Estimates of catches and mortalities of seabirds, mammals sharks and turtles in longline fisheries of the western and central Pacific Ocean, 1990–2004.

Brett Molony

Oceanic Fisheries Programme, Secretariat of the Pacific Community,
Noumea, New Caledonia
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Summary

Total numbers of individuals captured and the total mortalities of birds, mammals, sharks and turtles were estimated for the longline fisheries that have operated in the western and central Pacific Ocean (WCPO), within the Western and Central Pacific Fisheries Commission (WCPFC) convention area, 1990–2004. While abundant logsheet data existed for these fisheries, the reporting rates of these four taxa on logsheets were relatively low and observer data were used in order to generate estimates. Observer coverage of industrialised longline fisheries within this region varies among flags, fleets and areas and observer data for the region are not centrally available from a single location. As a result observer data held at the Secretariat of the Pacific Community (SPC) were used. Observer coverage rates for longline fisheries in the WCPO are relatively low (typically representing less than 1% of all fishing effort) but improving.

Three longline fisheries were defined for the region of the WCPO between 15ºN–31ºS; tropical shallow longline (TSL, 15ºN–10ºS, less than 10 hooks between floats (HBF)), tropical deep longline (TDL, 15ºN–10ºS, 10 or more HBF) and temperate albacore longline (TAL, 10ºS–31ºS). Annual catch-rates and mortality-rates of each taxa for each of the three fisheries were estimated and raised by the estimated total effort to generate total annual catches and mortalities for each taxa in each longline fishery.

Relatively few observer records of birds existed from the longline fisheries examined. Total raised annual catches of birds by these three fisheries averaged less than 1,593 birds per year (95% confidence intervals (CI): 554–8,181) between 1990 and 2004 (range of combined annual catches of birds by the three longline fisheries: 0–9,284), with most birds suffering mortality (annual mean, 1,440; 95% CI, 582–7,452). Most birds were reported from the TAL with fewer records of bird catches reported from the other fisheries. However, less than 100 birds per year were estimated to be captured by these three fisheries since 1998. Few birds were identified to species.

Fewer mammals were reported by observers in these longline fisheries and total mean annual catches were estimated at 722 mammals per year (95% CI: 0–73,974) between 1990 and 2004 (range of combined annual catches of mammals by the three longline fisheries: 0–3,075). In contrast to birds, most mammals were released alive by all fisheries, with annual average mortalities estimated at 265 mammals per year (95% CI: 43–1,874). Mortality rates of mammals have declined since the late 1990s. The highest catches were reported from the TSL fishery of the WCPO. Most mammals were not identified to species.

As expected, the total annual catches of sharks were much higher than for the other taxa examined due to the high number of shark species, relatively high abundance of sharks compared to the other taxa, the existence of dedicated shark longline fisheries and that sharks and shark products (e.g. fins) are part of the commercial catch of all longline fleets. An annual raised mean catch of 667,108 sharks per year (95% CI: 520,603–820,657) were estimated for these three fisheries between 1990 and 2004 (range of combined annual catches of sharks by the three longline fisheries: 75,664–1,497,574), mainly by the TSL fishery. Annual estimated mortalities were relatively low but were likely to be underestimated due to the relatively low rates of reporting condition and fate of sharks by observers. It is likely that estimated total shark mortalities for these three fisheries were similar to the estimated total catches. Most sharks were identified to species and catches were dominated by blue sharks, silky sharks, oceanic whitetip sharks and pelagic sting rays, although the relative abundances of shark species varied among longline fisheries and years.

An estimated average of 6,815 turtles per year (95% CI: 717–18,241) were captured by the three fisheries between 1990 and 2004 (range of combined annual catches of turtles by the three longline fisheries: 0–14,914), with an estimated total annual mortality of 918 turtles per

year (95% CI: 0–6,134). The highest catches were estimated from the TSL fishery as most turtles in the WCPO are found in the upper regions of the water column (less than 120 m) in tropical areas. However, the highest turtle mortalities were estimated for the TDL fishery, likely a result of turtles being unable to surface if hooked on this deeper gear. A high proportion of turtles were not identified to species but a high proportion of olive ridley turtles were reported by observers.

While total annual catches and moralities were estimated for all taxa, confidence intervals around each estimate were relatively large. This is a result of the small number of records for each taxa (especially birds, mammals, turtles and individual species of sharks) and the low observer coverage rates, which required the estimated catch and mortality rates to be raised by several orders of magnitude in order to generated estimates of total catches and mortalities. Increasing observer coverage rates for all fleets would result in more-robust estimates of catches and mortalities. Additionally, improving the rate of identification to the level of species and increasing the rates of observers reporting condition and fate of captured animals would also assist in the generation of more robust estimates of mortality. Finally, centralising all observer data would provide a larger dataset in order to better estimate total catches and mortalities of all taxa throughout the WCPO and WCPFC convention area.

Nonetheless, the estimates of annual mortalities of birds and mammals by the three longline fisheries examined in the current report have declined in recent years, while annual turtle mortalities are stable. This is despite significant increases in longline effort in the WCPO in recent years. Thus, it is likely that increased awareness of bycatch issues, better training in handling incidentally captured species of the taxa examined and changes in gear configuration and type, have led to reduced mortality rates and total mortalities.

Only the annual estimated mortalities of sharks have increased since 1990, a result of targeted sharks fisheries and the retention of sharks and shark products within the three longline fisheries examined. While the catches of species of sharks with a IUCN conservation status is very low, the status of the stocks of many species of sharks are unknown. Due to the large number of species of sharks that are captured by the longline fisheries in the WCPO (more than 100 species), future research should prioritise which species should receive most attention in the immediate future. This will allow the status of individual species of sharks and the relative impacts of industrialised fishing to be assessed.

Future work requires that the estimated catches and mortalities presented in this report are placed into perspective with other sources of mortality of these taxa in the WCPO and entire Pacific Ocean. Unfortunately, estimates of annual mortalities of these taxa from other sources (e.g. artisanal catches, egg harvesting, other fisheries, modification of habitat) are rare, as are estimates of total population sizes of species within these taxa. As such, the relative impacts of mortality of individual taxa imposed by the industrialised longline fisheries in the WCPO cannot currently be assessed. More efforts should be focussed to estimate annual mortality and mortality rates from all anthropogenic sources for these taxa, to allow valid comparisons among mortality sources. This information would focus mitigation and management efforts to ensure the sustainability of all species and stocks.

1. Introduction

The industrialised fisheries of the western and central Pacific Ocean (WCPO) captured approximately two million metric tones of tunas in 2004, with the longline fisheries accounting for approximately 11% (ca. 225,000 mt) (Williams and Reid 2005). Although albacore, bigeye and yellowfin tunas have dominated annual longline catches from the WCPO, longline fisheries have also captured a large range of other species. Some non-tuna taxa, such as billfishes and sharks, are important components of the retained catches of industrialised fisheries in the region, especially in the longline fisheries (Lawson and Williams 2005, Molony 2005a).

However, longline fisheries in the WCPO have also interacted with a range of other species with no commercial value, or species with non-commercial values (e.g. seabirds, mammals and turtles). Recently, estimates of the mortality of non-target species captured by he industrialised longline and purse-seine fisheries in the convention area of the Western and Central Pacific Fisheries Commission (WCPFC) were presented at the first meeting of the WCPFC Scientific Committee (Lawson and Williams 2005, Molony 2005b). These two reports highlighted the importance of bycatch issues to the industrialised fisheries in the WCPO. Further, the reports highlighted the support for further development of gears and strategies to reduce bycatch in the industrialised fisheries (e.g. Beverly et al. 2003).

The current paper expands of the work presented at the WCPFC Scientific Committee meeting in 2005 (Molony 2005b) and focuses on longline bycatch of seabirds, mammals, sharks and turtles in the WCPO for the *Hook, Line and Bycatch* workshop. Specifically, total annuals catches and mortalities of seabirds, mammals, sharks and turtles by the major longline fisheries of the WCPO were estimated for the period 1990–2004. In addition, limitations of the currently available data and ways to redress these limitations were provided in order to further develop and focus research into longline bycatch issues in the future.

2. Methods

2.1 Fisheries

The industrialised longline fisheries of the WCPO were the focus of this report. The longline method fisheries of the region, together with the industrialised purse-seine fisheries, are the major fisheries that have operated within the WCPO region in terms of effort, catches and levels of bycatch. While the purse-seine fishery was not the focus of this workshop, estimates of bycatch were recently reported by Molony (2005b). Other method fisheries in the WCPO region are either relatively minor (e.g. troll, sportfishing) or unlikely to significantly interact with birds, mammals, sharks or turtles in the region (e.g. pole-and-line fisheries).

2.2 Data sources

Individual longline vessel logsheets for the period 1990–2004 were examined (Table 1). However, very few records of birds, mammals or turtles existed from records of more than 1.6 million longline sets. As a result, observer data for longline fisheries were used. While observer coverage rates are relatively low (typically less than 0.1% overall, Table 1), the data recorded by observers included information on all species captured within an individual set (Tables 2–5). In addition, information about the condition of individual animals (e.g. dead or alive) and fate (e.g. retained or discarded) were also recorded in some cases. While observer data held at Secretariat of the Pacific Community (SPC) were detailed, areas north of approximately 15°N or south of approximately 31°S were not well represented (Figure 1). Thus, analyses were restricted to observer data from the central region of the WCPFC area

(Figure 2) (i.e. the WCPO). The ocean area under consideration was approximately 50 million km^2.

2.3 Longline fisheries

The longline fisheries of the WCPO were divided into three separate fisheries based on spatial regions (Figure 2) and gear configurations. The western tropical Pacific shallow longline (TSL) fishery was defined as operating between 15°N and 10°S with less than 10 hooks between floats (HBF). The western tropical Pacific deep longline (TDL) fishery operated within the same spatial region as the TSL fishery but with 10 or more hooks between floats. The temperate albacore longline (TAL) fishery was defined as operating between 10–31°S and encompassed all EEZs of Pacific Island States and Territories in the southern WCPFC region, with the exception of Australia and New Zealand. Longline fisheries to the north and south of these spatial regions were not considered due to the limited data currently held at SPC. Additionally, individual countries outside these regions (United States to the north-east; Australia and New Zealand to the south-west) report on catches of all species within their EEZs, including seabirds, mammals, turtles and sharks (e.g. Bradford 2002).

2.4 Analyses

Observer data for each of longline fishery (TSL, TDL and TAL) were analysed separately. Data were restricted to the period 1990–2004 for the longline fisheries as these years provided relatively high levels of observer data. However, only limited observer data were available for the TSL fishery prior to 1993 and the TDL fishery prior to 1992 and analyses were restricted to the periods 1993–2004 and 1992–2004, respectively, for these two fisheries.

Observer records of the numbers of individuals for all species within each of the four main taxa (birds, mammals, sharks and turtles) were pooled within years for each fishery due to the low number of records for individual species (Tables 2–5). Initially, the position of sets capturing one or more individuals of each taxa were examined for each year (Figures 3–6) in order to determine areas of greatest interaction between each fishery and taxa within the WCPO.

The distributions of the number of individuals captured per set of birds, mammals and turtles were heavily skewed in all three fisheries, being dominated by sets with zero catches (Figure 7). Relatively few sets from any of the three fisheries reported any catches of these three taxa. While sets recording zero shark catches per set still dominated the shark data for all three longline fisheries, the numbers of sharks per set by the fisheries displayed a broadly log-normal distribution of catches per set. Subsequently, all data were log(n+1) transformed prior to the estimation of total catches and mortalities.

For each fishery, annual mean catches and mortalities per unit effort (CPUE, number of individuals per hundred hooks, (hhooks)) for each taxa were estimated. The standard deviations for each estimate were also calculated for each taxa for each fishery.

Estimates of the total number of hooks set annually for each longline fishery were generated from raised Catch and Effort System (CES) data held at the SPC. These data were applied to the CPUE and standard deviation estimates of each taxa to estimates total numbers and mortalities of each taxa, plus 95% confidence intervals (CI), for each longline fishery. A summary of the calculations are provided in Appendix 1. Finally, the total overall catches and mortalities of each taxa by the three longline fisheries were estimated for the period 1990–2004. As some logsheets for all three longline fisheries were yet to be submitted for 2003 and 2004 at the time of preparing this report, catches and mortalities for 2003 and 2004 were likely to underestimated.

The relatively low numbers of observer records for birds, mammals and turtles from the three longline fisheries restricted estimates of total catches and mortalities to a high taxonomic level (i.e. bird, mammal, shark, turtle). A relatively high number of records for sharks allowed the estimation of total catches and mortalities at the species or genus level for common species. The minimum level was set at 1,000 individual records of any species or genus. This allowed the estimation of catches and mortalities of 13 species and two genera of sharks from the longline fisheries.

3. Results

3.1 Logsheet data

A total of 1,681,213 longline sets were examined, covering a period between November 1978 and October 2004. Logsheets described fishing activities in an area of the Pacific Ocean between 44.5°N–55.0°S and 100.8°E–85.3°W although effort was not evenly distributed temporally or spatially (Figures 1 and 2). Longline logsheets reported a total of 22 birds, 70 mammals, 348,748 sharks and 4 turtles over this period.

Logsheets were designed primarily to record the capture of commercial species, specifically tunas and billfish. The recording of sharks on logsheets is increasing as sharks are becoming an important commercial catch in some regions of the WCPO and WCPFC convention area. However, not all sharks captured by longline fisheries were likely to be recorded on logsheets, with generally only retained catches being reported. Further species identifications are rarely accurate for non-target species and sharks, with most logsheet entries reporting catches in a general 'shark' category.

The capture of non-commercial species is rarely recorded on logsheets. Thus few records of the capture of mammals, turtles or birds existed in the logsheet database

3.2 Observer data

Much more data on the four taxa were available from the observer database for the three fisheries examined (Tables 2–5). However, a large proportion of records of birds, mammals and turtles were identified only to a relatively high taxonomic level and many unidentified categories existed (e.g. "Bird (unidentified)", "Marine mammal (unidentified)"). In some cases, a high proportion of observer records were unidentified below the class level (e.g. more than 42% of all observer turtle records were reported as "Marine turtle (unidentified)"). While 'Sharks (unidentified)' were still a significant category in the longline databases (Table 4), most sharks were identified to a species or genus level. Sharks dominated the data of the four taxa under consideration, with very high catches reported from some individual sets.

3.3 Estimates of catches and mortalities

3.3.1 Birds

A total of 3,887 birds were recorded by observers on longline vessels as being captured during longline sets in the WCPO since 1980 (Table 2) (Figure 3). Most birds were recorded from longline sets in the New Zealand EEZ, within the Australian EEZ south of 31°S and to the north and east of the Hawaiian EEZ (Figure 3). Very few birds were recorded from observed longline sets in the WCPO outside of these areas (i.e. within the latitudinal range of 15ºN–31ºS). Australia, New Zealand and Hawaii (United States) already have very detailed reporting of seabird interactions with longline fisheries (and other method fisheries) within their respective EEZs and fisheries, and have various mitigation measures in place.

Observer data between 15ºN and 31ºS contained only 39 observer records of birds being captured by longline vessels in the WCPO, from 25 sets between 1990 and 2004 (Figure 3). Thirty seven of these records listed the bird as "unidentified" and two records identified the birds as 'albatross'. Thus records do not provide information about the species involved.

Of the 39 birds captured in the WCPO by longline vessels, 28 were dead at time of retrieval of the longline, three were alive and eight were listed as not observed. Although few birds were captured by longline in the WCPO, only about 10% of birds were recorded by observers as being alive at time of capture.

In most cases, only a single bird was captured per set (Figure 7). Only 12 birds from 8 sets were reported by observers as being captured by longline gear since 1995 in the WCPO, from a total of 6,846 observed sets, an interaction rate of approximately 0.11% of observed sets. The low number of birds reported by observers did not allow the identification of areas or times of high longline-bird interactions in the WCPO.

