# Questions and Answers About FADs and Bycatch

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## Table of Contents



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## 1. What are FADs?

The term FAD stands for "fish aggregating device". This term is supposed to strictly refer to man-made floating objects (usually bamboo rafts with old nets hanging underneath) deployed by fishers, although it is sometimes used to refer to any floating object, including natural ones such as logs, vegetal debris, etc. These floating objects attract fish, including schools of tropical tunas (skipjack, yellowfin and bigeye). After discovering that tunas aggregate around natural floating objects, tuna fishers started to fabricate and deploy bamboo rafts. Fishing on floating objects has existed for a long time, but the practice of using artificial FADs really took off in the 1990s and has become more and more important. Some FADs are anchored to the bottom and are used in semi-industrial fisheries (western Pacific and some areas of the Indian Ocean) or artisanal fisheries (small islands in all oceans).

Fishers have learned that setting their nets on FADs is very efficient; they tend to catch more tons of tunas more quickly during a trip than if they were looking for free-swimming tuna schools. Sets on FADs are almost always successful, while sets on free schools have a 50% chance of success; also, the tonnage per set is higher in FAD sets relative to free school sets (Fonteneau et al., 2000).

Fishers commonly equip drifting FADs with satellite buoys so they can be tracked remotely, some of them being satellite sonar buoys that estimate the amount of fish under a FAD, which helps fishers decide the most efficient strategy for when and where to go to maximize their catch during a trip. In some oceans (e.g. Indian Ocean), purse seiners are using supply vessels that are in charge of maintaining the FAD network (deploying or visiting them) for the purse seiner(s) they are working for. In other oceans, the use of supply vessels is forbidden (e.g. Eastern Pacific Ocean).

## 2. What is the difference between a FAD and a "Floating Object"?

A floating object is any object that floats at the surface of the ocean; it could be either natural (e.g. log) or artificial. A FAD is an artificial floating object, although some people use the term "FAD" for any floating object as long as it is used to catch tunas. With few exceptions (e.g., in the western Pacific), fishery statistics do not distinguish between purse seine sets made on natural objects and artificial objects. Most statistics differentiate between free-school sets (or "unassociated" sets) and sets on floating objects (or "associated" sets). In the eastern Pacific fishing statistics, sets on tuna-dolphin associations are also distinguished.

## 3. What is "bycatch"?

Different people use the term to mean different things, generally. And some people use the term to mean different things in different contexts. Very generally speaking, bycatch is the catch of anything that is not the reason for which the skipper is fishing.

In the case of tropical tuna fisheries, any species that is not the target species (skipjack, yellowfin, bigeye tuna) is bycatch. However, some tuna are discarded at sea (because of their small size for instance) and some people consider dead discards of tuna as bycatch.

The inclusion (or not) of discards of target species in bycatch is the main reason for differences in numbers when people compare % of bycatch in a fishery.

It is important to always define how the term is being used in a given context. Otherwise, people who cite a bycatch of x% in this fishery and a bycatch of y% in that fishery, too often end up mixing apples and oranges, because each study may be using the term "bycatch" to mean a different thing.

**4. What is the catch composition of target tuna species in FAD and Free School purse seine fisheries?**

Tropical tuna purse seine fisheries take three main species: Skipjack (SKJ), yellowfin (YFT) and bigeye (BET). FAD fisheries (including both artificial and natural objects) and free-school fisheries perform differently in different Ocean regions, depending on variables such as the relative abundance of the different species and their availability to the fishing gear.

In general, FAD target catches are comprised of skipjack tuna (from 57% to 82% depending on ocean region - see Figure 1), but also yellowfin and bigeye tuna. Combining all Oceans, the catches in FAD sets are 75% SKJ, 16% YFT, and 9% BET.

Sets on free-swimming schools are often mono-specific (but not always). Skipjack and yellowfin tuna represent the main catch on free-swimming schools. There is more variability by ocean region in free school sets than in FAD sets (Figure 2). For example, the catch of skipjack varies between 19% and 77% in free school sets. Combining all Oceans, the catches in free school sets are 63% SKJ, 35% YFT, and 2% BET.

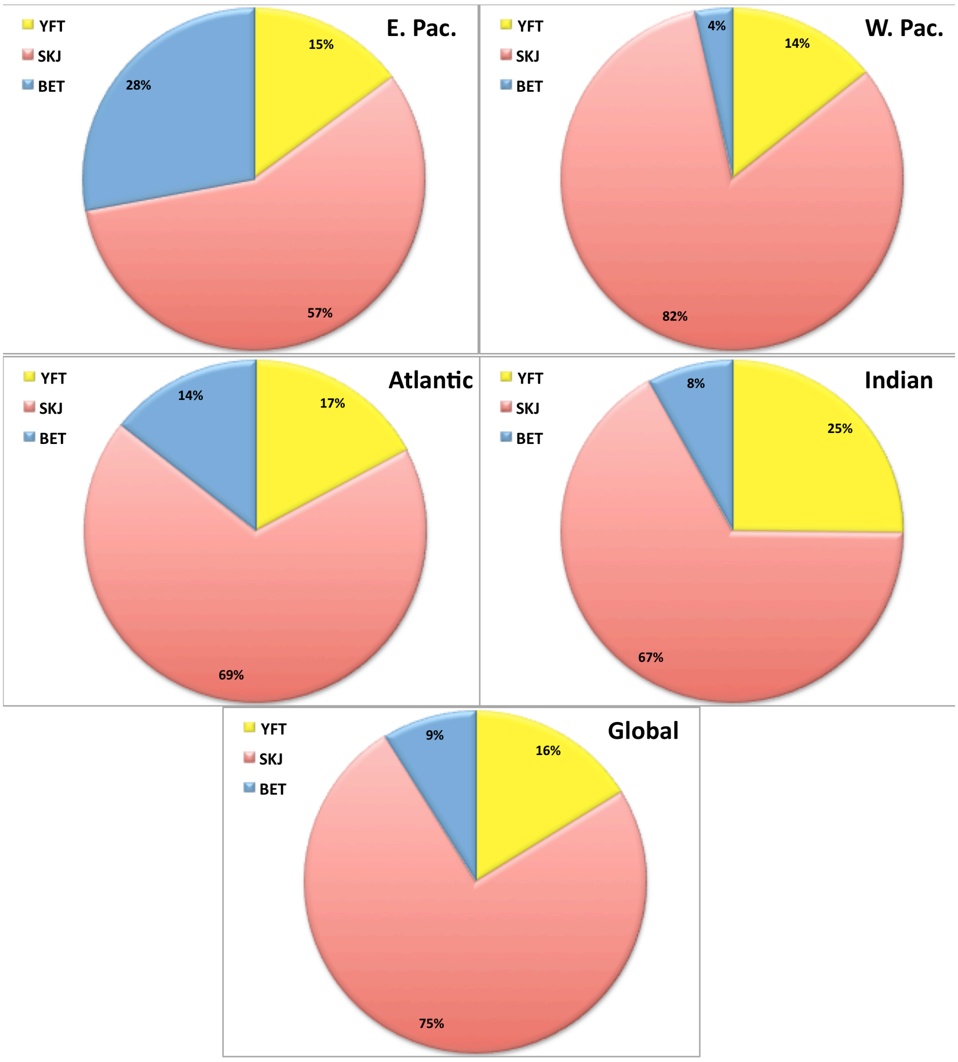


Figure 1. Composition of tropical tuna species in FAD sets, by Ocean region. Data are from the tuna RFMOs for the period 2000-2009.

