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With an eye to the future:
addressing failures in the global management of Bigeye Tuna

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Cover photograph: Unloading tuna caught by longline in the Western Central Pacific Ocean. © SPC Oceanic Fisheries Programme / Siosifa Fukofuka.

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Executive summary

Bigeye Tuna *Thunnus obesus* is a highly migratory species, of which separate stocks are considered to exist in the Atlantic, Indian, Western and Central Pacific, and Eastern Pacific Oceans. It is an important target species for industrial longline tuna fisheries on the high seas and smaller-scale longline, purse seine and ring-net fisheries in national waters. Increasingly, Bigeye Tuna is also taken as bycatch in purse seine fisheries fishing for Skipjack Tuna *Katsuwonus pelamis* and Yellowfin Tuna *Thunnus albacares* using fish aggregating devices.

Bigeye Tuna is widely traded. The mature fish taken by longline fleets attracts high prices on the sashimi markets of Japan and, increasingly, in Europe and North America. Juvenile Bigeye Tuna taken by purse seine fleets is used in the lower value canning industry.

Responsibility for the management of Bigeye Tuna and the status of the stocks is summarized in the table below. The best scientific advice available indicates that the Eastern Pacific Ocean (EPO) stock is overfished, that overfishing is occurring in the other three stocks and that all stocks are, at a minimum, fully exploited. There is no scope to increase catch of Bigeye Tuna without putting the stocks at risk.

Without swift and effective management action, the status of Bigeye Tuna stocks is likely to deteriorate in the same way as stocks of Atlantic Bluefin Tuna *Thunnus thynnus* and Southern Bluefin Tuna *Thunnus macoyii*, which are now considered by The World Conservation Union to be Critically Endangered or Endangered. The analysis in this report has, however, found that management of Bigeye Tuna has been far from swift and effective to date. On the contrary, management has been slow to respond to scientific advice and has generally failed to initiate management measures that address the specific causes of fishing pressure on Bigeye Tuna. Members of regional fisheries management organizations (RFMOs) have failed to meet their legal obligations under the United Nations Fish Stocks Agreement (UNFSA) and to act in accordance with accepted international protocols for fisheries management. A major reason for this is the absence of an agreed framework for management decision-making. The adoption of biological reference points and agreed decision rules that trigger management responses, through the development of precautionary management strategies for each of the Bigeye Tuna stocks, would improve the rigour of decision making and minimise the opportunities for delays in the implementation of appropriate management measures.

Management responsibility and stock status for Bigeye Tuna

	Atlantic Ocean	Indian Ocean	Western and Central Pacific Ocean	Eastern Pacific Ocean
Management Responsibility	International Commission for the Conservation of Atlantic Tunas (ICCAT)	Indian Ocean Tuna Commission (IOTC)	Western and Central Pacific Fisheries Commission (WCPFC)	Inter-American Tropical Tuna Commission (IATTC)
Stock status	• Fully exploited • Overfishing is occurring in some years	• Fully exploited	• Fully exploited • Overfishing is occurring	• Overfished • Overfishing is occurring
Estimated maximum sustainable yield (tonnes)	93 000-114 000	111 200	110 000 – 120 000	106 722
Total catch in 2005 (tonnes)	60 453	112 400	157 102	102 376
Proportion taken as bycatch by purse seine vessels	21%	23%	28%	60%

Apart from the legal and/or moral obligations of RFMO members to manage and conserve Bigeye Tuna stocks, the economic incentives to do so are high. As noted above, many industrial fishing fleets rely heavily on Bigeye Tuna. Long-term reductions in the abundance of stocks will have significant, direct and indirect impacts on income and employment in these fleets and in associated processing and trading enterprises. Further, a number of small, island States rely heavily on income derived from fees paid by these fleets to access Bigeye Tuna stocks in their national waters. Alternative income sources in many of these States are limited and depletion of Bigeye Tuna stocks will compromise their long-term economic prosperity. In addition, there are potential market opportunities that can be exploited by sustainably managed Bigeye Tuna fisheries. The first of these relates to the potential of Bigeye Tuna to fill the gap between supply and demand of major competing products in the sashimi market, namely Atlantic and Southern Bluefin Tuna, as restrictions on the catch of these species tighten in response to dwindling stocks. The second opportunity derives from the increasing consumer demand, particularly in emerging sashimi tuna markets, for fish from ecologically sustainable fisheries. There is growing interest at all market levels in fish products that meet certification standards such as those established by the Marine Stewardship Council. Meeting certification standards would provide a marketing advantage by differentiating Bigeye Tuna products from non-certified, competing products. Failure to manage Bigeye Tuna stocks sustainably denies these Bigeye Tuna fisheries access to these potential market opportunities.

The best available management advice is unequivocal in its call for stronger management action for all Bigeye Tuna stocks. Scientific advisory bodies have been seeking significant reductions in catch of, or effort on, Bigeye Tuna for over a decade. However, this report shows that:

- overfishing is occurring in all Bigeye Tuna stocks and at least one stock is in an overfished state
- members of RFMOs have, by and large failed to respect, and respond in a precautionary manner to, the best scientific advice available to them
- attempts to control and reduce capacity have been largely unsuccessful
- the allocation of catch or capacity limits is fraught and there remains a need in most RFMOs to establish agreed allocation procedures to avoid further delays in implementation of such limits
- flag State enforcement of catch limits, area and seasonal closures and effort limits cannot be relied upon
- implementation of trade-related measures in order to reduce reliance on flag State enforcement of conservation and management measures has been compromised by the failure of these measures to apply to all components of the catch
- failure to collect and analyse reliable bycatch data, and the failure to implement precautionary and ecosystem-based management measures to mitigate impacts on bycatch species in the absence of such data, continues to put at risk a range of threatened species of seabirds, sharks, turtles and other finfish
- the absence of independent observer programmes of sufficiently high coverage of the fleet severely compromises the collection and reliability of data on both target and bycatch species
- IUU fishing, by both members and non-members of RFMOs, remains a threat to Bigeye Tuna stocks

The economic viability of Bigeye Tuna fisheries and the economic stability of a number of small island States that rely heavily on such stocks, is threatened by ineffective management of Bigeye Tuna stocks and, in particular, by the failure to address the impact on sustainability and economic returns resulting from increased catch of juvenile Bigeye Tuna by purse seine fleets. These small fish are caught before they have made a contribution to recruitment to the stock and their size means that the low value canning market is the only source of demand. In the absence of this catch, juvenile fish would make a positive contribution to the size of the stock before becoming available as adults to the longline fleet and being capable of achieving high prices on the sashimi market. Since at least 20% of the weight of the catch of each stock, and up to 60% in the EPO, is taken by the purse seine fleet, addressing this issue is a priority for each of the RFMOs.

Longline fisheries for Bigeye Tuna also have impacts on a range of bycatch species including other tunas and finfish, sharks, seabirds, turtles and marine mammals. By and large, however, data on bycatch are not routinely collected in these fisheries and the data that are available derive from limited, ad hoc observer programmes. In relation to bycatch, the overwhelming priority identified by this report is the need to ascertain the nature and extent of bycatch interactions. At the same time, there is a need for a precautionary, risk-

based approach to be taken to bycatch mitigation, particularly where interactions are known to occur with highly vulnerable and protected species.

The status of Bigeye Tuna stocks globally, and the uncertainty surrounding the impacts of Bigeye Tuna fisheries on bycatch species, demands the attention of the members of the four responsible RFMOs. The adoption of precautionary and ecosystem-based approaches to management of Bigeye Tuna is now non-negotiable, regardless of whether individual RFMO members have a legal obligation to do so or whether the conventions under which RFMOs operate require it. Failure to do so will result in all four Bigeye Tuna stocks becoming overfished and may threaten the survival of especially vulnerable species of seabirds, sharks and turtles.

In light of the obligations imposed by the UNFSA, and the guidance offered by other international protocols such as the Code of Practice for Responsible Fishing, the members of RFMOs responsible for Bigeye Tuna must address the following questions as a matter of urgency:

- where overfishing is occurring, is the current management likely to reduce fishing mortality to levels below that consistent with maximum sustainable yield in order to avoid those stocks becoming overfished?
- where a stock is overfished, is there a rebuilding strategy in place that will return the biomass of the stock to at least a level consistent with maximum sustainable yield within an acceptable timeframe?
- are the bycatch mitigation measures currently in place likely to reduce mortalities on key bycatch species, particularly threatened species?
- are the data collection and MCS arrangements in place adequate to support the development and effective implementation of appropriate management measures for Bigeye Tuna and bycatch species taken in Bigeye Tuna fisheries?

The following recommendations have been made to assist RFMOs to address these questions and to ensure that Bigeye Tuna fisheries are ecologically and economically viable.

Management approaches

1. Management strategies must be adopted for Bigeye Tuna stocks. These strategies should include the following elements:

- species-specific management objectives;
- procedures for data collection, verification and analysis;
- precautionary limit and target reference points reflecting international best practice;
- where necessary, rebuilding programmes aimed at returning stocks to sustainable levels within biologically reasonable time-frames[1];
- consideration of the vulnerability of the Bigeye Tuna stock relative to that of other target and non-target species taken in conjunction with Bigeye Tuna;
- consideration of the trade-offs, both economic and biological, involved in the differential impacts on Bigeye Tuna stocks of longline and purse seine fleets; and
- agreed management actions triggered by the approach or breach of limit reference points.

2. Pending the implementation of a management strategy for each Bigeye Tuna stock, RFMOs must adopt measures that, on the basis of the best advice available, will allow for recovery of overfished stocks and reduce fishing mortality where overfishing is occurring. In particular, urgent action must be taken to reduce the catch of juvenile tuna taken in purse seine fisheries targeting Skipjack and Yellowfin Tuna.

3. Bigeye Tuna fisheries must be managed in an ecosystem context to ensure that all impacts on Bigeye Tuna stocks are accounted for and that all impacts of Bigeye Tuna fisheries are taken into account.

[1]Some guidance on what might be considered a biologically reasonable time frame is provided by: (1) the US Magnuson-Stevens Fishery Conservation and Management Act which specifies that the rebuilding time period be as short as possible and not exceed 10 years except where the biology of the stock or other environmental conditions dictate otherwise; and (2) Australia's Commonwealth Harvest Strategy Policy (draft available at: http://www.daff.gov.au/fisheries/domestic/harvest_strategy_policy) which specifies that a biologically reasonable time frame for stock rebuilding is a period of 10 years plus one mean generation time, or three times the mean generation time, whichever is less.

Bycatch management

4. Conservation and management measures for sharks must be reviewed to ensure that they are comprehensive, that they provide specific protection to the most vulnerable species and that the ratios of fins to carcass weight are meaningful[2].

5. Bycatch mitigation measures for seabirds should be based on the current best practice approach adopted by the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR)[3].

6. RFMO members must continue research to confirm the effectiveness of sea turtle mitigation measures, taking into account the impact of such measures on the catch of other species.

Data and monitoring

7. Independent observer programmes, operated centrally by each RFMO, must be implemented as a means of collecting and verifying target and non-target catch, estimating discards and monitoring compliance with conservation and management measures.

8. The application of vessel monitoring systems (VMS) by RFMOs must be upgraded, where necessary, to reflect a consistent set of core standards and to provide for central operation of the VMS by the RFMO and the provision of data to the RMFO either prior to, or simultaneously with, transmission to the flag State.

9. The provision of data on catch and non-target catch (particularly of seabirds, sharks and turtles and other species identified as high risk) to RFMOs must be made mandatory. These measures should reflect, at a minimum, the Standard Requirements for the Collection and Sharing of Data specified in Annex 1 of the UNFSA.

10. Documentation schemes for Bigeye Tuna must cover all components of the catch[4] rather than only product entering international trade.

11. Members of RFMOs that trade in Bigeye Tuna must ensure that species-specific trade codes are in place for the full range of Bigeye Tuna product types traded and encourage other significant traders of Bigeye Tuna to do likewise.

Structure and process

12. The structure and charter of advisory bodies must reflect the adoption of an ecosystem approach to management.

13. Decision-making processes of the Commissions must be reviewed to maximise the likelihood that appropriate conservation and management measures will be agreed and adhered to.

14. Full membership of Indonesia in the IOTC and WCPFC and the full participation of Taiwan in IOTC, ICCAT and IATTC must be facilitated.

15. Membership provisions of RFMOs must be reviewed to accommodate the full participation of port and market States.

16. The basis upon which fishing rights will be allocated amongst members and co-operating non-members and a process for accommodating the interests of new members must be developed as a priority.

17. Mechanisms to maximise opportunities for sharing of data and research and for harmonization of conservation and management measures across RFMOs must be formalised and improved.

[2]Specific guidance on maximizing the effectiveness of shark conservation measures is provided in Lack and Sant (2006).
[3]Information on CCAMLR's conservation and management measures is available at: http://www.ccamlr.org/pu/e/e_pubs/cm/06-07/toc.htm
[4]Specific guidance on maximizing the effectiveness of documentation schemes is provided in Lack (2007).

Introduction

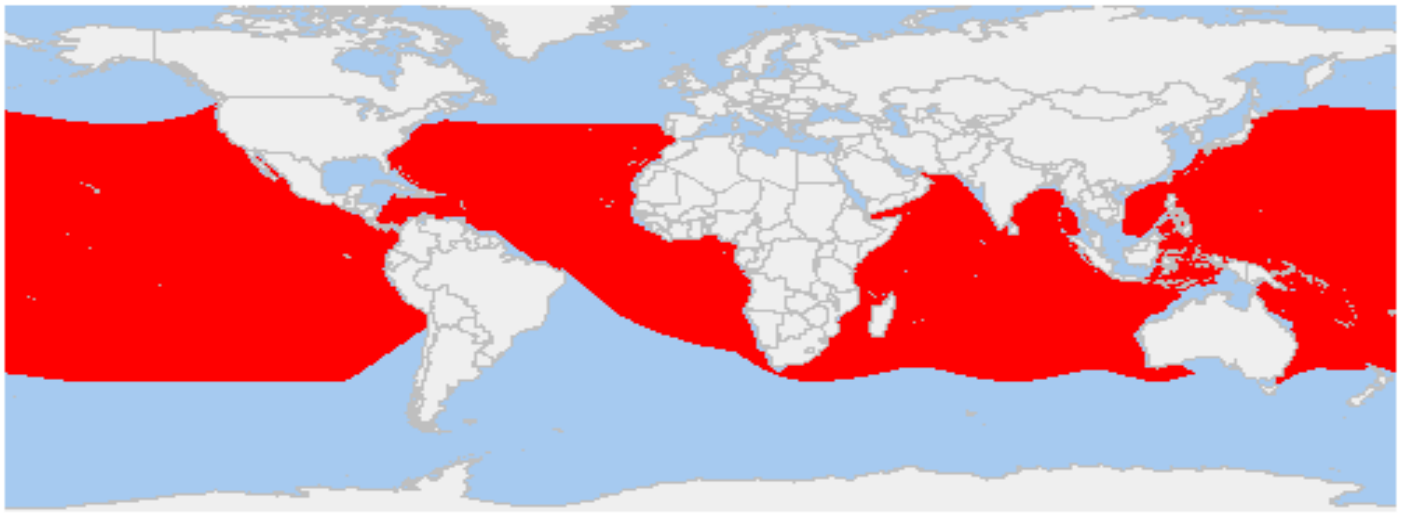
Bigeye Tuna *Thunnus obesus* is a highly migratory species that is traded extensively and commands a high price. In 2004, exports of this species totalled over 160 000 t and were valued at USD814 m (Food and Agriculture Organization of the United Nations (FAO), 2007a). Despite this, until recently, research and assessment of the stocks of Bigeye Tuna has been relatively limited.

Globally, many tuna stocks are under threat. For example, the World Conservation Union (IUCN) lists the western Atlantic Ocean stock of Atlantic Bluefin Tuna *Thunnus thynnus* and the Southern Bluefin Tuna *Thunnus macoyii* stock as Critically Endangered and the eastern Atlantic Ocean stock of Atlantic Bluefin Tuna as Endangered (IUCN, 2006). All stocks of Bigeye Tuna are now considered fully fished or overfished and overfishing[5] is occurring in some areas. In the absence of swift and effective management action the status of Bigeye Tuna is likely to deteriorate in the same way as that of Atlantic and Southern Bluefin Tuna.

While demand for high value seafood such as Bigeye Tuna continues to grow there is also an increasing awareness in the community generally, and by seafood consumers specifically, of the need for sustainable fisheries and marine ecosystems. Responsibility for ensuring this sustainability falls jointly on those who rely on fisheries for their livelihood, on national and regional management authorities and on consumers. As a result, traditional fisheries management tools and market-based measures that facilitate consumer involvement, such as certification by the Marine Stewardship Council (MSC), all have a role to play in delivering sustainable fisheries.

This report provides an overview of the biology and distribution of, and fisheries and markets for, Bigeye Tuna. It traces the history of scientific advice and management of Bigeye Tuna, and examines the current status of Bigeye Tuna stocks. The effectiveness of past and current management arrangements is examined and the implications for Bigeye Tuna and the ecosystems in which it is found are discussed. Recommendations are then developed for the members of the responsible regional fisheries management organizations (RFMOs) to assist them to implement sustainable fishing practices for Bigeye Tuna. In addition to contributing to ecological sustainability this will, ultimately, provide a platform from which Bigeye Tuna fisheries can seek MSC certification and take advantage of the growing consumer demand for sustainably-produced seafood should they wish to do so.

Figure 1: Distribution of Bigeye Tuna



Source: FAO, 2007a.

[5]There are various definitions of "overfished" and overfishing. For example, the US Magnuson-Stevens Fishery Conservation and Management Act uses the following definitions: "To overfish means to fish at a rate or level that jeopardizes the capacity of a stock or stock complex to produce MSY [maximum sustainable yield] on a continuing basis; Overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis."

Table 1: Life history characteristics of Bigeye Tuna

Age at maturity	3 years
Maximum reported age	11 years
Maximum size	250 cm (male/unsexed)
K[1]	0.11-0.23
Reproduction periodicity	Multiple spawners that may spawn every 1 to 2 days; variable throughout range; over several months in some areas and throughout the year in tropical waters
Fecundity	2 million eggs per event
Minimum population doubling time	1.4-4.4 years
Resilience	Medium

Source: Froese and Pauly, 2007.

[1] K expresses the rate at which the asymptotic size (the average length of the fish in a stock if they were to grow indefinitely) is approached.

Bigeye Tuna is a member of the Scombridae Family in the Order Perciformes. It is classified as a highly migratory species under Annex 1 of the United Nations Convention on the Law of the Sea of 10 December 1982 (UNCLOS). Bigeye Tuna is a pelagic species that is most commonly found between 0 and 250 m) in tropical and sub-tropical waters of 13-29°C. However, it often occurs in much deeper water and its distribution extends into temperate waters. While it occurs globally (see Figure 1), there are considered to be separate stocks in the Eastern Pacific, Western Pacific, Atlantic and Indian Oceans[6] (De Leiva Moreno and Majkowski, undated). Bigeye Tuna does not occur in the Mediterranean Sea.

The life history characteristics of Bigeye Tuna are summarized in Table 1. In comparison to other tuna species it is relatively long lived, later to spawn and of lower biological productivity. These characteristics make it more vulnerable to overfishing than species such as Skipjack Tuna *Katsuwonus pelamis* and Yellowfin Tuna *Thunnus albacares*. Adults of the species are found in deeper water while juveniles and small adults school at the surface in single species groups or mixed with other tunas. Schools may be associated with floating objects including larger marine animals such as dolphins, debris and man-made fish aggregating devices (FADs). Bigeye Tuna feed opportunistically on a variety of fishes, cephalopods and crustaceans (Froese and Pauly, 2007).

Management responsibility for Bigeye Tuna is distributed across four RFMOs. The Inter-American Tropical Tuna Commission (IATTC) has responsibility for the management of the Eastern Pacific Ocean (EPO) stock, the International Commission for the Conservation of Atlantic Tunas (ICCAT) for the Atlantic stock, the Indian Ocean Tuna Commission (IOTC) for the Indian Ocean stock, and the Western and Central Pacific Fisheries Commission (WCPFC) for the stock in the Western and Central Pacific Ocean (WCPO).

Purse seiner used for tuna fishing in the WCPFC area. © SPC Oceanic Fisheries Programme / Siosifa Fukofuka.

[6]It is possible that separate stocks (for example, northern and southern stocks) exist in the Atlantic Ocean and that there is a single stock in the Pacific Ocean (De Leiva Moreno and Majkowski, undated).

Bigeye Tuna is caught in numerous artisanal and commercial fisheries around the world. Fleets targeting Bigeye Tuna operate in both national waters and on the high seas. The distant water fishery for Bigeye Tuna developed in response to the development of ultra-low temperature freezers in Japanese longliners in the late 1960s that enabled the landing of sashimi grade Bigeye Tuna from the long distance fleet (Bayliff *et al*. (eds), 2005).

The bulk of the reported global catch of Bigeye Tuna is taken by industrial fleets operating on the high seas and, under agreement with coastal States, in the Exclusive Economic Zones of those States. Most of this catch is frozen on board and destined for the high value sashimi market, primarily in Japan, or for canning. National fleets also catch Bigeye Tuna in their own waters, usually supplying fresh, chilled product to domestic markets or for export to sashimi markets.

Bigeye Tuna fisheries vary by method, by product targeted and by market. Each of these aspects are discussed briefly below.

Fishing methods

The predominant commercial fishing methods for Bigeye Tuna are longline and purse seine. It is also taken by pole and line, by hand line and other methods such as set traps, gillnets and ring-nets in small scale fisheries. These methods are described in Appendix A.

Longline vessels generally target deep-swimming (older, bigger and higher value) Bigeye Tuna for the sashimi market in Japan and in other developed nations. Pole and line fishers and purse seine vessels target surface swimming (younger, smaller and lower value) Bigeye Tuna for canning and speciality products. Bigeye Tuna, particularly juveniles, are taken in significant quantities as bycatch in FAD-based purse seine fisheries for Skipjack and Yellowfin Tuna in both the Indian and Pacific Oceans. These industrial tuna fisheries utilise drifting FADs compared to the use of anchored FADs in artisanal tuna fisheries such as those in Papua New Guinea, Indonesia and the Philippines.

Artisanal fishers for tuna species, including Bigeye Tuna, use methods such as hand lines and gillnetting. Anon (2006) reports that in Sri Lanka, for example, catch taken by gillnet sustains high levels of damage and deterioration and as a result around 40% of the catch is sold to the lower value dried fish market rather than the higher value fresh fish market. In the WCPO small-scale purse seine and ring-net fleets in Indonesia and the Philippines are known to take a large proportion of the total WCPO tuna catch. While there is considerable uncertainty about the extent and composition of this catch it is estimated that around 20% of the total tuna purse seine catch in the Convention Area of the WCPFC is taken by the domestic fisheries in these two countries. Catch sampling suggests that the domestic surface fisheries of the Philippines and Indonesia take small (20-26 cm) Bigeye Tuna (Williams and Reid, 2006).

A summary of current Bigeye Tuna catch by method and area is provided in Table 2 and trends are provided in Figure 2. The data show that, except in the EPO, the majority of catch is taken by longline. In the EPO the catch of Bigeye Tuna by purse seine has increased over the last decade. The longline fishery for Bigeye Tuna in the EPO generally takes fish of around 50 kg that is destined for the sashimi market, however, the development of drifting FAD fishing in the purse seine fishery has seen increasing quantities of small (less than 10 kg) Bigeye Tuna taken. While the proportion of Bigeye Tuna taken by purse seine fishing is lower in other Oceans, the catch of Bigeye Tuna by purse seine has increased globally. In addition to increasing the vulnerability of Bigeye Tuna to fishing, it has been suggested by some studies that in areas where there are large number of FADs the migration and feeding behaviours of juvenile tuna will be affected and over time this will have a negative impact on tropical tuna species (see Bromhead *et al*. (2003) for a discussion of these studies).

