 2000–01 swordfish catches declined in each year coinciding with the decline in effort in the surface longline fishery, until 2005–06 when they increased again (Table 2). This increase is attributed to the development of a target fishery, which was, in part, initiated by the arrival of several surface longline vessels from Australia. Most of the catch is from FMA 1, FMA 2 and FMA 9. Figure 1 shows historical landings and TACCs and longline effort for SWO stocks.

Swordfish are processed at sea and the processed weight of the catch is converted to a greenweight using approved conversion factors. TLCER, CELR and LFRR data are provided for comparative purposes in Table 2 for the domestic fleet (New Zealand owned and operated vessels and chartered longline vessels).

Before the start of the domestic longline fishery in 1990–91, distant water longline fleets were granted foreign license access to fish for southern bluefin and bigeye tuna (Japan) and albacore (Korea). Swordfish catches for the Japanese fleet are given in Table 2 (Japan). The swordfish bycatch by the Japanese foreign licensed fishery averaged 388 t per year between 1979–80 and 1992–93 with a maximum catch of 761 t in 1980–81. Most of the Japanese swordfish catch (85%) was from FMA 2 and FMA 9. Korean catches were only small (0 to 7 t per year) and were mostly (79%) from FMA 9 and FMA 10.

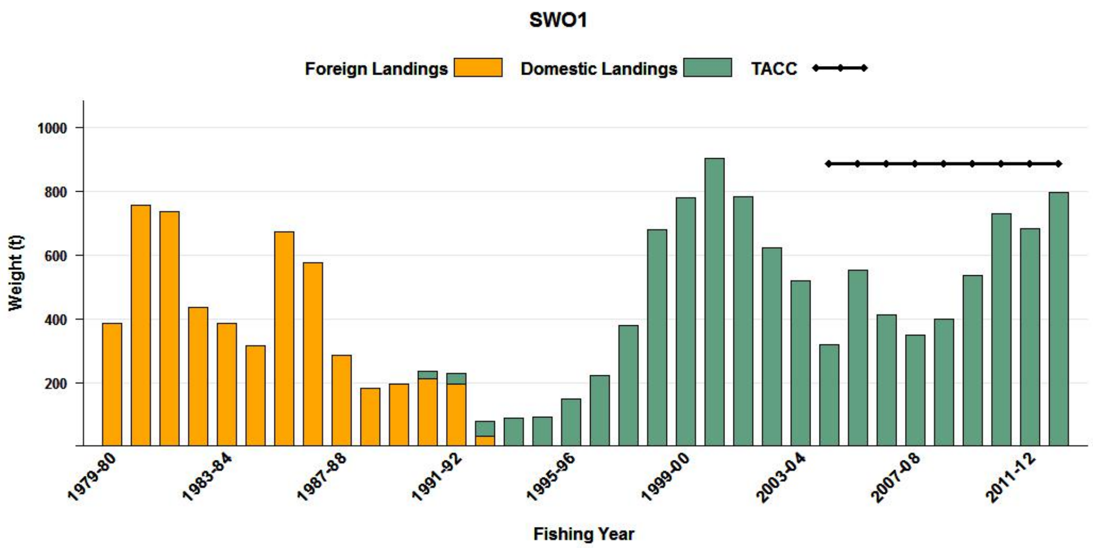


Figure 1: Swordfish catch by foreign licensed and New Zealand vessels from 1979–80 to 2012–13 New Zealand fishery waters (SWO 1). [Figure continued on next page].

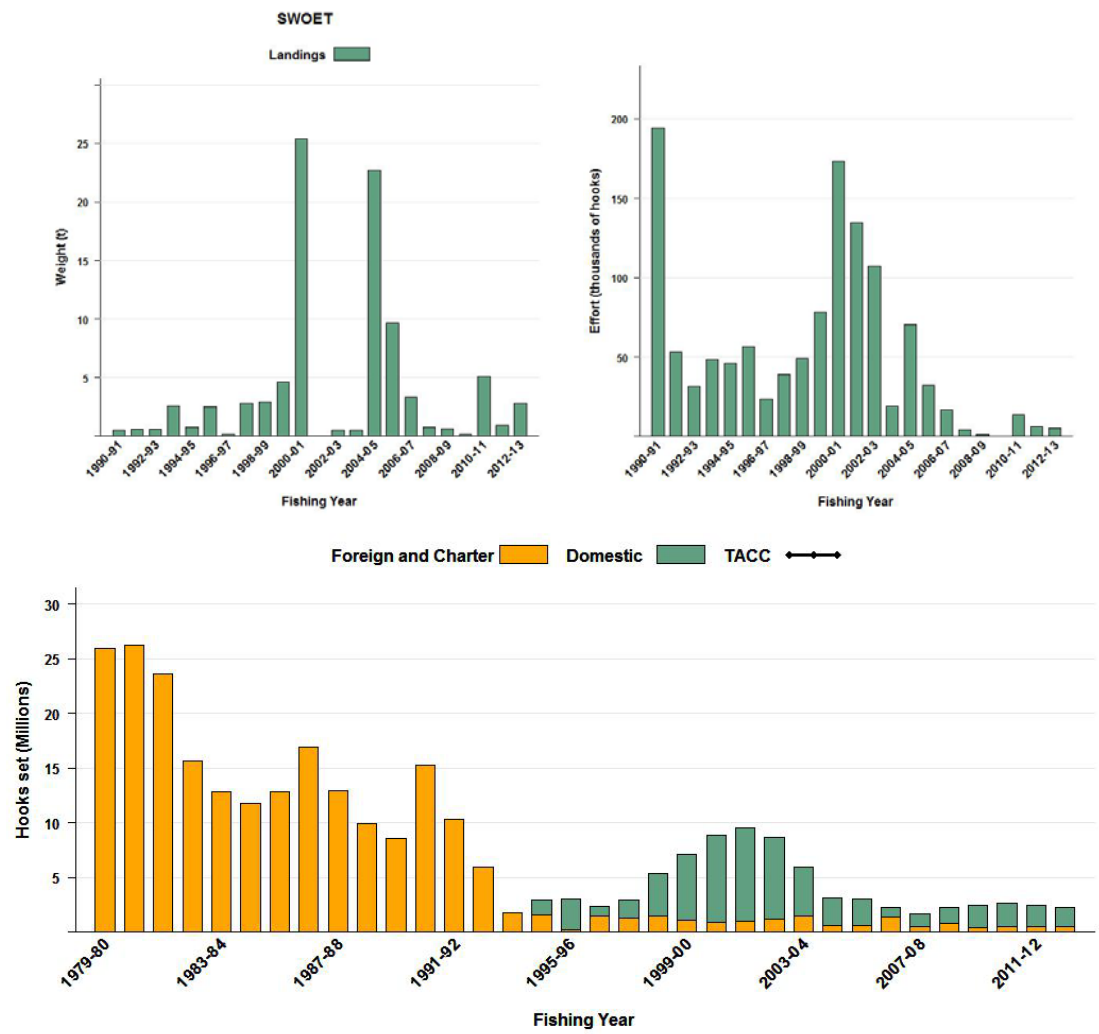


Figure 1 [Continued]: [Top] Swordfish catch by New Zealand vessels fishing on the high seas from 1990–91 to 2012–13. [Middle] Fishing effort (number of hooks set) for all New Zealand vessels fishing on the high seas; and [Bottom] fishing effort (number of hooks set) within New Zealand fishery waters for domestic and foreign vessels (including foreign charter vessels) from 1979–80 to 2012–13.

Table 2: Reported catches (t) of *X. gladius* by fishing year (from TLCER and CELR data) for the New Zealand domestic and chartered vessel fleet 1990-91 to 2012-13 and Japanese foreign licensed fleet 1979–80 to 2012–13; with annual totals from LFRR and MHR data from 2001–02 to present [Continued on next page].