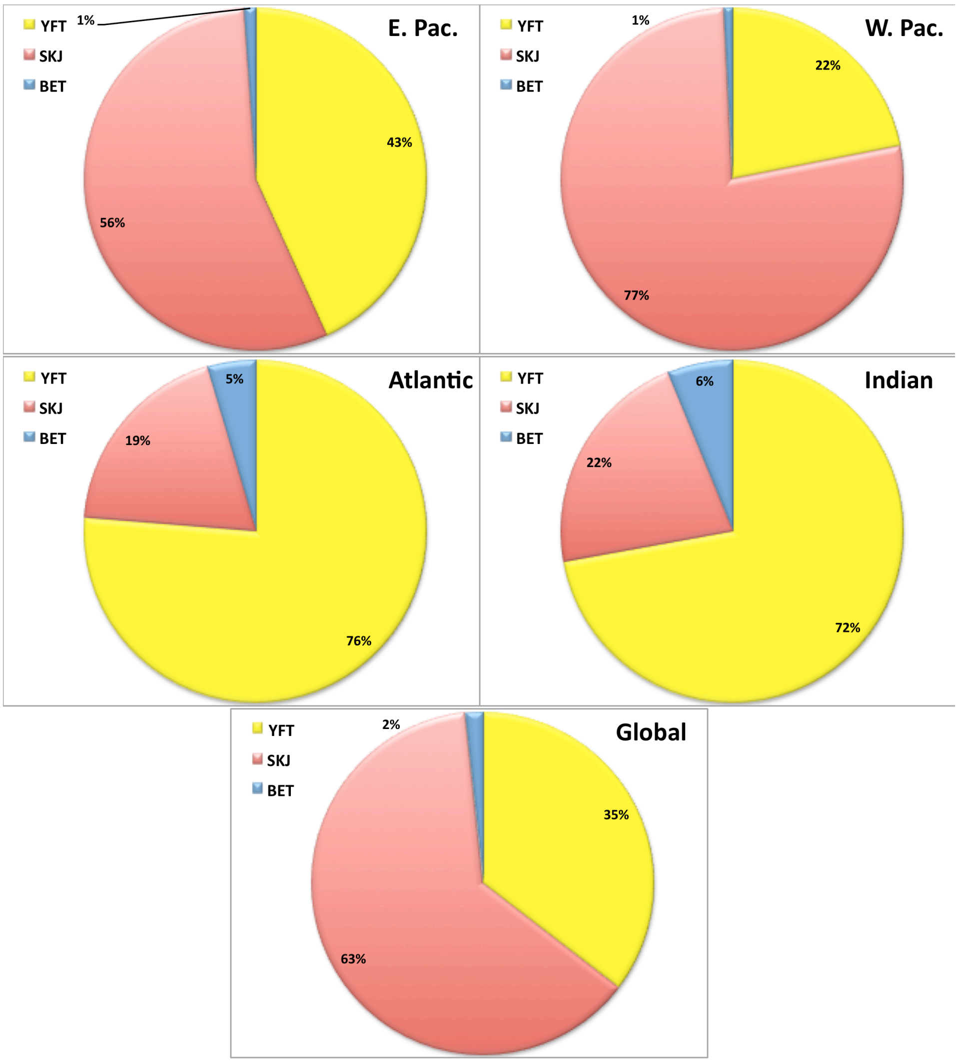


Figure 2. Composition of tropical tuna species in free-school sets, by Ocean region. Data are from the tuna RFMOs for the period 2000-2009.

## 5. How does the catch of tropical tuna species in FAD and Free school purse seine fisheries compare to other fishing gears?

Tropical tunas are not only caught by purse seining on FADs and Free schools. In the EPO, large amounts of yellowfin are also caught by purse seine sets on tuna-dolphin associations. Longliners catch large amounts of bigeye in all oceans, and pole-and-line fishing catch primarily skipjack but also about 10% bigeye and yellowfin. Gillnet and handline fisheries are also important in the Indian Ocean where they target mainly yellowfin.

The catch of skipjack by gear type is variable depending on ocean region. FADs account for 32% to 62% of skipjack catches (Figure 3). Combining all Oceans, the catches of skipjack are 48% by FAD sets, 25% by free school sets, and 27% by a variety of other gears.

The catch of the three tropical species together by gear type is also variable depending on ocean region. FADs account for 23% to 46% of the catches of skipjack, yellowfin and bigeye combined (Figure 4). Combining all Oceans, the catches of tropical tunas are 37% by FAD sets, 24% by free school sets, and 39% by a variety of other gears.

