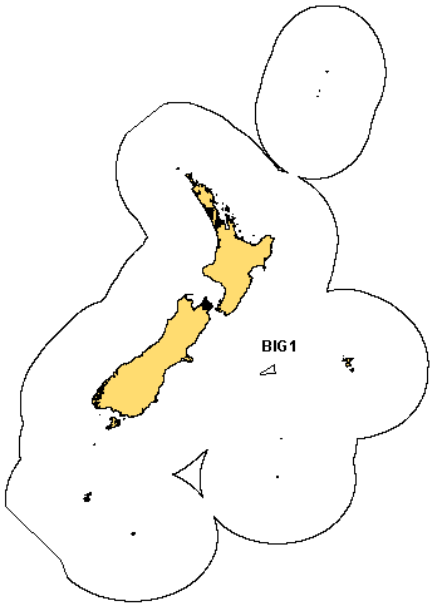
BIGEYE TUNA (BIG)
(Thunnus obesus)



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 maori allowances, TACCs and TACs by Fishstock.

Fishstock	Recreational Allowance	Maori customary 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 if bigeye tuna (http://www.wcpfc.org/). Key aspects of this CMM are summarised as follows:

For hand-line, pole and line, purse seine fisheries north of 20ºN or south of 20ºS, ring-net, troll and unclassified fisheries Commercial Tuna Fisheries: beginning in 2007, CCMs (Cooperating Non-members, and Participating Territories) shall take necessary measures to ensure that the total capacity of their respective other commercial tuna fisheries for bigeye and yellowfin tuna, including purse seining, but excluding artisanal fisheries and those fisheries taking less than 2000 t of bigeye and yellowfin, do not exceed the average level for the period 2001-2004 or 2004.

For purse seine (between 20°N and 20°S) fishing effort by their vessels in areas of the high seas does not exceed 2004 levels or the average of 2001-2004

These measures 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.

(a) 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).

Table 2: Reported total New Zealand within EEZ landings* (t) and landings from the Western and Central Pacific Ocean (t) of bigeye tuna by calendar year from 1991 to 2005.

Year	NZ landings (t)	Total landings (t)	Year	NZ landings (t)	Total landings (t)
1991	44	72 210	1999	421	118,477
1992	39	91 486	2000	422	109,794
1993	74	79 294	2001	480	107,121
1994	71	86 421	2002	200	124,285
1995	60	78 074	2003	205	114,735
1996	89	79 126	2004	185	119,472
1997	142	108 971	2005	174	163,419
1998	388	112 867	2006	178	Not available

Source: Ministry of Fisheries Licensed Fish Receiver Reports, Solander Fisheries Ltd, Anon. 2006 and the WCPFC Yearbook 2004.
*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.

(b) 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.

(c) Maori customary fisheries

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

(d) Illegal catch

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

(e) 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 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**	**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	195.6	0.6
2003/04			216.3	216.3	217.5	0.8
2004/05			162.3	162.3	159.8	0.7
2005/06			177.4	177.4	177.1	0.14

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, are 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 2006 assessment undertaken by OFP and reviewed by the WCPFC Scientific Committee in August 2006 is provided below.

The assessment used the stock assessment model and computer software known as MULTIFAN-CL. The bigeye tuna model is structured by age (40 age-classes) and space (6 regions) and catch, effort, size composition and tagging data are used in the model which is classified by 20 fisheries and quarterly time periods from 1952 through 2005. Detailed technical descriptions are given in Hampton and Fournier (2001) and in the SC documents (Hampton et al., 2006) (http://www.wcpfc.org/).

The sensitivity of the assessment model to the relative weighting applied to size-frequency data was investigated through changing the effective sample size applied to the size frequency data. The impact of a key structural assumption in the model was investigated through a reconfiguration of the spatial stratification of the model with the inclusion of an additional region (seven-region model). In summary, the analyses carried out were:

> "LOWSAMP - General linear model standardised effort for "main" longline fisheries, *M*-at-age assumed at fixed levels, lower effective sample size applied to the length and weight frequency samples.
> HIGHSAMP - General linear model standardised effort for "main" longline fisheries, *M*-at-age assumed at fixed levels, lower effective sample size applied to the length and weight frequency samples. This analysis approximates the base-case model run (GLM-MFIX) from the 2005 assessment. The only significant difference is the parameterisation of the selectivity functions for the principal longline fisheries — allowing a decline in the selectivity for the oldest age classes.

7REGION - Seven region spatial stratification, general linear model standardised effort for "main" longline fisheries, *M*-at-age assumed at fixed levels, lower effective sample size applied to the length and weight frequency samples."

Other sensitivities included in the 2005 assessment are not reported here (but see the 2006 Plenary document for details).

Current biomass is generally above equilibrium levels because of above-average recruitment since about 1990. On the basis of all of the results presented in the assessment, we conclude that maintenance of current levels of fishing mortality carries a high risk of overfishing. Should recruitment fall to average levels, current fishing mortality would result in stock reductions to near and possibly below MSY-based reference points.

(a) 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 provides information on rates of fishing mortality which in turn has improved estimates of abundance.

