International Seafood Sustainability Foundation

STATUS OF THE WORLD FISHERIES FOR TUNA

SECTION C – BYCATCHES AND DISCARDS

Bycatches, or incidental catches, of non-target species and discards of tunas are an important factor in the conservation and management of tuna fisheries. This section describes these bycatches and discards, and the measures taken to reduce both in each of the ocean areas covered by the four regional fisheries management organizations (RFMOs) responsible for such fisheries.[1]

INTRODUCTION

Like most fisheries, those for tunas generate bycatches and discards. Bycatches consist of fish other than commercially-important tunas, or other animals, such as sea turtles, seabirds, and marine mammals, that are caught incidentally during fishing operations for tunas and that are almost always discarded at sea because they are of no commercial value for the fishermen. Discards are commercially-important tunas that are discarded dead at sea.

Discards in the purse-seine fishery occur for various reasons, but mostly it is because the animals discarded are of little or no commercial value for the fishermen. Most of the yellowfin, skipjack and bigeye discarded are small individuals that the processing plants will not accept, or, if they would, only at lower prices, so they are discarded at sea. The same holds true for bycatches of sharks, most billfishes, and other types of fishes. Some of the catch that would otherwise be discarded is eaten aboard the vessel or is brought to port for subsequent sale in the fresh-fish mar-

[1] This report is based on data available on 15 April 2009

ket, but the quantities involved are small.

Longline vessels take a variety of species as bycatch, including sea turtles, a variety of seabirds, and sharks, many of which are threatened or endangered. Many seabirds, especially albatrosses and petrels, are declining in abundance, and have been listed by the International Union for Conservation of Nature (IUCN) as threatened or endangered. Because populations of these birds have been declining, and because these declines have in part been attributed to the impact of commercial longline fisheries, mitigating the mortality of seabirds caught in longline gear has a high priority, particularly in the temperate longline fisheries. Most of the RFMOs have introduced programs to quantify the mortality caused by tuna-fishing vessels and to develop mitigation measures designed to halt the declines in abundance. Many birds, particularly the imperiled albatrosses and petrels, follow longliners when they are paying out the baited lines, and catch the bait before it sinks below the surface, hooking themselves in the process. There are means of mitigating this problem, such as bird-scaring devices like *tori* lines, weighted lines that sink fast before birds have an opportunity to go for the bait, setting at night, dyed bait, circle hooks, alterations in spatio-temporal fishing strategies, and a variety of other modifications, but they need to be utilized on a broad scale to be effective in reducing mortality. This will require better development and use of such gear and techniques, and mitigation efforts such as purchasing and setting aside turtle nesting habitat to protect it from development.

Very little is known of the potential effects of these bycatches and discards on the marine ecosystem, but they almost certainly have some impact. All bycatches and discards represent a waste of a resource and, in some cases, a threat to species that are already endangered or overfished, such as sea turtles, albatrosses, and bigeye tuna. It is therefore very important to assess the impact of the mortality caused by the purse-seine fishery on the abundance of such species, and to develop means of reducing this mortality.

Regardless of the status of the various species involved, the problems of developing means to reduce or eliminate bycatches are similar. The solutions will result from a good understanding of the behavior of the species and their relationships to one another, and the development and use of fishing gear and methods that can be applied to reduce or eliminate bycatch. Discards may be somewhat easier to control and reduce, but more needs to be done in this respect.

Collecting and analyzing comprehensive information on the numbers and kinds of tunas discarded and of non-tuna species taken as bycatch, and their distribution in time and space, is essential to understanding the possible impacts of bycatches and discards on the diversity and health of the ecosystem.

1. EASTERN PACIFIC OCEAN

1.1. Bycatch and discards

In the eastern Pacific Ocean (EPO) there are several types of fishing gear used to capture tunas, and all of them have some associated bycatch and discards. There is good information on bycatch for the purse-seine fishery, but not much for the others.

1.1.1. Estimating bycatch and discards

Estimates of bycatch and discards from purse-seine vessels, which capture about 87 percent of the tunas and tuna-like fishes in the EPO, are among the best and most complete series of data available for any fishery in the world. Estimates of bycatch and discards for 2003-2006, which were provided by the Inter-American Tropical Tuna Commission (IATTC), are shown in Tables

C-1a-c. The basic data, which have been collected since 1992 through an international program in which trained observers are placed on every trip of every large purse-seine vessel fishing in the EPO, show a wide array of species taken as bycatch, including dolphins, billfishes, mahi-mahi, wahoo, rainbow runners, triggerfish, yellowtail, sharks and rays, sea turtles, and a variety of small fishes.

The purse-seine fishery on floating objects, which captures about 40 percent of all purse-seine caught tuna from the EPO, takes the greatest variety and largest numbers of bycatch species. Sets on unassociated schools of tuna, which take about 27 percent of the tunas from the EPO,

TABLE C-1a. Estimated discards and bycatch of tunas and bonito in the EPO on fishing trips with observers aboard, in tons (IATTC Annual Reports).

Year	Species	Set type			
		Dolphin	**Floating object**	**Unassociated**	**Total**
2003	Yellowfin	981	3,221	1,011	**5,214**
	Skipjack	2,565	19,023	1,610	**23,198**
	Bigeye	0	1,923	28	**1,951**
	Black skipjack	0	1,260	271	**1,531**
	Bullet	16	908	241	**1,165**
	Other tunas	0	0	0	**0**
	Bonito	0	0	0	**0**
	Total	**3,563**	**26,335**	**3,162**	**33,059**
2004	Yellowfin	222	1,827	805	**2,854**
	Skipjack	219	15,166	1,035	**16,420**
	Bigeye	0	1,604	7	**1,611**
	Black skipjack	8	311	32	**351**
	Bullet	24	819	156	**999**
	Other tunas	0	0	19	**19**
	Bonito	0	0	47	**47**
	Total	**473**	**19,727**	**2,101**	**22,301**
2005	Yellowfin	98	2,255	748	**3,101**
	Skipjack	273	15,607	3,066	**18,946**
	Bigeye	0	1,894	0	**1,894**
	Black	0	1,013	1,141	**2,154**
	Bullet	6	1,699	276	**1,981**
	Other tunas	0	0	15	**15**
	Bonito	0	8	18	**26**
	Total	**377**	**22,476**	**5,264**	**28,117**
2006	Yellowfin	78	1,131	285	**1,494**
	Skipjack	29	11,689	1,111	**12,829**
	Bigeye	0	1,850	13	**1,863**
	Black Skipjack	10	1,600	132	**1,742**
	Bullet	19	1,221	751	**1,990**
	Other tunas	0	0	0	**0**
	Bonito	0	0	84	**84**
	Total	**136**	**17,490**	**2,376**	**20,002**

TABLE C-1b. Estimated bycatch of billfishes in the EPO on fishing trips with observers aboard, in numbers of individuals.

