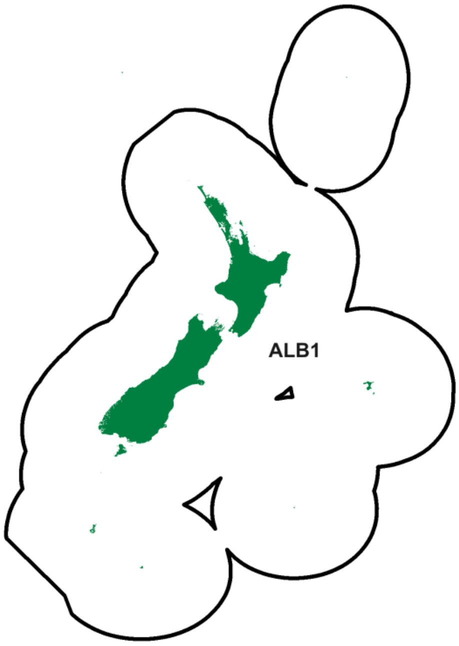
ALBACORE (ALB)

(*Thunnus alalunga)*
Ahipataha



1. FISHERY SUMMARY

Albacore is currently outside the Quota Management System.

Management of albacore stock throughout the South Pacific 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 seventh annual meeting in 2011 the WCPFC passed a Conservation and Management Measure (CMM) (this is a binding measure that all parties must abide by) CMM2010-05 relating to conservation and management measures for South Pacific albacore tuna. Key aspects of this CMM are repeated below:

1. "Commission Members, Cooperating Non-Members, and participating Territories (CCMs) shall not increase the number of their fishing vessels actively fishing for South Pacific albacore in the Convention Area south of 20°S above current (2005) levels or recent historical (2000–2004) levels".

2. The provisions of paragraph 1 shall not prejudice the legitimate rights and obligations under international law of small island developing State and Territory CCMs in the Convention Area for whom South Pacific albacore is an important component of the domestic tuna fishery in waters under their national jurisdiction, and who may wish to pursue a responsible level of development of their fisheries for South Pacific albacore.

3. CCMs that actively fish for South Pacific albacore in the Convention Area south of the equator shall cooperate to ensure the long-term sustainability and economic viability of the

fishery for South Pacific albacore, including cooperation and collaboration on research to reduce uncertainty with regard to the status of this stock.

4. This measure will be reviewed annually on the basis of advice from the Scientific Committee on South Pacific albacore."

In 2015 the WCPFC passed Conservation and Management Measure (CMM) 2015-02 that reaffirmed CMM2010-05 and added an additional clause as follows:

"CCMs shall report annually to the Commission the annual catch levels taken by each of their fishing vessels that has taken South Pacific albacore, as well as the number of vessels actively fishing for South Pacific albacore, in the Convention area south of 20°S. Catch by vessel shall be reported according to the following species groups: albacore tuna, bigeye tuna, yellowfin tuna, swordfish, other billfish, and sharks. Initially this information will be provided for the period 2006–2014 and then updated annually. CCMs are encouraged to provide data from periods prior to these dates."

1.1 Commercial fisheries

The South Pacific albacore catch in 2014 (83 033 t) was the second highest on record. Catches from within New Zealand fisheries waters in 2014 were about 4% of the South Pacific albacore catch. The South Pacific albacore catch declined to 68 504 t in 2015.

In New Zealand, albacore form the basis of a summer troll fishery, primarily on the west coasts of the North and South Islands. In 2013 about 55% of the albacore catch was taken by troll (Figure 2). Albacore are also caught throughout the year by longline. Total annual landings between 2000 and 2014 ranged between 2092 and 6744 t (Table 1). Figure 1 shows the historical landings and fishing effort for albacore stocks.

The earliest known commercial catch of tuna (species unknown but probably skipjack tuna) was by trolling and was landed in Auckland in the year ending March 1943. Regular commercial catches of tuna, however, were not reported until 1961. Prior to 1973 the albacore troll fishery was centred off the North Island (Bay of Plenty to Napier and New Plymouth) with the first commercial catches off Greymouth and Westport (54% of the total catch) in 1973. The expansion of albacore trolling to the west coast of the South Island immediately followed experimental fishing by the *W. J. Scott*, which showed substantial quantities of albacore off the Hokitika Canyon and albacore as far south as Doubtful Sound. Tuna longlining was not established as a fishing method in the domestic industry until the early 1990s.

Table 1: Reported total New Zealand landings (t) and landings (t) from the South Pacific Ocean (SPO) of albacore tuna from 1972 to 2015.

Year	NZ fisheries waters	SPO	Year	NZ fisheries waters	SPO	Year	NZ fisheries waters	SPO
1972	240	39 521	1987	1 236	25 052	2002	5 566	73 240
1973	432	47 330	1988	672	37 867	2003	6 744	62 477
1974	898	34 049	1989	4 884	49 076	2004	4 459	61 871
1975	646	23 600	1990	3 011	36 062	2005	3 459	62 566
1976	25	29 082	1991	2 450	35 600	2006	2 542	62 444
1977	621	38 740	1992	3 481	38 668	2007	2 092	58 591
1978	1 686	34 676	1993	3 327	35 438	2008	3 720	62 740
1979	814	27 076	1994	5 255	42 318	2009	2 216	82 901
1980	1 468	32 541	1995	6 159	38 467	2010	2 292	88 942
1981	2 085	34 784	1996	6 320	34 359	2011	3 205	66 476
1982	2 434	30 788	1997	3 628	39 490	2012	2 990	87 752
1983	720	25 092	1998	6 525	50 371	2013	3 142	84 698
1984	2 534	24 704	1999	3 903	39 614	2014	2 466	83 033
1985	2 941	32 328	2000	4 428	47 338	2015	2 537	68 594
1986	2 044	36 590	2001	5 349	58 344			

Source: LFRR and MHR and SC11-ST-IP-01

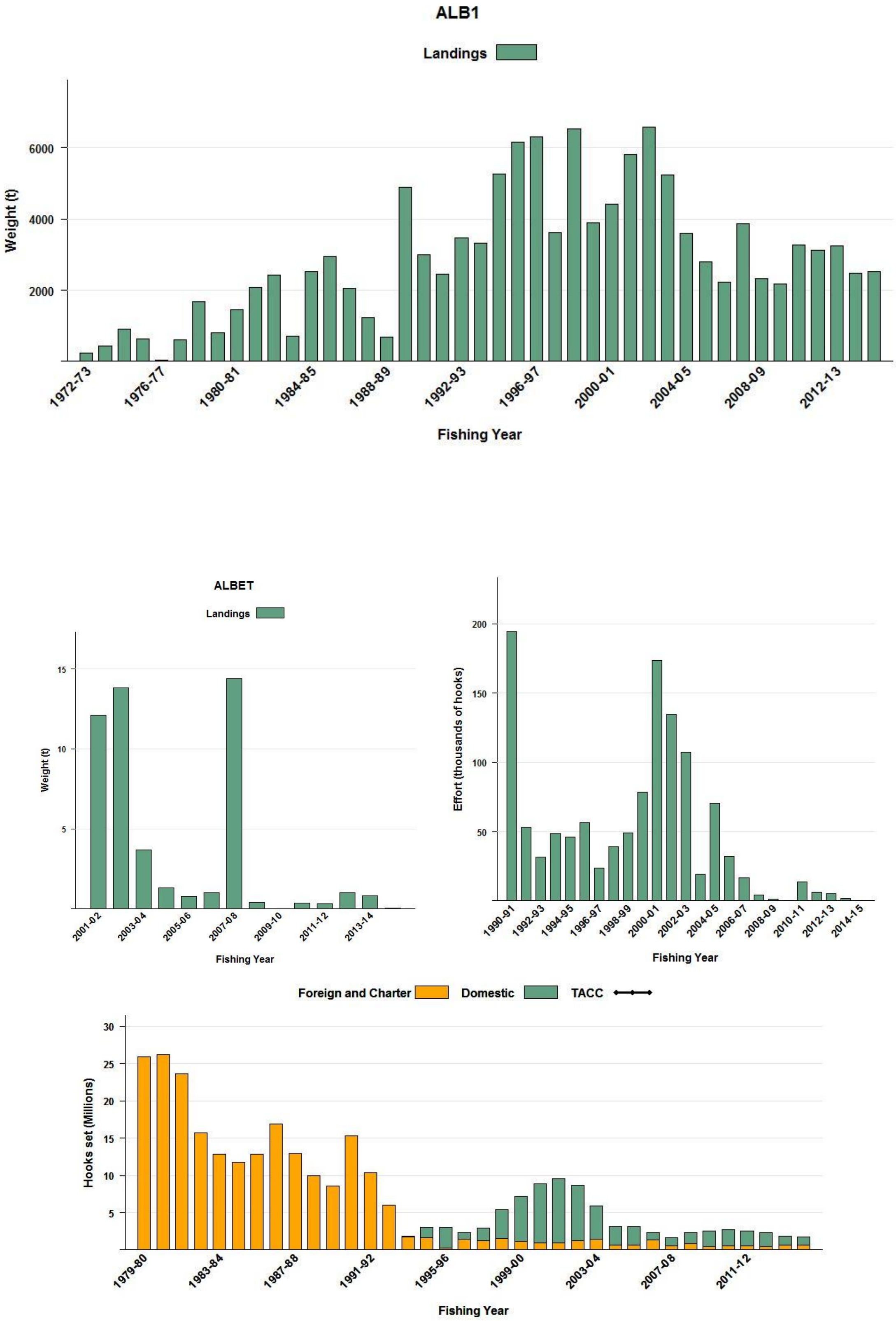


Figure 1: [Top and middle left] Albacore catch from 1972–73 to 2014–15 within New Zealand waters (ALB 1) and 2001–02 to 2014–15 on the high seas (ALB ET). [Middle right] Fishing effort (number of hooks set) for all high seas New Zealand flagged surface longline vessels, from 1990–91 to 2014–15. [Bottom] Fishing effort (number of hooks set) for all domestic and foreign vessels (including effort by foreign vessels chartered by New Zealand fishing companies), from 1979–80 to 2014–15.

The New Zealand albacore fishery, especially the troll fishery, has been characterised by periodic poor years that have been linked to poor weather or colder than average summer seasons. Despite this variability, domestic albacore landings have steadily increased since the start of commercial fishing in the 1960s. The average catch in the 1960s (19 t) increased in the 1970s to 705 t, in the 1980s to 2256 t, and in the 1990s averaged 4571 t but both catch and effort have declined almost continuously through the 2000s from a high in 2002–03.