	SWO 1 (all FMAs)				
Year	Japan	NZ/MHR	Total	LFRR	NZ ET
1979–80	386		386		
1980–81	756.1		756.1		
1981–82	734.6		734.6		
1982–83	436.1		436.1		
1983–84	384.8		384.8		
1984–85	316.1		316.1		
1985–86	673.6		673.6		
1986–87	575.5		575.5		
1987–88	286.2		286.2		
1988–89	181.1		181.1		
1989–90	194.3		194.3		
1990–91	211.9	21.9	233.8	41	0.5
1991–92	194.5	33.5	228	32	0.6
1992–93	31.1	46.8	77.9	79	0.6
1993–94		88.2	88.2	102	2.6
1994–95		91.4	91.4	102	0.8
1995–96		148.6	148.6	187	2.5

Table 2 [Continued]: Reported catches (t) of *X. gladius* by fishing year (from TLCER and CELR data) for the New Zealand domestic and chartered vessel fleet 1990-91 to 2012-13 and Japanese foreign licensed fleet 1979–80 to 2012–13; with annual totals from LFRR and MHR data from 2001–02 to present.

	SWO 1 (all FMAs)				
Year	Japan	NZ/MHR	Total	LFRR	NZ ET
1996–97		223.3	223.3	283	0.2
1997–98		379.7	379.7	534	2.8
1998–99		679.1	679.1	965	2.9
1999–00		778	778	976	4.6
2000–01		901.4	901.4	1 022	25.4
2001–02		945	783.9	958.8	
2002–03		673	622.0	670.1	0.5
2003–04		545	519.4	555.2	0.5
2004–05		344	320.7	344.7	22.7
2005–06		560.9	548.3	558.9	9.7
2006–07		412.7	412.7	425.8	3.3
2007–08		350.1	350.1	351.4	0.7
2008–09		398.7	398.7	393.9	0.6
2009–10		536.5	536.5	533.4	0.1
2010–11		729.6	729.6	739	5.1
2011–12		688.1	688.1	686.4	0.9
2012–13		796.8	796.8	788.4	2.8

The majority of swordfish are caught in the bigeye target surface longline fishery (64%) (Figure 2), however, across all longline fisheries swordfish make up 17% of the catch by weight (Figure 3). 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 east coast of the North Island targets a range of species including bigeye, swordfish, and southern bluefin tuna (Figure 4).

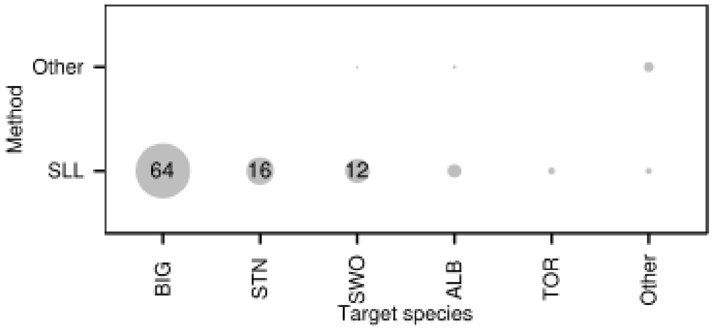


Figure 2: A summary of the proportion of landings of swordfish taken by each target fishery and fishing method. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage. SLL = surface longline (Bentley et al 2013).

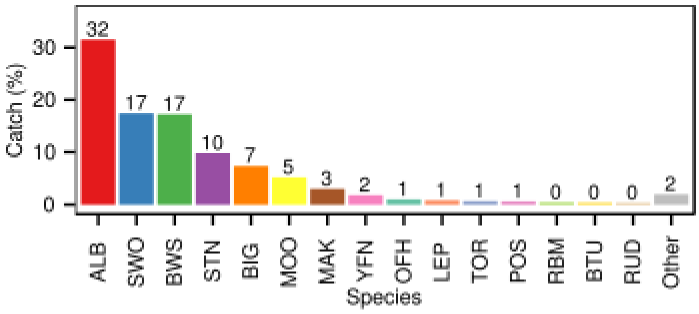


Figure 3: A summary of species composition of the reported surface longline catch. The percentage by weight of each species is calculated for all surface longline trips (Bentley et al 2013).

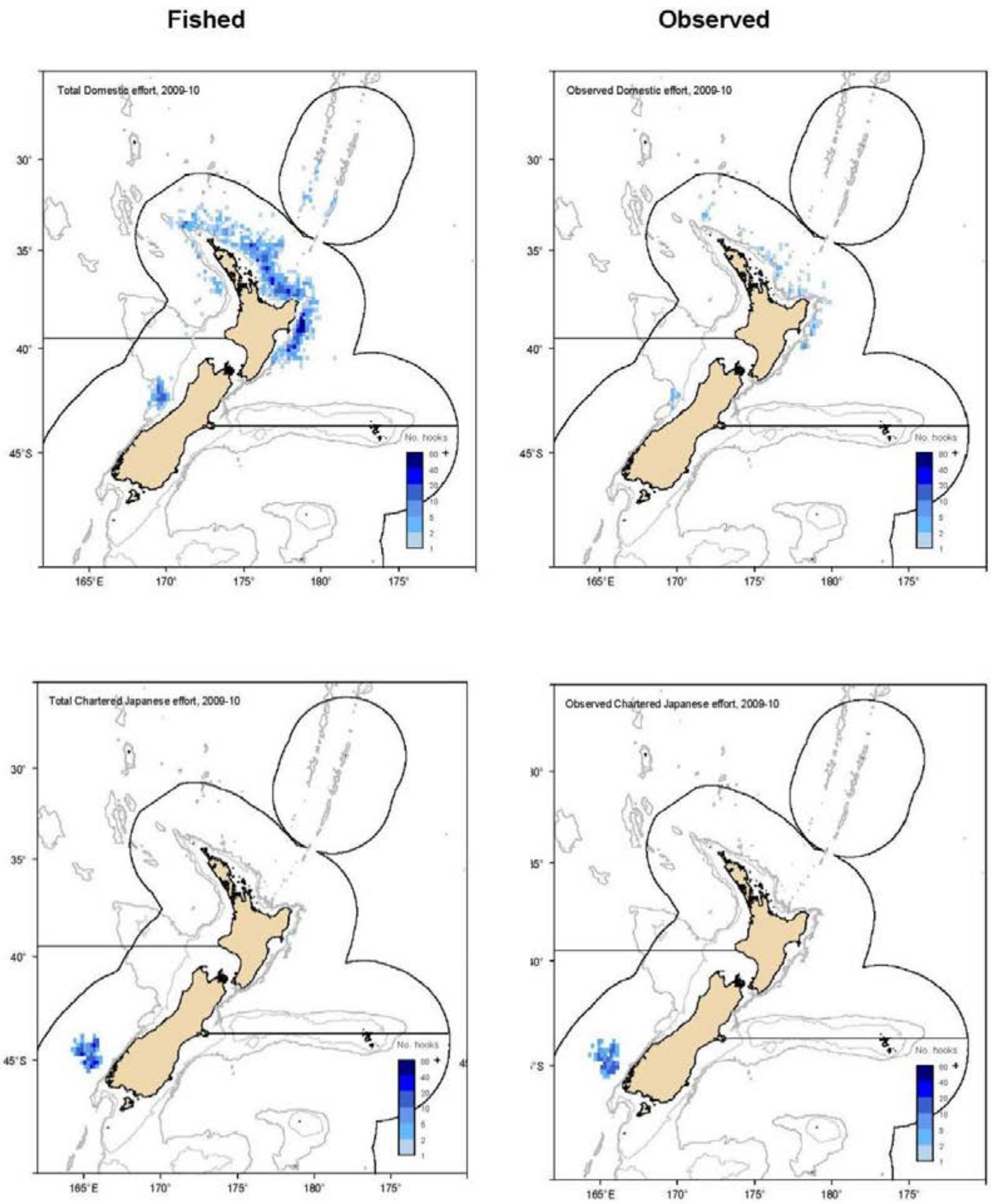


Figure 4: Distribution of fishing positions for domestic (top two panels) and charter (bottom two panels) vessels, for the 2009–10 fishing year, displaying both fishing effort (left) and observer effort (right).

Across all fleets in the longline fishery, 30.9% of the swordfish were alive when brought to the side of the vessel (Table 3). The domestic fleets retain around 90–99% of their swordfish catch, while the foreign charter fleet retain 99–100% of the swordfish catch, the Australian fleet that fished in New Zealand waters in 2006–07 retained most (94.8%) of their swordfish (Table 4).

