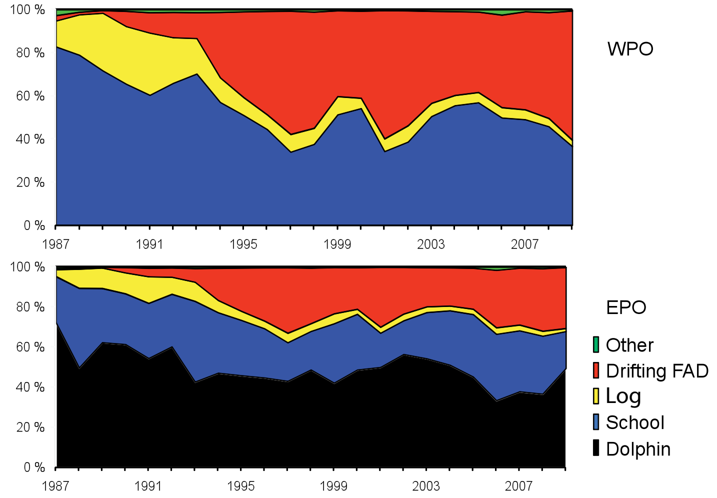
6. Distribution of effort by set type

Different fleets in different oceans utilize strategies that are adapted to their local conditions, markets and technology. This results in very variable proportions of sets of the different types. Moreover, these fleets are very dynamic, and changes are frequent. Figure 54 compares the changes in the Eastern and Western Pacific in recent decades, and they both show FADs becoming the major component of the fisheries, in terms of number of sets. In the EPO, dolphin sets represent an important part of the effort, and a segment of the fleet uses dolphin sets as the major source of its catches. Figure 55 shows the trends in the Atlantic and Indian Oceans. Pianet *et al.* (2010) show that for several fleets operating in the Atlantic the fishery on objects went from about 30 percent of the sets in the early 1990s to slightly more than 50 percent now; but the French fleet made only about 20 percent of sets on floating objects, while the Spanish fleet has made more than 60 percent of sets on floating objects in recent years (Delgado de Molina *et al.*, 2010b). In the Indian Ocean, for 2004–07 (Amandè *et al.*, 2008a), the distribution was 54 percent of school sets, 45 percent of FAD sets, and 1 percent of seamount sets. The category of seamount is not used in other oceans

FIGURE 54
Proportion of set types in the Western Pacific Ocean (WPO) and Eastern Pacific Ocean (EPO), 1987–2009



Source: William and Terawasi (2010).

FIGURE 55
Proportion of set types in the Western Indian Ocean (WIO, 1987–2008) and Eastern Atlantic Ocean (EAO, 1991–2008)

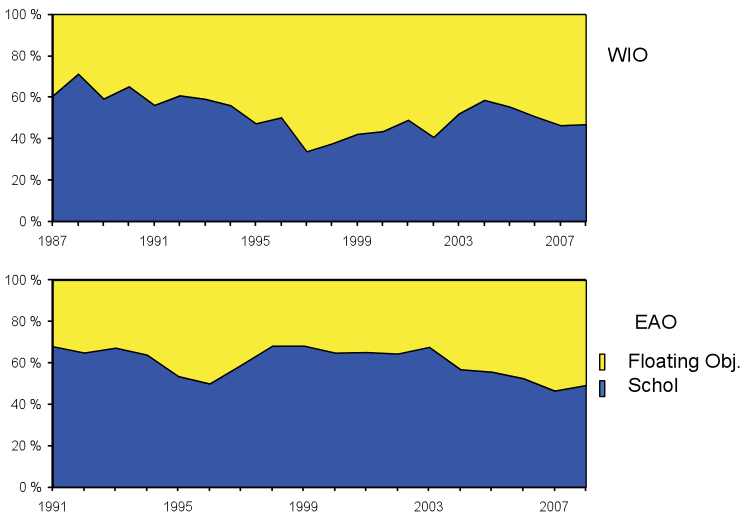
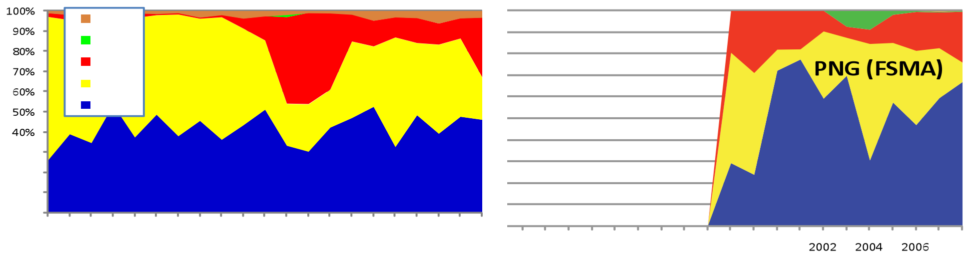


FIGURE 56
Percent catch by set type by fleet in the Western and Central Pacific



(Fonteneau, 1991), and these sets are included in the FAD set category because of their characteristics in the Atlantic and Indian Oceans. Figure 56 shows the variability by flag in the distribution of set types. Different fishing strategies are using by different fleets, and this causes problems if the sampling effort is not well distributed among the flags.

7. Sources of information on bycatch in the tuna purse seine fisheries

BIBLIOGRAPHIC INFORMATION

Information on research and management of bycatch, including all resolutions currently in place, is usually found on the Web sites of the t-RFMOs (provided above). The working groups on bycatch or on ecosystems are the places for the analyses and interpretation of the data. Two bibliographic projects are under way to bring all the information on bycatch issues together, and make it available in a systematic way. A database is being organized for the WCPFC (Williams, 2007; Fitzsimmons, 2010), and the International Commission for the Conservation of Atlantic Tunas (ICCAT) has another initiative to produce a meta-database (Cotter, 2010). These two will support the researchers and managers, at a time when the agendas have diversified so rapidly that it is hard to keep current with the activity on the subject. Perhaps, all t-RFMOs could contribute to a single bibliographic centre, providing service to all.

The best source of information for research and estimation of bycatch can be found in the t-RFMOs and related Web sites:

- IATTC – www.iattc.org
- ICCAT – www.iccat.int
- Indian Ocean Tuna Commission (IOTC) – www.iotc.org
- Secretariat of the Pacific Community (SPC) – www.spc.int
- WCPFC – www.wcpfc.int

BYCATCH DATA

Information on bycatch may come from three sources: logbooks (or other fisher's records), observer data, and electronic monitoring. In the EPO, the observer programmes were initiated to monitor dolphin mortality, and as the vast majority of the sets on dolphins were made by the larger vessels, they were limited to them (vessels of more than 363 tonnes capacity). In all oceans, the predominant sources of tuna catches are vessels of this size. These data may not be representative of the bycatch in smaller vessels that have smaller, shallower nets, and may be limited in their area of operations to more coastal regions. Therefore, extrapolations should be restricted to vessels operating with similar gear and in similar spatial and temporal strata.

Observer data are usually more complete and reliable because of the standardization of the collection process, and the dedication of the observer to that task. The quality of the observations made may depend on many conditions of the fishing operation, and on the requirements from the observer, whether they only collect scientific data, or if they have also enforcement functions (AIDCP MOP-21-09). Attempts are been made in all RFMOs to improve data quality, through observer training, identification guides, and setting of minimum standards (WCPFC-SC3/GN WP-6, 2007, at http://www.wcpfc.int/taxonomy/term/108/all?page=1; IOTC-2010-S14-CoC10-add1[E], at http://www.iotc.org/files/proceedings/2010/s/IOTC-2010-S14-CoC10-add1[E].pdf; IOTC-2010-ROS-R[E] on its Regional Observer Scheme and IOTC Resolution 10/04, at http://www.iotc.org/files/proceedings/2010/wros/IOTC-2010-WROS-R percent5BE percent5D.pdf; Domingo *et al.*, 2010).

However, there are cases where gathering quality information is not possible, even for a well-trained and motivated observer. For example, if the crew is forced to dump the catch, opening the sack by releasing the ortza (e.g. if a set is prolonged because of a malfunction, and the catch spoils in the water, or if the vessel completes its load and has no more storage space), then the observation will be of very poor quality with regard to species composition and quantity.

If the bycatch is thrown overboard from the deck, then the observation could be quite accurate for species taken in small numbers (e.g. billfishes, sharks), or accurate in composition but poor in the quantitative sense (e.g. large catches of small fishes such as triggerfishes) when only a weight can be seen.

Information on the catches of tuna purse seiners can be obtained from programmes sampling the landings of the vessels – the species composition of the catch, together with information on length frequency distributions, sex ratios, and in some cases reproductive and age data. However, this information does not provide a complete idea of the impacts of the fishery on the target species, and on other components of the ecosystems. Bycatch is occasionally reported by the fishers, but it is widely believed that only well-designed observer or electronic monitoring programmes can show the overall impacts with some accuracy.

Observer programmes are expensive and complex, and their level of coverage varies widely across the t-RFMOs (Table 12). In the EPO, the IATTC has been placing observers in 100 percent of the trips by seiners larger than 363 tonnes of capacity since 1993, following the requirements of an international agreement signed by many States

TABLE 12

Observer coverage

	EPO	WPO		Indian Ocean						Athlantic Ocean					
1979	29.3														
1980	29.6														
1981	28.2														
1982	25.2														
1983	n/a														
1984	13														
1985	21														
1986	29.8														
1987	47.9														
1988	42.3														
1989	51.5														
1990	52														
1991	53.2														
1992	96.2														
1993	100														
1994	100	2.0	1.5												
1995	100	2.0	3.6												
1996	100	3.0	5.7												
1997	100	3.0	4.9												
1998	100	3.0	5.6												
1999	100	2.0	3.1												
2000	100	4.0	3.5												
2001	98.2	5.0	4.8								9.6	13.4	7.5	10.0	8.4
2002	99.3	7.0	8.2								13.3	16.8	20.4	12.2	17.3
2003	99.3	6.0	8.2	2.3	4.0	1.4	2.4	2.4	2.7	1.5	23.2	21.9	20.9	32.7	24.6
2004	100	11	10.9	4.9	8.0	2.3	3.2	1.6	2.6	1.8	19.8	15.4	15.7	31.1	21.8
2005	100		7.7	3.7	6.7	3.6	3.0	2.9	4.5	3.7	11.6	8.5	18.1	20.1	19.1
2006	100		2.1			3.9	4.2	2.3	3.5	3.6					
2007	100					8.1				6.2					
2008	100														
2009	100														
UNIT	trips	sets	days fish	days	sets	sets	days	sets	sets	sets	days	trips	schools	obj. S	all sets
Ref	1	2	3	4	4	5	6	6	7	8	9	9	9	9	9

[1] Hammond and Tsai, 1983; Hammond, 1984; Hall and Boyer, 1986; IATTC Annual reports 1985; AIDCP Reports, 1993

[2] Molony, 2005

[3] OFP 2008

[4] Sarralde *et al.*, 2006 (Spanish fleet)

[5] Amande *et al.*, 2008

[6] Gonzalez *et al.*, 2007 (Spanish fleet)

[7] Sanchez *et al.*, 2007 (Spanish fleet)

[8] Amande *et al.*, 2010

[9] Sarralde *et al.*, 2007 (Spanish fleet)

to reduce dolphin mortality with a system of individual vessel mortality limits (the Agreement on the International Dolphin Conservation Program).

The only way to control the dolphin mortality of each vessel accurately was with full coverage of all trips of all flags. This leaves only the smaller seiners uncovered by the IATTC, but, in some cases, national programmes are providing some level of coverage (Dreyfus-León, Vaca-Rodríguez and Compeán-Jiménez, 2000). Prior to that, the EPO observer programme was initiated by the United States National Marine Fisheries Service during the 1960s when a few isolated trips were covered in United States-flagged vessels to monitor dolphin mortality. Beginning in 1972, the programme was expanded, and in 1979 the IATTC started sharing the observer coverage for the United States fleet. With the growth of fleets flagged in other countries, the IATTC share of the total sample increased (IATTC, 2008). In the WPO, coverage is going to be raised to 100 percent very soon. The Indian and Atlantic Oceans have observer coverage targets of 10 percent of their trips. In the Indian Ocean, coverage increased from 2 percent of fishing days in 2005 to 8 percent in 2007 (Amandè *et al.*, 2008b; Ariz *et al.*, 2010), and a Regional Observer Scheme has recently been adopted (IOTC-2010-ROS-R[E] and IOTC Resolution 10/04).

One of the problems of low sampling coverage is that, as the different fleets use different strategies, it is very easy to have a sample that is not well balanced, and does not have the right proportions of the different set types or modalities. Stratification can help solve these problems, if the numbers of samples in each stratum is adequate. An illustration of this is shown in Table 12 where the observer coverage of the regions is listed. Sarralde *et al.* (2007) present values for the Spanish fleet in the Atlantic that allows the calculation and comparison of coverage in units of trips, days fished, sets by type and all sets combined. Some of these values are reasonably similar, but the coverage of school sets is more than double the coverage of trips (31.15 percent vs 15.4 percent). This is because of operational preferences, and seasonal variability. Exploring the reasons for these discrepancies helps to understand the operational characteristics of the fleets. Another problem caused by low sampling coverage is the inability to record rare events with high mortality that may be significant in population terms, or the production of large overestimates if a rare event is sampled.

All observer programmes collect information on the vessel, gear, fishing operations, catch, bycatch, etc., and much of this is useful for estimation of bycatch or comparative studies of the effect of gear or practices on bycatch rates (Herrera and Evrat, 1998; Ariz *et al.*, 2010).

COMPARISON OF THE DATA COLLECTED BY THE DIFFERENT OBSERVER PROGRAMMES

The observer programmes from the different t-RFMOs have been mentioned above. Appendix 1 compares the data they collect on the different fleets. An obvious need for improved science and management would be to make sure that all programmes collect the same information, using similar definitions, etc. Consistency would enable comparisons across oceans.

The observer data from all t-RFMOs can be divided into several groups of data:

- vessel, gear, and trip data;
- set information;
- effort data (search);
- catch and bycatch;
- floating object characteristics – FADs.

