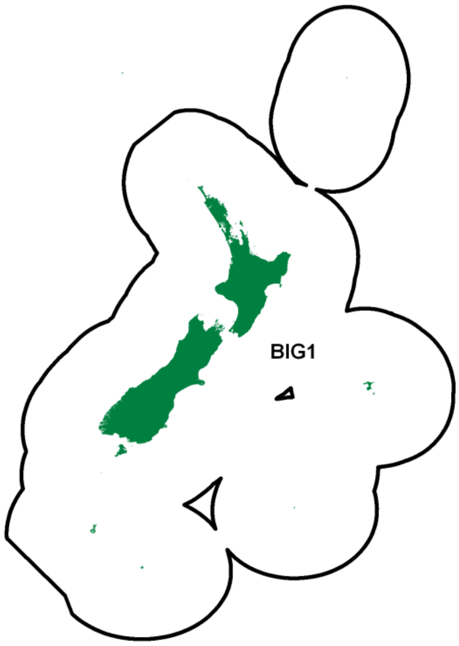
BIGEYE TUNA (BIG)

(Thunnus obesus)



1. FISHERY SUMMARY

Bigeye tuna were introduced into the QMS on 1 October 2004 under a single QMA, BIG 1, with allowances (t), TACC, and TAC in Table 1.

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

Fishstock	Recreational Allowance	Customary non-commercial Allowance	Other mortality	TACC	TAC
BIG 1	8	4	14	714	740

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

Management of the bigeye stock 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.

At its second annual meeting (2005) 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 tunas. Key aspects of this resolution were presented in the 2006 Plenary document. A number of subsequent CMMs that impact on the catches of bigeye have since been approved by the WCPFC.

At its annual meeting in 2014 the WCPFC approved CMM 2014-01. The aim of this CMM for bigeye is to reduce the fishing mortality rate for bigeye to a level no greater than Fmsy. This objective shall be achieved through a step by step approach through 2017 in accordance with the CMM. This measure is large and detailed with numerous exemptions and provisions. Reductions in fishing mortality are being attempted through seasonal fish aggregating device (FAD) closures, high seas area closures (in high seas pockets) for the purse seine fleets, purse seine effort limits, longline effort reductions, bigeye longline catch limits by flag, as well as other methods.

1.1 Commercial fisheries
Commercial catches by distant water Asian longliners of bigeye tuna, in New Zealand fisheries waters, began in 1962 and continued under foreign license agreements until 1993. Bigeye were not a primary target species for these fleets and catches remained modest with the maximum catch in the 1980s reaching 680 t. Domestic tuna longline vessels began targeting bigeye tuna in 1990. There was an exponential increase in the number of hooks targeting bigeye which reached a high of approximately 6.6 million hooks in 2000–01 and then declined thereafter.

Catches from within New Zealand fisheries waters are very small (0.2% average for 2001–2009) compared to those from the greater stock in the WCPO (Tables 2 and 3). Figure 1 shows historical landings and TACC values for BIG 1 and BIG ET. Figure 1 also shows historical longline fishing effort. In contrast to New Zealand, where bigeye are taken almost exclusively by longline, 40% of the WCPO catches of bigeye are taken by purse seine and other surface gears (e.g., ring nets).

1.2 Recreational fisheries
Recreational fishers make occasional catches of bigeye tuna while trolling for other tunas and billfish, but the recreational fishery does not regularly target this species. There is no information on the size of the catch.

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
There is no known illegal catch of bigeye tuna in the EEZ.

1.5 Other sources of mortality
The estimated overall incidental mortality rate from observed longline effort is 0.23% of the catch. Discard rates are 0.34% on average (from observer data), of which approximately 70% are discarded dead (usually because of shark damage). Fish are also lost at the surface in the longline fishery, 0.09% on average (from observer data), of which 100% are thought to escape alive.

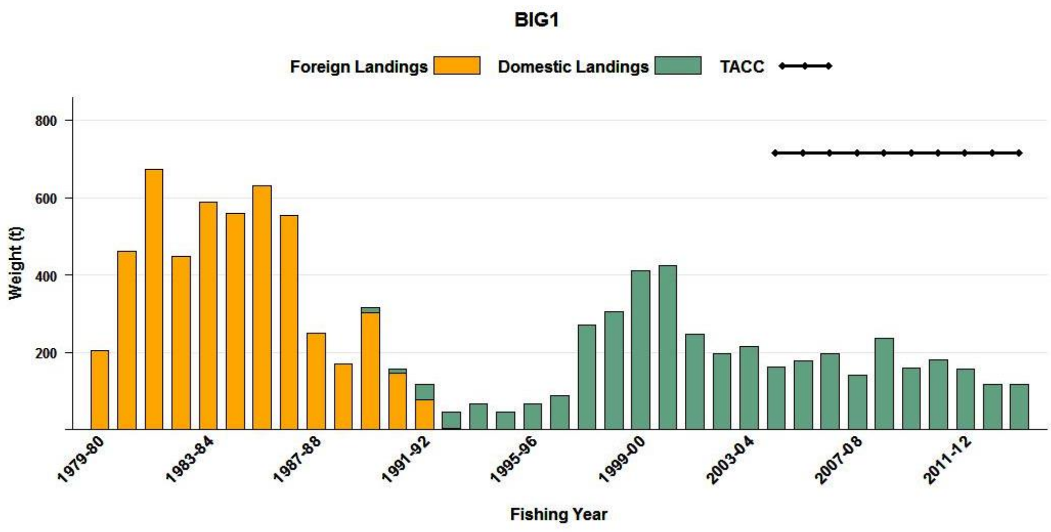


Figure 1: Bigeye catch by foreign licensed and New Zealand vessels from 1979–80 to 2013–14 within New Zealand waters (BIG 1) [Continued on next page].

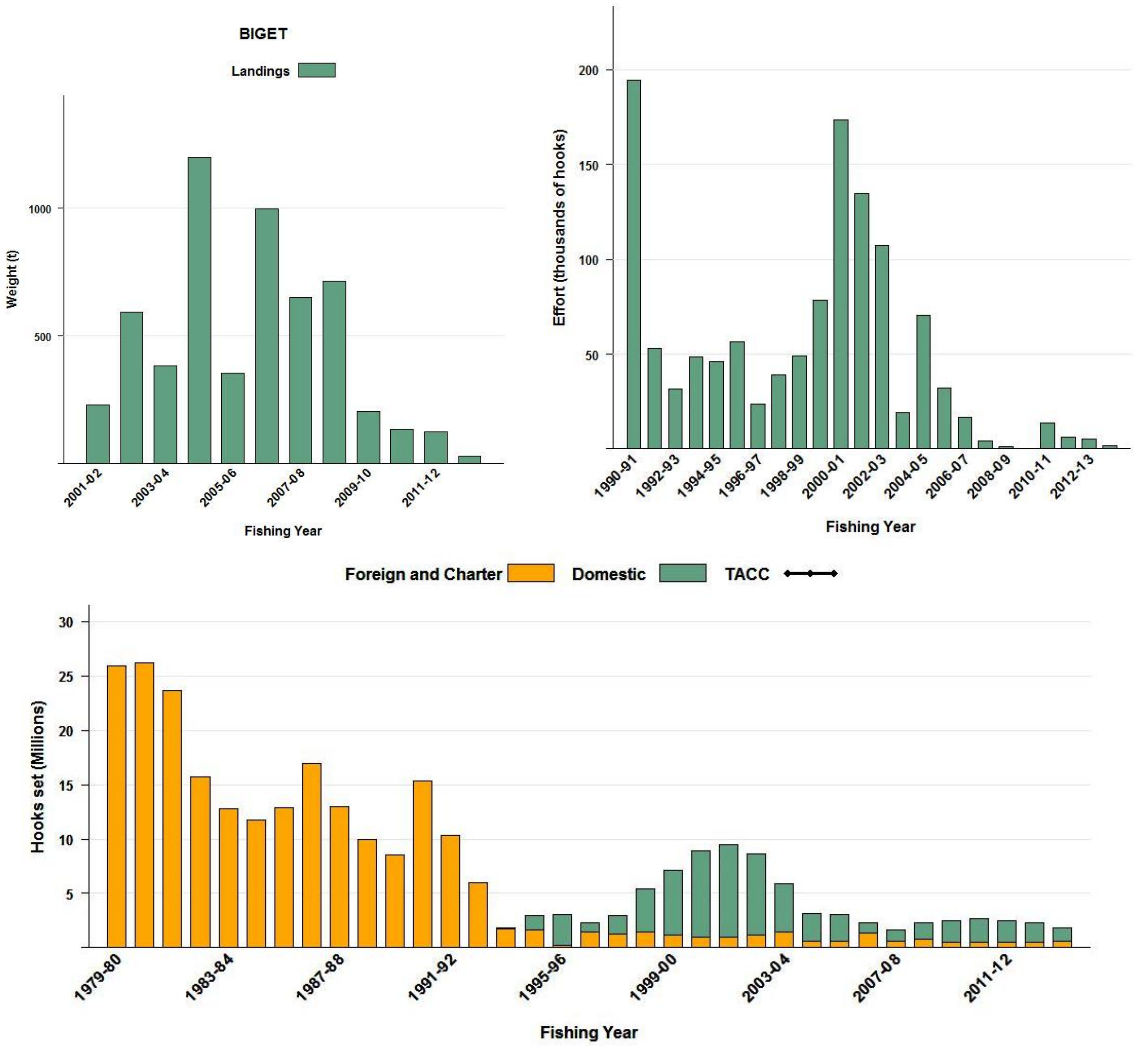


Figure 1: [Continued] Bigeye catch by foreign licensed and New Zealand vessels on the high seas from 2001–02 to 2013–14 for New Zealand vessels fishing on the high seas (BIG ET) (Anon 2012) and fishing effort (number of hooks set) for all high seas New Zealand flagged surface longline vessels from 1990–91 to 2013–14. [Bottom] Fishing effort (number of hooks set for all domestic vessels (including effort by foreign vessels chartered by NZ fishing companies), from 1979-80 to 2013-14.

Table 2: Reported total New Zealand within EEZ landings* (t), landings from the Western and Central Pacific Ocean (t) of bigeye tuna by calendar year from 1991 to present, and NZ ET catch estimates from 2001 to present.