(b) Biomass estimates

The stock assessment results and conclusions of the six-region model are similar to those presented in the 2005 base-case assessment − depletion levels estimated in the 2005 assessment (0.33) are similar to the current base-case (0.29), $F_{current} / F_{MSY}$ is slightly more pessimistic (1.32 cf 1.23) and $B_{current} / B_{MSY}$ is similar (1.25 cf 1.27). These estimates apply to the WCPO portion of the stock or an area that is approximately equivalent to the waters west of 150°W. For the three analyses, total biomass for the WCPO is estimated to have declined to about half of its initial level by about 1970 and has been fairly stable or subject to slight decline since then. Adult biomass has declined by about 20% over the last decade. 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.

(c) Estimation of Maximum Constant Yield (MCY)

No estimates of MCY are available.

(d) Estimation of Current Annual Yield (CAY)

No estimates of CAY are available.

(e) 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. 2001-2003 for the 2006 assessment (Table 5).

Table 5: Key reference points of bigeye.

MSY	$SSB_{current}/SSB_{MSY}$	Prob($SSB_{current}$ <SSB_{MSY})	$F_{current}/F_{MSY}$	Prob($F_{current}$>F_{MSY})
60000-90000 $t.year^{-1}$	1.10	Low (but not reported)	1.25	High (but not reported)

The estimate of MSY is lower than recent catches. This is due to high fishing mortality and above average recruitment. In contrast to the 2004 assessment, spawning biomass (SSB) was estimated (point estimate) to be only 1.10 times the level necessary to produce MSY. The ratio larger than 1.0 indicates that the stock has not yet reached an over-fished state. 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 indicating that current fishing mortality levels are high and there very high chance that $F_{current}$ is actually greater than F_{MSY} and that over-fishing is occurring.

(f) 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

The 2006 assessment was updated from 2005 and presented to the Commission, the reported stated that (Anon, 2006):

> "The 2006 assessment results were reviewed and confirmed as consistent with the 2005 assessment, although the point estimate for $F_{current}/F_{MSY}$ was slightly more pessimistic in this assessment. The assessment using the 6 region model indicates that there is a high probability that overfishing of bigeye has been occurring in the WCPO ($F_{current}/F_{MSY} \geq 1$, with >99% probability) since 1997. While the stock is not yet in an overfished state ($B_{current}/B_{MSY} > 1$, with >99% probability); further biomass decline is likely to occur at 2001-2004 levels of fishing mortality at long-term average levels of recruitment, moving the stock into an overfished state."
>
> "The greatest impact from the fishery is in the equatorial region, while the temperate regions are estimated to be moderately exploited. Furthermore, the attribution of depletion to various fisheries or groups of fisheries indicates that the longline fishery has the greatest impact; the purse seine fishery operating on associated sets has a lesser, but still substantial effect, particularly in the equatorial regions."

New Zealand domestic catches represent 0.2% of the total removals from the stock. The stock is presently above the level necessary to produce the maximum sustainable yield. Current catches from the stock are not sustainable and will move the stock towards and then below a size that will support the maximum sustainable yield.

6. FOR FURTHER INFORMATION

Anon. (2002). Annual Report of the Inter-American Tropical Tuna Commission. IATTC, La Jolla, California. 148 p.

Anon. (2004). Report of the 3rd meeting of the Scientific Coordinating Group. WCPFC/PrepCon/41. www.ocean-affairs.com.

Anon. (2004). Report of the 16th meeting of the Standing Committee on Tuna and Billfish. www.spc.int.

Anon. (2006). The Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean. Scientific Committee Second regular session, 7-18 August 2006, Manila, Philippines. Kolonia Pohnpei. 252 pp.

Hampton, J., and Fournier, D.A. (2001). A spatially-disaggregated, length-based, age-structured population model of yellowfin tuna (*Thunnus albacares*) in the western and central Pacific Ocean. *Marine and Freshwater Reearch.* **52**:937−963.

Hampton, J., Kleiber, P., Takeuchi, Y., Kurota, H. and Maunder, M. (2003). Stock assessment of bigeye tuna in the western and central Pacific Ocean, with comparisons to the entire Pacific Ocean. SCTB16 Working Paper BET–1. www.spc.int

Hampton, J., Kleiber, P., Langley, A., Hiramatsu, K. (2004). Stock assessment of bigeye tuna in the western and central Pacific Ocean, SCTB17 Working Paper SA–2. www.spc.int

Hampton, J., Kleiber, P., Langley, A., Takeuchi, Y., Ichinokawa, M. (2005). Stock assessment of bigeye tuna in the western and central Pacific Ocean. SC-1 SA-WP-2. First meeting of the WCPFC-Scientific Committee, 8-19 August 2005, Noumea, New Caledonia.

Hampton, J., Langley, A., Harley, S., Kleiber, P., Takeuchi, Y., Ichinokawa, M. (2005). Estimates of sustainable catch and effort levels for target species and the impacts on stocks of potential management measures. SC-1 SA-WP-10. First meeting of the WCPFC-Scientific Committee, 8-19 August 2005, Noumea, New Caledonia.

Harley, S.J., Maunder, M.N., and Deriso, R. (2005). Assessment of bigeye tuna (*Thunnus* obsesus) in the eastern Pacific Ocean. Collective Volume of Scientific Papers, ICCAT, 57(2).

Hampton, J., Langley, A and Kleiber, P. (2006). Stock assessment of bigeye tuna in the western and central Pacific Ocean, including an assessment of management options. **WCPFC-SC2-2006/SA WP-2.** . Second meeting of the WCPFC-Scientific Committee, 7-18 August 2006, Manila, Philippines. (www.wcpfc.org/).