Year	Species	Set type			
		Dolphin	Floating object	Unasso-ciated	Total
2003	Swordfish	31	7	19	**57**
	Blue marlin	116	1,452	104	**1,672**
	Black marlin	166	830	86	**1,082**
	Striped marlin	111	141	241	**492**
	Shortbill spearfish	15	16	54	**85**
	Sailfish	1,210	69	2,019	**3,298**
	Unidentified marlin	18	46	6	**70**
	Unidentified billfish	0	11	3	**14**
	Total	**1,668**	**2,572**	**2,531**	**6,771**
2004	Swordfish	15	4	15	**34**
	Blue marlin	65	1,110	78	**1,253**
	Black marlin	112	367	55	**534**
	Striped marlin	127	102	69	**298**
	Shortbill spearfish	6	13	7	**26**
	Sailfish	675	40	488	**1,203**
	Unidentified marlin	15	50	11	**76**
	Unidentified billfish	0	8	0	**8**
	Total	**1,015**	**1,694**	**723**	**3,432**
2005	Swordfish	13	3	11	**27**
	Blue marlin	141	1,639	138	**1,918**
	Black marlin	123	532	61	**716**
	Striped marlin	191	147	135	**473**
	Shortbill spearfish	17	8	10	**35**
	Sailfish	961	103	200	**1,264**
	Unidentified marlin	16	43	6	**65**
	Unidentified billfish	14	32	41	**87**
	Total	**1,476**	**2,507**	**602**	**4,585**
2006	Swordfish	20	5	28	**53**
	Blue marlin	97	1,539	136	**1,772**
	Black marlin	89	852	105	**1,046**
	Striped marlin	152	256	140	**548**
	Shortbill spearfish	13	12	7	**32**
	Sailfish	941	342	345	**1,628**
	Unidentified marlin	26	212	11	**249**
	Unidentified billfish	0	12	1	**13**
	Total	**1,339**	**3,229**	**774**	**5,342**

take the same kind of bycatch species as the floating-object fishery, but at about one-tenth the rate. Purse-seine sets on schools of tuna associated with dolphins also take bycatch of unwanted species, although in this case most of this bycatch is dolphins. In addition to dolphins, most of the other species taken as bycatch in other set types are also taken during sets on dolphins, but the amounts are only about one-tenth the amounts taken in unassociated sets. Dolphin sets ac-

count for about 35 percent of the catch of tunas made by purse seiners, but for about 62 percent of the catch of yellowfin.

TABLE C-1c. Estimated bycatches of animals other than tunas and billfishes in the EPO on fishing trips with observers aboard, in numbers of individuals.

Year	Species	Set type			
		Dolphin	Floating object	Unasso-ciated	Total
2003	Marine mammals	1,500	2	0	**1,502**
	Mahi-mahi	350	301,560	2,733	**304,643**
	Wahoo	77	184,139	239	**184,455**
	Rainbow runner	0	89,169	495	**89,663**
	Yellowtail	66	32,686	209	**32,961**
	Other large teleost fish	19	3,594	63	**3,677**
	Trigger fish	2	416,660	14,125	**430,786**
	Other small teleost fish	14,800	247,329	10,902	**273,031**
	Sharks and rays	3,310	23,747	12,120	**39,177**
	Sea turtles	7	17	2	**26**
	Unidentified fish	0	599	372	**971**
	Other fauna	2	0	1	**3**
2004	Marine mammals	1,461	8	0	**1,469**
	Mahi-mahi	681	328,639	3,315	**332,635**
	Wahoo	95	185,092	494	**185,681**
	Rainbow runner	0	72,906	103	**73,009**
	Yellowtail	38	181,693	2,682	**184,413**
	Other large teleost fish	16	3,693	86	**3,795**
	Triggerfish	3,188	594,699	3,993	**601,880**
	Other small teleost fish	777	127,157	11,503	**139,437**
	Sharks and rays	3,955	19,536	4,924	**28,415**
	Sea turtles	2	10	5	**17**
	Unidentified fish	40	8,299	5	**8,344**
	Other fauna	0	3	0	**3**
2005	Marine mammals	1,151	0	0	**1,151**
	Mahi-mahi	798	256,714	21,908	**279,420**
	Wahoo	105	198,916	645	**199,666**
	Rainbow runner	42	94,179	867	**95,088**
	Yellowtail	2	27,322	2,124	**29,448**
	Other large	40	13,810	133	**13,983**
	Triggerfish	453	350,459	2,458	**353,370**
	Other small teleost fish	234	2,745	41,457	**44,436**
	Sharks and rays	2,557	25,273	3,977	**31,807**
	Sea turtles	6	8	14	**28**
	Unidentified fish	1	1,363	0	**1,364**
	Other fauna	0	0	0	**0**
2006	Marine mammals	884	0	2	**886**
	Mahi-mahi	149	344,491	19,237	**363,878**
	Wahoo	408	234,503	646	**235,558**

Rainbow runner	37	145,399	547	**145,982**
Yellowtail	5	59,689	52,163	**111,857**
Other large teleost fish	124	7,675	158	**7,958**
Triggerfish	198	401,524	176	**401,899**
Other small teleost fish	970	240,792	8,350	**250,112**
Sharks and rays	2,193	32,767	5,542	**40,501**
Sea turtles	3	9	4	**16**
Unidentified fish	0	3,294	64	**3,358**
Other fauna	0	0	0	**0**

In recent years annual discards of tunas and tuna-like species averaged about 25 thousand tons per year, with most of these being skipjack tuna; billfish discards amounted to about 5 thousand individuals, sharks about 30 thousand individuals, various finfish species about 1.5 million animals, and about 22 turtles.

Of the approximately 5,000 billfishes taken annually as bycatch in the purse-seine fishery, about 33 percent are blue marlin, 35 percent sailfish, 21 percent black marlin, 7 percent striped marlin, and the rest swordfish and shortbilled spearfish. Sets on floating objects account for nearly 50 percent of the bycatch of all billfishes, most of them blue and black marlin. With the possible exception of these latter two species, none of the bycatch of the individual species of billfish represents a significant percentage of the commercial catch of that species, and consequently their impact, although not evaluated, may be minimal. The numbers of blue marlin taken as a bycatch have been included in a Pacific-wide stock assessment of this species, the results of which suggest that the population is not fully exploited, so the current levels of blue marlin bycatch in the purse-seine fishery are probably sustainable. A similar analysis for striped marlin has indicated that it are not overfished, so the effect of purse-seine fishing on this species is probably insignificant.

The greatest bycatch of other finfish are triggerfish, followed by mahi-mahi and then wahoo. Mahi-mahi are important commercial and recreational fish in the EPO, and many of the artisanal fishermen of coastal regions harvest them. Wahoo is an important recreational fish in the EPO where they are targeted by sportfishing vessels based in ports between San Diego, California, and Ecuador. The impact of this bycatch on the respective populations from which they are removed is unknown ,since there is very little knowledge of the abundance and biological parameters of these species in the oceanic regions of the EPO, particularly of how they interact with other species.

Although a variety of species of sharks are taken, the most common is the silky shark. Assessments of the population of this species suggest a decline in relative abundance since 1994. The reasons for the decline are not clear, but it could be due to the fishery and/or the environment, particularly El Niño events. Complicating an understanding of this decline is the lack of knowledge concerning north-south movements of silky sharks, and possible movements into coastal zones. An additional unknown is the level of fishing mortality that may be exerted on this species by other fisheries, particularly coastal and high-seas longline fleets.