Few birds were recorded by observers within the TSL and TAL longline fisheries in the WCPO during 1990–2004, with no birds reported within the TDL (Figures 8–10). Nonetheless, the low estimates of CPUE of capture and mortality resulted in estimates of between 0 and 9,823 birds captured in the WCPO per year (Figure 11–13), with annual mortality rates between 24 and 100% (Table 6a).

Between 1990 and 2004, the mean annual catch of birds from the three longline fisheries of the WCPO was estimated at 1,593 birds per year (95% confidence intervals (CI): 554–8,181) (range of combined annual catches of birds by the three longline fisheries: 0–9,284) (Figure 14). Most birds captured by the longline fisheries suffered mortality (annual mean, 1,440; 95% CI, 582–7,452). However, estimated catches and mortalities of birds have been very low since 1998, with less than 100 birds per year being captured by the longline fisheries of the WCPO between 1998–2004 (Figure 14).

3.3.2 Mammals

Observers recorded a total of 380 mammals interacting with longline fisheries in the WCPFC area between 1980 and 2004 (Table 3). Records of marine mammals from observers in the longline fishery were dominated by New Zealand fur seals (n = 321, ca. 75.7% of records) (Table 3) which are reported by the Ministry of Fisheries under New Zealand reporting requirements. To focus on the WCPO, records south of 31°S were excluded (i.e. sets within the New Zealand and southern Australian EEZs and US longline operations within and north-east of the Hawaiian EEZ).

The reduced data set contained mammals records from 22 longline sets (Figure 4). Records were dominated by unidentified marine mammal categories. Therefore, most records did not provide accurate species identifications. Most mammals were recorded as alive at the time of longline retrieval with most mammals in a healthy condition at time of release.

While all longline fisheries reported very low mammal CPUEs, the highest CPUEs for mammals were recorded in the TSL fishery (Figures 8–10). Most mammals captured by the TSL between 1994 and 1997 were recorded as dead by observers, however no mortalities have been reported from this fishery since 1997. No mortalities of mammals were observed in the TAL fishery.

When raised, the very low estimated CPUEs for mammals resulted in up to 3,075 mammals captured per year (mean, 722, 95% CI: 0–73,974) by the longline fisheries of the WCPO (Table 6b, Figures 11–13). However, mortality rates (the precent of individual captured that were reported as dead) were much lower than for birds, with annual rates generally being less

than 30% in most years (Table 6b). The mean number of mammal mortalities was estimated at 265 mammals per year (95% CI: 43–1,874) by the longline fisheries of the WCPO (Table 6b, Figures 11–13). However, the estimated mammals mortalities have declined in recent years with less than 110 mammal mortalities from the three longline fisheries estimated since 1998 (Table 6b, Figure 15).

While few sets captured one or mammals were reported by observers between 1990 and 2004, most sets capturing one or more mammals occurred in the tropical WCPO, west of 180º (Figure 4).

3.3.3 Sharks

More than 290,000 sharks representing more than 40 species were reported by observers from the longline fisheries of the WCPO from more than 21,000 sets (Table 4). Blue sharks dominated the observer longline data (approximately 196,000 records), with silky sharks (27,000 records) and pelagic sting rays (11,000 records) also reported in large numbers.

While very high CPUEs were reported from some sets (e.g. a maximum of 672 sharks were recorded from a single longline set of 800 hooks recorded in the TSL fishery), average CPUEs varied between 0 and approximately 5 sharks per hundred hooks in the three longline fisheries (Figures 8–10). CPUEs were much higher in the TSL fishery. Annual total catches and mortalities were estimated for each fishery (Figures 11–13), however the condition of most sharks and fate were recorded as unknown.

Most sharks were captured by the TSL fishery, with lower but similar levels of sharks captured by the TDL and TAL fisheries (Table 6c, Figure 16). Mortalities showed a pattern similar to catches (Figure 16), although shark mortalities were likely to be underestimated due to the low reporting rates of condition (alive or dead) and fate (retained, discarded). Further, anecdotal reports suggested that most if not all sharks captured by longline gears are killed before being discarded (P. Sharples, pers. comm.) and therefore estimates of total catches may be reasonable estimates of total mortality of sharks. Total shark catches (and therefore mortalities) were estimated between approximately 500,000 and 1,500,000 million sharks per year by the longline fisheries of the region of the WCPFC examined, with an annual estimated catch of 667,108 sharks per year (95% CI: 520,603–820,657) (Table 6c). Shark catches were reported throughout the range of the observers in the WCPO (Figure 5).

The CPUEs and mortality rates of the 15 most common species of sharks were examined for each longline fishery (Figures 17–19). Most of the individual species examined displayed the highest CPUEs (and mortality rates) within the TSL, including blue sharks and silky sharks (Figure 17). Oceanic whitetip sharks and shortfin mako sharks displayed similar CPUEs in all three longline fisheries, suggesting a wide distribution of these species. Crocodile sharks displayed similar, relatively high CPUEs in both tropical longline fisheries suggesting a tropical distribution. Only mako sharks and thresher sharks displayed higher CPUEs in the TAL.

Total estimated catches and mortalities of blue sharks and pelagic string rays were highest from the TSL and TDL fisheries (Figures 20–22, Appendix 2). The highest estimates of total catches and mortality were recorded from the TSL for silky, oceanic whitetip, hammerhead and silvertip sharks. The highest catches and mortalities of porbeagle sharks were reported from the TDL fishery, while the highest estimates of thresher sharks and unidentified mako sharks were reported form the TAL fishery. Crocodile sharks displayed similar total catches and mortalities in all longline fisheries.

3.3.4 Turtles

A total of 481 turtles were reported by observers from the longline fisheries of the WCPO (Table 5), dominated by an unidentified category and olive ridley turtles. However, only 159 records of turtles existed in the observer data for longline fisheries between 15ºN and 31ºS of the WCPFC. Most turtles were reported in the tropical longline fisheries, west of 170º (Figure 6). The highest CPUEs were reported from the TSL fishery (Figures 8–10). However, most turtles from this fishery were released alive. Despite lower CPUEs, a relatively high proportion of turtles captured in the TDL were reported dead at release. The estimated number of turtles captured in the TAL was very low (Table 6d).

Despite the low CPUEs, raised estimates generated annual catches of between 4,000 and 15,000 turtles per year by the longline fisheries, 1990–2004 (mean, 6,815; 95% CI: 717–18,241) (Table 6d, Figure 23). However, mortality rates were less than 26% in all years, with total annual mortalities estimated at less than 3,000 turtles per year (mean, 918; 95% CI: 0–6,134) (Figures 11–13, 23).

4. Discussion

4.1 Data issues

Considerable logsheet and observer data from the longline fisheries were examined. However, logsheets were primarily designed to record information on the three major tuna species (albacore, bigeye and yellowfin) and billfish species (e.g. blue marlin) targeted in the WCPO. As a result, information on other species is not often recorded on logsheets or records are underestimates of the true catches. For example, approximately 335,000 sharks were recorded on logsheets from approximately 1.6 million longline sets (overall CPUE of 0.2 sharks per longline set). In contrast, approximately 290,000 sharks were reported by observers from approximately 21,000 longline sets (overall CPUE of 14.2 sharks per set). Thus, logsheet data significantly underestimated shark catches. The reporting rates of other taxa within this report were rarely recorded on logsheets. Thus, observer data was the only data-source which could be used to provide reasonable estimates of catches of these taxa.

While the catches reported by observers were relatively detailed (for example, relatively few sharks were pooled into the unidentified shark category by observers within the longline fisheries), a significant proportion of records lacked information on condition and fate of individuals. These two data fields are essential in the estimation of mortality rates of taxa and the limited data are likely to have affected the estimated mortalities presented within this report. However, the mortality rates of some taxa can be accurately assumed (e.g. most sharks are likely to have been retained completely or finned and therefore suffered mortality).

With the exception of several species of sharks, the number of observer records for most of the species examined within this report were relatively few. The data for most species were dominated by zeros (i.e. most species were not recorded from most longline sets). As such, estimates of catches and mortalities were provided at relatively high taxonomic levels (i.e. bird, mammals, shark and turtle).

The low observer coverage rates required that the estimated catches and mortalities were raised considerably to provide total estimates for the area of the WCPO examined. For example, annual estimates of catches and mortalities generated from observer data were raised by a factor of between 50 and 1,000 times. Thus, a single observation in the dataset resulted in the estimation of a significant total catch. Similarly, a single mortality observation also generated large estimates of mortality (e.g. mammals, Table 6b).

Given the issues of the low observer coverage rates, the generally low rates of identification to the species level (especially for birds, turtles and mammals), and the small number of

records, the estimated catches and mortalities within this report had relatively wide confidence intervals, highlighting the uncertainty around each estimate. Wide confidence intervals around point estimates are common throughout the published literature in which estimates of bycatch are provided for longline fisheries (e.g. Baker and Wise 2005, Uhlmann et al. 2005). However, the wide confidence intervals must be treated with caution.

Finally, it should be noted that industrialised longline fisheries of the WCPO and elsewhere do not target birds, mammals or turtles. Individuals from these taxa are incidentally captured in all cases. In fact, capturing individuals from these taxa has negative economic consequences for longline fisheries. For example, capturing individuals from these taxa results in the loss of bait and or gear, reducing the potential catch of target tuna species. Further, time is required to remove captured individuals and repair or replace gears. Finally, there are risks to longline crews involved in the de-hooking of these taxa, especially turtles and mammals. Thus, there is an economic incentive to design cost-effective gears and strategies to reduce the incidental catches of birds, mammals and turtles by longline fisheries.

4.2 Birds

Overall, very few birds were reported by observers from the longline fisheries in the area examined. Thus, the interaction of the industrialised fleets with birds between 15ºN and 31ºS were extremely low and too low to generate reliable estimates of catches and mortalities. When condition or fate were recorded, a significant proportion of all bird records for the longline fisheries indicated that the birds were dead at release. The highest rates of bird capture were generated for the TAL fishery, suggesting the interactions between birds and the TAL were relatively high, although bird catches (and therefore mortalities) in all longline fisheries have declined sine the late 1990s (Figure 14). Compared to estimates from more southern temperate regions of the WCPFC (Watling 2002, Baker and Wise 2005, Uhlmann et al. 2005), the interactions between the industrialised longline fisheries and birds in the central WCPFC region were relatively low.

The risk of industrialised longline fishing to the sustainability of bird populations in the region of the WCPFC examined were likely to be relatively low. Further, other sources of anthropogenic bird-mortality exist in the WCPO (e.g. Watling 2003). However, many resident and transient seabirds in the tropical Pacific are listed as threatened by the IUCN (Watling 2002) and reducing seabird-fishery interactions in the region may improve the status of these bird stocks. Improved identification of birds by observers and improved reporting of condition and fate would improve the understanding of the interactions between birds and industrialised longline fisheries in the region.

4.3 Mammals

Similar to birds, very few mammals were reported by observers within the longline fisheries of the region examined. Therefore, the overall impact of longline fisheries with marine mammals appeared to be very low. The highest estimates of total catches were estimated for the TSL fishery, with very low estimates generated for the TAL fishery (Table 6b, Figure 15).

Higher estimated numbers of mammal mortalities were reported from the two tropical longline fisheries during the late 1990s, especially in the western tropical Pacific. However, very few mortalities were recorded by observers in recent years and the total number of mammals mortalities between 1998–2004 was estimated at less than 110 (Table 6b). Although most records existed for the TSL fishery, no mortalities have been reported since 1998. No records of mammal mortalities existed for the TAL fishery (Figure 15).

Overall, catches and mortalities of mammals by the industrialised longline fisheries of the WCPO were very low. Thus the risk of the industrialised fisheries to the sustainability of

marine mammals in the region appear to be low. However, as most mammals captured by the longline fishery in the WCPO were not identified to the species level, the risks to individual species could not be assessed. Better species identification would permit a more thorough understanding of the impacts of fishing on mammals stocks of the WCPFC.

In contrast, a great deal of recent effort has focussed on depredation of longline captured tunas by toothed whales (e.g. Lawson 2001, Nishida and Tanio 2001). Efforts to quantify the levels of depredation are likely to increase in the immediate future due to the perceived high economic losses associated with depredation. It is important that these interactions be monitored and reported by observers in all longline fisheries.

4.4 Sharks

Estimates of catches and mortalities of sharks were higher than for any other taxa examined in the current report. Sharks are more diverse and more abundant than seabirds, mammals and turtles in the tropical Pacific. Further, dedicated shark fisheries have been established in several EEZs within the region examined, especially in the TSL fishery. Thus sharks are targeted by some industrialised longline fisheries in the WCPO, contrasting to the catches of other taxa presented in this report.

An annual catch of more than 1.36 million sharks was estimated from observer data for the TSL fishery in 2002, with catches averaging approximately 520,000 sharks per year for the period 1990–2004. Further, the total estimated catches of sharks within the TSL fishery have steadily increased in recent years (Table 6c, Figure 11). Shark catches in the TSL were dominated by seven species of sharks and pelagic sting rays (Figure 17), with silky sharks being the most commonly captured species in the TSL fishery.

Shark catches in the TDL were much lower than for the TSL, with between 44,000 and 222,000 sharks captured by the TDL fishery per year. The estimated number of sharks annually captured in the TAL were generally less than 140,000. Thus, the observer data suggested that sharks were more common in the upper part of the water column in tropical waters than in other regions of the WCPO examined. Mortality rates were generally estimated at less than 30% in most years. However, this was likely to have underestimated the actual mortality rate as records of condition or fate of captured sharks were not available for more 50% of records. Further, the rate of shark-finning and/or retention is relatively high throughout the region. Thus the total mortalities of sharks in the longline fisheries of the region examined were likely to approach the estimated total catches.

Overall, the industrialised longline fisheries of the region of the WCPO examined captured significant numbers of sharks, with an annual estimated mean catch of 667,108 sharks per year between 1990–2004 (95% CI: 520,603–820,657) (Table 6c, Figure 16). This was a result of sharks forming part of the commercial catches for many longline fisheries in the region. Further, dedicated shark fisheries were present in the region. Finally, the high prices paid for shark fins are also likely to result in a high proportion of sharks being finned. As a result, many sharks that are captured by the industrialised fisheries are likely to suffer mortality.

Shark catches in the longline fisheries in the WCPO were dominated by blue sharks. Blue sharks are listed as ‘low risk/not threatened’ by the IUCN (www.redlist.org) (Table 4) due to the relatively high fecundity of this species compared to other species of sharks (Last and Stevens 1994). Other species of sharks commonly captured by the longline fisheries of the region were also listed as ‘low risk/not threatened’ or not listed by the IUCN (www.redlist.org) (Table 4). However, three species of sharks listed as ‘vulnerable’ by the IUCN were captured by the longline fisheries in the WCPO, although in very low levels (basking shark (n=138), great white shark (n=48), whale shark (n=2)). Further, the IUCN only

lists the north Pacific stock of basking shark as 'vulnerable' (www.redlist.org), which are found outside of the area examined in the current report.

While most sharks were not listed as threatened by the IUCN (www.redlist.org), the CPUEs estimated from observer data for some of the major species were lower in recent years (Figures 17–19). For example, blue, oceanic whitetip, silky, and crocodile sharks, and pelagic sting rays, all showed a decline in CPUE in recent years. While these trends may suggest declines in relative abundances of theses species, the changes in CPUE may also be due to changes in gear configurations (e.g. deeper sets hooks in the TDL and TAL fisheries) and the spatial distribution of fishing effort within each fishery. Further, the identification of species by observers has also improved, as displayed by the reduction in the CPUE of unidentified threshers in the TSL, and subsequent increases in thresher shark CPUE.