The fields in red are only applicable to IATTC data and they are related to the tuna–dolphin issue, so they are specific to the EPO. For example, the nets of vessels that fish on dolphins, have a special section called a “dolphin safety panel” that is added to the net to reduce entanglements of dolphins. Information on other equipment and their utilization is also linked to this problem.

However, the rapid development and the changing nature of the FAD fishery have resulted in information gaps (Dempster and Taquet, 2004) that may make it more difficult to understand the causes of bycatch. These gaps are being addressed to some extent, but the transition in focus causes lags even in identifying which information is needed for the new objectives. The collection of information on FADs has been significantly improved in recent years (see the floating object observer form in Appendix 2).

What information is especially relevant to bycatch issues? Besides the typical requirements for fisheries studies, additional data may be of use for bycatch studies, and many of these variables are not being collected:

- Detection equipment: Acoustic systems may provide information on the composition and size distribution of the schools to be set on, prior to setting.
- All the characteristics of the net and of the vessel that affect the speed of net hauling are important (dimensions of net, power of winches, etc.).
- FAD characteristics in detail, including underwater components.
- Whether there is towing of the FADs out of the area encircled or not.
- Presence and use of sorting grids.
- Description of the brailers, and other equipment involved in the brailing process.
- The characteristics of the sorting process on board.
- The systems used to return the bycatch to the water.
- The training of the crews. There is no current training concerning handling bycatch, but it needs to be developed.

8. Estimating bycatch

To estimate the total bycatch of a fleet in a period there are several options: (a) estimate a ratio expressing the bycatch per unit of effort (BPUE) (set), or per tonnes of tuna captured or retained, and extrapolate it to the total amount of effort by the fleet in sets, or the total tonnage captured or retained (Hall, 1999; Borges *et al.*, 2004); (b)develop a model from observer data to predict the bycatch in unobserved sets; (c) estimate total mortality of a population, and subtract an estimate of natural mortality where available, with the traditional fisheries methods; and (d) use tagging methods. Costs or logistic difficulties have limited most of the research to methods (a) and (b). Extrapolation based on observer data is the most common method in use in the tuna fisheries. Useful discussions of design issues, and of options utilized to estimate different bycatches can be found in: Hall and Boyer (1986); Matsuoka (1999); Hall (1999); Lawson (2001, 2006a); Babcock, Pikitch and Hudson (2003); Borges, Olim and Erzini (2003); and Bravington, Burridge and Toscas (2003).

The total tonnage retained (total catch) can be obtained from landing information; the other totals should come from other sources. The ratios must be observed at sea. Therefore, in order to estimate bycatch, it is necessary to make observations at sea, during the fishing operations. An additional statistical consideration is that the sampling units in observer programmes are usually trips, and a low coverage of trips may leave many gaps in the spatial–temporal coverage, besides introducing covariation in the data.

The issues of sampling units to utilize (trips, sets, etc.) and of alternative sampling designs require significant consideration in order to optimize the use of resources (Stratoudakis *et al.*, 2001; Stratoudakis *et al.*, 1999; Lennert-Cody, 2001; Allen *et al.*, 2002; Borges *et al.*, 2004; Borges *et al.*, 2005; Lawson, 2010), although practical reasons make the trip the most common unit for observer programmes. Potential biases to consider in observer programmes include non-representative practices in the presence of the observer (an "observer effect"), and pressures on the observer to affect reports (Liggins, Bradley and Kennelly, 1997; Lawson and Williams, 2005; Lennert-Cody and Berk, 2005; Benoit and Allard, 2009). These issues must be added to the usual precision and reliability problems arising from observer coverages, which are frequently very limited, or not distributed in an effective way (Pianet, Pallarés and Petit, 2000; Lawson, 2004a, 2006a; Cotter and Pilling, 2007). Fonteneau *et al.* (2008, 2009), and Lawson (2008) provide a list of potential biases affecting the sampling of catches by observers or port samplers, and many of these may apply also to bycatch. The variability of bycatch of the tuna species that are the object of the fishery is influenced by even more factors (Rochet and Trenkel, 2005).

The sources of information are limited to human observers (fishers or on-board observers) or electronic means. To date, it has not been possible to develop electronic monitoring systems able to produce the data needed in this fishery, but the experimentation needed for their development has begun. In some cases, it may be possible to ask fishers to report on bycatch, but these happen at the moment of maximum activity in the vessel, and there is also a potential conflict of interest; hence, scientific observers have been the only source of data for the estimates.

To obtain bycatch estimates of a given precision for a species would require a level of coverage that would depend on its statistical distribution (Lawson, 2006a; Pianet, Pallarés and Petit, 2000; Lennert-Cody, 2001; Babcock, Pikitch and Hudson, 2003; Sánchez *et al.*, 2007), assuming that a series of assumptions are valid (Rochet and

Trenkel, 2005). Some species are present in many sets in small numbers; others show a large number of zeroes, and some very large figures in a few sets (Fletcher, Mackenzie and Villouta, 2005; Kawakita *et al.*, 2005; Minami *et al.*, 2007; Amandè *et al.*, 2008b; Shono, 2008). In other cases, it is not possible to differentiate missing record of zeroes when relying on logbooks (Andrade, 2007). To obtain good estimates for all species would require a level of observer coverage determined by the rare species, with the "worst" distributions, and this would be very costly.

Except for the IATTC programme that has 100 percent coverage for the larger seiners, all other observer programmes require statistical procedures to estimate the totals from samples that are in some cases very limited (Lawson, 2006b). In the case of the IATTC, some estimation is needed for trips missing in the database (e.g. data on bycatch not provided by national programmes in earlier years), and there is a fleet of smaller seiners that is not covered in total (Dreyfus-León, Vaca-Rodríguez and Compeán-Jiménez, 2000; Lennert-Cody, 2001; Sánchez *et al.*, 2007). As data provision by the national programmes is practically complete, the estimation error shrinks. Coverages of the order of 10–33 percent have been estimated as adequate to reduce some biases, and to provide a reasonable level of precision for some species (Lawson, 1997; Hall, 1999; Lennert-Cody, 2001; Babcock *et al.*, 2003; Lawson, 2006a; Sánchez *et al.*, 2007; Amandè *et al.*, 2010a) based on simulations, or on the characteristics of the statistical distributions.

The traditional approach has been the use of ratio estimates using the tonnage caught in a set, or simply the average capture per set, and extrapolated to fleet totals (Lo, Powers and Wahlen, 1982; Hammond, 1984; Stratoudakis *et al.*, 1999). Frequently, this is applied with a stratification scheme, or with a procedure of post-stratification. Ratio estimates are frequently biased at low sample coverage, and there are corrected formulas or procedures to deal with the biases (Rao, 1969; Cochran, 1977; Efron, 1982; Hall and Boyer, 1986; Efron and Tibshirani, 1993; Stratoudakis *et al.*, 1999). As mentioned above, other approaches are being developed to address the issues of the high number of zeroes in some distributions (Minami *et al.*, 2007; Shono, 2008; Yee, 2010; Li, Jiao and He, 2011).

Given the very heterogeneous nature of the fishing operations, the data need to be stratified (Hall and Boyer, 1986; Lennert-Cody, 2001; Amandè *et al.*, 2008b; Chassot *et al.*, 2009). In order to stratify, and to standardize results, critical information on the vessels, gear and operations are needed (e.g. Matsumoto *et al.*, 2000; Gaertner and Pallares, 2001; Lawson, Coan and Hinton, 2002; Itano, 2004).

Some of the classifications that could be used to stratify are presented in the following sections.

STRATIFICATION BY TYPES OF SETS

This is an obvious variable to use, but the level of partition within each type of set is not clear, and it has to be discussed. The distributions of set types, mentioned above, are important for understanding the differences among ocean basins.

Dolphin sets

These sets are only significant in numbers in the EPO. Yellowfin tuna associates with different dolphin species, and there is some geographical separation in the different associations. In the past, sets on common dolphins, and sets on pure groups of spotted dolphins, or mixed groups of spotted and eastern spinners have been kept as separate strata because the behaviour of the different groups resulted in different mortality rates for the dolphins. However, that stratification was only meaningful for dolphin mortality estimates. In any case, bycatch of other species in dolphin sets is so low, and limited to the EPO, that this issue is not a significant one for most of the species.

Floating object sets

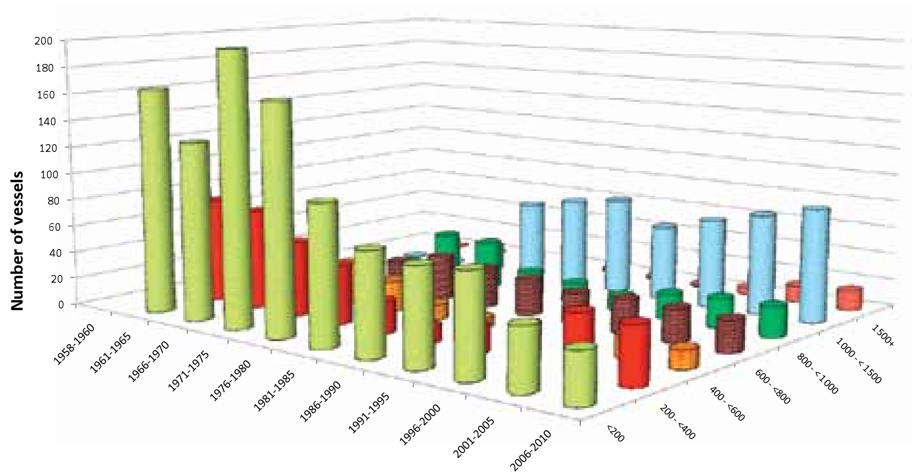
The major categories are anchored versus drifting objects. This stratification of anchored versus drifting is expected to have some impact on the Western and Central Pacific, where sets on payaos are of significant magnitude (OFP, 2010a). In the other oceans, the proportion is much lower, to the point of probably being negligible.

Beyond this, the level of stratification needed to separate meaningful units is not obvious. Are typical FADs the same as "encountered" logs with regard to catch and bycatch, even when all other sources of heterogeneity are accounted for? Are objects with netting hanging underneath (FADs), equivalent to objects without it (logs)? Which characteristics of FADs or logs make a difference? There are many different designs of FADs in use (Itano, Fukofuka and Brogan, 2004), but as the fishery is relatively new, there is still development, innovation and imitation.

The largest category of logs is a broad and ill-defined set including a very large number of objects of anthropomorphic origin (crates, pallets, lost fishing gear, etc.), or plant materials (tree trunks, branches, etc.). There is another group of dead animals (whale sharks, sharks, very few whales, and other animals including pinnipeds as the main group). Sets on live whales are only a handful, so it is not a sample large enough to make comparisons. Cooperative fishing between a seiner and a bait boat is not frequent. A more detailed list of the natural objects and artefacts that attracted tunas is shown in Hall *et al*. (1999a). Stratifications for this period would have been quite complex, not having adequate samples of some combinations to determine which types could be pooled together.

Frequently, the types of sets are not mixed at random in time or space. There are areas and seasons where one type of set is prevalent, and some other type may be completely absent (e.g. Figure 27), and this is a confounding effect that complicates the statistical comparisons.

FIGURE 57
Distribution of the tuna purse seine fleet by size class in the Eastern Pacific Ocean, 1961–2010



OTHER POSSIBLE STRATIFICATION VARIABLES

Different stratification schemes have been utilized for estimation in the different fisheries. Besides set type, the flag of the vessel has frequently been used where there is a variation in the operational mode by fleet.

- Season and areas: frequently, the fleets operate in different areas and/or ecoregions in different seasons, following oceanographic changes, migrations (Hall and

Boyer, 1986; Pianet, Pallarés and Petit, 2000; Sibert, 2005). These are the most obvious choices when detailed data on the location and date of the fleet operations are known. Vessels without observers may have their activities reported through a vessel monitoring system (VMS) that could provide information on the fishing grounds visited in a trip, and exact locations for sets.

- Flag of the vessel: frequently, it is associated with differences in equipment, fishing modalities, fishing areas, base ports, etc. (e.g. Figure 56).
- Vessel capacity: the smaller seiners tend to operate closer to the coast, the nets are smaller, etc., so their capture rates, and the species composition of the captures may be different. Vessel size and/or tonnage may affect both catch and bycatch rates, and they have changed over time (Figure 57).
- Gear characteristics: for example, net depth, acoustic equipment, presence of sorting grid.
- Vessel characteristics relevant to bycatch: brailer size, method to handle discards, etc.
- FAD characteristics: presence and depth of netting, etc.

Some of these characteristics are applied on a set-by-set basis (e.g. location), others are for a full trip (e.g. net depth). Thus, the level of detail needed in order to stratify will limit the application of some to observed trips, unless other sources such as VMS systems can fill in the data needs.

OBSERVER ISSUES AND ESTIMATION

Although observer data are by far the best for estimating bycatch, they are very far from perfect, and they offer a variety of problems that need to be considered when judging the quality of the data produced (e.g. Lawson, 2004b; Lawson and Williams, 2005). A full treatment of this subject would require a very long review, but some of the problems are covered briefly here.

Potential errors:

- Identification of species: The observers must identify a number of species in each set. Not all species are easy to identify, or the training of the observers may have been insufficient, but it is possible that individuals are assigned to the wrong species. A case in mind is the discrimination between juvenile yellowfin and bigeye tunas, which is problematic even for experts (Lawson and Williams, 2005; Fonteneau *et al.*, 2009). Good training and good identification aids are needed to address this issue.
- Misjudgement of quantities: Observers are asked to produce estimates of numbers or tonnages of the different species. Sometimes these values must be examined at some point during the loading operation, and it is not a trivial exercise.
- Misjudgements of sizes: Again, fish sizes must be examined in many cases, to allocate the quantity to size groups.
- Misjudgement of condition: In some cases, the observers are asked to state the condition of an individual to be released, without the proper training to judge the condition, or without the possibility of making a close examination.
- Impossibility to observe simultaneously all discards that may be originating from different locations of the vessel.
- All other errors, including positions, time of day, gear descriptions, etc.
- Potential biases:
- Representativeness: If the observer programme is voluntary, it is possible to avoid areas or conditions that lead to high bycatch when an observer is present. Comparison of the spatial distributions of effort in vessel with and without observers, or of other characteristics of the trips and their catches may show the presence of these biases.