All species of marine turtles endemic to the Pacific Ocean are taken as a bycatch in the EPO. Many of the turtles captured are released to the sea alive and unharmed, but others that become entangled in the purse-seine net, in netting hung from the bottom of fish-aggregating devices (FADs) to attract fish, or the machinery of the vessel, die and are discarded. During recent years discards of turtles of all species have been very limited. Of the most endangered species of tur-

tles – leatherback, hawksbill, and loggerhead – none have been killed in the purse-seine fishery for a number of years.

The data collected through the international observer program in the EPO is an important contribution to understanding the total impact of anthropogenic effects on turtle abundance and sustainability. In addition to collecting data on the numbers of turtles killed, the observers collect data on turtles captured and released to the sea unharmed. Scientists from the IATTC, in collaboration with scientists from other institutions, are using this information to study the distribution of turtles in time and space, and to hopefully develop techniques to reduce their capture in all types of fishing gear that target tunas, including the replacement of netting hung from FADs with strips of material, with which the entanglement of turtles can be eliminated or significantly reduced. The IATTC has also instituted a series of guidelines for fishermen to follow, including turtle resuscitation procedures, for reducing turtle mortality caused by the purse-seine fishery.

The most publicized issue concerning a bycatch species has been that of dolphins taken in association with tunas in the EPO. During the mid-1950s, because of economic reasons and technological advances, most tuna vessels in the EPO converted from pole-and-line gear to purse seines. One of the primary means of fishing employed by these newly converted seiners was to catch tuna associated with dolphins. During the fishing process, fishermen strive to catch and retain the tuna, but release the dolphins unharmed and alive. Unfortunately dolphins are killed during the capture and release process. In the early 1960s it was estimated that 200-300 thousand dolphins were killed annually in the fishery. This mortality, which created one of the most controversial environmental trade issues of the last century, resulted in the government of the United States embargoing numerous fishing states for fishing for tuna in association with dolphins, and in U.S. canners refusing to purchase tuna that was caught in association with dolphins. In an effort to address the problem of dolphin mortality, the nations fishing for tuna in the EPO plus the nations bordering the area, created the Agreement on the International Dolphin Conservation Program (AIDCP), an international treaty whose objective is to reduce dolphin mortality caused by the fishery to insignificant levels. The program, which is administered by the IATTC, has been successful in reducing dolphin mortality to biologically insignificant levels; since 1988, when the program was started, mortality has been progressively reduced, and in 2006 was less than 900 animals.

The second most important type of gear in terms of tonnage of tunas caught in the EPO is longline. Hundreds of longline vessels operate throughout the EPO each year. Large distant-water vessels, whose home ports are mostly outside the EPO, operate throughout the entire area, whereas the smaller vessels operating from Latin American ports confine their fishing mostly to within a few hundred miles of the coastline. Although longline vessels target tunas and billfishes, they make incidental catches of a wide variety of other species. These species include not only many species of bony fishes, but sharks, rays, turtles, a few marine mammals, and seabirds. Unfortunately there is very little data available on the catches of these non-target species. Part of the problem is that the large-scale longliners, which dominate the longline fishery, set sail from distant ports, mostly in Asia, may stay at sea for more than a year and, unlike the purse-seine vessels, do not carry observers. With respect to the smaller, coastal longline vessels, in 2003 the IATTC began a program to reduce the incidental mortality of sea turtles captured by these vessels. As a result of this program, a data base of bycatch species in the coastal longline fishery is being acquired. In general, there is an urgent need to collect data from all classes of longline vessels fishing in the EPO, particularly the larger ones.

1.1.2. Measures taken to reduce bycatch and discards

Because of concern over the possible impact that bycatch and discards in the purse-seine fishery for tunas in the EPO may be having on the populations of these species and the ecosystem to which they belong, the IATTC has initiated a number of programs in an attempt to reduce these impacts. The initiatives can be grouped into three categories: limits on the take of bycatch and discard species, fishing gear and technology, and spatio-temporal distribution of fishing effort.

The first attempts by the IATTC to reduce bycatch were the requirement to use specific types of fishing gear and practices proven effective in reducing dolphin mortality, and the establishment of mortality limits on dolphins that could be taken in the purse-seine fishery. As already mentioned, these initiatives were successful and continue to be used in the fishery.

With respect to the reduction of discards of tuna species, in 2000 the IATTC approved a resolution on bycatch which has led to several approaches to reducing such discards. One of these approaches, the full retention measure, established a one-year pilot program to require all purse-seine vessels to first retain on board and then land all bigeye, skipjack, and yellowfin tuna caught, except fish considered unfit for human consumption for reasons other than size; the objective of this was to provide a disincentive to the capture of small fish. Results from the pilot program were moderately encouraging, so the Commission has renewed the program each year. Data resulting from the program have been analyzed and show that discards have been reduced, although it is difficult to establish clearly whether these reductions were due to the program or ho other factors; nevertheless, the program is being continued.

The same resolution, as well as others subsequently approved, also requires fishermen on purse-seine vessels to promptly release unharmed, to the extent practicable, all sea turtles, sharks, billfishes, rays, mahi-mahi and other non-target species. In addition, in 2007 the Commission approved a specific resolution on sea turtles, implementing the FAO guidelines to reduce bycatch of sea turtles, which requires fishermen to undertake specific procedures for reducing capture and mortality, including, *inter alia*, stationing a speedboat near the point where the net is lifted out of the water and using it to remove any turtles captured within the net, disentangling and releasing any turtles entangled in the net, and if necessary, resuscitating any turtles brought on board before releasing them back into the water. For longline vessels, fishermen are required to carry and employ de-hookers, line cutters and scoop nets for the prompt release of incidentally-caught sea turtles. As a result of these resolutions, the Commission adopted a three-year program to mitigate the impact of tuna fishing on sea turtles. This program calls on members and cooperating non-members (CPCs) to undertake data-collection programs on interactions between fishing gear and sea turtles and on the bycatch resulting from these interactions, and requires the IATTC and CPCs to work jointly to improve techniques to further reduce sea turtle bycatch and to undertake research to determine the effectiveness of the use of circle hooks in reducing catches and mortality of sea turtles. Accordingly, in 2003 the IATTC initiated a program, funded by World Wildlife Fund, the Western Pacific Regional Fisheries Management Council, the U.S. National Marine Fisheries Service, the U.S. Department of State, the Overseas Fisheries Cooperation Foundation of Japan, the Ocean Conservancy, Defenders of Wildlife, and several other groups, to test the effectiveness of circle hooks in reducing turtle bycatch and mortality. The program, which started working with longline vessels in Ecuador, has been expanded to Colombia, Costa Rica, El Salvador, Guatemala, Panama, and Peru. Preliminary results from these experiments using circle hooks are encouraging, in that they show no significant reduction in catches of target species, but a definite reduction in turtle catch and mortality. Further work is

needed to confirm these results and to include more vessels, particularly the large-scale high-seas longliners.