In both the WCPO and the Atlantic Ocean significant quantities of Bigeye Tuna are caught by methods other than longline and purse seine (see Table 2). As noted above, in the WCPO these methods include pole and line and ring-nets used in domestic fisheries. In the Atlantic Ocean, bait boats operating in eastern tropical waters

Table 2: Bigeye Tuna catch by method and ocean, 2005, by (t and %)

Ocean	Longline		Purse seine		Other		Total
	t	%	t	%	t	%	t
WCPO	81 363	52	41 502	26	34 237	22	157 102
Indian Ocean	85 400	76	25 700	23	1300	1	112 400
EPO	32 082	31	70 294	69	0	0	102 376
Atlantic Ocean	35 361	58	13 527	22	11 565	19	60 453

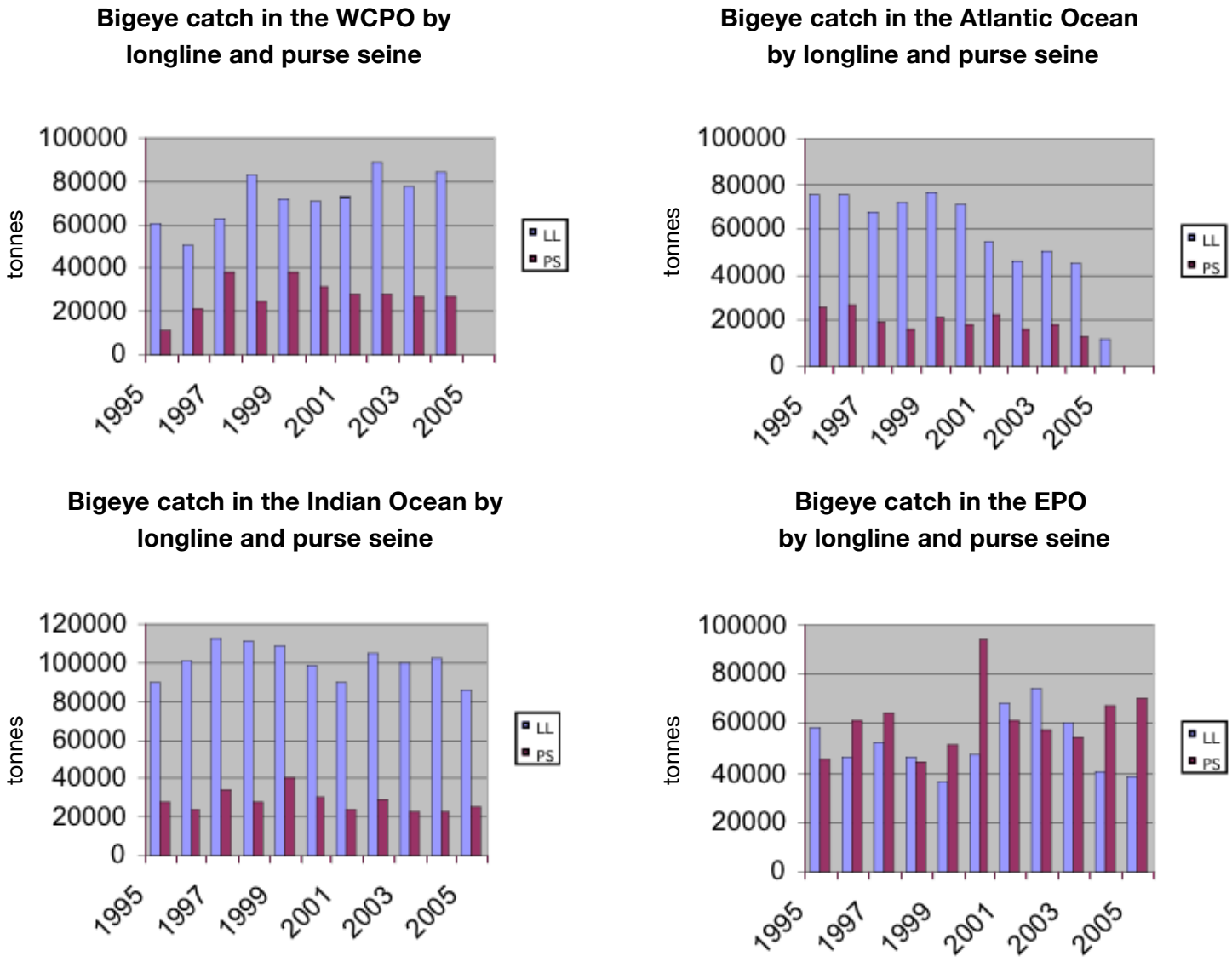
Sources: Oceanic Fisheries Programme, Secretariat of the Pacific Community, 2006; IOTC, 2006a; ICCAT, 2007a.

account for most of the 'other' catch. These vessels take smaller Bigeye Tuna (up to 20 kg) than that taken by the longline fleet (40-60 kg) (ICCAT, 2006a).

Farming of Bigeye Tuna

Atlantic Bluefin Tuna and Southern Bluefin Tuna product from 'farming'[7] operations now comprise a significant proportion of traded tuna. These farming operations have posed unique management and monitoring, control and surveillance (MCS) challenges for nations and RFMOs. Commercial farming of Bigeye Tuna has been trialled in Spain, Mexico, Chile and Hawaii (Sylvia *et al*., 2002) and small commercial quantities are produced in Mexico. Sylvia (2006), reports that Bigeye Tuna is now considered as an alternative species for tuna farming, especially in warmer water regions. However, there is no indication that a substantial increase in the quantity of Bigeye Tuna from farmed sources is imminent.

Figure 2: Trends in Bigeye Tuna catch by method and ocean, 1995-2005



Sources: Oceanic Fisheries Programme, Secretariat of the Pacific Community, 2006; IOTC, 2006a; ICCAT, 2007a.

[7]'Farming' or 'ranching' is a form of aquaculture that involves catching tuna in the wild and retaining and fattening the fish in moored pens until they have reached optimum market size.

The ecosystem impacts of fishing can be broadly classified as:

- incidental mortality (retained or discarded) of non-target species in fisheries operations (bycatch);
- indirect effects on food webs; and
- direct effects on habitat
  (MRAG Americas, Inc., 2002).

Bycatch[8]

The composition and extent of bycatch taken in fisheries targeting Bigeye Tuna varies by gear and by area. However non-reporting and under-reporting of bycatch are characteristic of all gear types and, consequently, it is difficult to provide accurate estimates of bycatch. Estimates of bycatch in tuna fisheries tend to be ad hoc and relate to studies of specific fisheries, species or types of bycatch (e.g., seabirds) rather than provide a comprehensive picture of the nature and extent of bycatch. However, it is possible to draw some general conclusions from the literature (see for example, Kelleher, 2005; Bromhead *et al*., 2003; Romanov, 2002) about the nature of bycatch in longline fisheries for tuna. Care should, however, be taken in interpreting the information provided below since it does not relate solely to longline fisheries for Bigeye Tuna, and it does not necessarily provide an indication of the frequency or level of interactions with, or mortality of, the species mentioned. Further, much of the information is drawn from observer programmes that may be restricted to certain areas of waters. In such cases the data may not be representative of the overall fishery in each Ocean.

Table 3 provides an overview of the species identified as bycatch in tuna longline fisheries. The species are listed in alphabetical order and the lists are not indicative of the relative proportion of the bycatch comprised by these species. In addition, while the data are presented by Ocean they may reflect the levels of reporting and observer coverage in place in these regions rather than necessarily representing geographical differences in bycatch.

The available data suggest that the bycatch species taken in longline tuna fisheries are sharks, other finfish, turtles, and, in temperate waters, seabirds. For example, Olson and Watters (2003) report that, apart from the main target species, Bigeye Tuna and Albacore *Thunnus alalunga*, longline fisheries in the EPO also take a range of other tunas and billfish, sharks, finfish and turtles as bycatch. It is also considered that, in the IATTC area, longline fisheries may have both direct and indirect impacts on some seabird populations. The level of the impact is currently not known. However, some of the main concerns relate to the potential for longline fisheries for Bigeye Tuna to affect populations of threatened populations of albatrosses and petrels. The four albatross species (see Table 3) of the north and equatorial Pacific Ocean are of concern in relation to direct interactions with fisheries (IATTC, 2006a; Rivera, 2006; IATTC, 2007a).

Records of ICCAT indicate that bycatch taken in the longline tuna fisheries of the Atlantic/Mediterranean include skates and rays, coastal sharks, pelagic sharks, billfish, sea turtles, species of marine mammals and a wide range of finfish (ICCAT, 2007b). ICCAT's Sub-committee on Ecosystems is currently undertaking an assessment of the impact of ICCAT fisheries on seabird populations (ICCAT, 2007c).

Data on bycatch taken in the WCPO tuna fisheries are available from the Secretariat of the Pacific Community (SPC) database covering various observer programmes from Australia, New Zealand, USA (Hawaii), vessels fishing under the Federated States of Micronesia Arrangement for Regional Fisheries Access and the US Multi-Lateral Treaty, and other SPC member country/territory national observer programmes. The data, which include both target and non-target species, comprise 236 species and 79 species groups. The species composition of the catch in the longline sector is uncertain due to low levels of observer coverage, however it is estimated that in the longline sector of the WCPO tunas comprise 53% of the total catch of the longline fleet, sharks and rays 25%, billfish 12% and other fish 10% (WCPFC, 2006a). Langley *et al*. (2006) report that the available data suggest that interactions with seabirds and marine mammals are very low in the longline sector and that, while catches of the five species of marine turtles were observed in the equatorial longline fishery, the encounter rate was very low and the most of the turtles caught were alive at the time of release.

Kirby (2006) used these data as the basis for a recent ecological risk assessment of species caught in WCPO tuna fisheries. The assessment found that, of the bycatch species, sharks are the highest risk group in both the longline and purse seine fisheries. Of the shark species, taking into account how often they are encountered, the Grey Reef Shark *Carcharhinus amblyrhynchos* and Blacktip Shark *Nasolamia velox* (both listed as highly migratory species under Annex 1 of UNCLOS and therefore, according to the WCPFC convention, under the management mandate of the Commission) had the highest apparent risk. Other shark species, including Silky Shark, Short-finned Mako Shark, Porbeagle and Oceanic Whitetip Shark, were considered of heightened risk

[8]The term bycatch is used here to refer to non-target catch whether discarded or retained.

Table 3: Bycatch species in Tuna longline fisheries

EPO	Atlantic Ocean	WCPO	Indian Ocean
Black-footed Albatross *Phoebastria nigripes*	Blue Marlin *Makaira nigricans*	Billfish	Angular Rough Shark *Oxynotus centrina*
Laysan Albatross *P. immutabilis*	Coastal sharks	Blue Shark *Prionace glauca*	Barracudas
Marlins	Finfish	Common Dolphinfish *Coryphaena hippurus*	Bigeye Thresher *Alopias superciliosus*
Rays	Green Turtle *Chelonia mydas*	Escolar *Lepidocybium flavobrunneum*	Black Escolar *Lepidocybium flavobrunneum*
Sailfish *Istiophorus platypterus*	Hawksbill Turtle *Eretmochelys imbricata*	Lancetfishes *Alepisaurus spp.*	Blue Shark
Sea turtles	Leatherback Turtle *Dermochelys coriacea*	Mako Sharks *Isurus spp.*	Broadnose Sevengill Shark *Notorynchus cepedianus*
Seabirds	Loggerhead Turtle *Caretta carretta*	Ocean Sunfish *Mola mola*	Butterfly Kingfish *Gasterochisma melampus*
Sharks	Marine mammals	Oceanic Whitetip Shark *Carcharhinus longimanus*	Common Dolphinfish
Short-tailed Albatross *P. albatrus*	Pelagic sharks	Oilfish *Ruvettus pretiosus*	Copper Shark *Carcharhinus brachyurus*
Skipjack Tuna	Skates and rays	Opah *Lampris guttatus*	Dogtooth Tuna *Gymnosarda unicolor*
Small Bigeye Tuna	White Marlin *Tetrapturus albidus*	Pomfrets *Tarachichthys spp.*	Dusky Shark *Carcharhinus obscurus*
Swordfish *Xiphias gladius*		Silky Shark *Carcharhinus falciformis*	Hammerhead sharks *Sphyrna spp.*
Wahoo *Acanthocybium solandri*		Wahoo	Longfin Mako Shark *Isurus paucus*
Waved Albatross *P. irrorata*			Longnose lancetfish *Alepisaurus Ferox*
Yellowfin Tuna			Marine mammals Ocean Sunfish Oceanic Whitetip Shark Oilfish Porbeagle *Lamna nasus* Rainbow Runner *Elegatas bipinnulata* Scalloped Hammerhead Shark *Sphyrna lewini* Sea turtles including Leatherback turtle Seabirds including albatrosses and petrels Shortfin Mako *Isurus oxyrhinchus* Smooth Hammerhead Shark *Sphyrna zygaena* Smooth-hound *Mustelus spp.* Tiger Shark *Galeocerdo cuvier* Tope Shark *Galeorhinus galeus*

Sources: ICCAT, 2007b; Olson and Watters, 2003; WCPFC, 2006a; IOTC, 2006c.

compared to other shark species, such as Hammerhead sharks and Blue Shark, because of their relatively lower productivity.

Bycatch data held by the IOTC is very incomplete (IOTC, 2006c). Information derived from specific research programmes in the IOTC area and recorded in the IOTC database indicate that sharks, a wide range of finfish, seabirds and sea turtles are taken in the tuna longline fisheries of the Indian Ocean.

In tuna purse seine fisheries, the nature and extent of purse seine bycatch varies markedly according to the nature of the 'set' (see, for example, Romanov, 2002):

- purse seine sets on FADs take a greater quantity and a more diverse range of bycatch than sets on free-schooling tuna (un-associated sets);
- purse seine sets on dolphin schools can have high rates of dolphin bycatch, if effective mitigation measures are not used, but generally take relatively less bycatch overall than purse seine sets on FADs or un-associated schools; and
- purse seine sets on FADs take bycatch of juvenile tuna (both target and non-target species), including Bigeye and Yellowfin Tuna, along with sharks, turtles and other finfish.

Bycatch issues in tuna fisheries highlight the complexity of managing the ecosystem in which fishing for Bigeye Tuna occurs. One example of this complexity relates to the implementation of management measures to reduce the bycatch of dolphins in purse seine fisheries for Skipjack Tuna in the EPO. The prohibition on setting of 'dolphins' resulted in purse seine fishers increasing their use of FADs. However, while this increased catch rates of Skipjack Tuna it also increased the catch of juvenile Yellowfin and Bigeye Tunas and sharks, billfish, sea turtles and other finfish that also aggregate around these devices. Bigeye Tuna has become an unintentional victim of a prohibition on the setting of purse seine sets on dolphins in order to reduce dolphin mortality. In this case management authorities are forced to assess the trade-off between:

- bycatch of juvenile Bigeye Tuna and other species and bycatch of dolphins; and/or
- target catch of other target tuna species such as Skipjack Tuna and Yellowfin Tuna and bycatch of juvenile Bigeye Tuna and other species.

How these trade-offs are assessed depends on the relative market value of species, the time frame in which biological and economic impacts are assessed and the relative bargaining power of the different sectors in the fishery, for example the purse seine and longline sectors.

While the above data provide some indication of the broad nature of the bycatch issues in Bigeye Tuna fisheries, the extent of the impact on bycatch species is largely unquantified. Most of the data available has been drawn from observer programmes that may be limited in their geographic and fleet coverage. Data available from logbooks is generally unverified. While it can be concluded that there are interactions with both vulnerable and threatened species in Bigeye Tuna fisheries the level of those interactions, the resulting mortalities and the overall impact on bycatch species remains unknown. This lack of information is the key bycatch issue facing Bigeye Tuna management.

Food web effects

Bigeye Tuna, like other tuna species, is a high level predator in the marine food chain. While there is little research on the role of Bigeye Tuna explicitly in the food web, Kitchell et al. (1999) have shown that other pelagic species, such as adult Yellowfin and Skipjack Tunas, have critical roles in the food web and that their removal resulted in significant and sustained changes to the structure of the ecosystem. This reflects their role as both predators and as prey for other predators such as billfishes and sharks.

Research into trophic structure is underway in the western, central and eastern Pacific Ocean in order to compare the pelagic food webs of the different areas. This work will define the trophic structure of the pelagic ecosystems in the three areas, establish an isotope-derived biogeography of the pelagic tropical pacific ecosystems and characterize large-scale tuna movements related to upwelling regions along the equator (Langley, *et al*., 2006).

Habitat

Habitat loss or degradation is a major threat to marine biodiversity. The potential physical impacts on marine habitats of the fishing techniques used in Bigeye Tuna fisheries are relatively benign in comparison to other methods such as deep sea trawling. However, MRAG Americas Inc. (2002) note that the mechanisms used for the anchoring of FADs in purse seine fisheries is likely to have some localised impacts on benthic habitats.

Bigeye tuna is sold as sashimi and sushi, as loins, as canned tuna, in foil pouches and as speciality products such as steaks. Traditionally, Japan has been the major market for sashimi and sushi-grade Bigeye Tuna with the USA being the major market for canned tuna. Domestic consumption in the flag State of the catching vessels is also a significant and, in some cases, growing market. For example, in Sri Lanka, tuna is a popular product and is sold fresh, frozen dried and cooked/baked to traditional recipes (Anon., 2006) and domestic consumption in the Republic of Korea (South Korea) of all tunas more than trebled for both canned and sashimi-grade product in the 15 years to 2005 (Korean Deep Sea Fisheries Association, 2006).

Japan continues to be the major market for both frozen and fresh Bigeye Tuna accounting for nearly 70% and 85% by volume of total imports of these products respectively in 2004. Within the Japanese market for high grade tuna there is a trend towards increased imports of tuna loins and fillets, including some Bigeye Tuna (Globefish, 2007a). However, the global market for sashimi grade tuna, including Bigeye Tuna is changing. While Japan was once the single market for such product, countries and territories such as the USA, members of the EU, South Korea, Taiwan and China are now significant consumers of sashimi tuna. The Organization for the Promotion of Responsible Tuna Fisheries (OPRT) estimates that these countries/territories now consume between 58 000 and 92 000 t of sashimi tuna annually (Anon, 2007).

US imports of both frozen and canned tuna products have declined in recent years. The data show that, while US imports of fresh/chilled Bigeye Tuna fell from a peak of 7300 t in 2003 to 4900 t in 2006, US imports of frozen Bigeye Tuna have continued to rise (National Marine Fisheries Service (NMFS), 2007). However, these trends need to be interpreted in the light of the closure, to protect sea turtles, of the Hawaii pelagic longline fishery from 2001-2004. This prompted a rise in imports of fresh chilled tuna during that time to compensate for the reduction in domestic supply. The decline in imports by 2006 is likely to reflect a return to more normal domestic supply patterns.

US imports of canned tuna fell from around 169 000 t in 2004 to 152 000 t in 2006 (Globefish, 2007b). It is not possible to identify the proportion of the canned market comprised of Bigeye Tuna since species-specific trade codes are not available for canned tuna. However, it is reasonable to assume that most of the purse seine catch of Bigeye Tuna is destined for the canned tuna trade since no other market exists for tuna of the size taken in these fisheries.

The market for tuna, in particular in traditional markets for canned product such as the USA, has been negatively affected in recent times by uncertainties about the relative risks and benefits of eating tuna. These uncertainties arise from the potential health benefits of the relatively high level of omega 3 fatty acids in tuna on the one hand, and the risks, especially for pregnant women, from the relatively high mercury levels in tuna, on the other (Globefish, 2007b). Markets for canned tuna in Europe, however, continue to be strong. The UK and France are ranked second and third behind the USA as importers of canned tuna.

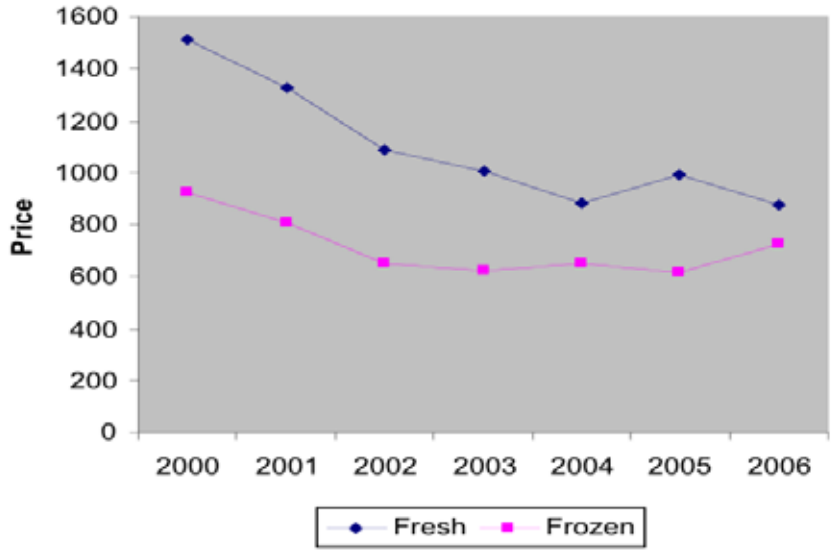
Bigeye Tuna for sale at the fish market in Hawaii. © WWF - Canon / Lorraine Hitch.

Traditionally, the bulk of the Bigeye Tuna catch has been taken by longliners targeting adults of the species. These fish attain very high prices on sashimi markets and despite declining stocks it remains profitable for operators to continue to fish. However, profits have also been squeezed as the average ex-vessel price of Bigeye Tuna has trended downwards over the last six years (see Figure 3). This trend is also reflected in the average unit value of global imports of Bigeye Tuna, which trended downward in the period 1995-2004 (FAO, 2007b).

The demand for, and the price of, species such as Bigeye Tuna is also affected by the supply of competing products on the sashimi market in particular. Bigeye Tuna is generally rated behind Atlantic Bluefin Tuna and Southern Bluefin Tuna for sashimi. In recent years the supply of Atlantic Bluefin Tuna, in particular, has been increasing as a result of increased supply of farmed product. This has placed downward pressure on the price for less prized sashimi species such as Southern Bluefin and Bigeye Tuna. Management measures that seek to reduce the catch of these competing species may also result in improved market conditions for Bigeye Tuna. The introduction of management measures, particularly the introduction of catch limits, can result in price increases if they succeed in restricting supply. This can have an offsetting affect on the impact on profits of reduced catches. For example, tuna prices have been increasing globally since 2006 following the regulation of catches for some species and consequently lower supplies (Globefish, 2007a). Japanese imports of frozen Bigeye Tuna have fallen consistently since 2003 as a result of reduced supply from South Korea and Taiwan (Globefish, 2006a), partially in response to catch limits imposed on these fleets.

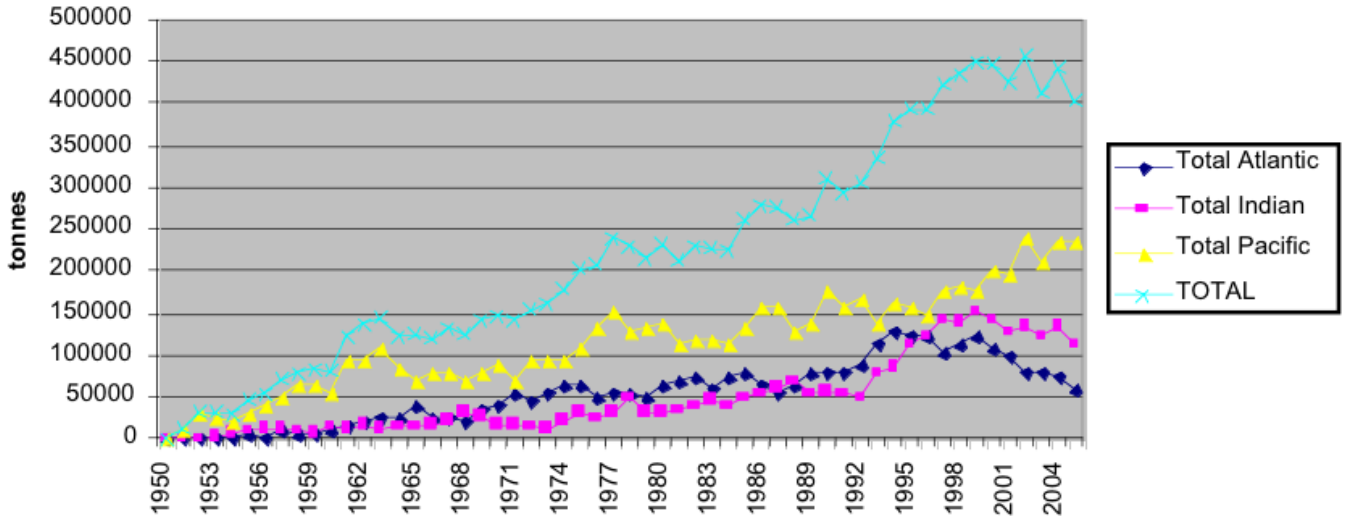
While prices have generally tended downwards, the cost of fuel has been rising. While the cost of fuel varies

Figure 3: Average annual ex-vessel price of Bigeye Tuna at major landing ports in Japan (Yen/kg)



Source: NMFS Southwest Regional Office, 2007.

Figure 4: Trends in Bigeye Tuna catch, 1950 -2005, by ocean and total



Source: FAO, 2007b.

around the world and tuna fleets are not affected equally, the upwards trend in fuel prices has further squeezed profits from Bigeye Tuna fishing. Escalating operating costs have resulted, for example in many offshore Japanese tuna boats, avoiding long, high seas trips with a consequent increase in the quantity of fresh, rather than frozen, Bigeye Tuna landed by Japanese vessels in 2006 (Globefish, 2006b).