Year	NZ landings (t)	Total landings (t)	NZ ET SPC estimate	Year	NZ landings (t)	Total landings (t)	NZ ET SPC estimate	Year	NZ landings (t)	Total landings (t)	NZ ET SPC estimate
1991	44	100 608		1999	421	150 364		2007	213	134 258	651
1992	39	119 624		2000	422	133 449		2008	133	144 101	713
1993	74	103 557		2001	480	136 153	230	2009	254	149 545	204
1994	71	118 759		2002	200	161 996	593	2010	132	126 458	134
1995	60	107 406		2003	205	129 955	383	2011	174	146 254	125
1996	89	110 276		2004	185	178 556	1 198	2012	154	158 573	95
1997	142	152 862		2005	176	141 342	353	2013	110	145 883	81
1998	388	168 393		2006	178	151 646	997	2014	122	154 601	185

Source: Licensed Fish Receiver Returns, Solander Fisheries Ltd, Anon. (2006), Lawson (2008), WCPFC5-2008/IP11 (Rev. 2), Williams & Terawasi (2011) and WCPFC Yearbook 2012 Anon (2013).
*New Zealand purse seine vessels operating in tropical regions also catch small levels of bigeye when fishing around Fish Aggregating Devices (FAD). These catches are not included here at this time as the only estimates of catch are based on analysis of observer data across all fleets rather than specific data for NZ vessels. Bigeye catches are combined with yellowfin catches on most catch effort forms.

Table 3: Reported catches and landings (t) of bigeye tuna by fleet and Fishing Year. NZ: New Zealand domestic and charter fleet, ET: catches outside these areas from New Zealand flagged longline vessels, JPNFL: Japanese foreign licensed vessels, KORFL: foreign licensed vessels from the Republic of Korea, and LFRR: Estimated landings from Licensed Fish Receiver Returns.

	BIG 1 (all FMAs)					
Fishing Year	JPNFL	KORFL	NZ/MHR	Total	LFRR	NZ ET
1979–80	205.8			205.8		
1980–81	395.9	65.3		461.2		
1981–82	655.3	16.8		672.1		
1982–83	437.1	11.1		448.2		
1983–84	567.0	21.8		588.8		
1984–85	506.3	51.6		557.9		
1985–86	621.6	10.2		631.8		
1986–87	536.1	17.6		553.7		
1987–88	226.9	22.2		249.1		
1988–89	165.6	5.5		171.1	4.0	
1989–90	302.7		12.7	315.4	30.7	0.4
1990–91	145.6		12.6	158.2	36.0	0.0
1991–92	78.0		40.9	118.9	50.0	0.8
1992–93	3.4		43.8	47.2	48.8	2.2
1993–94			67.9	67.9	89.3	6.1
1994–95			47.2	47.2	49.8	0.5
1995–96			66.9	66.9	79.3	0.7
1996–97			89.8	89.8	104.9	0.2
1997–98			271.9	271.9	339.7	2.6
1998–99			306.5	306.5	391.2	1.4
1999–00			411.7	411.7	466.0	7.6
2000–01			425.4	425.4	578.1	13.6
2001–02			248.9	248.9	276.3	2.0
2002–03			196.1	196.1	195.1	0.6
2003–04			216.3	216.3	217.5	0.8
2004–05*			162.9	162.9	163.6	0.7
2005–06*			177.5	177.5	177.1	0.14
2006–07*			196.7	196.7	201.4	0.05
2007–08*			140.5	140.5	143.8	0
2008–09*			237.2	237.2	240.2	0
2009–10*			161.2	161.2	169.7	9.9
2010–11*			181.1	181.1	201.0	20.3
2011–12*			174.0	174.0	276.5	125.0
2012–13*			154.0	154.0	148.0	95.0
2013–14*			116.0	116.0	116.0	235.0

*MHR rather than LFRR data.

The majority of bigeye tuna (88%) are caught in the bigeye tuna target surface longline fishery (Figure 2). While bigeye are the target, albacore make up the bulk of the catch (34%) (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.

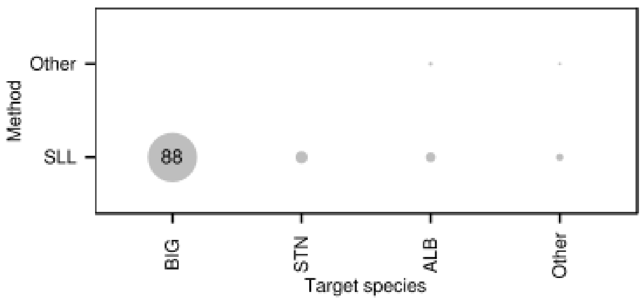


Figure 2: A summary of the proportion of landings of bigeye tuna taken by each target fishery and fishing method for 2012-13. The area of each circle is proportional to the percentage of landings taken using each combination of fishing method and target species. The number in the circle is the percentage. SLL = surface longline (Bentley et al 2013).

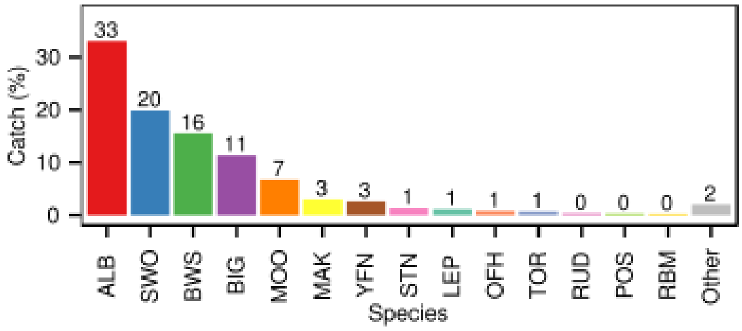


Figure 3: A summary of species composition of the reported bigeye target surface longline catch for 2012-13. The percentage by weight of each species is calculated for all surface longline trips targeting bigeye tuna (Bentley et al 2013).

2. BIOLOGY

Bigeye tuna are epi-pelagic opportunistic predators of fish, crustaceans and cephalopods generally found within the upper few hundred meters of the ocean. Tagged bigeye tuna have been shown to be capable of movements of over 4000 nautical miles over periods of one to several years. Juveniles and small adults school near the surface in tropical waters while adults tend to live in deeper water. Individuals found in New Zealand waters are mostly adults. Adult bigeye tuna are distributed broadly across the Pacific Ocean, in both the Northern and Southern Hemispheres and reach a maximum size of 210 kg and maximum length of 250 cm. The maximum reported age is 11 years old and tag recapture data indicate that significant numbers of bigeye reach at least 8 years old. Spawning takes place in the equatorial waters of the Western Pacific Ocean (WPO) in spring and early summer.

Natural mortality and growth rates are both estimated within the stock assessment. Natural mortality is assumed to vary with age with values about 0.5 for bigeye larger than 40 cm. A range of von Bertalanffy growth parameters has been estimated for bigeye in the Pacific Ocean depending on area (Table 4).

Table 4: Biological growth parameters for bigeye tuna, by country.

Country	L_∞ (cm)	K	t_0
Mexico	169.0	0.608	
French Polynesia	187.0	0.380	
Japan	195.0	0.106	-1.13
Hawaii	196.0	0.167	
Hawaii	222.0	0.114	
Hawaii	220.0	0.183	

3. STOCKS AND AREAS

Bigeye tuna are distributed throughout the tropical and sub-tropical waters of the Pacific Ocean. Analysis of mtDNA and DNA microsatellites in nearly 800 bigeye tuna failed to reveal significant evidence of widespread population subdivision in the Pacific Ocean (Grewe and Hampton 1998). While these results are not conclusive regarding the rate of mixing of bigeye tuna throughout the Pacific, they are broadly consistent with the results of SPC’s and IATTC’s tagging experiments on bigeye tuna. Before 2008, most bigeye tuna tagging in the Pacific occurred in the far eastern Pacific (east of about 120°W) and in the western Pacific (west of about 180°). While some of these tagged bigeye were recaptured at distances from release of up to 4,000 nautical miles over periods of one to several years, the large majority of tag returns were recaptured much closer to their release points (Schaefer and Fuller 2002; Hampton and Williams 2005). Since 2008, bigeye tuna tagging by the Pacific Tuna Tagging Programme has been focussed in the equatorial central Pacific, between 180° and 140°W. Returns of both conventional and electronic tags from this programme have been suggestive of more extensive longitudinal, particularly west to east, displacements (Schaefer et al. submitted). It is hypothesised that while bigeye tuna in the far eastern and western Pacific may have relatively little exchange, those in the central part of the Pacific between about 180° and 120°W may mix more rapidly over distances of 1,000 – 3,000 nautical miles. In any event, it is clear that there is extensive movement of bigeye across the nominal WCPO/EPO boundary of 150°W (Figure 2). While stock assessments of bigeye tuna are routinely undertaken for the WCPO and EPO separately, these new data suggest that examination of bigeye tuna exploitation and stock status on a Pacific-wide scale, using an appropriately spatially structured model, should be a high priority.

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 the bigeye tuna longline fishery; 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 (www.mpi.govt.nz/document-vault/5008) (Ministry for Primary Industries 2014).

4.1 Role in the ecosystem

Bigeye tuna (*Thunnus obesus*) are epi-pelagic opportunistic predators of fish, crustaceans and cephalopods generally found within the upper few hundred meters of the ocean. Bigeye tuna are large pelagic predators, so they are likely to have a 'top down' effect on the fish, crustaceans and squid they feed on.

4.2 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].

4.2.1 Seabird bycatch

Between 2002–03 and 2013–14, there were 88 observed captures of birds in bigeye target longline fisheries (Table 5). Seabird capture rates since 2003 are presented in Figure 4. Capture rates increased from low levels in 2002-03 to high levels in 2007-08 and 2009-10 and declined since. Seabird captures were more frequent off the east coast of the North Island and Kermadec Island regions (see Table 5 and Figure 5). 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 bigeye 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 s11 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

[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.

(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 the bigeye target surface longline fishery contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 7). This fishery contributes 0.886 of PBR_1 to the risk to black petrel and 0.299 of PBR_1 to Gibson's albatross; both species were assessed to be at very high from New Zealand commercial fishing. This fishery also contributes to the risk of high risk species; 0.207 of PBR_1 to Antipodean albatross and 0.190 of PBR_1 to North Buller's albatross (Richard & Abraham, *in press*).