Additional outcomes of the above-mentioned initiatives were programs on the conservation of sharks and seabirds caught in association with fisheries in the EPO. For sharks, the CPCs are called on to 1) implement a national plan of action on shark conservation and management that is in accordance with the FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks); 2) require their fishermen to utilize any retained catches of sharks fully (all parts of the shark except the head, guts and skin); 3) require that shark fins aboard their vessels total no more than 5 percent of the weight of sharks on board; 4) prohibit their fishermen from retaining on board, transshipping, landing, or trading in any shark fins in contravention of the program; and 5) encourage the release of any non-targeted sharks. For seabirds, the IATTC recommended that CPCs implement the FAO International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries (IPOA-Seabirds) – purse-seine vessels rarely or never catch seabirds during fishing operations – and undertook investigations to estimate seabird mortality in the tuna fisheries of the EPO. The results of the investigations revealed that albatrosses and petrels are the species most impacted by the fishery and, based on studies from other regions, longline vessels frequently interact with seabirds during the fishing operation. The scientific staff of the Commission has recommended an expanded data-collection program on how industrial and artisanal longline fisheries operate, the collection of seabird bycatch data by observers, and research directed towards reducing seabird bycatch in pelagic longline fisheries. It also recommended that longliners be required to adopt at least one of several mitigation measures proven useful in reducing seabird bycatch, such as side setting, night setting, bird-scaring lines, weighted branch lines, blue-dyed bait, underwater setting devices, and management of offal discharge.

The Commission has undertaken several programs related to fishing gear and technology. One of these is directed at examining the effect of a number of variables, such as vessel size, net depth, mesh size, fishing location, oceanographic features, FAD configuration and distribution, on the catch of bigeye tuna by purse-seiners in the EPO. The purpose of the analysis was to determine if certain modifications could be made to the gear or fishing practices that would be effective in reducing the catch of bigeye tuna. The results showed that longitude and latitude had the most impact on bigeye catch, but that net depth, and the depth to which the material hanging from the FAD reached, were positively correlated with bigeye catch. In another program, the Commission staff evaluated spatio-temporal catch-statistical data to determine if there are areas in the purse-seine fishery where bycatch and discards would be expected to be low relative to other areas, and where a prohibition of fishing in those other areas and times would result in reduced bycatch and discards. Although such areas were identified, because reduced catches of skipjack would result, such a program was deemed infeasible at this time, and without further studies of gear modifications and fishing techniques should not be implemented.

Scientists in Norway have developed sorting grids which are placed in the terminus of trawl nets to allow the release of undersized fish. The grids are large metal squares with bars placed vertically at varying intervals. When the fish captured in the net reach the grid, the small ones can pass through unharmed. Commission scientist built a small version of the grid that they tested with tunas at the IATTC's Achotines Laboratory in Panama, and found that the tunas passed readily through the grid. They are now working with fishermen in Ecuador and Venezuela to test a prototype sorting grid that can be placed in the purse-seine net. Although it is too early for any results from these experiments, it is an area of research that might hold promise. Addition-

ally, the tuna industry in Ecuador has been experimenting with a flexible sorting grid made of wire that is patched into the net. Because of the design of the net the openings tended to stretch and allowed the escape of fish of a size larger than intended. Further testing is planned, but nevertheless, the government of Ecuador has mandated vessels flying its flag to use such sorting grids.

In still another program, the scientists of the IATTC, in cooperation with scientists from Stanford University and the Monterey Bay Aquarium, have been conducting research on the behavior of tuna and other species around floating objects to determine if behavioral characteristics could be identified which might be useful in reducing bycatch and discards and could be applied to the fishing process. This work has mostly involved experiments with archival tags to determine movements of the tagged fish in the vertical and horizontal plane, and their reaction to external temperature changes. The experiments show that there is a vertical stratification among the different tuna species, particularly bigeye, which may be useful in the development of selective fishing practices, and that there seems to be some predawn separation of skipjack from FADs and other accompanying species. This behavioral characteristic is being further examined, to determine whether it might provide the opportunity to catch skipjack without the associated fauna they are found with around FADs.

2. WESTERN AND CENTRAL PACIFIC OCEAN

2.1. Bycatch and discards

A variety of fishing gear is used in the Western and Central Pacific Ocean (WCPO) to capture tunas, and most of the gear types have some associated bycatch and/or discards. There has been limited observer coverage on vessels operating in the WCPO, so the amount of information available on bycatch and discards is also limited, particularly for longline vessels.

2.1.1. Estimating the bycatch and discards

Since the mid-1980s the Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community (SPC), the Forum Fisheries Agency (FFA) and several nations with vessels fishing in the WCPO have initiated programs to place observers aboard purse-seine and longline vessels for the purposes of collecting a variety of information, including estimates of discards and bycatch. Though observer coverage has been very low, the Western and Central Pacific Fisheries Commission (WCPFC) is formulating guidelines to increase it substantially, and in fact, its Conservation and Management Measure (CMM) 08-01 calls for substantially increased observer coverage. During 1990-2004, 0.8 percent of all longline sets were covered by observers, and the corresponding figure for purse-seine vessels is 3.5 percent. These low levels of observer coverage cannot give very reliable estimates of discards and bycatch. Nevertheless, there have been several studies that have attempted to quantify discards and bycatch for the purse-seine and longline fleets operating in the region; some of the results are shown in Tables C-2 to C-4 below, which were compiled from data from the Scientific Committee of the WCPFC and the OFP.

Purse-seine vessels fishing on the high seas in the tropical regions of the WCPO may discard tu-

Skipjack	10 percent
Yellowfin	7 percent
Bigeye	12 percent

TABLE C-2. Discards of tuna as a percentage of the total catch by purse-seine vessels in the WCPO, 2004.

nas because they are too small and have no commercial value, or because in the last set of the trip they catch more tuna than the vessel has empty capacity to hold. In some cases bigeye tuna is discarded because the canners may offer a low price for it because of discoloration.

Species or Group	Longline	Purse Seine	Total
Blue shark	35,843	2	**35,845**
Mako sharks	3,935	26	**3,961**
Oceanic whitetip shark	6,362	403	**6,765**
Silky shark	13,621	704	**14,325**
Whale shark	0	250	**250**
Other sharks and rays	9,069	1,474	**10,543**
Barracudas	998	100	**1,097**
Mahi-mahi	1,499	574	**2,073**
Escolars	3,710	0	**3,710**
Lancetfishes	525	0	**525**
Ocean sunfish	1,387	0	**1,388**
Oilfish	1,153	7	**1,160**
Opah	3,403	0	**3,403**
Pomfrets	394	4	**398**
Rainbow runner	23	3,889	**3,911**
Wahoo	3,111	239	**3,350**
Other fish	4,438	9,261	**13,699**
Total	**89,470**	**16,933**	**106,403**

TABLE C-3. Estimated bycatch in tons during 2004 for purse-seine and longline fleets fishing in the WCPO.

As is the case for the EPO, purse-seine vessels in the WCPO also take large bycatches of a variety of fish species, and sets on floating objects usually take significantly more bycatch than sets on unassociated schools. Table C-3 shows the tonnage of various types of fish taken by purse-seine vessels and longliners. Longliners take many more times the number of sharks than do purse seiners; they also take many more tons of the deeper-swimming fish, such as escolar and opah, than do purse seiners. Purse seiners take large numbers of rainbow runners, which are found more at the surface and would not be expected to show heavily in the deep-fishing longline gear.