Most albacore troll fishery catches are in the first and second quarters of the calendar year, with the fourth quarter important in some years (1994 to 1996). Most of the troll fishery catch comes from FMA 7 off the west coast of the South Island although FMA 1, FMA 2, FMA 8 and FMA 9 have substantial catches in some years. High seas troll catches have been infrequent and a minor component (maximum catch of 42.2 t in 1991) of the New Zealand fishery over the 1991 to 2011 period. Albacore are caught by longline throughout the year as a bycatch on sets targeting bigeye and southern bluefin tuna. Most of the longline albacore catch is reported from FMA 1 and FMA 2 with lesser amounts caught in FMA 9. While albacore are caught regularly by longline in high seas areas, New Zealand effort and therefore catches are small.

Small catches of albacore are occasionally reported using pole-and-line and hand line gear. Pole-and-line catches of albacore have been reported from FMA 1, FMA 2, FMA 5, FMA 7, and FMA 9. Hand line catches have been reported from FMA 1 and FMA 7.

The majority of albacore caught in New Zealand waters is by troll fishing, which accounts for 55% of the overall effort in the surface lining fisheries (troll, surface longline, pole & line) and 91% of the albacore catch. In the surface longline fisheries, 65 % of fishing effort is directed at bigeye tuna, while for all surface lining fisheries combined, 55 % of fishing effort is directed at albacore (Figure 2). Albacore makes up 31 % of the catch in the surface longline fisheries and 69% of the catch for all surface lining fisheries combined (Figure 3).

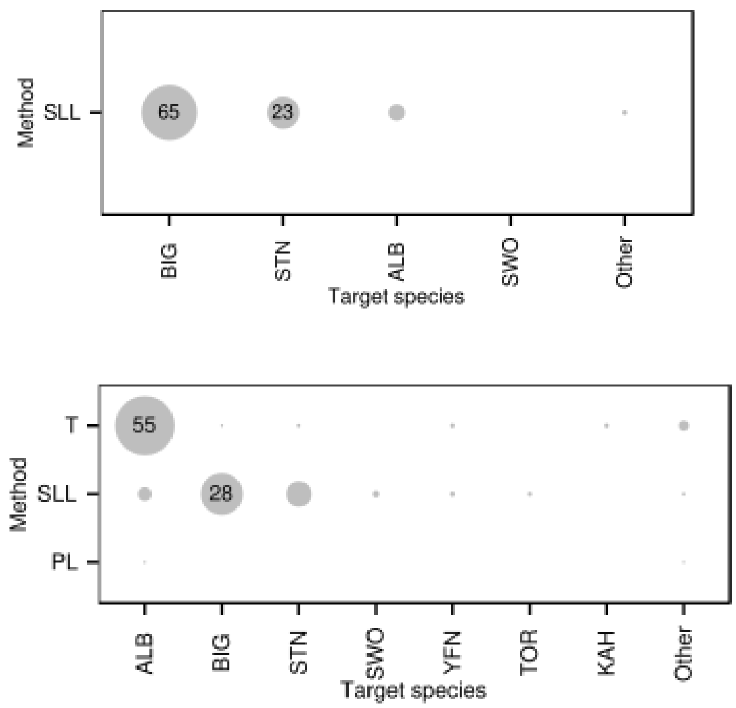


Figure 2: The proportion of effort in each of New Zealand's surface longline fisheries (top) and in all surface lining fisheries for 2012–13 (bottom), (T – troll; SLL – surface longline; PL – pole & line). The area of each circle is proportional to the percentage of overall effort and the number in the circle is the percentage (Bentley et al 2013).

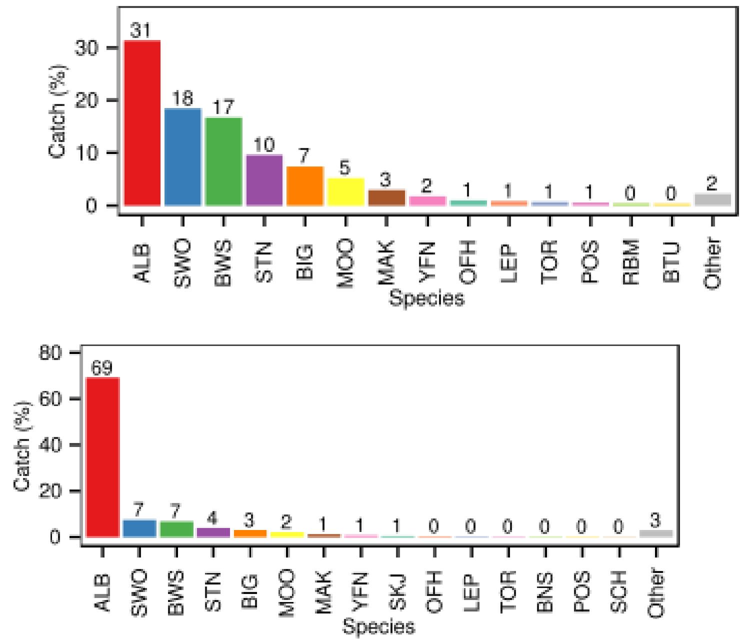


Figure 3: A summary of species composition by weight of the reported surface longline catch (top) and of the catch by all surface lining fisheries for 2013–14 (bottom) (Bentley et al 2013).

Across all fleets in the longline fishery, 38.2% of albacore tuna were alive when brought to the side of the vessel (Table 2). The domestic fleets retained around 96–98% of their albacore tuna catch, while the foreign charter fleet retain almost all the albacore (98–100%). The Australian fleet that fished in New Zealand waters in 2006–07 also retained most of the albacore catch (92.4%) (Table 3).

Table 2: Percentage of albacore (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	21.5	78.5	79
	Charter	North	61.2	38.8	784
		South	77.3	22.7	587
	Domestic	North	28.1	71.9	1 880
	Total		**44.4**	**55.6**	**3 330**
2007–08	Charter	South	71.3	28.7	167
	Domestic	North	22.7	77.3	1 765
	Total		**26.9**	**73.1**	**1 932**
2008–09	Charter	North	84.6	15.4	410
		South	79.5	20.5	112
	Domestic	North	33.7	66.3	1 986
	Total		**44.0**	**56.0**	**2 511**
2009–10	Charter	South	82.1	17.9	78
	Domestic	North	28.8	71.2	1 766
		South	42.9	57.1	42
	Total		**31.3**	**68.7**	**1 886**
Total all strata			**38.2**	**61.8**	**9 659**

Table 3: Percentage albacore 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	92.4	7.6	79
	Charter	97.7	2.3	1 448
	Domestic	96.1	3.9	1 882
	Total	**96.7**	**3.3**	**3 409**
2007–08	Charter	98.8	1.2	170
	Domestic	95.9	4.1	1 769
	Total	**96.1**	**3.9**	**1 939**
2008–09	Charter	99.7	0.3	605
	Domestic	97.8	2.2	1 993
	Total	**98.2**	**1.8**	**2 598**
2009–10	Charter	100.0	0.0	89
	Domestic	97.2	2.8	1 814
	Total	**97.3**	**2.7**	**1 903**
Total all strata		**97.1**	**2.9**	**9 849**

1.2 Recreational fisheries

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Albacore by virtue of its wide distribution in coastal waters over summer is seasonally locally important as a recreational species. It is taken by fishers targeting it predominantly for food, but it is also frequently taken as bycatch when targeting other gamefish. Albacore do not comprise part of the voluntary recreational gamefish tag and release programme. Albacore are taken almost exclusively using rod and reel (over 99% of the 2011–12 harvest), and from trailer boats (over 96% of the 2011–12 harvest). They are caught around the North Island and upper South Island, more frequently on the West Coast, with harvest by area in 2011–12 being: FMA 1 (16.6%), FMA 2 (10.6%), FMA 7 (15.6%), FMA 8 (29.4%) and FMA 9 (27.8%).

1.2.1 Management controls

There are no specific controls in place to manage recreational harvests of albacore.

1.2.2 Estimates of recreational harvest

Recreational catch estimates are available from a national panel survey conducted in the 2011–12 fishing year (Wynne-Jones et al 2014). The panel survey used face-to-face interviews of a random sample of New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and catch information collected in standardised phone interviews. Note that the national panel survey estimate includes harvest taken on recreational charter vessels, but for albacore is unlikely to estimate this proportion of the catch well. The national panel survey estimate does not include recreational harvest taken under s111 general approvals. The harvest estimate from this survey was 21 898 fish, with a mean weight of 4.21 kg, giving a total harvest of 92.09 tonnes (CV 0.21).

1.3 Customary non-commercial fisheries

It is uncertain whether albacore were caught by early Maori, although it is clear that they trolled lures (for kahawai) that are very similar to those still used by Tahitian fishermen for various small tunas. Given the number of other oceanic species known to Maori, and the early missionary reports of Maori regularly fishing several miles from shore, albacore were probably part of the catch of early Maori.

An estimate of the current customary catch is not available.

1.4 Illegal catch

There is no known illegal catch of albacore in the EEZ or adjacent high seas.

1.5 Other sources of mortality

Discarding of albacore has not been reported in the albacore troll fishery (based on limited observer coverage in the 1980s). Low discard rates (average 2.9%) have been observed in the longline fishery over the period 2006–07 to 2009–10. Of those albacore discarded, the main reason recorded by observers was shark damage. Similarly, the loss of albacore at the side of the vessel was low (0.6%). Mortality in the longline fishery associated with discarding and loss while landing is estimated at 1.8% of the albacore catch by longline.

2. BIOLOGY

The troll fishery catches juvenile albacore typically 5 to 8 kg in size with the mean fork length for 1996–97 to 2006–07 being 63.5 cm (Figure 4). Clear length modes associated with cohorts recruiting to the troll fishery are evident in catch length distributions. In 2006–07 three modes with median lengths of 51, 61, and 72 cm were visible, which correspond to the 1, 2, and 3 year old age classes.

The mean length of troll caught albacore in 2009–10 was 61.6 cm. The modal progressions in the available catch length frequency time series from 1996–97 to 2010–11 are of utility for estimating annual variations in albacore recruitment. Longline fleets typically catch much larger albacore over a broader size range (56–105 cm) with variation occurring as a function of latitude and season. The mean length of longline-caught albacore from 1987 to 2007 is 80.4 cm. The smallest longline caught albacore are those caught in May to June immediately north of the Sub-tropical Convergence Zone (STCZ). Fish further north at this time and fish caught in the EEZ in autumn and winter are larger. There is high inter-annual variation in the longline catch length composition although length modes corresponding to strong and weak cohorts are often evident between years.

Sampling of troll caught albacore has been carried out annually (except 2008–09) since the 1996–97 fishing year. The sampling programme aims to sample in the ports of Auckland, Greymouth and New Plymouth (which was included for the first time in 2003). Initially the programme aimed to sample 1000 fish per month in each port. In 2010 the sample targets were changed and the programme now aims to sample approximately 5000 fish per year and the sample targets (Table 4) are distributed throughout the season to reflect the fishing effort distribution. In addition, in each port at least 100 fish per month are sub-sampled for weight. Length weight relationships are presented in Table 5 and length frequency distributions are presented in Figure 4.