Table 5: Number of observed seabird captures in bigeye tuna longline fisheries, 2002–03 to 2013–14, 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 bigeye tuna using longline gear but rather the total risk for each seabird species. Other data, version 2015003.

Species	Risk ratio	Northland and Hauraki	East Coast North Island	West Coast North Island	Bay of Plenty	Kermadec Islands	Total
Southern Buller's albatross	Very high	6	4				9
Antipodean albatross	High	6		1	1		8
Gibson's albatross	Very high	8	1	1			8
Salvin's albatross	Very high	1	2		1		4
Wandering albatross	N/A	2	1				3
Campbell black-browed albatross	High	3					3
Antipodean and Gibson's albatross	N/A	2					2
Albatrosses	N/A			1			1
Black-browed albatrosses	N/A			1			1
Northern royal albatross	Medium				1		1
Southern royal albatross	Low	1					1
Wandering albatrosses	N/A	1					1
New Zealand white-capped albatross	Very high	1					1
Total albatrosses	N/A	31	8	4	3	0	43
Flesh-footed shearwater	Very high		9	2			11
Black petrel	Very high	8			1	1	10
White-chinned petrel	Medium	2	12	3	1		8
Grey-faced petrel	Negligible				3		1
Gadfly petrels	N/A	1					1
Total other seabirds	N/A	11	21	5	5	1	31

Table 6: Effort, observed and estimated seabird captures by fishing year for the bigeye tuna 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 2012–13 and preliminary estimates for 2013–14 are based on data version 20140131.

Fishing year	Fishing effort			Observed captures		Estimated captures	
	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	518 8307	80 640	1.6	0	0	1223	945–1 589
2003–2004	350 7507	120 740	3.4	1	0.01	829	639–1 087
2004–2005	164 8381	33 116	2.0	2	0.01	384	282–514
2005–2006	186 8306	45 100	2.41	6	0.1	521	390–690
2006–2007	153 2071	84 150	5.5	5	0.06	404	300–540
2007–2008	967 829	24 295	2.5	6	0.2	331	241–455
2008–2009	156 5517	91358	5.8	9	0.1	454	343–604
2009–2010	124 7437	80009	6.4	32	0.4	455	343–602
2010–2011	164 6956	87730	5.3	15	0.2	527	384–725
2011–2012	129 1923	39210	3.0	7	0.2	410	291–581
2012–2013	994 535	60180	6.0	3	0.05	344	245–491
2013–2014	743 381	20637	2.8	2	0.1	289	201–420

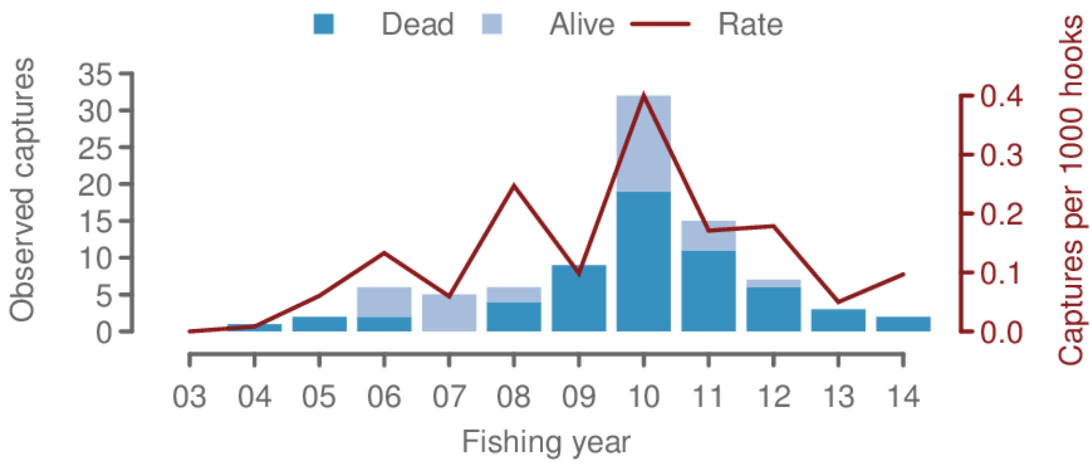


Figure 4: Observed captures of seabirds in bigeye tuna longline fisheries from 2002–03 to 2012–13.

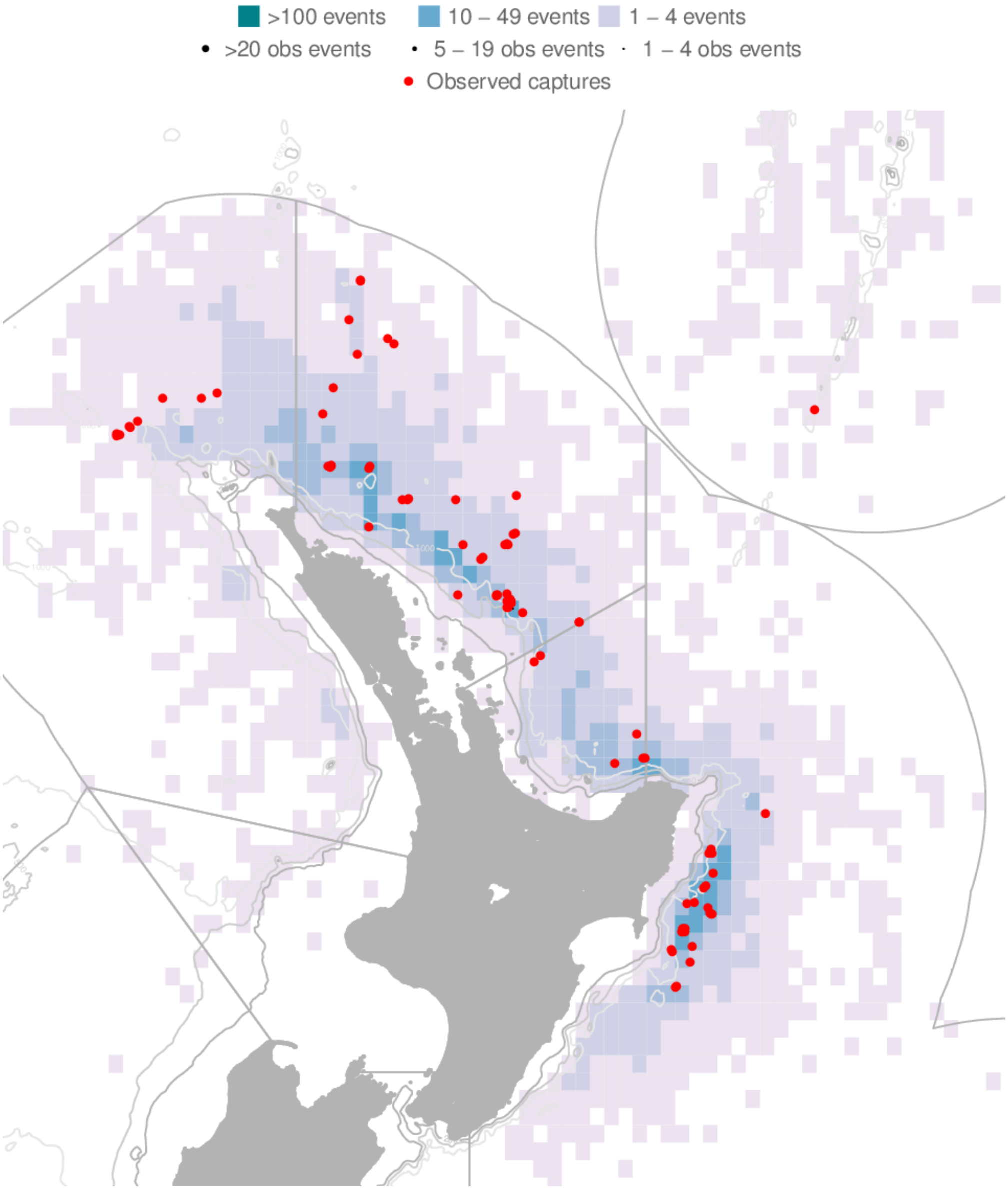


Figure 5: Distribution of fishing effort targeting bigeye tuna and observed seabird captures, 2002–03 to 2012–13. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures 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, 94.6% 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 bigeye target surface longline fishery and all fisheries included in the level two risk assessment, 2006–07 to 2012–13, showing seabird species with risk category of very high, 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	BIG target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0.886	15.095	5.87	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0.021	3.543	0.59	Very high	Threatened: Nationally Critical
Southern Buller's albatross	0.057	2.823	2.02	Very high	At Risk: Naturally Uncommon
Flesh-footed shearwater	0.077	1.557	4.91	Very high	Threatened: Nationally Vulnerable
Gibson's albatross	0.299	1.245	24.04	Very high	Threatened: Nationally Critical
New Zealand white-capped albatross	0.025	1.096	2.30	Very high	At Risk: Declining
Chatham Island albatross	0.000	0.913	0.00	High	At Risk: Naturally Uncommon
Antipodean albatross	0.207	0.888	23.33	High	Threatened: Nationally Critical
Westland petrel	0.040	0.498	7.95	High	At Risk: Naturally Uncommon
Northern Buller's albatross	0.190	0.336	56.70	High	At Risk: Naturally Uncommon
Campbell black-browed albatross	0.059	0.304	19.45	High	At Risk: Naturally Uncommon
Stewart Island shag	0.000	0.301	0.00	High	Threatened: Nationally Vulnerable
White-chinned petrel	0.008	0.268	2.90	Medium	At Risk: Declining
Northern royal albatross	0.009	0.181	5.12	Medium	At Risk: Naturally Uncommon

4.2.2 Sea turtle bycatch

Between 2002–03 and 2013–14, there were ten observed captures of turtles in bigeye tuna longline fisheries (Table 8, Table 9, and Figure 6). Observer recordings documented all sea turtles as captured and released alive. Sea turtle capture distributions are more common on the east coast of the North Island (Figure 7).