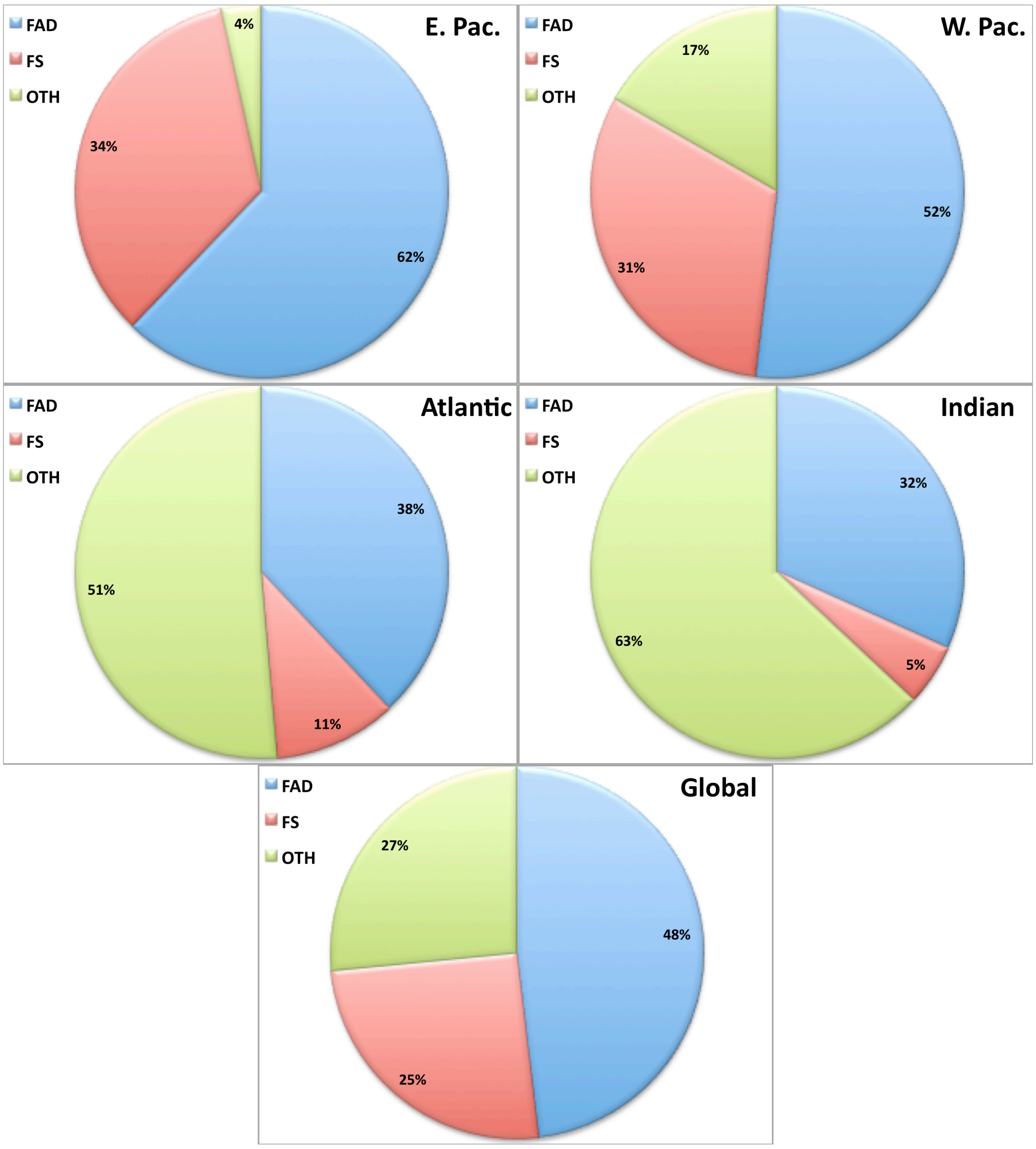


Figure 3. Catch of skipjack tuna by gear type (FAD, Free School and Other gears), by Ocean region. Data are from the tuna RFMOs for the period 2000-2009.

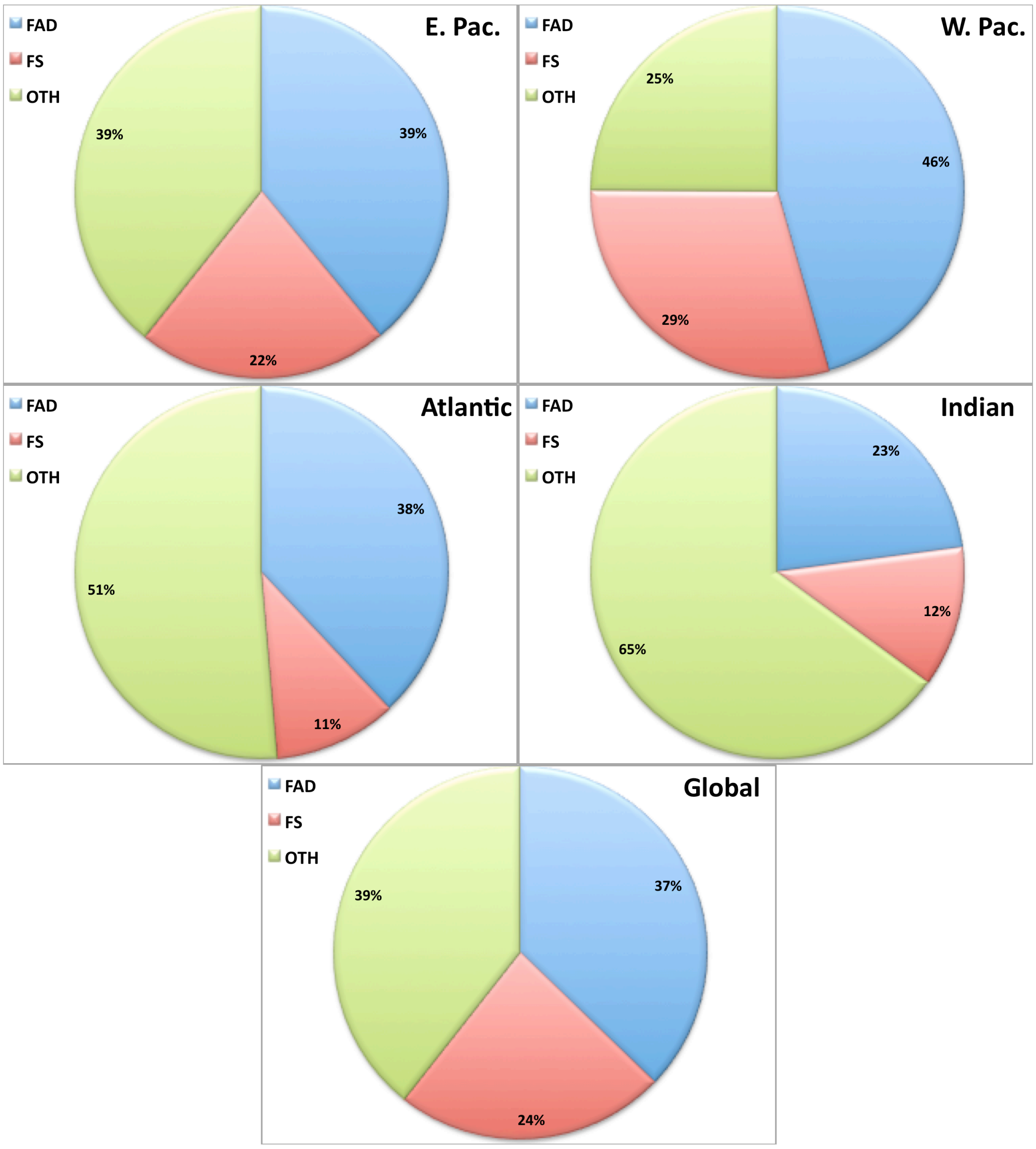


Figure 4. Catch of skipjack, yellowfin and bigeye tunas combined, by gear type (FAD, Free School and Other gears), by Ocean region. Data are from the tuna RFMOs for the period 2000-2009.