Table 3: Percentage of swordfish (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	42.8	57.2	325
	Charter	North	58.9	41.1	90
		South	61.9	38.1	21
	Domestic	North	27.3	72.7	355
	Total		**38.2**	**61.8**	**791**
2007–08	Domestic	North	25.1	74.9	495
	Total		**25.3**	**74.7**	**498**
2008–09	Charter	North	97.0	3.0	33
	Domestic	North	26.0	74.0	416
	Total		**31.6**	**68.4**	**455**
2009–10	Domestic	North	23.2	76.8	448
	Total		**23.7**	**76.3**	**452**
Total all strata			**30.9**	**69.1**	**2 196**

Table 4: Percentage of swordfish 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	% discarded or lost	Number
2006–07	Australia	94.8	5.2	326
	Charter	99.1	0.9	115
	Domestic	93.2	6.8	355
	Total	**94.7**	**5.3**	**796**
2007–08	Charter	100.0	0.0	3
	Domestic	91.5	8.5	496
	Total	**91.6**	**8.4**	**499**
2008–09	Charter	100.0	0.0	43
	Domestic	97.1	2.9	418
	Total	**97.4**	**2.6**	**461**
2009–10	Charter	100.0	0.0	3
	Domestic	94.3	5.7	454
	Total	**94.3**	**5.7**	**457**
Total all strata		**94.5**	**5.5**	**2 213**

1.2 Recreational fisheries

Swordfish are targeted by some recreational sport fishers with the annual recreational landed catch increasing over the last four years to 55 fish in 2012-13. There is renewed recreational interest in swordfish using deep drifted baits during the day rather than drifting or slow trolling at night. There has also been an increase in the number of swordfish tagged and released with 43 tagged by recreational fishers and 7 by commercial fishers in 2012–13.

1.3 Customary non-commercial fisheries

An estimate of the current customary catch is not available, but it is considered to be low.

1.4 Illegal catch

Prior to QMS introduction in 2004 it was illegal to target swordfish but analyses of CPUE data suggest targeting did occur. These catches were generally still reported (although as bycatch), so estimates of total annual catch were not affected.

1.5 Other sources of mortality

The estimated overall incidental mortality rate from observed longline effort is 0.44% of the catch. Discard rates from observer data are 0.7% on average, of which approximately 60% are discarded dead (usually small fish, or as a result of shark damage). Fish are also lost at the surface in the longline fishery, from observer data, 0.21% on average. Approximately 20% of those fish are also dead. Swordfish have occasionally been observed as a bycatch in the skipjack tuna purse seine fishery and in trawl fisheries for jack mackerel and hoki.

2. BIOLOGY

Swordfish (*Xiphias gladius* Linnaeus, 1758) are an epi- and mesopelagic highly migratory species found in all tropical and temperate oceans and large seas. Based on longline catches, swordfish range from 50ºN to 45ºS in the western Pacific Ocean and from 45ºN to 35ºS in the eastern Pacific Ocean.

Growth rates have been estimated for Pacific Ocean swordfish caught off Taiwan. Estimates of growth rate indicate rapid growth with fish reaching about 1 m in lower jaw to fork length during the first year. Growth rate slows progressively with age. Females grow significantly faster than males. Asymptotic length for males is 213 cm while asymptotic length for females is about 300 cm. The maximum age observed in Taiwanese samples was 10 years for males and 12 years for females. The maximum size reported for a swordfish is 445 cm total length (includes the bill and furthest extension of the tail) and about 540 kg.

A number of studies of swordfish growth have been undertaken in Australia and New Zealand (Young and Drake 2004; Young et al 2003; Young et al 2008). The results are generally consistent within the two areas, with maximum ages of 18 and 15 years, respectively. It is likely that swordfish attain a maximum age of 20 years. Given the lack of observations of swordfish in New Zealand with ripe or running ripe gonad condition, age-at-maturity was defined on the basis of the Australian estimates of length-at-50% maturity for males and females of 101 and 221 cm, respectively. Using the growth curves estimated for New Zealand swordfish, this corresponds to ages at 50% maturity for males and females of 1 and 10 years, respectively.

In the New Zealand EEZ swordfish size varies markedly with latitude, with larger swordfish (and hence fewer males) caught south of 40ºS. Average size of both males and females is larger in the southern region compared to the north: 228 and 158.4 cm for males, and 231.9 and 175 cm for females, respectively. Average length (lower jaw to fork length) of swordfish caught in the EEZ has been relatively stable since 1991, averaging 196.6 cm for the Japanese charter fleet and 163.9 cm for the domestic owned and operated fleet based on limited observer data. Overall the average size over all fleets since 1991 is 178.3 cm, however, this will be largely representative of the charter fleet. Males are substantially smaller than females with most males smaller than 189 cm (77%) and most females (51%) larger than 189 cm for all fleets. From 1987 to 2005 the average sex ratio of longline-caught swordfish in the EEZ was 1:3.15 (male:female).

A relationship between lower jaw-fork length and weight has been estimated for swordfish from observer records (n = 2 835): weight (kg) = (3.8787×10^{-6}) length$^{3.24}$.

Spawning takes place in the tropical waters of the western Pacific Ocean and to a lesser extent the equatorial waters of the central Pacific Ocean.

Swordfish are serial batch spawners, perhaps spawning as frequently as every few days over several months. Eggs are spawned in the upper layers of the tropical ocean and, like the protracted larval phase, are pelagic. Depending on fish size, swordfish egg production is estimated to range from 1 to 29 million eggs per year (for 68 – 272 kg females respectively).

Little information on mortality rate is available, but *M* has been estimated elsewhere in the Pacific to be 0.22 yr^{-1}. This value is consistent with the maximum estimated ages for swordfish in Australia and New Zealand.

3. STOCKS AND AREAS

Swordfish found in the New Zealand EEZ are part of a much larger stock that spawns in the tropical central to western Pacific Ocean. They are highly migratory and their residence time in the EEZ and adjacent waters is unknown. In the Pacific Ocean swordfish occur from 50ºN to 45ºS in the western Pacific Ocean and from 45ºN to 35ºS in the eastern Pacific Ocean. Swordfish are visual predators with a wide temperature tolerance. Extensive diel vertical migrations have been observed for swordfish in the Atlantic and Pacific Oceans from waters deeper than 600 m to the surface and across large temperature gradients (e.g., from 8º to 27ºC) in a few hours. Swordfish are found at or near the surface, at night. Within the EEZ most swordfish are caught in FMA 1, FMA 2, and FMA 9 when sea surface temperatures are 17º to 19ºC.

Stock structure is uncertain and recent genetic studies have indicated that there may be multiple Pacific Ocean stocks. There is limited information on swordfish movement from conventional tagging studies. From a release sample of 327 swordfish tagged in the New Zealand EEZ as part of the New Zealand gamefish tagging programme, three have been recaptured. Two small fish were tagged by commercial fishers one 120 nautical miles north of New Zealand and the other 80 nautical miles north east of East Cape. Both were recaptured after extended periods at liberty, 8 and 10 years respectively, and had grown to sizes consistent with being sexually mature. Despite the long liberty period the recapture positions were not far (less than 130 nautical miles) from the release locations. In February 2012 a recreational angler recaptured a 130 kg swordfish he personally had tagged from the same boat and same location 8 months previously. Although the apparent net movement is limited, little can be inferred from this information in relation to swordfish stock structure or migration in, and around, New Zealand waters.

From a release sample of 672 fish tagged in the Australian EEZ, eight recaptures have been reported. Although some fish tagged in east Australian waters have moved large distances (e.g., 893 nautical miles), none were recaptured outside of the Australian EEZ, or have crossed the Tasman Sea into the New Zealand EEZ. Nineteen pop-off satellite archival tags have been deployed on swordfish in New Zealand with the aim of tracking fish over the spring spawning period. The eight longer term tracks (4 to 8 months) show fish moving into sub-tropical waters in spring and returning to the New Zealand EEZ or adjacent waters in summer. Data from satellite tagged swordfish in New Zealand, Australia and the Cook Islands was used to describe the stock structure in the south-west Pacific region in the 2013 stock assessment model.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the November 2014 Fishery Assessment Plenary after review by the Aquatic Environment Working Group. This summary is from the perspective of the swordfish longline fishery; a more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment & Biodiversity Annual Review where the consequences are also discussed (http://www.mpi.govt.nz/Default.aspx?TabId=126&id=2122) (Ministry for Primary Industries 2013).