Table 8: Number of observed sea turtle captures in bigeye tuna 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	East Coast North Island	Kermadec Islands	West Coast North Island	Total
Leatherback turtle	3	1	3	7
Unidentified turtle	1	0	2	3
Total	4	1	5	10

Table 9: Fishing effort and sea turtle captures in bigeye tuna 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	5 188 307	80 640	1.6	0	0
2003–2004	3 507 257	120 740	3.4	1	0.008
2004–2005	1 648 181	33 116	2	2	0.060
2005–2006	1 868 386	45 100	2.4	1	0.022
2006–2007	1 532 071	84 150	5.5	1	0.012
2007–2008	967 829	24 295	2.5	0	0
2008–2009	1 565 517	91 358	5.8	2	0.022
2009–2010	1 247 437	80 009	6.4	0	0
2010–2011	1 646 956	87 730	5.3	1	0.011
2011–2012	1 291 923	39 210	3.0	0	0
2012–2013	994 535	60 180	6.1	2	0.033
2013–2014	743 381	20 637	2.8	0	0.0

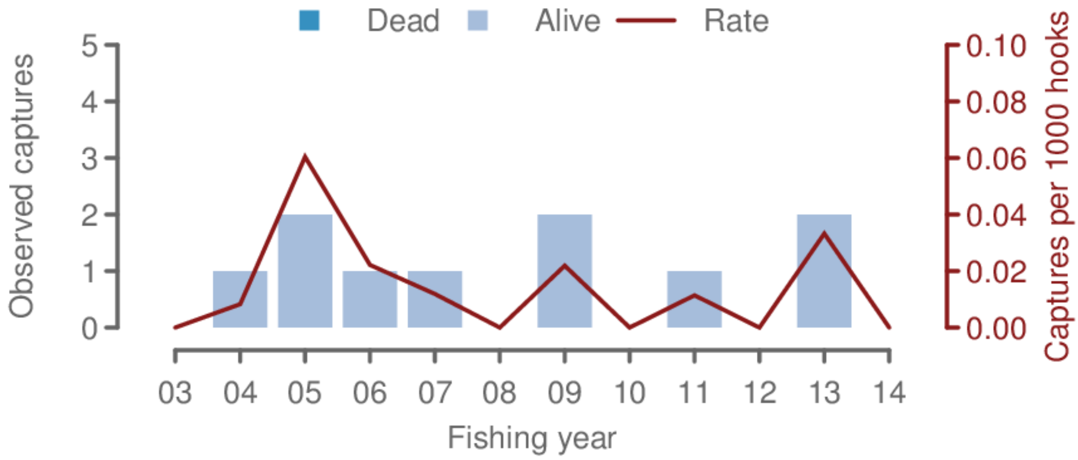


Figure 6: Observed captures of sea turtles in bigeye tuna longline fisheries from 2002–03 to 2013–14.

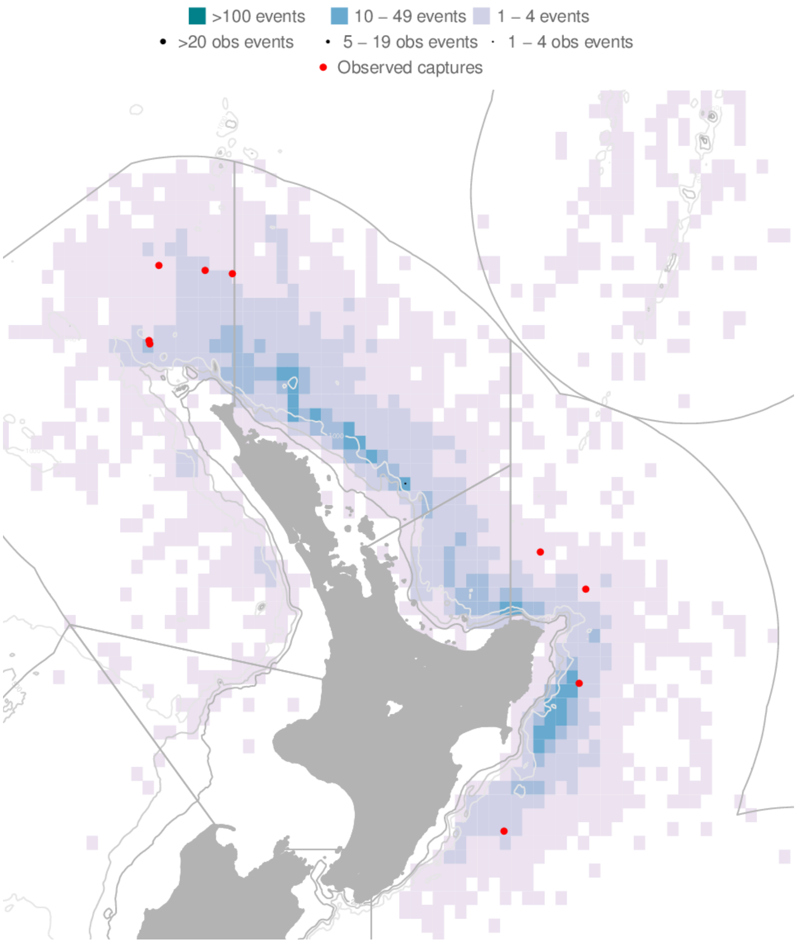


Figure 7: Distribution of fishing effort targeting bigeye tuna and observed sea turtle captures, 2002–03 to 2013–14. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures 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, 94.6% 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

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). The analytical methods used to estimate capture numbers across the commercial fisheries have depended on the quantity and quality of the data, in terms of the numbers observed captured and the representativeness of the observer coverage. Ratio estimation is used to calculate total captures in longline fisheries by target fishery fleet and area (Baird 2008) and by all fishing methods (Abraham et al 2010).

Between 2002–03 and 2013–14, there was one observed unidentified cetacean capture in bigeye longline fisheries (Tables 10 and 11). This capture took place on the west coast of the North Island (Figures 9 and 10) (Abraham & Thompson 2011). The captured animal recorded was documented as being caught and released alive (Thompson & Abraham 2010).

Table 10: Number of observed cetacean captures in bigeye tuna 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	West Coast North Island	Total
Unidentified cetacean	1	1

Table 11: Effort and cetacean captures by fishing year in bigeye tuna fisheries. 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	5 188 307	80 640	1.6	0	0
2003–2004	3 507 257	120 740	3.4	1	0.008
2004–2005	1 648 181	33 116	2	0	0
2005–2006	1 868 706	45 100	2.4	0	0
2006–2007	1 532 071	84 150	5.5	0	0
2007–2008	967 829	24 295	2.5	0	0
2008–2009	1 565 517	91 358	5.8	0	0
2009–2010	1 247 437	80 009	6.4	0	0
2010–2011	1 646 956	87 730	5.3	0	0
2011–2012	1 291 923	39 210	3.0	0	0
2012–2013	994 535	60 180	6.1	0	0
2013–2014	743 381	20 637	2.8	0	0

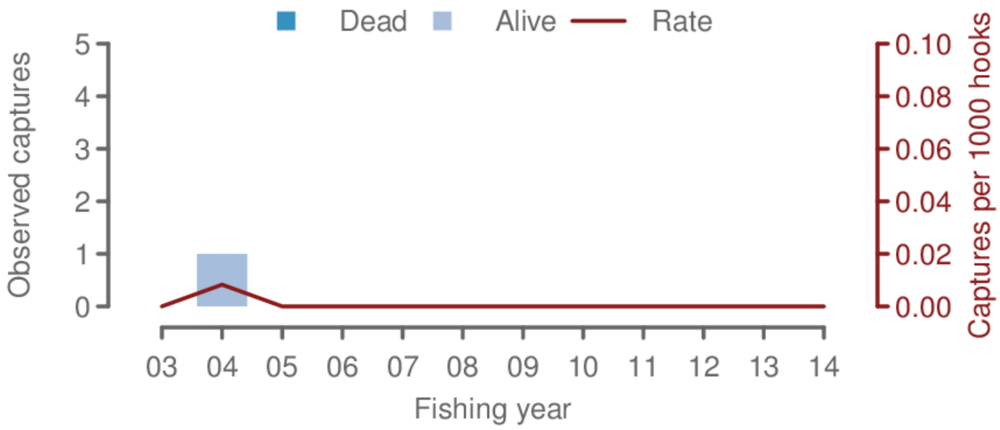


Figure 8: Observed captures of cetaceans in bigeye longline fisheries from 2002–03 to 2013–14.

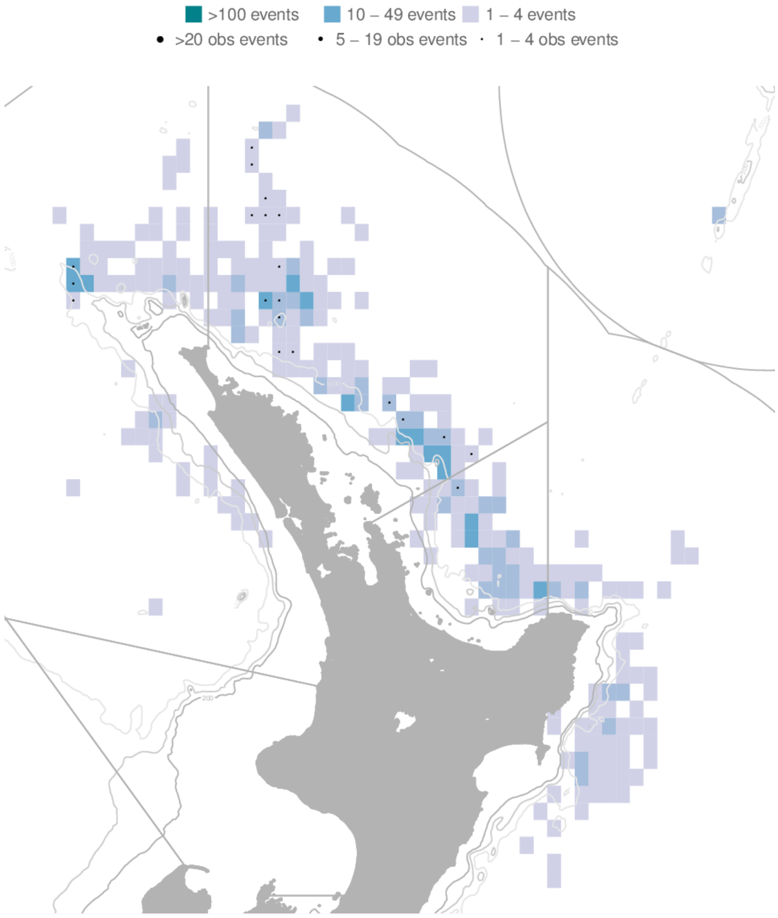


Figure 9: Distribution of fishing effort targeting bigeye tuna and observed cetacean captures, 2002–03 to 2013–14. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures 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, 94.6% of the effort is shown. See glossary for areas used for summarising the fishing effort and protected species captures.