Formal stock assessments for species of sharks in the Pacific Ocean are currently limited. A blue shark assessment for the north Pacific (Kleiber et al. 2001) indicated that significant numbers of blue sharks were captured by longline fisheries in the region. However, the assessment by Kleiber et al. (2001) indicated that current levels of catch for blue sharks were sustainable in terms of stock dynamics and fishery effort and that the north Pacific stock could sustain higher levels of effort and catch. The three longline fisheries examined in the current report captured an estimated average of 243,269 blue sharks per year (95% CIs, 151,115–346–195) between 1993 and 2004 (range of combined annual catches of blue sharks by the three longline fisheries, 38,519–369,310), and it is likely that the blue shark stock in the south Pacific can also sustain this level of annual catch. Formal stock assessments for other species of sharks are underway and more are planned in the future. However, assessments for many shark species are currently not available and the catch estimates of other species presented in this report cannot be placed in perspective.

While the total catches presented within this report appear realistic in terms of the order of magnitude of the estimates, an increased level of observer coverage would assist in the generation of more robust estimates. In addition, increasing the rates of identification of sharks to species level and the conditions and fates of sharks, would also benefit the generation of more accurate estimates. These additional data would be important inputs to any future assessment for sharks in the WCPFC area.

4.5 Turtles

Observers reported five species of turtles and an unidentified category being captured within the three fisheries examined in the present report (Table 6d), with the highest estimated total catches being generated for the TSL fishery (Table 6d, Figure 23). Estimates of turtle catches from the TDL fishery were much lower than those for the TSL fishery, but higher than the estimates of total turtle catches from the TAL (Figure 23). The highest mortality rates of turtles were estimated for the TDL fishery. The lower mortality rates of turtles in the TSL compared to the TDL maybe due to the shallower gear allowing incidentally captured turtles to reach the surface to breathe, whereas the deeper set gear of the TDL does not.

The relatively high estimated catches of turtles by the TSL fishery were expected. The shallow hook depth places hooks in the surface waters (less than 100 m) where all species of turtles spend nearly all their time (Beverly et al. 2004, Hays et al. 2004). Further, most species of turtles spend much of their lives within the tropics and most turtle catches were estimated from the western tropical WCPO. The high mortality rates of turtles from the TDL were also expected as the increased depth of the set does not permit hooked turtles to surface as easily as the shallow set hooks in the TSL, resulting in relatively high mortality rates.

A total estimated 6,815 turtles per year (95% CI: 717–18,241) were captured by the three longline fisheries between 1990 and 2004 (range of combined annual catches of turtles by the

three longline fisheries: 0–14,914), with an estimated total annual mortality of 918 turtles per year (95% CI: 0–6,134) (Table 6d, Figure 23). This was higher than previous estimates for the WCPO (an average of less than 2,500 turtle catches per year between 1990–2000, with approximately 500–600 mortalities per year) (OFP, 2001). The higher estimates in the current report were likely due to the significant increases in total effort by these since 2000 (Table 1). However, improved guidelines and training for the handling of incidentally captured turtles by the three industrialised longline fisheries of the WCPO and changes in gear configurations (Beverly et al. 2004, Watson et al. 2005) have resulted in stable or declining mortality of turtles (as well as birds and mammals) within these fisheries in recent years, despite increased effort.

Most records of turtle catches from the longline fisheries examined were reported from the tropical western Pacific, west of approximately 170ºE (Figure 6), similar to previous reports (OFP 2001). The higher turtle-fishery interactions in this region may be due to the proximity of nesting beaches in the western central Pacific. Future analyses of turtle-fishery interactions in the WCPO may consider further dividing the longline fisheries within the tropical regions into fisheries east and west of 170ºE, in order to better estimate turtle-fishery interactions.

All species of marine turtles are listed as 'endangered' or 'critically endangered by the IUCN (www.redlist.org) (Table 5). However, a high proportion of all turtle records reported by observers were not identified to the species level. Increasing the species identification rates by observers in all fisheries would permit a better assessment of the impacts of fishing on turtles stocks.

While the mortality of any marine turtles by longline fisheries of the WCPO should be avoided where possible, other sources of direct (e.g. trawl fisheries, Hays et al. 2003, Ferraroli et al. 2004, Kaplan 2005; cultural and traditional harvesting of turtles or eggs, OFP 2001, Kinch 2003, Kaplan 2005) and indirect (e.g. modification of nesting beaches) human-induced mortality of turtles also exist, although estimates are rare in the WCPO. Where estimates do exist for these other sources of mortality, they have been estimated to exceed turtle mortality from longline fisheries.

For example, Limpus (1997, in Kinch 2003) estimated an annual artisanal catch of 10,000–20,000 green turtles from the Papua New Guinea Exclusive Economic Zone alone, much higher than the total mortality for all turtles estimated within this report (918 turtle mortalities per year (95% CI: 0–6,134)). Further, the estimates of Limpus (1997, in Kinch 2003) did not include estimates of egg harvesting from turtle nests. Kaplan (2005) recently estimated that the mortality rates of leatherback turtles from coastal sources (i.e. inshore fisheries, egg harvesting), were much higher than from commercial longline fisheries in both the WCPO and eastern Pacific Ocean. Thus, while the mortality of turtles (and other taxa) by commercial longline fisheries in the WCPO should be reduced and avoided where possible, commercial fisheries are not the only sources of mortality, nor do they necessarily impose the highest levels of mortality, of turtles (and other taxa) in the region..

4.6 Conclusions and recommendations

Each of the three longline fisheries displayed differences in catches and mortalities of each taxa examined. However, the estimated mortalities of birds and mammals induced by the three fisheries examined in the current report were relatively low. Although formal estimates of the impacts of each fishery on the stock status of birds and mammals were not undertaken, the low number of observer reports suggested that the levels of impacts were relatively low.

There are however, anecdotal reports of significant interactions between toothed whales and the longline fisheries examined in the current report (e.g. Lawson 2001, Nishida and Tanio

2001). Depredation of tunas from longlines by toothed whales were not examined in this report but is likely to be an area of interest in the future.

Estimates of turtle mortalities in the WCPO as a result of industrialised longline fisheries appeared to be at a higher level than the mortalities of birds and mammals. However, the estimated mortalities have been relatively low in recent years. This may be a result of specific programmes designed to increase the awareness of turtle-fishery interactions, changes in gear configurations and type (e.g. deeper setting of gear and the use of circle hooks) (e.g. Beverly et al. 2004) and training of crews in correct turtle handling. However, the significance of the mortality estimates on the stock status of the species and the relativities with other sources of human-induced mortalities are unclear at present (Kaplan 2005). Nonetheless, reducing the mortality of turtles from all potential sources is critical in sustaining turtle populations in the WCPO.

Large catches of sharks were reported in all fisheries, especially the TSL fishery which includes specific shark fisheries. Formal stock assessments for most species are lacking. However, most sharks are not listed as threatened by the IUCN (www.redlist.org). Better estimates of shark catches through increased observer rates would allow the generation of more robust estimates of mortality for each species.

It is likely that the impacts of fishing on these four taxa will be the focus of further attention and research in the future in the WCPO and WCPFC convention area. In order to improve future analyses the following recommendations should be considered;

1. Increasing observer coverage rates

Observer coverage rates are relatively low. This results in relatively low levels of data and considerable raising of the data in order to generate total catches and mortalities. Further, the influence of single observation is relatively large. By expanding the observer coverage rates, more accurate estimates of catches and mortality will be able to be generated.

Additionally, observer coverage rates are not evenly distributed among flags or areas and are not in proportion to the distribution of effort within each fishery (Appendix 3). Thus, raising estimates of mortality from the observer coverage to the entire fishery introduces potentially significant biases. Further, the distribution of starting times for sets varies between observed sets and logsheet sets (Appendix 4) and is potentially a major variable influencing catch rates of these taxa (e.g. Baker and Wise 2005).

2. Increasing the identification of all individuals to species level

The high proportions of records that identified individuals to genus, family or class does not allow for accurate assessments of the impacts of fishing mortality and interactions on individual species. Better identification of all taxa is required.

3. Increasing the rates of reporting of fate and condition of all individuals captured.

Fate and condition at capture and release are essential data for the estimation of mortality rates and impacts of fishing. However, a majority of records lacked information for one or both of these categories. Thus assumptions about the likely mortality rates had to be imposed. Higher levels of recording of at least one of these variables would greatly assist the estimates of mortality for each species.

4. Increasing the rates of reporting of all species on vessels logsheet records.

Logsheet information typically only includes retained catches. As logsheets represent a significantly higher level of coverage than observer data, improving the reporting of these four taxa (at least) on logsheets would greatly improve the estimates of total catches and mortalities of all species.

5. Designing species observer programmes to address specific objectives and issues (e.g. NOAA turtle programme)

While the current observer programme allows the estimation of catches of a wide range of species, including major tunas, the programme was not specifically designed to estimate the mortalities of the taxa requested. For example, turtle-fishery interactions near Hawaii were recently examined with a specific observer programme designed to address specific objectives, coupled with high observer coverage rates. The resulting turtle CPUEs were much higher than previous estimates under a generic observer programme (M. McKoy, pers. comm.). While new programmes are currently being developed in the WCPFC area (e.g. the FFA and NOAA turtle programme), consideration should be given to designing specific programmes to address specific objectives.

6. Centralising all WCPO/WCPFC observer to allow data to be easily accessed from a single location

This report relied entirely on observer data held at SPC. While other data exist in the WCPFC region and the Pacific, there is no centralised location for all data sources. Centralisation should be considered to allow easier and more rapid access to the observer data for future analyses.

7. Prioritising the species for future research

There are more than 40 species of sharks and rays listed within the SPC observer database, and more than 180 species of sharks and 100 species of rays in the WCPFC region (Last and Stevens 1994). Future research should focus on the most important species of sharks. Importance of each species could be determined by using a combination of biological (e.g. age at first maturity, fecundity), catch (e.g. total catch estimates, trends in annual estimated catches, CPUEs) and stock status variables (e.g. IUCN listings, www.redlist.org) in a risk-analysis type framework. This framework could also be applied to other species that interact with the industrialised fisheries of the WCPFC region. This has been proposed to the WCPFC at the recent Scientific Committee meeting (August 2005, see www.spc.int/oceanfish/Html/WCPFC/SC1/scientific_committee.htm).

8. Considering focussing on the interactions of the four taxa with newly developing fisheries.

Several new fisheries have recently developed in the WCPFC convention area, including regional longline fisheries that specifically target sharks or swordfish. Longline sets in these fisheries use relatively few HBF and most of the hooks are within the upper 100 m of the water column. As seen in the estimated catches and mortalities from the TSL fishery, the interactions between longline fisheries using few HBF with sharks and turtles are relatively high. Consideration should be given to assessing interactions between these new shark and swordfish fisheries and specific taxa (e.g. turtles, sharks, other fishes).

9. Developing methodologies to allow the equitable comparison of all anthropogenic sources of mortality for each of these taxa.

The estimates of catches and mortalities for each of the taxa presented within this reported were generated due to the existence of observer data for the industrialised longline fisheries of the WCPO. While mortality estimates were able to be generated, comparing these estimates with other sources of mortality is difficult due to limited data or the complete lack of estimates. Estimates of other anthropogenic sources of mortality should be generated to allow equitable comparison of all mortality sources. Management strategies which aim to maintain and increase populations of turtles (and other taxa) in the region must consider and compare all sources of mortality, despite the difficulties in quantifying mortality estimates.

10. Estimating post-release survival.

While many mammals and turtles were recorded by observers as being released alive, the post-release survival of turtles is poorly known. For example, while some research has shown

relatively high post-release survival of turtles (e.g. Aguilar et al. 2005, Piovano 2005) other authors have suggested that post-release mortality can occur after relatively long-periods of time after release (e.g. Chaloupka et al. 2004). Further research into post-release survival of all incidentally captured taxa would improve the estimates of total mortality and the impacts of industrialised longline fishing.

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7. Tables

Table 1. Total observed effort (millions of longline hooks) and total effort of the three fisheries defined within the report. Sources: observer and CES databases held at SPC. Coverage rates estimated by dividing effort total annual observer effort with total (CES) estimated effort per year.

a). Western tropical Pacific shallow longline

	Effort (millions of hooks)		Estimated observer
Year	Observer	Total estimated	coverage rate
1993	0.05	128.81	0.000
1994	0.15	177.51	0.001
1995	0.14	208.31	0.001
1996	0.07	179.92	0.000
1997	0.12	128.72	0.001
1998	0.26	153.49	0.002
1999	0.24	235.38	0.001
2000	0.17	251.10	0.001
2001	0.15	308.31	0.000
2002	0.19	388.88	0.000
2003	0.03	280.32	0.000
2004	0.14	61.62	0.002

b). Western tropical Pacific deep longline

	Effort (millions of hooks)		Estimated observer
Year	Observer	Total estimated	coverage rate
1992	0.01	130.18	0.000
1993	0.07	159.16	0.000
1994	0.10	152.35	0.001
1995	0.17	126.27	0.001
1996	0.17	102.47	0.002
1997	0.42	98.98	0.004
1998	0.59	87.50	0.007
1999	0.39	93.76	0.004
2000	0.79	122.83	0.006
2001	0.69	101.02	0.007
2002	0.99	107.16	0.009
2003	0.65	92.05	0.007
2004	0.36	93.53	0.004

Table 1, continued. Total observed effort (millions of longline hooks) and total effort of the three fisheries defined within the report. Sources: observer and CES databases held at SPC. Coverage rates estimated by dividing effort total annual observer effort with total (CES) estimated effort per year.

c). Western temperate Pacific albacore longline

	Effort (millions of hooks)		Estimated observer
Year	**Observer**	**Total estimated**	**coverage rate**
1990	0.01	78.88	0.000
1991	0.32	100.52	0.003
1992	0.56	70.26	0.008
1993	0.26	74.70	0.003
1994	0.29	90.48	0.003
1995	0.31	96.95	0.003
1996	0.47	83.82	0.006
1997	0.72	83.83	0.009
1998	0.35	109.92	0.003
1999	0.31	109.72	0.003
2000	0.23	107.73	0.002
2001	0.27	135.93	0.002
2002	0.13	150.79	0.001
2003	1.29	198.39	0.007
2004	0.98	127.75	0.008

Table 2. Species of birds listed in the entire SPC longline observer database, 1980–2004. Code, international species code as used in SPC databases; IUCN code, Red Book status of each species, either vulnerable (VU), endangered (EN) or not threatened (NT) (full details at www.redlist.org), missing value indicates that the species is not listed in the Red Book; Stock status, as given in the IUCN Red Book, either increasing (↑), declining (↓) or stable (→). Blanks indicate that not enough information exists to determine status.

Common name	Scientific name	Code	IUCN code	Stock status	Number of observer records
Albatross	*Diomedea* spp.	ALZ			579
Bird (unidentified)	Aves	BIZ			1,533
Black petrel	*Procellaria parkinsoni*	PRK	VU		5
Black-browed mollymawk	*Thalassarche* (*Diomedea*) *melanophrys*	DIM	EN	↓	22
Black-footed albatross	*Phoebetria nigripes*	B19	EN	↓	730
Campbell Island black-browed mollymawk	*Diomedea melanophrys impavida*	B02	EN	↓	33
Cape pigeon	*Daption capensis*	DAC			7
Flesh-footed shearwater	*Puffinus carneipes* (*creatopus*)	PFC	VU		124
Grey headed albatross	*Thalassarche* (*Diomedea*) *chrysostoma*	DIC	VU	↓	4
Grey petrel	*Procellaria cinerea*	PCI	NT		126
Laysan albatross	*Phoebetria immutabilis*	B20	VU	↓	519
Light-mantled sooty albatross	*Phoebetria palpebrata*	PHE	NT	↓	38
New Zealand white capped mollymawk	*Thalassarche* (*Diomedea*) *cauta steadi*	DCU	NT	↑	16
Northern giant petrel	*Macronectes halli*	MAH	NT		2
Salvin's albatross	*Thalassarche* (*Diomedea*) *salvini*	B11	VU	→	5
Seagull	*Larus* spp.	B12			1
Sooty shearwater	*Puffinus griseus*	PFG	NT		4
Southern giant petrel	*Macronectes giganteus*	MAI	VU		7
Southern royal albatross	*Diomedea epomophora epomophora*	DIP	VU	→	8
Wandering albatross	*Diomedea exulans*	DIX	VU	↓	107
White-chinned petrel	*Procellaria aequinoctialis*	PRO	VU		17
Total birds					*3,887*

Table 3. Species of mammals listed in the entire SPC longline observer database, 1980–2004. Code, international species code as used in SPC databases; IUCN code, Red Book status of each species, either data deficient (DD) vulnerable (VU), endangered (EN), lower risk (LR) or not threatened (NT) (full details at www.redlist.org), missing values indicates that the species is not currently in the Red Book; Stock status, as given in the IUCN Red Book, either increasing (↑), declining (↓) or stable (→). Blanks indicate that not enough information exists to determine status.