- It is also possible that the mitigation equipment and actions are affected by the presence of the observer, with the crew becoming much more attentive to the release of bycatch, to the use of mitigation equipment, etc. This is an issue only in some fisheries, where there is an opportunity for the crew to affect survival of the individuals taken incidentally.
- Attempts to influence or alter the observer reports. Through bribes or intimidation, the skipper or crew may try to affect the observer reports. When there are many data for each observer, it is possible to compare the individual results with the rest of the observer population in order to detect anomalies (Lennert-Cody and Berk, 2007).

9. Species taken in association with tropical tunas

The group of species taken in floating object sets is remarkably similar in most oceans, reflecting the similarity of the pelagic communities in the open oceans throughout the world (Bailey, Williams and Itano, 1996; Stretta *et al.*, 1997; Arenas, Hall and García, 1999; Williams, 1999; Castro, Santiago and Santana-Ortega, 2002; Romanov, 2002; Taquet *et al.*, 2007b; Molony, 2008). At the same time, it is not easy to determine how different the communities associated with floating objects are, when comparing them with the communities not associated with them. School sets may help show the differences, but there is not really any kind of "random' sampling of the pelagic ecosystem, away from the objects, to study the differences. School sets have the bias that they occur under some special circumstances, and the schools are detected by the behaviour of the tunas. Comparison with catch by other gear types are not always adequate, as the operations can be different (e.g. longline catches are made on hooks, and frequently in much deeper waters). Some species have a strong association with floating objects (e.g. mahi-mahi [*Coryphaena hippurus*]), while others are seldom found in association with them (e.g. blue sharks [*Prionace glauca*], and leatherback sea turtles [*Dermochelys coriacea*]).

The group of species captured incidentally in school sets is considerably shorter. As these sets result from detection of schools of tuna engaged in feeding or other surface activities, not many species can maintain the cruising speed of the tuna schools. Similarly, the incidental captures in dolphin sets are very low, and limited to a few species. In this case, not only the other individuals have to keep up with the tuna school, but they must also stay with it during the chase of the dolphin–tuna group by the speedboats that precedes the set (median time about 15–20 minutes).

It should be noted that the data obtained by observers do not represent the totality of what was associated with the object (Massutí, Morales and Deudero, 1999). Small species or individuals may escape through the meshes, sometimes with injuries. Some species may avoid capture by diving before the net is closed at the bottom. The estimates of weights or numbers of triggerfishes and other small pelagic species may be absent, or only partial, with much guesswork.

Some authors have tried to classify the fishes associated with an object in groups based on their proximity (Parin and Fedoryako, 1999; Fréon and Dagorn, 2000). From the point of view of their capture, this classification does not make much difference, as they are all retained in the seine, given the dimensions of the net.

In the following sections, the bycatch of the different groups is reviewed. Using the databases available at the IATTC, four tables were prepared, summarizing the information on the numbers and tonnages captured (capture) and discarded dead or presumed dead (bycatch) for the period 1993–2009. To simplify the presentation, some minor or unidentified taxa were removed, but they do not constitute a major fraction of the total. As the observer programme functioned at levels very close to 100 percent for most of the period, the presentation is limited to the point estimates, with the understanding that the errors are negligible.

To present the data available for the EPO, a set of tables is included. Tables 13 and 14 show the tuna data in tonnes for: capture per set, bycatch per set, percentage bycatch, and total tonnage discarded for yellowfin, skipjack, bigeye tunas, and all three species combined, by type of set for 1993–2009. Tables 15–30 summarize the captures and bycatch of all other species:

- Tables 15–18: capture in numbers;
- Tables 19–22: bycatch in numbers;
- Tables 23–26: capture in tonnes;
- Tables 27–30: bycatch in tonnes.

TABLE 13

Capture and bycatch per set for each of the three major tuna species in the Eastern Pacific Ocean

YELLOWFIN TUNA																		
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all Years
Dolphin Sets																		
Capture/set	15.9	16.9	19.2	19.1	17.1	14.6	17.0	17.4	25.7	25.5	21.2	16.4	14.5	11.5	12.1	14.5	16.6	17.6
Bycatch/set	0.0	0.1	0.3	0.1	0.1	0.1	0.1	0.0	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
% Bycatch	0.3	0.6	1.5	0.7	0.4	0.4	0.3	0.3	1.0	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.4
Total Bycatch	271	577	2 545	879	620	709	471	397	2 463	1 289	1 503	346	166	121	216	368	296	779
Floating Obj. Sets																		
Capture/set	8.4	7.8	5.5	6.3	5.0	4.6	9.9	13.0	11.1	6.2	6.0	5.6	5.0	5.0	4.9	4.8	4.7	6.4
Bycatch/set	1.5	1.3	0.7	1.1	0.7	0.5	1.2	1.4	0.6	0.3	0.7	0.4	0.4	0.2	0.1	0.1	0.1	0.5
% Bycatch	18.2	16.3	13.7	17.3	15.1	11.6	12.1	10.7	5.2	5.0	11.0	6.4	8.4	3.7	3.0	1.8	2.5	8.6
Total Bycatch	3 158	3 337	2 579	4 394	4 483	3 183	5 282	5 099	3 525	1 788	3 608	1 782	2 041	1 325	890	609	800	2 817
School Sets																		
Capture/set	12.2	9.5	8.3	8.5	9.8	13.1	9.6	8.6	17.7	12.7	10.9	9.8	7.2	3.3	5.2	3.0	3.8	8.3
Bycatch/set	0.3	0.2	0.0	0.2	0.1	0.2	0.1	0.1	0.3	0.2	0.1	0.2	0.1	0.0	0.2	0.0	0.1	0.1
% Bycatch	2.1	1.7	0.5	2.4	1.3	1.4	1.5	1.6	2.0	1.7	1.3	1.6	1.3	0.8	2.9	0.2	2.1	1.6
Total Bycatch	1 313	617	151	1 039	413	806	794	711	1 040	1 063	839	881	722	219	840	42	358	697
SKIPJACK TUNA																		
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all Years
Dolphin Sets																		
Capture/set	0.1	0.1	0.4	0.3	1.0	0.5	0.2	0.1	0.2	0.3	1.1	1.0	1.1	0.5	0.4	0.9	0.3	0.5
Bycatch/set	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Bycatch	12.7	2.6	8.6	7.3	1.2	0.8	6.5	3.6	13.9	2.2	11.8	1.6	1.4	0.6	0.4	0.8	0.7	3.9
Total Bycatch	84	27	319	204	127	34	125	18	232	69	1676	156	150	19	10	50	35	196
Floating Obj. Sets																		
Capture/set	20.4	20.4	24.8	21.6	22.6	21.7	42.5	35.2	22.7	22.2	32.5	25.4	28.1	27.4	18.3	21.8	21.6	25.2
Bycatch/set	4.0	3.6	4.4	6.0	5.4	3.8	5.0	5.1	2.1	2.0	3.4	3.2	3.0	1.5	1.0	0.9	0.8	3.0
% Bycatch	19.8	17.6	17.6	27.7	24.0	17.3	11.8	14.4	9.5	9.2	10.6	12.5	10.6	5.4	5.4	4.1	3.7	11.7
Total Bycatch	9 939	9 513	14 904	23 464	30 198	20 880	22 554	18 715	12 265	11 733	19 081	15 868	14 852	11 091	6 222	6 142	5 940	14 904
School Sets																		
Capture/set	2.6	2.9	5.4	4.7	3.9	3.8	11.4	13.1	2.7	5.9	9.3	8.9	11.7	10.0	9.5	17.9	11.6	8.8
Bycatch/set	0.1	0.2	0.3	0.2	0.3	0.4	0.7	1.2	0.1	0.2	0.3	0.2	0.3	0.1	0.1	0.5	0.2	0.3
% Bycatch	4.6	7.2	5.7	4.5	7.5	11.1	6.1	9.5	3.8	3.6	3.1	2.6	2.8	1.4	1.3	2.8	1.3	3.8
Total Bycatch	659	986	1 150	835	1 012	1 730	3 367	5 775	318	704	1 696	1 158	2 226	1 293	927	2 974	826	1 626
BIGEYE TUNA																		
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all Years
Dolphin Sets																		
Capture/set	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bycatch/set	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Bycatch	0.0	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Total Bycatch	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
School Sets																		
Capture/set	0.6	0.2	0.6	0.7	0.4	0.3	0.2	0.3	0.1	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.3
Bycatch/set	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Bycatch	3.4	7.1	0.4	1.1	0.7	1.7	0.8	4.9	3.1	2.2	2.2	0.5	9.7	0.8	1.2	0.2	0.0	2.4
Total Bycatch	85	53	7	25	7	14	8	53	11	23	35	5	130	57	7	6	0	31
Floating Obj. Sets																		
Capture/set	3.6	10.5	10.8	14.2	10.5	7.6	12.1	23.9	9.7	7.8	9.3	11.4	10.7	9.6	9.2	10.1	8.8	10.5
Bycatch/set	0.3	0.9	1.0	1.5	1.0	0.5	1.0	1.5	0.2	0.2	0.4	0.3	0.4	0.2	0.2	0.3	0.2	0.5
% Bycatch	8.4	8.3	9.3	10.3	9.5	6.9	8.4	6.2	2.3	2.1	4.4	2.8	3.4	2.6	1.7	3.4	1.8	5.0
Total Bycatch	562	2 217	3 243	5 664	5 395	2 808	4 924	5 364	1 243	926	2 291	1 744	1 822	2 328	1 032	2 281	1 084	2 643

TABLE 14
Capture and bycatch per set for the three major tuna species in the Eastern Pacific Ocean

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg.all Years
Dolphin sets																		
Capture/set	15.9	17.0	19.6	19.4	18.2	15.1	17.2	17.5	25.9	25.8	22.3	17.4	15.6	11.9	12.5	15.4	16.9	18.2
Bycatch/set	0.1	0.1	0.3	0.2	0.1	0.1	0.1	0.1	0.3	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1
%Bycatch	0.4	0.6	1.7	0.8	0.5	0.4	0.4	0.3	1.1	0.4	1.0	0.2	0.2	0.1	0.1	0.2	0.1	0.5
Total Bycatch	355	604	2 864	1 082	748	743	579	415	2 695	1 358	3 179	502	316	140	226	418	331	975
Floating Obj. Sets																		
Capture/set	32.5	38.7	41.1	42.0	38.0	34.0	64.4	72.0	43.5	36.1	47.8	42.3	43.8	42.0	32.4	36.8	35.1	42.1
Bycatch/set	5.9	5.7	6.1	8.5	7.2	4.8	7.2	7.9	2.9	2.5	4.5	3.9	3.8	1.9	1.3	1.3	1.1	4.0
%Bycatch	18.1	14.8	14.9	20.3	18.8	14.2	11.2	11.0	6.8	6.9	9.4	9.1	8.6	4.5	0.4	3.6	3.1	9.6
Total Bycatch	13 659	15 067	20 726	33 522	40 077	26 870	32 760	29 178	17 033	14 447	24 979	19 394	18 715	14 744	8 144	9 032	7 824	20 363
School Sets																		
Capture/set	15.3	12.5	14.3	13.9	14.1	17.1	21.2	21.9	20.6	18.8	20.5	18.9	19.1	13.4	14.8	21.1	15.5	17.4
Bycatch/set	0.4	0.4	0.4	0.4	0.4	0.6	0.8	1.4	0.5	0.4	0.4	0.4	0.4	0.2	0.3	0.5	0.2	0.5
%Bycatch	2.6	3.1	2.5	3.0	3.0	3.6	3.9	6.4	2.2	2.3	2.1	2.0	2.3	1.3	1.9	2.4	1.5	2.7
Total Bycatch	2 057	1 657	1 309	1 898	1 432	2 550	4 169	6 540	1 369	1 789	2 570	2 044	3 078	1 569	1 774	3 022	1 184	2 354

TABLE 15
Capture in numbers, all species in the Eastern Pacific Ocean, 1993–2009 – dolphin sets

Dolphin sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	693	360	387	442	320	1.070	720	816	540	758	1.088	644	960	825	971	1.052	748	729
Blue marlin	64	55	51	58	86	77	81	84	72	71	115	68	133	88	76	81	154	83
Black marlin	60	57	71	70	48	64	73	129	117	111	175	114	130	98	87	78	58	91
Stripped marlin	125	32	65	125	76	98	63	45	28	66	104	120	195	137	114	129	92	95
Unid. & Others	120	42	38	103	28	55	42	73	41	47	58	36	48	74	66	94	68	61
Total	1 061	546	611	797	558	1 365	979	1 148	799	1 052	1 538	982	1 466	1 222	1 314	1.434	1 120	1 058
Mahi mahi	222	111	801	402	64	225	210	715	938	323	295	692	785	164	341	727	429	438
Wahoo	53	478	254	23	1.179	1.789	35	96	56	43	75	92	183	310	99	178	54	294
Rainbow runner	2	1	7	1	1	18	3	44	2	4	0	0	24	23	0	120	5	15
Yellowtail	49	1.709	0	0	4.317	8	0	10	45	20	103	38	2	4	1	0	3	371
Total	327	2 299	1 063	426	5 561	2 040	249	865	1 041	389	472	821	994	501	441	1 024	491	1 118
Silky shark	2 191	1 468	6.694	1 872	1 967	5 693	2 548	1 036	3 882	1 465	1 899	2 311	1 459	835	1 251	1 171	1 103	2 285
Unid. & Others	632	513	997	4 344	280	336	349	4 767	223	264	413	328	232	290	440	231	842	911
Whitetip shark	298	170	724	350	212	183	72	42	21	36	19	14	5	7	2	9	37	129
Hammerhead shark	312	76	76	96	88	181	112	466	67	127	108	96	58	66	56	53	36	122
Total	3 433	2 227	8 491	6 662	2 547	6 393	3 080	6 311	4 192	1 892	2 438	1 749	1 754	1 198	1 749	1 464	2 018	3 447
Mantaray	509	375	555	385	396	338	480	1 349	570	1 119	1 350	535	657	1 011	597	387	792	671
Stingray	134	205	144	176	993	170	151	160	174	153	135	86	173	202	133	100	122	201
Total	643	579	699	561	1 399	598	631	1 509	744	1 272	1 485	621	831	1 213	730	488	914	872
Olive ridley	13	13	14	9	7	20	9	11	4	7	3	2	4	3	3	0	2	7
Unid. turtle	2	9	3	2	2	7	3	2	5	2	3	0	1	0	2	0	1	3
Green/bjack turtle	0	0	1	0	2	1	4	0	0	0	0	0	0	0	0	0	0	0
Loggerhead turtle	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Hawkbill turtle	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Leatherback turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	15	23	18	12	12	28	17	13	9	9	6	2	5	3	5	0	3	11