Other factors affecting the economics of Bigeye Tuna fishing are the growing range of national and regional fisheries management and MCS requirements imposed on the Bigeye Tuna fleet. Closed seasons and areas, statistical documentation programmes for monitoring of trade, bycatch mitigation measures, introduction of compulsory vessel monitoring systems (VMS), observer programmes, restrictions on transhipment etc, all add to the operating costs of vessels.

In an environment where profits are squeezed, fishers increase their lobbying of governments to resist stronger management and MCS measures in RFMOs. Declining profitability as a result of reduced abundance, lower prices and increased costs creates an environment that is not conducive to the adoption or enforcement of more effective management.

Purse seining for tuna in the Atlantic Ocean. © WWF-Canon / Hélène Petit.

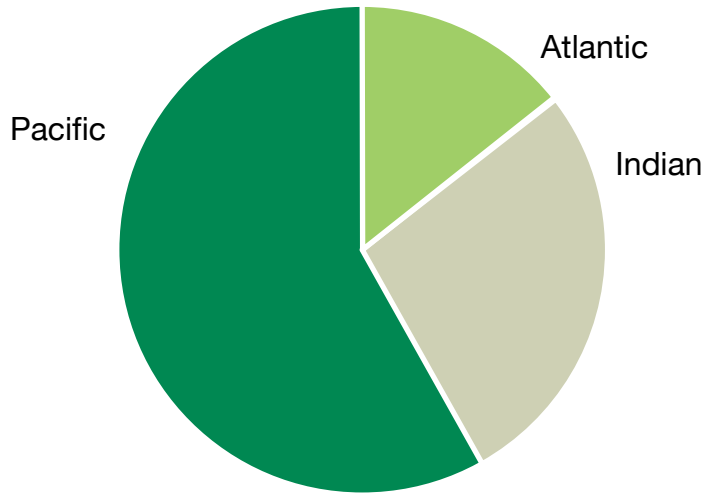
Catch

Reported catch of Bigeye Tuna peaked at 455 000 t in 2002 according to FAO data (See Table 4 and Figure 4). The total catch of 403 000 t in 2005 was the lowest recorded catch in the past decade. Estimates of Bigeye Tuna catch made by the four RFMOs responsible for managing the species suggest that in that year catch totalled 432 000 t (see Table 2). Both sets of data confirm that around 60% of the Bigeye Tuna is taken in the Pacific Ocean, around 26% in the Indian Ocean and the remaining 14% in the Atlantic Ocean (Figure 5). This reflects a significant shift in the relative contributions of these fishing areas since the mid 1990s. In 1995, the Pacific Ocean accounted for around 40% and the Atlantic and Indian Oceans each accounted for around 30% of the global Bigeye Tuna catch. The change reflects a 50% reduction in the catch of Bigeye Tuna in the Atlantic Ocean while catch in the Pacific has increased by nearly the same proportion since the mid 1990s. It should be noted, however, that these data may also reflect some mis-reporting of catch following the introduction of catch limits in the Atlantic Ocean.

Catch by the top 10 catching countries/territories over the period 1995 to 2005 and in 2005 alone is presented in Table 5. Between 1995 and 2005, 10 countries/territories took more than 80% of the total reported catch of Bigeye Tuna. Japan and Taiwan took 40% of the total catch over the period, but by 2005 their annual contribution had declined slightly to 37% as the share of others, China and the Philippines in particular, increased. Most of these participants are members of relevant RFMOs (Table 6). However, Indonesia is not a member of the IOTC or WCPFC, yet its vessels fish extensively in the waters of the Indian Ocean and the WCPO, although predominantly in national waters rather than on the high seas.

The changing pattern of catch by the major catchers of Bigeye Tuna Table is demonstrated in Figure 7. The data indicate that between 1995 and 2005 significant changes occurred in the source of catch of Panama[9], Indonesia, Spain and Taiwan. In 1995, about 94% of the catch attributed to Panama was taken in the Atlantic Ocean but by 2005 this had dropped to 20% with around 80% then taken in the Pacific Ocean. Similarly, the Pacific Ocean accounted for 74% of Indonesia's Bigeye Tuna catch in 2005 compared with 38% in 1995 while the proportion of Indonesia's catch taken in the Indian Ocean declined[10]. Over the same period, Spain increased the proportion of its Bigeye Tuna catch taken in the Pacific Ocean from 7% to 29%, reflecting increased activity of the Spanish purse seine fleet in the Pacific Ocean. The proportion of Taiwan's catch taken in the Pacific Ocean increased from 10% to 29% over the period reflecting a shift from Albacore to Bigeye Tuna. China reduced the share of its catch taken in the Pacific Ocean with expansion into the Indian and Atlantic Oceans.

Figure 5: Bigeye Tuna catch by ocean, 2005



Source: FAO, 2007b.

[9]Panama has been one of a number of countries that has operated an open registry, providing opportunities for vessels wishing to avoid regulation of their operations on the high seas to register under its flag (see for example HSTF, 2006). It is unclear to what extent this practice accounts for the changing pattern of catch.

[10]As noted previously, much of Indonesia's catch is taken in national waters, which includes areas of both the WCPO and the Indian Ocean. The accuracy of the data in relation to allocation to allocation of catch between these Oceans is uncertain.

Trade

The major sources of data on trade in Bigeye Tuna are the FAO's Fishstat Commodities Production and Trade Database (1976-2004), data compiled by trading nations under specific trade codes for Bigeye Tuna and data compiled by RFMOs from statistical documentation schemes and trade monitoring processes.

FAO data

The number of countries/territories recorded by FAO as trading in frozen or fresh/chilled Bigeye Tuna[11] has increased markedly since 2002. Prior to that year, data for imports are recorded only for South Korea, Japan and Taiwan. However, since 2002, imports have consistently been recorded for around 12 countries/territories and sporadically for a number of others. A similar, although less marked, pattern is evident for exports of Bigeye Tuna. Prior to 2002, only Taiwan, South Korea, Vanuatu, Cambodia and Kiribati consistently recorded exports of Bigeye Tuna with sporadic exports recorded from around a further 13 countries/territories. Since 2002, more than 19 countries/territories have consistently recorded exports of Bigeye Tuna and a further 31 have recorded sporadic exports. It is unclear whether the data reflect significant changes in the pattern of catch or trade or improved species-specific reporting of trade, or both. It is likely that greater reliance on trade-based measures for Bigeye Tuna since 2001 in ICCAT, IOTC and IATTC have prompted members of those organizations to implement trade codes specific to Bigeye Tuna and this improved data collection is now reflected in the statistics available to the FAO.

Imports and exports of fresh/chilled and frozen Bigeye Tuna are provided in Tables 8 and 9 respectively and the contribution of major countries/territories to this trade is depicted in Figures 6 - 9.

Japan remains the major market for fresh/chilled Bigeye Tuna accounting for 67% of total fresh/chilled imports in 2004. Other major importers of fresh/chilled Bigeye Tuna are the USA and Thailand, which accounted for 24% and 5% respectively of total imports of this product in 2004. Malaysia accounted for a further 2% of fresh/chilled imports in that year.

Japan also remains the major market for frozen Bigeye Tuna accounting for 85% of imports in 2004. Other significant importers of frozen Bigeye Tuna in 2004 were Thailand (6%), Spain (2%), Côte d'Ivoire (2%), United Arab Emirates (1%) and the USA (1%).

Taiwan is the major exporter of Bigeye Tuna, accounting for 64% of frozen exports in 2004. Other significant exporters in that year were South Korea (15%), Spain (10%), France (4%) and Vanuatu (2%). In 2004, Japan was the major exporter of fresh/chilled Bigeye Tuna accounting for 36% of exports of this product. Other significant exporters of fresh chilled Bigeye Tuna in 2004 were the Marshall Islands (13%), the Maldives (10%), the Federated States of Micronesia (8%), Australia (8%) and the Solomon Islands (5%).

It should be noted that the FAO data on Bigeye Tuna trade rely on individual countries/territories providing data on imports and exports specific to Bigeye Tuna. Since many countries/territories still do not have species-specific trade codes for tuna species, much of the Bigeye Tuna trade is unidentifiable since it is recorded under generic 'tuna' codes. The FAO trade data inevitably, therefore, understates the extent of trade in Bigeye Tuna and cannot provide a complete picture of the pattern of such trade. This issue is discussed further, below, in light of the trade data available from national records and from the statistical document schemes for Bigeye Tuna operated by IATTC, ICCAT and IOTC.

National trade data

Of the major catchers of Bigeye Tuna, Japan, Taiwan, Spain, South Korea, China and the USA are known to have trade codes for 'fresh or chilled Bigeye Tuna (excluding fillets)' and 'frozen Bigeye Tuna (excluding fillets)'. Taiwan also has trade codes for 'Bigeye Tuna fillets and its meat (whether or not minced), fresh or chilled' and 'Bigeye Tuna fillets or steaks, frozen'. The import statistics of Japan, the USA and the EU confirm that each of the remaining top 10 catching countries/territories (Indonesia, Ecuador, the Philippines and Panama) export significant quantities of both fresh chilled and frozen Bigeye Tuna. Ecuador and Panama are recorded (see Table 9) by FAO as exporting small quantities of Bigeye Tuna, suggesting that these countries may have separate trade codes for this species. However, neither Indonesia nor the Philippines are recorded in FAO export statistics suggesting that they do not have separate trade codes for Bigeye Tuna and that their trade data for this species are included in generic tuna categories.

Trade documentation schemes

The data collected under IATTC's Statistical Document Program for Bigeye Tuna is not publicly available. There is scant reference to the operation, implementation or impact of the scheme in the reports of the IATTC. Since its implementation in 2003 the Joint Working Group on Fishing by Non-Parties has reported once, in a two paragraph statement, on implementation of the Scheme (IATTC, 2005).

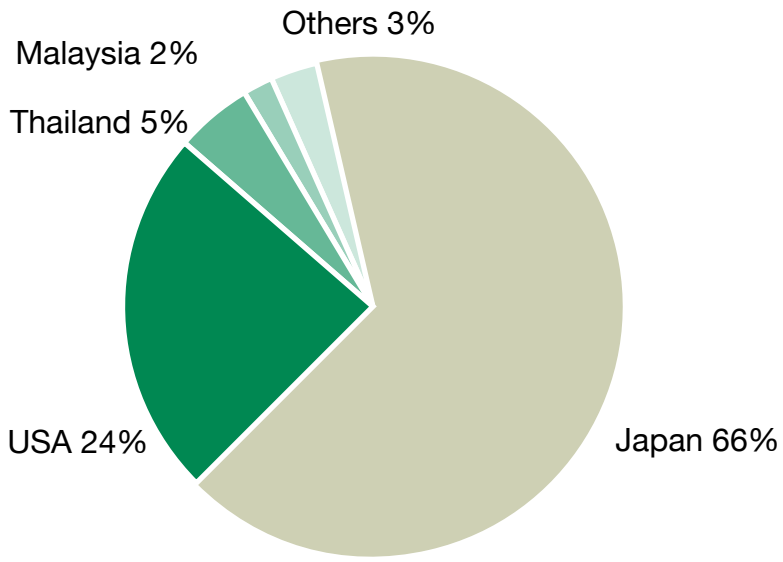
[11]The trade data do not include trade in other Bigeye Tuna products such as canned product.

Data collected under ICCAT's Statistical Document Program for Bigeye Tuna is not publicly available. However the ICCAT secretariat has produced an analysis comparing catch data provided to ICCAT and trade data collected under the Program (ICATT, 2006b).

In contrast, the IOTC reports summaries of the information contained in its Statistical Document Programme on its website. The data report the amount of Bigeye Tuna recorded per year, the point of export and the importing country/territory, the amount recorded by importing country/territory, including by the flag of harvest, and information on re-exports and direct imports. The data (see Table 10) provide further indication of the important role in trade of Bigeye Tuna of countries that are not identified in the FAO trade data.

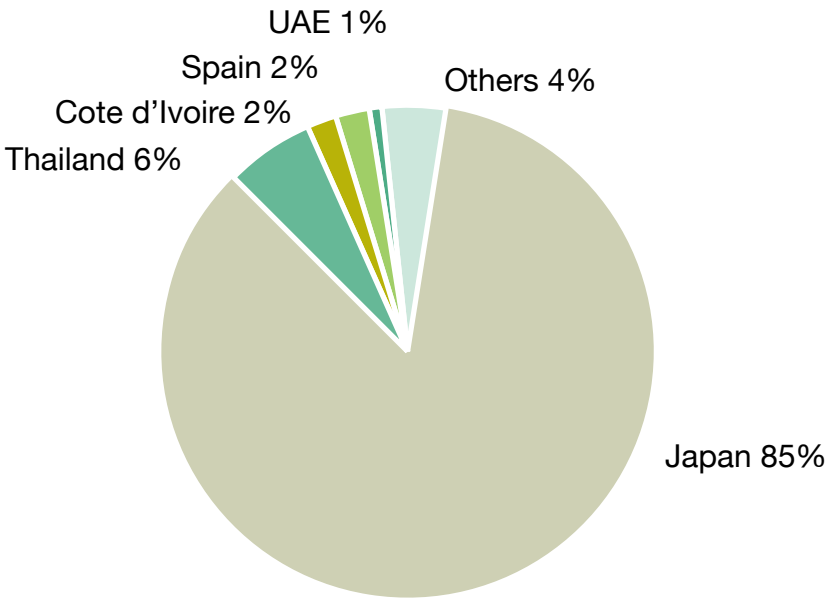
The WCPFC has not yet implemented any form of statistical documentation programme for Bigeye Tuna.

Figure 6: Imports of fresh, chilled Bigeye Tuna, 2004, by country (%)



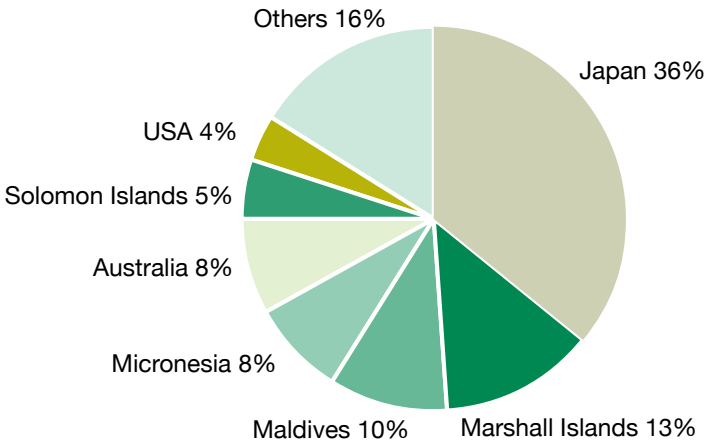
Source: FAO, 2007a.

Figure 7: Imports of frozen Bigeye Tuna, 2004, by country (%)



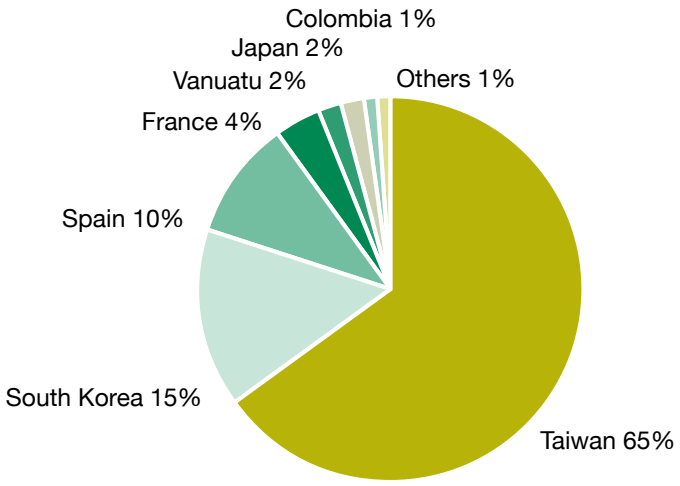
Source: FAO, 2007a.

Figure 8: Exports of fresh, chilled Bigeye Tuna, by country, 2004, (%)



Source: FAO, 2007a.

Figure 9: Exports of frozen Bigeye Tuna, by country/territory, 2004 (%)



Source: FAO, 2007a.

Table 4: Catch of Bigeye Tuna by area, 1995 to 2005 (t)

Area	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Atlantic, E. Central	84 264	86 520	72 795	81 302	85 432	68 269	67 160	44 031	49 653	44 587	35 162
Atlantic, Northeast	5295	2,338	3028	4956	2591	1574	1381	1935	450	1200	6806
Atlantic, Northwest	1156	910	1011	1124	1866	957	1038	567	367	500	594
Atlantic, Southeast	24 325	19 778	15 561	16 540	23 474	24 307	19 111	19 805	17 717	14 728	8524
Atlantic, Southwest	8128	11 697	9370	6061	5618	7951	8039	10 170	8163	7339	3913
Atlantic, W. Central	951	1091	1325	1756	2941	3927	4173	2788	4118	6101	2632
Total Atlantic Ocean	124 119	122 334	103 090	111 739	121 922	106 985	100 902	79 296	80 468	74 455	57 631
Indian Ocean, E.	38 932	50,658	58 308	56 869	55 117	47 091	38 374	43 184	27 281	31 383	24 155
Indian Ocean, W.	73 360	71,900	84 225	82 978	95 028	93 457	87 520	90 570	93 472	102 657	87 757
Total Indian Ocean	112 292	122 558	142 533	139 847	150 145	140 548	125 894	133 754	120 753	134 040	111 912
Pacific, E. Central	71 314	55,803	56 998	78 116	61 440	67 252	77 740	93 055	79 306	89 527	75 820
Pacific, Northeast	-	-	-	1	-	-	1	-	-	-	-
Pacific, Northwest	8182	6610	9674	10 145	10 173	9378	8573	9279	13 901	11 549	12 773
Pacific, Southeast	35 001	46 103	48 632	30 064	36 257	67 420	45 619	41 203	36 375	44 693	44 958
Pacific, Southwest	833	1341	1483	3186	2374	2321	2755	1798	1983	1700	1799
Pacific, W. Central	42 069	37 634	60 423	61 335	66 207	53 494	62 269	97 272	79 132	86 443	98 087
Total Pacific Ocean	157 399	147 491	177 210	182 847	176 451	199 865	196 957	242 607	210 697	233 912	233 437
TOTAL	**393 810**	**392 383**	**422 833**	**434 433**	**448 518**	**447 398**	**423 753**	**455 657**	**411 918**	**442 407**	**402 980**

Source: FAO, 2007b.

Table 5: Major catchers of Bigeye Tuna, 1995 to 2005

	1995-2005		2005	
Catcher	Average % global catch	Catcher	% global catch	2005 catch (t)
Japan	23.5	Japan	19.1	76 961
Taiwan	19.5	Taiwan	18.3	73 737
Indonesia	7.6	Indonesia	8.9	35 905
Spain	7.1	Spain	6.4	25 741
South Korea	6.7	Ecuador	6.2	24 952
Ecuador	5.1	South Korea	6.0	24 178
China	3.3	China	5.8	23 571
France	2.9	Philippines	5.8	23 178
Philippines	2.6	USA	3.0	12 189
USA	2.0	Panama	2.8	11 427

Source: FAO, 2007c.

Table 6: Participation in RFMOs by major catchers of Bigeye Tuna

Catcher	IATTC	ICCAT	IOTC	WCPFC
Japan	Member	Member	Member	Member
Taiwan	Co-operating fishing entity	Co-operating fishing entity		Full participation as a fishing entity
Indonesia	NR	NR	Co-operating non-contracting party	Co-operating non-contracting party
Spain	Member	Member (EU)	Member (EU)	Member (EU)
Ecuador	Member	NR	NR	NR
South Korea	Member	Member	Member	Member
China	Co-operating non-contracing party	Member	Member	Member
Philippines	NR	Member	Member	Member
USA	Member	Member	NR	Co-operating non-contracting party
Panama	Member	Member	NR	NR

NR: Not relevant: does not fish in the relevant waters

Table 7: Trends in catch by ocean and major catcher

Catcher	Ocean	1995		2000		2005	
		t	%	t	%	t	%
Japan	Atlantic Ocean	36 499	29	23 943	25	13 525	18
	Indian Ocean	19 203	15	13 316	14	11 080	14
	Pacific Ocean	70 914	56	58 808	61	52 356	68
	Total	**126 616**		**96 067**		**76 961**	
Taiwan	Atlantic Ocean	18 022	30	22 040	27	11 984	16
	Indian Ocean	36 289	60	53 645	65	40 212	55
	Pacific Ocean	5806	10	6799	8	21 541	29
	Total	**60 117**		**82 484**		**73 737**	
Indonesia	Indian Ocean	12 211	62	20 926	66	9315	26
	Pacific Ocean	7353	38	10 584	34	26 590	74
	Total	**19 564**		**31 510**		**35 905**	
Spain	Atlantic Ocean	17 849	55	11 251	26	7634	30
	Indian Ocean	12 233	38	11 306	26	10 711	42
	Pacific Ocean	2220	7	21 124	48	7396	29
	Total	**32 302**		**43 681**		**25 741**	
Ecuador	Pacific Ocean	10 193	100	29 398	100	24 952	100
	Total	**10 193**		**29 398**		**24 952**	
South Korea	Atlantic Ocean	421	2	70	0	681	3
	Indian Ocean	6154	23	3220	11	2481	10
	Pacific Ocean	20 244	75	26 789	89	21 016	87
	Total	**26 819**		**30 079**		**24 178**	
China	Atlantic Ocean	476	9	6563	55	6201	26
	Indian Ocean	140	3	2699	23	8867	38
	Pacific Ocean	4744	89	2731	23	8503	36
	Total	**5360**		**11 993**		**23 571**	
Philippines	Atlantic Ocean	-		975	9	.	
	Indian Ocean	-		1461	14	1492	6
	Pacific Ocean	5573	100	8260	77	21 686	94
	Total	**5573**		**10 696**		**23 178**	
USA	Atlantic Ocean	891	9	400	7	266	2
	Pacific Ocean	8508	91	5315	93	11 923	98
	Total	**9399**		**5715**		**12 189**	
Panama	Atlantic Ocean	9927	94	952	23	2310	20
	Pacific Ocean	630	6	3126	77	9117	80
	Total	**10 557**		**4078**		**11 427**	
France	Atlantic Ocean	8363	53	5949	47	2816	30
	Indian Ocean	7280	47	6673	53	6481	70
	Pacific Ocean	-		-		-	
	Total	**15 643**		**12 622**		**9297**	

Source: FAO, 2007b.

Table 8: Imports of Bigeye Tuna, 1995-2004 (t)[1]

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Fresh/Chilled										
Australia	.	.	.	.	.	.	.	-	43	1
Canada	.	.	.	.	.	.	.	160	459	291
Denmark	.	.	.	.	.	.	.	3	26	-
Fiji Islands	.	.	.	.	.	.	.	3	10	-
France	.	.	.	.	.	.	.	84	74	320
Italy	.	.	.	.	.	.	.	2	6	5
Japan	23 240	25 460	23 234	24 500	24 085	21 969	21 876	21 990	17 817	19 067
South Korea	1	6	18	2	4	7	30	14	2	5
Malaysia	.	.	.	.	.	.	.	586	794	660
Micronesia, Fed. States of	.	.	.	.	.	.	.	7	72	72
Netherlands	.	.	.	.	.	.	.	14	1	2
New Zealand	.	.	.	.	.	.	.	15	12	25
Spain	.	.	.	.	.	.	.	576	78	42
Thailand	.	.	.	.	.	.	.	967	784	1325
USA	.	.	.	.	.	.	.	6313	7312	6753
Others							1	4	12	6
Total Fresh Chilled	**23 241**	**25 466**	**23 252**	**24 502**	**24 089**	**21 976**	**21 907**	**30 738**	**27 502**	**28 574**
Frozen										
Argentina	.	.	.	.	.	.	.	.	20	-
Canada	.	.	.	.	.	.	.	44	63	239
China	.	.	.	.	.	.	.	.	.	955
Côte d'Ivoire	.	.	.	.	.	.	.	.	.	2,461
Ecuador	.	.	.	.	.	.	.	.	141	129
Fiji Islands	.	.	.	.	.	.	.	40	119	144
France	.	.	.	.	.	.	.	32	9	168
Ghana	.	.	.	.	.	.	.	.	.	263
Italy	.	.	.	.	.	.	.	85	33	60
Japan	103 421	98 378	97 233	124 170	108 831	112 765	119 001	140 638	126 776	116 323
South Korea	464	55	454	104	119	351	770	1038	901	835
Malaysia	.	.	.	.	.	.	.	19	260	316
Mexico	.	.	.	.	.	.	.	.	.	505
Portugal	.	.	.	.	.	.	.	30	147	76
Russian Federation	.	.	.	.	.	.	.	.	.	25
Singapore	.	.	.	.	.	.	.	26	107	78
South Africa	.	.	.	.	.	.	.	.	7	6
Spain	.	.	.	.	.	.	.	1964	1870	2440
Thailand	.	.	.	.	.	.	.	5808	8901	8359
United Arab Emirates	.	.	.	.	.	.	.	.	.	1,465
USA	.	.	.	.	.	.	.	319	561	1,176
Viet Nam	.	.	.	.	.	.	.	.	51	111
Others	8		44		7	1	1	21	10	31
Total Frozen	**103 893**	**98 433**	**97 731**	**124 274**	**108 957**	**113 117**	**119 772**	**150 064**	**139 976**	**136 165**

Source: FAO, 2007a.
[1]Data on imports of Bigeye Tuna is only available since separate trade codes were introduced for this species. It is likely that countries in addition to those listed, trade in this species but this trade is not readily identifiable.