4.1 Role in the ecosystem

Swordfish (*Xiphias gladius*) are large pelagic predators, so they are likely to have a 'top down' effect on the squid, fish and crustaceans they feed on.

4.2 Incidental catch of seabirds, sea turtles and mammals

These capture estimates relate to the swordfish target longline fishery only, from the New Zealand EEZ. The 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).

4.2.1 Seabird bycatch

Between 2002–03 and 2012–13, there were 87 observed captures of seabirds in swordfish longline fisheries. Seabird capture rates since 2003 are presented in Figure 5. Peaks in observed capture rate were seen in 2006-07 and 2009-10. The seabird capture locations are predominantly within the northern area of New Zealand's EEZ (see Table 5 and Figure 6). The high number of captures in 2007 (Figure 5) are anomalous and are the result of an Australian vessel fishing in the EEZ with inappropriate mitigation gear, this issue has since been resolved. 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 albacore longline fisheries are provided in Table 6.

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 2013b). 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 2014 iteration of the seabird risk assessment (Richard & Abraham in press) assessed the swordfish target fishery contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 7). This target fishery contributed 0.441 of PBR_1 to the risk to Gibson's albatross which was assessed to be at very high risk from New Zealand commercial fishing. This fishery also contributed 0.232 of PBR_1 to Antipodean albatross, which was assessed to be at high risk from NZ commercial fishing (Richard & Abraham in press).

Table 5: Number of observed seabird captures in swordfish longline fisheries, 2002–03 to 2012–13, by species and area. See glossary above for a description of the areas used for summarising the fishing effort and protected species captures. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard and Abraham (2014) where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for swordfish using longline gear but rather the total risk for each seabird species. Other data, version 20140201.

Species	Risk ratio	Kermadec Islands	Northland and Hauraki	West Coast South Island	East Coast North Island	West Coast North Island	Total
Albatrosses	N/A	33					33
Antipodean albatross	High	12	3				15
Gibson's albatross	Very high	4	5	1			10
Antipodean and Gibson's albatross	N/A	5					5
Campbell black-browed albatross	High		2	1			3
New Zealand white-capped albatross	Very high			2		1	3
Black-browed albatrosses	N/A	2					2
Southern Buller's albatross	Very high				1		1
Total albatrosses	**N/A**	**56**	**10**	**4**	**1**	**1**	**72**
White-chinned petrel	Medium	2		3			5
Grey petrel	Low	3					3
Black petrel	Very high		1			1	2
Grey-faced petrel	Negligible	1	1				2
Flesh-footed shearwater	Very high				1		1
Sooty shearwater	Negligible	1					1
Westland petrel	High			1			1
Total other seabirds	**N/A**	**7**	**2**	**4**	**1**	**1**	**15**

Table 6: Effort, observed and estimated seabird captures by fishing year for the swordfish 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 (both dead and alive); 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) and are available via http://www.fish.govt.nz/en-nz/Environmental/Seabirds/. Estimates from 2002–03 to 2011–12 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	N/A	0	N/A	0	N/A	0	0–3
2003–2004	0	0	N/A	0	N/A	0	0–0
2004–2005	132 503	11 553	8.7	2	0.173	52	27–95
2005–2006	228 305	4 800	2.1	2	0.417	173	69–416
2006–2007	210 175	40 138	19.1	71	1.769	283	156–610
2007–2008	125 330	21 630	17.3	1	0.046	74	36–139
2008–2009	41 700	3 990	9.6	0	0	16	4–51
2009–2010	137 840	500	0.4	3	6	90	42–196
2010–2011	177 248	18 638	10.5	0	0	68	30–155
2011–2012	195 400	43 450	22.2	7	0.161	86	34–223
2012–2013†	316 390	8 250	2.6	1	0.121	175	75–396

†Provisional data, model estimates not finalised.

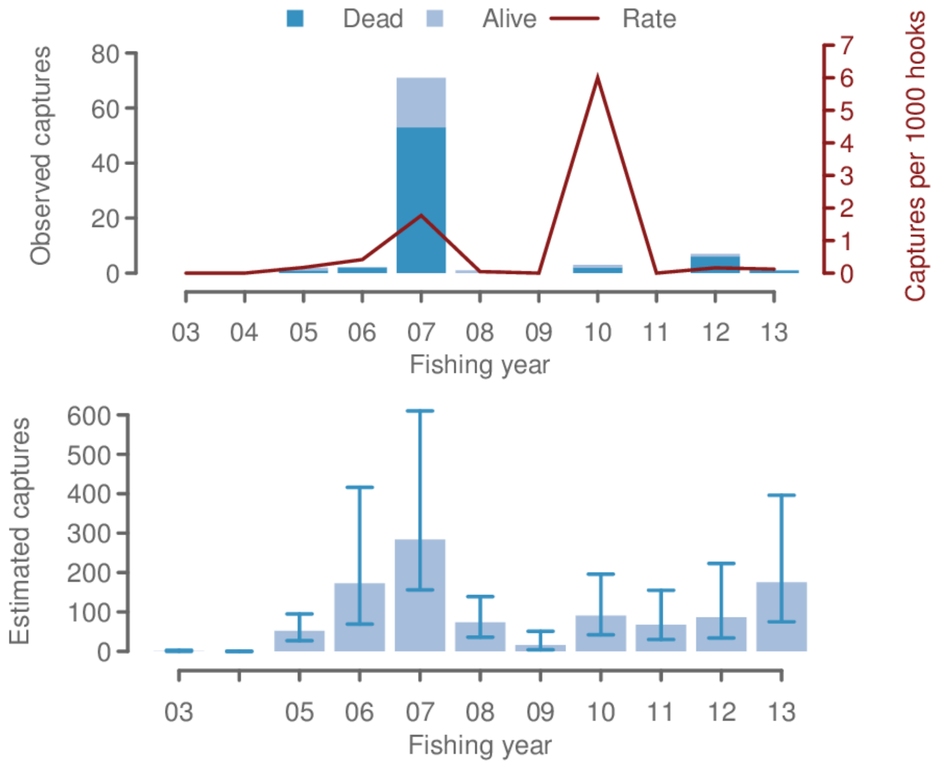


Figure 5: Observed captures and estimated captures of seabirds in swordfish longline fisheries from 2002–03 to 2012–13.