TABLE 16
Capture in numbers, all species in the Eastern Pacific Ocean, 1993–2009 – school sets

School sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	1 121	1 011	489	275	428	785	582	746	1 387	322	1 710	401	226	301	708	135	78	630
Blue marlin	108	137	82	78	166	66	145	211	133	432	128	107	118	120	95	99	63	135
Black marlin	143	75	75	89	73	84	144	181	69	148	82	68	70	127	76	57	27	93
Stripped marlin	145	95	116	154	146	55	77	88	91	540	150	66	147	260	101	181	20	143
Unid. & others	106	18	48	39	30	23	45	44	62	16	108	26	27	53	92	86	24	50
Total	1 622	1 336	810	635	844	1 014	994	1 270	1 743	1 457	2 179	667	588	860	1 071	558	212	1 051
Mahi mahi	13 481	7 991	23 055	7 617	5 629	5 879	179	19 323	8 130	4 349	4 083	7 789	19 855	19 895	21 243	5 284	1 790	10 423
Wahoo	6 399	629	282	329	1 609	317	250	827	1 050	292	231	446	493	557	856	633	137	896
Rainbow runner	38	31	12	10 443	3 154	156	202	2 654	159	582	600	103	395	540	330	107	0	1 147
Yellowtail	35 067	4 258	19 484	153 652	3 837	2 924	46 435	17 975	60	2 774	197	3 490	2 132	52 161	27 081	34 796	1 518	23 937
Total	54 986	12 911	42 833	172 041	14 229	9 276	48 676	39 879	9 390	7 997	5 110	11 828	22 875	73 153	49 510	40 719	3 445	36 403
Silky shark	14 337	9 677	4 376	3 585	8 795	1 632	4 091	3 950	2 410	4 156	3 262	3 259	1 249	1 658	4 526	1 017	662	4 273
Unid. & others	1 063	3 353	1 403	1 165	490	351	262	2 378	429	999	637	768	400	1 081	965	425	354	972
Whitetip shark	655	316	1 199	194	328	222	205	424	16	161	47	4	0	1	0	0	2	222
Hammerhead shark	652	817	437	900	376	559	782	551	66	235	301	716	290	201	200	234	77	441
Total	16 708	14 263	7 414	5 844	9 989	2 764	5 339	7 303	2 920	5 550	4 247	4 746	1 939	2 941	5 692	1 676	1 095	5 908
Mantaray	9 674	1 408	2 330	1 485	709	9 953	1 563	3 407	489	5 540	2 097	2 218	2 265	2 303	1 503	1 032	202	2 834
stingray	1 857	1 507	151	165	106	259	403	221	64	60	8 347	39	52	91	54	24	18	789
Total	11 531	2 915	2 481	1 650	816	10 212	1 966	3 628	553	5 600	10 444	2 257	2 317	2 394	1 557	1 056	220	3 623
Olive ridley	41	17	11	9	33	22	18	29	11	3	4	3	6	4	1	0	0	12
Unid. Turtle	16	2	7	6	15	8	4	9	14	5	0	2	7	0	0	0	1	6
Green/bjack turtle	13	9	2	1	3	1	2	0	2	0	0	0	1	0	1	0	0	2
Loggerhead turtle	4	2	2	0	3	0	3	0	0	0	0	0	0	0	0	0	0	1
Hawkbill turtle	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Leatherback turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	74	32	22	16	53	31	27	38	27	8	4	5	15	4	4	0	1	21

TABLE 17

Capture in numbers, all species in the Eastern Pacific Ocean, 1993–2009 – floating object sets

Log sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	105	10	56	51	109	13	90	74	89	51	51	41	225	295	57	76	51	85
Blue marlin	605	477	564	482	892	1 088	1 538	864	1 074	1 308	1 405	1 072	1 537	1 283	891	913	1 226	1 013
Black marlin	490	376	401	423	650	694	835	442	778	703	968	421	665	1 001	504	528	484	609
Stripped marlin	404	179	109	57	110	100	277	75	106	218	133	87	140	224	203	124	156	159
Unid. & Others	6 41	162	106	80	80	86	139	38	56	66	95	74	71	272	123	148	85	137
Total	2 140	1 194	1 180	1 042	1 733	1 968	2 790	1 419	2 015	2 294	2 601	1 654	2 413	2 780	1 721	1 712	1 951	1 918
Mahi mahi	302 810	607 350	491 714	565 381	455 654	334 638	585 578	551 690	857 835	652 671	325 159	334 790	269 780	348 718	368 914	327 178	473 286	46 1950
Wahoo	78 720	338 363	233 553	149 474	320 104	223 641	149 912	157 983	571 102	688 803	292 769	190 345	210 827	214 227	214 963	126 929	269 715	237 143
Rainbow runner	17 153	15 402	11 035	36 073	79 780	180 246	189 547	85 902	103 467	113 342	165 582	73 853	74 965	98 401	226 975	42 900	55 454	92 357
Yellowtail	8 058	14 607	13 348	25 634	71 679	81 990	43 299	12 873	46730	15 579	45 111	95 066	24 162	42 428	14 274	48 192	21 298	36 725
Total	406 741	975 721	749 650	776 562	927 216	820 515	968 336	808 448	1 579 134	1 070 395	828 620	694 055	579 734	703 774	285 125	545 198	819 753	828 175
Silky shark	30 124	23 199	27 447	26 786	50 190	44 259	36 819	21 194	21 431	17 979	18 983	16 269	23 088	27 341	25 121	40 146	20 541	27 701
Unid. & Others	8 756	5 198	4 952	5 670	7 408	8 809	6 074	1 406	2 725	3 103	1 641	2 192	634	1 881	1 097	1 112	3 380	3 885
Whitetip shark	2 016	3 940	7 788	8 257	8 443	7 280	5 498	3 018	3 103	894	598	256	74	152	77	62	121	3 034
Hammerhead shark	760	1 875	1 374	1 646	1 742	1 140	1 580	502	1 064	2 258	2 574	2 264	1 256	891	570	583	587	1 333
Total	41 657	34 212	41 561	42 360	67 782	61 488	49 970	26 120	28 323	24 234	23 797	20 981	25 052	30 265	26 865	41 902	24 630	35 953
Mantaray	297	53	73	124	126	77	150	71	65	77	183	80	88	140	126	126	79	114
Stingray	80	140	159	101	106	97	164	104	150	113	94	138	91	153	98	113	70	116
Total	377	193	232	225	232	174	314	175	215	190	277	218	179	293	225	239	149	230
Olive ridley	24	50	66	47	54	66	82	46	51	23	16	8	7	8	6	3	9	33
Unid. Turtle	3	34	24	30	25	26	39	17	22	6	5	4	4	1	7	1	2	15
Green/bjack turtle	2	7	10	11	8	7	5	6	6	3	0	0	1	2	0	0	1	4
Loggerhead turtle	0	0	0	0	1	1	1	2	1	0	0	0	0	1	1	1	0	1
Hawkbill turtle	0	0	0	0	0	3	1	1	1	0	0	0	0	0	1	0	0	0
Leatherback turtle	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	29	93	100	88	88	103	128	72	81	32	21	12	12	12	15	5	12	53

TABLE 18

Capture in numbers, all species in the Eastern Pacific Ocean, 1993–2009 – set types combined

All sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	1 919	1 382	932	767	857	1 868	1 392	1 636	2 017	1 131	2 849	1 086	1 411	1 420	1 736	1 263	877	1 444
Blue marlin	777	669	697	619	1 144	1231	1 764	1 160	1 279	1 811	1 648	1 247	1 788	1 491	1 061	1 092	1443	1 231
Black marlin	693	508	546	581	771	842	1 052	752	965	962	1 225	603	865	1 225	667	663	569	793
Stripped marlin	674	306	290	336	333	253	418	208	225	823	387	274	481	621	418	433	268	397
Unid. & Others	866	222	192	222	138	164	226	155	160	129	261	135	146	400	281	328	176	247
Total	4 929	3 087	2 658	2 525	3 243	4 359	4 852	3 911	4 646	4 855	6 369	3 344	4 692	5 158	4 164	3 780	3 333	4 112
Mahi mahi	316 514	615 452	515 571	573 401	461 347	340 742	587 577	571 729	86 6903	657 343	329 536	343 271	290 420	368 778	390 498	333 188	475 505	472 810
Wahoo	85 172	339 470	234 089	149 825	322 891	225 747	150 197	158 906	572 208	289 138	293 075	190 883	211 503	215 094	215 918	127 639	269 906	238 333
Rainbow runner	17 194	15 434	11 054	46517	82 935	180 420	189 753	88 600	103 628	113 927	166 181	73 956	75 385	98 964	227 304	43 126	55 459	93 520
Yellowtail	43 175	20 574	32 832	179 286	79 833	84 922	89 734	29 958	46 825	18 373	45 410	98 595	26 295	94 593	41 356	82 987	22 819	61 033
Total	462 054	990 930	793 546	949 029	947 006	831 831	1 017 261	849 193	1 589 564	1 078 781	834 203	706 704	603 603	777 429	875 076	586 941	823 689	865 696
Silky shark	46 652	34 344	38 518	32 243	60 952	51 583	43 457	26 180	27 722	23 600	24 144	21 839	25 796	29 834	30 898	42 334	22 307	34 259
Unid. & Others	10 451	9 065	7 352	11 178	8 178	9 497	6 685	8 551	3 377	4 365	2 691	3 288	7 266	3 251	2 503	1 768	4 576	5 767
Whitetip shark	2 970	4 426	9 710	8 801	8 982	7 685	5 775	3 483	3 140	1 091	664	274	79	160	79	71	160	3 385
Hammerhead shark	1 725	2 868	1 886	2 643	2 206	1 880	2 473	1 519	1 197	2 620	2 984	3 076	1 604	1 158	826	870	700	1 896
Total	61 798	50 702	57 465	54 866	80 318	70 645	58 389	39 734	35 436	31 676	30 482	28 477	28 745	34 403	34 306	45 043	27 743	45 307
Mantaray	10 490	1 837	2 958	1 994	1 231	10 368	2 193	4 827	1 123	6 736	3 630	2 833	3 010	3 454	2 227	1 545	1 074	3 619
Stingray	2 072	1 851	453	442	1 206	526	718	485	388	325	8 576	263	316	446	285	237	210	1 106
Total	12 552	3 688	3 412	2 436	2 437	10 894	2 911	5 312	1 511	7 061	12 207	3 096	3 326	3 900	2 512	1 732	1 284	4 725
Olive ridley	78	81	91	66	94	108	109	86	66	33	23	13	17	15	10	3	11	53
Unid. Turtle	21	46	34	38	42	41	46	29	41	13	8	6	12	1	9	1	4	23
Green/bjack turtle	15	16	13	12	13	9	11	6	8	3	0	0	2	2	1	0	1	7
Loggerhead turtle	4	2	2	0	5	1	4	2	1	0	0	0	0	1	1	1	0	1
Hawkbill turtle	0	2	0	1	0	3	2	1	1	0	0	0	0	0	3	0	0	1
Leatherback turtle	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	118	148	141	116	153	162	172	123	117	49	31	19	32	19	24	5	16	85

TABLE 19
Bycatch in numbers, all species in the Eastern Pacific Ocean, 1993–2009 – dolphin sets

Dolphin sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	384	189	270	244	125	482	210	313	194	321	537	211	230	234	146	159	251	265
Blue marlin	21	20	26	24	7	10	14	18	29	14	44	9	15	22	3	1	8	17
Black marlin	12	9	15	11	1	7	7	5	4	10	6	3	9	2	2	6	11	7
Stripped marlin	83	23	21	63	7	29	9	30	20	27	25	5	10	8	18	3	1	22
Unid. & Others	37	10	35	37	4	8	3	7	6	7	8	0	6	8	1	2	6	11
Total	537	251	367	380	145	535	243	373	253	380	620	228	269	274	170	171	277	322
Mahi mahi	148	74	15 328	267	15	39	44	95	54	113	12	180	183	48	42	92	231	998
Wahoo	34	303	179	14	1 112	10	3	0	3	0	0	5	103	63	8	83	4	113
Rainbow runner	2	1	12	1	0	0	0	11	0	2	0	0	16	7	0	80	0	8
Yellowtail	28	974	11 107	0	3 891	0	0	0	0	0	103	185	0	0	1	0	1	947
Total	211	1 352	26 626	283	5 018	49	47	106	57	115	114	1 770	302	118	51	255	236	2 066
Silky shark	1 742	1 096	3 479	1 488	886	4 660	677	144	1051	212	685	111	265	267	94	166	33	1 101
Unid. & Others	469	378	1 077	3 397	195	204	201	4 532	48	178	224	1	121	72	268	91	62	684
Whitetip shark	267	153	1 075	313	80	88	20	8	10	13	1	16	1	2	0	1	2	120
Hammerhead shark	206	50	288	64	37	111	67	46	26	51	43	1 899	11	41	27	20	5	65
Total	2 684	1 677	5 920	5 262	1 198	5 062	965	4 730	1 135	454	953	511	398	382	389	278	102	1 970
Mantaray	488	355	2 234	369	369	318	473	792	554	1 084	1 309	86	635	989	571	364	773	717
Stingray	132	208	148	173	979	166	151	156	170	153	133	597	173	200	133	99	118	198
Total	620	556	2 381	542	1 348	484	624	949	724	1 237	1 442	2	809	1 189	704	463	891	915
Olive ridley	13	10	11	6	5	18	9	7	4	7	2	0	4	3	3	0	2	6
Unid. Turtle	2	7	7	2	2	6	3	2	5	2	1	0	1	0	2	0	1	3
Green/bjack turtle	0	0	2	0	2	1	4	0	0	0	0	0	0	0	0	0	0	1
Loggerhead turtle	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Hawkbill turtle	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Leatherback turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	15	18	20	9	10	25	17	9	9	9	3	2	5	3	5	0	3	10