Table 9: Exports of Bigeye Tuna, 1995-2004 (t)[1]

Country/Territory	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Fresh/Chilled										
Australia	.	.	.	.	.	.	.	1214	1024	646
Canada	.	.	.	.	.	.	.	206	133	168
Costa Rica	.	.	.	.	.	.	.	.	34	129
Fiji Islands	.	.	.	.	.	.	.	38	225	51
France	.	.	.	.	.	.	.	.	4	62
Ireland	.	.	.	.	.	.	.	.	527	-
Japan	.	.	.	.	.	.	.	2937	2654	3049
South Korea	183	72	88	-	-	2	-	-	-	-
Maldives	.	.	.	.	.	.	.	.	615	817
Marshall Islands	.	.	.	.	.	.	40	550	817	1113
Micronesia, Fed. States	.	.	.	.	.	.	.	1154	1114	699
Netherlands	.	.	.	.	.	.	.	19	4	.
Netherlands Antilles	.	.	.	.	.	.	.	13	-	-
New Zealand	.	.	.	.	.	.	.	198	115	209
Panama	.	.	.	.	.	.	.	.	27	-
Papua New Guinea	1	.	19	.	38	-	-	-	-	98
Senegal	.	.	.	.	.	.	.	101	.	.
Solomon Islands	.	.	.	.	.	.	637	798	572	442
South Africa	.	.	.	.	.	.	.	.	-	42
Spain	.	.	.	.	.	.	.	36	9	11
Taiwan	3	-	-	1	-	-	-	3	45	171
Tonga	.	.	.	.	22	41	8	81	25	19
Trinidad and Tobago	.	.	.	.	.	.	.	.	.	301
USA	.	.	.	.	.	.	.	106	345	362
Uruguay	55	146	72	42	11	6	-	-	8	17
Viet Nam	122	186	-	-	-	-	-	-	-	-
Others								13	34	42
Total Fresh/Chilled	**364**	**404**	**179**	**43**	**71**	**49**	**685**	**7467**	**8331**	**8448**
Frozen										
Angola	.	.	.	.	.	.	.	.	.	20
Australia	.	.	.	.	.	.	.	29	29	24
Brazil	.	.	.	.	.	.	.	.	20	-
Cambodia	.	.	.	302	679	636	515	29	-	-
Colombia	.	.	.	.	.	.	.	42	793	1407
Côte d'Ivoire	.	204	-	-	-	-	-	-	-	-
Ecuador	.	.	.	.	.	.	.	.	.	50
Fiji Islands	.	.	.	.	.	.	.	16	43	3
France	.	.	.	.	.	.	.	5993	8804	6782
Ghana	.	.	.	.	.	.	.	33	-	63
Italy	.	.	.	.	.	.	.	.	23	-
Japan	.	.	.	.	.	.	.	4315	2663	2339
Kiribati	15	40	10	51	192	50	100	70	50	-
South Korea	24 171	24 738	24 698	35 443	25 027	27 820	25 762	26 887	18 886	22 738
Libyan Arab Jamahiriya	.	.	.	.	.	494	-	593	-	-
Maldives	.	.	.	.	.	.	.	.	124	366
Marshall Islands	.	.	.	.	.	26	-	-	-	299
Micronesia, Fed. States	.	.	.	.	.	.	.	25	17	21
Netherlands Antilles	.	.	.	.	.	.	.	155	123	576
Papua New Guinea	2	-	8	-	14	-	-	8	-	14
Singapore	.	.	.	.	.	.	.	502	65	97
South Africa	.	.	.	.	.	.	.	.	52	.
Spain	-	-	-	-	-	-	-	6649	9085	15 840
St. Pierre and Miquelon	.	.	.	.	78	-	90	.	.	-
Taiwan	56 958	53 741	70 470	72 582	74 089	70 997	79 261	101 987	106 006	98 431
USA	.	.	.	.	.	.	.	9	45	48
Uruguay	1	8	-	8	-	1	14	17	-	-
Vanuatu	7482	8236	5524	3791	4383	4838	3489	2226	5231	3622
Others		135		17			10	29	40	25
Total Frozen	**88 629**	**87 102**	**100 710**	**112 194**	**104 462**	**104 862**	**109 241**	**149 614**	**152 099**	**152 765**

Source: FAO, 2007a.

[1]Data on exports of Bigeye Tuna is only available since separate trade codes were introduced for this species. It is likely that countries in addition to those listed, trade in this species but this trade is not readily identifiable.

Table 10: Additional exporters identified by national import statistics and trade programmes

US import data	t	EU import data	t	Japanese import data	t	IOTC	t
Brazil	674	China	39	China	14 485	China	2531
Chile	7	Morocco	6	Philippines	3659	Indonesia	2104
Cook Isl.	9	Mauritius	15	Indonesia	8692	Philippines	1374
El Salvador	15	Panama	1030	Seychelles	4010	Seychelles	4287
Indonesia	129	Seychelles	453	Guam	882		
Panama	1531	Viet Nam	25	Viet Nam	1023		
Philippines	57	Brazil	1394	India	2		
Sri Lanka	57	Senegal	16	Panama	2		
Venezuela	47			Canary islands	4		
Viet Nam	16			Mauritius	5		
				Cook Islands	16		
				Palau	691		

Sources: NMFS, 2007; European Commission, 2007; Ministry of Finance, Japan, 2007; IOTC, 2007a.

Table 11: Major participants in the catch and trade of Bigeye Tuna

Catch (2005)	Export (2004)	Import (2004)
Japan (19%)	Taiwan (61%)	Japan (82%)
Taiwan (18%)	South Korea (14%)	Thailand (6%)
Indonesia (9%)	Spain (10%)	USA (5%)
Spain (6%)	France (4%)	Spain (2%)
Ecuador (6%)	Japan (3%)	Côte d'Ivoire (2%)
South Korea (6%)	Vanuatu (2%)	United Arab Emirates (1%)
China (6%)	Marshall Islands (1%)	Malaysia (1%)
Philippines (6%)	Maldives (1%)	
USA (3%)	Colombia (1%)	
Panama (3%)		

Table 12: Status of Bigeye Tuna stocks

Stock	Latest assessment	Estimated MSY (t)	2005 Catch (t)	Status
Atlantic Ocean	2004	93 000 - 114 000	60 453	Fully exploited Overfishing is occuring in at least some years
Indian Ocean	2006	111 200	112 400	Fully exploited
EPO	2006	106 722	102 376	Overfished Overfishing is occurring
WCPO	2006	110 000 - 120 000	157 102	Fully exploited Overfishing is occurring

Sources: Hampton, Langley and Kleiber, 2006; ICCAT, 2005a; ICCAT, 2006a; IATTC, 2006b; IATTC 2006c; IOTC, 2006a; WCPFC, 2006b.

Summary

The FAO trade data provide the most comprehensive set of publicly available information on global trade in Bigeye Tuna. However, as discussed above, the absence of trade codes specific to Bigeye Tuna in some countries/territories, results in the FAO data understating the extent of trade.

According to FAO data and the above analysis of catch and trade it is possible to identify the major players in the catch, export and import of fresh/chilled and frozen Bigeye Tuna (Table 11). The countries/territories identified accounted for 82% of the Bigeye Tuna catch in 2005, 97% of the exports of Bigeye Tuna in 2004 and 99% of the imports in that year[12]. Importantly, only eight of the 10 major catchers, appear to have specific trade codes for Bigeye Tuna and only two, Taiwan and the USA, are known to have trade codes for products such as fillets.

Of the 10 major catchers of Bigeye Tuna there are no FAO trade data available for either Indonesia or the Philippines. The data available from national trade statistics and the IOTC Statistical Document Programme for Bigeye Tuna show that there are a number of major exporters of Bigeye Tuna that were not identified in the FAO data for 2004, the latest year for which a comparison is possible (Table 10). The most significant of these are China, Indonesia, the Philippines, Panama, Brazil, Viet Nam and the Seychelles. In 2004, the import statistics of the USA, the EU and Japan indicate that Indonesia exported 8821 t while the FAO reports no exports of Bigeye Tuna from Indonesia. In addition, the FAO records of exports for a number of countries are significantly lower than those recorded in national statistics. For example, in 2004, the import statistics of the USA, the EU and Japan indicate that China exported 14 524 t whereas the FAO records less than half a tonne. Further, the import statistics of the USA alone show that 618 t of fresh Bigeye Tuna and 58 t of frozen Bigeye Tuna were imported from Ecuador. The FAO data for that year indicate that Ecuador exported a total of 50 t.

The lack of comprehensiveness in the available trade data for Bigeye Tuna compromises the role that trade analysis can play in contributing to a better understanding of the total catch of Bigeye Tuna, of the changing patterns of trade in the species, and of the scope and source of illegal, unreported and unregulated (IUU) fishing. It underscores the importance of ensuring that the statistical documentation programmes introduced by RFMOs for Bigeye Tuna are comprehensive. These schemes are discussed in the section on the Structure and Nature of Management Arrangements.

Workers saw up Bigeye Tuna at a tuna shipping company, Majuro, Marshall Islands. © Greenpeace / Natalie Behring-Chisholm.

[12]This analysis of trade reflects only raw product. Considerable quantities of Bigeye Tuna are processed and exported or re-exported as canned tuna, in pouches or as loins. Species-specific codes for these products are generally not available.

Globally, Bigeye Tuna is classified as Vulnerable by the IUCN[13] while the Pacific Ocean stock is classified as Endangered (IUCN, 2006). The following discussion on stock status relies on the latest scientific advice available from the scientific advisory bodies of the RFMOs responsible for each of the four stocks.

Each of the Bigeye Tuna stocks is considered fully exploited or overfished (Table 12). In at least three of those stocks, overfishing is occurring. There is no scope for sustained increased catches of Bigeye Tuna and there is a need to reduce fishing mortality in at least three of the stocks.

Assessment models for Bigeye Tuna are generally quite new and there remains considerable uncertainty around their results. In particular, there are unanswered questions about natural mortality, recruitment trends and stock structure. In addition there are serious deficiencies in the catch data underlying stock assessments. Gaps in the reporting of catch data, the need to estimate IUU catch and issues associated with the misidentification of juvenile Bigeye Tuna as Yellowfin Tuna increase the uncertainties associated with the scientific advice. For example, in the IOTC up to 25% of the catch has to be estimated (IOTC, 2006a).

The assessment of Bigeye Tuna stocks in all Oceans has been made more complex by the changing pattern of fishing, notably the increased catch of juvenile fish taken by the purse seine fishery targeting Skipjack Tuna on FADs. The purse seine catch of Bigeye Tuna, together with the high, and in some areas still increasing, levels of catch of adults taken by the traditional longline fishery has placed increased pressure on all stocks. However, the potential impact of purse seine fishing on FADs on Bigeye Tuna stocks appears highest in the EPO where, between 1995 and 2005 the proportion of the total Bigeye Tuna catch taken in the purse seine fishery has been between 43 and 64%. This compares with proportions of between 18 and 37% in other areas (See Appendix B).[14] The increased catch of small Bigeye Tuna by the purse seine fleet results in the removal of not only additional biomass of Bigeye Tuna, but the removal of juveniles before they have had the opportunity to contribute to recruitment. In the longer term this, in combination with the continuation of the longline fishery that targets mature Bigeye Tuna, places additional pressure on the sustainability of the stocks. Further, the removal of juveniles for which the only market is the relatively low value canning market, reduces the potential economic returns from Bigeye Tuna fisheries.

Despite the uncertainties and complexities, there is sufficient knowledge, data and analysis available in respect of these stocks to ensure that their overall status is not regarded as 'unknown'. The best available management advice is unequivocal in its call for stronger management action for all Bigeye Tuna stocks. Scientific advisory bodies have been seeking significant reductions in catch of, or effort on, Bigeye Tuna for over a decade. Details of the scientific advice and the current status of each stock are provided below. The nature and the effectiveness of the management response to this advice are examined in the following section.

A FAD (Fish Aggregating Device) with shoals of fish. FAD's often attract large shoals of tuna. © Greenpeace / Roger Grace.

[13]The IUCN classifies (Version 2.3 (1994)) Bigeye Tuna as VUA1bd which means that the species, while not Critically Endangered or Endangered, is facing a high risk of extinction in the wild in the medium-term future, as defined by population reduction in the form of an observed, estimated, inferred or suspected reduction of at least 80% over the last 10 years or three generations, whichever is the longer, based on an index of abundance appropriate for the taxon and actual or potential levels of exploitation.

[14]It should be noted that the accuracy of the data underlying these figures varies. For example, in the WCPO there is considerable uncertainty in the data provided on catch by method by a number of countries including Papua New Guinea, Indonesia and the Philippines.

The Atlantic Ocean stock

ICCAT's Standing Committee on Research and Statistics (SCRS) first recommended a reduction in the overall catch of Bigeye Tuna in 1994 (ICCAT, 1995) and a reduction in the catch of small Bigeye Tuna in 1995 (ICCAT, 1996). In 1997, the SCRS recommended a reduction of overall catch to at least 1992 levels (initially set at 85 000 t but subsequently revised to 97 000 t and then to 99 000 t) and in 1999 this advice was amended to recommend a reduction in overall catch towards 80 000 t. This advice was reiterated in 2000 along with a recommendation for the implementation of effective measures to reduce fishing mortality (F) of small Bigeye Tuna. In 2001, the SCRS advised that the individual quotas introduced for the major parties in 2000 would not limit catch sufficiently to rebuild the stock to the maximum sustainable yield (MSY)[15] level and reiterated its earlier advice in relation to fishing mortality on juveniles. In 2002, the SCRS advised that in order to halt the decline in the stock, total catches made by all countries in the Atlantic should be limited to 100 000 t or less and called for the full implementation of the moratorium on FAD fishing by all surface fisheries in the Gulf of Guinea. This advice was reiterated in 2003.

The last stock assessment for this stock was carried out in 2004 and relied on catch information up to 2002. A new stock assessment will be conducted in 2007. Catch of the stock in 2005 was 60 000 t, a decline of 50% from the peak of 132 000 t in 1994. This decline is evident in each of the longline, purse seine and bait boat sectors.

The 2004 assessment found that large catches since the mid 1990s had resulted in a stock decline and that F had exceeded F_{MSY}[16] in several years since the mid-1990s. Taking into account uncertainties related to catches, abundance indices and other parameters, the assessment indicated that catches of 90 000 t or lower would facilitate stock recovery. However, updated relative abundance data suggest that the stock has continued to decline in recent years despite annual catches since 2002 being considerably lower than 90 000 t (ICCAT, 2006a). The stock is therefore considered fully fished and in some years, at least, overfishing is occurring.

There remains considerable uncertainty about the accuracy of the current estimate of MSY of around 100 000 t, which is considerably higher than the 70 000 t estimate of the mid 1990s. The 2007 stock assessment will attempt to determine whether the higher estimate is due to increased productivity of the stock or reflects data and methodological idiosyncrasies.

The latest management recommendations arising from the 2004 stock assessment were:

- the full implementation of the moratorium on FAD fishing by all surface fisheries in the Gulf of Guinea in order to reduce fishing mortality on small fish (<3.2 kg).
- catch levels of 90 000 t or lower be maintained at least for the near future in order to rebuild the stock (ICCAT, 2005a).

The Indian Ocean stock

The first session of the IOTC's Scientific Committee, in 1998, considered the final report of the Expert Consultation on Indian Ocean Tunas. That report noted that, although the present knowledge of Bigeye Tuna was poor, there appeared to be cause for concern about the condition of the stock, in view of the high level of effort and increased catches of juveniles in the fishery on FADs and recommended that a comprehensive stock assessment was needed urgently. The Scientific Committee recommended that as a first step a comprehensive list of all vessels of all gears catching Bigeye Tuna should be compiled (IOTC, 1999).

The major finding from the second meeting of the Scientific Committee was that given uncertainties in, and lack of, data, it was not possible to conclude whether the Bigeye Tuna stock was fully or over-exploited. However, the Committee agreed that if catches continued at their high level (115 500 t in 1996, the latest data then available to the Committee) the stock was likely to become over-exploited and, cognisant of the precautionary approach, there was a need for immediate management action. The Committee recommended that the increase in catches of Bigeye Tuna by all gears should be halted immediately, that the increase in catches of small Bigeye Tuna by purse seiners on floating objects should be halted, if not reversed immediately, and that the best option to achieve the latter was through the use of area and seasonal closures to fishing on floating objects. The third meeting of the Scientific Committee identified specific area and seasonal closures for purse seine fishing on FADs for consideration by the Commission.

In 2001 the Scientific Committee advised that if catches of Bigeye Tuna continued at the 1999 level the spawning stock biomass (SSB) would fall below B_{MSY}[17] in five or six years and recommended that a reduction on catches

[15]MSY is the average or maximum catch that can be removed under existing environmental conditions over an indefinite period without causing the stock to be depleted, assuming that removals and natural mortality are balanced by stable recruitment and growth (Coad and McAllister, 2007).

[16]F_{MSY} is the fishing mortality that if applied constantly would result in maximum sustainable yield.

[17]B_{MSY} is the calculated long-term average biomass value expected if fishing at F_{MSY}.

of Bigeye Tuna from all gears, eventually to the level of MSY (90 000 t) be started as soon as possible. This advice was reiterated in 2002 and 2003. The 2004 stock assessment for Bigeye Tuna was more pessimistic than previous assessments and the Scientific Committee reiterated, in both 2004 and 2005, its earlier advice regarding reduction in catches to the level of MSY and recommended that fishing effort should be reduced or at least not increased.

The results of the 2006 stock assessment (based on data up to 2004) showed that the 2005 catch of 112 400 t was close to the estimated MSY of 111 200 t. However, the mean catch over the period 2001-2005 of 122 800 t was higher than MSY. The assessment also showed that SSB in 2004 was just above the MSY level and that F is just below F_{MSY}. While the exploitation pattern in 2004 meant that juvenile catches of Bigeye Tuna by the surface fleets were less detrimental in terms of yield-per-recruit, this was thought likely to be anomalous and that the surface fleet was likely to revert to its previous exploitation pattern with a consequent increase in catches of juvenile Bigeye Tuna. Given that these fish were below the optimum size for maximum yield-per-recruit, such an eventuality would be detrimental to the stock. The stock is considered fully fished.

Uncertainties in the current assessment relate to the indices of abundance; how well the models approximate the true dynamics of the population; the size of fish taken in the longline fishery; and estimates of catch-at-size, catch-at-age, natural mortality, and catchability, especially in the purse seine sector.

Based on the 2006 assessment the Scientific Committee recommended that:

- catches should not exceed MSY (111 200 t (between 95 000 t and 128 000 t)); and
- fishing effort should not increase further from 2004 levels (IOTC, 2006a).

The Eastern Pacific Ocean stock

Since at least 1998 the scientific advice before the IATTC has been that some form of catch limit for Bigeye Tuna should be considered. This advice, acknowledged the uncertainty about the rate of natural mortality and stock structure, but reflected a general conclusion that the longline catch would continue to decline if the purse seine effort remained at or above its then level (IATTC, 1999). In 2000, the stock assessment indicated that, as a result of above average recruitment in 1997 and 1998, the stock was temporarily above B_{MSY}. In 2001, the spawning biomass was estimated to be at about the level that would support average MSY but was expected to decline in future years. There was general agreement in the Working Group on Stock Assessment[18] that effort should not be allowed to increase and some participants suggested that effort should be lowered, that catches of Bigeye Tuna of <60 cm in length should be monitored and that catch quotas that depended on the estimated recruitment of these fish be considered. The Working Group emphasized that the relatively high level of uncertainty relating to the Bigeye Tuna fishery meant that there should be a more cautious attitude towards this fishery (IATTC, 2001). In 2002 the scientific advice indicated that the spawning biomass was below that which supported average MSY and that recruitment had been below average each quarter since mid-1998. The Working Group noted that 'near-term caution' was required in the management of Bigeye Tuna because the spawning biomass has reached the lowest levels ever estimated and because a recent series of weak recruitment had occurred. It suggested that a reduction in fishing effort on FADs for three months in offshore waters (west of 95°W) or for two months in the eastern Pacific would be a precautionary approach. Further, the Group agreed that the recent management measures, of holding catches of fish of <60 cm in length at levels reached in 1999, were not likely to be adequate since such measures work well only with large recruitments, which had not occurred in recent years (IATTC, 2002). The 2003 stock assessment confirmed the findings of 2002 and the IATTC was advised that the stock was expected to fall to levels lower than those previously seen and that a substantial reduction in catch from all sectors would be necessary if the stock was to recover (IATTC, 2003).

In 2004, the IATTC was advised that, given the very low projected levels of spawning stock size, catches of both large and small Bigeye Tuna should be reduced by 50%. On the basis of the stock assessment results in 2005 the IATTC was advised that "further measures, similar to those proposed by the staff last year are necessary to allow the stock to rebuild to the A_{MSY} level…measures that encourage purse seine vessels to avoid catching bigeye while fishing for skipjack would be beneficial. The individual vessel catch limits proposed for 2004 are one way of allowing purse seine vessels to continue fishing for skipjack while reducing catches of bigeye." (IATTC, 2005).

The 2006 assessment for this stock, reflecting the base-case model, indicated that it is overfished and that overfishing is occurring. Recent estimates of fishing mortality are nearly 50% greater than those corresponding

[18]IATTC employs scientific staff to provide independent advice to Commission members. A Working Group on Stock Assessment comprised of scientific representatives of member nations and other interested organizations reviews the staff's research.

to AMSY. While the previously reported decline in the stock had been interrupted by above average recruitment in 2001 and 2002, the stock assessment indicated that, if fishing effort is not reduced, total biomass and spawning biomass will eventually decline to levels at least as low as those observed in 2004 (IATTC, 2006b).

In 2006, the scientific staff of the Commission recommended that purse seine fishing effort on floating objects be reduced by 38% and that, in order to achieve this with the least reduction in catch of Skipjack Tuna, for 2007 to 2009:

- the purse seine fishery on floating objects be closed when the estimated purse seine catch of Bigeye Tuna reached 46 000 t; or
- the total annual catch of Bigeye Tuna by each purse seine vessel be limited to 930 t by prohibiting further sets on floating objects after this limit was reached.

In addition, it was recommended that the longline catch limits established under the multi-year program be reduced to 94% of those limits for 2007-2009 (IATTC, 2006c).

The latest stock assessment was reviewed in May 2007 by the Working Group on Stock Assessment. The assessment (IATTC, 2007b) indicated that:

- at the beginning of 2007 the SSB of Bigeye Tuna in the EPO was near the historic low level;
- the ratio of the current SSB to that of the un-fished stock was about 0.20 and about 10% less than the level corresponding to the average MSY;
- the level of fishing effort corresponding to the average MSY is about 77% of the 2004-2006 average fishing effort;
- under current effort levels, the population is unlikely to remain at levels that support AMSY unless fishing mortality levels are greatly reduced or recruitment is above average for several consecutive years.

The preliminary advice of the scientific staff[19] indicates, broadly, that:

- further measures are necessary to allow the stock to be maintained at or above the average MSY level;
- the average MSY has been significantly reduced by purse seine catches of small Bigeye Tuna and measures that encourage purse seiners to avoid catching Bigeye Tuna while targeting Skipjack Tuna would be beneficial; and
- the combined fishing effort (longline and purse seine) should be reduced to 85% through reducing the Bigeye Tuna catch limits for longline fleets and reducing the catch of Bigeye Tuna by the purse seine fleets by extending the closure of the purse seine fishery on floating objects or by setting a total allowable catch (TAC) for Bigeye Tuna for the purse seine fleet or by imposing TACs on each purse seine vessel.

Major areas of uncertainty in the EPO stock assessment for Bigeye Tuna include natural mortality and the steepness of the stock-recruitment relationship.

