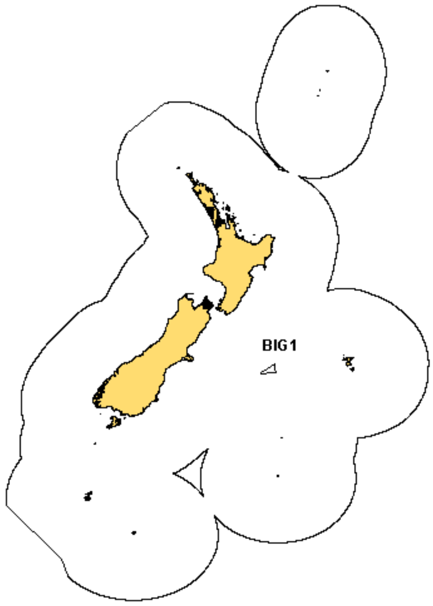
BIGEYE TUNA (BIG)

(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 of 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 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^{o}N and 20^{o}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. 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).

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 2007.

Year	NZ landings (t)	Total landings (t)	Year	NZ landings (t)	Total landings (t)	Year	NZ landings (t)	Total landings (t)
1991	44	73 474	1999	421	115 721	2007	221	137 511
1992	39	91 032	2000	422	113 836			
1993	74	79 665	2001	480	105 238			
1994	71	89 662	2002	200	120 222			
1995	60	83 057	2003	205	110 260			
1996	89	84 107	2004	185	146 069			
1997	142	113 444	2005	174	129 369			
1998	388	113 293	2006	178	134 072			

Source: Ministry of Fisheries Licensed Fish Receiver Reports, Solander Fisheries Ltd, Anon. 2006 and Lawson 2008.
*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.

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 Maori customary 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 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
2006/07			197	197	201	.05

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 2008 assessment undertaken by OFP and reviewed by the WCPFC Scientific Committee in August 2008 is provided below (from Langley *et al*. 2008):

"The bigeye tuna model is age (40 age-classes) and spatially structured (6 regions) and the catch, effort, size composition and tagging data used in the model are classified by 25 fisheries and quarterly time periods from 1952 through 2007. The catch, size and tagging data used in the assessment were updated from the 2006 assessment. It should be noted that, at the time the assessment was conducted, 2007 data were not complete for some fisheries, most notably the distant-water longline fisheries. The estimation of standardised effort for the main longline fisheries used the GLM approach as per the 2006 assessment. The current assessment included a number of additional fisheries (Japanese coastal pole-and-line and purse-seine and equatorial purse-seine) and reconfigured several main fisheries (Indonesia and Philippines domestic fisheries and the longline fishery within region 3). The revised fisheries structure was equivalent to the 2007 yellowfin assessment.

The sensitivity of the assessment model to a wide range of assumptions was examined, including the natural mortality-at-age schedule, steepness of the spawning stock-recruitment relationship, historical and current catch levels from the Philippines and Indonesian domestic fisheries, alternative catch history for the equatorial purse-seine fishery, the assumption of constant (versus increasing) catchability of the Japanese longline fleet, and structural assumptions related to recruitment distribution and movement. Of the sensitivity analyses, it was decided to focus on the results of the analyses which were considered more plausible, while still deviating significantly from the base-case analysis. Four sensitivities were selected for detailed examination.

• Lower steepness (run s11, h=0.75). The base-case estimates a high value of steepness (0.97); however, the model is not very informative about this parameter which is crucial in the determination of the MSY-based performance measures. Limited information is available to determine steepness for any tuna species or stock. A lower value of steepness is considered plausible and results in more conservative MSY-based reference points.
• Increasing longline catchability (run s7b, LL incr. q). The base-case model assumes that the GLM CPUE model accounts for all significant changes in the longline fishery that might have resulted in an increase in the efficiency (catchability) of the fleet. However, the CPUE model only includes a limited number of variables (location, gear configuration, and proportion of yellowfin in the catch) and does not consider the increase in efficiency of the longline fleet achieved from the adoption of a wide range of technological advances in fishing gear over the history of the fishery (see Ward 2008) or the increase in fisher knowledge and experience. A sensitivity analysis with increasing longline catchability is, therefore, a plausible alternative to the base-case assessment. The sensitivity formulated includes a 1% per annum increase prior to 1985 and a 2% per annum increase from 1985 onwards when bigeye was the main species targeted by the longline fleet. These values are considered to represent "best guesses" of the increase in fishing efficiency in the absence of any definitive quantitative study.
• Purse-seine revised catch. Current catches from the equatorial purse-seine fishery may be substantially under-estimated (Lawson 2008). The sensitivity incorporates an alternative bigeye tuna catch history, doubling the catch from 1980 onwards.
• Low catches from the Indonesian and Philippines domestic fisheries (run s5, low ID/PH). Historical and recent catches from these two fisheries are highly uncertain, particularly for the Indonesian fishery. A range of alternative catch histories were considered, of which the run with a 50% reduction in the level of catch from both fisheries represented a substantial improvement in the objective function of the model."

