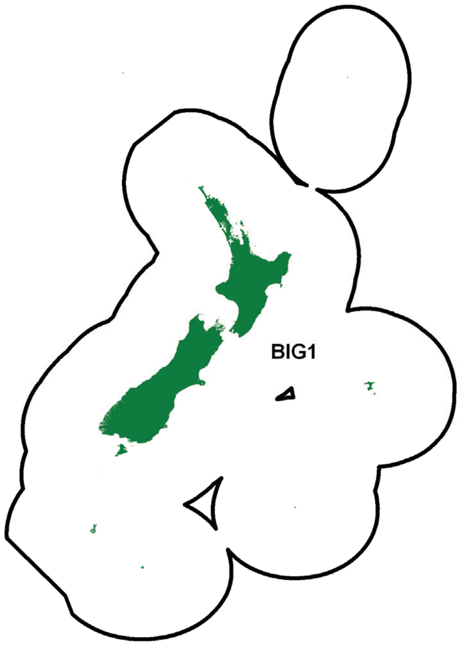
BIGEYE TUNA (BIG)

(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, TACCs and TACs 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. That measure was reviewed by the Scientific Committee (SC) and further recommendations were made such that at its third annual meeting (2006) the WCPFC passed a new CMM relating to conservation and management of bigeye tuna (http://www.wcpfc.int). A further measure CMM2008-01 was agreed to in December 2008, the aim of which was to:

- "Ensure through the implementation of compatible measures for the high seas and EEZs that bigeye and yellowfin tuna stocks are maintained at levels capable of producing their maximum sustainable yield; as qualified by relevant environmental and economic factors including the special requirements of developing States in the Convention area as expressed by Article 5 of the Convention.

- Achieve, through the implementation of a package of measures, over a three-year period commencing in 2009, a minimum of 30% reduction in bigeye tuna fishing mortality from the annual average during the period 2001-2004 or 2004;
- Ensure that there is no increase in fishing mortality for yellowfin tuna beyond the annual average during the period 2001-2004 average or 2004; and
- Adopt a package of measures that shall be reviewed annually and adjusted as necessary by the Commission taking account of the scientific advice available at the time as well as the implementation of the measures. In addition, this review shall include any adjustments required by Commission decisions regarding management objectives and reference points."

This measure is large and detailed with numerous exemptions and provisions. Despite this effort reductions are being attempted through seasonal FAD closures, and high seas area closures (in high seas pockets) for the purse seine fleets, longline effort reductions as well as other methods. At the 2009 meeting the Scientific Committee recommended that this measure would need to be strengthened if it was to achieve its objectives.

This measure will be reviewed annually and may be adjusted, considering the advice of the Scientific Committee concerning fishing mortality levels associated with maintaining the bigeye and yellowfin stocks at or above B_{MSY} in accordance with Article 5 in the Convention. No adjustments have been made at present to this CMM.

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 before a plateau was reached at approximately 6.6 million hooks in 2000/01.

Catches from within New Zealand fisheries waters are very small (0.2% average for 1991-2005) compared to those from the greater stock in the WCPO (Tables 2 & 3). 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). Figures 1 shows historical landings and TACC values for BIG1 and BIGET. Figure 2 shows historical longline fishing effort.