To compare bycatch rates of the more iconic species, a sample of longline fleets are broken into three categories: tropical shallow longline, which fish nearer to the surface, tropical deep longline, which as the name implies, fish deeper, and temperate albacore longline (Table C-4).

	TSL	TDL	TAL	Total
Birds	0	0	90 (100)	90 (100)
Sharks	193,250 (29)	78,504 (32)	70,751 (24)	342,505 (28)
Mammals	313 (0)	0	0	313 (0)
Turtles	2,197 (0)	1,563 (58)	271 (33)	1,834 (54)

TABLE C-4. Bycatch, in number of individuals, by tropical shallow- line longliners (TSL), tropical deep-water longliners (TDL), and temperate albacore longliners (TAL), fishing in the WCPO during 2004. The percentage of the catch that was presumed to have died is shown in parenthesis.

As turtles usually inhabit the upper mixed layer, the greatest catches of turtles are made with shallow longlines. However, mortality with this gear is negligible, since the turtles when hooked can still get to the surface to breathe. Catches are lower for deep-fishing longliners and albacore longliners, but mortality is higher because the hooked turtles cannot get to the surface to breathe. The purse-seine fishery was estimated to take about 60 turtles during 2004, and all of them were returned to the sea unharmed. All of the turtle species taken in the longline and purse-seine fisheries are either threatened or endangered, so any mortality of these species is undesirable. Other, and perhaps more significant, causes of turtle mortality are alteration of nesting habitat, small coastal subsistence fishing, and harvesting eggs for human consumption.

Many of the oceanic seabirds throughout the world are imperiled, and much of this is attributed to fishing activities. The incidence of bird/fishing gear interactions has been low for the tropical western Pacific; the problem seems to be much more severe in temperate waters. Bird mortality in the southern bluefin fishery is a great concern to many states. There were almost no interactions identified in the observer data base for purse-seine vessels and longliners fishing in the tropical regions. Longline vessels fishing for albacore in temperate regions were shown to have taken small numbers of birds; however, most of the birds taken were killed. (Recent information attributable to Bird Life International corroborates lower catches in the tropics and increasing catches poleward, but suggests much higher rates of bird mortality than are indicated in Table C-4.)

Observers have recorded very few mammals being taken by fishing gear in the WCPO. Purse seiners were reported to have taken about 250 animals per year, including dolphins incidentally taken in sets on floating objects, and some whales that were deliberately set on in order to capture the tuna associated with them. However, there were almost no recorded mortalities associated with the capture of marine mammals.

The most commonly taken sharks are blue sharks and silky sharks. Analysis of the status of blue sharks in the Pacific Ocean shows that they are at a sustainable level of exploitation. No studies of the status of silky sharks in the WCPO have been completed, but studies of the species in the EPO showed the catch rate to be declining, but it was not determined whether the decline was due to fishing or environmental changes such as El Niño events. Other species taken as bycatch, such as oceanic whitetip sharks, crocodile sharks and pelagic stingrays, show a decline in catch rates, which could be related to a decrease in abundance.

In the WCPO fishery for tuna, the number of fishing trips accompanied by an on-board observer whose duty is to collect bycatch and discard information is very low, therefore the resulting quantities are extremely poorly estimated. It is a high priority of the WCPFC to increase observer coverage to a level that can yield statistically-significant estimates. This needs to be done for all gear types operating in the area, both inshore and on the high seas.

2.1.2. Measures taken to reduce bycatch and discards

The Convention establishing the WCPFC, Article 5 Part II, deals with non-target species. It gives a clear mandate for addressing the bycatch problem, stating "….assess the impacts of fishing, other human activities and environmental factors on target stocks, non-target species, and species belonging to the same ecosystem or dependent upon or associated with the target stocks; ….promote the development and use of selective, environmentally safe and cost-effective fishing gear and techniques……."

In accordance with its mandates, the organization has undertaken programs to identify, quantify,

and mitigate bycatch. There are several working groups within the WCPFC's Scientific Committee that deal directly with the bycatch issue. These are the Biology Specialist Working Group, the Ecosystem and Bycatch Specialist Working Group, and the Fishing Technology Specialist Working Group. Prior to the ratification and entry into force of the Convention, similar groups were established within the Scientific Committee on Tunas and Billfish (SCTB), but were transferred to the WCPFC after its establishment. The Scientific Committee and the three aforementioned working groups have held several meetings for which reports are available. Although the work of the groups deals with a broad array of topics concerning the fishery in the WCPO, a significant amount of the effort is devoted to the bycatch issue in both the longline and purse-seine fishery. With the exception of the U.S. purse-seine fleet, which under the U.S. Treaty Arrangement maintains a 20 percent observer coverage, there has been limited data collected for most of the fisheries in the WCPO; therefore, the working groups have concentrated on studying means of improving the data base for these fisheries. The limited data base hinders their ability to understand the bycatch problem and their research to develop effective methods of mitigation. Nevertheless, the three working groups have kept under review a number of programs designed to reduce bycatch, and which have relevance to bycatch problems in the WCPO.

For the purse-seine fishery these include:

1. A program funded by the Spanish government and the Spanish tuna industry, and carried out by scientists of the Spanish Institute of Oceanography and members of the Spanish tuna industry, designed to develop mechanisms to improve targeting and reduce bycatch. This has involved the design of FADs and the replacement of hanging netting with other materials that do not entangle turtles, billfish and sharks. Preliminary results have been promising, and further research is anticipated.
2. A second program funded by the Spanish designed to develop acoustical and echo-sounding technology to identify the species and size of fish associated with FADs, with the objective of allowing more selective fishing practices.
3. A series of programs carried out by Japan, Korea, the United States, and the European Union to study the behavior of tunas and other species around FADs and floating objects, with the objective of avoiding unwanted species and sizes of fish in the catch of purse seiners fishing around FADs and floating objects.

For the longline fisheries these include:

1. The study of the operational characteristics of longline gear, utilizing time-depth recorders and hook timers, in an effort to identify fishing practices that are more selective regarding the species to be taken and to be avoided.
2. The study of mechanisms such as *tori* lines, side setting, and night setting with minimum artificial background lighting, to reduce the bycatch of seabirds.
3. The evaluation and implementation of programs similar to the NMFS Hawaiian Island program to mitigate turtle mortality in the longline fishery by the use of circle hooks and dyed bait.

The Ecosystem and Bycatch Working Group has initiated a risk study to prioritize research with respect to each bycatch and discard species, and within the Scientific Committee the following approaches to reducing and eventually eliminating bird mortality associated with longlining have been identified and targeted for evaluation: line-weighting to make hooks sink more rapidly, be-

low-the-water setting chutes, bird-scaring (*tori*) lines, setting lines at night, regulations regarding the discharge of offal, release of live birds, water cannon to deter birds, area and season closures, and dyed bait to make it more difficult for birds to see.