4.2.4 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.

The analytical methods used to estimate capture numbers across the commercial fisheries have depended on the quantity and quality of the data, in terms of the numbers observed captured and the representativeness of the observer coverage. 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. These capture rates include animals that are released alive (100% of observed surface longline capture in 2008–09; Thompson & Abraham 2010). Between 2002–03 and 2013–14, there were two observed captures of New Zealand fur seals in bigeye longline fisheries (Tables 12 and 13, Figures 11 and 12).

Table 12: Number of observed New Zealand fur seal captures in bigeye tuna 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.

	West Coast North Island	Total
New Zealand fur seal	2	2

Table 13: Effort and captures of New Zealand fur seal by fishing year in bigeye tuna longline fisheries. 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 2013–14 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	5 188 307	80 640	1.6	0	0	24	3–67
2003–2004	3 507 257	120 740	3.4	0	0	8	1–24
2004–2005	1 648 181	33 116	2	0	0	4	0–11
2005–2006	1 868 386	45 100	2.4	0	0	3	0–10
2006–2007	1 532 071	84 150	5.5	0	0	1	0–6
2007–2008	967 829	24 295	2.5	2	0.082	2	0–8
2008–2009	1 565 517	91 358	5.8	0	0	4	0–11
2009–2010	1 247 437	80 009	6.4	0	0	3	0–11
2010–2011	1 646 956	87 730	5.3	0	0	5	0–15
2011–2012	1 291 923	39 210	3.0	0	0	7	1–20
2012–2013	994 535	60 180	6.1	0	0	4	0–13
2013–14†	743 381	20 637	2.8	0	0	2	0-7

†Provisional data, model estimates not finalised.

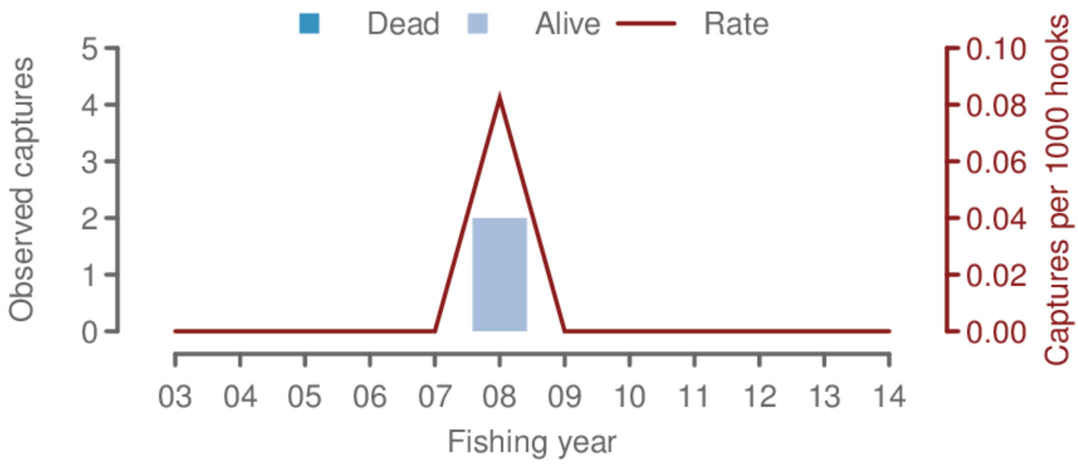


Figure 10: Observed captures of New Zealand fur seal in bigeye tuna longline fisheries from 2002-03 to 2013-14 [Continued on next page].

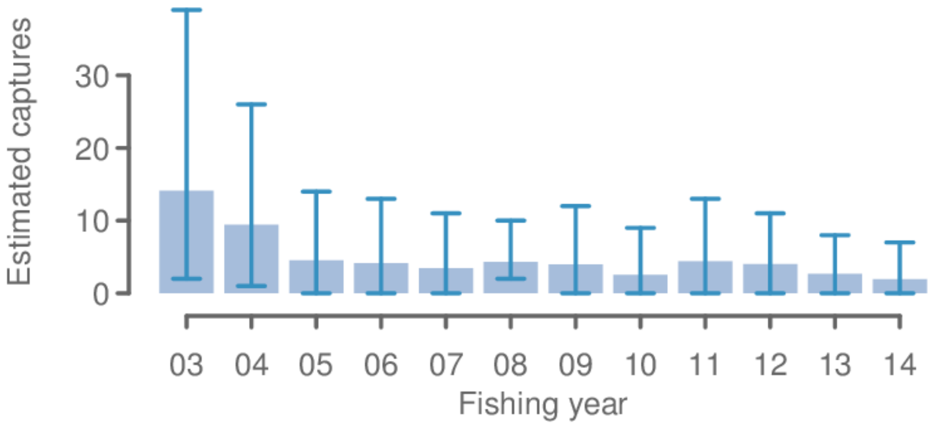


Figure 10 [Continued]: Estimated captures of New Zealand fur seal in bigeye tuna longline fisheries from 2002-03 to 201-14.

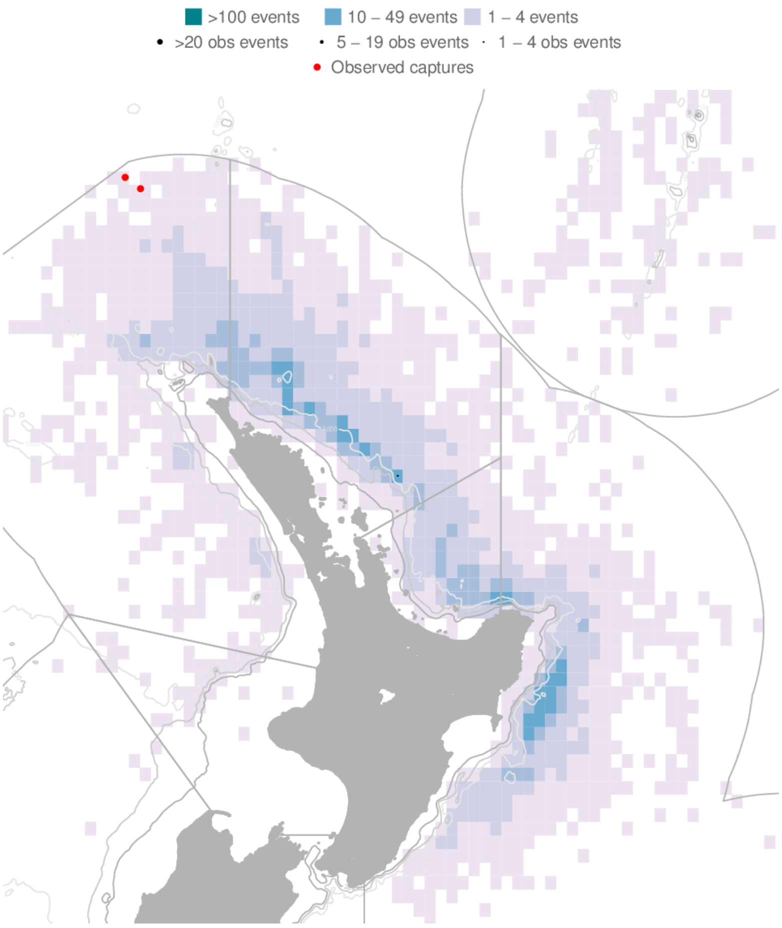


Figure 11: Distribution of fishing effort targeting bigeye tuna and observed New Zealand fur seal captures, 2002–03 to 2013–14. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and 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, 94.6% 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 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 2009 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 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 the WCPFC in 2004, future stock assessments of the WCPO stock of bigeye tuna are undertaken by the Oceanic Fisheries Programme (OFP) of Secretariat of the Pacific Community under contract to WCPFC. As noted above, there is continuing work on a Pacific-wide bigeye assessment.

No assessment is possible for bigeye within the New Zealand EEZ as the proportion of the total stock found within New Zealand fisheries waters is unknown and is likely to vary from year to year.

The bigeye stock assessment was updated by the SPC in 2014 in SC10-SA-WP-01 (Harley et. al. 2014a) and reviewed by the WCPFC Scientific Committee (SC10) in August 2014. In addition SC10-SA-IP-01 (Harley et. al. 2014b) summarized the major changes to the tropical tuna stock assessments resulting from the recommendations provided in SC8-SA-WP-01 (Independent Review of the 2011 bigeye tuna stock assessment). Also, status quo stochastic projections were provided for bigeye tuna in SC10-SA-WP-06 (Pilling 2014).

The following is a summary of the 2014 bigeye stock assessment as agreed by the WCPFC Scientific Committee (SC10) in August 2014.

Some of the main improvements in the 2014 assessment are:

- Increases in the number of spatial regions to better model the tagging and size data;
- Inclusion of catch estimates from Vietnam and some Japanese coastal longline data previously not included;
- The use of operational longline data for multiple fleets to better address the contraction of the Japanese fleet and general changes over time in targeting practices;
- Improved modelling of recruitment to ensure that uncertain estimates do not influence key stock status outcomes; and
- A large amount of new tagging data corrected for differential post-release mortality and other tag losses

The large number of changes since the 2011 assessment (some of which are described above), and the nature of some of those changes, means that full consideration of the impacts of individual changes is not possible. Nevertheless, the report details some of the key steps from the 2011 reference case (Run3j – Ref.case) to the 2014 reference case (037_L0W0T0M0H0). Distinguishing features of the 2014 reference case model include:

- The steepness parameter of the stock recruitment relationship is fixed at 0.8.
- The mean length of the oldest age class in the model is fixed at 184 cm.
- Natural mortality at age is fixed according to an external analysis in which it is assumed that the natural mortality rate of females increases with the onset of reproductive maturity.
- The likelihood function weighting of the size data is determined using an effective sample size for each fishing observation of one-twentieth of the actual sample size, with a maximum effective sample size of 50.
- For modelling the tagging data, a mixing period of 2 quarters (including the quarter of release) is applied.
- The last six quarterly recruitments aggregated over regions are assumed to lie on the stock-recruitment curve.