TABLE 20
Bycatch in numbers, all species in the Eastern Pacific Ocean, 1993–2009 – school sets

School sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	619	542	270	152	244	470	42	215	1 186	138	1 036	186	55	33	115	10	7	313
Blue marlin	50	26	26	31	8	15	23	21	28	52	16	19	9	25	7	4	3	21
Black marlin	21	24	15	15	10	5	23	17	5	29	7	6	5	3	28	7	1	13
Stripped marlin	69	7	21	23	6	4	15	13	28	7	89	6	6	9	24	7	0	20
Unid. & Others	44	29	35	46	10	4	13	1	25	4	9	8	30	5	8	7	1	16
Total	802	628	367	267	278	499	116	266	1 272	230	1 158	225	105	76	182	35	12	383
Mahi mahi	8 963	5 310	15 328	5 064	2 068	2 018	1 194	2 102	6 250	2 951	640	1 860	7 515	2 291	12 331	729	753	4 551
Wahoo	4 056	400	179	208	395	48	98	42	490	78	4	49	75	152	27	40	10	373
Rainbow runner	37	30	12	10 041	2 979	156	147	1 535	157	376	68	90	164	3	139	83	0	942
Yellowtail	19 991	2 428	11 107	87 592	811	2 409	3 557	1 330	40	2 439	183	8	946	253	16 006	1 983	500	8 917
Total	33 047	8 168	26 626	102 905	6 253	4 631	4 996	5 009	6 936	5 843	895	2 008	8 699	2 699	28 503	2 834	1 263	14 783
Silky shark	11 398	7 695	3 479	2 850	5 901	1 074	2 887	1 348	1 093	3 269	2 567	2 843	547	910	2 222	136	74	2 958
Unid. & Others	790	2 548	1 077	886	290	136	105	341	159	913	488	573	147	511	502	101	43	566
Whitetip shark	595	283	1 075	174	266	156	115	335	10	90	40	4	0	1	0	0	0	185
Hammerhead shark	430	599	288	594	140	326	71	218	33	172	266	197	153	113	55	62	14	219
Total	13 214	11 125	5 920	4 504	6 597	1 691	3 178	2 242	1. 95	4 444	3 360	3 617	848	1 535	2 786	299	131	3 929
Mantaray	9 273	1 345	2 234	1 423	605	9 941	1 467	3 328	478	5 210	2 071	2 153	2 239	2 289	1 487	1 019	201	2 751
Stingray	1 824	1 480	148	162	103	257	402	213	64	60	8 347	39	52	90	53	24	18	784
Total	11 097	2 824	2 381	1 585	708	10 198	1 870	3 540	542	5 269	10 418	2 192	2 291	2 379	1 540	1 042	219	3 535
Olive ridley	38	17	11	4	25	21	16	25	9	3	4	2	6	4	1	0	0	11
Unid. Turtle	15	2	7	3	15	8	4	9	14	4	0	2	6	0	0	0	1	5
Green/bjack turtle	13	9	2	1	3	1	2	0	2	0	0	0	1	0	1	0	0	2
Loggerhead turtle	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Hawkbill turtle	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Leatherback turtle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	66	32	20	8	43	30	23	34	25	7	4	4	14	4	4	0	1	19

TABLE 21
Bycatch in numbers, all species in the Eastern Pacific Ocean, 1993–2009 – floating object sets

Log sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	58	6	31	28	65	4	24	22	27	24	20	21	65	157	7	15	13	35
Blue marlin	171	144	140	147	163	212	325	131	352	183	168	17	51	131	51	63	41	146
Black marlin	115	84	107	92	110	152	274	160	312	229	154	155	99	165	72	56	118	144
Stripped marlin	433	110	59	47	47	38	96	18	38	23	34	35	28	30	27	50	16	66
Unid. & Others	121	54	33	17	13	18	116	24	53	43	30	6	10	22	33	15	15	37
Total	898	397	369	332	399	425	836	355	782	502	406	234	253	505	190	199	204	429
Mahi mahi	201 323	405 206	326 916	375 941	295 672	199 244	422 317	351 784	585 977	407 490	173 258	135 996	88 796	132 074	120 502	199 013	138 797	263 548
Wahoo	49 818	215 206	148 040	94 736	196 993	116 203	110 146	84 123	392 367	128 824	162 254	45 446	49 437	62 202	56 129	30 097	70 232	118 372
Rainbow runner	16 492	14 800	10 609	34 682	72 985	173 946	184 900	82 418	97 726	107 259	163 488	64 805	70 726	93 068	223 167	37 380	51 553	88 236
Yellowtail	4 597	8 430	7 607	14 612	59 490	65 066	27 237	7 607	43 209	10 475	38 029	73 435	16 984	32 649	7 521	31 958	18 152	27 474
Total	272 310	643 643	493 173	519 971	625 140	554 459	744 600	525 932	1 119 279	654 048	537 029	319 682	225 942	319 999	407 319	218 449	278 734	497 630
Silky shark	23 948	18 516	21 825	21 296	32 392	37 739	27 846	16 200	17 299	15 947	17 140	12 478	16 035	16 536	9 708	11 290	10 910	19 241
Unid. & Others	6 777	4 315	3 844	4 432	3 997	8 609	2 894	1 020	1 751	1 721	1 430	568	512	768	797	936	367	2 621
Whitetip shark	1 805	3 562	6 990	7 415	7 467	6 383	4 864	2 583	2 987	824	502	194	72	149	70	46	93	2 706
Hammerhead shark	502	1 253	906	1 086	1 540	967	1 347	369	860	2 113	2 453	2 058	1 066	782	393	344	459	1 088
Total	33 032	27 465	33 564	34 230	45 396	53 697	36 951	20 171	22 898	20 605	21 525	15 298	17 684	18 235	10 967	12 616	11 829	25 657
Mantaray	285	51	70	119	123	77	149	71	61	77	181	79	85	137	125	121	79	111
Stingray	79	137	156	99	106	94	162	102	145	112	93	131	91	152	98	112	67	114
Total	364	189	226	218	229	171	311	173	206	189	274	210	175	289	224	233	146	225
Olive ridley	22	46	61	39	52	63	77	42	49	20	16	8	7	8	6	3	9	31
Unid. Turtle	1	34	23	30	25	26	39	17	22	6	5	4	4	1	7	1	2	15
Green/bjack turtle	1	7	9	8	8	6	2	6	6	2	0	0	1	2	0	0	1	3
Loggerhead turtle	0	0	0	0	1	1	1	2	1	0	0	0	0	1	1	1	0	1
Hawkbill turtle	0	0	0	0	0	2	1	1	1	0	0	0	0	0	1	0	0	0
Leatherback turtle	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	24	89	93	77	86	98	120	68	79	28	21	12	12	12	15	5	12	50

TABLE 22
Bycatch in numbers, all species in the Eastern Pacific Ocean, 1993–2009 – set types combined

All sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	1 062	737	572	424	435	956	276	549	1 407	484	1.593	418	349	424	268	184	271	612
Blue marlin	241	190	191	202	178	237	362	170	409	249	228	45	76	178	61	68	53	185
Black marlin	148	117	138	118	120	165	304	182	321	268	168	164	113	171	102	69	130	165
Stripped marlin	585	140	100	134	61	71	120	60	86	57	148	46	43	47	68	60	17	108
Unid. & Others	202	92	102	100	28	31	133	32	84	54	47	14	46	35	42	24	22	64
Total	2 238	1 276	1 103	978	821	1 459	1 195	994	2 308	1 112	2 184	687	628	855	541	405	493	1 134
Mahi mahi	210 434	410 589	357 573	381 272	297 755	201 301	423 555	353 981	59 2281	410 554	173 909	138 036	96 494	134 419	132 875	119 835	139 782	269 097
Wahoo	53 987	215 909	148 397	94 959	198 500	116 261	110 246	84 165	392 859	128 902	162 257	45 500	49 614	62 416	56 164	32 219	70 245	118 859
Rainbow runner	16 531	14 831	10 632	44 724	75 964	174 102	185 048	83 965	97 884	107 636	163 556	64 895	70 906	93 078	223 306	37 543	51 553	89 186
Yellowtail	24 616	11 832	29 822	102 204	64 191	67 476	30 794	8 937	43 249	12 914	38 315	73 443	17 929	32 902	23 528	33 941	18 653	37 338
Total	305 568	653 162	546 424	623 159	636 410	559 140	749 643	531 047	1 126 272	660 007	538 238	321 875	234 944	322 815	435 874	221 538	280 233	514 479
Silky shark	37 088	27 307	28 784	25 634	39 179	43 472	31 411	17 691	19 443	19 428	20 391	17 291	16 847	17 713	12 023	11 593	11 016	23 301
Unid. & Others	8 036	7 061	5 998	8 715	4 482	8 948	3 200	5 892	1 958	2 812	2 141	1252	780	1 351	1 574	1 127	472	3 871
Whitetip shark	2 668	3 997	9 140	7 903	7 814	6 627	4 999	2 926	3 007	928	543	199	73	152	70	47	95	3 011
Hammerhead shark	1 138	1 902	1 482	1 744	1 717	1 404	1 485	634	919	2 336	2 762	2 271	1 230	936	475	425	478	1 373
Total	48 929	40 266	45 404	43 996	53 191	60 450	41 095	27 143	25 327	25 503	25 838	20 814	18 930	20 153	14 142	13 193	12 061	31 555
Mantaray	10 046	1 751	4 537	1 911	1 098	10 336	2 090	4 191	1 093	6 371	3 561	2 743	2 959	3 415	2 184	1 504	1 053	3 579
Stingray	2 034	1 818	452	434	1 188	517	715	472	379	324	8 573	256	316	442	284	234	203	1 096
Total	12 080	3 569	4 989	2 345	2 285	10 852	2 804	4 662	1 472	6 695	12 135	2 998	3 275	3 857	2 468	1 738	1 256	4 675
Olive ridley	73	74	83	49	82	102	102	73	62	30	22	12	17	15	10	3	11	48
Unid. Turtle	18	44	37	35	42	40	46	29	41	12	6	6	11	1	9	1	4	22
Green/bjack turtle	14	16	13	9	13	8	8	6	8	2	0	0	2	2	1	0	1	6
Loggerhead turtle	0	2	0	0	2	1	2	2	1	0	0	0	0	1	1	1	0	1
Hawkbill turtle	0	2	0	1	0	2	2	1	1	0	0	0	0	0	3	0	0	1
Leatherback turtle	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	105	138	133	94	139	153	160	111	113	44	28	18	31	19	24	5	16	78

TABLE 23
Capture in tonnes, all species in the Eastern Pacific Ocean, 1993–2009 – dolphin sets

Dolphin sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	20	11	12	13	9	33	22	24	16	23	31	18	28	24	28	32	26	22
Blue marlin		7	8	9	5	7	9	13	13	13	19	14	16	12	11	9	8	11
Black marlin	6	7	6	7	10	9	10	10	9	9	14	8	16	10	9	9	19	10
Stripped marlin	7	3	6	11	6	9	6	4	2	6	9	10	15	12	8	8	7	8
Total	9	32	34	48	33	65	49	57	44	54	78	52	79	63	60	64	67	55
Mahi mahi	55	0	3	0	0	1	1	2	3	1	1	1	1	1	1	3	1	1
Wahoo	1	1	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	1
Rainbow runner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellowtail	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	4	4	1	7	6	2	4	4	2	2	3	3	3	4	6	2	4
Silky shark	1	37	161	47	41	170	74	30	53	35	59	75	51	27	41	25	33	59
Unid. & Others	50	14	26	41	8	10	13	166	6	9	15	11	14	18	25	12	32	26
Whitetip shark	20	3	3	4	5	8	5	8	2	4	6	5	4	4	3	3	2	5
Hammerhead shark	7	4	18	12	6	5	2	1	1	1	1	0	0	0	0	0	1	4
Total	9	59	208	104	60	194	94	205	62	49	80	92	68	49	69	41	68	93
Mantaray	86	6	11	6	6	6	6	12	9	19	20	11	17	53	12	11	16	14
Stingray	9	2	1	1	6	1	0	0	1	1	1	0	1	1	0	0	0	1
Total	1	8	11	6	12	7	7	13	10	10	20	11	18	54	13	11	17	14
Olive ridley	9	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 24
Capture in tonnes, all species in the Eastern Pacific Ocean, 1993–2009 – school sets

School sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Sailfish	34	29	15	8	12	25	17	23	44	10	53	12	7	9	20	4	3	19
Blue marlin	14	17	10	10	20	8	18	26	17	50	16	13	15	15	11	12	9	17
Unid. & Others	12	1	4	4	3	2	4	4	3	1	6	2	2	4	8	9	3	4
Black marlin	19	9	9	11	9	10	17	21	7	18	10	8	8	15	10	7	4	11
Stripped marlin	13	9	10	13	14	5	7	8	9	49	14	6	14	23	9	15	2	13
Total	92	65	48	46	57	49	64	81	80	128	99	42	45	67	57	47	21	64
Mahi mahi	14	20	22	18	12	18	4	51	17	8	11	17	75	58	47	19	6	25
Wahoo	11	1	1	1	3	1	0	2	2	1	0	1	1	1	2	1	0	2
Rainbow runner	0	0	0	3	2	0	0	5	0	1	2	0	1	0	1	0	0	1
Yellowtail	35	6	19	153	16	7	46	19	0	9	0	15	3	228	93	36	3	41
Total	80	152	52	306	42	38	110	82	30	21	17	35	89	302	153	62	14	93
Silky shark	363	241	118	105	185	58	98	96	74	139	100	68	41	46	156	27	21	114
Unid. & Others	33	64	33	32	12	21	20	61	13	45	60	37	19	63	40	14	10	34
Hammerhead shark	16	25	14	34	13	24	10	20	3	6	11	15	13	9	9	12	4	14
Whitetip shark	9	5	18	3	6	3	3	5	0	3	0	0	0	0	0	0	0	3
Total	421	335	183	174	216	106	131	182	90	193	172	120	74	118	205	53	36	165
Mantaray	144	23	18	27	13	218	31	67	11	63	40	45	26	42	17	30	5	48
Stingray	9	5	1	1	1	1	1	1	0	0	25	0	0	1	0	0	0	3
Total	152	32	19	28	14	220	32	68	11	63	65	45	26	43	17	30	5	51