The bycatch working groups are also examining the use of circle hooks to reduce turtle bycatch. In the Hawaii region the NMFS requires the use of circle hooks in the longline fishery, and closed areas and seasons have been used to reduce encounters with sea turtles. The experience gained in the Hawaiian fishery will be useful in the fisheries of the WCPO, just as the experience being acquired in the EPO with sorting grids will be useful for the WCPO fisheries.

Recent action within the Commission has led to the passage of several resolutions directed towards mitigating bycatch in the fisheries. CMM 07-04 calls on member countries and cooperating non-members (CCMs) to implement the IPOA-Seabirds and report to the Commission on a regular basis actions being taken that are consistent with the IPOA. The CMM also requires longline vessels to use bird-scaring devices and deep-setting line launchers or underwater chutes, as well as manage offal discharge. CMM 08-03 deals with turtles, and lays out requirements for disentangling, resuscitating and releasing alive sea turtles. Longline vessels are required to carry line-cutters and de-hookers for releasing turtles, and beginning in 2010 longline vessels fishing swordfish in shallow sets must use large circle hooks and only finfish for bait. CMM 08-06 calls on all CCMs to implement the IPOA-Sharks, and to fully utilize all sharks captured and not released. Fully utilized is defined as retention of all parts of the shark except the head, guts and skin; the weight of fins on board cannot exceed 5 percent of the weight of sharks on board. CMM 08-01 makes provision for purse-seine vessels to retain on board and then land or transship at port all bigeye, skipjack and yellowfin tuna. This full retention concept, which creates a disincentive to the capture of small fish, applies to the capture of all small tunas with the exception when the vessel is nearly loaded and there is no storage capacity to take all of the fish made in the last set, when the fish are unfit for human consumption, or when serious equipment malfunctions occur.

3. ALBACORE IN THE PACIFIC

3.1. Bycatch and discards

Of the total catch of albacore from the Pacific, about 68 percent is taken by longline, 18 percent by pole and line, and 14 percent by trolling. Of these three gear types, longline vessels take by far the greatest amount of bycatch. Trolling and pole-and-line vessels are very selective and have hardly any bycatch, but may have small amounts of discards.

3.1.1. Estimating the bycatch and discards

A detailed review of bycatch rates and discards was given earlier for purse-seine and longline vessels, and the information presented there applies to the albacore longline fleets fishing in the Pacific Ocean. The data presented in Table C-4 show that in the deep and shallow tropical longline fisheries few birds were captured, but in the temperate albacore longline (TAL) fishery approximately 90 seabirds were captured in 2004 (note that Seabird International data show higher bycatch rates). More detailed data for the TAL fleets in the reports of the WCPFC shows that as many as 8,000 seabirds were captured in 1990, but with the use of bird-scaring gear the numbers dropped very rapidly to the low of 2004. Most of the seabirds captured in the TAL fishery suffer mortality. The tropical shallow longline (TSL) fishery catches about 6 times as many turtles as the TAL fishery, and the tropical deep longline (TDL) fishery about 8 times as many. About 33 percent of the turtles captured suffer mortality.

The trolling and pole-and-line fisheries have very little bycatch, and often the bycatches they do take are landed and sold or kept for consumption on board. In some instances there are discards of albacore as a result of high-grading (selecting only the largest fish in the catch), but this is not too common.

3.1.1.a Measures taken to reduce bycatch and discards

The work discussed above involving the use of mitigation measures such as bird-scaring *tori* lines, colored bait, and circle hooks is being undertaken with respect to some of the albacore longline fleets, and the implementation of CMMs 07-04 on seabirds, 08-03 on turtles, and 08-06 on sharks apply to many of the vessels fishing for albacore.

4. ATLANTIC OCEAN

4.1. Bycatch and discards

In the Atlantic Ocean, some gear types, such as pole-and-line and trolling, have few discards and bycatch, whereas others, such as longline and trawls, generate more. In most cases, bycatch and discard data for longline fleets are much more sparse than for purse-seine fleets.

4.1.1. Estimating the bycatch and discards

To facilitate the collection of discard and bycatch information for the tuna fisheries of the Atlantic Ocean, and to develop methods of mitigating them, ICCAT created a sub-committee for ecosystems within its Standing Committee on Research and Statistics (SCRS). This sub-committee has dealt with the issue of estimating the kinds and quantities of species making up bycatch and discards for the various types of fishing fleets operating in the tuna fisheries of the Atlantic. The program has suffered from very low observer coverage for most of the fisheries, but some useful data has been collected.

A Spanish program placed observers on a number of trips by purse-seine vessels during 2001-2004 and the results showed many qualitative similarities among bycatch to results for other oceans. Data was collected from about 1,500 sets which captured 24,000 tons of tuna, nearly 800 tons of which were discarded. The discard rate for sets on floating objects was about four times as great as for sets on unassociated schools. Skipjack made up about 62 percent of the discards for floating-objects sets, frigate mackerel about 30 percent, yellowfin and bigeye about 3 percent each, and black skipjack about 1 percent; the corresponding figures for sets on unassociated schools were skipjack 24 percent, frigate mackerel about 90 percent, and black skipjack about 5 percent, discards of the other species being negligible. A wide variety of other fish species were taken as bycatch; many of the same species taken in the fishery of the Pacific were encountered in similar proportions in the Atlantic. Of the 1,500 sets examined, floating-object sets had about 150 times more finfish bycatch (2,500 tons), about 5 times more billfish (2,250 individuals), and 6 times more sharks (600) than did unassociated sets.

In most cases, bycatch and discard data for longline fleets were much more sparse than for purse-seine fleets. Most of the available data comes from nations with the smallest longline fleets. For example, of the 12 nations with significant commercial longline fleets fishing in the Atlantic, Chinese Taipei and Japan account for 55 percent of all effort, but bycatch data from them is very limited, while Spain, Brazil, South Africa and the US account for a much smaller proportion of the effort, they have provided nearly all of the available data on bycatch. Most of the bycatch data reviewed by ICCAT is for seabirds and turtles. Dozens of species of seabirds have been found to interact with longline vessels in the Atlantic, and of these one is critically endangered,

seven are endangered, and nine are vulnerable. For the Brazilian longline fleet fishing inside their EEZ, recent estimates show a catch rate of 0.15 birds per 1000 hooks during winter months and 0.07 hooks during the summer. Similar data for South African and Namibian longline fleets fishing throughout the south Atlantic show rates of 0.2 and 0.07, respectively; the total annual kill in the Benguela Current for these two fleets was estimated to be 2,900 birds per year. The Chinese Taipei longline fleet fishing between 25°-35°S had kill rates for 2003 and 2004 of 0.045 and 0.05, respectively. All of the foregoing estimates were made with very limited data; comprehensive quantitative data with which to assess the impact of the fishery on the various species of seabirds is not available. Nevertheless the sub-committee has used risk assessment analyses to examine the vulnerability of seabirds to mortality by longline gear, and has used the results to prioritize its efforts to collect and evaluate data on seabird interactions.