The rationale for these choices, which comprise the key areas of uncertainty for the assessment, is described in detail in SC10-SA-WP-01. We report the results of "one-off" sensitivity models to explore the impact of these choices for the reference case model on the stock assessment results. A sub-set of key, plausible model runs was taken from these sensitivities to include in a structural uncertainty analysis (grid) for consideration in developing management advice.

The main conclusions of the current assessment are consistent with recent assessments presented in 2010 and 2011. The main conclusions based on the results from the reference case model and with consideration of results from performed sensitivity model runs, are as follows:

1) The new regional structure, modelling and data improvements appear to have improved the current assessment with the previously observed increasing trend in recruitment much reduced and the fit to Coral Sea tagging data greatly improved.

2) Nevertheless there is some confounding between estimated growth, regional recruitment distributions and movement which, while having minimal impact on stock status conclusions, lead to a complex solution surface and the presence of local minima.

3) Current catches exceed maximum sustainable yield (MSY);

4) Recent levels of fishing mortality exceed the level that will support the MSY;

5) Recent levels of spawning potential are most likely at (based on 2008-11 average) or below (based on 2012) the level which will support the MSY;

6) Recent levels of spawning potential are most likely at (based on 2008-11 average) or below (based on 2012) the LRP of 20%$SB_{F=0}$ agreed by WCPFC;

7) Recent levels of spawning potential are lower than candidate biomass-related target reference points (TRPs) currently under consideration for skipjack tuna, i.e., 40-60% $SB_{F=0}$; and

8) Stock status conclusions were most sensitive to alternative assumptions regarding the modelling of tagging data and the longline CPUE series included, identifying these as important areas for continued research. However, the main conclusions of the assessment are robust to the range of uncertainty that was explored.

Paper SC10-SA-WP-06 (Pilling 2014) contained status quo stochastic projections for bigeye, skipjack, and yellowfin tunas. The paper outlined an assessment of the potential consequences of recent (2012) fishing conditions on the future biological status of the three tropical tuna stocks, based on the 2014 tropical tuna stock assessments. Projected status in 2032 was reported relative to spawning biomass and fishing mortality reference levels in absolute terms (as a median of the projection outcomes) and in probabilistic terms.

A single assessment model run (the reference case model for each tropical tuna stock) was used as the basis for projecting future stock status. Only uncertainty arising from future recruitment conditions was therefore captured in the results, using two alternative hypotheses: where recruitment was assumed to follow the estimated stock recruitment relationship on average with randomly selected deviates from the period used to estimate the relationship in each stock assessment; or was assumed to be consistent with actual recruitments estimated over the period 2002-2011.

Under 2012 conditions, stochastic projection results indicated bigeye tuna were dependent upon the recruitment assumption, the stock was either very likely (>90%; long-term recruitment deviate assumption) or unlikely (<25%; recent recruitment assumption) to fall below both the LRP and SB_{MSY} levels by 2032. Under both recruitment assumptions, it was virtually certain (>99%) that fishing mortality would be above the F_{MSY} level in 2032.

Stock status and trends

There have been significant improvements to the 2014 stock assessment resulting from the implementation of the 2012 bigeye review recommendations. Improvements were made to regional and fisheries structures, CPUE, size, and tagging data inputs, and the MULTIFAN-CL modelling framework. This assessment is also the first since the adoption of a LRP based on the spawning biomass in the absence of fishing ($0.2SB_{F=0}$).

SC10 selected the reference case model as the base case to represent the stock status of bigeye. To characterize uncertainty SC10 chose three additional models based on alternative values of steepness and a shorter tag mixing period. Details of the base case and other models are provided in Table 15.

Table 15: Description of the base case and key model chosen for the provision of management advice.

Name	Description
Base Case	JP CPUE for regions 1, 2, and 4, all flags for regions 3, 7, 8, 5, and 6, and nominal for region 9. Size data weighted as the weighted number of samples divided by 20, steepness fixed at 0.8, M fixed, tag mixing at 2 quarters, and the mean length of fish in the oldest age class (L2) fixed at 184 cm.
h_0.65	Steepness=0.65.
h_0.95	Steepness=0.95.
Mix_1qtr	Tag mixing period=1 quarter

Time trends in estimated recruitment, biomass, fishing mortality and depletion are shown in Figures 13-18.

Fishing mortality has generally been increasing through time, and for the reference case $F_{current}$ (2008-11 average) is estimated to be 1.57 times the fishing mortality that will support the MSY. Across the four models (base case and three sensitivity models) $F_{current}/F_{MSY}$ ranged from 1.27 to 1.95. This indicates that overfishing is occurring for the WCPO bigeye tuna stock and that in order to reduce fishing mortality to F_{MSY} levels the base case indicates that a 36% reduction in fishing mortality is required from 2008–2011 levels (Table 16 and Figure 14). This is similar to the 32% reduction from 2006-2009 levels recommended from the 2011 assessment.

The latest (2012) estimates of spawning biomass are below both the level that will support the MSY (SB_{latest}/SB_{MSY} = 0.77 for the base case and range 0.62-0.96 across the four models) and the newly adopted LRP of $0.2SB_{F=0}$ ($SB_{latest}/SB_{F=0}$ = 0.16 for the base case and range 0.14-0.18).

An analysis of historical patterns in the mix of fishing gear types indicates that MSY has been reduced to less than half its level prior to 1970 through the increased harvesting of juveniles (Figure 15).

The estimated maximum sustainable yield (MSY) of 108,520 mt is higher than previous assessments (Table 17). This is for three key reasons 1) the improved assessment has higher average recruitment; 2) application of the lognormal bias correction to the spawner-recruitment relationship; and 3) increased catches used in the new assessment.

Table 16: Estimates of management quantities for selected stock assessment models (see Table BET1 for details). For the purpose of this assessment, "current" is the average over the period 2008–2011 and "latest" is 2012.

	Base case	h=0.65	h=0.95	Mix_1qtr
MSY(mt)	108,520	101,880	116,240	107,880
C_{latest}/MSY	1.45	1.55	1.36	1.45
$F_{current}/F_{MSY}$	1.57	1.95	1.27	1.73
B_0	2,286,000	2,497,000	2,166,000	2,183,000
$B_{current}$	742,967	744,596	741,549	640,645
SB_0	1,207,000	1,318,000	1,143,000	1,153,000
SB_{MSY}	345,400	429,900	275,200	328,700
$SB_{F=0}$	1,613,855	1,848,385	1,483,216	1,585,331
SB_{curr}	325,063	326,007	324,283	269,820
SB_{latest}	265,599	266,290	264,937	218,679
$SB_{curr}/SB_{F=0}$	0.20	0.18	0.22	0.17
$SB_{latest}/SB_{F=0}$	0.16	0.14	0.18	0.14
SB_{curr}/SB_{MSY}	0.94	0.76	1.18	0.82
SB_{latest}/SB_{MSY}	0.77	0.62	0.96	0.67

Table 17: Comparison of selected WCPO bigeye tuna reference points from the 2010, 2011, and 2012 base case models.

Management quantity	Base case 2010	Base case 2011	Base case 2014
MSY(mt)	73,840	76,760	108,520
$F_{current}/F_{MSY}$	1.41	1.46	1.57
$SB_{latest}/SB_{F=0}$	0.16	0.21	0.16

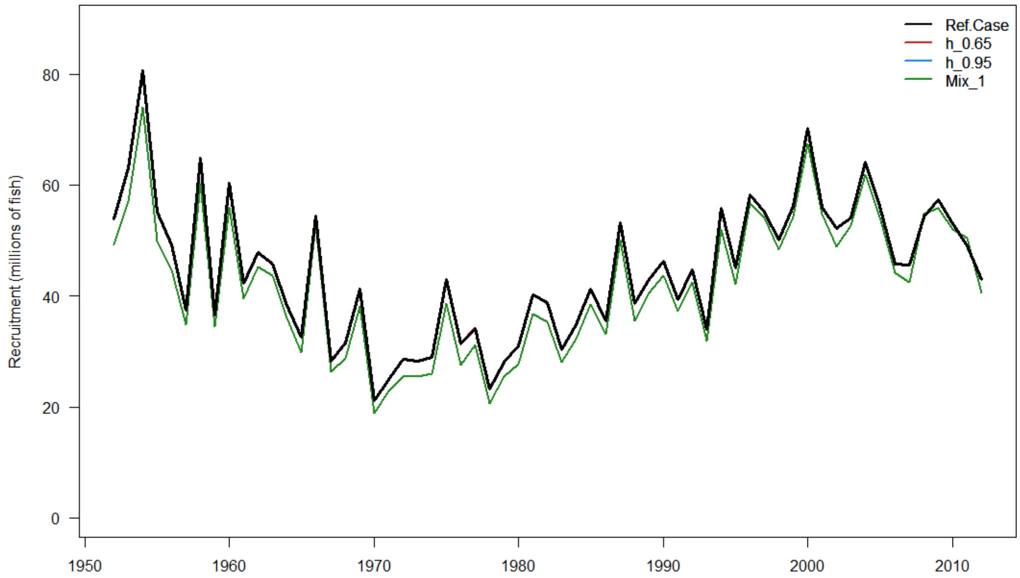


Figure 12: Estimated annual recruitment (millions of fish) for the WCPO obtained from the base case model and three additional runs described in Table BET1. The model runs with alternative steepness values give the same recruitment estimates.