## 6. What is the magnitude of non-target species caught in FAD and Free School purse seine fisheries?

Both of these fishing methods result in bycatch of non-target species. Data collected by scientific observers onboard purse seiners indicate that FAD sets usually have a higher catch of non-target species (Figure 5). In three Ocean regions, the catch of non-target species in FAD sets is 3 to 4 times higher than it is on free-swimming school sets. In the western Pacific Ocean, this ratio goes up to 6.6 times higher, but percentages of bycatch are less than in the other oceans.

Average proportion of non-target species (compared to target species) in free-school sets is 0.3% versus 1.7% in FAD schools in the Western Pacific Ocean, 0.8% versus 2.4% in the Eastern Pacific Ocean, 0.8% versus 3.6% in the Indian Ocean, 2.8% versus 8.9% in the Atlantic Ocean. The main difference in the Atlantic Ocean comes from the high catches of other tuna species (e.g. little tuny, bullet tuna; Amandé et al., 2010). These figures correspond to catches expressed as weight (not numbers of individuals).

The accuracy of these data depends on the coverage of the observers programmes in each ocean. Coverage is 100% on large purse seine vessels only in the eastern Pacific Ocean. Observer coverage is less than 10% in the Atlantic and Indian Oceans. In the western Pacific, WCPFC has recently adopted 100% coverage for vessels fishing on the high seas or in several EEZs, but the bycatch data from these programs are not generally available yet.

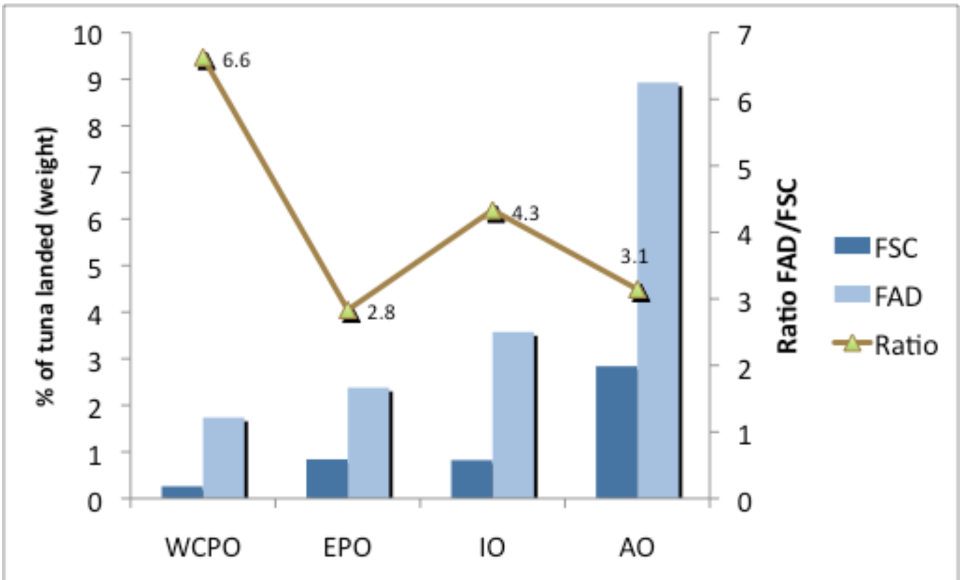


Figure 5. Amount of non-target species bycatch as a percentage of the landings of target species (tropical tunas), with information on the ratio of bycatch between FAD and free schools sets, from Amandé et al. (2008) for Indian & Amandé et al. (2010) for Atlantic using EU observers data 2003-2007, and using IATTC (2000-2009) and WCPFC (2005-2010) for Eastern and Western Pacific, respectively.

## 7. What is the composition of non-target species in FAD sets?

Different categories of non-target bycatch for tuna fisheries are:

- tunas other than SKJ, BET and YFT (e.g. little tuny, bullet tuna, kawakawa)
- other bony fishes (e.g. mahi-mahi, triggerfish, rainbow runners)
- billfishes
- sharks and rays
- marine mammals
- sea turtles
- sea birds

In terms of weight, the first four make up most of the non-target species bycatch in FAD set purse seining (Figure 6). Other Tunas and Bony Fishes make up between 81% and 95% of these non-target species bycatches.