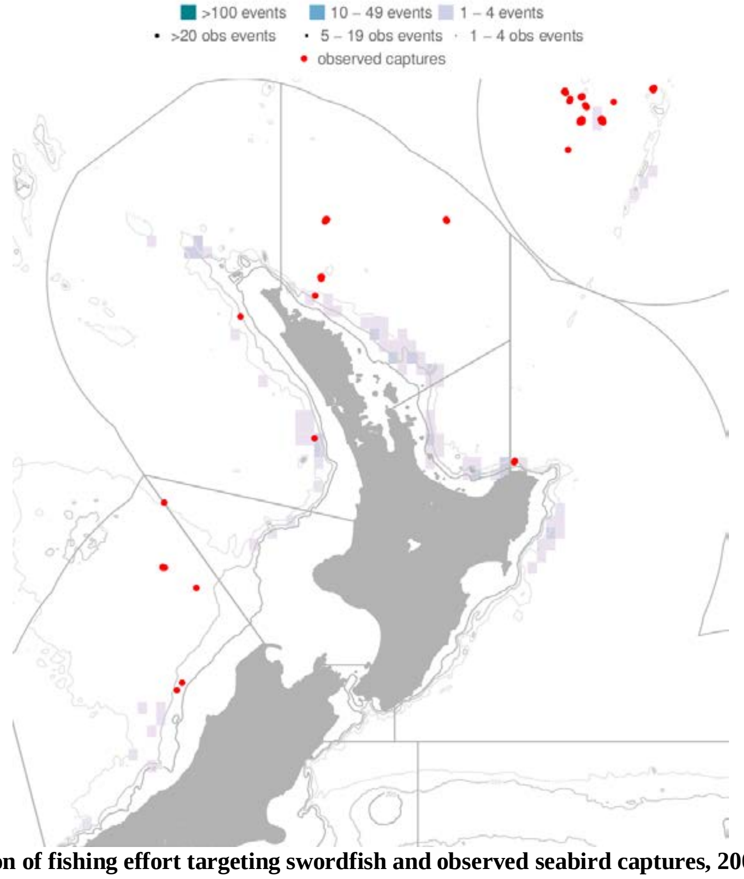


Figure 6: Distribution of fishing effort targeting swordfish and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures 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, 36.6% 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 swordfish target surface longline fisheries and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very 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	SWO target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.088	15.095	0.58	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.002	3.543	0.06	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.011	2.823	0.39	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.005	1.557	0.29	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.441	1.245	35.43	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.003	1.096	0.26	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.232	0.888	26.10	High	Threatened: Nationally Critical
Westland petrel	0.024	0.498	4.85	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.007	0.336	2.18	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.009	0.304	2.95	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable
White-chinned petrel	0.004	0.268	1.34	Medium	At Risk: Declining

4.2.2 Sea turtle bycatch

Between 2002–03 and 2012–13, there were two observed captures of sea turtles in swordfish longline fisheries (Table 9 and Figure 7). Observer recordings documented all sea turtles as captured and released alive. Sea turtle captures for this fishery have only been observed in the Kermadec Islands fishing area (Table 8 and Figure 8).

Table 7: Number of observed sea turtle captures in swordfish longline fisheries, 2002–03 to 2012–13, 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	Kermadec Islands	Total
Leatherback turtle	2	2

Table 8: Fishing effort and sea turtle captures in swordfish 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 effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	N/A	0	N/A	0	N/A
2003–2004	0	0	N/A	0	N/A
2004–2005	132 503	11 553	8.7	0	0
2005–2006	228 305	4 800	2.1	0	0
2006–2007	210 175	40 138	19.1	1	0.025
2007–2008	125 330	21 630	17.3	1	0.046
2008–2009	41 700	3 990	9.6	0	0
2009–2010	137 840	500	0.4	0	0
2010–2011	177 248	18 638	10.5	0	0
2011–2012	195 400	43 450	22.2	0	0
2012–2013	316 390	8 250	2.6	0	0

Figure 7: Observed captures of sea turtles in swordfish longline fisheries from 2002–03 to 2012–13.

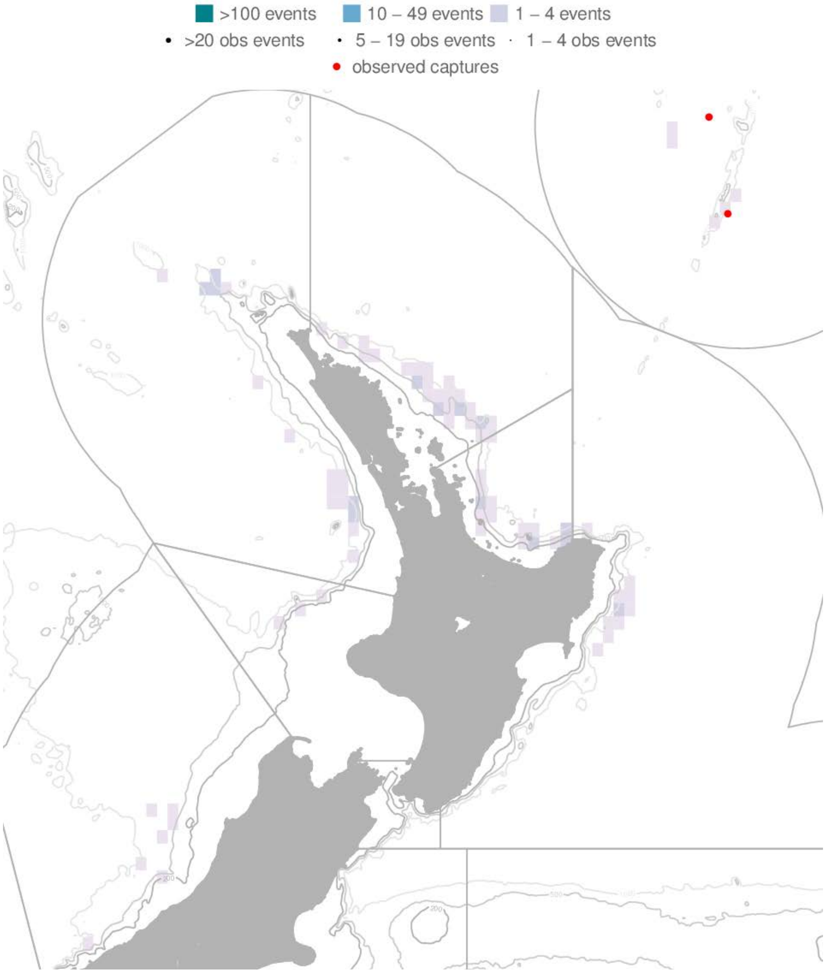


Figure 8: Distribution of fishing effort targeting swordfish and observed sea turtle captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures 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, 36.6% 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

Between 2002–03 and 2012–13, there were no observed captures of whales or dolphins in swordfish longline fisheries (Table 10 and Figure 9).

4.2.3.2 New Zealand fur seal bycatch

Currently, New Zealand fur seals are dispersed throughout New Zealand waters, but are more common 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.

Table 10: Effort and cetacean captures in swordfish 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 effort			Observed captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate
2002–2003	N/A	0	N/A	0	N/A
2003–2004	0	0	N/A	0	N/A
2004–2005	132 503	11 553	8.7	0	0
2005–2006	228 305	4 800	2.1	0	0
2006–2007	210 175	40 138	19.1	0	0
2007–2008	125 330	21 630	17.3	0	0
2008–2009	41 700	3 990	9.6	0	0
2009–2010	137 840	500	0.4	0	0
2010–2011	177 248	18 638	10.5	0	0
2011–2012	195 400	43 450	22.2	0	0
2012–13	316 390	8 250	2.6	0	0

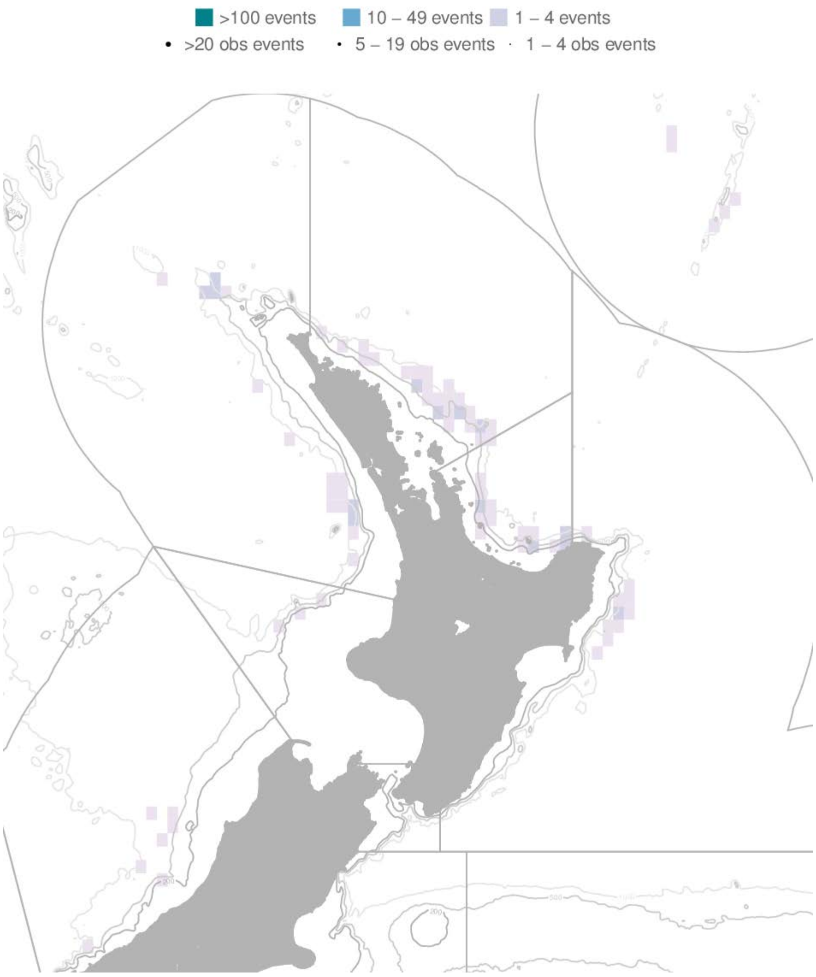


Figure 9: Distribution of fishing effort targeting swordfish, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures are indicated by red dots. Fishing 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, 36.6% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

Between 2002–03 and 2012–13, there were two observed captures of New Zealand fur seals in swordfish longline fisheries (Table 11 and 12, Figures 10 and 11). These captures include animals that are released alive (Thompson et al 2013).