Common name	Scientific name	Code	IUCN code	Stock status	Number of observer records
Bottlenose dolphin*	*Tursiops truncatus*	DBO	DD		3
Common dolphin*	*Delphinus delphis*	DCO	Not listed for WCPFC		3
Dolphins / porpoises (unidentified)*	*Delphinidae*	DLP			2
Dusky dolphin*	*Lagenorhynchus obscurus*	DDU	DD		1
Humpback whale*	*Megaptera novaeangliae*	HUW	VU	↑	2
Marine mammal (unidentified)	Mammalia	MAM			15
New Zealand fur seal	*Arctocephalus forsteri*	SEA			321
Pygmy killer whale*	*Feresa attenuata*	KPW	DD		0
Risso's dolphin*	*Grampus griseus*	DRR	DD		7
Seals	*Otariidae, phocidae*	SXX			3
Short-finned pilot whale	*Globicephala macrorhynchus*	SHW	LR		4
Sperm whale	*Physeter macrocephalus*	SPW	VU		2
Spinner dolphin	*Stenella longirostris*	DSI	LR		2
Toothed whales (blackfish)	Odontoceti	ODN			2
Whale (unidentified)	Cetacea	WLE			11
Total mammals					*380*

Table 4. Species of sharks and rays listed in the entire SPC longline observer database, 1980–2004. Code, international species code as used in SPC databases; IUCN code, Red Book status of each species, either data deficient (DD) vulnerable (VU), endangered (EN), lower risk (LR) or not threatened (NT) (full details at www.redlist.org), missing values indicates that the species is not currently in the Red Book; Stock status, as given in the IUCN Red Book, either increasing (↑), declining (↓) or stable (→). Blanks indicate that not enough information exists to determine status. [*, North pacific stock of basking shark is endangered, (EN A1ad)].

Common name	Scientific name	Code	IUCN code	Stock status	Number of observer records
Basking shark*	*Cetorhinus maximus*	BSK	VU	?	138
Bigeye thresher	*Alopias superciliosus*	BTH			2,445
Bignose shark	*Carcharhinus altimus*	CCA			27
Blacktip reef shark	*Carcharhinus melanopterus*	BLR	LR./NT	?	344
Blacktip shark	*Carcharhinus limbatus*	CCL	LR./NT	?	1,441
Blue shark	*Prionace glauca*	BSH	LR./NT	?	196,192
Broadsnouted sevengill shark	*Notorynchus cepedianus*	NTC	DD	?	2
Bronze whaler shark	*Carcharhinus brachyurus*	BRO	NT	?	269
Bull shark	*Carcharhinus leucas*	CCE	LR./NT	?	15
Bullhead sharks	*Heterodontiformes*	HDQ	DD		121
Carpet shark	*Cephaloscyllium isabella*	CPS			2
Cookie cutter shark	*Isistius brasiliensis*	ISB			106
Crocodile shark	*Pseudocarcharias kamoharai*	PSK	LR./NT	?	1,799
Dusky shark	*Carcharhinus obscurus*	DUS	LR./NT	?	514
Galapagos shark	*Carcharhinus galapagensis*	CCG	NT	?	648
Great hammerhead	*Sphyrna mokarran*	SPK	DD	?	62
Great white shark	*Carcharodon carcharias*	WSH	VU	?	48
Grey reef shark	*Carcharhinus amblyrhynchos*	AML			2,059
Hammerhead sharks	*Sphyrna* spp.	SPN			1,320
Long finned mako	*Isurus paucus*	LMA			670
Mako sharks	*Isurus* spp.	MAK			2,986
Manta rays (unidentified)	Mobulidae	MAN		?	270
Oceanic whitetip shark	*Carcharhinus longimanus*	OCS	LR./NT		9,140
Pelagic sting-ray	*Dasyatis violacea*	PLS			11,950
Pelagic thresher	*Alopias pelagicus*	PTH			703
Plunkets shark	*Scymnodon plunketi*	F54	NT	?	4
Porbeagle shark	*Lamna nasus*	POR	LR./NT	?	16,217
Rays, skates and mantas	Batoidimorpha (Hypotrmata)	BAI			181
Salmon shark	*Lamna ditropis*	LMD	DD	?	80
Sandbar shark	*Carcharhinus plumbeus*	CCP	LR./NT	?	204

Table 4, continued. Species of sharks and rays listed in the entire SPC longline observer database, 1980–2004. Code, international species code as used in SPC databases; IUCN code, Red Book status of each species, either data deficient (DD) vulnerable (VU), endangered (EN), lower risk (LR) or not threatened (NT) (full details at www.redlist.org), missing values indicates that the species is not currently in the Red Book; Stock status, as given in the IUCN Red Book, either increasing (↑), declining (↓) or stable (→). Blanks indicate that not enough information exists to determine status.

Common name	Scientific name	Code	IUCN code	Stock status	Number of observer records
Scalloped hammerhead	*Sphyrna lewini*	SPL	LR./NT	?	15
School shark	*Galeorhinus galeus*	GAG	VU	↓	2,439
Seal shark / black shark	*Dalatias licha*	SCK	DD	→	52
Sharks (unidentified)	*Elasmobranchii*	SHK			3,420
Sharpsnouted sevengill shark	*Heptranchias perlo*	HXT	NT	?	1
Short finned mako	*Isurus oxyrhinchus*	SMA	LR./NT	?	5,278
Silky shark	*Carcharhinus falciformis*	FAL			27,019
Silvertip shark	*Carcharhinus albimarginatus*	ALS			1,150
Smooth hammerhead	*Sphyrna zygaena*	SPZ	LR./NT	?	38
Spiny dogfish	*Squalus acanthias*	DGS	LR./NT	?	92
Thresher	*Alopias vulpinus*	ALV	DD	?	1,108
Thresher sharks (unidentified)	*Alopias* spp.	THR			1,038
Tiger shark	*Galeocerdo cuvier*	TIG	LR./NT	?	453
Velvet dogfish	*Scymnodon squamulosus*	SSQ			241
Whale shark	*Rhincodon typus*	RHN	VU	↓	2
Whip stingray	*Dasyatis akajei*	WST			103
Whitenose shark	*Nasolamia velox*	CNX			12
Whitetip reef shark	*Triaenodon obesus*	TRB	LR./NT	?	61
Zebra shark	*Stegostoma fasciatum*	OSF	VU	?	10
Total sharks					*292,651*

Table 5. Species of turtles listed in the entire SPC longline observer database, 1980–2004. Code, international species code as used in SPC databases; IUCN code, Red Book status of each species, either data deficient (DD) critically endangered (CR) or endangered (EN) (full details at www.redlist.org), missing values indicates that the species is not currently in the Red Book; Stock status, as given in the IUCN Red Book, either increasing (↑), declining (↓) or stable (→). Blanks indicate that not enough information exists to determine status.

Common name	Scientific name	Code	IUCN code	Stock status	Number of observer records
Green turtle	*Chelonia mydas*	TUG	EN	↓	44
Hawksbill turtle	*Eretmochelys imbricata*	TTH	CR		12
Leatherback turtle	*Dermochelys coriacea*	LTB	CR		65
Loggerhead turtle	*Caretta caretta*	TTL	EN		180
Marine turtle (unidentified)	Testudinata	TTX			76
Olive ridley turtle	*Lepidochelys olivacea*	LEO	EN		104
Total turtles by gear					*481*

Table 6. Final estimates of total catches (Total, in numbers), mortalities (Mort.) and 95% confidence intervals (CI) of all birds, mammals, sharks and turtles for the three WCPO longline fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records exist for individual fishery and year combinations.

a). Birds

i). Estimates by fishery

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													9,824	6,494	13,168	9,824	6,835	12,824
1991													2,632	0	6,852	2,551	0	6,337
1992							0	0	0	0	0	0	1,101	0	4,047	262	0	2,903
1993	0	0	1,592	0	0	1,507	0	0	0	0	0	0	2,117	0	5,253	1,999	0	4,812
1994	0	0	2,194	0	0	2,076	0	0	0	0	0	0	214	0	4,004	214	0	3,614
1995	2,069	0	4,646	1,034	0	3,472	0	0	0	0	0	0	1,975	0	6,043	1,759	0	5,408
1996	0	0	2,224	0	0	2,104	0	0	0	0	0	0	248	0	3,759	248	0	3,398
1997	3,405	1,812	5,000	3,405	1,897	4,914	0	0	0	0	0	0	209	0	3,720	209	0	3,358
1998	0	0	1,897	0	0	1,795	0	0	0	0	0	0	0	0	4,603	0	0	4,129
1999	0	0	2,909	0	0	2,753	0	0	0	0	0	0	0	0	4,594	0	0	4,121
2000	0	0	3,103	0	0	2,937	0	0	0	0	0	0	0	0	4,511	0	0	4,047
2001	0	0	3,811	0	0	3,606	0	0	0	0	0	0	0	0	5,692	0	0	5,106
2002	0	0	4,806	0	0	4,548	0	0	0	0	0	0	0	0	6,314	0	0	5,664
2003	0	0	3,465	0	0	3,279	0	0	0	0	0	0	0	0	8,307	0	0	7,452
2004	0	0	762	0	0	721	0	0	0	0	0	0	90	0	5,440	90	0	4,890
Mean	*456*	*151*	*3,034*	*370*	*158*	*2,809*	*0*	*0*	*0*	*0*	*0*	*0*	*1,227*	*433*	*5,754*	*1,144*	*456*	*5,204*

Table 6, continued. Final estimates of total catches (Total, in numbers), mortalities (Mort.) and 95% confidence intervals (CI) of all birds, mammals, sharks and turtles for the three WCPO longline fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records exist for individual fishery and year combinations.

a). Birds

ii). Total estimates of catches and mortalities of all birds for all three longline fisheries in the WCPO, 1990–2004.

Year	Total	95% CI		Mort.	95% CI		Ratio
		Low.	Upp.		Low.	Upp.	
1990	9,824	6,494	13,168	9,824	6,835	12,824	1.00
1991	2,632	0	6,852	2,551	0	6,337	0.97
1992	1,101	0	4,047	262	0	2,903	0.24
1993	2,117	0	6,845	1,999	0	6,319	0.94
1994	214	0	6,198	214	0	5,690	1.00
1995	4,044	0	10,688	2,793	0	8,879	0.69
1996	248	0	5,983	248	0	5,502	1.00
1997	3,613	1,812	8,719	3,613	1,897	8,273	1.00
1998	0	0	6,500	0	0	5,924	-
1999	0	0	7,503	0	0	6,874	-
2000	0	0	7,615	0	0	6,984	-
2001	0	0	9,502	0	0	8,712	-
2002	0	0	11,120	0	0	10,212	-
2003	0	0	11,772	0	0	10,731	-
2004	90	0	6,202	90	0	5,610	1.00
Mean	*1,592*	*554*	*8,181*	*1,440*	*582*	*7,452*	*0.87*

Table 6, continued. Final estimates of total catches (Total, in numbers), mortalities (Mort.) and 95% confidence intervals (CI) of all birds, mammals, sharks and turtles for the three WCPO longline fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records exist for individual fishery and year combinations.

b). Mammals

i). Estimates by fishery

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													0	0	51,265	0	0	0
1991													0	0	65,331	0	0	0
1992							0	0	1,571	0	0	602	0	0	45,666	0	0	0
1993	0	0	1,457	0	0	893	0	0	1,921	0	0	735	0	0	48,547	0	0	0
1994	835	0	2,843	835	0	2,066	0	0	1,839	0	0	704	0	0	58,807	0	0	0
1995	0	0	2,356	0	0	1,444	0	0	1,524	0	0	583	215	0	63,238	0	0	0
1996	1,889	0	3,927	1,889	641	3,138	425	0	1,663	425	0	899	0	0	54,480	0	0	0
1997	715	0	2,172	715	0	1,608	911	0	2,107	0	0	457	161	0	54,654	0	0	0
1998	406	0	2,142	0	0	1,064	103	0	1,159	0	0	404	220	0	71,676	0	0	0
1999	668	0	3,330	0	0	1,632	0	0	1,132	0	0	433	0	0	71,309	0	0	0
2000	0	0	2,840	0	0	1,741	216	0	1,699	108	0	676	330	0	70,371	0	0	0
2001	0	0	3,487	0	0	2,138	0	0	1,219	0	0	467	350	0	88,716	0	0	0
2002	2,909	0	7,311	0	0	2,696	0	0	1,293	0	0	495	165	0	98,176	0	0	0
2003	0	0	3,170	0	0	1,944	0	0	1,111	0	0	425	0	0	128,940	0	0	0
2004	313	0	1,011	0	0	427	0	0	1,129	0	0	432	0	0	83,027	0	0	0
Mean	*645*	*0*	*3,004*	*287*	*53*	*1,733*	*127*	*0*	*1,490*	*41*	*0*	*563*	*96*	*0*	*70,280*	*0*	*0*	*0*

Table 6, continued. Final estimates of total catches (Total, in numbers), mortalities (Mort.) and 95% confidence intervals (CI) of all birds, mammals, sharks and turtles for the three WCPO longline fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records exist for individual fishery and year combinations.

b). Mammals

ii). Total estimates of catches and mortalities of all mammals for all three longline fisheries in the WCPO, 1990–2004.