Table 4: Catch sample targets for length measurements in the New Zealand troll sampling programme.

Month	Target number of fish
December	400
January	1 600
February	1 600
March	1 000
April	400
Total	5 000

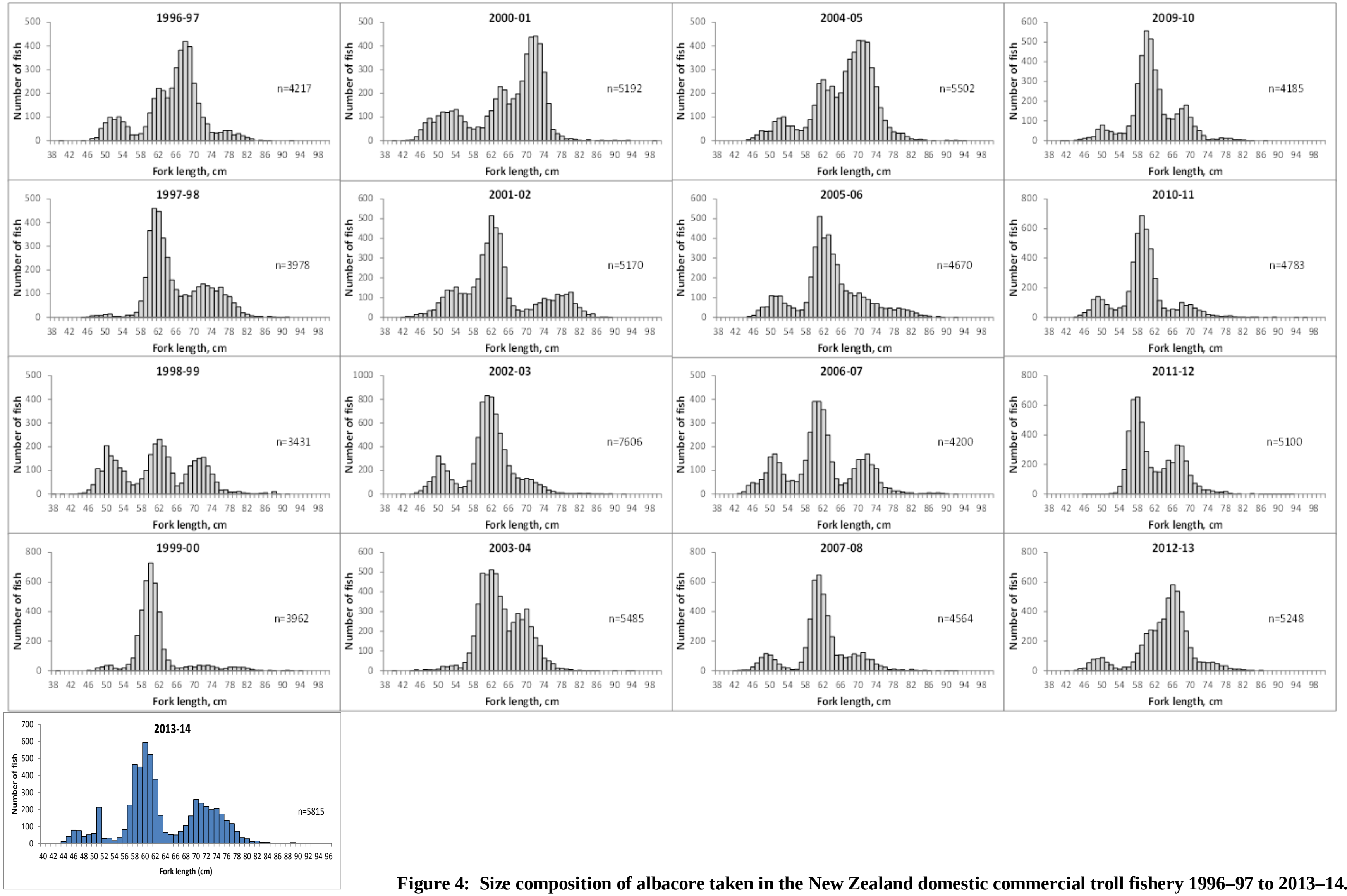


Figure 4: Size composition of albacore taken in the New Zealand domestic commercial troll fishery 1996–97 to 2013–14.

Histological gonadosomatic index analysis has shown that female albacore from New Caledonian and Tongan waters spawn from November–February.

Farley et al (2012) have recently completed a comprehensive analysis of South Pacific albacore biology. They found that otoliths were more reliable as ageing material then vertebrae. Their work using otoliths (validated by direct marking with oxytetracycline, and indirect methods) showed that the longevity of albacore was found to be at least 14 years, with significant variation in growth between sexes and across longitudes. They found that growth rates were similar between sexes up until age 4, after which the growth for males was on average greater than that for females, with males reaching an average maximum size more than 8 cm larger than females. Farley et al (2012) contend that the different growth rates between sexes may be responsible for the observed dominance of males among fish in the larger size classes (greater than 95 to 100 cm fork length). This study showed that growth rates were also consistently greater at more easterly longitudes than at westerly longitudes for both females and males. While they were not able to identify the determinants of the longitudinal variation in growth of albacore, they suggest that variation in oceanography, particularly the depth of the thermocline, may affect regional productivity and therefore play a role in modifying growth of South Pacific albacore.

Sex ratios appear to vary with fishery from 1:1 (male:female) in the New Zealand troll and longline fishery and, 2:1 to 3:1 in the Tonga–New Caledonia longline fishery.

Estimates of growth parameters from Farley et al (2012) are presented in Table 6.

Table 5: The ln(length)/ln(weight) relationships of albacore [ln(greenweight) = b_0 + b_1 * ln(fork length)]. Weight is in kilograms and length in centimetres.

	n	b_0	SE b_0	b_1	SE b_1	R^2
Males	160	-10.56	0.18	2.94	0.04	0.97
Females	155	-10.10	0.26	2.83	0.06	0.93
Troll caught	320	-10.44	0.16	2.91	0.03	0.95
Longline caught	21 824	-10.29	0.03	2.90	0.01	0.91

Table 6: Parameter estimates (± standard error) from five candidate growth models fitted to length-at-age data for South Pacific albacore. Parameter estimates also given for the logistic model fitted separately to female and male length-at-age data. The small-sample bias-corrected form of Akaike's information criterion AICc are provided for each model fit, and Akaike differences AICcΔi, and Akaike weights *wi* are given for the fit of the five candidate models to all data. Note that the parameters *k* and *t* are defined differently in each model (see text for definitions), such that values are not comparable across models (Farley et al 2012).

Sex	Model	L_∞	k	t	p	δ	γ	v	AICc	ΔAICc	w_i
All	VBGM	104.52	0.40	-0.49					11831.67	23.89	0
		(0.44)	(0.01)	(0.05)							
	Gompertz	103.09	0.50	0.47					11811.54	3.77	0.08
		(0.37)	(0.01)	(0.03)							
	Logistic	102.09	0.61	1.12					11807.77	0.00	0.53
		(0.33)	(0.01)	(0.03)							
	Richards	102.30	0.58	0.98	1.32				11809.40	1.63	0.24
		(0.49)	(0.04)	(0.24)	(0.68)						
	Schnute-	101.52	0.05			-0.97	3.54	2.07	11810.25	2.48	0.15
	Richards	(0.60)	(0.08)			(0.08)	(2.65)	(0.76)			
Female	Logistic	96.97	0.69	0.99					5746.90		
		(0.37)	(0.02)	(0.03)							
Male	Logistic	105.34	0.59	1.25					5729.26		
		(0.44)	(0.02)	(0.04)							

3. STOCKS AND AREAS

Two albacore stocks (North and South Pacific) are recognized in the Pacific Ocean based on location and seasons of spawning, low longline catch rates in equatorial waters and tag recovery information. The South Pacific albacore stock is distributed from the coast of Australia and archipelagic waters of Papua New Guinea eastward to the coast of South America south of the equator to at least 49ºS. However, there is some suggestion of gene flow between the North and South Pacific stocks based on an analysis of genetic population structure.

Most catches occur in longline fisheries in the EEZs of other South Pacific states and territories and in high seas areas throughout the geographical range of the stock.

Troll and longline vessels catch albacore in all FMAs in New Zealand and there may be substantial potential for expansion to high seas areas.

4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

The figures and tables in this section were updated and additional text included for the November 2016 Fishery Assessment Plenary following review of the text by the Aquatic Environment Working Group in 2015. This summary is from the perspective of the albacore 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/11521) (Ministry for Primary Industries 2015).

4.1 Role in the ecosystem

Albacore (*Thunnus alalunga*) are apex predators, found in the open waters of all tropical and temperate oceans, feeding opportunistically on a mixture of fish, crustaceans, squid and juveniles also feed on a variety of zooplankton and micronecton species.

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.

4.3 Troll fishery

From 2006 to 2012 the troll catch averaged 93% albacore, the remaining 7% was made up mostly of teleosts. The observer coverage of the troll fleet was ongoing between 2006–07 and 2011–12 and coverage averaged 0.7% of the effort during that time. No protected species have been observed as bycatch in this fishery. Observer coverage was suspended after 2011–12 due to the difficulties experienced placing observers on the small vessels in this fishery.

4.4 Longline

4.4.1 Seabird bycatch

Between 2002–03 and 2014–15, there were 73 observed captures of birds in albacore longline fisheries. Seabird capture rates since 2003 are presented in Figure 5.There have been no seabird captures since 2004–05, although observer coverage has been low to non-existent in this fishery where effort has been very low. Seabird capture locations were more frequent off the east coast of the North Island and Kermadec Island regions (see Table 7 and Figure 6). Previously bayesian models of varying complexity dependent on data quality were used (Richard & Abraham 2014); more recently a single model structure has been developed to provide a standard basis for estimating seabird captures across a range of fisheries (Richard & Abraham in prep.). Observed and estimated seabird captures in albacore longline fisheries are provided in Table 8.

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 (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 & Abraham 2013, Richard et al 2013 and Richard & Abraham 2015). 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 2016 iteration of the level 2 risk assessment has included significant modifications to the methodology; in order to include the full uncertainty around population size the total population size was included instead of N_{min} in the PST calculation; using the allometric survival rate and age at first reproduction for the calculation of R_{max}, applying a revised correction factor as the previous was found to be biologically implausible; applying a constraint on the fatalities calculated based on observed survival rates; including live release survival; allowing change in vulnerability over time where there is enough data; switch to assuming number of incidents is related to vulnerability. There were also changes made to the fisheries groups, seabird demographic data were updated and the Stewart Island shag was split into the Otago and Foveaux shags. The 2016 iteration derives a risk ratio, which is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Population Sustainability Threshold, PST (an analogue of the Potential Biological Removals, PBR, approach) (Richard & Abraham in prep).