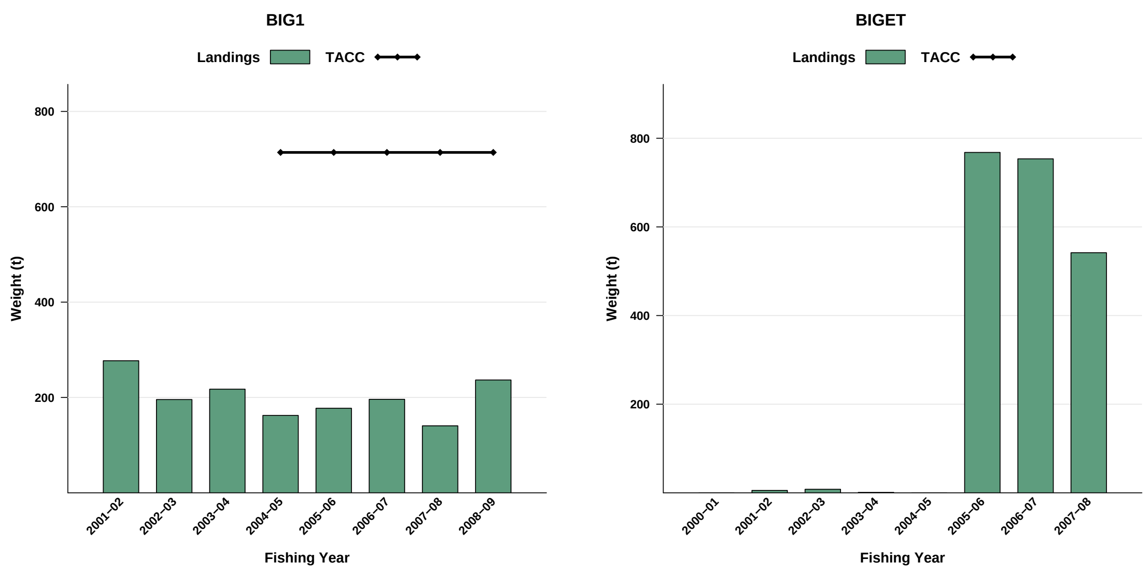


Figure 1: Bigeye catch from 2001-02 to 2008-09 within NZ waters (BIG1) and on the high seas (BIGET).

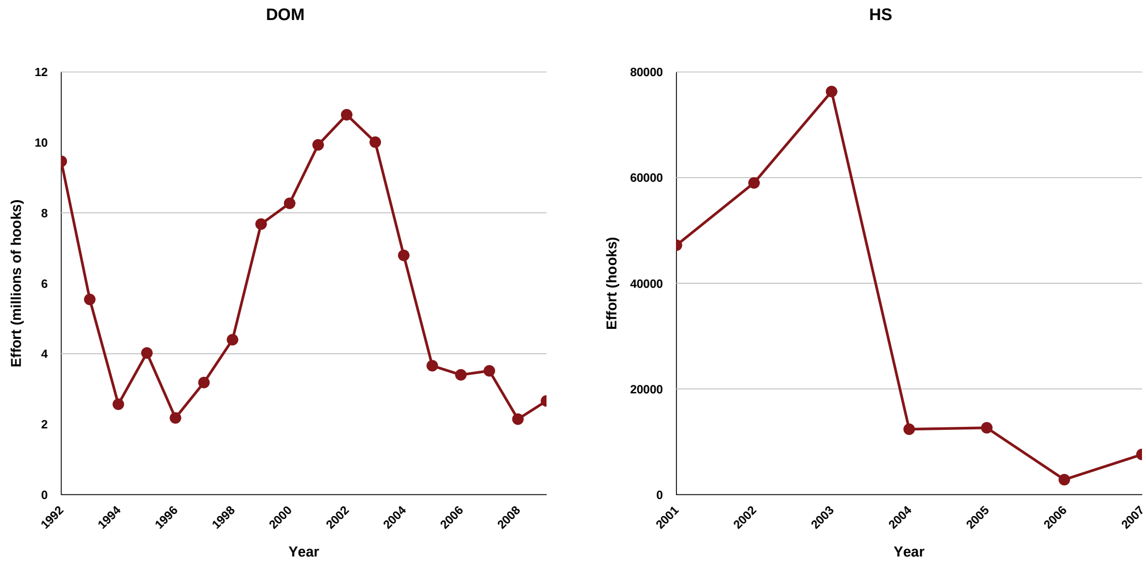


Figure 2: Fishing effort (number of hooks set) for all domestic and high seas surface longline vessels, from 1992 to 2009 and 2001 to 2007, respectively.

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 the species. There is no information on the size of 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.

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 WCPFC5 Information Paper 11 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	73 474		1999	421	115 721		2007	213	137 511	431
1992	39	91 032		2000	422	113 836		2008	133		
1993	74	79 665		2001	480	105 238	230				
1994	71	89 662		2002	200	120 222	593				
1995	60	83 057		2003	205	110 260	383				
1996	89	84 107		2004	185	146 069	1 198				
1997	142	113 444		2005	176	129 369	353				
1998	388	113 293		2006	178	134 072	859				

Source: Ministry of Fisheries Licensed Fish Receiver Reports, Solander Fisheries Ltd, Anon. 2006, Lawson 2008, and WCPFC5-2008/IP11 (Rev. 2).