TABLE 25
Capture in tonnes, all species in the Eastern Pacific Ocean, 1993–2009 – floating object sets

Log sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
BLUE MARLIN	83	60	71	60	110	134	191	107	133	162	176	133	190	159	117	116	151	127
BLACK MARLIN	63	46	49	51	78	82	99	54	94	85	117	51	81	118	62	68	66	74
STRIPPED MARLIN	45	17	10	5	10	9	24	7	10	20	12	8	13	22	19	10	16	15
UNID. & OTHERS	77	19	10	7	8	9	14	3	5	6	9	7	7	26	11	15	7	14
SAILFISH	3	0	2	1	3	0	3	2	2	2	1	1	7	9	2	3	2	3
Total	271	142	141	125	210	234	331	173	245	275	316	200	298	335	210	211	242	233
MAHI MAHI	707	1 225	1 071	1 312	1 225	816	1 238	1 437	2 202	1 815	894	1 018	972	1 197	1 235	1 093	1 797	1 250
WAHOO	154	475	379	271	475	396	161	277	1 023	571	428	380	420	424	421	243	543	414
RAINBOW RUNNER	16	14	11	28	60	93	110	53	90	94	108	62	66	73	157	39	30	65
YELLOWTAIL	13	19	18	34	69	76	54	29	71	27	44	66	30	91	21	48	23	43
Total	894	1 738	1 482	1 653	1 843	1 414	1 577	1 804	3 395	2 521	1 486	1 543	1 499	1 821	1 847	1 436	24 09	1 786
SILKY SHARK	415	412	439	412	785	661	428	287	371	271	298	235	321	361	316	550	340	406
WHITETIP SHARK	30	81	136	142	160	143	110	66	65	21	13	7	2	5	2	2	4	58
HAMMERHEAD SHARK	19	46	33	43	58	44	44	26	49	93	117	101	70	56	40	35	38	54
UNID. & OTHERS	65	60	79	54	70	63	37	16	25	19	6	14	6	21	17	20	45	36
Total	537	616	693	665	1 091	932	632	404	524	434	450	391	406	450	383	612	31	568
MANTARAY	4	1	1	2	2	2	4	1	2	2	4	2	2	5	2	3	2	2
STINGRAY	0	0	1	0	1	0	1	1	1	0	0	2	0	1	0	0	0	1
Total	4	1	2	2	2	2	5	2	2	2	4	4	3	5	3	3	2	3

TABLE 26
Capture in tonnes, all species in the Eastern Pacific Ocean, 1993–2009 – set types combined

All sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Blue marlin	104	84	87	76	141	151	219	143	159	222	206	155	221	185	137	137	179	153
Black marlin	88	62	67	70	93	100	125	87	115	116	146	72	105	145	83	84	79	96
Sailfish	57	40	28	22	24	59	42	49	63	34	86	32	43	43	49	39	31	43
Stripped marlin	67	29	26	29	30	23	37	19	21	74	36	24	42	57	36	33	25	36
Unid. & Others	101	25	16	20	12	17	20	13	11	11	19	11	12	35	23	29	16	23
Total	418	239	223	218	300	348	443	311	369	457	493	294	423	465	328	323	330	352
Mahi mahi	722	1 245	1 097	1 331	1 237	835	1 243	1 490	2 222	1 825	905	1 037	1 048	1 256	1 283	1 114	1 805	1 276
Wahoo	165	477	380	271	480	400	162	279	1 025	572	428	381	422	426	423	244	544	416
Rainbow runner	16	14	11	30	62	93	110	58	90	95	110	62	67	73	158	39	30	66
Yellowtail	48	26	53	186	87	83	99	48	71	36	44	82	33	320	114	84	26	84
Total	975	1 894	1 538	1 960	1 892	1 457	1 688	1 890	3 429	2 544	1 504	1 581	1 592	2 126	2 004	1 505	2 425	1 883
Silky shark	829	690	717	564	1011	889	600	412	499	445	457	378	413	435	513	602	394	579
Unid. & Others	126	156	144	141	108	115	82	253	58	102	97	96	46	109	89	51	92	110
Whitetip shark	42	74	51	82	76	76	58	54	53	103	134	121	87	69	52	50	45	72
Hammerhead shark	48	90	172	156	172	152	116	72	66	24	14	7	2	5	2	2	5	65
Total	1 045	1 010	1 084	943	1 367	1 231	857	791	676	676	702	603	548	618	657	705	535	826
Mantaray	156	33	29	34	21	227	41	81	22	84	63	57	46	100	31	44	23	64
Stingray	10	8	2	2	8	2	2	2	1	1	26	3	1	2	1	1	1	4
Total	166	41	32	36	29	229	43	83	23	85	89	60	47	102	32	45	24	69

TABLE 27

Bycatch in tonnes, all species in the Eastern Pacific Ocean, 1993–2009 – dolphin sets

Dolphin sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Black marlin	2	2	3	3	1	1	2	2	3	1	4	1	2	3	1	0	2	2
Blue marlin	1	1	1	1	0	1	1	1	1	1	1	0	1	0	1	1	1	1
Sailfish	11	6	6	7	4	15	6	9	6	10	15	6	7	7	4	6	9	8
Unid. & Others	9	3	1	6	1	3	1	3	2	2	2	0	1	0	1	0	0	2
Stripped marlin	3	1	2	3	0	1	7	1	0	1	1	0	1	1	0	0	0	1
Total	22	9	9	16	5	19	7	13	8	12	19	7	8	8	5	7	10	11
Mahi mahi	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wahoo	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Rainbow runner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellowtail	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	1	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1
Silky shark	40	28	128	37	14	137	21	5	15	6	20	61	10	8	4	3	1	32
Unid. & Others	14	11	20	32	6	6	8	158	2	6	9	5	7	4	16	4	4	18
Whitetip shark	8	4	16	11	2	3	1	0	0	0	0	0	0	0	0	0	0	3
Hammerhead shark	5	2	2	3	2	5	3	2	0	2	2	1	1	2	1	1	0	2
Total	81	55	187	115	30	157	40	323	19	21	41	71	25	18	36	12	9	73
Mantaray	8	6	10	5	5	6	6	10	9	18	19	10	17	52	11	11	16	13
Stingray	1	2	1	1	6	1	0	0	1	1	1	0	1	1	0	0	0	1
Total	9	8	11	6	12	6	6	10	10	19	19	10	18	53	12	11	16	14

TABLE 28
Bycatch in tonnes, all species in the Eastern Pacific Ocean, 1993–2009 – school sets

All sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. all years
Black marlin	31	23	23	24	22	28	42	21	48	30	26	5	9	21	8	8	7	22
Blue marlin	20	15	16	15	15	20	38	23	40	33	21	21	14	21	13	8	15	20
Sailfish	32	21	15	12	11	31	8	17	45	15	49	13	11	13	8	7	10	19
Unid. & Others	69	16	9	13	7	8	12	6	6	5	9	5	4	4	5	6	1	11
Stripped marlin	20	9	8	9	3	3	11	3	8	5	4	1	4	3	4	2	2	6
Total	171	84	72	73	57	89	111	69	146	88	109	44	41	62	38	31	36	78
Mahi mahi	480	829	729	885	703	426	751	785	1275	938	346	317	295	385	350	327	468	605
Wahoo	105	302	241	172	249	185	102	153	666	240	160	83	92	115	98	50	132	185
Rainbow runner	15	13	11	29	51	85	101	48	80	85	104	54	59	64	152	31	24	59
Yellowtail	27	15	21	106	61	64	35	18	65	26	37	49	20	82	32	24	15	41
Total	627	1 160	1 002	1 192	1 063	760	989	1 005	2 086	1 289	648	503	466	646	631	432	640	890
Silky shark	659	548	570	448	717	708	424	269	365	357	377	290	260	267	226	178	200	404
Unid. & Others	97	120	111	110	80	99	61	204	38	88	83	71	25	55	55	29	14	79
Whitetip shark	43	82	154	141	147	127	101	60	63	21	11	5	2	5	2	1	3	57
Hammerhead shark	28	49	34	54	60	54	41	31	42	92	123	96	69	56	30	26	31	54
Total	827	798	869	753	1.004	989	627	567	508	558	595	462	357	382	313	235	248	593
Mantaray	150	32	28	33	18	226	39	78	21	75	62	56	45	98	31	44	23	62
Stingray	10	7	2	2	8	2	2	2	1	1	26	3	1	2	1	1	1	4
Total	159	39	31	34	26	228	41	80	23	77	88	59	46	100	31	44	23	66

TABLE 29

Bycatch in tonnes, all species in the Eastern Pacific Ocean, 1993–2009 – floating object sets

Log sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. All years
Black marlin	22	18	17	18	20	25	38	16	43	22	20	2	6	15	6	7	5	18
Blue marlin	16	11	13	11	13	19	34	20	39	29	19	19	12	20	10	6	14	18
Sailfish	2	0	1	1	2	0	1	1	1	1	1	1	2	5	0	1	1	1
Unid. & Others	52	13	6	5	5	4	10	2	4	2	3	3	3	3	2	5	1	7
Stripped marlin	14	5	3	2	1	2	9	2	5	4	3	1	1	2	3	1	1	3
Total	83	29	23	19	22	25	54	25	48	36	26	24	18	30	15	13	17	30
Mahi mahi	470	815	712	873	699	420	749	780	1265	932	344	312	270	379	334	324	465	597
Wahoo	97	301	240	172	247	185	101	153	65	240	160	83	91	114	98	50	132	184
Rainbow runner	15	13	11	27	49	85	101	45	79	85	104	54	59	64	152	31	24	59
Yellowtail	7	11	10	18	52	60	31	17	65	19	37	49	19	81	12	22	14	31
Total	593	1 144	976	1 096	1 056	775	989	998	2 082	1 284	652	508	447	652	604	437	644	879
Silky shark	330	329	349	327	578	533	334	229	311	243	275	176	232	232	144	171	196	293
Unid. & Others	57	62	66	54	67	80	40	19	30	41	19	35	10	15	19	20	8	38
Whitetip shark	27	73	122	127	140	122	99	56	62	19	11	5	2	5	2	1	3	52
Hammerhead shark	13	31	22	29	53	34	35	19	41	87	111	91	63	49	28	22	29	44
Total	427	495	558	537	838	770	508	323	444	390	416	307	307	301	192	214	236	427
Mantaray	3	1	1	1	2	2	4	1	1	2	4	2	2	5	2	3	2	2
Stingray	0	0	1	1	1	0	1	0	1	0	0	2	0	1	0	0	0	1
Total	4	1	2	2	2	2	5	2	2	2	4	4	3	5	3	3	2	3

TABLE 30
Bycatch in tonnes, all species in the Eastern Pacific Ocean, 1993–2009 – set types combined

All sets	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg. All years
Black marlin	31	23	23	24	22	28	42	21	48	30	26	5	9	21	8	8	7	22
Blue marlin	20	15	16	15	15	20	38	23	40	33	21	21	14	21	13	8	15	20
Sailfish	32	21	15	12	11	31	8	17	45	15	49	13	11	13	8	7	10	19
Unid. & Others	69	16	9	13	7	8	12	6	6	5	9	5	4	4	5	6	1	11
Stripped marlin	20	9	8	9	3	3	11	3	8	5	4	1	4	3	4	2	2	6
Total	171	84	72	73	57	89	111	69	146	88	109	44	41	62	38	31	36	78
Mahi mahi	480	829	729	885	703	426	751	785	1 275	938	346	317	295	385	350	327	468	605
Wahoo	105	302	241	172	249	185	102	153	666	240	160	83	92	115	98	50	132	185
Rainbow runner	15	13	11	29	51	85	101	48	80	85	104	54	59	64	152	31	24	59
Yellowtail	27	15	21	106	61	64	35	18	65	26	37	49	20	82	32	24	15	41
Total	627	1 160	1 002	1 192	1 063	760	989	1 005	2 086	1 289	648	503	466	646	631	432	640	890
Silky shark	659	548	570	448	717	708	424	269	365	357	377	290	260	267	226	178	200	404
Unid. & Others	97	120	111	110	80	99	61	204	38	88	83	71	25	55	55	29	14	79
Whitetip shark	43	82	154	141	147	127	101	60	63	21	11	5	2	5	2	1	3	57
Hammerhead shark	28	49	34	54	60	54	41	31	42	92	123	96	69	56	30	26	31	54
Total	827	798	869	753	1.004	989	627	567	508	558	595	462	357	382	313	235	248	593
Mantaray	150	32	28	33	18	226	39	78	21	75	62	56	45	98	31	44	23	62
Stingray	10	7	2	2	8	2	2	2	1	1	26	3	1	2	1	1	1	4
Total	159	39	31	34	26	228	41	80	23	77	88	59	46	100	31	44	23	66

Data come from the IATTC observer programme and from the national observer programmes that have contributed significantly to the database.

To complete the data summary for the EPO, a brief exploration of trends is done by looking at changes in frequency of occurrence over time. If there are significant trends, then the results should reflect that. Long-term averages are not good descriptors. Figure 58–60, show the frequency of occurrence of the different species in FAD sets, because most of the bycatch happens in these sets. Figure 58 shows the frequency of many of the more common species caught in FAD sets for three time periods (1994–1998, 1999–2003, and 2004–2008) to verify that there were no substantial trends in the data. It shows that the sharks are the group showing clear declining trends, while the others are relatively stable. Frequency of occurrence is a coarse measure of abundance, but readily available. Figures 59 and 60 break the full table down into a more frequent group and a less frequent group in order to show the variability in all the species with more detail. The structure of these communities begins to show in these figures; there are a few very frequent components, present in almost all sets.