The 2016 iteration of the seabird risk assessment (Richard & Abraham in prep.) assessed the albacore target surface longline fishery contribution to the total risk posed by New Zealand commercial fishing to seabirds (see Table 9). This fishery contributes 0.002 of PST to the risk to Gibson's albatross and 0.001 of PST to Southern Buller's albatross; both species were assessed to be at high risk from New Zealand commercial fishing included in the risk assessment (Richard & Abraham in prep.).

Table 7: Number of observed seabird captures in albacore longline fisheries, 2002–03 to 2014–15, by taxon and area. The risk category is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Population Sustainability Threshold, PST (an analog of PBR approach) (Richard & Abraham in prep). The current version of the risk assessment does not include recovery factor. The New Zealand threat classifications are shown (Robertson et al 2013 at http://www.doc.govt.nz/documents/science-and-technical/nztcs4entire.pdf)

Species	Risk category	East Coast North Island	Kermadec Islands	Northland and Hauraki	Total
Campbell black-browed albatross	High	15		3	18
Southern Buller's albatross	High	7			7
Gibson's albatross	High	7			7
Antipodean albatross	Medium	3			3
Salvin's albatross	High	1			1
Total albatrosses	**N/A**	33	0	3	36
Grey-faced petrel	Negligible	5	11	3	19
Sooty shearwater	Negligible	6			6
Grey petrel	Negligible	3		2	5
White-chinned petrel	Negligible	2			2
White-headed petrel	Negligible		2		2
Westland petrel	High	1			1
Black petrel	Very high			2	2
Total other seabirds	**N/A**	17	13	7	37

Table 8: Effort, observed and estimated seabird captures by fishing year for the albacore 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 Richard and Abraham (in prep) and are available via https://data.dragonfly.co.nz/psc/ . Estimates from 2002–03 to 2014–15 are based on data version 2016001.

Fishing year	Fishing effort			Observed captures		Estimated captures	
	All hooks	Observed hooks	% observed	Number	Rate	Mean	95% c.i.
2002–2003	1 893 010	980 872	51.8	72	0.07	527	276–1137
2003–2004	463 164	1 600	0.3	0	0	401	117–1559
2004–2005	136 812	4 317	3.2	1	0.23	84	25–234
2005–2006	60 360	600	1.0	0	0	67	9–367
2006–2007	13 730	0	0	0		10	0–37
2007–2008	600	0	0	0		0	0–3
2008–2009	7800	2100	26.9	0	0	5	0–29
2009–2010	23329	4979	21.3	0	0	12	1–44
2010–2011	13610	1000	7.34	0	0	8	0–34
2011–2012	0	0		0			NA–NA
2012–2013	6450	0	0	0		4	0–21
2013–2014	3500	0	0	0		2	0–14
2014–2015	0	0		0			

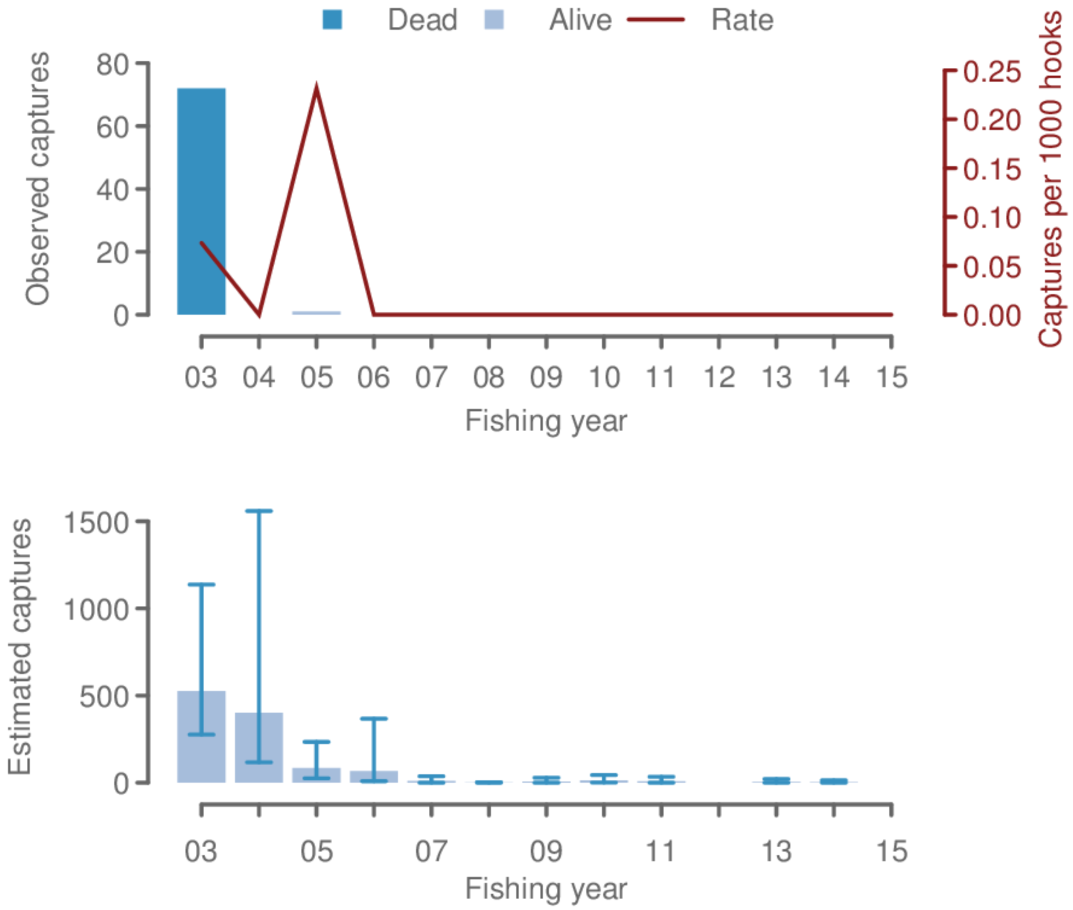


Figure 5: Observed captures and estimated captures of seabirds in albacore longline fisheries from 2002–03 to 2014–15. Estimates are based on methods described in Richard and Abraham (in prep) and are available via https://data.dragonfly.co.nz/psc/. Estimates from 2002–03 to 2014–15 are based on data version 2016001.

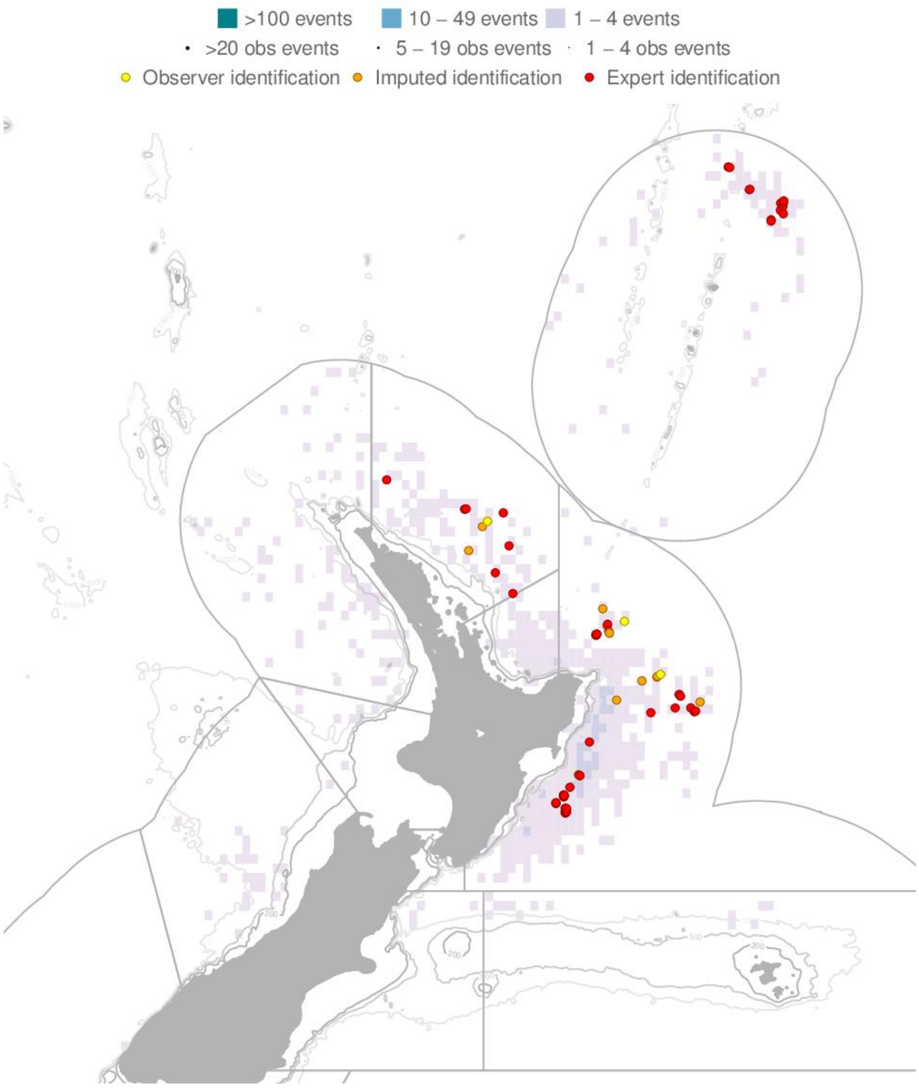


Figure 6: Distribution of fishing effort targeting albacore and observed seabird captures, 2002–03 to 2014–15. Fishing effort is mapped into 0.2-degree cells, with the colour of each cell being related to the amount of effort. Observed fishing events are indicated by black dots, and observed captures 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. Data grooming methods are described in Richard and Abraham (in prep) and are available via https://data.dragonfly.co.nz/psc/. Data version 2016001.

Table 9: Risk ratio of seabirds predicted by the level two risk assessment for the albacore target surface longline fishery and all fisheries included in the level two risk assessment, 2006–07 to 2013–14, showing seabird species with risk category of very high or high, or a medium risk category and risk ratio of at least 1% of the total risk. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Population Sustainability Threshold, PST (an analogue of PBR approach) (Richard & Abraham in prep). The current version of the risk assessment does not include a recovery factor. 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	ALB target SLL	Total risk from NZ commercial fishing	% of total risk from NZ commercial fishing	Risk category	NZ Threat Classification
Black petrel	0	1.153	0.01	Very high	Threatened: Nationally Vulnerable
Salvin's albatross	0	0.78	0	High	Threatened: Nationally Critical
Southern Buller's albatross	0	0.392	0	High	At Risk: Naturally Uncommon
Flesh-footed shearwater	0	0.669	0.01	High	Threatened: Nationally Vulnerable
Gibson's albatross	0	0.337	0.06	High	Threatened: Nationally Critical
New Zealand white-capped albatross	0	0.353	0.01	High	At Risk: Declining
Chatham Island albatross	0	0.362	0	High	At Risk: Naturally Uncommon
Westland petrel	0	0.476	0.01	High	At Risk: Naturally Uncommon

4.4.2 Sea turtle bycatch

Between 2002–03 and 2014–15, there were no observed captures of turtles in albacore longline fisheries.