*New Zealand purse seine vessel 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 or 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)				
Fish Yr	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	.05
2007/08*			140.5	140.5	143.7	0
2008/09*			236.2	236.2	238.9	0

2. BIOLOGY

Bigeye tuna are epi-pelagic opportunistic predators of fish, crustaceans and cephalopods generally found within the upper few hundred meters of the surface. 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 stay deeper. 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 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, by country.

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

3. STOCKS AND AREAS

There are insufficient data available to determine whether there are one or more stocks of bigeye tuna in the Pacific Ocean. The present information, based on tagging data, is summarized below. By the end of 2003, over 18 000 bigeye had been tagged in the Pacific Ocean, 8 074 in the WCPO and 10 336 in the Eastern Pacific Ocean (EPO). A lower proportion of fish tagged in the WCPO (12.5% or about 1000 fish) have been recovered compared to the EPO (39.3% or about 4060 fish). In each region approximately 95% of fish were recaptured within 1000 nm of the release point, which could be due to a combination of high fishing mortality and low movement rates. Of the over 5000 recoveries, only four fish (<0.08%) have been reported recaptured after crossing the 150°W meridian. Thus, the best available data suggest minimal exchange of fish between the WCPO and EPO. Also, analysis of mtDNA and DNA microsatellites from approximately 800 bigeye tuna failed to reveal significant evidence of widespread population subdivision in the Pacific Ocean. For the purposes of stock assessment and management, it is assumed that there are two stocks, one in the EPO, east of 150°W, and the other in the western and central Pacific, and that there is no net movement between these areas. Notwithstanding this assumption, the Commissions responsible for tuna management in the Pacific, the Inter-American Tropical Tuna Commission (IATTC) and WCPFC, will collaborate closely on bigeye research and stock assessment. In the past few years, the IATTC, the Secretariat of the Pacific Community, and the National Research Institute of Far Seas Fisheries of Japan have been developing a Pacific-wide assessment of bigeye.

4. STOCK ASSESSMENT

With the establishment of the WCPFC in 2004, future stock assessments of the WCPO stock of bigeye tuna will be 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 greater stock found within New Zealand fisheries waters is unknown and likely varies from year to year.

A summary of the 2009 assessment undertaken by OFP and reviewed by the WCPFC Scientific Committee in August 2009 is provided below (from Harley *et al*. 2009):

"Changes to the data from the 2008 assessment included: updated catch, effort, and size data for 2007 and some limited data for 2008; revisions to recent historical data for some fisheries (e.g. since 2000); an extended purse seine catch history that partially corrects for logsheet reporting bias; new standardised CPUE series for the main longline fisheries based on an improved methodology; exclusion of some historical size data from the Philippines which was contaminated' with samples from two different fisheries. Other changes included: an updated version of the MULTIFAN-CL software which had some new features and minor bug fixes; and decreased penalties for effort deviates for all fisheries (i.e. increased c.v.'s) to make them both more realistic and consistent with approaches used in other Pacific tuna assessments.

Over 130 different model runs were undertaken in developing this assessment, examining the impacts of changes in data, weighting of different data sources, key parameter values, and other structural model assumptions."

"The main conclusions of the current assessment are as follows:

1. Recruitment in all analyses is estimated to have been high during 1995–2005. This result was similar to that of previous assessments, and there are some indications that the high recruitment may be, at least partly, an artefact of the structural assumptions of the model. Recruitment in the most recent years is estimated to have declined to a level approximating the long-term average, although these estimates have high uncertainty.
2. Total and spawning biomass for the WCPO are estimated to have declined to about half of its initial level by about 1970, with total biomass remaining relatively constant since then ($B_{current}/B_0$= 47.4%)