FIGURE 58
Capture probability: FAD sets in the Eastern Pacific Ocean

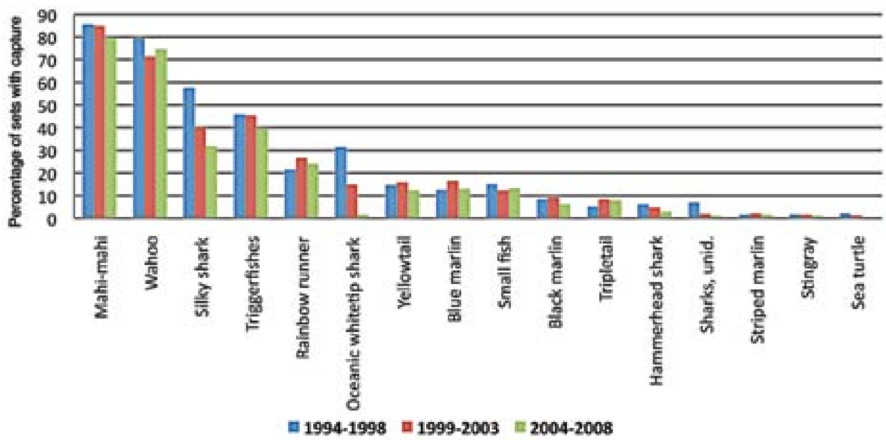


FIGURE 59
Capture probability: FAD sets in the Eastern Pacific Ocean

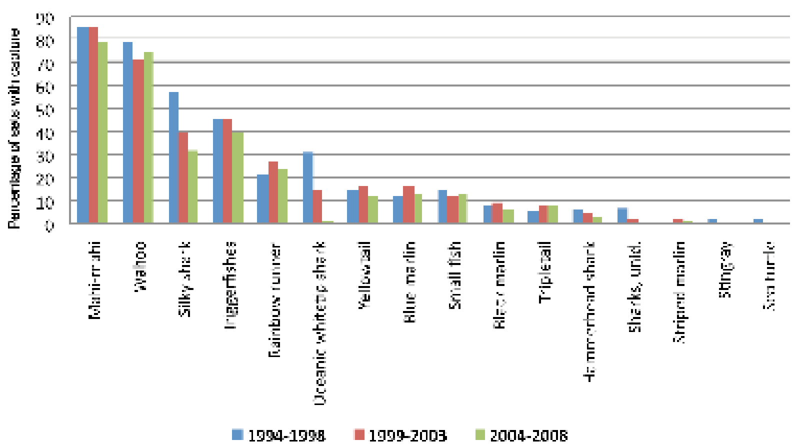
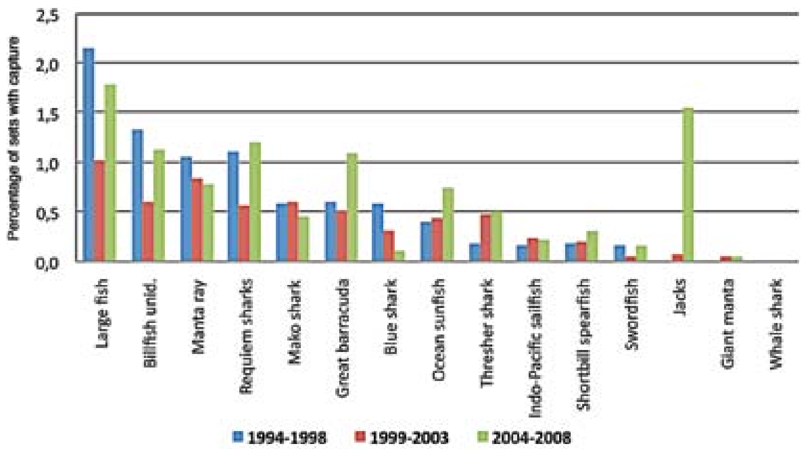


FIGURE 60
Capture probability: FAD sets in the Eastern Pacific Ocean



For other oceans, information from the most recent decade is used where possible. There have been many previous estimates of bycatch for a group, or for a short period, but recently, the different databases available for the Atlantic and Indian Oceans have been merged to produce the most recent complete estimates, making use of all the information from the period. Different attempts to estimate bycatch have been made over the years. With low levels of observer coverage, it was impossible to obtain accurate estimates, and to know whether there were biases, etc.

Several major studies have been carried out on the fisheries on logs and FADs over the years. Stretta *et al.* (1997) produced an important synthesis of the activities of the French and Spanish fleets in both the Atlantic and the Indian Oceans although it was based on a small sample size. Bailey, Williams and Itano (1996) produced a major review for the WPO, followed by very significant and recent contributions from Molony (2007, 2008). Information covering the characteristics of natural and deployed objects, the mode of detection, operational data, and detailed lists of species captured, sizes, etc., have been summarized and analysed to determine the structure of the communities. The fisheries on logs have been the subject of two workshops (Scott *et al.*, 1999; Le Gall, Cayré and Taquet, 2000b).

CATCH AND BYCATCH

The different observer programmes in the tuna fishing regions of the world have provided the only data available on the bycatch of the purse seine fisheries. The observer coverage was initially, and until recently, very low, and did not allow for sophisticated statistical treatments to extrapolate to the total effort (Table 12). Many documents were presented at the different t-RFMOs, and those contain valuable information on limited data sets. To keep the information more or less contemporaneous, data for the last decade have been given more relevance.

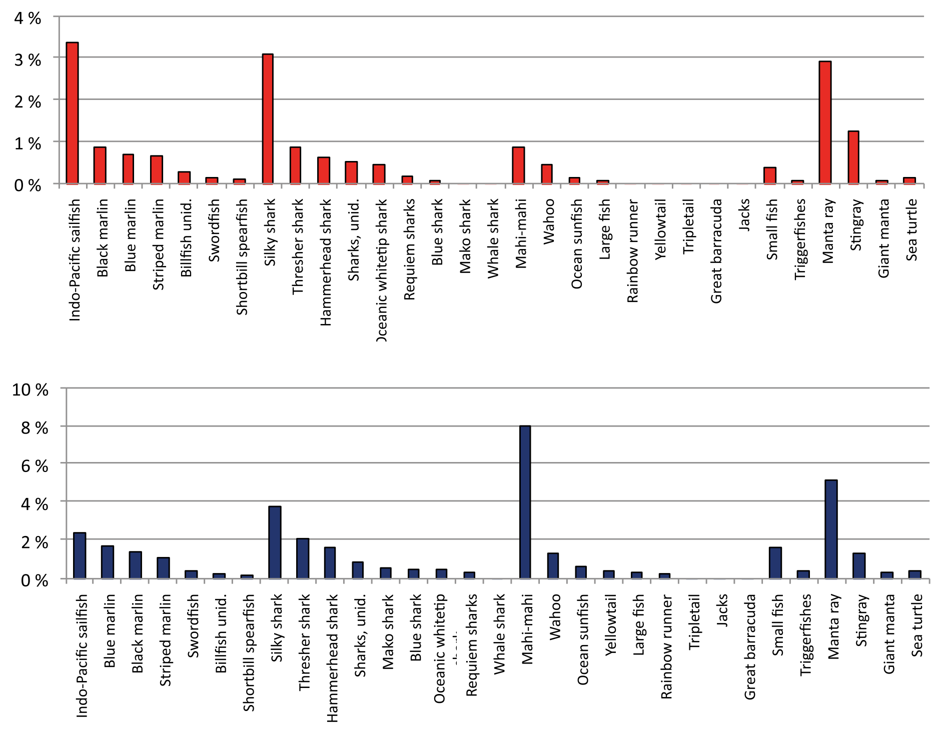
As mentioned above, the data have many inconsistencies among the t-RFMOs, because different categories have been considered for set types, units of measurement, etc., and efforts are needed to make the data comparable. In some cases, the differences reflect regional characteristics; payaos are only significant in the WPO, seamounts seem to have more influence in the Indian Ocean, etc. The inclusion and taxonomic aggregation of the estimates is also variable. The IATTC has been working using numbers of individuals as the basic unit, but the other RFMOs have based their statistics on weights. The variables of interest to understand bycatch issues include:

- lists of species present in a region;
- frequency of occurrence;
- capture per set;
- capture or bycatch per tonne of tuna captured;
- capture per positive set;
- capture per tuna positive set;
- bycatch rate;
- utilization rate;
- overall bycatch and utilization rates;
- expression of bycatch as a function of the catch;
- more complex units that reflect the significance of the removals beyond the numbers or weights.

The lists of species present in a region are usually presented by gear and type of operation (e.g. set type, shallow or deep longline sets, fixed or drifting gillnet). For tuna fisheries, there are many such lists (Stretta *et al.*, 1997; Arenas, Hall and García, 1999; Williams, 1999; Castro, Santiago and Santana-Ortega, 2002; Romanov, 2002; Taquet *et al.*, 2007b; Molony, 2008).

Frequency of occurrence, also called incidence in some studies, is the percentage of sets where a species is present, or the probability of encountering a given species in a set taken at random. Figure 61 and 62 show the frequency of occurrence of the more common species by set type in the EPO. The different scales used in the plots reflects the fact that very few individuals are captured in dolphin sets; sailfish, manta rays, and pelagic stingrays are a relatively important component of dolphin sets and practically absent in sets on floating objects. Conversely, mahi-mahi and wahoo are the most frequent species in sets on floating objects, and very rare in dolphin sets. Silky sharks

FIGURE 61
Frequency of occurrence in dolphin (top) and school sets (bottom) in the Eastern Pacific Ocean



are the dominant species in all types of sets. Dolphin and school sets are more similar to each other than to log or FAD sets. Log and FAD sets appear very similar in the frequency of their components.

Figure 63 shows a similar plot by weight for the WPO in recent years (OFP, 2010a). The concept behind this figure is not the same as the frequency plot. This plot shows the biomass distribution among taxa. However, some features of the communities are visible. School sets have far fewer species than floating object sets, and of these, log sets have the larger biomass of non-tuna species. The rainbow runner replaces the mahi-mahi as the main species in the WPO. Log sets have a much higher biomass of non-tuna species than FAD or payao sets, and all of these are orders of magnitude higher than school sets. In the WPO, log and FAD sets appear much more different from each other than in the EPO, but the units used are different.

Capture per set (CPS) is the number of individuals or tonnage taken in an average set. It is obtained by dividing the total numbers or total tonnage captured by the number of sets. A way to clarify the meaning of this variable would be to use NPS for numbers per set, and WPS for weight per set. This is a measure of the average impact of a set, and it is used for estimation. It is not obvious which the best measure is. For population dynamics studies, the numbers are important, and expressing impacts on turtles, marine mammals, seabirds, etc., in weights is not reasonable. However, it may not be possible to enumerate bycatch of triggerfishes, so estimates of weights are normally used, and from there a conversion is feasible. Whichever is used, it is necessary to specify the choice made, and if possible provide a way to make a conversion if wanted. Bycatch-per-set data facilitate the extrapolation, when the total numbers of sets in

FIGURE 62
Frequency of occurrence in log (top) and FAD sets (bottom) in the Eastern Pacific Ocean, 1994–2009

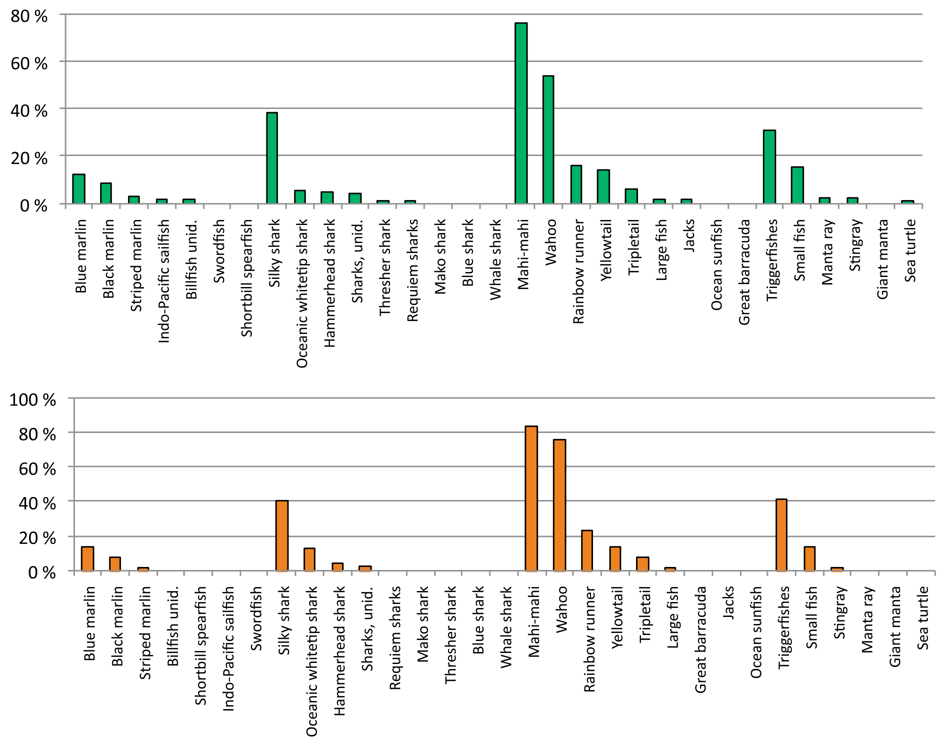
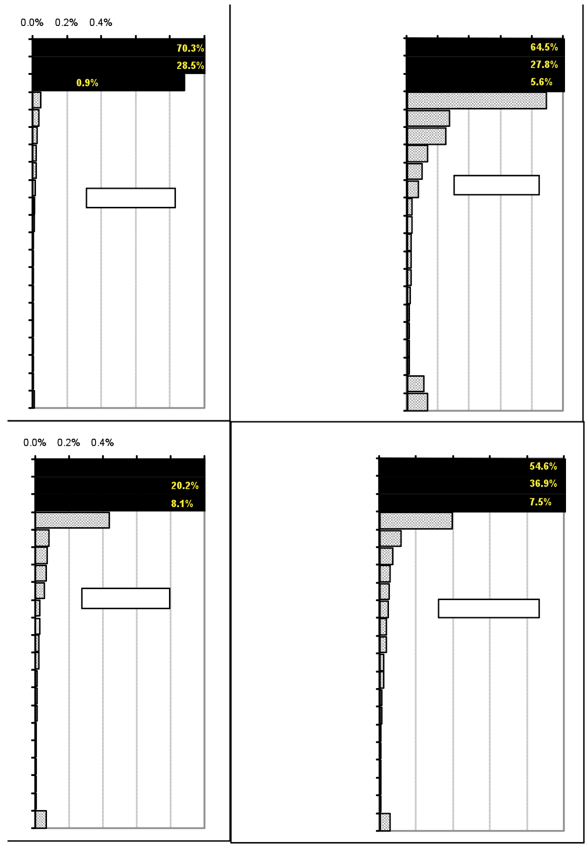


FIGURE 63
Percentage composition of 20 main species taken by set type



Note: Percentage by weight in WCP-CA from observer data (2001–07), number of sets = 8 140, 5 743, 5 077 and 6 381, respectively.

known, and the stratification of the data, given the marked differences between set types.