4.4.3 Marine Mammals

4.4.3.1 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). In 2002–03 there was one observed capture of an unidentified cetacean in the albacore longline fisheries; there have been no observed captures since (Thompson et al 2013). This capture was recorded as being caught and released alive (Thompson & Abraham 2010). The cetacean capture took place in the Northland region.

4.4.3.2 New Zealand fur seal bycatch

New Zealand fur seal captures in surface longline fisheries have been generally observed in waters south and west of Fiordland, but also in the Bay of Plenty-East Cape area when the animals have attempted to take bait or fish from the line as it is hauled. Between 2002–03 and 2014–15, there were no observed captures of New Zealand fur seals in albacore longline fisheries

4.5 Incidental fish bycatch

See above Section 4.3.

4.6 Benthic interactions

N/A

4.7 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

No assessment is possible for albacore within New Zealand fisheries waters as the proportion of the greater stock found within New Zealand fisheries waters is unknown and is likely to vary from year to year. With the establishment of WCPFC in 2004, stock assessments of the South Pacific Ocean (SPO) stock of albacore tuna are now undertaken by the Oceanic Fisheries Programme (OFP) of Secretariat of the Pacific Community (SPC) under contract to WCPFC.

A new stock assessment was conducted for South Pacific albacore tuna in 2015 and described in SC11-SA-WP-06 (Harley et al 2015). This was the first assessment since 2012 (Hoyle et al 2012). There have been many developments since the last assessment in terms of both the fishery and the integrated stock assessment model known as MULTIFAN-CL which is used to assess this stock.

The 2015 stock assessment includes much new data and new features reflecting recommendations from previous south Pacific albacore tuna assessments as well as relevant recommendations from the review of the 2011 bigeye tuna assessment. This assessment is supported by the analysis of operational longline data to construct both the CPUE time series and regional weights and the analysis of longline size data. The assessment also includes results from a wide-scale study of the biological parameters of albacore – in particular results from the age and growth study aimed to address uncertainty around growth which has troubled previous assessments.

The main developments in the 2015 assessment are described in table 1 of Harley et al (2015). The three most significant changes are: (1) the use of a spatially explicit model covering the southern region of the WCPFC Convention area; (2) the inclusion of direct age-length observations and tagging data from the 2009–10 releases; and (3) changing natural mortality from 0.4 to 0.3 per annum for consistency with albacore stock assessments conducted elsewhere.

The major structural changes (e.g., the spatial and fishery structures) to the assessment mean that full consideration of the impacts of individual changes from the 2012 assessment is not possible. However, generally the results and main conclusions of the current assessment are similar to those from the 2012 assessment.

In addition to a single reference case model which we present here, we report the results of "one-off" sensitivity models to explore the impact of key data and model assumptions for the reference case model on the stock assessment results and conclusions. We also undertook a structural uncertainty analysis (grid) for consideration in developing management advice where all possible combinations of those areas of uncertainty from the one-off models were included. The main conclusions of the current assessment are consistent with the previous assessment conducted in 2012. The main conclusions based on results from the reference case model and with consideration of results from performed sensitivity model runs, are as follows:

1) The new regional structure used for the 2015 assessment is better aligned with those of the assessments for bigeye and yellowfin tunas and provides an improved basis for further development of this assessment and providing advice to WCPFC;

2) There is some conflict between some of the data sources available for this assessment including conflicts between the length-frequency data and the CPUE series and between the troll length frequency samples and the age-length data;
3) Current catch is either at or less than MSY;
4) Recent levels of spawning potential are most likely above the level which will support the maximum sustainable yield, and above the WCPFC-adopted Limit Reference Point (20%SBF=0);
5) Recent levels of fishing mortality are lower than the level that will support the maximum sustainable yield;
6) Increasing fishing mortality to FMSY levels would require a significant increase in effort, yield only very small (if any) increases in long-term catch, and would greatly reduce the vulnerable biomass available to the longline fleet;
7) Recent levels of spawning potential are lower than candidate bio-economic-related target reference points currently under consideration for south Pacific albacore tuna, though these analyses should be updated to incorporate the results of this assessment; and
8) Stock status conclusions were most sensitive to alternative assumptions regarding the weighting of different data sets and natural mortality, identifying these as important areas for continued research.

Stock status and trends

There have been significant improvements to the 2015 stock assessment including: improvements to the MULTIFAN-CL modelling framework, a regional disaggregated framework, access to operational data for construction of CPUE indices and regional weights, age-length data to improve growth estimation, and additional tagging data. Further, the regional structure of the model was changed to cover the southern Convention area and be better aligned with the other tuna assessments. This will enable better consideration of the multispecies impacts of management measures. Natural mortality was set at 0.3 in the reference case for consistency with the value used in the assessments performed in other RFMOs.

SC11 selected the reference case model as the base case to represent the stock status of south Pacific albacore tuna. To characterize uncertainty SC11 chose all the grid model runs except for those relating to the alternative regional weight hypothesis. This gave a total of 18 model runs and we report the 5%, median and 95% values on the base case estimate in this stock status summary. Details of the base case and axes of uncertainty for the grid are provided in Table 10

Table 10: Description of the structural sensitivity grid used to characterize uncertainty in the assessment. The base case option is denoted in bold face.

Name	Description	One-off change model name(s)
Natural mortality	0.25, **0.30**, and 0.40 per year	Low_M and High_M
Length data weighting	**Standard weighting** or down-weighted	SZ_dwnwht
Steepness	0.65, **0.80**, and 0.95	h_0.65 and h_0.95

Time trends in estimated recruitment, spawning biomass, fishing mortality and fishery impacts are shown in Figures 7–10.

The estimated maximum sustainable yield (MSY) of 76 800 t is lower than in the 2012 assessment (2012 MSY = 99 085 t). Aside from general improvements to the stock assessment this was also influenced by 1) exclusion of catches from outside the southern part of the WCPFC Convention area; and 2) a reduction in the assumed value of natural mortality. Based on the range of MSY estimates (range: 62 260–129 814 t), current catch is likely at or slightly less than the MSY.

Fishing mortality has generally been increasing through time, with $F_{current}$ (2009–12 average) estimated to be 0.39 times the fishing mortality that will support the *MSY*. Across the grid $F_{current}/F_{MSY}$ ranged from 0.13–0.62. This indicates that overfishing is not occurring, but fishing mortality on adults is approaching the assumed level of natural mortality (Table 11 and Figure 9).

The fishery impact by sub-tropical longline fisheries has increased continuously since 2000 (Figure 10).

The latest (2013) estimates of spawning biomass are above both the level that will support the MSY (SB_{latest}/SB_{MSY} = 2.86 for the base case and range 1.74–7.03 across the grid) and the adopted LRP of $0.2SB_{F=0}$ ($SB_{latest}/SB_{F=0}$ = 0.40 for the base case and range 0.30–0.60 across the grid). It is important to note that SB_{MSY} is lower than the limit reference point (0.14 $SB_{F=0}$) due to the combination of the selectivity of the fisheries and maturity of the species.

For the first time SC considered an index of economic conditions in the south Pacific albacore fishery (MI-WP-03). This index, which integrates fish prices, catch rates, and fishing prices, estimates a strong declining trend in economic conditions, reaching an historical low in 2013. While there was a slight recovery in 2014, conditions are still well below the average primarily due to high fishing costs and continued low catch rates. Domestic vessels from some longline fleets have reduced their fishing effort (i.e., tied up for periods of time) in response to these conditions.

In 2016 SC12 noted that no stock assessment was conducted for South Pacific albacore tuna in 2016. Therefore, the stock status description from SC11 is still current. For further information on the stock status and trends from SC11, please see http://www.wcpfc.int/node/26922.

SC12 noted that the total south Pacific albacore catch in 2015 was 68 594 t, 16% lower than both the catch in 2014 and the average catch for 2010–14. Longline south Pacific albacore catch in 2015 was 17% lower than that in 2014, while troll catch in 2015 was 16% higher than that in 2014.

Table 11: Estimates of management quantities for base case and grid of 18 models (see Table 10 for details). For the purpose of this assessment, "current" is the average over the period 2009–2012 and "latest" is 2013.

		Grid		
	Base case	5%	Median	95%
MSY(t)	76 800	62 260	84 980	129 814
C_{latest}/MSY	1.00	0.60	0.91	1.23
$F_{current}/F_{MSY}$	0.39	0.13	0.34	0.62
B_0	711 400	638 465	806 900	1 024 500
$B_{current}$	456 984	365 962	509 653	783 308
SB_0	396 500	368 925	438 700	502 275
SB_{MSY}	57 430	35 762	59 180	90 778
$SB_{F=0}$	408 361	392 358	442 163	486 146
SB_{latest}	164 451	131 456	190 467	272 696
$SB_{latest}/SB_{F=0}$	2.86	1.74	3.20	7.03
SB_{latest}/SB_{MSY}	0.40	0.30	0.44	0.60

Table 12: Comparison[1] of selected south Pacific albacore tuna reference points from the 2009, 2011, 2012, and 2015 assessments. These represent the value used to provide management advice. Note that the time window for assessment and reference point calculation changes for $F_{current}/F_{MSY}$ and $SB_{latest}/SB_{F=0}$ and that prior to the 2015 assessment, the south Pacific albacore assessments covered the entire south Pacific Ocean rather than the convention area south of the equator used in 2015.

Management quantity	2015	2012[2]	2011	2009[3]
MSY(t)	76 800	99 085	85 130	97 610
$F_{current}/F_{MSY}$	0.39	0.21	0.26	0.25
$SB_{latest}/SB_{F=0}$	0.40	0.58	0.60	0.68

[1] 2015 assessment was conducted for WCPF CA and 2011/2012 stock assessment was for the whole South Pacific.
[2] The median of the grid was used to provide management advice instead of a single model run
[3] Only $SB_{current}$ is available

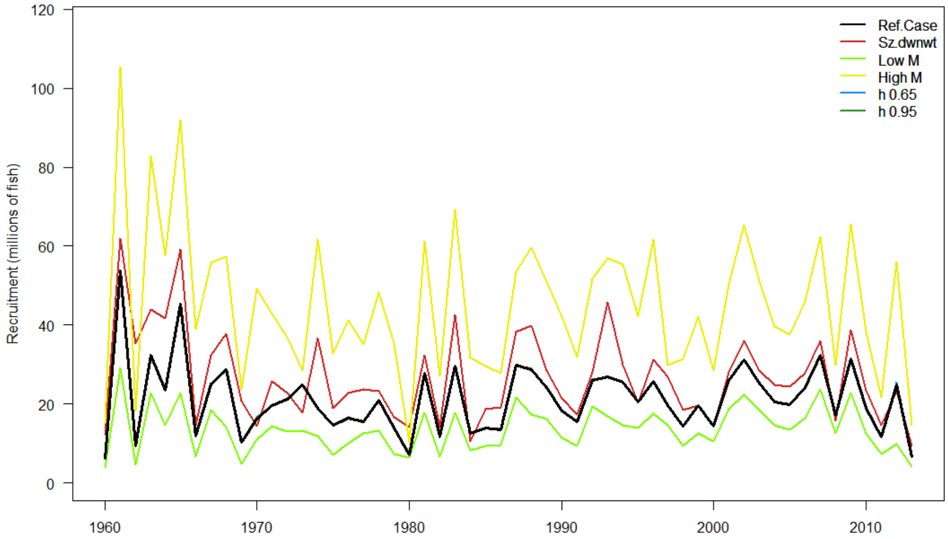


Figure 7: Estimated annual recruitment (millions of fish) for the base case model and one-change sensitivity analyses (a subset of runs from the grid). See Table 10 for a description of these sensitivity analyses. The model runs with alternative steepness values give the same recruitment estimates.