(where current is the average for 2004-07), while spawning biomass has continued to decline ($SB_{current}/SB_0$=29.2%). Declines are larger for the model with increasing longline catchability and increased purse seine catches.
3. When the non-equilibrium nature of recent recruitment is taken into account, we can estimate the level of depletion that has occurred. It is estimated that spawning biomass is at 15% of the level predicted to exist in the absence of fishing considering the average over the period 2004-07, and that value is reduced to 10% when we consider 2008 spawning biomass levels.
4. The attribution of depletion to various fisheries or groups of fisheries indicates that the longline fishery has the greatest impact throughout the model domain. The purse seine and Philippines/Indonesian domestic fisheries also have substantial impact in region 3 and to a lesser extent in region 4. The Japanese coastal pole-and-line and purse-seine fisheries are also having a significant impact in their home region (region 1). For the sensitivity analysis with higher purse seine catch, the longline and purse seine fisheries are estimated to have approximately equal impact on spawning biomass.
5. Recent catches are well above the MSY level of 56,880 mt, but this is mostly due to a combination of above average recruitment and high fishing mortality. When MSY is re-calculated assuming recent recruitment levels persist, catches are still around 20% higher than the re-calculated MSY. Based on these results, we conclude that current levels of catch are not sustainable even at the recent [high] levels of recruitment estimated for the last decade.
6. Fishing mortality for adult and juvenile bigeye tuna is estimated to have increased continuously since the beginning of industrial tuna fishing. For the models with higher purse-seine catch and increasing longline catchability, estimates of recent juvenile fishing mortality are considerably higher than for run 10, while the opposite is the case for the PH/ID low catch option.
7. For all of the model runs $F_{current}/F_{MSY}$ is considerably greater than 1. For run 10 the ratio is estimated at 1.785 indicating that a 44% reduction in fishing mortality is required from the 2004-07 level to reduce fishing mortality to sustainable levels. The results are far worse with lower values of steepness. Based on these results, we conclude that overfishing is occurring in the bigeye tuna stock.
8. The reference points that predict the status of the stock under equilibrium conditions are $B_{current}/B_{MSY}$ and $SB_{Fcurrent}/SB_{MSY}$. The model predicts that total biomass and spawning biomass would be reduced to 48.1% and 33.6%, respectively, of the level that supports MSY. In terms of the reduction against virgin biomass the declines reach as low as 8% for spawning biomass. Current stock status compared to these reference points indicates that the current total and spawning biomass are higher than the associated MSY levels ($B_{current}/B_{MSY}$ =1.44 and $SB_{Fcurrent}/SB_{MSY}$ =1.22). However, in the case of spawning biomass, the estimate for 2008 (still considered relatively reliable) is below SB_{MSY} (0.947). The likelihood profile analysis indicates a 3% probability that $SB_{Fcurrent} < SB_{MSY}$ which increases to 70% for SB_{latest} (based on 2008 levels). Some of the more plausible alternative models are more pessimistic as are the conclusions of the structural uncertainty analysis. Based on these results, we conclude that it is likely that bigeye tuna is in, at least, a slightly overfished state, or will be in the near future.
9. Consideration of current levels of fishing mortality and historical patterns in the mix of fishing gears indicates that considerable levels of potential yields from the bigeye tuna stock are being lost through harvest of juveniles and overfishing. Based on these results, we conclude that greater overall yields could be obtained by reducing the mortality of small fish."

4.1 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 SCP provide information on rates of fishing mortality which in turn has improved estimates of abundance.

4.2 Biomass estimates

The stock assessment results and conclusions of the six-region model are similar to those presented in 2008 at the same value of steepness (0.75) with $B_{current} / B_{MSY}$ estimated at 1.112 in 2009. Six other model runs that were considered equally plausible, but with a steepness of 0.95, resulted in $B_{current} / B_{MSY}$ estimates of 1.11-1.55. These estimates apply to the WCPO portion of the stock or an area that is approximately equivalent to the waters west of 150°W. Total biomass for the WCPO is estimated to have declined to about half of its initial level by about 1970 and has continued to decline since then (Figure 3). The equilibrium total and adult biomass at MSY are estimated to be 30−33% and 18−22% of the equilibrium unexploited total and adult biomass, respectively.

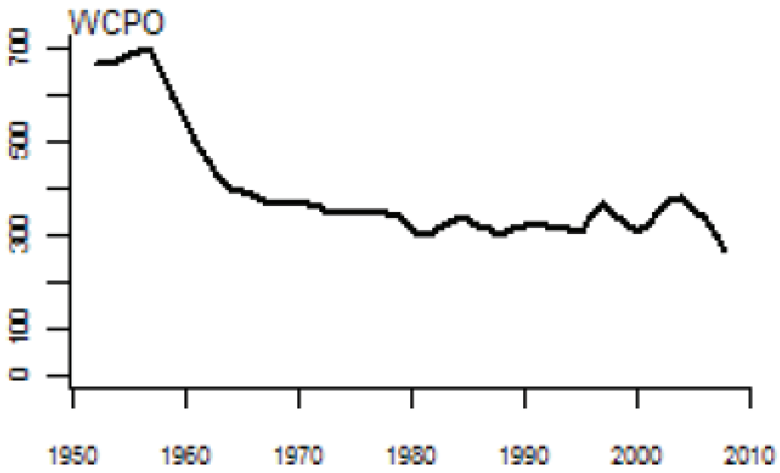


Figure 3: Estimated annual average total biomass by region and for the WCPO (modified from Harley et al. 2009).