Year	Total	95% CI		Mort.	95% CI		Ratio
		Low.	Upp.		Low.	Upp.	
1990	0	0	51,265	0	0	0	
1991	0	0	65,331	0	0	0	
1992	0	0	47,237	0	0	602	
1993	0	0	51,925	0	0	1,629	
1994	835	0	63,489	835	0	2,770	1.00
1995	215	0	67,117	0	0	2,028	0.00
1996	2,315	0	60,069	2,315	641	4,037	1.00
1997	1,788	0	58,933	715	0	2,066	0.40
1998	729	0	74,977	0	0	1,469	0.00
1999	668	0	75,771	0	0	2,065	0.00
2000	546	0	74,909	108	0	2,417	0.20
2001	350	0	93,422	0	0	2,605	0.00
2002	3,075	0	106,780	0	0	3,191	0.00
2003	0	0	133,222	0	0	2,369	
2004	313	0	85,167	0	0	859	0.00
Mean	*722*	*0*	*73,974*	*265*	*43*	*1,874*	*0.26*

Table 6, continued. Final estimates of total catches (Total, in numbers), mortalities (Mort.) and 95% confidence intervals (CI) of all birds, mammals, sharks and turtles for the three WCPO longline fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records exist for individual fishery and year combinations.

c). Sharks

i). Estimates by fishery

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													964,471	893,674	1,038,247	60,809	41,993	80,052
1991													75,664	32,018	121,146	17,631	0	40,797
1992							222,041	177,009	268,445	104,462	76,202	133,301	50,382	19,975	82,068	10,831	0	26,990
1993	295,916	245,143	348,370	34,163	4,684	64,313	175,090	122,881	228,888	62,729	29,485	96,655	61,149	28,517	95,154	13,212	0	30,429
1994	312,123	245,220	381,241	57,515	16,658	99,303	142,311	93,084	193,038	20,911	0	52,583	82,218	42,361	123,752	22,546	2,007	43,550
1995	476,354	394,317	561,108	111,164	62,246	161,198	127,935	86,840	170,281	29,121	3,162	55,613	104,645	61,272	149,843	21,280	0	43,720
1996	550,405	475,092	628,212	159,847	116,172	204,518	125,128	91,148	160,143	27,130	5,993	48,701	86,727	49,376	125,650	21,778	2,730	41,256
1997	233,013	184,285	283,355	52,097	22,238	82,636	95,548	63,473	128,599	25,294	4,894	46,111	88,126	50,717	127,109	25,341	6,214	44,901
1998	426,924	364,042	491,889	124,236	87,247	162,068	81,337	53,077	110,458	14,991	0	33,241	109,134	60,340	159,981	29,917	4,910	55,491
1999	753,897	654,287	856,805	222,764	165,322	281,514	95,258	64,735	126,710	14,059	0	33,575	90,995	43,016	140,993	13,325	0	38,477
2000	664,249	562,473	769,395	261,017	199,218	324,225	154,458	113,597	196,564	43,182	17,633	69,256	61,504	15,517	109,426	9,437	0	34,052
2001	930,616	801,964	1,063,528	193,070	120,031	267,774	198,845	163,115	235,663	71,983	50,236	94,176	137,179	76,752	200,150	18,354	0	49,556
2002	1,361,425	1,193,140	1,535,283	549,622	450,673	650,828	56,678	23,337	91,034	15,381	0	37,671	79,472	15,375	146,266	18,787	0	53,363
2003	76,231	0	171,580	14,611	0	78,863	44,271	15,761	73,648	12,957	0	32,099	72,441	0	158,972	14,898	0	60,169
2004	193,205	167,262	220,008	52,318	37,414	67,561	78,504	48,546	109,374	25,520	6,213	45,223	70,751	16,309	127,484	16,709	0	46,021
Mean	*522,863*	*440,602*	*609,231*	*152,702*	*106,825*	*203,734*	*122,877*	*85,892*	*160,988*	*35,978*	*14,909*	*59,862*	*142,324*	*93,681*	*193,749*	*20,990*	*3,857*	*45,922*

Table 6, continued. Final estimates of total catches (Total, in numbers), mortalities (Mort.) and 95% confidence intervals (CI) of all birds, mammals, sharks and turtles for the three WCPO longline fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records exist for individual fishery and year combinations.

c). Sharks

ii). Total estimates of catches and mortalities of all sharks for all three longline fisheries in the WCPO, 1990–2004.

Year	Total	95% CI		Mort.	95% CI		Ratio
		Low.	Upp.		Low.	Upp.	
1990	964,471	893,674	1,038,247	60,809	41,993	80,052	0.06
1991	75,664	32,018	121,146	17,631	0	40,797	0.23
1992	272,423	196,984	350,513	115,293	76,202	160,291	0.42
1993	532,154	396,542	672,411	110,104	34,169	191,397	0.21
1994	536,652	380,665	698,031	100,972	18,666	195,436	0.19
1995	708,934	542,429	881,232	161,566	65,408	260,530	0.23
1996	762,260	615,617	914,004	208,755	124,895	294,475	0.27
1997	416,687	298,475	539,063	102,731	33,346	173,648	0.25
1998	617,395	477,458	762,327	169,144	92,157	250,800	0.27
1999	940,149	762,038	1,124,508	250,147	165,322	353,566	0.27
2000	880,211	691,587	1,075,386	313,636	216,850	427,532	0.36
2001	1,266,641	1,041,831	1,499,341	283,407	170,267	411,507	0.22
2002	1,497,574	1,231,851	1,772,583	583,789	450,673	741,863	0.39
2003	192,943	15,761	404,200	42,466	0	171,131	0.22
2004	342,460	232,116	456,866	94,547	43,628	158,805	0.28
Mean	*667,108*	*520,603*	*820,657*	*174,333*	*102,238*	*260,789*	*0.26*

Table 6, continued. Final estimates of total catches (Total, in numbers), mortalities (Mort.) and 95% confidence intervals (CI) of all birds, mammals, sharks and turtles for the three WCPO longline fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records exist for individual fishery and year combinations.

d). Turtles

i). Estimates by fishery

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													0	0	1,506	0	0	754
1991													0	0	1,919	0	0	960
1992							0	0	3,773	0	0	3,217	0	0	1,341	0	0	671
1993	3,670	0	8,708	0	0	1,363	3,262	0	7,884	1,630	0	5,567	403	0	1,830	0	0	714
1994	11,025	4,086	17,990	835	0	2,714	2,044	0	6,465	2,044	0	5,813	0	0	1,727	0	0	864
1995	13,051	4,909	21,225	0	0	2,204	1,002	0	4,664	501	0	3,622	861	0	2,713	215	0	1,142
1996	5,674	0	12,713	0	0	1,904	425	0	3,396	0	0	2,532	0	0	1,600	0	0	801
1997	4,298	0	9,334	0	0	1,362	1,244	0	4,116	916	0	3,364	161	0	1,762	0	0	801
1998	6,503	515	12,514	1,623	0	3,249	515	0	3,052	309	0	2,472	220	0	2,318	0	0	1,050
1999	10,426	1,243	19,646	668	0	3,159	665	0	3,384	499	0	2,817	0	0	2,094	0	0	1,048
2000	6,266	0	16,082	0	0	2,657	648	0	4,209	540	0	3,576	0	0	2,056	0	0	1,029
2001	2,765	0	14,799	0	0	3,263	825	0	3,755	564	0	3,061	350	0	2,945	0	0	1,299
2002	13,109	0	28,325	1,454	0	5,571	523	0	3,630	299	0	2,947	165	0	3,044	83	0	1,523
2003	7,296	0	18,256	0	0	2,966	683	0	3,352	487	0	2,763	107	0	3,894	107	0	2,002
2004	2,197	0	4,609	0	0	652	1,563	0	4,278	910	0	3,223	271	0	2,710	90	0	1,311
Mean	*7,190*	*896*	*15,350*	*382*	*0*	*2,589*	*1,031*	*0*	*4,305*	*669*	*0*	*3,459*	*169*	*0*	*2,231*	*33*	*0*	*1,065*

Table 6, continued. Final estimates of total catches (Total, in numbers), mortalities (Mort.) and 95% confidence intervals (CI) of all birds, mammals, sharks and turtles for the three WCPO longline fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records exist for individual fishery and year combinations.

d). Turtles

ii). Total estimates of catches and mortalities of all turtles for all three longline fisheries in the WCPO, 1990–2004.

Year	Total	95% CI		Mort.	95% CI		Ratio
		Low.	Upp.		Low.	Upp.	
1990	0	0	1,506	0	0	754	
1991	0	0	1,919	0	0	960	
1992	0	0	5,114	0	0	3,888	
1993	7,336	0	18,422	1,630	0	7,644	0.22
1994	13,068	4,086	26,182	2,878	0	9,391	0.22
1995	14,914	4,909	28,602	716	0	6,968	0.05
1996	6,100	0	17,709	0	0	5,237	0.00
1997	5,703	0	15,212	916	0	5,527	0.16
1998	7,238	515	17,885	1,932	0	6,771	0.27
1999	11,092	1,243	25,124	1,167	0	7,024	0.11
2000	6,914	0	22,348	540	0	7,262	0.08
2001	3,940	0	21,498	564	0	7,622	0.14
2002	13,798	0	34,999	1,836	0	10,042	0.13
2003	8,085	0	25,501	594	0	7,731	0.07
2004	4,032	0	11,597	1,001	0	5,186	0.25
Mean	*6,815*	*717*	*18,241*	*918*	*0*	*6,134*	*0.14*

8. Figures

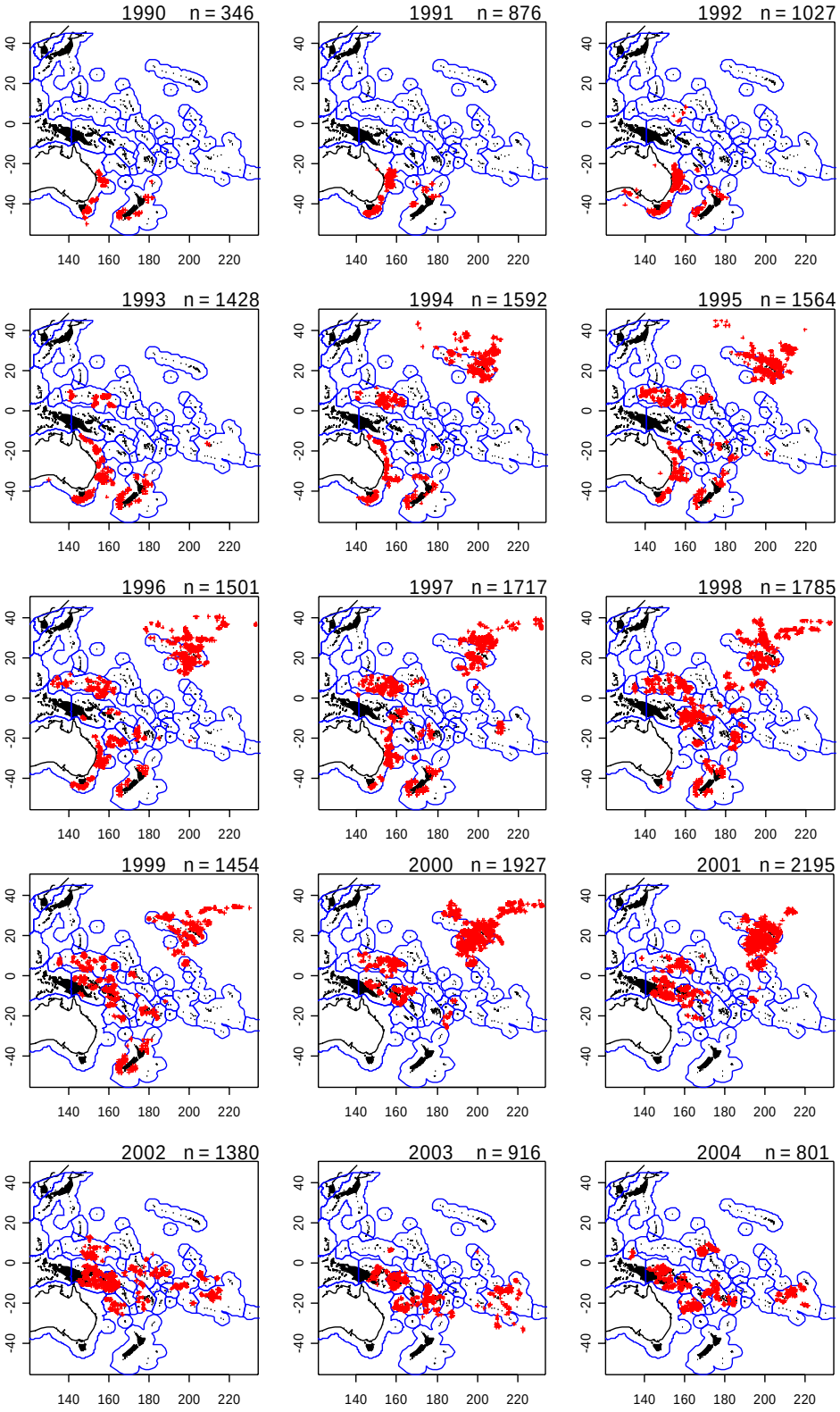

Figure 1. Position of observed longline sets in the WCPO, 1990–2004. Source: observer longline data held by SPC. n denotes the number of observed sets per year.

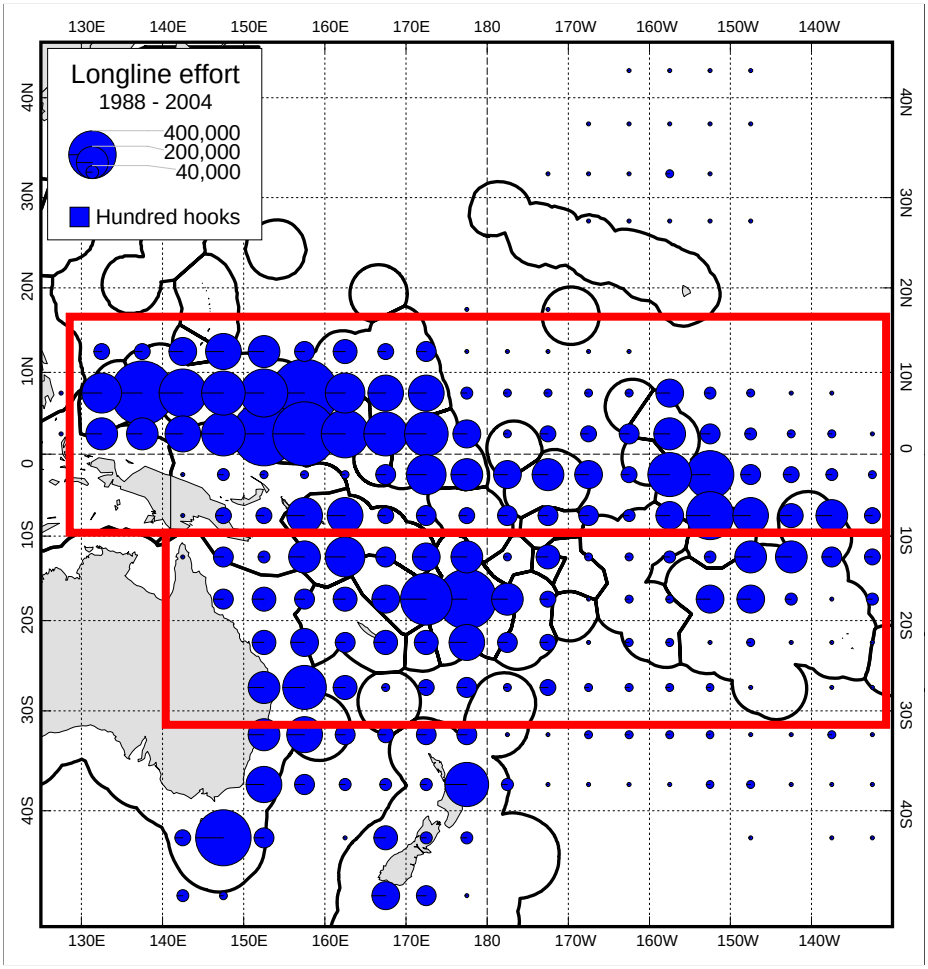

Figure 2. Longline effort (hundreds of hooks) by all fleets in the WCPO, 1988–2004. Source: logsheet data held by the SPC. The red boxes indicate the approximate spatial boundaries of the two tropical longline fisheries (upper box) and the temperate albacore longline fishery (lower box).