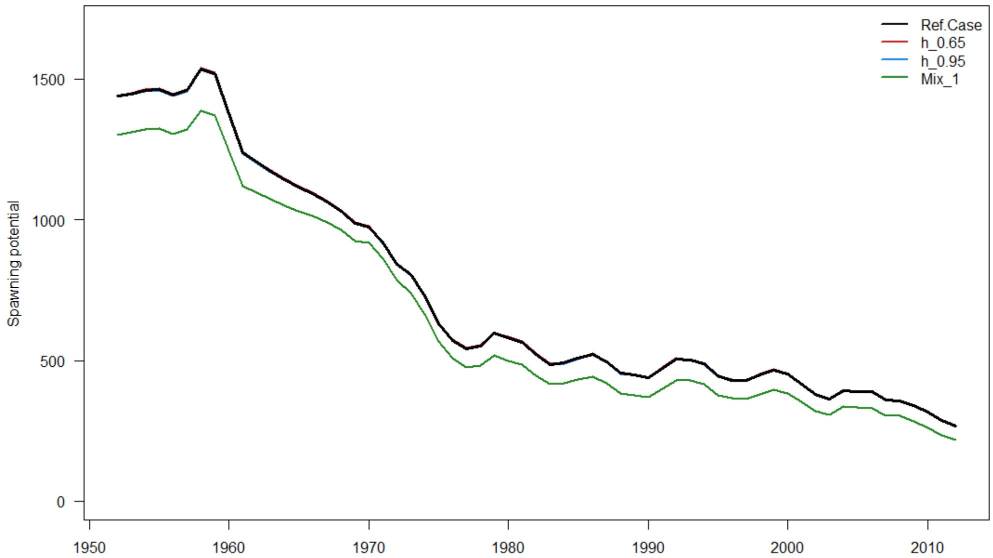


Figure 13: Estimated annual average spawning potential for the WCPO obtained from the base case model and three additional runs described in Table BET1. The model runs with alternative steepness values give the same spawning potential trajectory estimates as the reference case.

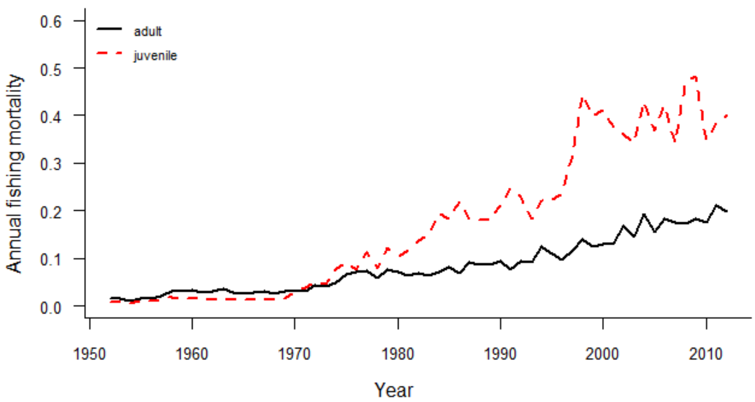


Figure 14: Estimated annual average juvenile and adult fishing mortality for the WCPO obtained from the base case model.

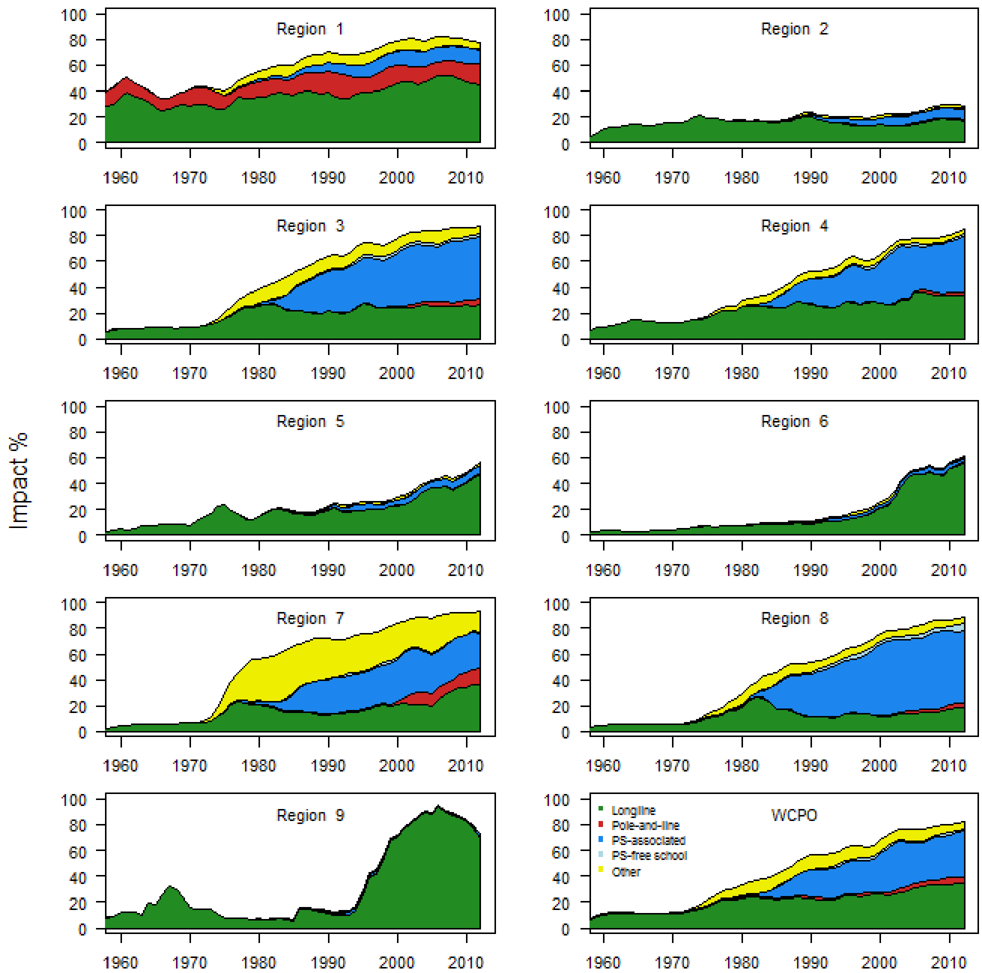


Figure 15: Estimates of reduction in spawning potential due to fishing (fishery impact = 1-$SB_t/SB_{t,F=0}$) by region and for the WCPO attributed to various fishery groups for the base case model.

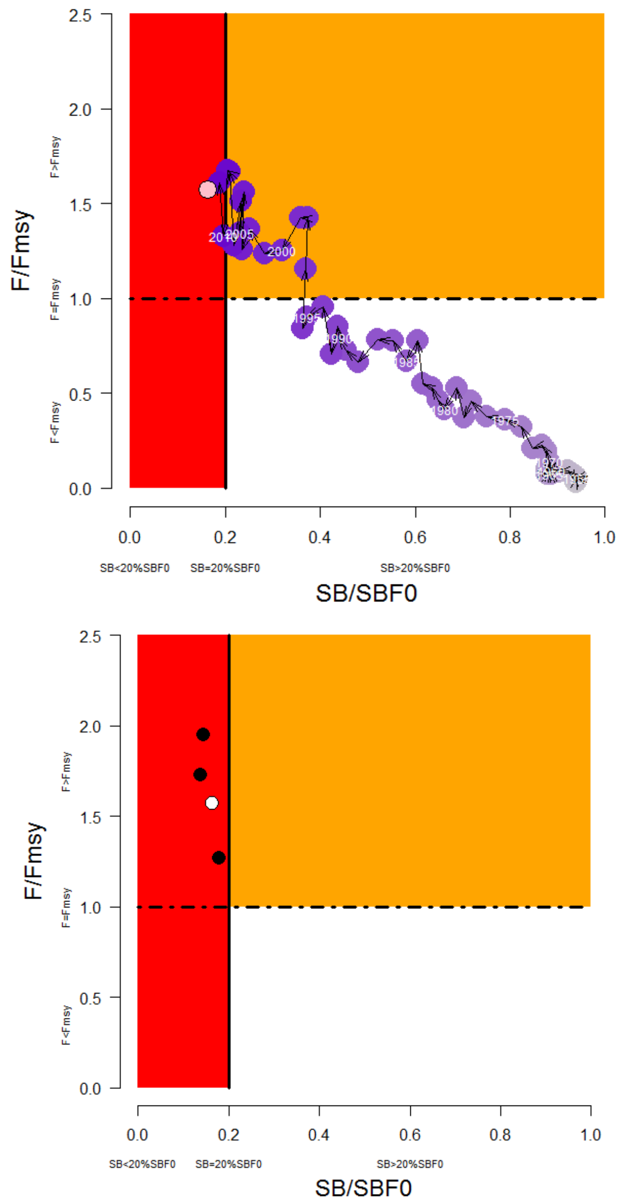


Figure 16: Temporal trend for the base case model (top) and terminal condition for the base case and other sensitivity runs (bottom) in stock status relative to $SB_{F=0}$ (x-axis) and F_{MSY} (y-axis). The red zone represents spawning potential levels lower than the agreed LRP which is marked with the solid black line ($0.2SB_{F=0}$). The orange region is for fishing mortality greater than F_{MSY} ($F=F_{MSY}$; marked with the black dashed line). The pink circle (top panel) is $SB_{2012}/SB_{F=0}$ (where $SB_{F=0}$ was the average over the period 2002-2011). The bottom panel includes the base case (white dot) and sensitivity analyses described Table BET-1.

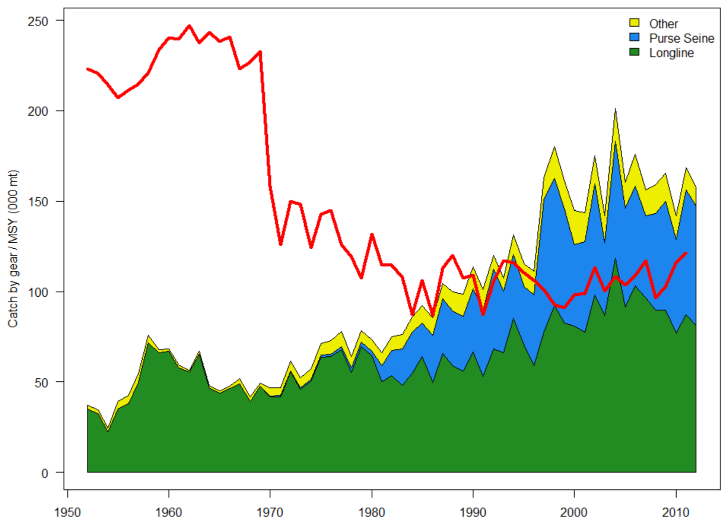


Figure 17: History of annual estimates of MSY compared with catches of three major fisheries for the base case model.