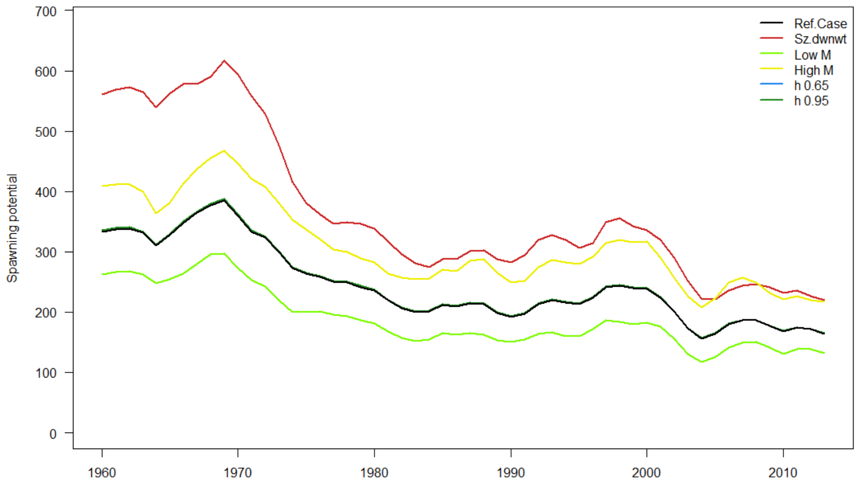


Figure 8: Estimated annual average spawning potential for the base case model and one-change sensitivity analyses (a subset of runs from the grid). The model runs with alternative steepness values give the same spawning potential estimates.

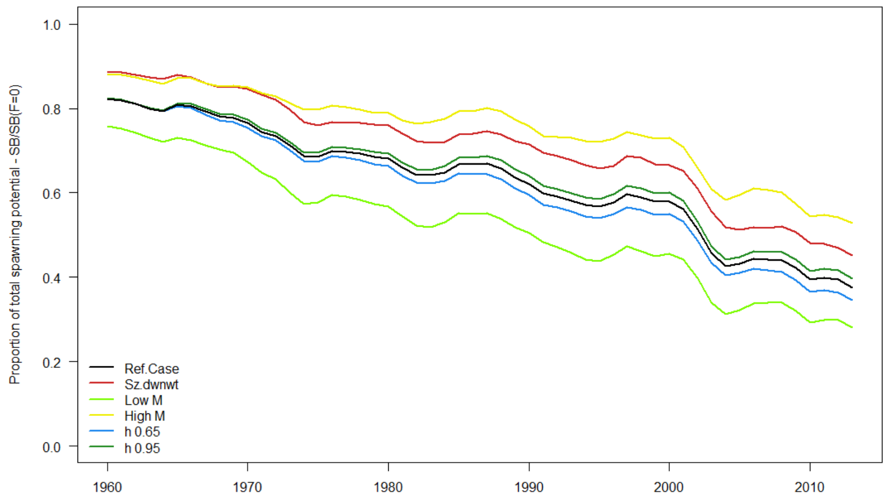


Figure 9: Estimated annual average spawning depletion for the base case model and one-change sensitivity analyses (a subset of runs from the grid).

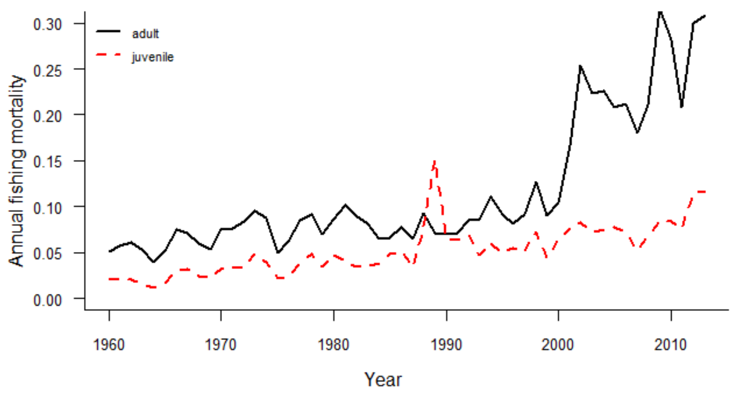


Figure 10: Estimated annual average juvenile and adult fishing mortality for the base case model.

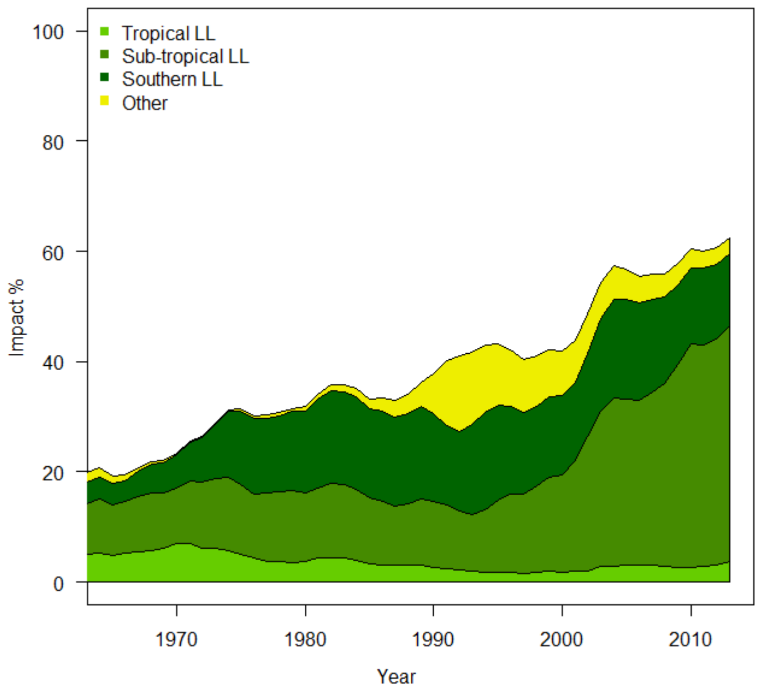


Figure 11: Estimates of reduction in spawning potential due to fishing (fishery impact = 1-$SB_t/SB_{t,F=0}$) to different fishery groups for the base case model.

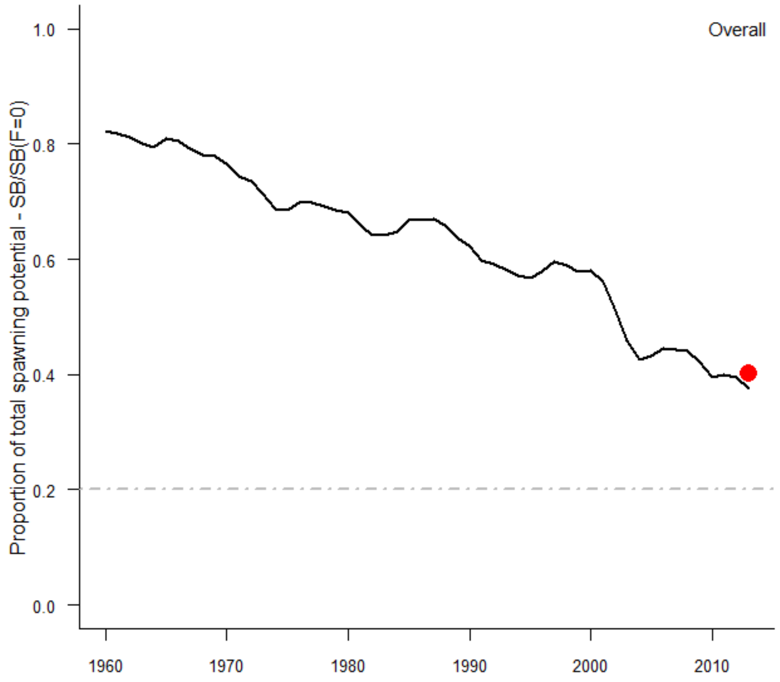


Figure 12: Ratio of exploited to unexploited spawning potential, $SB_{latest}/SB_{F=0}$, for the reference case. The current WCPFC limit reference point of 20%$SB_{F=0}$ is provided for reference as the grey dashed line and the red circle represents the level of spawning potential depletion based on the agreed method of calculating $SB_{F=0}$ over the last ten years of the model (excluding the last year).

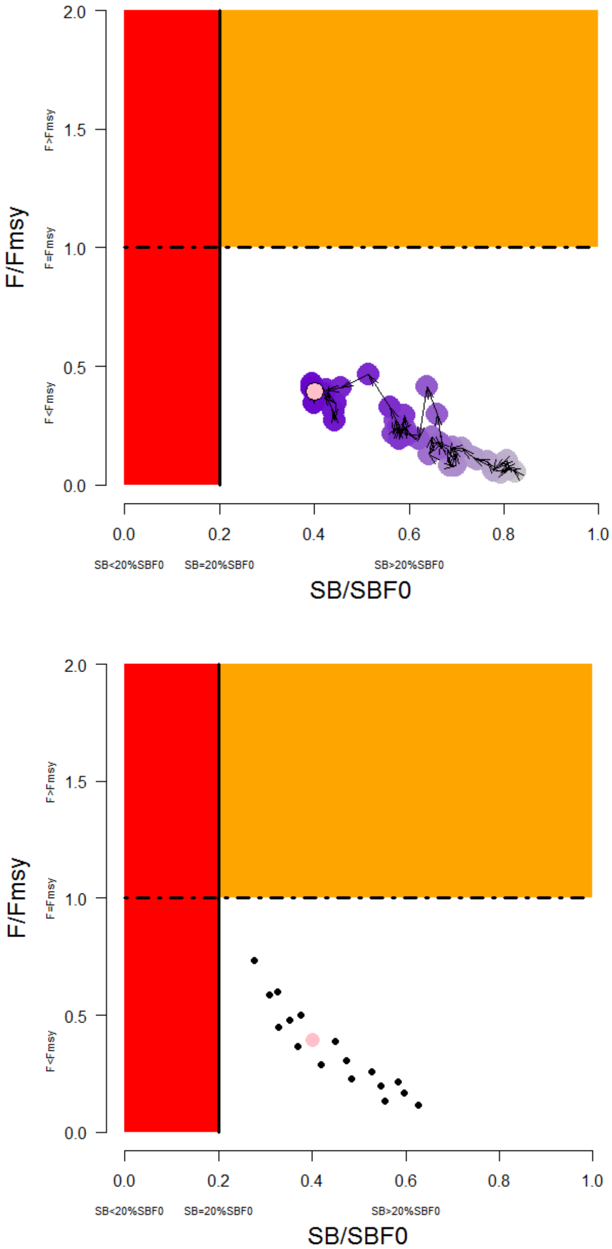


Figure 13: Temporal trend for the base case model (top) and terminal condition for the base case and other sensitivity runs (bottom) in stock status relative to $SB_{F=0}$ (x-axis) and F_{MSY} (y-axis). The red zone represents spawning potential levels lower than the agreed LRP which is marked with the 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 (pink circle) and 18 models from the grid.