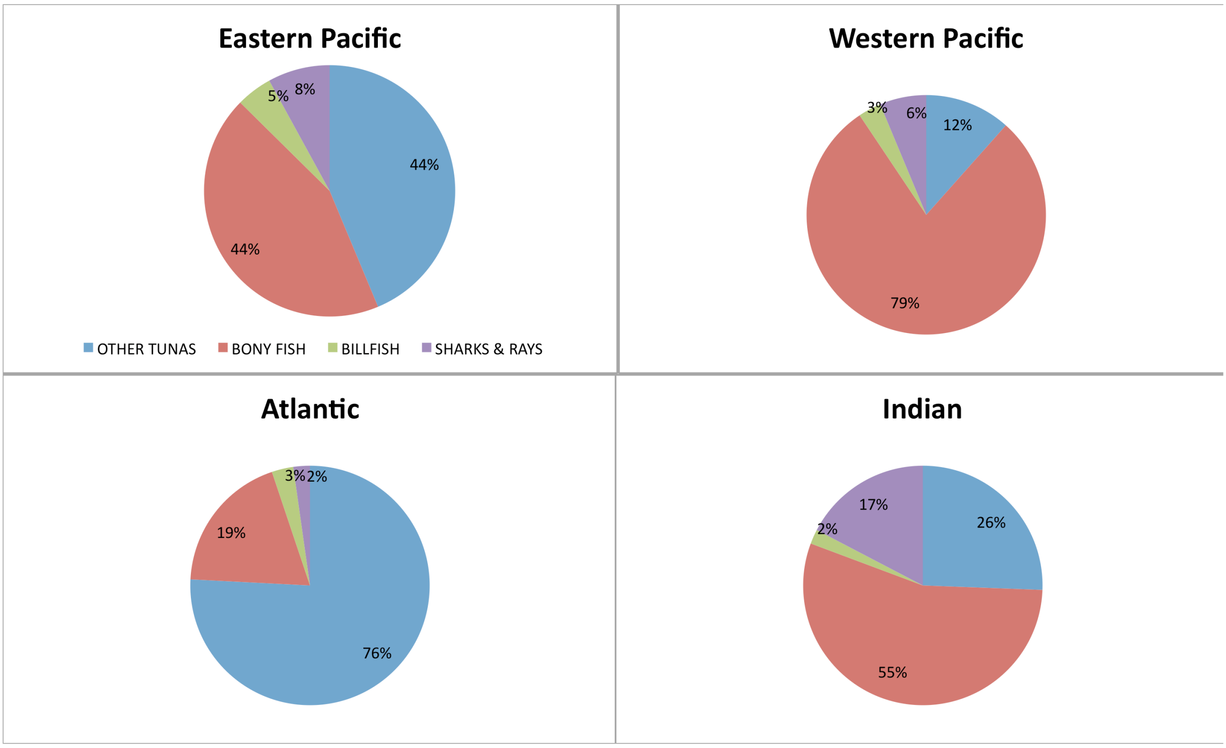

Figure 6. Composition of non-target species bycatch in FAD fisheries, by Ocean region, from Amandé et al. (2008) for Indian & Amandé et al. (2010) for Atlantic using EU observers data 2003-2007, and using IATTC (2000-2009) and WCPFC (2005-2010) for Eastern and Western Pacific, respectively.

## 8. Which of these FAD-caught species are of concern from a conservation viewpoint?

Other fishes. In purse seine fisheries, most of the non-target species bycatch (more than 80%) is represented by other tuna species and bony fishes (see Question 7, above). These species are generally considered fast growing, highly fertile with high natural mortality rates, which makes them resilient to exploitation. Therefore, the main concern with these species is that they are not utilized if discarded.

Sea birds. Sea bird bycatch is not a concern in purse seine fisheries (Gilman 2011).

Marine mammals. Catches of marine mammals on FADs are rare but can occur (SPC/OFP, 2010b).

Billfishes. Some billfishes are of concern because they are thought to be below $SSB_{MSY}$ (e.g. Atlantic marlins). Catches of billfishes are relatively small in purse seine fisheries compared to other gears such as longlining.

Turtles. Sea turtles are caught in small numbers by purse seiners and can be released alive relatively easily. For example, in the EPO, a total of 9 turtles were estimated to be killed in sets on FADs during 2009 (Olson, 2010). But there are some concerns on the use of netting to build FADs as turtles can get entangled in the underwater netting, which would go unnoticed by observers. Turtles are rated by IUCN from Vulnerable (Olive Ridley) to Endangered (Green) to Critically Endangered (Hawksbill and Loggerhead), which justifies current research conducted by ISSF and others to develop mitigation measures such as 'ecological' FADs (or 'turtle-friendly' FADs) that would avoid their entanglement.

Sharks. FAD fisheries catch sharks, primarily silky and oceanic white tip sharks. These are also caught in other tuna fisheries (e.g., estimates reported by Gilman, 2011, indicate that the catch of silky sharks by purse seiners in the Pacific are about ten times lower than the catch by longliners). IUCN lists silky shark as Near Threatened or Vulnerable depending on the oceans, and lists oceanic white tip shark as Vulnerable or Critically Endangered. These species usually have a slow growth, low fertility, and low natural mortality rates, which makes them sensitive to overexploitation.

### 9. Is all of the non-target fish discarded? Are all discards dead?

Both WCPFC (WPO) and IATTC (EPO) have adopted mandatory measures for the full retention of yellowfin, skipjack and bigeye, unless the fish are unfit for human consumption; IOTC (Indian Ocean) has adopted a similar, but voluntary, measure. IATTC estimates the amount of tunas discarded in purse seine fisheries and these are used in the stock assessments. In the Atlantic Ocean, catches of very small tunas are frequently kept and sold in local markets in western Africa (as a product called "faux poisson"); these quantities have been estimated in recent years by ICCAT. Little information is available from other regions.

In terms of other non-target species, little data are generally reported to RFMOs. Most countries do not report non-target species bycatch to the RFMOs, even where the RFMOs have adopted measures to encourage or mandate such reporting.

Many sea turtles and some sharks would be expected to be alive when caught in purse seine operations. Several RFMO measures require their release, but it is not generally known what proportion would survive. The ISSF bycatch mitigation research program includes deploying pop-up archival tags to estimate post-release survival.

### 10. How does the by-catch of non-target species compare to other major global fisheries?

Bycatch occurs in almost all fisheries. The table below from Kelleher (2005) illustrates the rates of discards in different fisheries globally. They range widely from less than a tenth of a percent, to over 60% (Note: the tuna pole-and-line figure given does not include the use of baitfish which would amount to about 3% of the tuna landings; see Gillett, 2011).

| Fishery | Landings | Discards[1] | Weighted average discard rate (%) | Range of discard rates (%) |
|---|---|---|---|---|
| Shrimp trawl | 1 126 267 | 1 865 064 | 62.3 | 0-96 |
| Demersal finfish trawl | 16 050 978 | 1 704 107 | 9.6 | 0.5-83 |
| Tuna and HMS longline | 1 403 591 | 560 481 | 28.5 | 0-40 |
| Midwater (pelagic) trawl | 4 133 203 | 147 126 | 3.4 | 0-56 |
| Tuna purse seine | 2 673 378 | 144 152 | 5.1 | 0.4-10 |
| Multigear and multispecies | 6 023 146 | 85 436 | 1.4 | n.a. |
| Mobile trap/pot | 240 551 | 72 472 | 23.2 | 0-61 |
| Dredge | 165 660 | 65 373 | 28.3 | 9-60 |
| Small pelagics purse seine | 3 882 885 | 48 852 | 1.2 | 0-27 |
| Demersal longline | 581 560 | 47 257 | 7.5 | 0.5-57 |
| Gillnet (surface/bottom/trammel)[2] | 3 350 299 | 29 004 | 0.5 | 0-66 |
| Handline | 155 211 | 3 149 | 2.0 | 0-7 |
| Tuna pole and line | 818 505 | 3 121 | 0.4 | 0-1 |
| Hand collection | 1 134 432 | 1 671 | 0.1 | 0-1 |
| Squid jig | 960 432 | 1 601 | 0.1 | 0-1 |

## 11. Does purse seining on FADs catch juvenile tunas?

Yes. Practically all tuna fishing gears catch juveniles (immature individuals).

Figure 7 shows the size distributions of bigeye (BET) yellowfin (YFT) and skipjack (SKJ) caught in FAD sets in the eastern Pacific, western and central Pacific, Atlantic and Indian Oceans. Both BET and YFT become sexually mature around a size of 100 cm, and SKJ matures at near 40 cm (actual estimates of size at maturity vary by region and by study, but these sizes should suffice as an approximation to illustrate the catches of juveniles for these three species). Most of the catch of bigeye and yellowfin in FAD sets consists of juvenile individuals (see also Table 2).