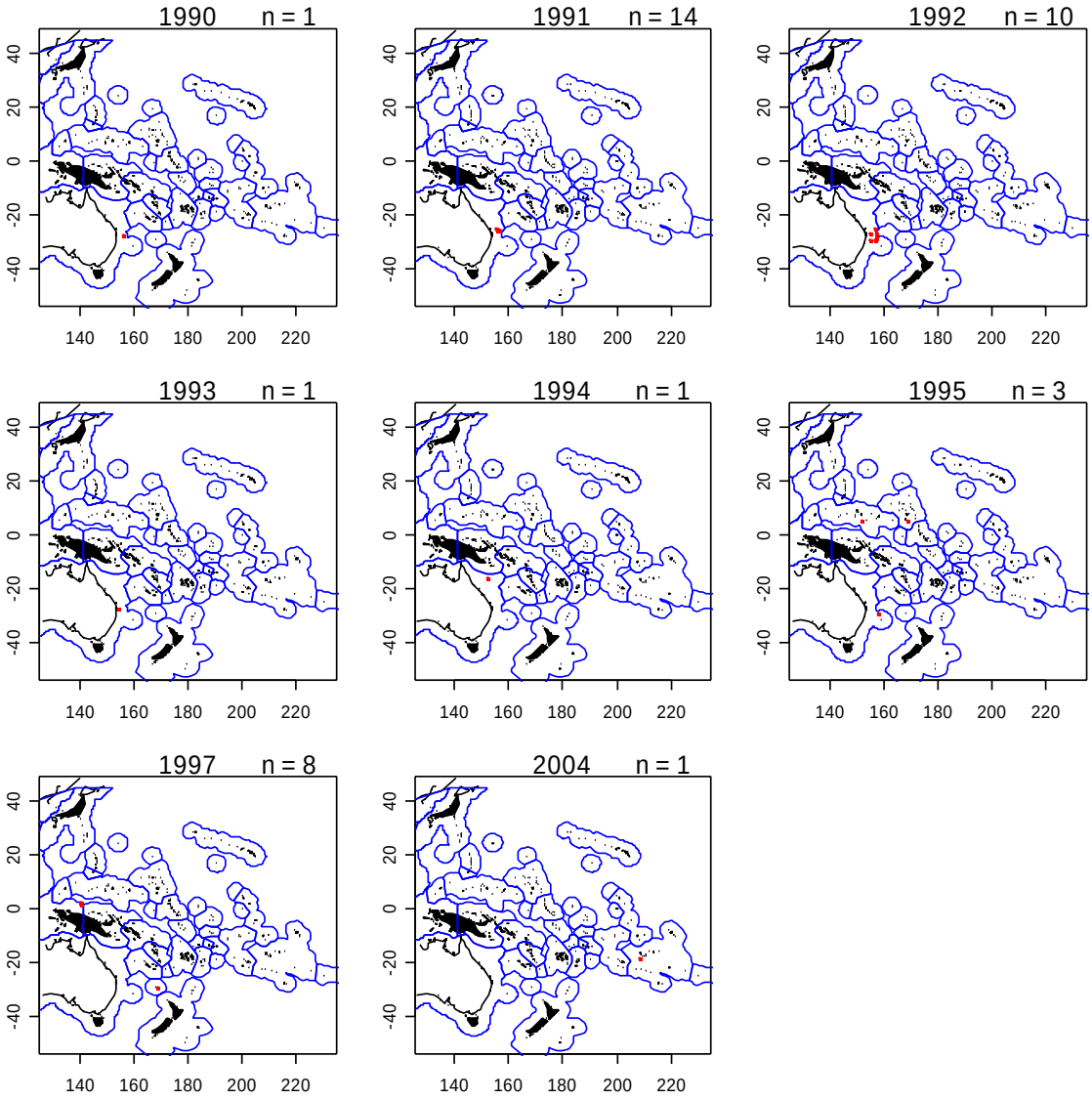

Figure 3. Position of observed longline sets in which one or more birds were captured in the WCPO, 1997–2004, excluding sets south of 31°S and observed sets on US vessels within and north-east of the Hawaiian EEZ. Source: observer longline data held by SPC. Missing years indicate that no birds were observed captured from longline sets in that year.

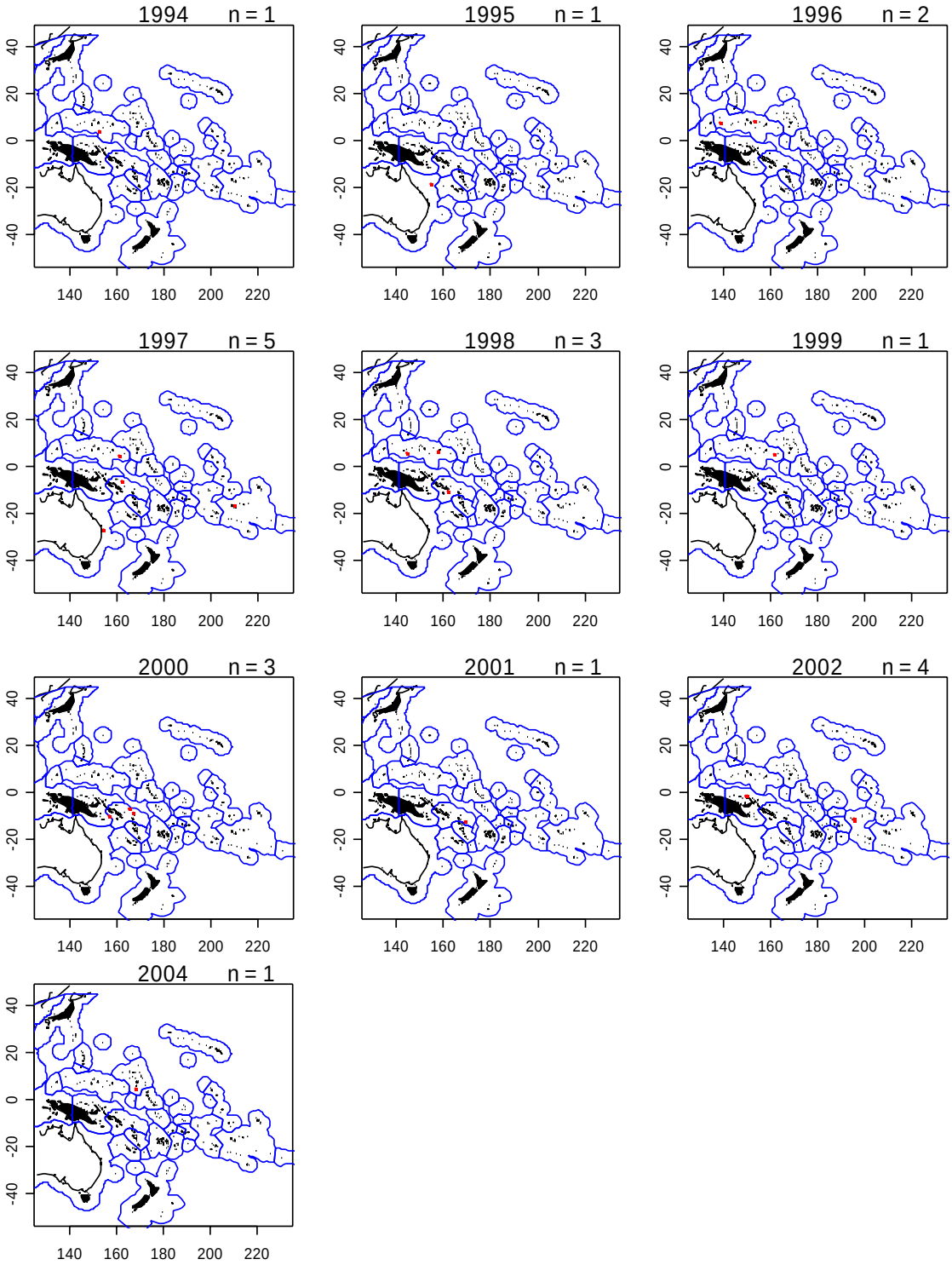

Figure 4. Position of observed longline sets in which one or more mammals were captured in the WCPO, 1989–2004, excluding sets south of 31°S and observed sets on US vessels within and north-east of the Hawaiian EEZ. Source: observer longline data held by SPC. Missing years indicate that no mammals were observed captured from longline sets in that year.

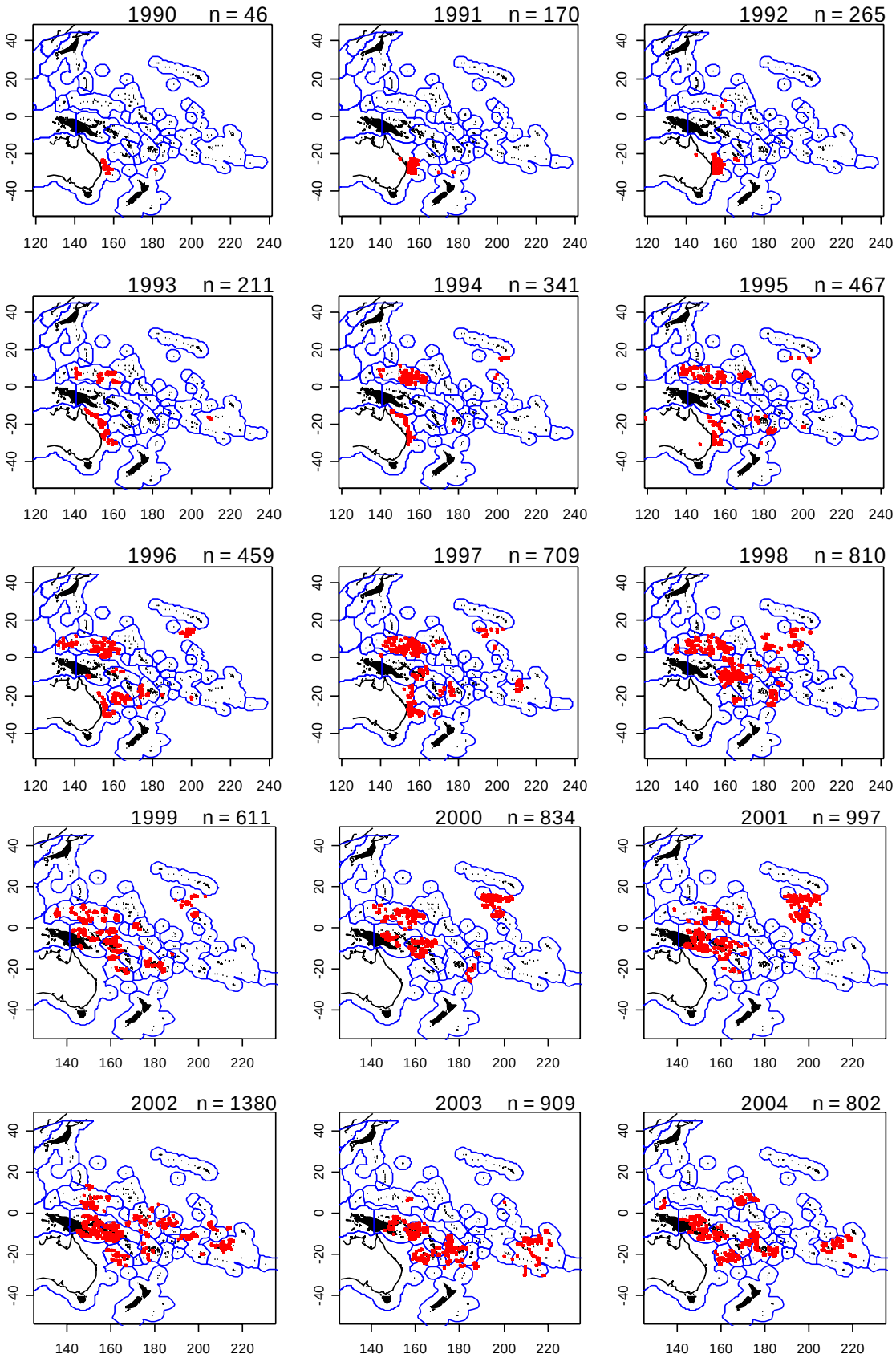

Figure 5. Position of observed longline sets in which one or more sharks were captured in the WCPO, 1989–2004, excluding sets south of 31°S and observed sets on US vessels within and north-east of the Hawaiian EEZ. Source: observer longline data held by SPC. n= number of sets in which one or more sharks were captured.

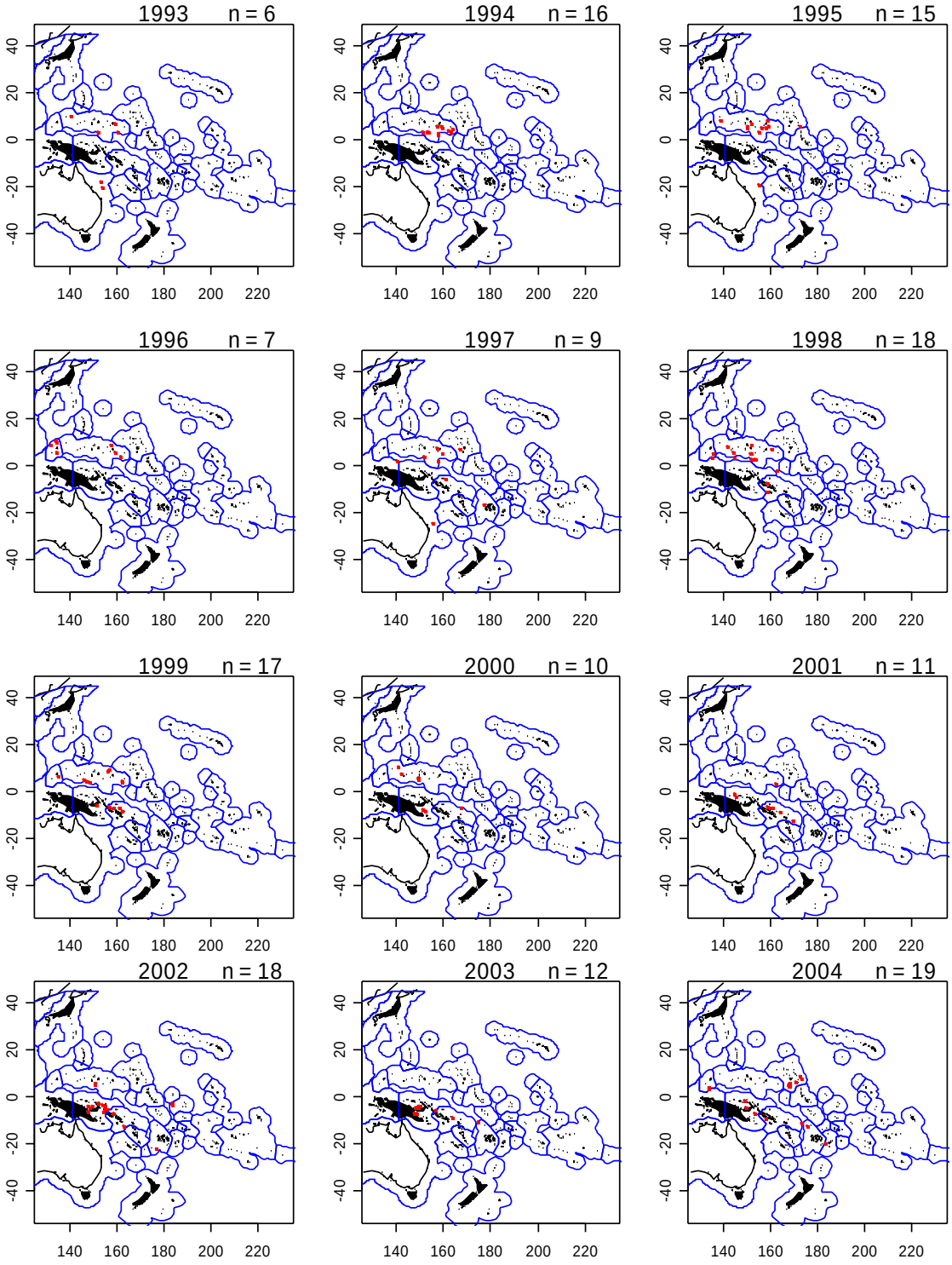

Figure 6. Position of observed longline sets in which one or more turtles were captured in the WCPO, 1989–2004, excluding sets south of 31°S and observed sets on US vessels within and north-east of the Hawaiian EEZ. Source: observer longline data held by SPC. Missing years indicate that no turtles were observed captured from longline sets in that year.