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 provides 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 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.

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. 2001-2003 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.

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

The 2006 assessment was updated in 2008 and presented to the Commission, the reported stated that (Anon, 2008):

"The assessment results from the base-case model closely approximate the results from the 2006 assessment, with inclusion of the additional fisheries and changes in the fishery configurations. These changes represent refinements to the model rather than substantive changes to model structure and resulted in only minor changes to the biomass trajectories. The key conclusions of the models presented are similar to the comparative model runs from the 2006 base-case assessment – depletion levels estimated in the base-case (0.26) were slightly lower than the 2006 (LOWSAMP) assessment

(0.29), $F_{current}/\tilde{F}_{MSY}$ was more pessimistic (1.44 (Figures 3 and 4) compared to 1.32 for 2006) and $B_{current}/\tilde{B}_{MSY}$ was higher (1.37 (Figures 3 and 5) compared to 1.27) while $SB_{current}/\tilde{SB}_{MSY}$ was comparable (1.19 compared to 1.20). These metrics indicate that recent fishing mortality has continued to increase unless fishing patterns and MSY have changed, although biomass levels have continued to be sustained by higher recruitment. However, the MSY-based reference points are not directly comparable as there has been a shift in the age-specific fishing mortality in recent years due to the recent decline in the longline catch.

The estimate of $F_{current}/\tilde{F}_{MSY}$ indicates that overfishing of bigeye tuna is occurring in the WCPO with a very high probability (100% for the scenario shown in Figure 4. While the stock is not yet in an overfished state with respect to total biomass ($B_{current}/\tilde{B}_{MSY}$ > 1), the situation is less optimistic with respect to adult biomass and a number of plausible model options indicate that adult biomass has been below the $\tilde{SB}_{MSY}$ level for a considerable period ($SB_{current}/\tilde{SB}_{MSY}$ < 1). For the base-case, there is also a 42.8% probability that the $SB_{2006}/\tilde{SB}_{MSY}$ is less than 1.0. Further, both the adult and total biomass are predicted to become over-fished at 2003–2006 levels of fishing mortality and long-term average levels of recruitment. This is consistent with a recent decline in biomass under increasing levels of fishing mortality resulting in an increase in the probability of the stock becoming overfished over time.

Recent catches are high relative to the estimated MSY both because of high recent fishing mortality and because the stock has benefited from above-average recruitment over the past 15 years.
The SC recommended a minimum 30% reduction in fishing mortality from the average levels for 2003–2006 with the goal of returning the fishing mortality rate to F_{MSY}. The point estimate of the $F_{current\ (2003–2006)}/F_{MSY}$ ratio (1.44) in the 2008 assessment was higher than the point estimate (1.32) in the 2006 assessment. A recommendation of a 30% reduction in fishing mortality is consistent with the SC recommendation issued in 2006 of a 25% reduction. The SC acknowledged that projections indicate that the bigeye tuna stock may become overfished (biomass<B_{MSY}, spawning biomass<SB_{MSY}) in the future with regard to both total biomass and spawning biomass even with a 30% reduction in fishing mortality. Therefore, it may be necessary to recommend additional reductions in fishing mortality in the future if assessments indicate that fishing mortality is greater than F_{MSY}.

The SC also provided alternative schemes to achieve this reduction in fishing mortality and suggested that these results be seriously considered when management measures are discussed.

The SC reiterated SC2 advice that exploitation rates differ between regions and that exploitation rates were highest in the western equatorial region; therefore, the SC recommended a reduction in fishing mortality throughout the WCPO from all major fishing types with priority in the western equatorial region.

In relation to the Commission’s request for advice on the potential for technological solutions to minimize the impact of fishing gear for small tuna on floating objects (or juvenile yellowfin and bigeye tunas) while minimizing the impact on the skipjack fishery, the SC noted that research was reviewed by the SC and is still ongoing in this area, but it had no further recommendations for the Commission beyond those provided by SC2.”

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.

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