The Western Pacific Ocean stock

The WCPFC took effect in 2004[20]. Prior to that time, advice on the status of tuna stocks in the WCPO had been provided by the Standing Committee on Tuna and Billfish (SCTB) of the SPC. In the lead up to the introduction of the WCPFC the SCTB provided scientific advice to the Preparatory Conference for the WCPFC (PrepCon) and, in particular, to the Scientific Coordinating Group (SCG) established by PrepCon. In 2002, the SCG adopted the SCTB's advice that the Bigeye Tuna stock was nearing full exploitation, that further increases in fishing mortality were, with the current pattern of age-specific exploitation, unlikely to result in long-term increases in the average yield of the fishery, and that any increase in juvenile fishing mortality was likely to move the stock to an overfished state.

In 2003 the SCG accepted SCTB's advice that, based on the most recent assessment, overfishing of the Bigeye Tuna stock was occurring, but that the stock was not yet in an overfished state because of high levels of recruitment since 1990. The SCG recommended that the precautionary approach should be applied and called for management action to ensure no increase in fishing mortality on Bigeye Tuna.

The 2004 stock assessment was slightly more optimistic, in particular, suggesting that fishing mortality was around, rather than in excess of, FMSY and that the fishery was not yet overfished. However, the assessment indicated that current levels of F carried a high risk of overfishing and a decrease in total catch would be likely to be necessary in order to maintain the stock at a sustainable level if there is a further decrease in recruitment. The SCG recommended that, as a minimum measure, there be no further increase in F for Bigeye Tuna from the average levels of 1999-2001.

[19]At the time of writing this advice had not been finalised for consideration by the Commission.

[20]During the negotiations to develop the Convention for the WCPFC the participants adopted, in 1999, a non-binding resolution urging all States and other entities concerned to exercise reasonable restraint in respect of any expansion of fishing effort and capacity in the region and to apply the precautionary approach. This resolution was reinforced in 2002 by the participants in the Preparatory Conference (PrepCon) who reiterated the call for reasonable restraint in respect of any expansion of fishing effort and capacity, for application of the precautionary approach and for States and other entities to address IUU fishing. In 2003, the PrepCon participants called for States and other entities that had breached the previous resolutions on fishing capacity, to reduce any overcapacity they had created, noting the need to prevent any increase in fishing mortality of Bigeye Tuna.

In 2005 however, the stock assessment again indicated that overfishing was occurring but confirmed that the stock was not in an overfished state, largely due to higher than average recruitment occurring over the last decade. The first meeting of the WCPFC's Scientific Committee recommended that F be reduced from the average levels of 2001-2003 and noted that, if future recruitment declines to levels closer to the long-term average, a further decrease in total catch and effort is likely to be necessary and that more urgent management actions may be required in equatorial regions where the impacts of the fishery for Bigeye Tuna are greatest.

The 2006 assessment for this stock indicates that overfishing is occurring and that there is a high probability that it has been occurring since 1997. While the stock is not yet overfished 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 probability of the stock becoming overfished is increasing over time (Hampton, *et al*., 2006). The assessment indicates that the major impact of fishing has been in the equatorial regions of the WCPO with minimal impacts in the peripheral temperate regions. The longline fishery continues to have the greatest impact on the stock but the purse seine fishery operating on associated sets has a lesser, but still substantial impact, particularly in equatorial regions. After declining from the previous peak of 38 000 t in 1999, the purse seine catch of Bigeye Tuna catch increased in 2005 to a new record of 41 500 t despite a reduction in the proportion of sets on logs and drifting FADs (Williams and Reid, 2006). In order to maintain the Bigeye Tuna stock at a level capable of producing MSY, the 2006 meeting of the Scientific Committee recommended a 25% reduction in fishing mortality from the average levels for 2001-2004 (WCPFC, 2006b).

Ongoing uncertainties in the stock assessment for Bigeye Tuna in the WCPO include the spatial distribution of the stock, limited catch, effort and size composition data for some sectors and some fleets, and biological characteristics including natural mortality.

Unloading Bigeye Tuna caught by longline. © SPC Oceanic Fisheries Programme / Siosifa Fukofuka.

Management measures for Bigeye Tuna

An overview of the management measures applied over time by each of the four Bigeye Tuna RFMOs and the stated objectives of these measures is provided in Table 13. This shows that the management measures implemented for Bigeye Tuna by RFMOs have included:

- catch limits either by country/territory or by country/territory and by fleet
- effort and capacity limits
- temporal and spatial closures
- size limits
- trade documentation schemes[21]
- controls on transhipment, on the number of FADs carried and on the use of tender vessels.

The application of these measures in the management of Bigeye Tuna by RFMOs is discussed below. In the main, RFMOs require their contracting parties and co-operating non-contracting parties (CPCs)[22] to implement, monitor and enforce management measures. Some flag State members of RFMOs impose additional management measures on their vessels fishing for Bigeye Tuna in waters under their jurisdiction and on the high seas. Those national management measures are not reviewed in this report.

Size limits

In theory, restricting the minimum size of Bigeye Tuna that can be retained has the potential to improve yield per recruit and to improve the spawning stock biomass. However realising this potential poses practical difficulties. Only ICCAT has implemented a size limit for Bigeye Tuna and while it remained in place for over 15 years, until 2005, compliance was low and its effectiveness questionable at best, due to the mixed nature of the fishery. In 2004, the SCRS reported that the percentage and total number of fish taken that were smaller than the minimum size had increased since 1989 and was more than 45% of the total fish caught (ICCAT, 2005a). Both the IOTC and IATTC have, in the past, considered and rejected size limits on the grounds that they require high levels of enforcement and are ineffective if they simply result in discarding and subsequent mortality of smaller fish.

Catch limits

Catch quotas represent the most direct form of control on catch. Each of the four RFMOs has imposed some form of control on catch. The form of the catch limits applied include:

- annual catch limits on purse seine catch of Bigeye Tuna (in total or on fish of a certain size) on FADs (IATTC); and/or
- annual catch limits on all or a portion of the fleet at the level of a previous period (IATTC, ICCAT and IOTC, WCPFC); and/or
- annual catch limits for specific national fleets of CPCs (IATTC, ICCAT); and/or
- a TAC for catch of Bigeye Tuna in the area of the RFMO (ICCAT).

Only IATTC and ICCAT have imposed specific quotas on certain CPCs. In those cases the quotas are temporary rather than representing a long-term allocation of a participatory right, as called for under Article 10 of the United Nations Fish Stocks Agreement[23] (UNFSA).

Experience with the implementation of catch limits for Bigeye tuna is not positive. In general:

- they have not been set at levels that restrict the catch to the extent required by the scientific advice; and/or
- their introduction has not reflected the urgency of the scientific advice; and/or
- the limits have not been adhered to.

Where catch limits have been imposed on CPCs there have been serious breaches of the limits. For example, in establishing the Multi-annual Conservation and Management Program for Bigeye Tuna in 2004, ICCAT acknowledged the over-catch of both Taiwan and China by reducing their annual allocation for 2005-2009 by 1600 t and 500 t respectively. In 2005, ICCAT reduced Taiwan's Bigeye Tuna quota for 2006 by a further 10 300 t per annum to 4600 t in response to "excessive catch and laundering activities in Bigeye fisheries…" (ICCAT, 2006c)[24].

The reports of ICCAT's Conservation and Management Measures Compliance Committee show that other countries/territories have also exceeded the limits set by ICCAT. For example, Ghana's average catch in 1991-92 (the benchmark against which catch should not increase)

[21]Trade documentation schemes are, technically, a mechanism for monitoring trade, rather than managing fishing mortality. They have been included in this discussion of management measures since they are significant element of the package of measures implemented in respect of Bigeye Tuna stocks to date.

[22]RFMOs use various terms to refer collectively to their contracting parties, entities and co-operating non-parties. The acronym CPC has been used throughout this report to refer to this grouping.

[23]Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.

[24]Taiwan's catch limit was reinstated for 2007 in recognition of its efforts to address enforcement of catch limits on its vessels.

Table 13: The history of management arrangements for Bigeye Tuna, by RFMO

RFMO/Management measure IATTC	Management Decision (year-no.) Resolutions[1]
1. Catch limit for small Bigeye Tuna in the EPO to be implemented by a closure of the purse seine fishery on floating objects	C-98-05* and C-99-06*
2. Prohibition on the use of tender vessels repairing, picking up or maintaining FADs at sea	C-98-10*
3. Transshipment of tuna on the high seas by purse seine vessels fishing for tunas prohibited	C-98-10*, C-99-07
4. The number of FADs that a purse seine vessel can carry aboard in the tuna fishery in the EPO limited	C-98-10*, C-99-07
5. Seasonal closure of fishery on FADs (not linked to a catch limit)	C-00-02*
6. Agreed to reduce EPO fishing capacity to 135 000 t by 1 January 2005	C-00-10*
7. Purse seine fishery that takes Bigeye Tuna to be closed if the catch of Bigeye Tuna of <60 cm reaches the 1999 level of such catch	C-01-06*
8. Seasonal closure of the purse seine fishery	C-02-04*
9. Reaffirmed the fishing capacity target set in 2000. Prohibited entry of new purse seine vessels except as replacements and subject to a limit on overall gross registered tonnage	C-02-03
10. Seasonal closure of the purse seine fishery for 2003 and 2004	C-03-12*
11. Statistical Document Program for Bigeye Tuna	C-03-01
12. CPCs to ensure that their annual longline catch in 2004 does not exceed that in 2001	C-03-12*
13. CPCs to chose one of two specified seasonal closures for purse seine fishing (2004-2006)	C-04-09*
14. Annual longline catch limits of Bigeye Tuna for the fleets of China, Japan, South Korea and Taiwan (2004-2006)	C-04-09*
15. Other CPCs to constrain their annual longline catch to the level of their 2001 catch or 500 t whichever is greater (2004-2006)	C-04-09*
16. Introduction of a program for transshipments by large scale fishing vessels	C-06-04
17. Extension of arrangements for seasonal closure and longline catch limits for 2007 (supersedes C-04-09)	C-06-02
ICCAT	**Recommendations[2]**
1. Bigeye Tuna size limit (minimum of 3.2 kg with a tolerance level of up to 15% per landing)	79-1*
2. Voluntary closed areas and seasons for the use of FADs by purse seine fleets of EU countries introduced in 1997*	98-1*
3. Closed areas and seasons for purse seine vessels operating on FADs	98-3
4. Limit on the no. of vessels of >24 m length overall of each CPC having taken more than 2000 t of Bigeye Tuna on average in the most recent 5 years, to the average no. of vessels having fished for Bigeye Tuna in 1991 and 1992 and subject to not exceeding the gross registered tonnage in those years	98-3
5. Specific catch limit and vessel number limit imposed for Taiwan	00-1*, 01-1*, 02-1*, 03-01
6. Limit on catch by each CPC (with catch in 1999 >2100 t of Bigeye Tuna) to their average catch taken in 1991 and 1992	00-1*, 01-1*, 02-1*, 03-01
7. Specific catch and vessel no. limits for Taiwan and China and vessel limit for the Philippines	00-21*, 03-19
8. ICCAT Bigeye Tuna Statistical Document Program	02-18*, 03-18, 04-14*, 04-15*
9. Trade restrictive measures on specific countries with relation to imports of Bigeye Tuna from these countries	04-01
10. Multi-annual Management and Conservation Program for Bigeye Tuna for 2005 to 2008: • Numbers of vessels of >24 m length overall of each CPC limited to average of 1991 and 1992; • The TAC set at 90 000 t/year (subject to change pending 2007 stock assessment); • Catch quotas established for China, the EU, Ghana, Japan, Panama and Taiwan;	05-02*

• Limits on the number of vessels by gear (longline and purse seine) for China, the Philippines, Taiwan and Panama; and • Closed areas and seasons for purse seiners	
11. Reduction in Taiwan's catch limit for 2006 under the Multi-annual Management and Conservation Program	05-06*
12. Introduction of a program for transhipments by large scale fishing vessels	06-11
13. Establishing a program of transshipment (supersedes 05-06)	

IOTC	**Resolutions[3]**
1. IOTC Bigeye Tuna Statistical Document Programme	01-06, 03-03
2. Request for non-members of IOTC to reduce their fishing effort in 2002 to 1999 levels	01-04
3. CPCs with more than 50 vessels on the 2003 IOTC Record of Vessels to limit, from 2004, the no. of fishing vessels >24 m length overall to the no. on the Record in 2003 and replacement vessels subject to not exceeding the gross registered tonnage of those vessels	03-01
4. Limitation of catch of Bigeye Tuna by CPCs to recent levels reported to the Commission and a request to Taiwan to limit annual Bigeye Tuna catch in the IOTC area to 35 000 t.	05-01
5. CPCs to limit vessels >24 m length overall, and <24 m length overall if fishing on the high seas, to the number notified to the IOTC in 2006 and replacement vessels subject to not exceeding the gross registered tonnage of those vessels	06-05
6. Introduction of a programme for transshipments by large scale fishing vessels	06-02
7. No resolutions specific to Bigeye Tuna were taken at the 2007 meeting of the IOTC	

WCPFC	**Resolutions/Conservation and Management Measures (CMMS)[4]**
1. Resolution to reduce, by the end of 2007, the overcapacity of developed CPCs that has been created since the resolutions on restricting expansion of effort and capacity were taken in 1999 by the participants to the Multilateral High Level Conference and in 2002 and 2003 by the PrepCon	Res. 2005-02
2. For 2006-2008, the longline catch of Bigeye Tuna for each CPC that took more than 2000 t in 2004, not to exceed the average annual Bigeye Tuna catch for the years 2001-2004 or the year 2004	CMM 2005-01
3. The longline catch of CPCs that took less than 2000 t of Bigeye Tuna in 2004 shall not exceed 2000 t in each of the years 2006-2008	CMM 2005-01
4. Purse seine effort levels not to exceed either 2004 levels or the average of 2001-2004 levels in waters under national jurisdiction[25]	CMM 2005-01
5. CPCs to develop and submit to the Commission plans for the use of FADs (anchored and drifting) within waters under national jurisdiction	CMM 2005-01
6. The capacity of fisheries for Bigeye Tuna using methods other than longline and purse seine (excluding artisanal fisheries and those taking less than 2000 t) shall not exceed the average level of 2001-2004 or 2004	CMM 2006-01
7. Purse seine effort levels of CPCs on the high seas not to exceed either 2004 levels or the average of 2001-2004	CMM 2006-01
8. CPCs to develop management plans for the use of FADs in areas beyond national jurisdiction to limit the interaction with Bigeye Tuna	CMM 2006-01
9. Prior to the 2007 meeting of the Commission, CPCs to develop and submit to the Commission plans to require purse seine vessels to retain on board and land all Skipjack, Yellowfin and Bigeye Tuna (except fish unfit for human consumption for reasons other than size) and including details of implementation and enforcement of these plans	CMM 2006-01

[1] IATTC resolutions are binding.
[2] ICCAT Recommendations are binding and ICCAT Resolutions are non-binding.
[3] IOTC Resolutions are binding and Recommendations are non-binding.
[4] WCPFC Conservation and Management Measures are binding and Resolutions are non-binding.
* Over time the measures identified have been superseded or removed. Those marked with an asterisk are no longer in force.

[25]An overall limit on the number of purse seine vessels operating in areas of national jurisdiction in the WCPO has also been implemented since 1993 under the Palau Agreement for the Management of the Western Pacific Purse Seine Fishery.

was 3478 t, yet in 2004 Ghana's catch was 1326 t over its limit. Also, the Netherlands Antilles, a co-operating non-contracting party until 2006, took between 2000 and 3000 t annually between 2001 and 2003 despite having no average catch for the period 1991-1992 (ICCAT, 2005b).

Effort and capacity limits

Each of the Bigeye Tuna RFMOs has implemented some measures to reduce capacity or effort. These have taken the form of:

- a cap on fishing effort of CPCs to that of a previous period (IOTC, WCPFC);
- a cap on the number of vessels of a certain size and total gross registered tonnage to that of a previous period (ICCAT, IOTC);
- a limit on vessel numbers for specific national fleets (ICCAT);
- a target for reductions in fishing capacity and limits on increases in the gross registered tonnage of the purse seine fleet (IATTC); and
- calling for reductions in purse seine capacity by an amount equivalent to that which has entered the fishery since previous resolutions calling for restraint (WCPFC).

ICCAT, IATTC and IOTC have each attempted to prevent further increases in capacity by establishing vessel registers and boat replacement policies that allow new vessels to be introduced only if they replace an existing vessel and do not increase gross registered tonnage. However the relationship between overall fishing capacity and catch is not necessarily strong. The use of capacity controls to influence overall catches of Bigeye Tuna is a coarse instrument and ignores, for example, the influence of improvements in fishing efficiency through adoption of new technology or fishing patterns. Constraints on capacity can be compensated for by fishing more days, setting more often or using new technology that improves efficiency. Thus, even if capacity is constrained, effort and catch may still increase. Gillet and Lewis (2003) have highlighted the deficiencies in using carrying capacity of purse seiners as a proxy for the ability to catch fish but noted that the appropriateness of doing so may differ according to the operational characteristics of the fleet and, that despite its deficiencies, no better proxy is available.

Measures that attempt to constrain effort, such as those implemented by IOTC and WCPFC are more directly linked to catch but suffer some of the same issues as catch limits, namely they can be ineffective if the MCS measures to enforce them are not in place. Also, such measures are not immune from the 'compensatory' issues associated with capacity limits. Controls on other forms of effort, for example vessel days, can still be countered by substitution with another input, for example, new technology.

In addition some effort controls fail to directly address the catch of Bigeye Tuna. For example, in the WCPO purse seine effort (days fished) is capped at 2004 levels however there is no constraint on the use of FADs within that cap. Since it is the use of FADs that increases the catch of juvenile Bigeye Tuna, this effort cap is unlikely to result in a reduction or even containment of the Bigeye Tuna catch in the WCPO.

Temporal and spatial closures

Time-area closures for purse seiners operating on FADs have been the most widely adopted measure for the purpose of reducing catches of Bigeye Tuna by FAD fishing. The IATTC and ICCAT have each adopted time-area closures for this purpose in an attempt to reduce catches of juvenile Bigeye Tuna. The IOTC has given consideration to the introduction of time-area closures but uncertainty about the long-term effect of a moratorium, and issues surrounding compliance of the purse seine fleets, have prevented agreement on the issue. However, three European organizations of frozen tuna producers implemented a voluntary time-area closure in 1999 in the Indian Ocean[26].

The enforcement requirements associated with ensuring compliance with time-area closures can be high depending on the nature of the closure. If, for example, the closure relates to the use of FADs, enforcement effectively requires the presence of observers on board all purse seine vessels to ensure that sets are not made on FADs in the time and area to which the closure relates. IATTC places observers on all trips made by purse seiners of more than 363 gross registered tonnes[27]. ICCAT recommends that its members place observers on purse seiners during the closed period. In the Indian Ocean and the WCPO the coverage of observers remains ad hoc. Apart from the costs associated with this requirement there may be logistical problems involved with accommodating observers on smaller purse seine vessels.

However, if the closure is a blanket closure on purse seining, then a VMS reporting to a central hub administered by the RFMO may be adequate for enforcement purposes.

[26]In an area from the African coast to 53°East, 5°South to 10°North.

[27]Observers are also required on purse seiners of less than 363 t gross registered tonnes if they have been identified as having intentionally set on dolphins.

However, many VMS operated by flag States report directly to those States and this involves reliance on flag State enforcement. Unfortunately, the VMS programmes agreed by IATTC, ICCAT and IOTC fail to acknowledge the best practice option of a centralised VMS, opting instead to allow flag States to be responsible for monitoring VMS data. In addition, these VMS apply only to vessels greater than 24 m length overall in IATTC and ICCAT and greater than 15 m length overall in the IOTC. Only the WCPFC has, as required by its convention, agreed to implement a centralised VMS, which will apply to all vessels greater than 24 m length overall fishing on the high seas in the Convention Area by 1 January 2008 and will apply to vessels of less than 24 m length overall by 1 January 2009[28].

An assessment by IATTC's Working Group on Stock Assessment of the closures to purse seine fishing in the EPO in 2004 and 2005 showed that the closures failed to reduce effort to the MSY level because of the growth in the purse seine fleet and because many vessels scheduled their normal maintenance during the closure period and would not have been fishing anyway (IATTC, 2007c). A 2006 meeting of the Group concluded that the current 6-week closure to purse seine fishing was inadequate for Bigeye Tuna conservation because there is too much fishing capacity in the EPO and that other management action in addition to the seasonal closure is required (IATTC, 2006d).

Bromhead *et al*. (2003) summarised an assessment of management measures to reduce catch of juvenile Bigeye Tuna in purse seine fisheries as follows:

"The use of time-area moratoria needs to be considered carefully. FADs contribute to overfishing effects but do not constitute the only gear contributing to these scenarios. In that case, should time-area moratoria be used on FAD fisheries or fishing all together? This will depend on the region and current status of fisheries and stocks. In addition, the time and area selected for a closure should also be extensively researched to ensure that the expected benefits are sufficiently large enough to compensate for the costs involved in implementing a moratorium."

Trade documentation schemes

Trade documentation schemes for Bigeye Tuna are in place in the IATTC, ICCAT and the IOTC. The WCPFC will consider a proposal for the introduction of a documentation scheme for Bigeye Tuna at its 2007 meeting. Each of the existing schemes identifies its objectives as improving the reliability of, or reducing uncertainty in, catch data and assisting in the elimination of IUU fishing.

Importantly, all of the statistical programmes for Bigeye Tuna track only product that enters international trade i.e., they are trade documentation schemes rather than catch documentation schemes and therefore don't cover domestically landed product. The comprehensiveness of the schemes is further compromised by:

- the exemption of Bigeye Tuna caught by purse seiners and pole and line (bait) vessels and destined principally for the canneries in the Convention Areas of ICCAT and IOTC and to all such product taken in the IATTC area and destined for canneries, regardless of their location; and
- the exemption of fresh Bigeye Tuna from the ICCAT, IOTC and IATTC schemes. In this respect it is interesting to note that between 2001 and 2004 the quantity of Bigeye Tuna product exported as fresh/chilled product increased from 651 t to 8448 t and the proportion of total exports of Bigeye Tuna exported as fresh/chilled product increased from 0.6% to 5%.

Given their failure to cover all components of catch, the trade documentation schemes in place for Bigeye Tuna are of limited value in verifying landings, and no value at all in estimating total mortality (including discards) of Bigeye Tuna.

All of the programmes for Bigeye Tuna rely on manual completion and submission of forms rather than electronic means. Electronic forms have been shown, for example in the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), to be more efficient, more cost effective and to minimise the opportunity for fraud. In 2006, ICCAT passed a recommendation encouraging CPCs to develop pilot projects to investigate the feasibility of electronic systems to improve ICCAT's statistical document programmes. ICCAT noted that electronic systems could improve these programmes through expediting cargo handling, increasing the ability to detect fraud and deter IUU shipments, facilitating more efficient exchange of information between exporting and importing parties, and encouraging automated links between national catch reporting and customs processing systems. While this is a positive step, the need for pilot projects, given CCAMLR's positive assessment and experience with such systems, and given that many members of ICCAT are also CCAMLR members, is unclear.

Further, there remains considerable variation between the documentation and operational characteristics of the existing three schemes. Given that the product monitored by each of these schemes is derived from the same species, is caught by the same methods and is destined for largely the same markets, the effectiveness

[28]This excludes vessels operating in the north-western quadrant of the WCPFC area. The date for application of the scheme to these vessels is yet to be determined.

of the schemes would be enhanced, and the scope for circumvention of the schemes reduced, by further harmonization.

Lack (2007) has examined the effectiveness of these and other catch and trade documentation schemes in place in RFMOs and some key findings of that study are summarised in Box 1.

One of the key objectives of the statistical document programmes in place for Bigeye Tuna is to combat illegal fishing. However, the failure of the schemes to cover all components of the catch also limits their capacity to deter IUU fishing.

Given their nature, estimates of IUU fishing are necessarily uncertain. However, there is a marked downwards trend in the estimates of IUU catch of Bigeye Tuna since the late 1990s. ICCAT estimates that IUU catch of Bigeye Tuna in the Atlantic Ocean had fallen from an estimated 25 000 t in 1998 to less than 2000 t by 2004 (ICCAT, 2006a). The IOTC notes that the number of vessels operating under flags of non-reporting countries has decreased markedly since 2001, although the reason for the decrease is not fully known (IOTC, 2006b). Bigeye Tuna catch data in IOTC's 'Not Elsewhere Included - Deep Freezing' category[29] suggest that IUU catch of Bigeye Tuna by longline vessels has dropped from around 17 000 t in 1998 to around 2000 t in 2005 (IOTC, 2007b). While the IATTC has established a list of vessels considered to be conducting IUU fishing in the EPO and has established a Statistical Document Program for Bigeye Tuna to combat IUU fishing, there is no indication that estimates of IUU catch are made on a regular basis in IATTC. Similarly, estimates of IUU fishing do not appear to be available for the WCPO.