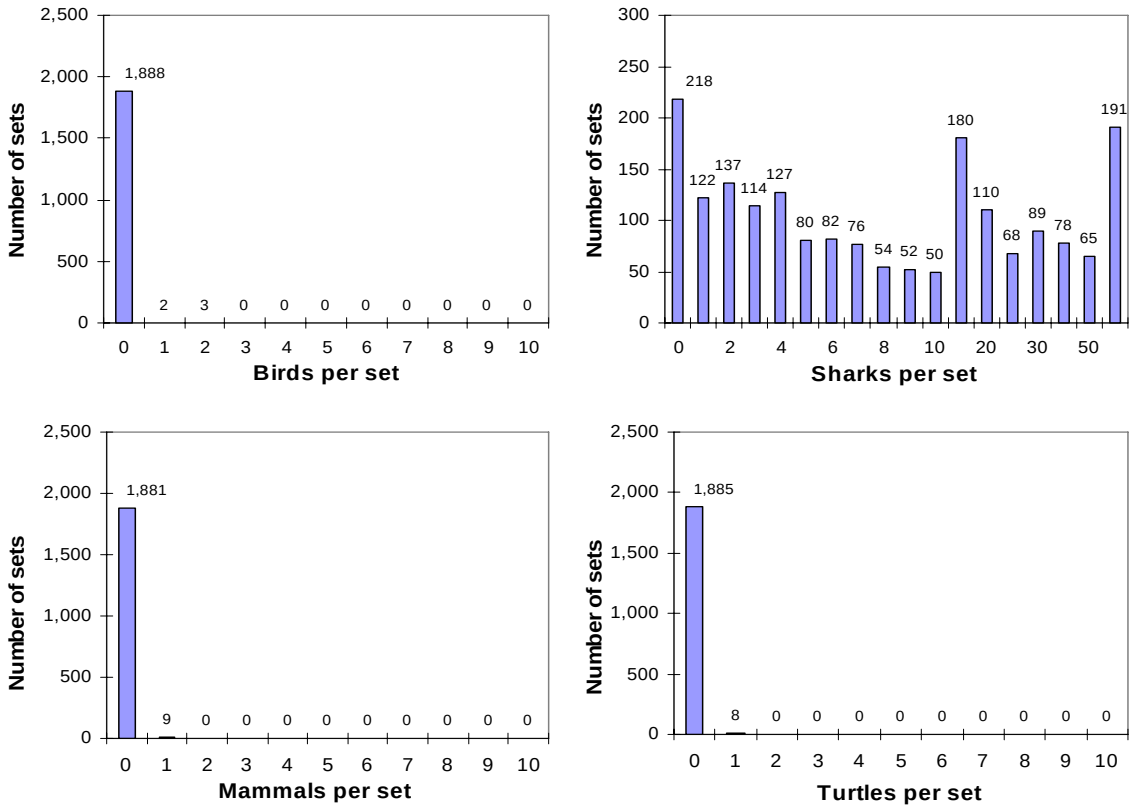

Figure 7a. Frequency of occurrence of major taxa in sets of the tropical shallow Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Total numbers of sets for each frequency category are provided above each bar.

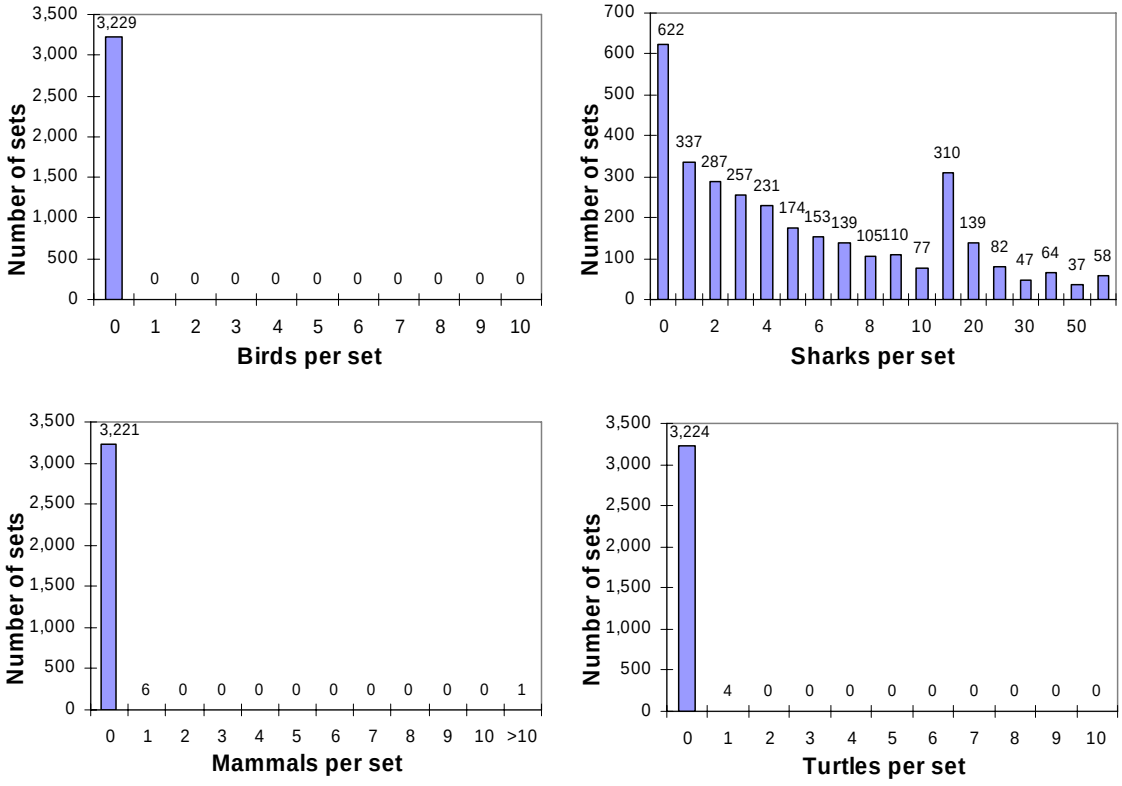

Figure 7b. Frequency of occurrence of major taxa in sets of the tropical deep Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Total numbers of sets for each frequency category are provided above each bar.

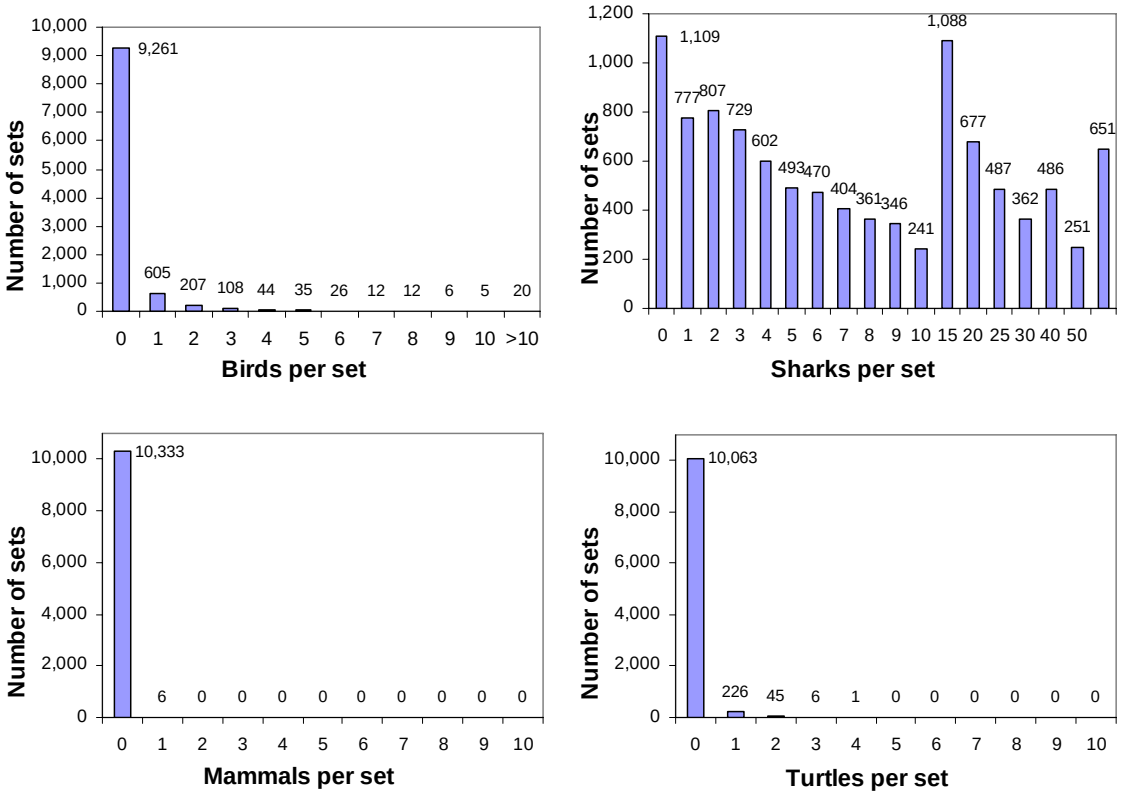

Figure 7c. Frequency of occurrence of major taxa in sets of the temperate Pacific albacore longline fishery, 1990–2004. Source: observer database maintained by SPC. Total numbers of sets for each frequency category are provided above each bar.

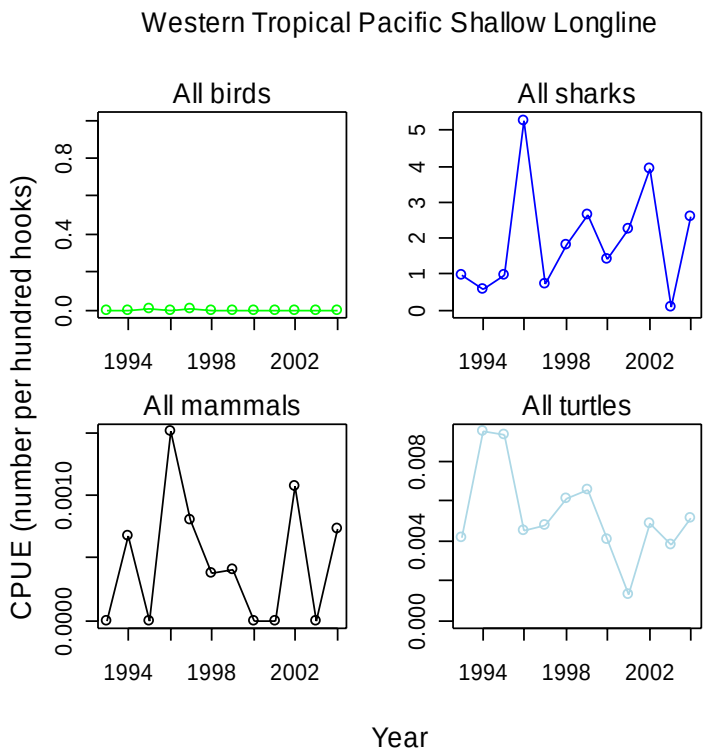

Figure 8a. Estimated catch per unit effort (number per hundred hooks) of each major taxa by the tropical shallow Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC.

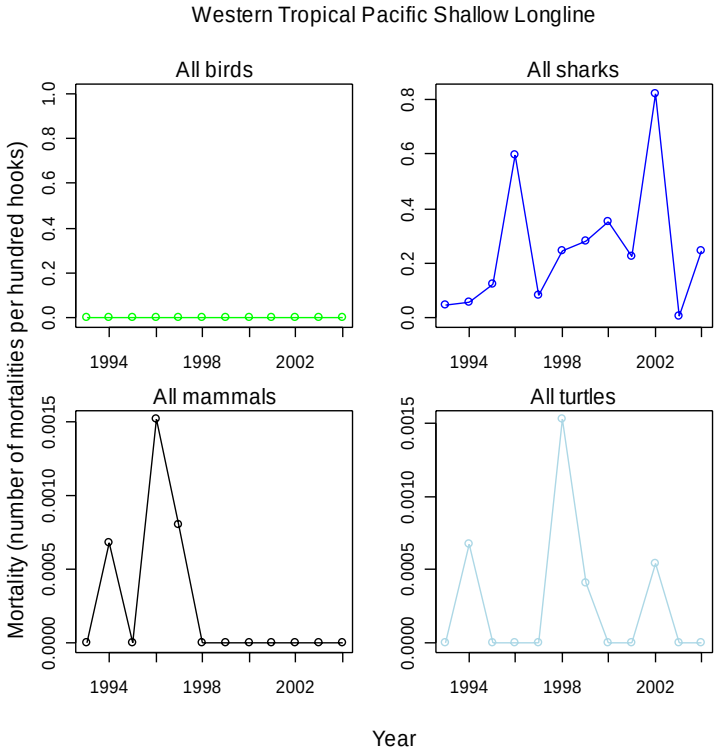

Figure 8b. Estimated mortality rates (number of observed mortalities per hundred hooks) of each major taxa in the tropical shallow Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Shark mortalities include observed mortalities, plus retained plus finned and discarded sharks.

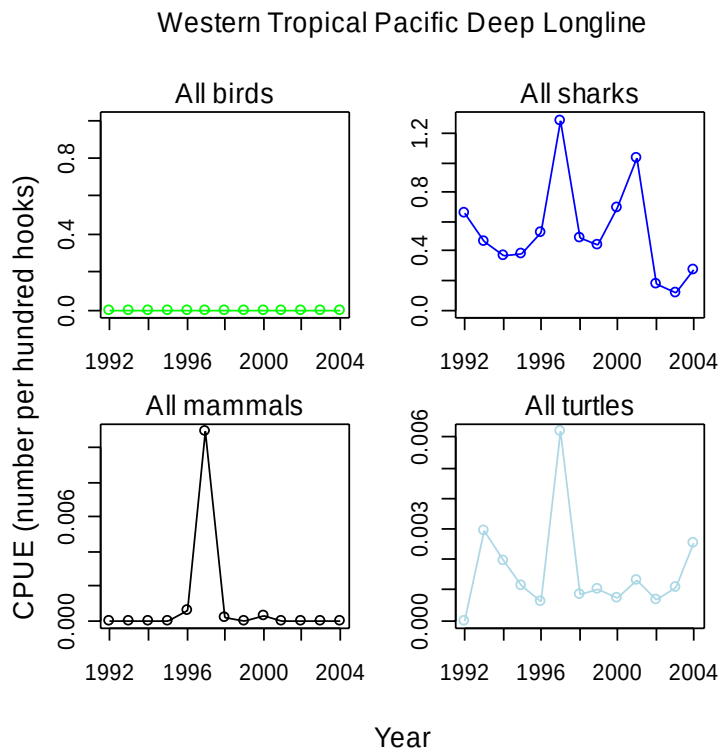

Figure 9a. Estimated catch per unit effort (number per hundred hooks) of each major taxa by the tropical deep Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC.

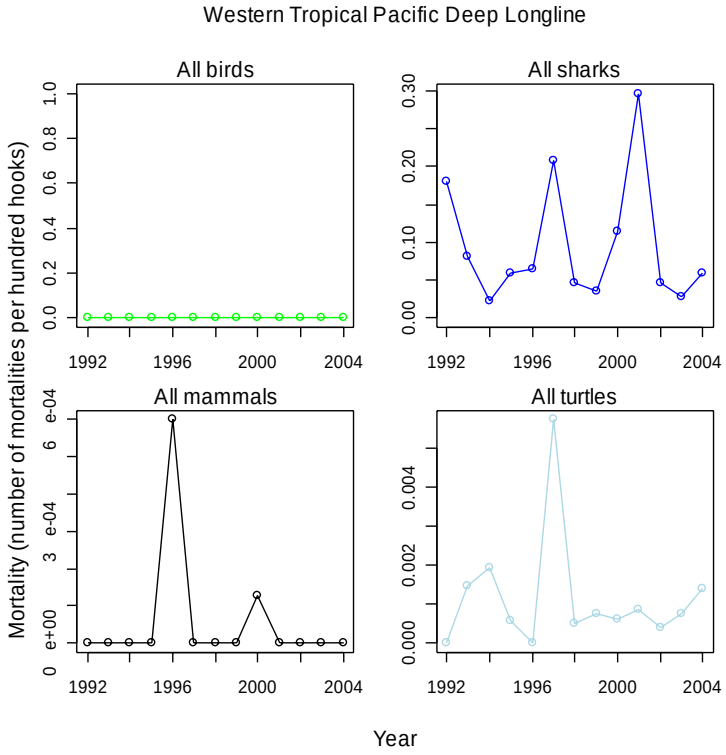

Figure 9b. Estimated mortality rates (number of observed mortalities per hundred hooks) of each major taxa by the tropical deep Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Shark mortalities include observed mortalities, plus retained plus finned and discarded sharks.