Table 11: Number of observed New Zealand fur seal captures in swordfish longline fisheries, 2002–03 to 2012–13, 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	Total
New Zealand fur seal	1	1	2

Table 12: Effort and captures of New Zealand fur seal in swordfish 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). 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 2011–12 and preliminary estimates for 2012–13 are based on data version 20140131.

	Fishing effort			Observed captures		Estimated captures	
Fishing year	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	N/A	0	N/A	0	N/A	0	0–0
2003–2004	0	0	N/A	0	N/A	0	0–0
2004–2005	132 503	11 553	8.7	2	0.173	2	0–5
2005–2006	228 305	4 800	2.1	0	0	2	0–5
2006–2007	210 175	40 138	19.1	0	0	0	0–1
2007–2008	125 330	21 630	17.3	0	0	1	0–3
2008–2009	41 700	3 990	9.6	0	0	0	0–2
2009–2010	137 840	500	0.4	0	0	1	0–3
2010–2011	177 248	18 638	10.5	0	0	2	0–5
2011–2012	195 400	43 450	22.2	0	0	6	1–12
2012–2013†	316 390	8 250	2.6	0	0	8	2–16

†Provisional data, model estimates not finalised.

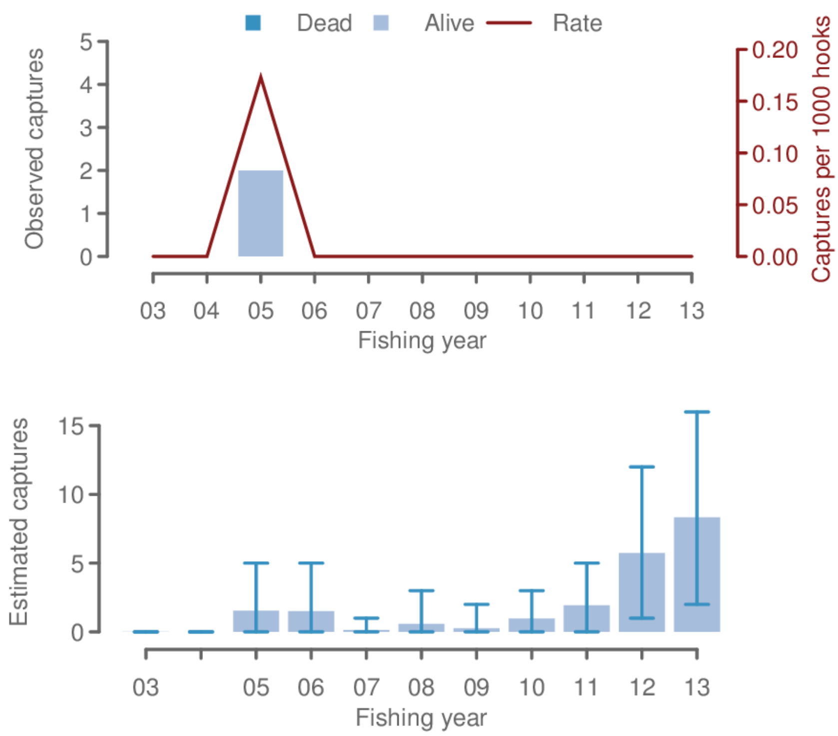


Figure 10: Observed and estimated captures of New Zealand fur seal in swordfish longline fisheries from 2002–03 to 2012–13.

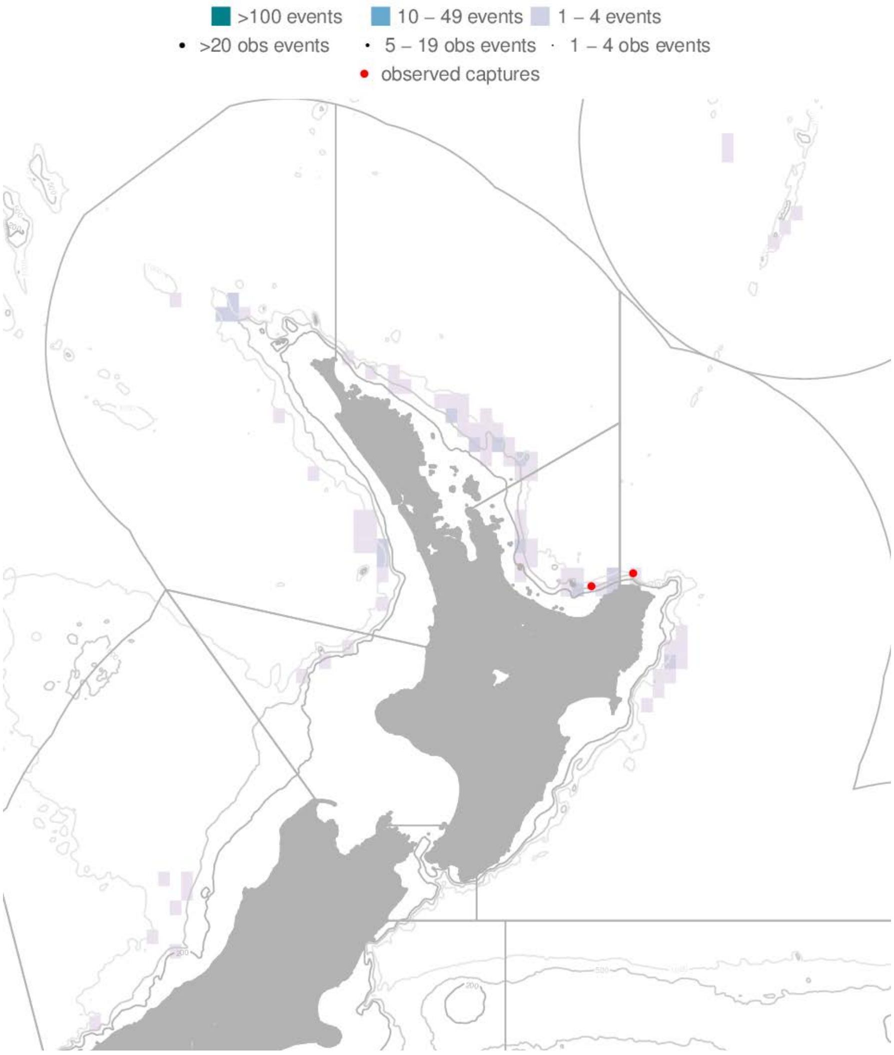


Figure 11: Distribution of fishing effort targeting swordfish and observed New Zealand fur seal captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed 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, 36.6% 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 13). Southern bluefin tuna and albacore tuna are the only target species that occur in the top five of the frequency of occurrence.