Box 1: Lessons learned from the use of documentation schemes

- Significant improvements in estimates of fishing mortality can only be achieved through the use of schemes that apply at the point of harvest, i.e., catch documentation schemes.
- Meaningful estimates of total fishing mortality require the introduction of measures to supplement a catch documentation scheme in order to provide a reliable and timely record of catches, discards and other incidental mortality from commercial operations and, where relevant, mortality from recreational fishing.
- Documentation schemes must apply to all sectors of the fleet (regardless of size or gear), all forms of product (live, fresh, frozen, traded, for domestic consumption) and all stages of the catching, landing, transport, processing, trading and marketing chain.
- Trade documentation schemes, such as those in place in IATTC, IOTC and ICCAT, have failed to prevent IUU fishing or provide significant improvements in catch data since they monitor only subsets of the catch and of the supply chain.
- Where a documentation scheme is introduced by an RFMO the benefits will be enhanced by the adoption of consistent, and if possible standardized, schemes by other RFMOs managing relevant species (for example, across the tuna RFMOs).
- The effectiveness of documentation schemes will be enhanced by the adoption of complementary MCS measures, particularly standardized, centralized highly specified VMS, electronic documentation, port State controls and restrictions on transshipment.
- Ongoing monitoring of the patterns of trade is necessary to ensure that emerging gaps in the implementation of documentation schemes are addressed. This may require that members and co-operating non-members are required to implement species-specific and product-specific trade codes and are required to report all trade data to the RFMO annually.
- Electronic documentation can reduce the potential for abuse of documentation systems, improve the speed at which information can be exchanged and reduce the compliance burden on legitimate operators and regulatory authorities.

Source: Lack (2007).

[29]Catches of non-reporting longline vessels, estimated by the IOTC Secretariat using, in most cases, the number of vessels operating per year. Most of them are recorded operating under the flags of Honduras, Belize, Panama or Equatorial Guinea.

Other controls

Other attempts to reduce fishing effort on Bigeye Tuna and to reduce IUU fishing have included measures such as prohibiting at-sea transhipment, limiting the number of FADs that can be carried and prohibiting the use of tender vessels for servicing FADs. Such measures rely on reducing the efficiency of catching operations. The limitation on the number of FADs that can be carried appears only to have applied for one year in the IATTC, however the 1999 prohibition on at-sea transshipment and the use of tender vessels remain in place.

Only the IATTC has introduced a ban on transshipment by purse seine vessels in order to reduce Bigeye Tuna catch. While it is unclear to what extent this measure has contributed to this objective, Bromhead *et al*. (2003) note that it has facilitated monitoring of catch relative to quotas and supported timely data collection.

Prompted by concerns of laundering of IUU-caught tuna, including Bigeye Tuna, IATTC, ICCAT and IOTC have agreed to introduce programmes for transshipments by large scale fishing vessels, focusing initially on longline vessels. The programmes will effectively prohibit at-sea transshipment unless an observer is present. In parallel to this decision, these RFMOs have agreed to develop a centralised, independent observer programme to monitor compliance with the transshipment controls.

The impact of restrictions on use of supply vessels as a means of reducing the fishing effort of purse seine vessels is uncertain since it remains unclear whether supply vessels increase the efficiency and overall catch levels of purse seine vessels. Some research on this issue has been conducted in the Indian Ocean, but the results were not conclusive (Arrizabalaga *et al*., 2001).

Management of bycatch in Bigeye Tuna fisheries

As noted earlier in this report, the nature and extent of bycatch taken in Bigeye Tuna fisheries varies by method. The following analysis focuses on bycatch in longline fisheries for Bigeye Tuna. While purse seine fisheries take significant quantities of Bigeye Tuna this is largely as bycatch to targeted fishing for Skipjack and Yellowfin Tuna. Management of this bycatch has been discussed above as part of the overall management arrangements for Bigeye Tuna.

The main bycatch species in longline tuna fisheries are sharks, other finfish, turtles and seabirds. Of these groups, turtles and seabirds are discarded, either dead or alive. Many species of sharks are finned and their carcasses discarded. In recent years the four RFMOs responsible for Bigeye Tuna have implemented measures intended to reduce the incentive to capture shark for their fins by requiring that carcasses also be retained. Other finfish are retained or discarded depending on their market value.

Under the guidance of the FAO Code of Conduct for Responsible Fisheries, International Plans of Action (IPOAs) for the conservation of sharks and seabirds have been developed and Guidelines to reduce sea turtle mortality have also been developed by the FAO (FAO, 1998; FAO, 2000; FAO, 2004). While voluntary, the IPOAs call on States to implement National Plans of Action (NPOAs) and, on members of regional fisheries bodies, to develop Regional plans where required.

A summary of the major bycatch management initiatives in place in each of the RFMOs is provided in Table 14. Overall, there are few mandatory requirements imposed on members of RFMOs regarding mitigation of bycatch in Bigeye Tuna fisheries. Some individual members do, however, impose stricter requirements on their own fleets. For example, a number of countries/territories require the use of specific seabird bycatch mitigation measures on longline vessels operating in waters where the potential for interactions with seabirds is known to be high.

In the main, bycatch measures agreed by RFMOs have been framed around seeking voluntary collection and submission of data or encouraging research and development of mitigation measures. There are few measures in place that require the adoption of mitigation measures that will stem bycatch of threatened or high risk species in the short term or that will provide comprehensive and reliable data on bycatch in the longer term. Collection of data on bycatch is variable across the RFMOs and across sectors of the fleets catching Bigeye Tuna.

Table 14: The history of bycatch management measures in longline fisheries for Bigeye Tuna

RFMO/ Bycatch issue	Key management measure	Decision (year-no.)
IATTC		**Resolutions[1]**
Bycatch	• IATTC staff to develop a mechanism for estimating quantity and species of discards in the tuna fisheries of the EPO • IATTC develop and implement research plans for specified bycatch issues	C-99-11*
Seabirds	• CPCs to report status of their NPOA - Seabirds • CPCs encouraged to select and voluntarily provide data on interactions with Seabirds to the Commission • Where feasible and appropriate the Working Group on Stock Assessment to assess the impact of IATTC's fisheries on seabirds	C-05-01
Sharks	• IATTC staff to develop techniques to facilitate release of sharks from the deck or net, seek funds to determine the survival rates of released sharks, and define areas and periods in which shark species are most likely to be caught	C-04-05 (Rev. 2)
	• CPCs to establish an NPOA - sharks In relation to sharks caught in association with fisheries managed by IATTC: • Sought preliminary advice on stock status of sharks and a research plan for assessment of shark stocks • Fishers to fully utilise retained catches of sharks • Maximum weight of fins onboard shall not exceed 5% of the weight of sharks • Release of live sharks encouraged • CPCs to report data for catches, effort by gear type, landing and trade of sharks by species	C-05-03
Turtles	• CPCs to encourage the release of all sea turtles caught and report on the number and condition in which they are released to the extent practicable.	C-99-11*
	• CPCs encouraged to collect and provide data on interactions with turtles to the Commission and adopt measures to improve collection of scientific data on sea turtle bycatch • CPCs and IATTC should review available information and data regarding sea turtle biology, conservation measures and mitigation measures	C-04-07
	• Fishers required to promptly release unharmed, to the extent practicable, all sea turtles • Prohibit the disposal of plastic trash at sea • Ensure longline vessels carry necessary equipment for releasing sea turtles	C-04-05 (Rev. 2)
Finfish	• Identify areas of high bycatch of large pelagic fish of interest to the artisanal fishery, particularly Dorado *Coryphaena hippurus* • IATTC staff to develop techniques to facilitate release of billfish from the deck or net, seek funds to determine the survival rates of released billfish, define areas and periods in which billfish species are most likely to be caught	C-04-05 (Rev. 2)
ICCAT		**Resolutions/ Recommendations[2]**
Seabirds	• CPCs to implement the IPOA-Seabirds and advise the Commission of the status of their NPOA- Seabirds • CPCs to collect and voluntarily provide information on interactions with seabirds • When feasible and appropriate the SCRS should conduct an assessment of the impact on incidental catch of seabirds of ICCAT fisheries	Res. 02-14
Sharks[30]	CPCs to: • Encourage the release of live sharks that are caught incidentally, especially juveniles • Minimize waste and discards from shark catches	Res. 01-11
	• CPCs to provide information on shark catches, by effort or gear type, landings and trade	Res. 03-10
	In relation to sharks caught in association with fisheries managed by ICCAT: • CPCs to report data for sharks in accordance with ICCAT data reporting procedures • Fishers to fully utilise retained catches of sharks • Maximum weight of fins onboard shall not exceed 5% of the weight of sharks • Release of live sharks encouraged	Rec. 04-10,
Turtles	CPCs encouraged: • to trial circle hooks in pelagic longline fisheries • exchange ideas regarding safe handling and release of incidentally caught species • When feasible and appropriate the SCRS should assess the impact of circle hooks on the dead discard levels in ICCAT pelagic longline fisheries	Res. 05-08
Marlin	• By end 1999 reduce catch of both blue and white marlin by at least 25% each from the 1996 level • Promote the voluntary release of live blue and white marlin • Adopted a two phase program to rebuild blue and white marlin populations	Rec. 97-9*

[30]ICCAT has called for a reduction in fishing mortality of Shortfin Mako Shark, however this is regarded as a target, rather than a bycatch, species in ICCAT fisheries.

RFMO/ Bycatch issue	Key management measure	Decision (year-no.)
IOTC		**Resolutions[3]**
Seabirds	• Commission will develop a mechanism to enable CPCs to record and exchange data on seabird interactions • CPCs to collect and provide all available information on interactions with seabirds • CPCs shall seek to achieve reductions in levels of seabird bycatch through the use of effective mitigation measures • Vessels fishing south of 30°S shall carry and use bird scaring lines (tori poles)	Res. 06-04
Sharks	In relation to sharks caught in association with fisheries managed by IOTC a binding resolution that: • CPCs to report data for sharks in accordance with ICCAT data reporting procedures • Fishers to fully utilise retained catches of sharks • Maximum weight of fins onboard shall not exceed 5% of the weight of sharks • Release of live sharks encouraged • Scientific Committee to provide preliminary advice in 2006 on the stock status of key shark species and propose a research plan and timeline for a comprehensive assessment of stocks	Res. 05-05
WCPFC		**Resolution/ Conservation and Management Measures[4]**
Seabirds	• CPCs to implement the IPOA-Seabirds and to report annually to the Commission on its implementation including the status of their NPOA-Seabirds • CPCs to require their longline vessels to use at least two of a group of specified mitigation measures when operating in areas south of 30°S (from 1 January 2008 for vessels > 24 m length overall and from 1 January 2009 for vessels < 24 m) and north of 23°N (by 30 June 2008 for vessels greater than 24 m) and advise the Commission of the measures adopted • Commission will adopt in 2007 minimum technical specifications for mitigation measures • CPCs to provide the Commission with all available information on interactions with seabirds	CMM 2006-02
Sharks	In relation to sharks caught in association with fisheries managed by WCPFC and to sharks listed in Annex 1 of UNCLOS: • CPCs to implement the IPOA-Sharks and to report annually to the Commission on its implementation including the status of their NPOA-Sharks • Fishers to fully utilise retained catches of sharks • Release of live sharks encouraged • CPCs to report data for key shark species in accordance with the WCPFC convention and agreed reporting procedures • Maximum weight of fins onboard vessels of more than 24 m length shall not exceed 5% of the weight of sharks	CMM 2006-05
Non-target finfish	• CPCs shall encourage their vessels operating in fisheries managed under the WCPFC Convention to avoid to the extent practicable, the capture of all non-target fish species that are not to be retained • Any such non-target fish species that are not to be retained, shall, to the extent practicable, be promptly released to the water unharmed.	Res. 2005-03
Sea turtles	• CPCs to implement, as appropriate, the FAO Guidelines to Reduce Sea Turtle Mortality in Fishing Operations • CPCs encouraged to collect and provide the WCPFC with data on interaction with sea turtles in fisheries managed under the WCPFC • CPCs to enhance the implementation, and conduct further trials, of turtle mitigation measures • CPCs urged to require specific mitigation measures by purse seine vessels	Res. 2005-04

1. IATTC resolutions are binding.
2. ICCAT Recommendations are binding and ICCAT Resolutions are non-binding.
3. IOTC Resolutions are binding and Recommendations are non-binding.
4. WCPFC Conservation and Management Measures are binding and Resolutions are non-binding.

* Over time the measures identified have been superseded or removed. Those marked with an asterisk are no longer in force.

The relevant advisory bodies on bycatch in both the IOTC and the WCPFC have highlighted the important role of observer programmes in delivering reliable data on the nature and extent of bycatch in tuna fisheries as well as for verifying mortality of target species, including discards. In 2006 the WCPFC, in accordance with Article 28 of its Convention, agreed to the development of a Regional Observer Programme, for adoption in 2007. The Programme will consist of independent and impartial observers authorized by the secretariat of the WCPFC. The Convention requires that the Programme collect verified data, other scientific data, additional information related to the fishery in the Convention Area and monitor implementation of conservation and management measures.

The IATTC, driven by high levels of dolphin mortality, has implemented full observer coverage of the purse seine fleet (with the exception of small purse seiners of less than 363 t gross registered tonnage) and this provides comprehensive and reliable data on that sector of the fishery. However, there are very few data collected on non-target and associated species in the longline sector of the fishery. The IATTC's Working Group on Bycatch has recently recommended that consideration be given to making the provision of seabird bycatch data from tuna longliners mandatory (IATTC, 2007d). In ICCAT there is no mandatory observer coverage and resolutions on seabirds, sharks and turtles merely request the submission of data on catch of these species.

The IOTC has agreed to collect data on non-target and associated species. However the IOTC Working Party on Bycatch noted in 2006 that "to date, the IOTC secretariat has not received any reports from members or co-operating parties on the amounts of seabirds, sea turtles or other fauna incidentally caught by their vessels" (IOTC, 2006c). Observer coverage in the IOTC area is ad hoc and provides no basis for estimation of overall catch of non-target species.

Sharks are caught as a bycatch in all the tuna longline fisheries. This is a Silky Shark, caught in the WCPO. © WWF-Canon / Cat Holloway.

Bigeye Tuna

The absence of explicit management objectives and, in particular, target and limit reference points for Bigeye Tuna stocks, does not facilitate assessment of the effectiveness of management measures. As noted by Maunder and Harley (2006) "….the management objectives for tuna stocks in the EPO and elsewhere are quite vague. Maximising yield as modified by other factors, while taking into consideration the precautionary approach, allows considerable flexibility in interpreting them." Despite the lack of specificity in the overarching management objectives across the tuna RFMOs the concept of MSY as an objective is either explicitly included in the stated objectives of the RFMO or can be implied, from the formulation of the scientific advice and its subsequent consideration by the Commission, as an objective.

The ultimate test of the effectiveness of management of Bigeye Tuna is the status of the stocks. Annex II of the UNFSA, which should guide most members of the tuna RFMOs who are signatories to the agreement, specifies the following in relation to precautionary reference points:

".. the fishing mortality which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For stocks which are overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield and that the biomass does not fall below a pre-defined threshold. For overfished stocks, the biomass which will provide maximum sustainable yield can serve as a rebuilding target."

This implies that F_{MSY} and B_{MSY} should be the limit reference points. If $F_{CURRENT}$ is equal to or greater than F_{MSY}, overfishing is occurring and if $B_{CURRENT}$ is equal to or less than B_{MSY}, the stock is overfished. As described above, the best scientific advice available indicates that all Bigeye Tuna stocks are considered at least fully exploited or overfished and overfishing is occurring in at least three of the four stocks. At this level, it is clear that management has generally failed to ensure that Bigeye Tuna stocks are fished sustainably. The limit reference point for fishing mortality has been breached in the EPO, the WCPO and the Atlantic, and in the EPO the limit reference points for both fishing mortality and biomass have been breached.

There is a great deal of uncertainty in the stock assessments for Bigeye Tuna. However, there is no evidence that a precautionary management approach has been adopted in response to this uncertainty. In short, members of RFMOs that are parties to the have failed to meet their legal obligation under that Agreement to take a precautionary approach to conservation and management of Bigeye Tuna.

Maunder and Harley (2006) have tracked the effect on Bigeye Tuna fishing mortality arising from the decisions taken by the IATTC in response to the scientific advice between 2000 and 2004. This summary is reproduced in Table 15. It shows that in four of those years the management response resulted in levels of fishing mortality of up to 60% higher than the levels recommended. In the one year where fishing mortality fell it was by 10% rather than the recommended 30-60%.

It is also possible to assess the effectiveness of the measures implemented for Bigeye Tuna against the specific stock issues that they were intended to address. An examination of the scientific advice, and the wording of the resolutions/recommendations adopted for Bigeye Tuna by the four RFMOs, suggest that three key objectives were pursued by the management measures implemented:

1. To reduce the overall catch of Bigeye Tuna, including IUU catch;
2. To reduce the catch of juvenile Bigeye Tuna; and
3. To reduce uncertainty in the catch data for Bigeye Tuna.

In relation to the first two objectives, effectiveness can be assessed against whether management achieved the reductions in the overall and/or juvenile catch of Bigeye Tuna that were recommended on the basis of the best available scientific advice at the time. This will depend on factors including:

- whether the limits set reflected the scientific advice;
- the extent of delay between receipt of the advice and its implementation;
- whether the management measures were implemented by member States;
- the effectiveness of the MCS regime of the RFMO and member States in ensuring that such limits were complied with; and
- how well the management measure addressed the underlying issue.

It should be noted that analysing trends in total and juvenile catch of Bigeye Tuna will not necessarily provide a meaningful indication of the success or otherwise of management measures. These trends can be influenced by other factors, only some of which may be under the control of the RFMOs. For example, changes in fishing and targeting patterns may occur in response to changes in market demand or operating costs. Similarly, the catch of Bigeye Tuna may be influenced by changes to

Table 15: Impact of management on fishing mortality of Bigeye Tuna in the EPO

Year of assessment	Stock assessment conclusion	IATTC staff recommendation (includes action for all species)	Conservation measures adopted	Effect on bigeye fishing mortality
2000	Assuming a moderate spawner-recruitment relationship, fishing mortality should be kept at 1999 levels	No recommendation for bigeye; catch quota for yellowfin	3-mo closure of the floating object fishery	Fishing mortality increased 57% from 1999 levels
2001	Assuming a moderate spawner-recruitment relationship, fishing mortality should be reduced (10%) from 2000 levels	Limitation of fishing effort to current levels	Closure of floating object fishery if catches of small bigeye reach 1999 levels, but not before November 2001; no closure occurred	Fishing mortality increased 4% from 2000 levels
2002	Assuming a moderate spawner-recruitment relationship, fishing mortality should be kept at 2001 levels	Closure of the floating-object fishery if small bigeye catches reach 1999 levels; complete EPO closure for December 2002	Complete closure of the EPO for December 2002	Fishing mortality increased 59% from 2001 levels
2003	Fishing mortality must be reduced substantially (20-50%) from levels observed in 2000 and 2001	Complete EPO closure for 2 mo, plus 2-mo closure of an area of high bigeye catches; reduction of longline catches to 2000 levels	Closure of a smaller region (than proposed) for December 2003; longline catches reduced to 2001 levels	Fishing mortality increased 33% from 2000-2001 levels
2004	Fishing mortality must be reduced substantially (30-60%) from levels observed in 2001 and 2002	Complete EPO closure for 2 mo, plus a 6-mo closure of an area of high bigeye catches or of an areas for floating object sets or 500 met individual vessel catch limits; reduction of longline catches to 2000 levels	Complete closure of the EPO for 6 weeks (agreed upon in October 2003); longline catches reduced to 2001 levels	Fishing mortality decreased 10% from 2001-2002 levels.

Source: Maunder and Harley, 2006.

management measures not directed at Bigeye Tuna, for example the shift in purse seine sets from dolphins to FADs, and highly variable recruitment may also affect the purse seine catch of Bigeye Tuna. Further, reductions in catch over time may reflect stock decline rather than the effectiveness of management. However, if the measures were successful it would be reasonable to expect that catches did not increase above the levels recommended by the scientific advice.

Data on a number of indicators, including numbers of total Bigeye Tuna catch, vessels, capacity (m^3), number of longline hooks set, number of purse seine sets on floating objects and retained Bigeye Tuna catch from those sets, have been compiled for each of the RFMOs for the period from 1990. These data are presented in Appendix B.

The data show, for example (see Table B1), that it is not surprising that the stock in the EPO has continued to deteriorate. In 1999 the scientific advice recommended that catch of Bigeye Tuna by purse seine vessels should be constrained to 1998 levels (42 000 t), however the retained Bigeye Tuna catch of the purse seine fleet peaked in 2000 at around 91 000 t. In 2004, the IATTC was advised that total catch of Bigeye Tuna should be

Table 16: IOTC management response to scientific advice on Bigeye Tuna

Year	Scientific Advice on Bigeye Tuna	Management Response
1999	Immediate management action required Immediate cessation of the increase in catches of the stock by all gears Cessation of the increase in catch of small Bigeye Tuna associated with floating objects	Resolution 99/01 • undertook to consider in 2000 the limitation of capacity • asked the Scientific Committee to recommend to the 2000 meeting the optimum fishing capacity and to specify seasonal/area closures for purse seine fishing on FADs
2000	Provided requested advice	No decision on a reduction in longline capacity No decision on a moratorium on purse seine fishing on FADs
2001	A reduction in catches of Bigeye Tuna from all gears, eventually to the level of MSY be started as soon as possible	No decision on a reduction in longline capacity No decision on a moratorium on purse seine fishing on FADs Agreed to establish a Bigeye Tuna Statistical Document Programme
2002	It is likely that catches are well above MSY and a reduction in catches from all gears, eventually to the level of MSY, be started as soon as possible	The Commission sought further advice from the Scientific Committee on potential management measures to reduce fishing mortality on juvenile Bigeye Tuna and other measures to maintain or reduce fishing effort on Bigeye Tuna
2003	Provided requested advice Noted that catches had declined and were closer to estimated MSY levels but that there was uncertainty about the level of SSB corresponding to MSY Recommended a reduction in catches from all gears	Agreed on measures to limit overall capacity in the fleets of IOTC members from 2004, acknowledging that this measure would not necessarily limit fishing effort Agreed to develop Terms of Reference for a Working Group of the Commission to meet in 2005 to consider the conservation and management options that may be applicable to the highly migratory fish stocks of the Indian Ocean
2004[31]	A reduction in catches from all gears, eventually to the level of MSY, be started as soon as possible and that fishing effort should be reduced or at least, it should not increase further.	Agreed to establish an IOTC record of vessels authorized to operate in the IOTC area as a means of addressing IUU fishing Agreed to limit catches of Bigeye Tuna by CPCs to levels of 'recent years' from 2006. Agreed that the Commission would develop, in 2006, catch limits for countries with annual catch of Bigeye Tuna in excess of 1000 t
2005	A reduction in catches from all gears, eventually to the level of MSY, be started as soon as possible and that fishing effort should be reduced or at least, it should not increase further.	The issue of setting catch quotas for Bigeye Tuna was discussed and the Commission agreed that such an approach is highly complex and more work was needed to develop the concept. Agreed that, from 2007-2009, CPCs should limit the number of their vessels, by gear type, to the number of vessels notified to IOTC in 2006, and replacement vessels will be subject to the corresponding gross registered tonnage of that year.
2006	Catches should not exceed the MSY and fishing effort should not increase further from the 2004 levels	The 2007 meeting of the IOTC did not pass any resolutions relating to Bigeye Tuna.[32]

[31]The IOTC did not meet in 2004 and the advice of the 2004 meeting of the Scientific Committee was considered by the Commission in June-July 2005.
[32]The report of the 2007 meeting of the IOTC was not available at the time of writing.

reduced by 50%. However between 2002 and 2006, total catch of Bigeye Tuna in the EPO declined by only 24%. Since 1999 the number of purse seine vessels operating in the EPO has increased from 203 to 225 and purse seine capacity has increased from 180 000 m^3 to 225 000 m^3. In the same period the number of purse seine sets on floating objects, where Bigeye Tuna catch is more likely, was generally stable but between 2005 and 2006 increased from 5763 to 8226. Longline fishing effort for Bigeye Tuna increased from 169 million hooks in 1999 to a peak of 324 million in 2002, but declined to 171 million by 2005. The overall conclusion is that the measures implemented by IATTC have not been capable of delivering the reductions in catch that the best available scientific advice recommended in order to sustain or rebuild the stock. Maunder and Harley (2006) note, in relation to the IATTC's management of Bigeye Tuna, "substantial management recommendations for conservation of Bigeye Tuna, based on MSY-related management quantities estimated from the stock assessment, were made in 2003 but the IATTC decided on less restrictive management action. The 2004 stock assessment indicated the need for even more restrictive management action, but the IATTC again decided on less restrictive action. The results of the Bigeye Tuna stock assessment suggest that the management measures adopted were insufficient to produce the desired management objectives."