Management advice and implications

From the 2015 stock assessment the South Pacific albacore spawning stock is currently above both the level that will support the MSY and the adopted spawning biomass limit reference point, and overfishing is not occurring (F less than F_{msy}).

While overfishing is not occurring, further increases in effort will yield little or no increase in long-term catches and result in further reduced catch rates.

Decline in abundance of albacore is a key driver in the reduced economic conditions experienced by many PICT domestic longline fleets. Further, reductions in prices are also impacting some distant water fleets.

For several years, SC has noted that any increases in catch or effort in sub-tropical longline fisheries are likely to lead to declines in catch rates in some regions (10°S–30°S), especially for longline catches of adult albacore, with associated impacts on vessel profitability.

Despite the fact that the stock is not overfished and overfishing is not occurring, SC11 reiterates the advice of SC10 recommending that longline fishing mortality and longline catch be reduced to avoid further decline in the vulnerable biomass so that economically viable catch rates can be maintained.

In 2016 SC12 noted that no management advice has been provided since SC11. Therefore, the advice from SC11 should be maintained, that longline fishing mortality and longline catch be reduced to avoid further decline in the vulnerable biomass so that economically viable catch rates can be maintained. SC12 also noted that the results of the indicator analyses supported the stock status results for South Pacific albacore that were obtained from the 2015 assessment.

Based on the indicator analysis, SC12 also advised that there is a 19% chance that the south Pacific albacore stock will fall below the Limit Reference Point by 2033 if 2014 fishing effort levels continue, and that overall decreases in vulnerable biomass (a proxy for longline CPUE) of 14% would also be likely to occur.

5.2 Estimates of fishery parameters and abundance

There are no fishery-independent indices of abundance for the South Pacific stock. Relative abundance information is available from catch per unit effort data. Returns from tagging programmes provides information on rates of fishing mortality, however, the return rates are very low and lead to highly uncertain estimates of absolute abundance.

5.3 Biomass estimates

Estimates of absolute biomass are highly uncertain, however, relative abundance trends are thought to be more reliable. Spawning potential depletion levels ($SB_{curr}/SB_{curr F=0}$) of albacore were moderate at about 37%. However, depletion levels of the exploitable biomass is estimated between about 10% and 60%, depending on the fishery considered, having increased sharply in recent years particularly in the longline fisheries (Figure 11).

5.4 Yield estimates and projections

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

5.5 Other yield estimates and stock assessment results

No other yield estimates are available.

5.6 Other factors

Declines in CPUE have been observed in some Pacific Island fisheries. This is problematic for South Pacific states that rely on albacore for their longline fisheries. Given the recent expansion of the Pacific albacore fishery and recent declines in exploitable biomass available to longline fisheries, maintaining catch rates for Pacific Island states is important for the economic survival of their domestic longline operators.

6. STATUS OF THE STOCK

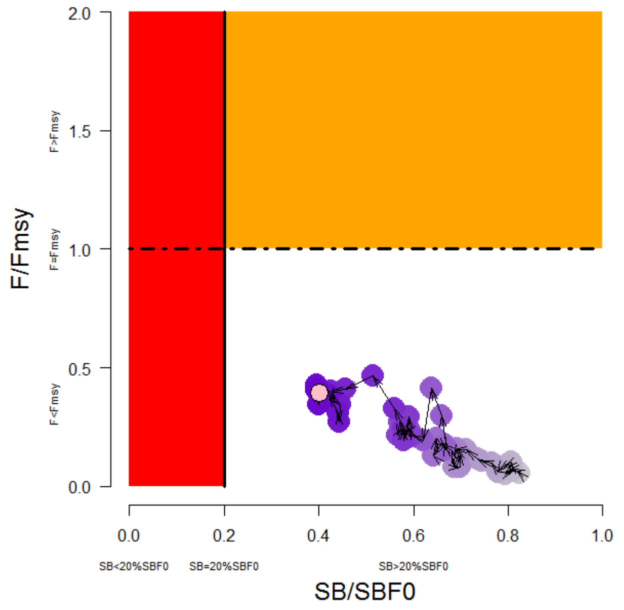
Stock status is summarised from Harley et al (2015).

Stock structure assumptions
In the Western and Central Pacific Ocean, the South Pacific albacore stock is distributed from the coast of Australia and archipelagic waters of Papua New Guinea eastward to the coast of South America south of the equator to at least 49ºS. However, there is some suggestion of gene flow between the North and South Pacific stocks based on an analysis of genetic population structure.

All biomass estimates in this table refer to spawning biomass (SB).

Stock Status	
Year of Most Recent Assessment	2015
Assessment Runs Presented	Base case model and selected sensitivity runs
Reference Points	Candidate biomass-related target reference point (TRP) currently under consideration for key tuna species is 40–60% SB_0 Soft Limit: 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 are About as Likely as Not (40–60%) to be at or above the lower end of the range of 40–60% SB_0 (based on both the 2008–11 average and the 2012 estimate). Very Likely (> 90%) that $F < F_{MSY}$
Status in relation to Limits	Soft Limit: About as Likely as Not (40–60%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Overfishing is Very Unlikely (< 10%) to be occurring

Historical Stock Status Trajectory and Current Status



$F_{current}/F_{MSY}$ and *$SB_{latest}/SB_{F=0}$* for 18 model runs in the uncertainty grid.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Spawning biomass has been steadily declining, but is currently well above the MSY level.
Recent Trend in Fishing Intensity or Proxy	Fishing mortality has generally been increasing through time, but is currently well below the MSY level.
Other Abundance Indices	South Pacific albacore is the only WCPFC species that is assessed with standardised CPUE indices constructed with operational data. There was a rapid decline from the early 1960s until 1975 followed by a slower decline thereafter.
Trends in Other Relevant Indicator or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	There is no indication that current levels of catch are causing recruitment overfishing. However, current levels of fishing mortality may be affecting longline catch rates on adult albacore.
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Exceptionally Unlikely (< 1%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Very Unlikely (< 10%)

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: 2015	Next assessment: 2018
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	The model is age structured and the catch, effort, size composition and tagging data used in the model are classified both spatially and temporally.	1 – High Quality
Data not used (rank)	N/A	
Changes to Model Structure and Assumptions	The structure of the assessment model was similar to the previous (2012) assessment, but there were some substantial revisions to key data sets which are noted in the text.	
Major Sources of Uncertainty	CPUE is used as an abundance index in the model. However, in the 1990s there was an increase in standardised CPUE in the west (regions 1 and 3) which was not evident in the east (regions 2 and 4). There was a decline in standardized CPUE for the Taiwan distant-water fleet since 2000 that also occurred in most domestic Pacific Island fisheries. It is not certain whether depressed CPUE since 2002 results from a decline in population abundance or a change in the availability of albacore in the South Pacific that affected the Taiwan fleet and domestic Pacific Island fleets (Bigelow & Hoyle 2009). There is also a conflict between the CPUE index and the longline length frequency data.	

Qualifying Comments
Although the latest assessment made some good improvements there is still a need to resolve the conflict between the CPUE and the longline length frequency data.
Fishery Interactions
Although no specific seabird/fishery interactions have been observed or reported for the troll fishery in New Zealand fishery waters, anecdotal reports and expert opinion consider that some albatross species are at risk of capture from this method. The troll fishery has a minor bycatch of Ray’s bream. While longline albacore target sets are limited within New Zealand fishery waters 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. 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.

FOR FURTHER INFORMATION

Abraham, E R; Thompson, F N (2009) Capture of protected species in New Zealand trawl and longline fisheries, 1998–99 to 2006–07. *New Zealand Aquatic Environment and Biodiversity Report No. 32*.

Abraham, E R; Thompson, F N (2011) Summary of the capture of seabirds, marine mammals, and turtles in New Zealand commercial fisheries, 1998–99 to 2008–09. Final Research Report prepared for Ministry of Fisheries project PRO2007/01. (Unpublished report held by the Ministry for Primary Industries, Wellington.) 170 p.

Abraham, E R; Thompson, F N; Oliver, M D (2010) Summary of the capture of seabirds, marine mammals, and turtles in New Zealand commercial fisheries, 1998–99 to 2007–08. *New Zealand Aquatic Environment and Biodiversity Report No. 45*. 148 p.

Anon (1946) Marine Dept. Fisheries Tables for the Years 1941, 1942, 1943, and 1944.

Anon (1962) Marine Dept. report on Fisheries for 1961.

Anon (2008) Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean: Scientific Committee Summary report. Western and Central Pacific Fisheries Commission, Pohnpei, Federated States of Micronesia. 234 p.

Anon (2013) Tuna fishery yearbook 2012. Western and Central Pacific Fisheries Commission, 154 p.

Bailey, K (1988) Albacore tagging produces results. *Catch*, 15(11): 10–11.

Baird, S J (2008) Incidental capture of New Zealand fur seals (*Arctocephalus forsteri*) in longline fisheries in New Zealand waters, 1994–95 to 2005–06. *New Zealand Aquatic Environment and Biodiversity Report No. 20.* 21 p.

Bentley, N; Langley, A D; Middleton, D A J; Lallemand, P (2013) Fisheries of New Zealand, 1989/90-2011/12. Retrieved from http://fonz.tridentsystems.co.nz. Accessed 11 October 2013.

Bertignac, M; Lehodey, P; Hampton, J (1996) An analysis of the South Pacific albacore tagging data: estimation of movement patterns, growth and mortality rates. SPAR-6 working paper 3. www.spc.int/DigitalLibrary/Doc/FAME/Meetings/SPAR/6/WP3.pdf

Best, E (1929) Fishing methods and devices of the Maori. *Dominion Museum Bulletin* No. 12.