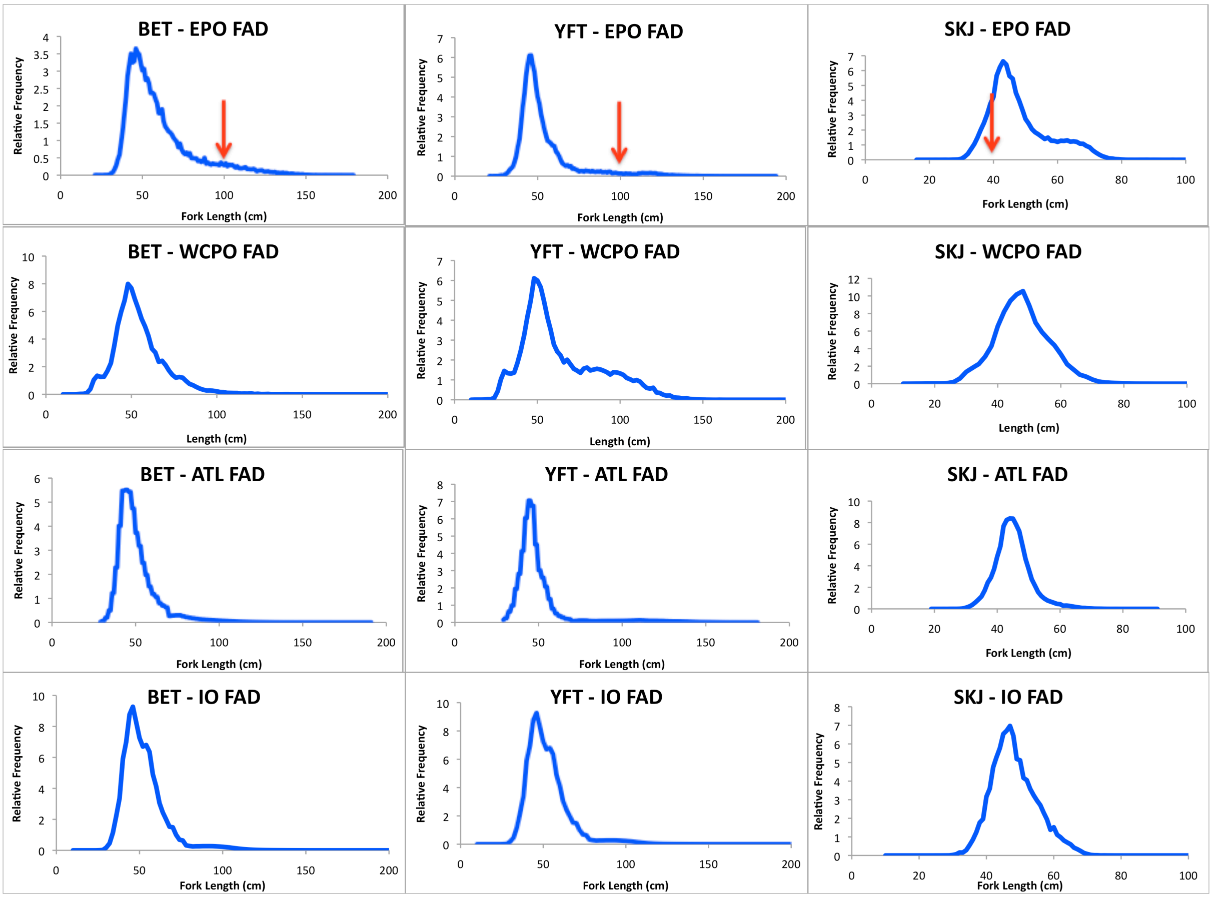

Figure 7. Size composition, in numbers, of bigeye (BET), yellowfin (YFT) and skipjack (SKJ) caught in FAD sets in different Ocean regions. Data are from IATTC (EPO), SPC (WCPO), ICCAT (ATL.) and IOTC (IO); years are 2000-2009, except for ICCAT (2000-2005).

## 12. Does purse seining on free schools also catch juvenile tunas?

Yes. Practically all tuna fishing gears catch juveniles.

Figure 8 shows the size distributions of bigeye (BET), yellowfin (YFT) and skipjack (SKJ) caught in Free School (FSC) sets in the eastern Pacific, western and central Pacific, Atlantic and Indian Oceans. The catch of bigeye and yellowfin in free school sets consists primarily of juvenile individuals in some stocks, and of both adults and juveniles in other stocks (in some cases, more adults than juveniles).

Comparing the size distributions in numbers of yellowfin and bigeye caught in FAD and free school sets (Figures 7 and 8), it is evident that both modes of fishing catch juveniles in the range 40 to 70 cm. In several free school fisheries, a second mode with larger individuals (with a mode between 125 and 150 cm) is evident, and sometimes more pronounced than the mode for small fish (for example, free-school sets catch considerably larger yellowfin in the western Pacific and Indian Oceans). For skipjack, free school fisheries consistently catch a larger size range than FAD fisheries.

Note that Figures 7 and 8 are in numbers of fish. Figures in weight would show larger differences (e.g., most of the catch of yellowfin by weight in free-school sets is adults, except in the eastern Pacific; see Table 2).