This view has been supported by a recent meeting of an IATTC group considering management options. The group noted that between 2003 and 2006 the management measures applied by the IATTC were less restrictive than recommended by the scientific advice (IATTC, 2007c).

In the IOTC the situation appears more stable (see Table B4) with the numbers of purse seiners and purse seine carrying capacity remaining relatively constant over the last decade. However, both the total and the purse seine catch of Bigeye Tuna have fallen markedly since peaking in 1999. Since this fall cannot be attributable to management action to constrain catch or effort it raises serious questions about the state of the Bigeye Tuna stock in the Indian Ocean. The catch of Bigeye Tuna in the Indian Ocean peaked in 1998 at around 150 000 t and recent catches have fallen to around 130 000 t (IOTC, 2006b).

While the experience of the IATTC suggests inadequacy of management arrangements, the experience of the IOTC is largely one of inaction. For example, it took five years before any management was implemented in response to scientific advice recommending immediate management action on Bigeye Tuna (see Table 16). Even then the management action was not specific to Bigeye Tuna and was acknowledged by the Commission as being unlikely to reduce effort. Eight years after the advice recommending action to reduce the catch of juvenile Bigeye Tuna by purse seine operations on FADs, no management measures have been implemented.

In the Atlantic Ocean, catch of Bigeye Tuna and the number of both longliners and purse seiners operating fell markedly between the late 1990s and 2005 (see Table B3). Catch has almost halved since that time and there have been falls of over 50% and 70% in the numbers of reported longliners and purse seiners. It is difficult, however, to determine the cause of the reduction in effort and catch. Have the management measures introduced by ICCAT since the late 1990s driven reductions in effort and catch or have the operators responded to lower levels of abundance by diverting their vessels elsewhere?

In response to these questions it is interesting to note the SCRS's finding that "The 2003 and 2004 total reported catch for the major countries and fishing entities to which the catch limit applies (EC-Spain, EC-France, EC-Portugal, Japan, Ghana, China and Chinese Taipei) were 67,000 t and 59,500 t, respectively. These were much lower than the total catch limit of (84,200 t) for these countries/entities." (ICCAT, 2006a). This suggests that abundance, rather than management measures, has been driving reductions in catch.

While the experience of the WCPFC is limited, to date, voluntary calls for restraint appear to have had little or no impact on catches of Bigeye Tuna in the WCPO. The number of vessels operating and the total Bigeye Tuna catch have increased since calls were first made in 1999 for restraint in increases in fishing capacity (see Table B2). Gillet and Lewis (2003) estimated that the total carrying capacity of purse seine vessels participating in the WCPO fishery grew from around 200 000 m^3 to 233 000 m^3 between 1995 and 2003. While the data suggest that the number of active purse seine vessels in the WCPO has more than trebled between 1999 and 2005, this increase is largely a result of increases in the number of small scale vessels operating in national waters rather than in the distant water fleet (Langley *et al*., 2006).

The total catch of Bigeye Tuna in the WCPO increased from around 110 000 t in the late 1990s to 128 000 t in 2004. In 2005 the reported catch increased significantly to 157 000 t however this may reflect a change in the reporting of Indonesian catch. While the total purse seine catch of Bigeye Tuna in the WCPO fell from a peak of 37 000 t in 1999 to between 22 000 t and 32 000 t from 2000 to 2004, it increased to a record 44 000 t in 2005. However, given the overall increase in Bigeye Tuna catch, the proportion of the catch taken by purse seine fell from around 32% in 1999 to 28% in 2005.

Since 1999, Taiwan, one of the catching countries/territories party to the calls for restraint in the WCPO, has increased its longline fleet in the WCPO from 78 to

142 vessels, or by 80% between 2000 and 2003 and has diverted considerable effort from albacore to targeting Bigeye Tuna (Williams and Reid, 2006).

In general, RFMOs have acted with insufficient haste and insufficient precaution in managing Bigeye Tuna. They have implemented and persisted with measures in the full knowledge that these measures have little chance of achieving their stated objectives or they have failed to implement management measures. Most members of RFMOs are bound by obligations imposed by the UNFSA. They have clearly failed to meet those obligations in relation to Bigeye Tuna.

In addition, there is an apparent unwillingness or inability on the part of some members and co-operating non-members to enforce regionally agreed measures on their flag vessels. Reliance on flag State MCS measures has been identified as a major deficiency across RFMOs (see, for example, Willock and Lack, 2007; High Seas Task Force, 2007). The experience of Bigeye Tuna only serves to reinforce the need for MCS measures to be agreed and enforced centrally and for additional measures that support RFMO and flag State efforts with port and market State enforcement of management measures.

RFMO members are inconsistent across RFMOs in relation to their support for binding and effective conservation and management measures. A member might, for example, support a centralized VMS, an independent observer programme, a catch, rather than trade, documentation scheme and/or comprehensive bycatch mitigation measures in one RFMO to which they are a party. However, they fail to apply the same rationale in other RFMOs in which they participate, and may in fact lead the opposition to adoption of such measures. This inconsistency suggests that objectives other than sustainability are being pursued in some cases.

In addition, in areas such as the WCPO where much of the Bigeye Tuna stock is found in waters under national jurisdiction, the legitimate development aspirations of developing island States and the reliance on access fees paid by distant water fishing nations, acts as a disincentive to take strong management measures and to the application of domestic measures that are consistent with those adopted for the high seas.

Bycatch

Fisheries for Bigeye Tuna have broader ecosystem impacts. The most significant of these are considered to be impacts on seabirds, sharks, turtles and other finfish. An assessment of the effectiveness of Bigeye Tuna management must therefore include an analysis of the effectiveness of measures to mitigate these impacts. As discussed above, there remain serious concerns about the bycatch of seabirds, sharks and turtles particularly in the longline sector of Bigeye Tuna fisheries. Much of this concern stems from the lack of credible and comprehensive data on interactions with these species.

Seabirds

Three of the four RFMOs have in place resolutions relating to seabird bycatch. The IATTC and ICCAT impose no binding obligations on members in relation to seabird bycatch only 'encouraging' data collection. The IOTC and the WCPFC require the use of specified mitigation measures for seabird bycatch. The IOTC's measures currently represent the minimum standards, requiring only the use of tori poles while the WCPFC's measures are more comprehensive requiring, by 2008, the use of at least two mitigation measures. The IOTC has, however, undertaken to consider, in 2007, the application of the measures implemented by CCAMLR[33]. CCAMLR has the most comprehensive seabird bycatch mitigation measures of any of the RFMOs (see Croxall, *et al*., in press). Given that there is a significant overlap of membership between CCAMLR and the RFMOs responsible for Bigeye Tuna it would seem logical to assume that those members would support these measures. However, as noted above, members are often inconsistent in their approaches across RFMOs.

Sharks

Each of the four RFMOs has in place resolutions relating to shark bycatch. IATTC, ICCAT, IOTC and WCPFC have adopted very similar resolutions on sharks. These resolutions purport to reduce mortalities by providing a disincentive for 'finning'[34] sharks. However, these resolutions are flawed and require significant revision if they are to be provide any effective protection to vulnerable shark species (see Lack, 2007). None of the Bigeye Tuna RFMOs have implemented measures that require their members to adopt specific mitigation measures that have a high probability of ensuring that shark mortalities from longline fishing are reduced, such as banning the retention of shark fins or the targeting of sharks.

Further, the measures implemented to date apply generically to 'sharks' and fail to positively discriminate in favour of protection of more vulnerable shark species. This reflects, in part, the lack of information available to RFMOs on the species composition of sharks taken by vessels operating under their authority and on the status of stocks of shark species regularly taken in their fisheries.

[33]The IOTC did not pass any resolutions on seabirds at its 2007 meeting.

[34]Finning refers to the practice of removing and retaining the fins and discarding the carcass of the shark.

Turtles

There are no binding measures in place to reduce the catch of endangered species of turtles by longliners targeting Bigeye Tuna. This is despite the available information, which suggests that the use of circle hooks rather than the traditional 'J-shaped' hook can significantly reduce turtle bycatch. For example, the 2006 meeting of the Scientific Committee of the WCPFC noted that:

"i. New information presented at the Ecosystem and Bycatch SWG confirms previous understanding of the efficacy of circle hooks in reducing hook ingestion by sea turtles and the efficacy of large sized circle hooks in reducing turtle bycatch.

ii. Some of the new results have indicated variations in catch rates with some sizes of circle hooks, e.g. reduced target species catch rates. This is also similar to previous findings.

iii. The magnitude of impacts on sea turtle bycatch and target species catch varies between the studies conducted to date.

iv. Notwithstanding the above, results presented to the Ecosystem and Bycatch SWG clearly show that a specifically designed management regime employing sea turtle bycatch mitigation measures, such as circle hooks and fish baits, applied to a fishery sector with a turtle bycatch problem can substantially reduce sea turtle bycatch while maintaining viable target species catch rates." (WCPFC, 2006b)

However, the impacts of the use of circle hooks on other bycatch species remains uncertain. Read (2007) suggests that further analyses is required to examine the potential effects of circle hooks on non-target species and to ensure that their use does not have adverse consequences for other taxa. This finding has been supported by the ICCAT Sub-committee on Ecosystems, which reviewed the use of circle hooks in February 2007. The Sub-committee noted, among other things that the impact of the hook on bycatch species and target species can vary according to the shape (degree of offset) of the circle hook and the bait used. The Sub-committee concluded that:

"Overall, the Sub-Committee felt that the results of the studies reviewed during the meeting are encouraging and that, in general, the use of circle hooks tend to reduce mortality of species incidentally caught and released from longlines. The Sub-Committee encourages the continuation of these types of studies since it is not clear that use of circle hooks alone, is the best technological solution to minimizing bycatch while maintaining productive fisheries in all cases." (ICCAT, 2007c)

Finfish

Table 14 indicates there are few examples of RFMO measures to restrict bycatch of other finfish species.

The causes of management failure

Why has management failed to protect Bigeye Tuna stocks and key bycatch species associated with fisheries for Bigeye Tuna? Factors that might contribute to management failure include the:

- level of knowledge and data on stocks and fisheries;
- quality of the scientific advice;
- existence and functionality of management infrastructure;
- extent to which decision makers are bound by international law;
- extent to which legal obligations are upheld; and the
- complexities of managing multiple species of varying productivity.

A brief analysis of the relevance of those factors in explaining the poor management outcomes is provided below.

The level of knowledge and data on stocks and fisheries

As noted above, the modelling underlying Bigeye Tuna stock assessments is relatively new and continues to evolve. Further, there remain considerable uncertainties about key parameters of the models for Bigeye Tuna stock assessment and there is ongoing concern about the accuracy and timeliness of catch and effort data provided by members of RFMOs.

The poor quality and lack of timeliness of data submitted by RFMO members on both target and non-target species, constitutes a significant element of uncertainty in stock assessments. Resolution of this issue is within the power of RFMO members yet many fail to meet their obligations in this respect suggesting that reducing uncertainty is not high on their list of priorities. This might be acceptable if those members were prepared to accept that the trade-off for not reducing uncertainty is more precautionary management. There is no evidence of such acceptance.

In any case, the UNFSA's requirement to apply the precautionary approach and to act on the basis of the best available scientific advice acknowledges the inherent uncertainties in fisheries management and specifies the approach to deal with this. Uncertainty is therefore not a legitimate excuse for poor management outcomes.

Many of the members of the RFMOs responsible for management of Bigeye Tuna have had considerable experience in the management of other, similar species, particularly of Atlantic and Southern Bluefin Tuna. Japan, Australia and New Zealand were founding members of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) in 1994 and had worked together informally since the 1980s to manage the stock. South Korea and Taiwan are more recent participants in that forum. Each of these members is also a member of at least one, and in the case of Japan and South Korea, all four of the RFMOs responsible for Bigeye Tuna. The SSB of Southern Bluefin Tuna has been below the agreed target 1980 level for at least 20 years. CCSBT's attempts to rebuild the stock to 1980 levels by 2020 have been abandoned as a lost cause. Despite reductions in catch in the 1980s the SSB has continued to decline. Disputes about the status of the Southern Bluefin Tuna stock arising from uncertainty and lack of information dogged the CCSBT for years and are largely responsible for the failure of the Commission to reduce the TAC between 1988 and 2006.

ICCAT is also responsible for management of Atlantic Bluefin Tuna. Despite management of this species since the mid-1970s the most recent assessment indicates that overfishing is occurring in both stocks and that the SSB of the Eastern and Western stocks are at 48% and 18% respectively of SSB in ICCAT's agreed reference years (ICCAT, 2007d). All members of ICCAT have first hand experience of the consequences of delayed and inadequate management and around half of ICCAT's members are also members of other RFMOs responsible for management of Bigeye Tuna.

Given the experience with the management of bluefin tunas and the overlap in management responsibility for the bluefin tunas and Bigeye Tuna there should be no uncertainty in the minds of members of the RFMOs as to consequences of poor management of these tuna species. Yet this experience has not resulted in more precautionary management of Bigeye Tuna.

The quality of the scientific advice

The scientific advice provided to RFMOs on Bigeye Tuna is generally clear, specific about the uncertainties and reflects a precautionary approach with regard to appropriate management responses. Further, there is little doubt as to the credibility of the advice provided. The records of the relevant RFMOs record no dispute about the scientific advice provided to the members. In some fora, for example IATTC, the advice developed by the scientific staff is reviewed by scientists from members prior to going to the Commission and this provides a strong peer review process. Similarly, in the WCPFC, the advice of the SPC's Oceanic Fisheries Programme is reviewed by the Scientific Committee. In ICCAT and IOTC the advice is provided by scientific representatives of members in the Scientific Committee however the reports emerging from these Committees appear to be unanimous in their assessment of the stock status. Further, stock assessment methodologies for Bigeye Tuna have been examined and peer reviewed by stock assessment experts from around the world in 1996 and 2004 at the First and Second World Meetings on Bigeye Tuna respectively.

There appears to be little scope to attribute the poor status of Bigeye Tuna to the quality of the scientific advice provided to members of RFMOs.

The existence and functionality of management infrastructure

RFMOs responsible for management of Bigeye Tuna have been in place in the EPO since 1950 and in the Atlantic Ocean since 1969. While Bigeye Tuna fisheries have been operating in the Indian Ocean since the early 1950s and the WCPO since at least 1950, the IOTC did not come into force until 1996 and the WCPFC until 2004. However, there seems little positive correlation between the status of the stocks and the length of time that management has been in place. On the contrary, in the EPO, where the RFMO has been in operation for the longest period, the status of the Bigeye Tuna stock is worse than in other Oceans.

While it must be acknowledged that the management mandates of the four RFMOs vary and, reflect to some extent the thinking about fisheries management at the time they were established, this does not excuse the members of RFMOs for failing to live up to their individual obligations imposed under more recent international law and protocols or for failing to ensure that RFMOs of which they are party are structured, both legally and operationally, to reflect current international laws and protocols.

Willock and Lack (2006) examined the experiences of a number of RFMOs, including those responsible for Bigeye Tuna, to identify impediments to positive management outcomes. The analysis found that the following factors contributed to poor performance:

- reliance on consensus decision making for adoption of conservation and management measures;
- allowing members to 'opt out' of conservation and management measures;
- failure to agree on the basis for the allocation of fishing opportunities between members and how new members will be accommodated;

- lack of collaboration, exchange of information and consistency in compliance and enforcement measures between RFMOs sharing management responsibility for the same species and/or overlapping geographical areas;
- reliance on flag State enforcement of conservation and management measures;
- lack of agreed sanctions in response to failure of members to comply with conservation and management measures;
- absence of agreed management strategies based on precautionary reference points; and
- the lack of agreed standards for the collection and verification of data and the lack of data collection on non-target and associated species and broader ecosystem impacts.

The examination of the management of Bigeye Tuna contained in this report suggests that many of these factors have contributed to poor management outcomes. In particular, the absence of agreed management strategies[35] (see Box 2) based on precautionary reference points, the lack of comprehensiveness and reliability of data on target and non-target species and reliance on flag state enforcement have emerged as common elements underlying management of Bigeye Tuna. It is more difficult to gauge the extent to which failure to agree on effective management is attributable to factors such as consensus decision making. It is notable, however, that the records of discussion of the various Commissions indicate that some members have sought more rigorous conservation and management measures for both Bigeye Tuna and non-target species than have subsequently been implemented. The extent of support for such views is not necessarily clear from the record of discussion. However, both logic and experience to date across all RFMOs suggest that requirements for consensus decision making, and/or opportunities to opt-out of decisions significantly reduce the likelihood that sufficiently precautionary conservation and management measures will be agreed and/or will be effective.

Long-term allocations of catch quotas for Bigeye Tuna have not yet been made in any RFMO. The 2006 decision of the IOTC to defer such a decision pending further consideration is indicative of the complexity involved in decisions on allocation of rights to fish. Catch quotas are likely to have a significant, but not exclusive, role in effective longer term management of Bigeye Tuna. In the absence of agreed criteria upon which allocation decisions will be made amongst members and co-operating non-members and for accommodating the interests of new members, it is likely that the implementation of catch quotas will be delayed.

Collaboration between RFMOs responsible for Bigeye Tuna appears to be increasing, as evidenced by the

Box 2: Management strategy

There are four key components of a management strategy:

- agreed operational objectives
- an agreed monitoring programme;
- stock assessment; and
- decision rules.

Decisions rules are pre-agreed management responses that are linked to stock assessment outcomes by the specification of target and limit reference points. Target and limit reference points generally relate to fishing mortality or biomass. Implicit in the decision rule is the level of level of precaution to be adopted.

Management Strategy Evaluation (MSE) is a technique that can be used to compare the relative performance of alternative management strategies. MSE is implemented as follows:

- an operating model reproduces the dynamics of the stocks and fisheries and acts as a representation of the 'real world', including the full range of plausible uncertainty;
- a data generation component of the operating model generates data of appropriate types;
- these data are fed into an assessment model;
- the results of the assessment are used to make management decisions according to decision rules;
- the management decisions are then applied to the operating model; and
- the performance of the management strategies are evaluated using pre-defined performance measures (IATTC, 2006d).

[35]Management strategies are also known as harvest strategies or management procedures.

meeting in January 2007 of the five RFMOs responsible for management of tunas. In addition, the IATTC and the WCPFC have recently concluded a Memorandum of Understanding to underpin the relationship and collaboration between the two bodies in the Pacific Ocean. Further, there is considerable similarity between the statistical documentation schemes of ICCAT, IOTC and IATTC and between the recent resolutions on sharks and controls on transshipment. While there is considerable scope to improve these measures, compatibility is at least a positive sign.

The extent to which RFMO members are bound by international law

Coastal States and fishing States that are signatories to UNCLOS have a duty to co-operate to manage highly migratory species such as Bigeye Tuna (UNCLOS, Article 118) and coastal State signatories to the UNFSA also have a responsibility to ensure compatibility of conservation and management measures adopted within and beyond areas of national jurisdiction (UNFSA, Article 7). Parties to the FAO Compliance Agreement[36] also have obligations to prevent the circumvention of international fisheries regulations through the practice of 're-flagging' vessels under the flags of States that are unable or unwilling to enforce such measures. Such practices have severely undermined national and regional management measures for highly migratory species, including Bigeye Tuna.

Membership of the four relevant tuna RFMOs is highly representative of the significant Bigeye Tuna catching countries/territories. Table 17 includes all countries/territories recorded by FAO as having taken an average annual catch of more than 100 t over the five-year period 2001 to 2005. Of those, Indonesia, Colombia, Liberia, the Maldives and Netherlands Antilles[37] are not members of any relevant RFMO[38]. More importantly, a significant number of members of RFMOs are yet to ratify UNCLOS, the UNFSA or the Compliance Agreement (see Table 18).

Longline fishing vessels berthed at the Fiji Fish Marketing Group Ltd jetty. © WWF-Canon / Penina Solomona.

[36]Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas.
[37]The Netherlands Antilles were a co-operating non-member of ICCAT until 2006.
[38]There may also be other countries/entities identified as a member of one or more RFMOs that should also be members or co-operating non-members of other RFMOs.

Table 17: Participation in RFMOs by significant catching countries/territories

Country/Territory	Average catch 2001-05 (t)	Participation in RFMOs			
		IATTC	ICCAT	IOTC	WCPFC
American Samoa	173	Yes (USA)	Yes (USA)		No (USA*)
Australia	1193			Yes	Yes
Belize	1336	No*	Yes	No***	Yes
Brazil	2054				
Canada	206	No*	Yes		Yes
China	22 456	No*	Yes	Yes	Yes
Colombia	1176				
Cook Islands	165	No*			Yes
Ecuador	23 185	Yes			
El Salvador	1904	Yes			
Fiji Islands	816				Yes
France	9 872	Yes	Yes	Yes	Yes
French Polynesia	587				Yes (France)
Ghana	6816		Yes		
Guatemala	1843	Yes	Yes		
Honduras	1063	No*	Yes		
Indonesia	32 003			No*	No*
Iran (Islamic Rep.)	111			Yes	
Italy	329	No (EU*)	Yes (EU)	Yes (EU)	Yes (EU)
Japan	91 757	Yes	Yes	Yes	Yes
Kiribati	192				Yes
Korea, South	27 133	Yes	Yes	Yes	Yes
Liberia	190				
Libyan Arab Jamahiriya	243		Yes		
Malaysia	252			Yes	
Maldives	1154				
Marshall Islands	865				Yes
Mayotte (France)	119	No (EU*)	Yes (EU)	Yes (EU)	Yes (EU)
Micronesia, Fed. States	1218				Yes
Morocco	821		Yes		
Namibia	322		Yes		
Netherlands Antilles	2216				
New Caledonia (France)	125				Yes (EU)
New Zealand	754				Yes
Panama	5938	Yes	Yes		
Papua New Guinea	5162				Yes
Philippines	14 304		Yes	Yes	Yes
Portugal	2190	No (EU*)	Yes (EU)	Yes (EU)	Yes (EU)
Réunion (France)	189	No (EU*)	Yes (EU)	Yes (EU)	Yes (EU)
St. Vincent/Grenadines	138		Yes		
Samoa	120				yes
Senegal	857		Yes		
Seychelles	7718			Yes	
Solomon Islands	1382				Yes
South Africa	379		Yes	No*	
Spain	25 790	Yes			
Sri Lanka	240			Yes	
Taiwan	94 946	No*	No*		Yes**
Thailand	432			Yes	
Tonga	133				Yes
USA	10 409	Yes	Yes		No*
Vanuatu	5251	Yes	Yes	Yes	Yes
Venezuela, Boliv. Rep.	1183	Yes	Yes		

* Co-operating non-contracting party
** Participates as a fishing entity
*** Application under consideration

Table 18: Members of IATTC, ICCAT, IOTC and WCPFC and participation in binding international agreements

Country/Territory	UNCLOS	UNFSA	Compliance Agreement
Algeria	Yes		
Angola	Yes		Yes
Australia	Yes	Yes	Yes
Barbados	Yes	Yes	Yes
Belize	Yes	Yes	Yes
Brazil	Yes	Yes	
Canada	Yes	Yes	Yes
Cape Verde	Yes		Yes
China	Yes		
Comoros	Yes		
Cook Islands	Yes	Yes	Yes
Costa Rica	Yes	Yes	
Cote d'Ivoire	Yes		
Croatia	Yes		
Ecuador			
European Community	Yes	Yes	Yes
El Salvador	Signed		
Equatorial Guinea	Yes		
Eritrea			
Fiji Islands	Yes	Yes	
France	Yes	Yes (EU)	Yes (EU)
Gabon	Yes		
Ghana	Yes		Yes
Guatemala	Yes		
Guinea, Republic of	Yes	Yes	
Honduras	Yes		
Iceland	Yes	Yes	
India	Yes	Yes	
Iran, Islamic Rep.		Yes	
Japan	Yes	Yes	Yes
Kenya	Yes	Yes	
Kiribati	Yes	Yes	
Korea, South	Yes		Yes
Libyan Arab Jamahiriya	Signed		
Madagascar	Yes		Yes
Malaysia	Yes		
Marshall Islands	Yes	Yes	
Mauritius	Yes	Yes	Yes
Mexico	Yes		Yes
Micronesia, Fed. States of	Yes	Yes	
Morocco	Signed		Yes
Namibia	Yes	Yes	Yes
Nauru	Yes	Yes	
New Zealand	Yes	Yes	Yes
Nicaragua	Yes		
Niue	Yes	Yes	
Norway	Yes	Yes	Yes
Oman, Sultanate of	Yes		
Pakistan	Yes		
Palau, Republic of	Yes		
Panama	Yes		
Papua New Guinea	Yes	Yes	
Peru			Yes
Philippines	Yes		
Russia	Yes	Yes	
Sao Tome and Principe	Yes		
St. Vincent/Grenadines	Yes		
Samoa	Yes	Yes	
Senegal	Yes	Yes	
Seychelles	Yes	Yes	Yes
Solomon Islands	Yes	Yes	
South Africa	Yes	Yes	
Spain	Yes	Yes	Yes
Sri Lanka	Yes	Yes	
Sudan	Yes		
Syria			Yes
Taiwan			
Thailand	Signed		
Tonga	Yes	Yes	
Trinidad and Tobago	Yes	Yes	
Tunisia	Yes		
Turkey			
Tuvalu			
United Kingdom			
Uruguay			Yes
USA	Yes	Yes	Yes
Vanuatu	Yes		
Venezuela, Boliv. Rep.			