4.3 Estimation of Maximum Constant Yield (MCY)
No estimates of MCY are available.

4.4 Estimation of Current Annual Yield (CAY)
No estimates of CAY are available.

4.5 Other yield estimates and stock assessment results
Though no reference points have yet been agreed by the WCPFC, stock status conclusions are generally presented in relation to two criteria. The first reference point relates to “overfished” which compares the current biomass level to that necessary to produce the maximum sustainable yield (MSY). The second relates to “over-fishing” which compares the current fishing mortality rate to that which would move the stock towards a biomass level necessary to produce the MSY. The first criteria is similar to that required under the New Zealand Fisheries Act while the second has no equivalent in our legislation and relates to how hard a stock can be fished.

Because recent catch data are often unavailable, these measures are calculated based on the average fishing mortality/biomass levels in the ‘recent past’, e.g. 2001-2007 for the 2009 assessment.

Recent catches (157.054 t in 2008) are well above the MSY level of 56,880 mt, this is mostly due to a combination of above average recruitment and high fishing mortality. When MSY is re-calculated assuming recent recruitment levels, catches are still around 20% higher than the re-calculated MSY. The ratio of $F_{current}$ compared with F_{MSY} (the fishing mortality level that would keep the stock at MSY) is greater than 1.0 in all model runs indicating that current fishing mortality levels are high and there is a very high chance that $F_{current}$ is greater than F_{MSY} and that over-fishing is occurring.

4.6 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;
- the historic and continuing large catch of adults by the longline fishery that dramatically reduced the spawning stock over time. At present, there is uncertainty about some of the key

data inputs to the assessment and as a result the true stock status could be better or worse than currently estimated; and

- several consecutive weak year classes have been observed in neighbouring 'stock' of bigeye tuna in the EPO leading to a dramatic decline in abundance. A similar decline in recruitment in the WCPO or a shift of effort from the EPO would increase the risk to the WCPO stock.

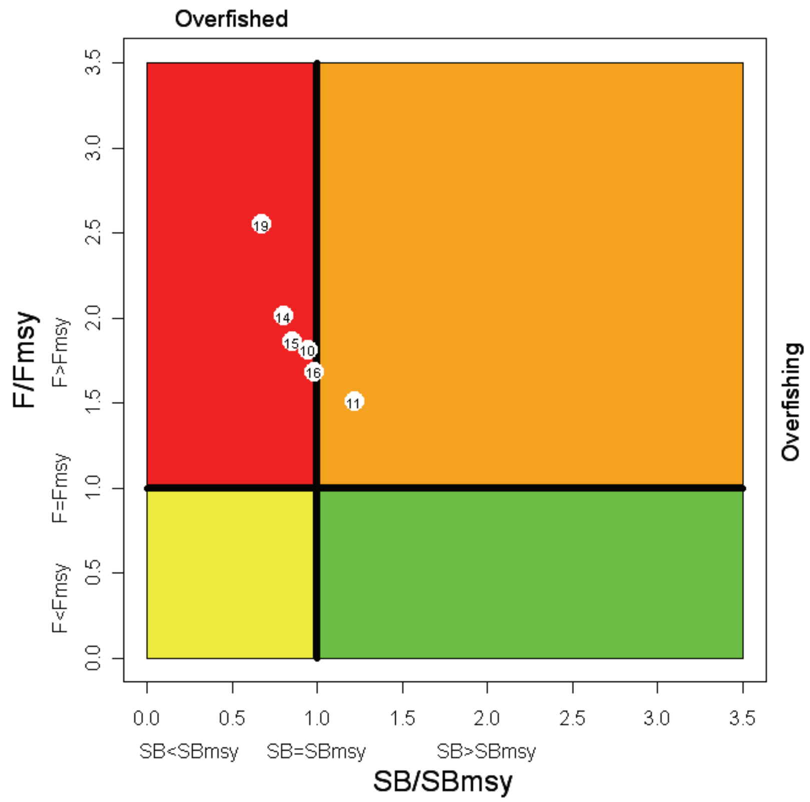
5. STATUS OF THE STOCKS

Stock structure assumptions

Western and Central Pacific Ocean
All biomass in this Table refer to spawning biomass (SB)