Bigelow, K; Hampton, J; Fournier, D (2001) Stock assessment of albacore tuna in the South Pacific Ocean. SCTB14 Working Paper ALB-1.

Bigelow, K; Hoyle, S (2009) Standardized cpue for distant–water fleets targeting south Pacific Albacore. Report to the Western and Central Pacific Fisheries Commission Scientific Committee WCPFC-SC5-2009/SA-WP-05. 24 p.

Bradford, E (1996) Marine recreational fishing survey in the Ministry of Fisheries North region, 1993–94. *New Zealand Fisheries Data Report No. 80.*

Bradford, E (1998) Harvest estimates from the 1996 national marine recreational fishing surveys. New Zealand Fisheries Assessment Research Document 98/16. (Unpublished document held by NIWA library, Wellington.)

Chow, S; Ushiama, H (1995) Global population structure of albacore (*Thunnus alalunga*) inferred by RFLP analysis of the mitochondrial ATPase gene. *Marine Biology 123:* 39–45.

CMM2010-07 (2010) Conservation and Management measure for sharks, for the Western and Central Pacific Ocean. CMM2010-07 of the Western and Central Pacific Fisheries Commission.

Davies, N M; Griggs, L; Unwin, M (2005) Information available for developing a stock assessment for New Zealand albacore (*Thunnus alalunga*). Final Research Report for Ministry of Fisheries Research Project TUN2002/03 Objective 4. 38 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)

Farley, J H; Williams, A J; Davies, C R; Clear, N P; Eveson, J P; Hoyle, S D; Nicol, S J (2012) Population biology of albacore tuna in the Australian region. Final report for FRDC project 2009/012. Available at http://www.frdc.com.au/research/reports.

Griggs, L (2004) Monitoring the length structure of commercial landings of albacore tuna during the 2003–04 fishing year. Final Research Report for Ministry of Fisheries Research Project ALB2003/01, Objective 1. 17 p. (Unpublished report held by Ministry for Primary Industries.)

Griggs, L (2005a) Historical and biological data summaries for albacore (*Thunnus alalunga*). Final Research Report for Ministry of Fisheries Research Project TUN2002/03. Objective 1 and 2. 36 p. (Unpublished report held by Ministry for Primary Industries.)

Griggs, L (2005b) Monitoring the length structure of commercial landings of albacore (*Thunnus alalunga*) during the 2004–2005 fishing year. Final Research Report for Ministry of Fisheries Research Project ALB2003/01, Objective 2. November 2004. 21 p. (Unpublished report held by Ministry for Primary Industries.)

Griggs, L (2008a) Monitoring the length structure of commercial landings of albacore (*Thunnus alalunga*) during the 2005–2006 fishing year. *New Zealand Fisheries Assessment Report* 2008/15. 20 p.

Griggs, L (2008b) Monitoring the length structure of commercial landings of albacore (*Thunnus alalunga*) during the 2006–07 fishing year. *New Zealand Fisheries Assessment Report* 2008/50 23 p.

Griggs, L H; Baird, S J (2013) Fish bycatch in New Zealand tuna longline fisheries 2006–07 to 2009–10. *New Zealand Fisheries Assessment Report 2013/13*. 71 p.

Griggs, L; Murray, T (2000) Determination of size composition, sex ratio, and length:weight relationships of albacore tuna during the 1998–99 fishing year from samples collected in fish sheds. Final Research Report for MFish Research Project TUN9801. (Unpublished report held by Ministry for Primary Industries.)

Hamilton, A. (1908) Fishing and sea-foods of the ancient Maori. *Dominion Museum Bulletin* No. 2.

Harley, S J; Davies, N; Tremblay-Boyer, L; Hampton, J; McKechnie, S (2015) Stock assessment for south Pacific albacore tuna. WCPFC-SC11-2015/SA-WP-06.

Hoyle, S (2011) Stock assessment of albacore tuna on the South Pacific Ocean. Report to the Western and Central Pacific Fisheries Commission Scientific Committee WCPFC-SC7-2011/SA-WP-06. 90 p.

Hoyle, S; Davies, N (2009) Stock assessment of albacore tuna on the South Pacific Ocean. Report to the Western and Central Pacific Fisheries Commission Scientific Committee WCPFC-SC5-2009/SA-WP-6. 129 p.

Hoyle, S; Hampton, J; Davies, N (2012) Stock assessment of albacore tuna in the South Pacific Ocean. Report to the Western and Central Pacific Fisheries Commission Scientific Committee WCPFC-SC8-2012/SA-WP-04. 116 p.

Hoyle, S; Langley, A; Hampton, J (2008) Stock assessment of albacore tuna on the South Pacific Ocean. Report to the Western and Central Pacific Fisheries Commission Scientific Committee WCPFC-SC4-2008/SA-WP-8. 124 p.

Kendrick, T H; Bentley, N (2010) Relative abundance of troll caught albacore. *New Zealand Fisheries Assessment Report* 2010/45 33 p.

Labelle, M; Hampton, J; Bailey, K; Murray, T; Fournier, D; Sibert, J (1993) Determination of age and growth of South Pacific albacore (*Thunnus alalunga*) using three methodologies. *Fishery Bulletin* 91: 649–663.

Laurs, R M; Nishimoto, R (1989) Summary of South Pacific albacore tagging conducted during 1986–1989. NOAA Administration Report. NMFS-SWFC, La Jolla, LJ-89-15.

Lawson, T A (2008) Western and Central Pacific Fisheries Commission Tuna Fishery Yearbook 2007. Western and Central Pacific Fisheries Commission, Pohnpei, Federated States of Micronesia. 203 p.

Mattlin, R H (1987) New Zealand fur seal, *Arctocephalus forsteri*, within the New Zealand region. In Croxall, J P; Gentry, R L Status, biology, and ecology of fur seals: Proceedings of an international symposium and workshop, Cambridge, England, 23–27 April 1984. *NOAA Technical Report NMFS-51*.

Ministry for Primary Industries (2015) Aquatic Environment and Biodiversity Annual Review 2015. Compiled by the Fisheries Management Science Team, Ministry for Primary Industries, Wellington, New Zealand. 682 p.

Ministry for Primary Industries (2013) National Plan of Action – 2013 to reduce the incidental catch of seabirds in New Zealand Fisheries. Ministry for Primary Industries, Wellington, New Zealand. 59 p.

Murray, T (1994) A review of the biology and fisheries for albacore, *Thunnus alalunga*, in the South Pacific Ocean. *FAO Fisheries Technical Paper 336/2:* 188–206.

Perrin, W F; Wursig, B; Thewissen, J G M (Eds.) (2008) *Encyclopedia of marine mammals*. Second Edition. Academic Press, San Diego.

Ramon, D; Bailey, K (1996) Spawning seasonality of albacore, *Thunnus alalunga*, in the South Pacific Ocean. *Fishery Bulletin* 94: 725–733.
Ratty, F J; Laurs, R M; Kelly, R M (1990) Gonad morphology, histology, and spermatogenesis in South Pacific albacore tuna *Thunnus alalunga* (Scombridae). *Fishery Bulletin* 88: 207–216.
Richard, Y; Abraham, E R (2013) Application of Potential Biological Removal methods to seabird populations. *New Zealand Aquatic Environment and Biodiversity Report No. 108*. 30 p.
Richard Y; Abraham, E R (2014) Estimated capture of seabirds in New Zealand trawl and longline fisheries, 2002–03 to 2011–12. Draft New Zealand Aquatic Environment and Biodiversity Report held by Ministry for Primary Industries, Wellington.
Richard Y; Abraham, E R (2015) Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006–07 to 2012–13. *New Zealand Aquatic Environment and Biodiversity Report No 162*.
Richard, Y; Abraham, E R; Filippi, D (2011) Assessment of the risk to seabird populations from New Zealand commercial fisheries. Final Research Report for projects IPA2009/19 and IPA2009/20. (Unpublished report held by the Ministry for Primary Industries, Wellington.) 137 p.
Richard, Y; Abraham, E R; Filippi, D (2013) Assessment of the risk of commercial fisheries to New Zealand seabirds, 2006–07 to 2010–11. *New Zealand Aquatic Environment and Biodiversity Report No. 109*. 58 + 70 p.
Robertson, H A; Dowding, J E; Elliot, G P; Hitchmough, R A; Miskelly, C M; O'Donnell, C F J; Powlesland, R G; Sagar, P M; Scofield, R P; Taylor, G A (2013) Conservation status of New Zealand Birds, 2012. *New Zealand Threat Classification Series 4*. Department of Conservation, Wellington. 22 p.
Rowe, S J (2009) Conservation Services Programme observer report: 1 July 2004 to 30 June 2007. *DOC Marine Conservation Services Series 1*. Department of Conservation, Wellington. 93 p.
Sharp, B; Waugh, S; Walker, N A (2011) A risk assessment framework for incidental seabird mortality associated with New Zealand fishing in the New Zealand EEZ., Unpublished report held by the Ministry for Primary Industries, Wellington, 39 p.
Strickland, R R (1990) Nga tini a Tangaroa, a Maori-English, English-Maori dictionary of fish names. *New Zealand Fisheries Occasional Publication* No. 5.
Thompson, F N; Abraham, E R (2010) Estimation of fur seal (*Arctocephalus forsteri*) bycatch in New Zealand trawl fisheries, 2002–03 to 2008–09. *New Zealand Aquatic Environment and Biodiversity Report No. 61*. 37 p.
Thompson, F N; Berkenbusch, K; Abraham, E R (2013) Marine mammal bycatch in New Zealand trawl fisheries, 1995–96 to 2010–11. *New Zealand Aquatic Environment and Biodiversity Report No. 105*. 73 p.
Unwin, M; Richardson, K; Davies, N; Uddstrom, M; Griggs, L; Wei, F (2005) Standardised CPUE indices for longline- and troll-caught albacore tuna in the New Zealand EEZ, 1993–2004. Final Research Report for Ministry of Fisheries Research Project TUN2002/03 Objective 3. 42 p. (Unpublished report held by Ministry for Primary Industries.)
Waugh, S; Fillipi, D; Abraham, E (2009) Ecological Risk Assessment for Seabirds in New Zealand fisheries, Final Research Report for Ministry of Fisheries project PRO2008-01. 58 p. (Unpublished report held by Ministry for Primary Industries, Wellington.)
Williams, P; Terawasi, P (2011) Overview of tuna fisheries in the western and central Pacific Ocean, including economic conditions – 2010. Unpublished report to the Western and Central Pacific Fisheries Commission, WCPFC-SC7-2011/GN WP-01. 47 p.
Wynne-Jones, J; Gray, A; Hill, L; Heinemann, A (2014) National Panel Survey Of Marine Recreational Fishers 2011–12: Harvest Estimates. *New Zealand Fisheries Assessment Report 2014/67*. 139 p.