Data on the bycatch of sea turtles suffer from the same shortcomings as for other species taken by longline vessels; availability of data is very limited. However, what data is available suggest significant interactions between turtles and longline vessels. During 2005-2007 observers aboard Brazilian and Uruguayan longline vessels reported a total of 2,267 sea turtles captured. Since those two fleets account for less than 10 percent of the total longline effort expended in the Atlantic the overall catches of all fleets combined are probably substantial.

In order to improve bycatch data collection, the sub-committee is working with CPCs to help them initiate observer programs aboard their longline fleets to collect discard and bycatch statistics and has recommended that ICCAT institute an observer program similar to the ones being used by other RFMOs.

4.1.2. Measures taken to reduce bycatch and discards

Probably one of the most significant actions taken to reduce bycatch in the Atlantic was the implementation of a closed area to fishing on floating objects during November-January from 1997 through 1999 in the Gulf of Guinea. This measure was voluntarily implemented by the French and Spanish industry and was subsequently included as a conservation measure by ICCAT. Since floating objects account for most of the bycatch and discards in the purse-seine fishery, the closures should have resulted in a significant reduction in bycatch and discards.

Scientists from some of the ICCAT CPCs have been carrying out programs to study the behavior of aggregations of animals around floating objects and the development of gear and fishing technique modifications to either avoid catching these unwanted species or remove them alive from the net after capture. Although no breakthroughs have resulted, a lot of useful information is being gathered.

It is likely that the majority of turtle mortalities in purse seining result from entanglement in the netting that is hung under FADs. Scientists from the Spanish government have been experimenting with different types of materials for hanging under FADs. Preliminary results are suggesting that this type of mortality can be reduced significantly by selecting materials to hang under the FAD that do not entangle turtles. Further research on this is planned.

The ecosystem sub-committee is encouraging CPCs to develop national plans of actions for seabirds and turtles. These plans of action will set conservation and management standards by which nations can mitigate the problems caused by fisheries interactions with these bycatch species. Brazil has implemented a plan of action for seabirds that is proving effective in gathering bycatch data on seabirds and implementing the use of measures for reducing bycatch on longline vessels. The use of bird-scaring devices like *tori* lines, weighted hooks to sink the line faster be-

fore birds can take the bait, setting at night, when birds do not feed, avoiding the release of offal and garbage which attracts seabirds, and releasing lines below the water level instead of high off the ship's deck, are included within the plan of action, and are being recommended generally by the Commission. The ICCAT Sub-Committee on Ecosystems has undertaken studies to assess the abundance of the populations of seabirds that interact with the tuna fisheries; it has also set about prioritizing its future work respecting bycatch and ecosystem impacts, and will undertake an ecological risk-assessment exercise recommended by the SCRS.

ICCAT has recently implemented a regulation requiring all longline vessels fishing south of 20ºS to use *tori* lines when laying out longline during day light hours. An analysis for the Brazilian longline fleet showed that the catch of birds was reduced by 64 percent when *tori* lines were used, and the catch of target species of fish increased by 15 percent.

The sub-committee has attempted to pull together much of the information that scientists from the CPC have generated on the use of circle hooks for reducing the catch of unwanted species and has tried to coordinate research in this area among the different countries. There has been an ongoing debate over the effects of using circle hooks versus more standard J hooks. There are many factors besides just hook type that can affect results, particularly the shape of the hook, degree of offset, and hook size. Bait type, size and color have also been important in affecting bycatch. Circle hooks were found to generally reduce the catch rate and increase survival of incidentally-caught species such as turtles and marlins (and possibly seabirds); however, bait type can be an important factor as well. For example, using mackerel bait instead of squid bait tends to reduce the catch rate of turtles. Also, turtles tend to swallow circle hooks much less than J hooks, which allows more live release. Based on the results of these studies, the sub-committee has encouraged the use of circle hooks for longline and handline fishing and the continuation of studies evaluating the effectiveness of circle hooks for reducing bycatch. Scientists from the Spanish Institute of Oceanography have extended these studies, and the results are similar to those from their earlier studies.

The sub-committee has also encouraged CPCs to undertake educational programs, including the disbursement of materials introducing these mitigation measures to their fishermen.

Two resolutions dealing with sharks were approved during 2008. One calls on all CPCs to require their vessels to release alive all bigeye thresher sharks taken during tuna-fishing operations, the other calls on ICCAT to work jointly with the International Council for the Exploration of the Sea (ICES) to assess the status of the porbeagle shark population in the Atlantic Ocean.

5. INDIAN OCEAN

5.1. Bycatch and discards

In the Indian Ocean a number of different types of fishing gear are used to capture tunas, and most of them have some associated bycatch and discards.

5.1.1. Estimating the bycatch and discards

In order to facilitate the collection of information on discards and bycatch for vessels fishing tuna in the Indian Ocean, the IOTC established a Working Party on Bycatch (WPBy) which reports to the Scientific Committee. The first meeting of the WPBy, held in July 2005, recognized that there were severe shortcomings in the availability of data on discards and bycatch and therefore reliable quantitative estimates could not be made. The WPBy recommended that there be better cooperation among the CPCs in establishing programs to collect bycatch information, and

noted that without an adequate number of observers to accompany fishing trips, good and reliable data could not be collected. At the second and third meetings of the WPBy an expanded effort was made to compile information available in the archives of other organizations.

Data from a Spanish experimental longline cruise provided valuable information on discards and bycatch to the WPBy. During that campaign 531,916 hooks representing 539 longline sets were fished, and a total of 28,106 individual animals weighing 1,162 tons were caught. Of this total, 86 tons were returned to the sea as discards or bycatch, 15 tons were discarded due to predation, 40 tons were discarded for other reasons, and 30 tons were bycatch. The 30 tons of bycatch included 25 turtles, 3 birds and 3 marine mammals, as well as a variety of sharks, rays, and other finfish, most of the latter lancetfish and molas. The mammals and turtles were released back to the sea alive.

A French program provided bycatch and discard data for a sample of purse-seine vessels operating during 2005 and 2006. A total of 194 purse-seine sets were made, 116 of which were successful. About 85 percent of the sets were on unassociated schools and the rest on floating objects. There were virtually no discards of tunas reported, and bycatch was reported to amount to about 1 percent by weight of the total catch. Of the bycatch about 5 percent was billfish, 12 percent sharks, and the remainder a variety of other fish, mainly triggerfish, rainbow runners, and wahoo. No turtles or seabirds were reported captured. Similar data were collected during a series of 11 cruises aboard Spanish purse-seine vessels during 2003 and 2004. Scientific observers collected data from 224 sets over a period of 336 days. For sets on unassociated schools, the bycatch was comprised of about 85 percent sharks, 10 percent finfish, and 5 percent billfish; for sets on floating objects the percentages were 35, 55, and 10, respectively. Similar to the situation in other oceans, the amount of bycatch on floating objects was far greater than that on unassociated schools.