The extent to which legal obligations are upheld

By and large, the members of the four RFMOs responsible for Bigeye Tuna management have failed to heed the management recommendations of their scientific advisory bodies. They have delayed, deferred or failed to reach agreement on management measures that have a high chance of achieving the cuts in the catch and/or effort on Bigeye Tuna identified as necessary in light of the stock assessment outcomes. The management response has been far from precautionary and has failed to reflect the best available scientific advice. The failure to implement management measures consistent with the scientific advice is largely a reflection of the failure to establish agreed objectives and decision rules as part of a management strategy. The absence of agreement on the trigger for, and nature of, the appropriate management response creates a vacuum that members can exploit in order to defer or prevent effective conservation and management measures.

The UNFSA places a range of other obligations on its parties, when acting individually and collectively, in relation to the management of highly migratory species. In particular, the UNFSA imposes an obligation to apply the precautionary approach (Article 5), provides guidance (Annex II) on the application of the approach and specifies the need for States and RFMOs to apply precautionary limit and target reference points. Further, the UNFSA notes that the level of fishing mortality that generates MSY should be regarded as the minimum standard for limit reference points and that for overfished stocks BMSY should serve as the rebuilding target.

None of the four RFMOs with management responsibility for Bigeye Tuna have adopted a management strategy. This means that no target or limit reference points have been set for the species and conservation and management actions in response to breaching or approaching such reference points have not been agreed. In this environment there remains ample scope for members of RFMOs to delay or defer or simply ignore the scientific advice on stock status. In particular, it is clear that members have used the uncertainties inherent in the stock assessments for Bigeye Tuna as an excuse for inaction. This behaviour is in complete contradiction of the precautionary approach and ignores the biological characteristics of Bigeye Tuna that make it more vulnerable to overfishing than some other tuna species, namely Skipjack Tuna and Yellowfin Tuna, with which it is commonly associated in purse seine fisheries.

The failure to address the differential impact on Bigeye Tuna stocks arising from the catch of juvenile Bigeye Tuna by purse seine operations on FADs is particularly concerning. This catch increases pressure on the stock by increasing total mortality and by removing young fish before they have had a chance to contribute to recruitment to the spawning stock. In addition, it prevents maximization of revenue from the fishery by capturing lower value fish. The impact of the removal of juvenile Bigeye Tuna will depend on the relative rate of natural mortality of juvenile and mature fish. As this report has noted, there remains considerable uncertainty about natural mortality of Bigeye Tuna, which is unlikely to be resolved in the medium term.

Resolution of this issue is likely to involve some trade off between catches of Skipjack Tuna and Bigeye Tuna. The extent of this trade-off and the appropriate management response will vary across the fisheries depending on the relative reliance of the fisheries on these two species. However, given the relative vulnerability of the species the onus is on managers to ensure that sustainability of Bigeye Tuna is not compromised by targeted fishing operations for other tunas, which may be able to sustain greater fishing pressure due to their higher productivity.

Some RFMOs, for example IATTC[39] and ICCAT, pre-date the UNFSA and, as shown in Table 18, some members of RFMOs are not bound by the Agreement. Of the four relevant RFMOs only the Convention of the WCPFC makes explicit reference to the precautionary approach[40]. However, this in itself does not preclude members of other RFMOs from advocating precautionary management. It is clear, for example, that the scientific advice being provided to RFMO members acknowledges uncertainty and reflects the need for precautionary management. Further, the objectives of each of the four relevant RFMOs clearly require their members to ensure the sustainable management of the species under their mandate. The reality appears to be that, regardless of the obligations imposed by international law or agreed to by participation in RFMOs, members have failed to meet those obligations.

[39]A new convention, the Antigua Convention, has been agreed for the IATTC but has not yet come into force.
[40]The Antigua Convention makes explicit reference to the precautionary approach.

Conclusions

The following conclusions can be drawn from the above analysis of Bigeye Tuna fisheries:

- overfishing is occurring in all Bigeye Tuna stocks and at least one stock is in an overfished state
- members of RFMOs have, by and large failed to respect, and respond in a precautionary manner to, the best scientific advice available to them
- attempts to control and reduce capacity have been largely unsuccessful
- the allocation of catch or capacity limits is fraught and there remains a need in most RFMOs to establish agreed allocation procedures to avoid further delays in implementation of such limits
- flag State enforcement of catch limits, area and seasonal closures and effort limits cannot be relied upon
- implementation of trade-related measures in order to reduce reliance on flag State enforcement of conservation and management measures has been compromised by the failure of these measures to apply to all components of the catch
- failure to collect and analyse reliable bycatch data, and the failure to implement precautionary and ecosystem-based management measures to mitigate impacts on bycatch species in the absence of such data, continues to put at risk a range of threatened species of seabirds, sharks, turtles and other finfish
- the absence of independent observer programmes providing sufficiently representative coverage of the fleet severely compromises the collection and reliability of data on both target and bycatch species
- IUU fishing, by both members and non-members of RFMOs, remains a threat to Bigeye Tuna stocks
- the economic viability of Bigeye Tuna fisheries and the economic stability of a number of small island States that rely heavily on such stocks, is threatened by ineffective management of Bigeye Tuna stocks in their entirety and, in particular, by the failure to address the impact on sustainability and economic returns resulting from increased catch of juvenile Bigeye Tuna by purse seine fleets.

These conclusions are indicative of a failure on the part of members of RFMOs to apply their obligations under the UNFSA and/or to act in accordance with accepted international protocols for fisheries management. The deteriorating status of Bigeye Tuna stocks means that adoption of precautionary and ecosystem-based approaches to management of Bigeye Tuna is now non-negotiable, regardless of whether individual RFMO members have a legal obligation to do so or whether the conventions under which RFMOs operate require it. Failure to do so will result in all four Bigeye Tuna stocks becoming overfished and may threaten the survival of especially vulnerable species of seabirds, sharks and turtles. An ecosystem approach to management will involve a significant shift in thinking and operations of the members of RFMOs. It requires an acceptance that the monetary value of a species should not be the sole determinant of its place in the management hierarchy. That hierarchy must also reflect the relative vulnerability of species and habitats.

If these approaches are adopted in determining a sustainable level of catch this will provide a strong platform from which management measures appropriate to the operational characteristics of the fleet and the composition of the catch can be developed.

As noted above, Bigeye Tuna stock assessments are subject to considerable uncertainty and management objectives are complex, because of the interactions with other target, for example Skipjack Tuna, and non-target species. Further, the assessment of management effectiveness provided above suggests that management measures applied to date have been too little and too late. The adoption of a formal management strategies approach and its evaluation through MSE would provide a structured and transparent means of incorporating the precautionary approach explicitly into management decisions and potentially improve the timeliness of decision making. This would provide certainty in the operating and management environment and minimise the opportunity for short-term interests to outweigh the longer-term benefits of sustainable management decisions.

Approaches involving the application of MSE to determine the most appropriate management strategy are becoming recognized as critical to the development of effective management arrangements under circumstances of high uncertainty. In CCSBT, for example, the failure of management to rebuild the SBT stock to agreed safe levels has led to that RFMO agreeing to develop a management procedure for management of the stock. Maunder and Harley (2006) have supported the application of an MSE approach for the tuna fisheries in the EPO and the Scientific Committee of the WCPFC has identified the need to determine target and limit reference points and to develop methods to evaluate potential management strategies, including MSE (WCPFC, 2006b).

The role of observer programmes in supporting conservation and management measures cannot be overstated. Throughout this report the important role that observers can play has been highlighted. Observers can monitor compliance with management measures, provide information to allow assessment of the performance of

management measures, verify catches and estimate mortalities of discarded target species, and collect information on the nature and extent of bycatch, the effectiveness of mitigation measures and the presence of IUU vessels. The value and credibility of observer information will be enhanced if the observer programme includes provision for 'international' observers to be placed on vessels.

Inadequate data remains a major issue for scientists and managers. Validated, logbook data on all aspects of catch and effort is a prerequisite to good management, yet most RFMOs acknowledge that their members fail to comply with established standards of data collection and provision. In some cases standards have not been established or are not sufficiently rigorous. The lack of data to confirm the nature and extent of bycatch issues, particularly in longline Bigeye Tuna fisheries, remains a key challenge for RFMOs.

The move to introduce statistical documentation schemes for Bigeye Tuna has reflected, in part, a growing appreciation of the need to involve port and market States in enforcement of fisheries management measures. However there is considerable scope to expand and formalise this role. In particular, RFMOs need to be able to accommodate such States as full members so as to ensure their full co-operation in implementation of such measures.

At present, the poor management of Bigeye Tuna fisheries, compromises the long-term sustainability of the stock and associated species, the economic viability of fisheries for this species and the economic contribution to national economies of this valuable resource. Apart from the legal and moral obligations of RFMO members to manage and conserve Bigeye Tuna stocks, the economic incentives to do so are high. Long term reductions in the abundance of the stocks will have significant direct and indirect impacts on income and employment of longline fleets and associated processing and trading enterprises. Further, a number of small, island States rely heavily on income derived from fees paid by these fleets to access Bigeye Tuna stocks in their national waters. Alternative income sources in many of these States are limited and depletion of Bigeye Tuna stocks will compromise their long term economic prosperity. In addition, there are potential market opportunities that can be exploited by sustainably managed Bigeye Tuna fisheries. The first of these relates to the potential of Bigeye Tuna to fill the gap between supply and demand of major competing products in the sashimi market, namely Atlantic and Southern Bluefin Tuna, as restrictions on the catch of these species tighten in response to dwindling stocks. The second opportunity derives from the increasing consumer demand, particularly in emerging sashimi tuna markets such as the USA and European countries, for fish from ecologically sustainable fisheries. There is growing interest at all market levels in fish products that meet certification standards such as those established by the MSC. The certification programme of the MSC responds to this demand and provides consumers with confidence that certified products come from sustainably managed fisheries. There are potential benefits for Bigeye Tuna fisheries that meet internationally accredited standards, such as those of the MSC, to have a competitive edge in the market place over other competing products.

Adoption of the recommendations made below would facilitate the adoption of management measures consistent with international legal and moral obligations of RFMO members and better position Bigeye Tuna fisheries to take advantage of market opportunities for sustainably managed Bigeye Tuna.

Bigeye Tuna. © David Itano.

Recommendations

The status of Bigeye Tuna stocks globally demands the urgent attention of the members of the four responsible RFMOs. In light of the obligations imposed by the UNFSA and the guidance offered by other international protocols such as the Code of Practice for Responsible Fishing, the members of RFMOs responsible for Bigeye Tuna must address the following questions as a matter of urgency:

- where overfishing is occurring is the current management likely to reduce F to levels below F_{MSY} in order to avoid those stocks becoming overfished?
- where a stock is overfished is there a rebuilding strategy in place that will return the stock to at least B_{MSY} within an acceptable timeframe?
- are the bycatch mitigation measures currently in place likely to reduce mortalities on key bycatch species, particularly threatened species?
- are the data collection and MCS arrangements in place adequate to support the development and effective implementation of appropriate management measures for Bigeye Tuna and bycatch species taken in Bigeye Tuna fisheries?

The following recommendations are intended to assist the RFMOs address these questions. No attempt is made to recommend specific management actions. The nature and effectiveness of management measures will necessarily vary according to the status of the stock, the nature of species interactions by both Ocean and fleet and the operational characteristics of the fleets.

Many of the recommendations made below are consistent with the action plan that was developed by the participants at the joint meeting of tuna RFMOs held in Kobe, Japan in January 2007[41]. Given the voluntary nature of the action plan, it remains to be seen whether the RFMOs will implement the actions agreed.

Management approaches

1. Management strategies must be adopted for Bigeye Tuna stocks. These strategies should include the following elements:
   - species-specific management objectives;
   - procedures for data collection, verification and analysis;
   - precautionary limit and target reference points reflecting international best practice;
   - where necessary, rebuilding programmes aimed at returning stocks to sustainable levels within biologically reasonable time-frames[42];
   - consideration of the vulnerability of the Bigeye Tuna stock relative to that of other target and non-target species taken in conjunction with Bigeye Tuna;
   - consideration of the trade-offs, both economic and biological, involved in the differential impacts on Bigeye Tuna stocks of longline and purse seine fleets; and
   - agreed management actions triggered by the approach or breach of limit reference points.
2. Pending the implementation of a management strategy for each Bigeye Tuna stock, RFMOs must adopt measures that, on the basis of the best advice available, will allow for recovery of overfished stocks and reduce fishing mortality where overfishing is occurring. In particular, urgent action must be taken to reduce the catch of juvenile tuna taken in purse seine fisheries targeting Skipjack and Yellowfin Tuna.
3. Bigeye Tuna fisheries must be managed in an ecosystem context to ensure that all impacts on Bigeye Tuna stocks are accounted for and that all impacts of Bigeye Tuna fisheries are taken into account.

Bycatch management

4. Conservation and management measures for sharks must be reviewed to ensure that they are comprehensive, that they provide specific protection to the most vulnerable species and that the ratios of fins to carcass weight are meaningful[43].
5. Bycatch mitigation measures for seabirds should be based on the current best practice approach adopted by CCAMLR[44].
6. RFMO members must continue research to confirm the effectiveness of sae turtle mitigation measures taking into account the impact of such measures on the catch of other species.

[41]The action plan can be found at http://www.tuna-org.org/.

[42]Some guidance on what might be considered a biologically reasonable time frame is provided by: (1) the US Magnuson-Stevens Fishery Conservation and Management Act which specifies that the rebuilding time period be as short as possible and not exceed 10 years except where the biology of the stock or other environmental conditions dictate otherwise; and (2) Australia's Commonwealth Harvest Strategy Policy (draft available at: http://www.daff.gov.au/fisheries/domestic/harvest_strategy_policy) which specifies that a biologically reasonable time frame for stock rebuilding is a period of 10 years plus one mean generation time, or three times the mean generation time, whichever is less.

[43]Specific guidance on maximizing the effectiveness of shark conservation measures is provided in Lack and Sant (2006).

[44]Information on CCAMLR's conservation and management measures is available at: http://www.ccamlr.org/pu/e/e_pubs/cm/06-07/toc.htm

Data and monitoring

7. Independent observer programmes, operated centrally by each RFMO, must be implemented as a means of collecting and verifying target and non-target catch, estimating discards and monitoring compliance with conservation and management measures.
8. The application of VMS must be upgraded, where necessary, to reflect a consistent set of core standards and to provide for central operation of the VMS by the RFMO and the provision of data to the RMFO either prior to, or simultaneously with, transmission to the flag State.
9. The provision of data on catch and non-target catch (particularly of seabirds, sharks and turtles and other species identified as high risk) to RFMOs must be made mandatory. These measures should reflect, at a minimum, the Standard Requirements for the Collection and Sharing of Data specified in Annex 1 of the UNFSA.
10. Documentation schemes for Bigeye Tuna must cover all components of the catch[45] rather than only product entering international trade.
11. Members of RFMOs that trade in Bigeye Tuna must ensure that species-specific trade codes are in place for the full range of Bigeye Tuna product types traded and encourage other significant traders of Bigeye Tuna to do likewise.

Structure and process

12. The structure and charter of advisory bodies must reflect the adoption of an ecosystem approach to management.
13. Decision-making processes of the Commissions must be reviewed to maximise the likelihood that appropriate conservation and management measures will be agreed and adhered to.
14. Full membership of Indonesia in the IOTC and WCPFC and the full participation of Taiwan in IOTC, ICCAT and IATTC must be facilitated.
15. Membership provisions of RFMOs must be reviewed to accommodate the full participation of port and market States.
16. The basis upon which fishing rights will be allocated amongst members and co-operating non-members and a process for accommodating the interests of new members must be developed as a priority.
17. Mechanisms to maximise opportunities for sharing of data and research and for harmonization of conservation and management measures across RFMOs must be formalised and improved.

*Opah (*Lampris guttatus*) caught as bycatch in tuna longline fisheries in the WCPO. © WWF Aust/Lorraine Hitch.*

[45]Specific guidance on maximizing the effectiveness of documentation schemes is provided in Lack (2007).

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Acronyms and abbreviations

CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CPC	Contracting and co-operating non-contracting parties (to an RFMO)
EPO	Eastern Pacific Ocean
EU	European Union
F	Fishing mortality
FAD	Fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
IOTC	Indian Ocean Tuna Commission
IPOA	International Plan of Action
IUCN	The World Conservation Union
IUU	Illegal, unreported and unregulated (fishing)
MCS	Monitoring, control and surveillance
MSC	Marine Stewardship Council
MRAG	Marine Resources Assessment Group Ltd
MSY	Maximum sustainable yield
NMFS	National Marine Fisheries Service (USA)
NPOA	National Plan of Action
OPRT	Organization for the Promotion of Responsible Tuna Fisheries
PrepCon	Preparatory Conference of the WCPFC
RFMO	Regional Fisheries Management Organization
SCG	Scientific Coordinating Group (PrepCon)
SCRS	Standing Committee on Research and Statistics (ICCAT)
SCTB	Standing Committee on Tuna and Billfish
SPC	Secretariat of the Pacific Community
SSB	Spawning stock biomass
TAC	Total allowable catch
UNCLOS	United Nations Convention on the Law of the Sea
UNFSA	United Nations Fish Stocks Agreement
VMS	Vessel monitoring system
WCPFC	Western Central Pacific Fisheries Commission
WCPO	Western and Central Pacific Ocean

Appendix A

Fishing methods[46]

1. **Longline:** a fishing line with baited hooks set at intervals on branch lines; it may be 150 km long and have several thousand hooks and can be on the sea bed or above it supported by floats. It may be anchored or drift free and is marked by floats. Seabirds may take the baited hook before it sinks and are pulled underwater to drown. This can be partly avoided by setting streamers that flap and scare birds away, by setting lines at night when most albatross do not feed, weighting the line so it sinks quickly, using bird-scaring water cannons, and setting the line nearer the water surface rather than over the side of the boat.
2. **Purse seine:** a seine used to encircle a school of fish in open water (contact with the bottom is avoided as the small mesh is easily damaged). It is set at speed from a large, powered vessel and the other end is anchored by a small boat. A purse line at the bottom (bag or bunt) of the n*et al*lows it to be closed like a purse. A purse seine can be 1 km long and 200 m deep.
3. **Pole-and-line fishing:** surface schooling fish such as tuna are attracted to a vessel and driven into very active feeding behavior by throwing live or dead bait into the water, by spraying water onto the sea surface to simulate the escape behavior of small prey, and sometimes by use of lights. The fish are lured with a line and a barbless hook attached to a pole and pulled off the water by manual (sometimes with two people to each pole) or powered devices.
4. **Ring net:** a modified lampara net with purse rings operated by two vessels (a lampara net is similar to, but much smaller than, a purse seine with no pursing action used for catching schools of small fish attracted to lights, e.g. anchovy and pilchard. There is a central spoon-shaped section and two lateral wings and the net is usually operated from a small boat. The rapid retrieval of the lead line does close the bottom of the net but it is not a true purse).
5. **Gill net:** a net suspended in the water at varying depths by means of floats on the upper margin and weights on the lower margin. The mesh size determines the size of fishes caught, the fish being entangled around the gill region or gilled. Also called entangling net.

Raw tuna for preparation of sushi and sashimi. Tsukiji fish market, Tokyo, Japan. © WWF-Canon / Michel Gunther.

[46]Source Coad & McAllister (2007).

Appendix B

Table B1: Indicators of trends in Bigeye Tuna fisheries in the EPO

	Bigeye Tuna[1] catch	EPO purse seine capacity (m^3)	No. of purse seine vessels	Purse seine sets (floating objects)	Bigeye Tuna retained from purse seine sets on floating objects	Longline effort ('000 hooks[2])
1990	104 807	143 946	172	3277	3995	238 129
1991	109 116	124 501	155	2984	2747	283 401
1992	91 999	117 017	160	2631	2048	270 768
1993	82 834	118 730	152	2556	6141	227 416
1994	109 326	122 214	167	3438	33 960	225 064
1995	108 209	124 096	175	4228	41 873	191762
1996	114 703	132 731	183	5237	58 371	154 499
1997	122 348	146 533	194	7352	62 704	141 548
1998	93 946	161 560	203	6679	41 909	176 407
1999	93 300	180 652	208	5250	49 330	169 344
2000	147 250	180 625	205	4420	91 474	142 354
2001	131 475	189 966	205	6545	60 627	253 360
2002	132 810	200 075	218	6638	55 916	324 935
2003	116 474	202 674	215	6201	52 705	305221
2004	112 513	206 302	217	5698	65 829	218 711
2005	113 534	213 005	220	5763	67 510	171 361
2006	101 222	225 397	225	8226	69 564	

Source: IATTC, 2007e
[1]EPO data from 1993 includes discards from purse seine vessels with a carrying capacity of more than 363 t.
[2]Includes hooks sets by China (since 2001), Japan, South Korea, French Polynesia, Taiwan and USA.

Table B2: Indicators of trends in Bigeye Tuna fisheries in the WCPO

	Bigeye Tuna catch (t)	Active longliners (No.)	Longline hooks set (million)	Active purse seiners (No.)	Purse seine effort on associated schools (days fished)	Purse seine catch of Bigeye Tuna
1990	90 411	3709		781		12 411
1991	72 551	3447		783		13 750
1992	91 975	4628	2155	648		20 208
1993	79 428	5178		624		14 146
1994	88424	5422		620	37 244	10 904
1995	79 921	5171		603	48 025	12 230
1996	81 233	4712		597	47 662	22 378
1997	110 471	5120	2358	606	49 991	35 981
1998	110 242	4983		338	54 058	21 708
1999	116 956	4898		417	32 917	37 206
2000	108 789	4889		406	30 616	32 356
2001	106 434	5873		1291	34 955	28 507
2002	123 250	5814		1099	40 549	26 855
2003	111 027	5014	2451	1233		22 418
2004	127 775	5070		1427		29 345
2005	157 102	5015		1430		43 885
2006						

Sources: Lawson (ed.), 2006; WCPFC, 2006a; Lawson and Williams, 2005.

Appendix B

Table B3: Indicators of trends in Bigeye Tuna fisheries in the Atlantic Ocean

	Bigeye Tuna catch (t)	Longliners reported	Purse seiners reported	Purse seine catch of Bigeye tuna
1990	84 337	1008	143	9407
1991	95 264	1888	211	15 524
1992	98 434	921	175	19 223
1993	111 568	1356	152	31 582
1994	132 225	1228	166	32 665
1995	126 284	1459	145	25 355
1996	121 131	1337	144	26 919
1997	106 476	1455	380	19049
1998	109 890	960	125	16 362
1999	121 498	1459	381	21 239
2000	102 635	1304	345	17 908
2001	95 821	1958	368	22 062
2002	75 743	1022	37	16 191
2003	82 804	702	46	17 913
2004	76 093	878	107	13 388
2005	59 818			12 530

Sources: ICCAT, 2006d

Table B4: Indicators of trends in Bigeye Tuna fisheries in the Indian Ocean

	Bigeye Tuna catch (t)	Purse seiners (no.)[1]	Purse seine catch of Bigeye Tuna	Purse seine carrying capacity (m^3)[1]	Log sets
1990	73 500	46	12 700	34 525	3123
1991	77 000	39	15 600	33781	3419
1992	71 900	39	11 300	35 061	3444
1993	102 000	42	16 000	39 521	3701
1994	110 200	42	18 900	40 113	4313
1995	119 400	42	28 400	42 153	5164
1996	126 900	47	24 500	45 384	5007
1997	147 300	58	34 000	56 796	6842
1998	141 400	53	28 300	54 669	6676
1999	150 500	52	40 700	51 875	5945
2000	128 900	50	29 900	52 740	5824
2001	115 000	50	23 700	53 519	5246
2002	134 900	49	29 000	55 410	6112
2003	124 000	44	22 900	52 177	4790
2004	126 400	48	22 600	51 717	4602
2005	112 400	48	25 700	56 431	5923

Sources: IOTC, 2006a; Pianet, *et al*. (2006)
[1]Statistics relate to the French, Spanish, Italian, Seychelles and EU-related 'not elsewhere included' purse seine fleets.

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Back cover photograph: Diver swims in front of FAD (Fish Aggregating Device) made from bamboo plants. © Greenpeace / Roger Grace.