Stock Status	
Year of Most Recent Assessment	A full stock assessment was conducted in 2008 and a comparative assessment was conducted in 2009.
Reference Points	Target: $SB>SB_{MSY}$ and $F<F_{MSY}$ Soft Limit: Not established by WCPFC; but evaluated using HSS default of $20\%SB_0$. Hard Limit: Not established by WCPFC; but evaluated using HSS default of $10\%SB_0$.
Status in relation to Target	Likely that $SB<SB_{MSY}$ and Very Likely that $F>F_{MSY}$
Status in relation to Limits	Soft Limit: Unlikely to be below Hard Limit: Unlikely to be below

Historical Stock Status Trajectory and Current Status



A comparison of SB_{2008}/SB_{MSY} versus $F_{current}/F_{MSY}$ for selected model runs (denoted in the plot) based on MSY-related quantities being calculated for the period 2004-07.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass has decreased consistently since the 1950's to levels below SB_{MSY} in recent years. Total and spawning biomass for the WCPO are estimated to have declined to about half of its initial level by about 1970, with total biomass remaining relatively constant since then ($B_{current}/B_0$= 47.4% where current is the average for 2004-07), while spawning biomass has continued to decline ($SB_{current}/SB_0$=29.2%). Declines are larger for the model with increasing longline catchability and increased purse seine catches. When the non-equilibrium nature of recent recruitment is taken into account it is estimated that spawning biomass is at 15% of the level predicted to exist in the absence of fishing considering the average over the period 2004-07, and that value is reduced to 10% when we consider 2008 spawning biomass levels.
Recent Trend in Fishing Mortality or Proxy	Fishing mortality has generally increased and has recently escalated to levels near or above F/F_{MSY} = 1.5.
Other Abundance Indices	
Trends in Other Relevant Indicator or Variables	Recruitment in all analyses is estimated to have been high during 1995–2005. This result was similar to that of previous assessments, and there are some indications that the high recruitment may be, at least partly, an artifact of the structural assumptions of the model. Recruitment in the most recent years is estimated to have declined to a level approximating the long-term average, although these estimates have high uncertainty.

Projections and Prognosis	
Stock Projections or Prognosis	The bigeye stock status is concluded to be in an overfished state, or will be in the near future with high levels of overfishing occurring.
Probability of Current Catch / causing decline below limits	Soft Limit: Likely in the next five years Hard Limit: About as Likely as Not in the next five years

Assessment Methodology		
Assessment Type	Level 1: Quantitative Stock assessment	
Assessment Method	The assessment uses the stock assessment model and computer software known as MULTIFAN-CL.	
Main data inputs	• Catch and effort data; • size data; and • growth data.	
Period of Assessment	Latest assessment: 2009	Next assessment: 2011
Changes to Model Structure and Assumptions	Changes to the data from the 2008 assessment included: • updated catch, effort, and size data for 2007 and some limited data for 20085; • revisions to recent historical data for some fisheries (e.g. since 2000); an extended purse seine catch history that partially corrects for logsheet reporting bias; • new standardised CPUE series for the main longline fisheries based on an improved methodology; and • exclusion of some historical size data from the Philippines which was contaminated' with samples from two different fisheries.	

Changes to Model Structure and Assumptions continued	Other changes included: • an updated version of the MULTIFAN-CL software which had some new features and minor bug fixes; and • decreased penalties for effort deviates for all fisheries (i.e. increased c.v.'s) to make them both more realistic and consistent with approaches used in other Pacific tuna assessments.
Major Sources of Uncertainty	

Qualifying Comments
The six model runs accepted by the Western and Central Pacific Fisheries Commission Scientific Committee all used a fixed value of steepness of 0.95. An alternative model run that used an estimated value of steepness (0.75) was substantially more pessimistic.

Fishery Interactions
Interactions with protected species are known to occur in the longline fisheries of the South Pacific, particularly south of 30°S. Seabird bycatch mitigation measures are required in the New Zealand, Australian EEZ's 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 some extent through Conservation and Management Measure (CMM2008-06).

6. FOR FURTHER INFORMATION

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