A generic form of this variable, applicable to all gear types, has been called bycatch per unit of effort (BPUE), understanding that the measure of effort to be used to estimate bycatch is not equivalent to the fisheries effort concept used in CPUE studies. For example, tonnage per hour searching or per day fishing does not connect to the impact of the fishing operation; the incidental mortality is a result of the fishing activity itself resulting in the capture, and the extrapolation unit is the number of sets or other fishing operations (Hall, 1996, Hall, Alverson and Metuzals, 2000). The BPUE may refer to unit fishing operations (e.g. bycatch per set, bycatch per haul) or, whenever possible, it should be standardized by the amount of gear fished (e.g. per number of hooks, per area of a net), and/or by a time unit (e.g. per hour trawling).

Regarding capture or bycatch per tonne of tuna captured, for estimation purposes, it is possible to replace the bycatch per set measure by a ratio estimate with the bycatch in numbers or weights standardized to a measure of tuna tonnage. If the bycatch in a set is correlated to the amount of tuna captured, this measure will be more precise than catch per set (Hammond and Hall, 1983). In the tuna purse seine fisheries, dolphin bycatch per tonne has been used as an alternative to dolphin bycatch per set (Hall and Boyer, 1986).

In the literature, the bycatch is often expressed as x tonnes of a species or group of species per 1 000 tonnes of tuna catch because this produces figures with fewer zeroes before the significant numbers. Examples of this variable are tuna bycatch of 19.2 tonnes/1 000 tonnes of tuna catch, and shark bycatch of 3.6 tonnes/1 000 tonnes of tuna catch (Amandè *et al.*, 2008a). Landings data are then used to extrapolate to the total catch of the fishery. Most probably, the tonnage of tuna captured (rather than the retained portion) will have a stronger correlation to the bycatch, and, therefore, when available, it should produce better estimates. However, the extrapolation factor will be the total capture, and this may require a more complex estimation process than the total catch.

The need to separate what is captured from what is retained is very clear here. Large whales are seldom included in the bycatch tables, but whale sharks are included in some cases, even though they are both released alive. Without certainty about the potential implications of the capture for the survival of those released alive, it becomes important to maintain a record of the number of captures, in case some post-release mortality factor should be applied. In many bycatch studies, it is reported that x percent of a species was released alive, and there remains the doubt on whether they were included in the tabulated figures, or if they had been subtracted from the total capture. This shows the need of a distinction between a "capture per set" and a "bycatch per set", where the latter reflects the mortality component, and the former includes everything released alive, or retained as catch.

Capture per positive set is the average number or tonnage of a species in the sets where it is present. This is a measure of group or school size that is of interest for ecological and behavioural studies. The notation could be numbers per positive set or weight per positive set (WPPS). If the number of negative sets is included, it is possible to transform it into the above variable.

Capture per tuna positive set is a subset of the one above, and a measure of the capture that eliminates the skunk sets, where tuna capture is zero. However, zero is defined as the lack of any capture of the main tuna species. In the majority of cases, these sets will not produce any bycatch either, but it is possible that some bycatch may be retained in the set. In the Atlantic and Indian Oceans, many tuna statistics are expressed in these units, while also including the proportion of null sets, which allows the NPS or WPS to be computed if desired. The problem of this variable is that a set may be a negative set for one tuna species, but not for the other, and the studies of school size must be done on a specific basis.

Bycatch rate (BR) is defined as the ratio of the bycatch of a species (or group of species) to the capture of a species (or group of species). It is a measure of the proportion of those captured that were discarded dead of any target or non-target species or of a group of species (Hall, Alverson and Metuzals, 2000). This is a measure of the level of waste of the fishery. Low BR figures mean that the operation is close to full use of the resource.

The complement of the bycatch rate is the utilization rate, the ratio of the production of the fishery to the biomass extracted from the system from all species: the catch of a species (or group of species) divided by the capture of a species (or group of species).

From the above variables, it is possible to generate a measure of the overall bycatch rate, the ratio of everything discarded dead to all that was captured – and an overall utilization rate in a similar way.

Perhaps more meaningful than the above variables is the expression of bycatch as a function of the catch, the net product of the fishery. Besides the use for estimation, described above, bycatch/catch ratios, such as number or tonnage of a species per 1 000 tonnes of tuna retained (catch), are useful to link impact with production, and therefore to assess the relative ecological costs of different gear types or set types. The tuna catch is the sum of all tuna species retained, or one could use all species retained. Areas and periods with high bycatch/catch ratios are good candidates for spatial or temporal closures, using bycatch reduction curves (Hall, 1996).

More meaningfully, any of the variables used to measure bycatch could be replaced by more complex units that reflect the significance of the removals beyond the numbers or weights. For example, the reproductive value of the individuals, or elasticity analyses taking demographic considerations into account, could be used to provide a statistical weighting to the different numbers (Heppell, 1998; Heppell, Caswell and Crowder, 2000; Gallucci, Taylor and Erzini, 2006; Wallace *et al.*, 2008). This is the direction to pursue in order to obtain an accurate assessment of impacts, and the current estimates of numbers or weights should be considered a simplistic first step.

All these variables provide information of value to estimate and analyse different aspects of bycatch in a fishery, and to compare among types of sets or gear. As far as they are clearly defined, many of them complement each other.

OBSERVER COVERAGE

The data available come from the observer programmes developed in the different regions. The implications of the levels of coverage were discussed in the estimation section. An important source of heterogeneity among RFMOs is the use of definitions of coverage based on different units. Coverage expressed as the percentage of fishing days that were observed makes sense for some fisheries variables (Sarralde *et al.*, 2007; OFP, 2008a), such as the catch per days fishing, etc., but is not the adequate measure of coverage for bycatch estimation that is dependent on the sets themselves. In some cases, the two measures are close enough; for the Spanish fleet in the Indian Ocean, Gonzalez *et al.* (2007) report coverages in fishing days and (in sets): for 2003, 2.4 percent in days (2.4 percent in sets); for 2004, 3.2 percent in days (1.6 percent in sets); for 2005, 3.0 percent in days (2.9 percent in sets); and for 2006, 4.2 percent in days (2.3 percent in sets).

However, for reasons of convenience, sets cannot be sampled at random; hence, the units that are sampled are fishing trips, and this introduces a covariation element – the sets are a cluster, and not independent samples. If the operations and technology are reasonably similar in the vessels fishing in a region, then a given proportion of trips should correlate with a given proportion of sets. Following the same reasoning, if the trips are distributed at random in areas and seasons, then the proportion of trips covered will yield similar proportions of coverage for the different set types (e.g. every trip performs a number of sets of each type that reflect, within the margins of sampling error, the fleet proportions). When the coverage is very dissimilar, then the vessel operated in a "biased" way, and the data may have a spatial, temporal or other bias. Several of the data sets available have this characteristic. Gonzalez *et al.* (2007) show coverage of FAD sets of 3.4 percent of the fleet total, but only 0.5 percent of the school sets, explained by a temporal bias in sampling distribution. In this case, a temporal stratification could have helped if a larger sample size had been available.

In the EPO, the problem of dolphin mortality in the tuna purse seine fishery that had been brought to the public's attention in the late 1960s resulted in the National Marine Fisheries Service of the United States of America starting an observer programme to estimate the mortality. After a few years of very low coverage, by 1972, the passage of the Marine Mammal Protection Act raised the coverage levels, and from then on estimates of mortality improved significantly. The tuna–dolphin issue is discussed below. The IATTC shared the sampling of the United States vessels with the NMFS, and started a programme to sample the fleets from other flags operating in the region that grew rapidly. Subsequently, an international agreement, the Agreement on the International Dolphin Conservation Program (AIDCP) was signed by the fishing countries of the region to reduce dolphin mortality. A critical component of the programme was the assignment of individual vessel mortality limits; every vessel had an annual dolphin mortality limit that if exceeded would require the vessel to stop fishing on dolphins. For this requirement, a 100 percent coverage was required, and the IATTC has been running an observer programme that, combined with several national programmes, has completed coverage of 100 percent since 1993. As a result of this programme, the databases for the period 1993–2009, and available at the IATTC, comprise:

- 125 548 sets on dolphins;
- 71 618 sets on schools;
- 82 417 sets on floating objects.

Besides these sets, there is adequate coverage going back to 1986, and some coverage back to 1979 (Table 12). The coverage for the period 1993–2009 was more than 97 percent, so for all practical purposes, the error of the estimates will be considered negligible. The level of information available allows for many analyses that cannot be performed with other databases, and it is readily available to the authors. Many answers are valid in all oceans, and can inform the discussion for them. Some documents containing estimates of bycatch in the area include: IATTC Annual Reports from (1980–latest), Fisheries Status Report (2003–2010), International Review Panel reports (1998–2002), Executive Reports of the AIDCP (2002–09); Hall and Boyer (1986, 1988); Lennert and Hall (1995, 1996); Wade (1995); Hall (1996, 1998); Hall, Alverson and Metuzals (2000); Hall, Campa and Gómez (2003).

In the Atlantic, observer programmes were enlarged during periods in which a moratorium on setting on FAD was voluntarily adopted by the fleets between 1997 and 2005 (Pallares and Kebe, 2002; Ariz *et al.*, 2005; Ariz *et al.*, 2009; Fonteneau, 2010). The problem with this data set is that it may not be representative of the fishing patterns in a regular year. Recently, the combined data collections for the European fleets, and associated vessels, were analysed for the period 2003–07 (Amandè *et al.*, 2010b), and this is the most comprehensive treatment of the data. In the area, most of the effort has been traditionally applied by the European fleets from France and Spain, with some regional components. During this period, the observer coverage (in number of trips) was 3.0 percent on average, with a range of 1.5–6.2 percent (Table 12). Other recent documents containing bycatch information for the region include: an extensive study by Stretta *et al.* (1997), and several other more recent studies, some of them utilizing special ICCAT programmes, or a voluntary industry moratorium on the fishery on FADs – Santana *et al.*, 1998; Fonteneau *et al.*, 2000; Ménard *et al.*, 2000b; Gaertner *et al.*, 2003; Delgado de Molina *et al.*, 2000, 2010, 2010b; Goujon, 2004a; Sarralde *et al.*, 2004, 2007; Chassot *et al.*, 2009; Pianet *et al.*, 2008, 2009, 2010), and ICCAT documents including the Statistical Bulletins (2010).

In the WPO, a major review of the bycatch in the region was prepared in the mid-1990s (Bailey, Williams and Itano, 1996). Other relevant documents include: Lawson, 1997; Coan *et al.*, 1999; Molony, 2005a; OFP, 2008b, 2009, 2010b). The magnitude of the fleet operating in the area together with the diversity of operations make this area the most challenging to monitor because of: (i) origins (purse seiners from the United States of America, Japan, Taiwan Province of China, the Republic of Korea, Ecuador, etc.), which correlate with technological and operational differences; (ii) habitats covered (open ocean, island systems, coastal habitats, etc.); and (iii) the type of operations including a significant role of payaos; and other sources of heterogeneity. A series of annual updates present the catches of many of the species of interest (e.g. Williams and Terawasi, 2009; OFP, 2010a). The significant contributions of Molony (2005a, 2007) provide one of the best summaries of the biology and ecology of the specie encountered, and of the impacts of the fishery. The observer coverage in the period 1994–2006 ranges from 1.5 percent to 11 percent (Table 12).

In the Indian Ocean, most of the effort has been applied by the French and Spanish fleets. In the 1990s, the former Soviet Union participated in the fishery (Romanov, 2000, 2002). A statistical synthesis was prepared recently, based on observer coverage ranging from 1.4 percent to 8.1 percent for the period 2003–07, with an average of 4 percent (Amandè *et al.*, 2008a). The fishery in this region was heavily disrupted by the piracy problems off the Somali coast (Chassot *et al.*, 2010), and that restricted the fishing areas, and led to movements of vessels to the Atlantic. Recent studies that include information relevant to bycatch estimation, fishing effort, etc. include: Romanov, 2000, 2002; Rajruchithing, Prajakjitt and Siriraksophan, 2005; Sarralde, Delgado de Molina and Ariz, 2006; Viera and Pianet, 2006; Sánchez *et al.*, 2007; Delgado de Molina *et al.*, 2007, 2010a; González *et al.*, 2007; Pianet *et al.*, 2009).

The quality of the data available depends on the quality of the observers training, their dedication, the opportunities to do their job properly (e.g. access to instruments, specimens), the cooperation of the vessel personnel, and the editing and quality controls implemented at the end of the trips.

With the data available, an initial comparative review was possible. The vast majority of the bycatch comes from the main target species. Smaller pelagic species such as many carangids and balistids are sometimes missing from the tables, or probably underestimated, or evaluated without much precision in aggregates; hence, they are not included.

In the following sections, the groups that are covered include:

- small tunas (including small sizes of targets species and other minor tuna species such as *Auxis* sp., *Euthynnus* sp., *Sarda* sp.);
- billfishes (mainly marlins, and sailfish);
- sharks (silky, oceanic whitetip, hammerheads);
- rays: mantas, devil rays, and pelagic stingrays;
- large pelagic bony fishes: rainbow runner, mahi-mahi, wahoo, yellowtail amberjack;
- sea turtles;
- marine mammals.

Many of the references used have been presented at the Scientific Committee meetings, or working groups of ecosystem and bycatch of the t-RFMOs, or included in the annual reports or fisheries statistical bulletins. Traditionally, the major target tuna species, and the billfishes have been the objectives of the RFMOs, and the statistics cover them.