Table 13: Total estimated catch (numbers of fish) of common bycatch species in the New Zealand longline fishery as estimated from observer data from 2009 to 2013. 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	2010	2011	2012	2013	% retained (2013)	discards % alive (2013)
Blue shark	66113	53432	132925	158736	45.2	97.4
Lancetfish	43425	37305	7866	19172	0.1	37.6
Rays bream	20041	18453	19918	13568	97.4	4.2
Porbeagle shark	4679	9929	7019	9805	34.0	79.8
Mako shark	4490	9770	3902	3981	35.5	84.9
Moonfish	5398	3418	2363	2470	99.0	0.0
Escolar	1539	6602	2181	2088	30.2	76.3
Sunfish	3148	3773	3265	1937	2.7	100.0
Pelagic stingray	1983	4090	712	1199	1.0	97.0
Butterfly tuna	1158	909	713	1030	48.1	11.1
Deepwater dogfish	377	548	647	743	1.2	88.5
Oilfish	886	1747	509	386	26.5	72.2
Rudderfish	326	338	491	362	13.0	80.0
Thresher shark	209	349	246	256	33.3	75.0
Skipjack tuna	91	255	123	240	100.0	N/A
Dealfish	1160	223	372	237	1.7	25.1
Striped marlin	471	175	124	182	0.0	44.4
Big scale pomfret	505	139	108	67	88.2	100.0
School shark	62	49	477	21	100.0	N/A

4.4 Benthic interactions
N/A

4.5 Key environmental and ecosystem information gaps
Cryptic mortality is unknown at present but developing a better understanding of this in future may be useful for reducing uncertainty of the seabird risk assessment and could be a useful input into risk assessments for other species groups.

The survival rates of released target and bycatch species is currently unknown.

Observer coverage in the New Zealand fleet is not spatially and temporally representative of the fishing effort.

5. STOCK ASSESSMENT

With the establishment of WCPFC in 2004, stock assessments of the western and central Pacific Ocean stock of swordfish are reviewed by the WCPFC. Unlike the major tuna stocks, in the short-term, development of a regional assessment for swordfish is to be undertaken by collaboration among interested members.

Davies et al. (2013) undertook a stock assessment for swordfish (*Xiphias gladius*) in the Southwest Pacific. This was presented to the Western and Central Pacific Fisheries Commission Scientific Committee in 2013 and is summarised as follows:

The main developments from previous assessments were to model structural assumptions as follows: assume two model regions, that are biologically connected, this was based on the results of recent electronic tagging programmes; relaxing assumptions such as the relative recruitment to each region; fixing steepness at 0.8; and estimating spline and non-decreasing selectivities for the main longline fisheries. A new statistical assumption was to include time-variant precision in fitting the model to standardized CPUE indices. The model was highly sensitive to the assumption about growth. The full uncertainty grid was presented (Figure 12). Two equally plausible growth schedules were modelled.

The main conclusions of the assessment are:

a) The relatively steep decline in biomass over the period 1997 to 2011 over all key model runs, despite the no concurrent temporal change in recruitment, is a notable feature of the current assessment. It is concurrent with large increases in catch particularly in region 2, and declines in CPUE and median fish sizes in the main fisheries. The recent increase in the AU_1 CPUE index is best described by the Ref.case model for which the faster Hawaiian schedule is made; whereas no increase is predicted when the slower Australian schedule is assumed.
b) Estimates of absolute biomass and equilibrium yield were sensitive to including the NZ_2 standardized CPUE time series in the model fit (key model run cpopt_TW_NZ). The recent declines in the Ref.case model indices for region 2 appear to be consistent with declines in median size over the same period, whereas the NZ_2 index is in conflict with this trend, and is derived from a limited spatial distribution. On this basis, the cpopt_TW_NZ model is considered unreliable, or at least highly uncertain, and this model estimate is excluded from the ranges of the key model runs provided in this section below.
c) The key source of uncertainty in this assessment is the assumed growth/maturity/mortality at age schedule. Estimates of stock status are highly uncertain with respect to this assumption. Across the full uncertainty grid, where the Hawaiian schedule was assumed, the probability of $F_{current}/F_{MSY}$ being greater than 1 was less than 2%, while where the slower Australian schedule was assumed, this increased to 51%.
d) Total and spawning biomass are estimated to have declined most notably since the late 1990s, with more gradual declines before that time. Current levels of total biomass $B_{current}/B_0$ = 44 – 68 % and spawning biomass $SB_{current}/SB_0$ = 27 - 55% (range of key model runs).
e) When the non-equilibrium nature of recent recruitment is taken into account, we can estimate the level of depletion that has occurred. It is estimated that, for the current period, spawning potential is at 26 - 60% (range of key model runs) of the level predicted to exist in the absence of fishing while assuming the historical estimated annual recruitments.
f) Recent catches are between 82% of the MSY level and 102% above the MSY level of between 5299 and 12,730 mt (range of key model runs). Within this range,
g) Based on these results, it was concluded that under the Hawaiian growth schedule current catches are around the MSY level, while under the Australian growth schedule current levels of catch are above the MSY level.
h) Fishing mortality for adult and juvenile swordfish is estimated to have increased sharply in the mid-1990s following the significant increases in catches at that time. $F_{current}/F_{MSY}$ was estimated to be between 0.33 and 1.77 (range of key model runs). Within this range:

    i. assuming the Hawaiian schedule produces estimates between 0.40 to 0.70, while,

ii. assuming the Australian schedule produces estimates that are between 1.06 to 1.77.

i) Based on these results, it was concluded that under the Hawaiian schedule overfishing is not occurring, while under the Australian schedule overfishing is occurring.

The Scientific Committee of the Western and Central Pacific Fisheries Commission made the following conclusion regarding the stock status:

- "*The South Pacific swordfish assessment was highly sensitive to growth assumptions. Two different growth models, one from Australia (GA) and the other from Hawaii (GH), were included in alternative model runs. The Scientific Committee could not decide which of these two assumptions was more reliable. Assessment runs using the GA growth data indicated that overfishing was occurring but that the stock was not in an overfished state. Assessment runs using the GH growth data indicate that no overfishing is occurring and that the stock is not in an overfished state.*
- *Although the median of the uncertainty grid indicates that overfishing (Fcurrent/FMSY = 0.74) was not occurring those sensitivity runs that used the GA growth and maturity schedule indicate that overfishing may be occurring (grid range 5th–95th percentiles: 0.51-2.02). Recent preliminary findings from tagging data indicate that this alternative growth schedule (GA) warrants further consideration. Estimates of stock status are highly uncertain with respect to this assumption. The equivalent grid range of Fcurrent/FMSY for the Hawaiian schedule (GH) is 0.25 – 0.97. Across the uncertainty grid of 378 runs, where the Hawaii schedule was assumed, the probability of Fcurrent/FMSY being greater than 1.0 was less than 3%, while when the slower Australian schedule was assumed, 54% of runs estimated the stock to be experiencing overfishing.*"

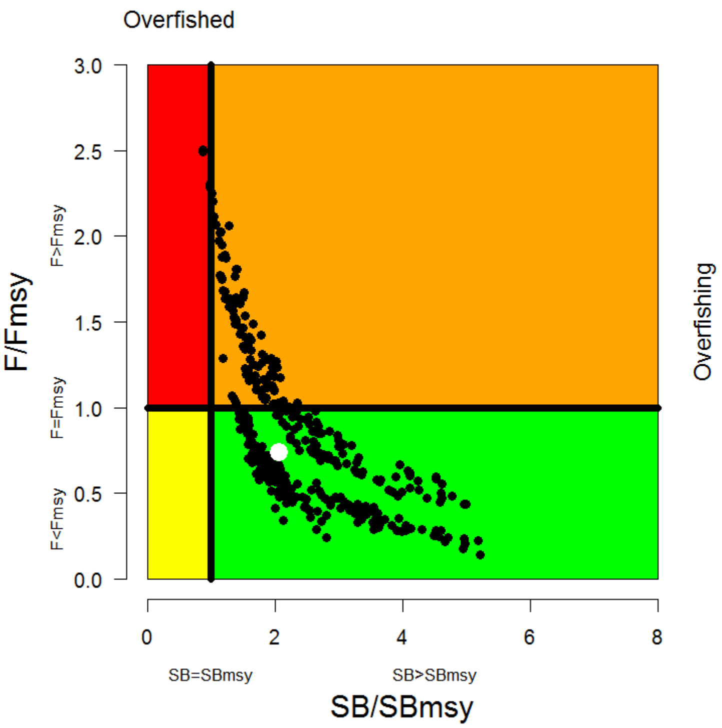


Figure 12: $F_{current}/F_{MSY}$ and $SB_{current}/SB_{MSY}$ for the median of the selected uncertainty grid (white circle) and the individual uncertainty grid runs.