An additional study reviewed by the WPBy was reported for the South African domestic longline fishery as well as a sample from foreign longliners fishing from South African ports. The report dealt with only turtles, birds and sharks. A total of 4.1 million hooks were set during 2000-2003 by domestic longliners, and 9 percent of these were examined for catches of birds, turtles and sharks. In addition to the domestic fishery, about 350,000 hooks set by foreign-flag vessels fishing in the study zone were included in the data base. It was estimated that 0.82 birds per thousand hooks were killed by the foreign fleet and 0.2 birds per thousand hooks by the South African fleet. For turtles the catch rate for the domestic fleet was 0.05 animals per thousand hooks, and 85 percent of all turtles captured were released alive. The catch of sharks for the domestic fleet was 7 per thousand hooks, which represents about 25 percent of the directed catch. An update of the South African report was presented to the WPBy at its most recent meeting. The information presented corroborated the earlier data.

At the 2007 meeting of the Commission the name of the WPBy was changed to the Working Party on Ecosystems and Bycatch (WPEB) and its terms of reference were expanded. The terms of reference emphasize 1) monitoring bycatch, improving the statistical data base for all fleets, and improving information on interactions with species not under the mandate of IOTC; 2) research to evaluate the impact of both abiotic and biotic factors affecting abundance, distribution and migration of IOTC species; 3) development and monitoring of reference points and indicators that incorporate ecosystem considerations; and 4) development of mechanisms which can be used to better integrate ecosystem considerations into the scientific advice provided by the Scientific Committee to the Commission.

With these new terms of reference, the WPEB will concentrate greater effort over the short term on collecting bycatch information and evaluating the impact of bycatch on sharks, seabirds and turtles.

Overall, the availability of data on bycatch and discards for the Indian Ocean tuna fisheries is not good, especially when compared to that of the EPO. However, the IOTC recognizes these shortcomings in data and the need to improve them if the impact of bycatch on the various species is to be evaluated and mitigated and therefore has directed a great deal of their effort to improving the situation.

5.1.2. Measures taken to reduce bycatch and discards

One of the primary charges of the WPEB is to foster the development of means to reduce bycatch and discards, and it attempts to do this in a number of ways. One of these is to encourage, coordinate, and review research to modify fishing gear and technology to make it more effective in reducing the frequency and levels of bycatch and discards. Another way is to recommend, based on such research, measures to the Commission that can prove useful in reducing bycatch and discards. Still another way is through education and transfer of technology. Much of the effort carried out by the CPCs is directed toward encouraging the design of FADs that are more efficient in avoiding bycatch, and the use of sonar and echo-sounding equipment to determine the behavior of species associated with floating objects so that that information can be used to make modifications to the gear and fishing techniques that can lead to lowering bycatch rates. Accordingly, there has been several research programs conducted by CPCs and coordinated through the IOTC whose aim has been to develop technology to lower bycatch rates. For illustrative purposes a few of these are discussed here. In 2005 the Spanish government and industry carried out a series of experiments over a six-month period during which scientific observations were made for 330 days aboard two purse-seine vessels and two supply vessels. A number of different FAD designs were used to determine whether the incidence of turtle entanglement and the catch of juvenile yellowfin and bigeye could be reduced. Comparing the results of sets with modified FADs and the use of sonar and echo-sounding gear with the results of fishing using standard gear and practices, it was found that the incidence of turtle entanglement and the amount of juvenile yellowfin and bigeye captured was significantly less for the experimental fishing. These preliminary results are encouraging and further tests are being considered. Japanese researchers reported on the results of experiments to reduce seabird and turtle catches by longline vessels. A number of bird deterrent devices such as *tori* lines, water streams, electrical, magnetic and acoustical devices, fast-sinking lines, thawed bait, various colored baits, and night setting were examined. For turtles, they experimented with circle hooks, bait type, bait color, deep setting, de-hookers, line cutters, and hoop nets. Some of these experiments yielded positive results and the IOTC has approved measures to require their use. Additionally the WPEB has made available educational and training materials for fishermen on the use of certain devices that have proven useful in reducing bycatch.

The Commission has expressed a great deal of concern over the bycatch of sharks and has directed much of its effort towards dealing with this issue; it has worked with the CPCs to encourage them to support the IPOA-Sharks, and this has resulted in a number of them developing national plans of action on sharks. The task of managing shark bycatch in the tuna fisheries is complicated by the fact that there are so many directed fisheries for sharks in the coastal countries bordering the Indian Ocean. In 2005 the Commission approved a resolution concerning the conservation of sharks caught in association with fisheries managed by IOTC. The resolution

calls on CPCs to annually report catches of sharks, requests the Scientific Committee to provide preliminary advice on the status of key shark species and propose a research plan for comprehensive assessment of these stocks of sharks, calls on CPCs to undertake research to identify ways to make fishing gear more selective, calls for full utilization of captured sharks, and provides a number of guidelines regarding shark finning. The resolution also calls requires full utilization of sharks brought on board, meaning utilization of everything except head, guts, and skin. It also requires that the total weight of shark fins on board not exceed 5 percent of the weight of sharks on board, and encourages the live release of all sharks taken incidentally to other targeted species.

Regarding the bycatch and mortality of sea turtles, the Commission has called on all CPCs to require their fishermen to make every effort to avoid the incidental capture of turtles and when captured to release them alive, including resuscitation measures, and the maintenance onboard and the use of equipment appropriate for releasing incidentally-caught turtles. Purse-seine operators are requested to avoid encirclement of sea turtles to the extent practicable, to develop and implement appropriate gear specifications to minimize bycatch of sea turtles, to monitor FADs and release entangled sea turtles as quickly as possible, and to remove the FADs when not in use. Longline operators are asked to develop and implement appropriate combinations of hook design, bait type, gear specifications and fishing practices in order to minimize bycatch of turtles, and are requested to retain on board and use de-hookers, line cutters, and scoop nets for releasing turtles.

The IOTC has given a great deal of attention to seabird mortality in tuna fisheries in the Indian Ocean, and in recent years has encouraged the development of programs among the CPCs directed to the conservation of seabirds. This has resulted in an increasing level of research to estimate the levels of mortality in the various tuna fisheries and the design and testing of fishing gear and techniques to reduce mortality. Additionally, the IOTC has approved three resolutions dealing with the conservation of seabirds. One resolution, approved in 2005, calls on CPCs to implement national plans of action for reducing incidental catches of seabirds in longline fisheries which are complementary to the IPOA-Seabirds. The resolution also encourages CPCs to collect information on interactions with seabirds, including estimates of mortality caused by vessels fishing under their flag. The Scientific Committee is requested to assess the impact of incidental catch of seabirds resulting from the activities of vessels fishing tunas in the IOTC area of competence. The second resolution, approved in 2006, notes that the ultimate aim of the IOTC and the CPCs is to achieve a zero bycatch of seabirds, especially threatened albatross and petrel species, in longline fisheries. It calls for CPCs to collect and exchange information on seabird mortality and to require all vessels fishing south of 30ºS to carry and use bird-scaring lines. In an additional resolution approved in 2006 the Commission set a number of guidelines for design and deployment of *tori* lines. The most recent resolution approved in 2008 for seabirds specifically requires longline vessels fishing south of 30°S to use any two of the following measures to reduce seabird bycatch: night setting, bird-scaring devices such as *tori* lines, weighted branch lines, blue-dyed bait, line-shooting devices, and offal control. Longline vessels fishing north of that line are required to use only one of the methods.