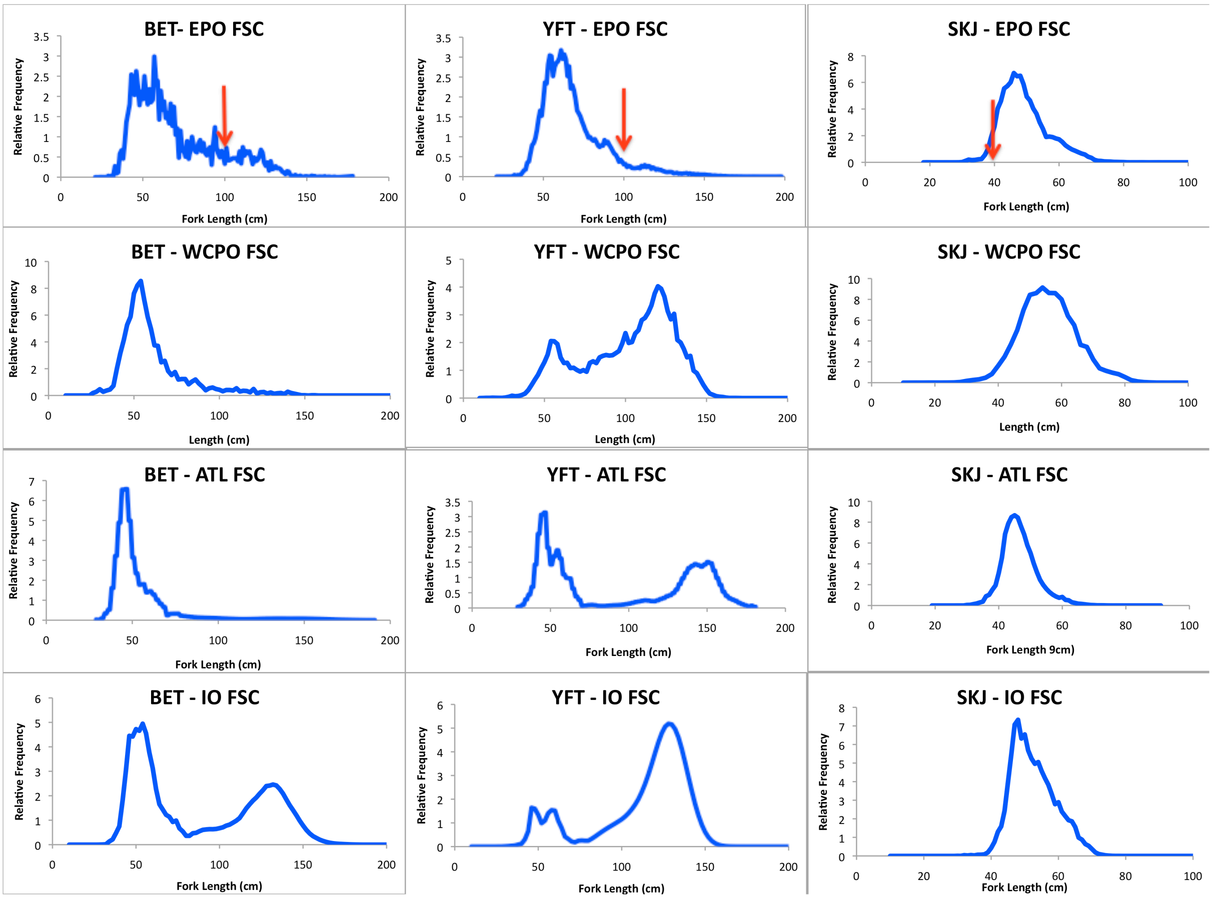


Figure 8. Size composition, in numbers, of bigeye (BET) and yellowfin (YFT) caught in free school sets different Ocean regions. Data are from IATTC (EPO), SPC (WCPO), ICCAT (ATL) and IOTC (IO); years are 2000-2009, except for ICCAT (2000-2005).

## 13. What is the percentage of juvenile tunas caught in various tuna fisheries?

Practically all tuna fishing gears catch juveniles (immature individuals), some more than others. Table 2 shows the percentages of small bigeye, skipjack and yellowfin caught in four of the main types of fishing used for tunas globally: Purse seining on FADs, purse seining on free schools, pole-and-line fishing, and longlining. FAD and Pole-and-line fishing captures more juveniles, and longlining catches fewer juveniles, in general. In the EPO, sets on tuna-dolphin associations tend to catch larger yellowfin (about 62% of the yellowfin - in numbers - in these sets are below 100 cm in size).

Table 2. Percentage of the catch of bigeye, skipjack and yellowfin composed of fish below 100 cm, 40 cm, and 100 cm (approximate sizes at maturity for the three species, respectively) in different fisheries. Top table is in numbers; bottom table is in weight. Data are from IATTC (EPO), SPC (WCPO), ICCAT (ATL.) and IOTC (IO); years are 2000-2009, except for ICCAT (2000-2005) and IO Pole and Line (1995-1997, the only available data).

| **BET** | (percent in numbers below 100 cm) | | | |
|---|---|---|---|---|
| | PS FAD | PS FSC | Pole&Line | Longline |
| EPO | 93 | 85 | 100 | N/A |
| WPO | 99 | 93 | N/A | 21 |
| ATL | 99 | 95 | 95 | 14 |
| IO | 99 | 57 | 100 | 6 |
| **SKJ** | (percent in numbers below 40 cm) | | | |
| EPO | 19 | 7 | 24 | N/A |
| WPO | 14 | 2 | 5 | N/A |
| ATL | 14 | 6 | 6 | 6 |
| IO | 7 | 1 | 11 | 11 |
| **YFT** | (percent in numbers below 100 cm) | | | |
| EPO | 96 | 92 | 97 | N/A |
| WPO | 88 | 40 | N/A | 16 |
| ATL | 96 | 52 | 98 | 26 |
| IO | 94 | 23 | 98 | 5 |

| **BET** | (percent in weight* below 100 cm) | | | |
|---|---|---|---|---|
| | PS FAD | PS FSC | Pole&Line | Longline |
| EPO | 65 | 48 | 100 | N/A |
| WPO | 89 | 65 | N/A | 8 |
| ATL | 90 | 51 | 69 | 4 |
| IO | 89 | 12 | 100 | 2 |
| **SKJ** | (percent in weight* below 40 cm) | | | |
| EPO | 8 | 3 | 11 | N/A |
| WPO | 5 | 1 | 2 | N/A |
| ATL | 7 | 3 | 3 | 1 |
| IO | 3 | 0 | 3 | 2 |
| **YFT** | (percent in weight* below 100 cm) | | | |
| EPO | 69 | 66 | 84 | N/A |
| WPO | 56 | 13 | N/A | 7 |
| ATL | 61 | 5 | 80 | 7 |
| IO | 62 | 5 | 84 | 2 |

* Approximate values, calculated assuming that weight is proportional to length raised to the power of 3.

## 14. So, what are the impacts of catching juvenile tunas?

There are two potential impacts: Loss in potential yield, and reduction in stock size.

## 15. How does catching juveniles impact potential yield?

Picture 1000 fish that are hatched at the same time. Each fish will grow larger and heavier through time. Meanwhile, some fish will be dying through time due to natural mortality. The overall biomass of this cohort of fish will be at a maximum at a particular age that depends on the tradeoff between these two variables (growth and natural mortality), as in the example below (Figure 9). In this example, the maximum yield would be obtained by harvesting the fish when they are exactly age 4 (this is known as the age that would give the "maximum yield per recruit"). Catching them at a younger or older age would not maximize the yield that can be obtained from the cohort.