5.1 Catch per unit effort indices (CPUE)

Catch per unit effort (CPUE) indices for swordfish (*Xiphias gladius*) in the New Zealand surface longline fishery were updated to include fishery data from the five years since the previous analysis, for use as relative abundance indices in a revised south Pacific-wide swordfish stock assessment model being assembled by the Western and Central Pacific Fisheries Commission (WCPFC) (Anderson *et al.* 2013).

Examination of changes in the fishery data (including the use of light sticks, depth of the longline, and timing of fishing around hours of darkness and with respect to the fullness of the moon) showed that targeting of swordfish has effectively been increasing over time, particularly since 2004 when targeting became legal after the introduction of swordfish into the Quota Management System (QMS).

Generalised Additive Models (GAMs) assuming a quasi-poisson error distribution were applied to commercial catch-effort data and remote-sensed environmental variables to produce three alternative CPUE series: **all-data**, based on data from 1993 to 2012 and all vessels in the fishery; **core-vessel**, based on a core set of vessels and the more recent fishery, 1998 to 2012; and **late-series**, based on the core set of vessels and the period subsequent to the introduction of swordfish into the QMS, i.e., 2005 to 2012.

Each model showed an increase in CPUE as the fraction of the longline soak-time occurring in darkness increased. Recorded target species in the all-data model, and rate of light stick usage in the late-series model were also significant.

The indices of the updated models followed a similar temporal pattern to each other and to those of the earlier analyses for the overlapping years, indicating a decline in CPUE between 1993 and 2004, followed by a small increase to 2007. For the subsequent period, 2004 to 2012, the revised models all showed a continuation of this increasing CPUE, reaching a level higher than that of any previous year in the series.

Although it was suspected that changes in operational procedures affecting swordfish catch rates were at least partly responsible for the recent increase in CPUE, it was not possible to determine whether these changes were sufficiently accounted for by the model variables and therefore to have confidence in the use of the year-effects as relative abundance indices.

5.2 Other factors

Other fleets also fish the stock fished in the New Zealand EEZ and the impact of current regional catches on the stock are unknown. It is often assumed that swordfish, particularly large swordfish, may have long residence times which may make them vulnerable to over fishing. Recent Australian research suggests that swordfish CPUE has declined in areas that have been fished the longest and that vessels have maintained high catch rates by travelling further each season, suggesting that serial depletion may be occurring.

6. STATUS OF THE STOCKS

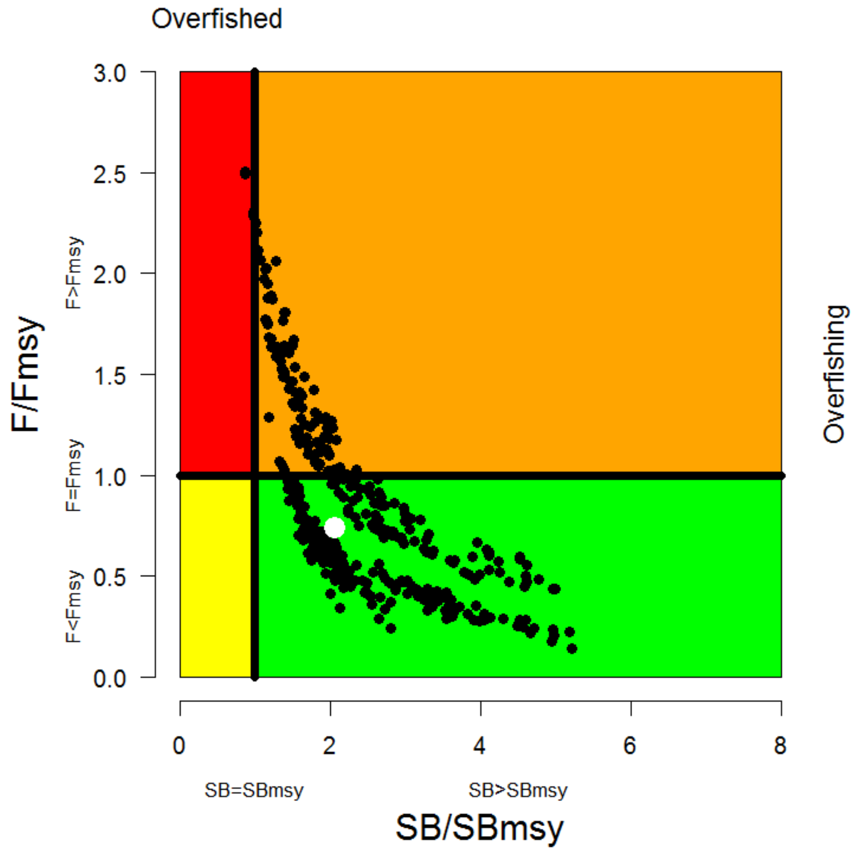
Stock structure assumptions

Swordfish taken in New Zealand are part of larger southwest and south-central Pacific stocks; the evaluation below refers to the assessment of the southwest portion of that stock.

Stock Status	
Year of Most Recent Assessment	A full stock assessment was conducted in 2013

Assessment Runs Presented	Full uncertainty grid
Reference Points	Target: $B > B_{MSY}$ and $F < F_{MSY}$ Soft Limit: Not established by WCPFC but evaluated using HSS default of 20% SB_0 Hard Limit: Not established by WCPFC but evaluated using HSS default of 10% SB_0 Overfishing threshold: F_{MSY}
Status in relation to Target	Likely (> 60%) that B is at or above B_{MSY} and Likely (> 60%) that F < F_{MSY}
Status in relation to Limits	Soft Limit: Unlikely (< 40%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Overfishing is About as Likely as Not (40-60%) to be occurring

Historical Stock Status Trajectory and Current Status



$F_{current}/F_{MSY}$ and $SB_{current}/SB_{MSY}$ for the median of the selected uncertainty grid (white circle) and the individual uncertainty grid runs.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Following a period of continuous decline, the southwest Pacific swordfish biomass has recently increased.
Recent Trend in Fishing Intensity or Proxy	Fishing mortality increased substantially from 1995 to present.
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Recruitment trends have fluctuated without trend from 1950 to present.

Projections and Prognosis		
Stock Projections or Prognosis	Projections based on the model that used Hawaii growth predict further increases in stock size at current fishing mortality levels. However, using the Australian growth the stock is About as Likely as Not to decline.	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unlikely (< 40%) Hard Limit: Unlikely (< 40%)	
Probability of Current Catch or TACC causing Overfishing to continue or commence	About as Likely as Not (40-60%)	
Assessment Methodology and Evaluation		
Assessment Type	Level 1: Full Quantitative Stock Assessment	
Assessment Method	The assessment uses the stock assessment model and computer software known as MULTIFAN-CL.	
Assessment Dates	Latest assessment: 2013	Next assessment: 2016
Overall assessment quality rank	1 - High Quality	
Main data inputs (rank)	Commercial catch and effort data, CPUE, catch-at-age	1 - High Quality
Data not used (rank)		
Changes to Model Structure and Assumptions	Major changes from the 2006 assessment include: • assumes two model regions • relaxing assumptions such as the relative recruitment to each region • fixing steepness at 0.8 • estimating spline and non-decreasing selectivities for the main longline fisheries • A new statistical assumption to include time-variant precision in fitting the model to standardized CPUE indices	
Major Sources of Uncertainty	• Targeting and learned behaviour in the last decade make the CPUE data from many fleets (including New Zealand) unreliable as indices of abundance • Assumed growth schedule	

Qualifying Comments
-

Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 25°S. Seabird bycatch mitigation measures are required in the New Zealand and Australian EEZs and through the WCPFC Conservation and Management Measure (CMM2012-07). Sea turtles also get incidentally captured in longline gear; the WCPFC is attempting to reduce sea turtle interactions through Conservation and Management Measure (CMM2008-03). Shark bycatch is common in longline fisheries and largely unavoidable; this is being managed through New Zealand domestic legislation and to a limited extent through Conservation and Management Measure (CMM2010-07).

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