Management advice and implications

SC10 noted that the spawning biomass of WCPO bigeye tuna breached the biomass LRP in 2012 and that the stock was overfished. Rebuilding spawning biomass to be above the biomass LRP will require a reduction in fishing mortality.

SC10 recommended that fishing mortality on WCPO bigeye tuna be reduced. A 36% reduction in fishing mortality from the average levels for 2008–2011 would be expected to return the fishing mortality rate to F_{MSY}. This reduction of at least 36% should also allow the stock to rebuild above the LRP over a period of time. This recommended level of reduction in fishing mortality could also be stated as a minimum 33% reduction from the 2004 level of fishing mortality, or a minimum 26% reduction from the average 2001-2004 level of fishing mortality.

Future status quo projections (assuming 2012 conditions) depend upon assumptions on future recruitment. When spawner-recruitment relationship conditions are assumed, spawning biomass continues to decline and the stock is very likely (94%) to remain below the LRP based on projections through 2032 ($SB_{2032}<0.2SB_{F=0}$). If recent (2002-2011) actual recruitments are assumed, spawning biomass increases and it was unlikely (13%) to remain below the LRP. Under both recruitment assumptions, it was virtually certain (100%) that the stock would remain subject to overfishing ($F>F_{MSY}$).

Overfishing and the increase in juvenile bigeye catches have resulted in a considerable reduction in the potential yield of the WCPO bigeye stock. The loss in yield per recruit due to excess harvest of juvenile fish is substantial. SC10 concluded that MSY levels would increase if the mortality of juvenile bigeye was reduced.

Fishing mortality varies spatially within the Convention Area with high mortality in the tropical Pacific Ocean. WCPFC could consider a spatial management approach in reducing fishing mortality for bigeye tuna.

Considering the unavailability of operational longline data for the assessment from some key fleets, SC10 recommended that all operational data including high seas should be available for future stock assessments. The current lack of operational data for some fleets, and in particular the lack of operational longline data on the high seas hampered the 2014 assessment in a number of ways (e.g. the construction of abundance indices) and consequently hindered the SC from achieving "best practice" in the 2014 stock assessment.

SC10 noted that arrangements are being developed between CCMs and SPC to facilitate the availability of operational data for the Pacific wide bigeye stock assessment scheduled for 2015.

SC10 recommended that the Commission consider the results of updated projections at WCPFC11, including evaluation of the potential impacts of CMM 2013-01, to determine whether the CMM will achieve its objectives and allow the bigeye stock to rebuild above the LRP.

5.1 Estimates of fishery parameters and abundance

There are no fishery independent indices of abundance for the bigeye stock. Relative abundance information is available from longline catch per unit effort data, though there is no agreement on the best method to standardise these data and several methods are compared. Returns from a large scale tagging programme undertaken in the early 1990s, and an updated programme from 2007–2009 undertaken by the SPC provide information on rates of fishing mortality which in turn has improved estimates of abundance.

5.2 Biomass estimates

The stock assessment results and conclusions of the 2014 assessment show $SB_{current}$ / SB_{MSY} estimated at 0.94 over the period 2008-2011. This estimate applies to the WCPO portion of the stock or an area that is approximately equivalent to the waters west of 150°W. Spawning biomass for the WCPO is estimated to have declined to about 16% of its initial level by 2012.

5.3 Yield estimates and projections

No estimates of *MCY* and *CAY* are available.

5.4 Other yield estimates and stock assessment results

SC10 achieved consensus to accept and endorse the reference case proposed in the assessment document, and that $SB_{20\%,F=0}$ be used as the LRP for stock status purposes as agreed by WCPFC. There was further discussion about whether to use SB_{latest} or $SB_{current}$ as the terminal spawning biomass for management purposes. The SC agreed to use the most recent information on bigeye tuna spawning biomass, SB_{latest} corresponding to 2012, given recent trends of increasing catch, high fishing mortality and decreasing CPUE.

SC10 also endorsed the use of the candidate biomass-related target reference point (TRP) currently under consideration for skipjack tuna, i.e., 40-60% $SB_{F=0}$. At 0.16 $SB_{F=0}$ SB_{latest} is below both the target and limit reference points.

5.5 Other factors

There are three areas of concern with the bigeye stock:

- Juveniles occur in mixed schools with small yellowfin and also with skipjack tunas throughout the equatorial Pacific Ocean. As a result, they are vulnerable to large-scale purse seine fishing, particularly when fish aggregating devices (FADs) are set on. Catches of juveniles can be a very high proportion of total removals in numbers from the stock;

- Overfishing and the increase in juvenile bigeye catches have resulted in a considerable reduction in the potential yield of the WCPO bigeye stock. The loss in yield per recruit due to excess harvest of juvenile fish is substantial. SC10 concluded that MSY levels would increase if the mortality of juvenile bigeye was reduced.

- Fishing mortality varies spatially within the Convention Area with high mortality in the tropical Pacific Ocean. WCPFC could consider a spatial management approach in reducing fishing mortality for bigeye tuna.

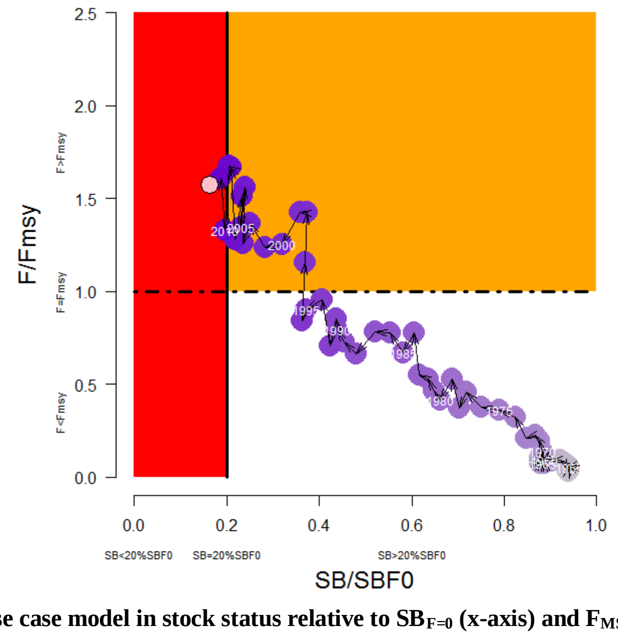
6. STATUS OF THE STOCKS

Stock structure assumptions

Western and Central Pacific Ocean
All estimates of biomass in this table refer to spawning biomass (SB).

Stock Status	
Year of Most Recent Assessment	A full stock assessment was conducted in 2014.
Assessment Runs Presented	Base case model and selected sensitivity analyses
Reference Points	Candidate biomass-related target reference point (TRP) currently under consideration for key tuna stocks is 40-60% SB_0 Limit reference point of 20% SB_0 established by WCPFC equivalent to the 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	Recent levels of spawning biomass (either the 2008-11 average or the 2012 estimate) are Very Unlikely (< 10%) to be at or above 40-60% SB_0 Very Unlikely (< 10%) that F < F_{MSY}
Status in relation to Limits	Soft Limit: Likely (> 60%) to be below Hard Limit: Unlikely (< 40%) to be below
Status in relation to Overfishing	Overfishing is Very Likely (> 90%) to be occurring

Historical Stock Status Trajectory and Current Status



Temporal trend for the base case model in stock status relative to $SB_{F=0}$ (x-axis) and F_{MSY} (y-axis). The red zone represents spawning biomass levels lower than the agreed LRP which is marked with the solid black line ($0.2SB_{F=0}$). The orange region is for fishing mortality greater than F_{MSY} ($F=F_{MSY}$; marked with the black dashed line). The pink circle is $SB_{2012}/SB_{F=0}$ (where $SB_{F=0}$ was the average over the period 2002-2011).

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass has decreased consistently since the 1950s to levels below SB_{MSY} in recent years.

	Spawning biomass for the WCPO is estimated to have declined to about half of the initial levels by about 1970, and has continued to decline (SB_{2012}/SB_0 = 0.16).
Recent Trend in Fishing Intensity or Proxy	Fishing mortality has generally increased and has recently escalated to levels near or above F_{2012}/F_{MSY} = 1.57.
Other Abundance Indices	-
Trends in Other Relevant Indicator or Variables	Recruitment in all analyses was estimated to have been high during the last two decades. This result is similar to that of previous assessments, and appears to be partly driven by conflicts between some of the CPUE, catch, and size data inputs.

Projections and Prognosis	
Stock Projections or Prognosis	Stochastic projection results were dependent upon the recruitment assumption. Under the long-term recruitment deviate assumption, the stock was Very Likely (> 90%) to be below both the LRP and SB_{MSY} levels by 2032; under the recent recruitment assumption, the stock was Unlikely (< 40%) to be below both the LRP and SB_{MSY} levels by 2032.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Under the long-term recruitment deviate assumption, the stock was Very Likely (> 90%) to be below the LRP in 2032; under the recent recruitment assumption, the stock was Unlikely (< 40%) to be below the LRP in 2032.
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Under both recruitment assumptions, it was Virtually Certain (> 99%) that fishing mortality would be above the F_{MSY} level in 2032.

Assessment Methodology and Evaluation		
Assessment Type	Level 1- Quantitative Stock Assessment	
Assessment Method	The assessment uses the stock assessment model and computer software known as MULTIFAN-CL.	
Assessment Dates	Latest assessment: 2014	Next assessment: 2017
Overall assessment quality rank	1 - High Quality	
Main data inputs (rank)	- Catch and effort data - Size data - Growth data; and - Tagging data	1 – All High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	Changes to the data from the 2011 assessment included: • Increases in the number of spatial regions to better model the tagging and size data; • Inclusion of catch estimates from Vietnam and some Japanese coastal longline data previously not included; • The use of operational longline data for multiple fleets to better address the contraction of the Japanese fleet and general changes over time in targeting practices; • Improved modelling of recruitment to ensure that uncertain estimates do not influence key stock status outcomes; and • A large amount of new tagging data corrected for differential post-release mortality and other tag losses	
Major Sources of Uncertainty	- Catch estimates from the most recent years are uncertain - Lack of availability of operational longline data for some fleets	

	- High levels of uncertainty regarding the recruitment estimates and the resulting estimates of steepness

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 CMM2007-04. 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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