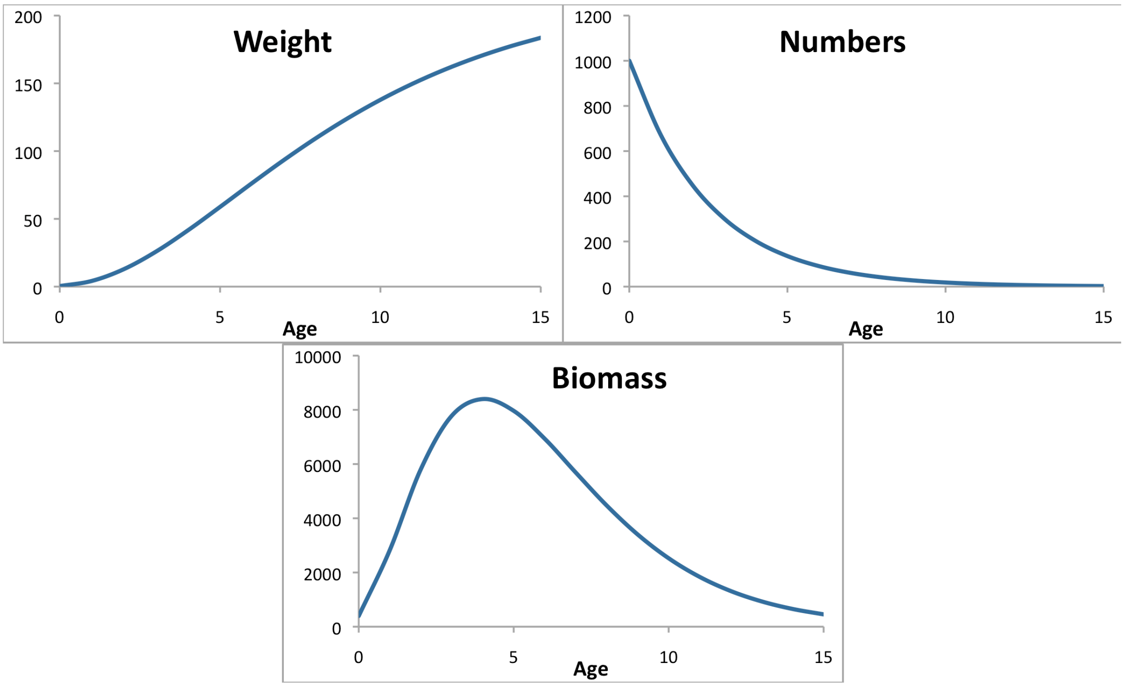

Figure 9. Hypothetical example of how the biomass of a cohort of fish changes through time due to natural mortality and growth.

In real life, it is not possible to harvest wild fish at exactly a given age (or size). All tuna fishing gears catch individuals of a range of sizes; some tend to catch larger fish (like longline fisheries) and some tend to catch smaller ones (like FAD purse seining and pole-and-line fisheries). If the overall mix of fishing gears that target a stock tend to select individuals below (or above) the age/size that would maximize yield-per-recruit, then there will be a loss in potential yield, relative to a case where the mix of fishing gears selected individuals at around the age of the maximum. Bigeye tuna in the Pacific Ocean are a good example of this effect. For instance, in the EPO, scientists estimate that the Maximum Sustainable Yield (MSY[1]) for the stock has been reduced to about half its level in 1993, when the expansion of the floating-object fishery began and the overall selectivity from all fleets combined shifted towards smaller individuals (IATTC 2010).

## 16. How does catching juveniles impact stock size?

Any amount of fishing in a population will reduce its stock size. An important indicator is the size of the parental stock, because this theoretically determines how many fish will hatch in the near future. This is usually measured as spawning stock biomass, SSB. Tuna RFMOs aim to maintain SSB at or above the size that would be able to produce MSY.

People may think that taking juveniles is necessarily a bad thing because fish should have a chance to spawn at least once before being subject to fishing. But this way of

[1] See http://iss-foundation.org/wp-content/uploads/downloads/2011/03/Stock-Assessments-101.pdf

thinking is most appropriate for species such as mammals that have low reproductive rates and mature at a relatively old age. Tropical tunas are very fecund, mature at a relatively young age, and have high rates of natural mortality. What matters in terms of ensuring a healthy level of recruitment in the future is that a sufficient number of fish survive to reproductive age. In management of tunas, this means ensuring that SSB will be at least at the level $SSB_{MSY}$.

A recent workshop (Anonymous, 2011) classified tuna stocks as being above or below the SSB corresponding to MSY, depending on the level of fishing mortality on juveniles relative to that on adults during the last 10 years or so. Regarding the tropical tunas (bigeye, skipjack and yellowfin), the workshop found that:

- Four stocks (BET-EPO, YFT-EPO, BET-WCPO, YFT-WCPO) that have experienced higher juvenile fishing mortality are currently above $SSB_{MSY}$;
- None of the stocks that have experienced high juvenile fishing mortality are currently below $SSB_{MSY}$;
- One stock (YFT-ATL) that has experienced higher adult fishing mortality is currently below $SSB_{MSY}$;

Therefore, catching juvenile tunas does not necessarily result in overfishing. The fact is that SSB can be reduced by taking juveniles, but also by taking adults.

**17. Where do juvenile tunas end up after being caught?**

This varies by region. IATTC and WCPFC mandate the full retention of all yellowfin, skipjack and bigeye caught, unless the fish are unfit for human consumption. In the Atlantic Ocean, catches of very small tunas are frequently kept and sold in local markets in western Africa (as a product called "faux poisson", together with other non-target species; see Chavance et al. 2010). Little information is available from other regions.

**18. Can bycatch from FAD fishing be reduced?**

We are convinced that it can. As Hall et al. (2000) show, reductions in bycatch rates can be achieved by a combination of (a) technological changes in gear and equipment, (b) deployment and retrieval changes, (c) skipper training, and (d) management regulations. ISSF has launched an ambitious research program to address (a) and (b), focusing on reducing the catch of small bigeye tuna, as well as turtle and shark bycatches. ISSF has already carried out training workshops (c) in Ecuador, Ghana, Panama, Samoa, Seychelles and Spain and is planning to continue doing so as one of its priority efforts. And, ISSF's potential to advocate policy changes in RFMOs (d) should be fully utilized so that more complete data are reported on bycatch, and known mitigation techniques are adopted as mandatory requirements.

Significant pressure is being exerted by some environmental NGOs to call attention to bycatch issues in FAD fisheries. This can be a driver for improvement in these very efficient fisheries that harvest a very large quantity of tunas for human consumption. We note, however, that FAD fisheries are not the only tuna fisheries with bycatch issues (in fact, some of the bycatch issues in FAD fisheries are very minor compared to those of other fisheries). Therefore, bycatch of species of concern (especially some sharks and turtles) need to be tackled for all major gears. The first step towards this is to improve bycatch data collection and reporting to the RFMOs, for all major gears.

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