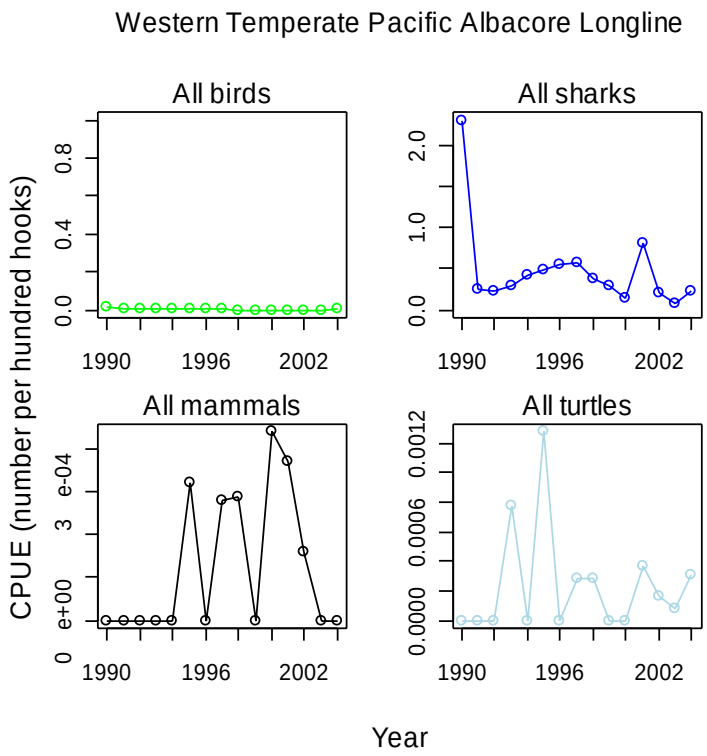

Figure 10a. Estimated catch per unit effort (number per hundred hooks) of each major taxa by the temperate Pacific albacore longline fishery, 1990–2004. Source: observer database maintained by SPC.

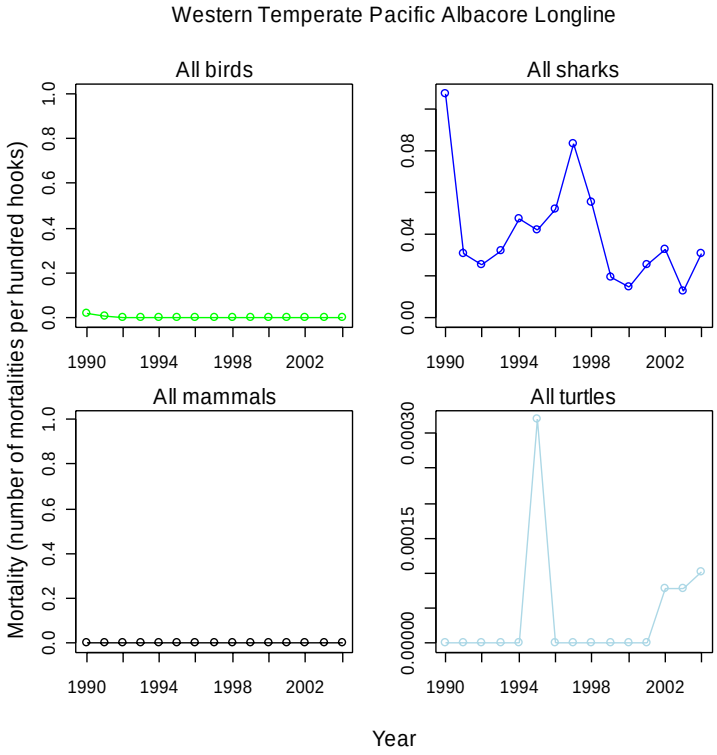

Figure 10b. Estimated mortality rates (number of observed mortalities per hundred hooks) of each major taxa in the temperate Pacific albacore longline fishery, 1990–2004. Source: observer database maintained by SPC. Shark mortalities include observed mortalities, plus retained plus finned and discarded sharks.

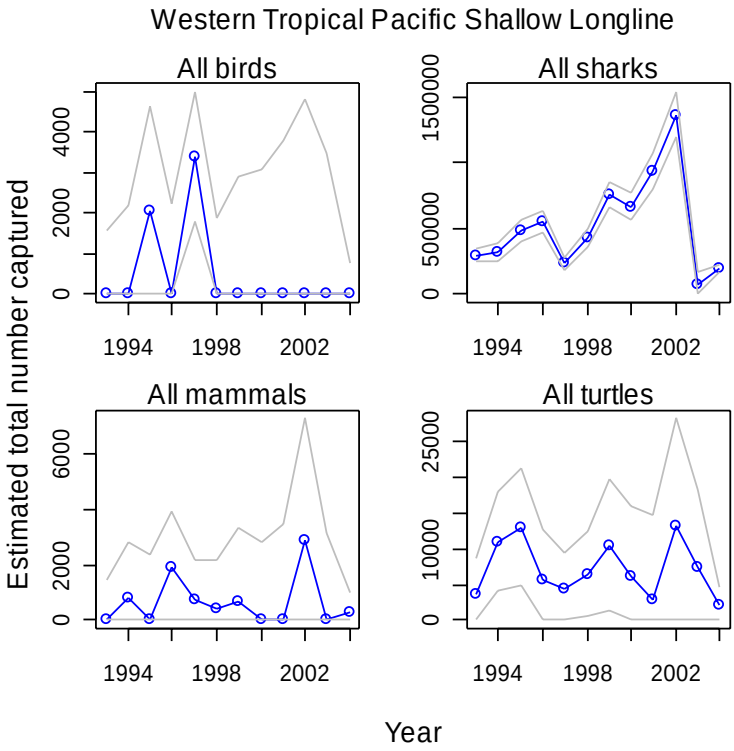

Figure 11a. Estimated total catches (numbers, blue lines) of each major taxa by the tropical shallow Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Grey lines represent 95% confidence intervals generated from global standard deviations for each taxa.

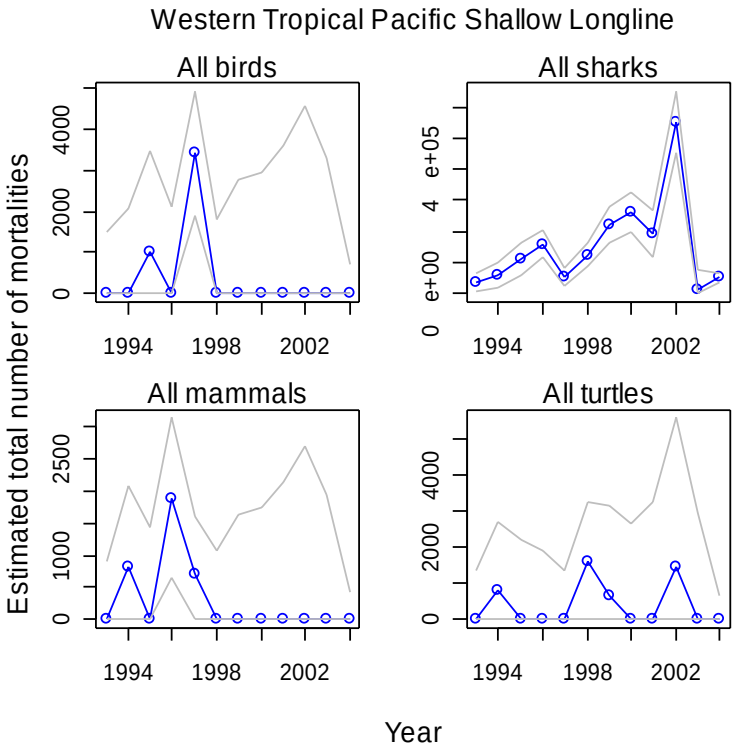

Figure 11b. Total estimated mortalities (numbers, blue lines) of each major taxa by the tropical shallow Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Shark mortalities include observed mortalities, plus retained plus finned and discarded sharks. Grey lines represent 95% confidence intervals generated from global standard deviations for each taxa.

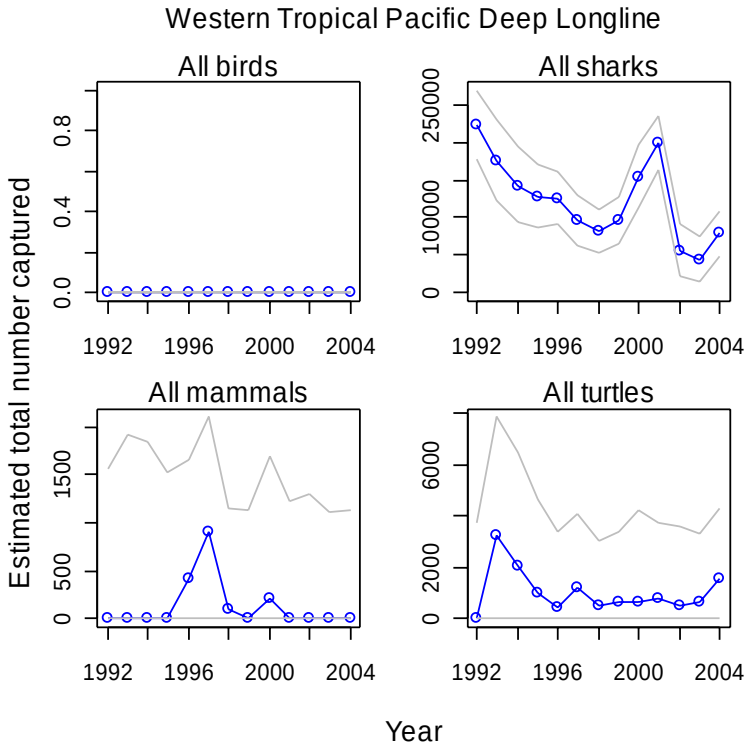

Figure 12a. Estimated total catches (numbers, blue lines) of each major taxa by the tropical deep Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Grey lines represent 95% confidence intervals generated from global standard deviations for each taxa.

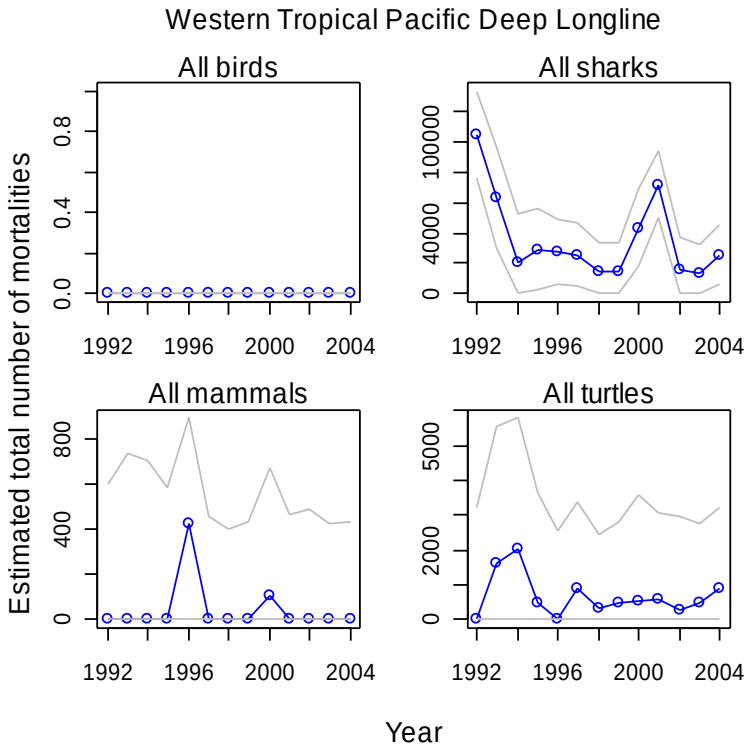

Figure 12b. Total estimated mortalities (numbers, blue lines) of each major taxa by the tropical deep Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Shark mortalities include observed mortalities, plus retained plus finned and discarded sharks. Grey lines represent 95% confidence intervals generated from global standard deviations for each taxa.

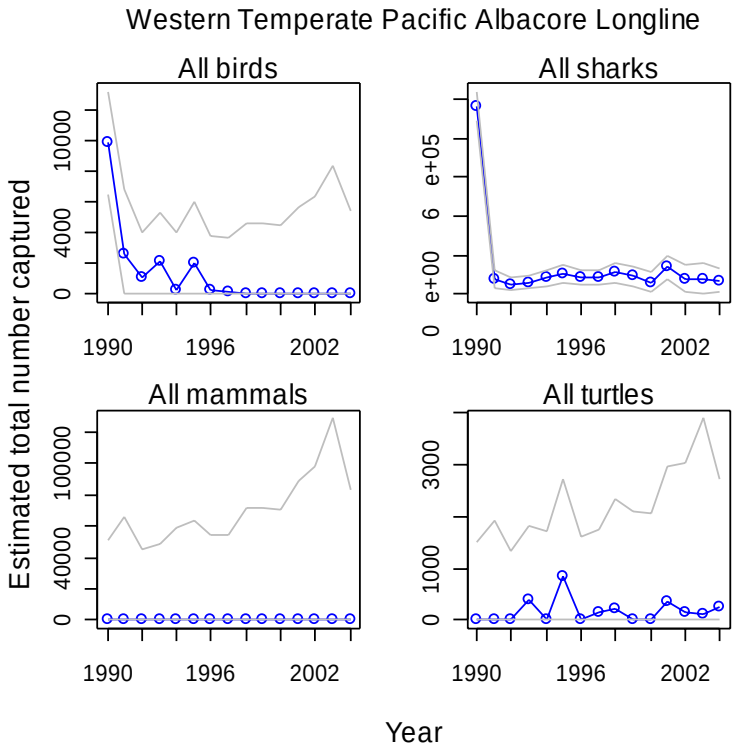

Figure 13a. Estimated total catches (numbers, blue lines) of each major taxa by the temperate Pacific albacore longline fishery, 1990–2004. Source: observer database maintained by SPC. Grey lines represent 95% confidence intervals generated from global standard deviations for each taxa.

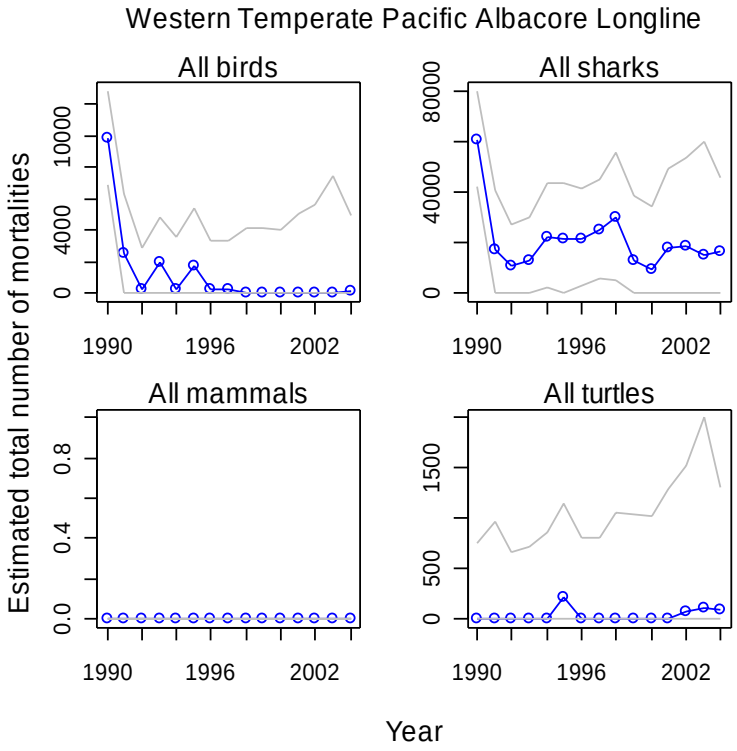

Figure 13b. Total estimated mortalities (numbers, blue lines) of each major taxa by temperate Pacific albacore longline fishery, 1990–2004. Source: observer database maintained by SPC. Shark mortalities include observed mortalities, plus retained plus finned and discarded sharks. Grey lines represent 95% confidence intervals generated from global standard deviations for each taxa.

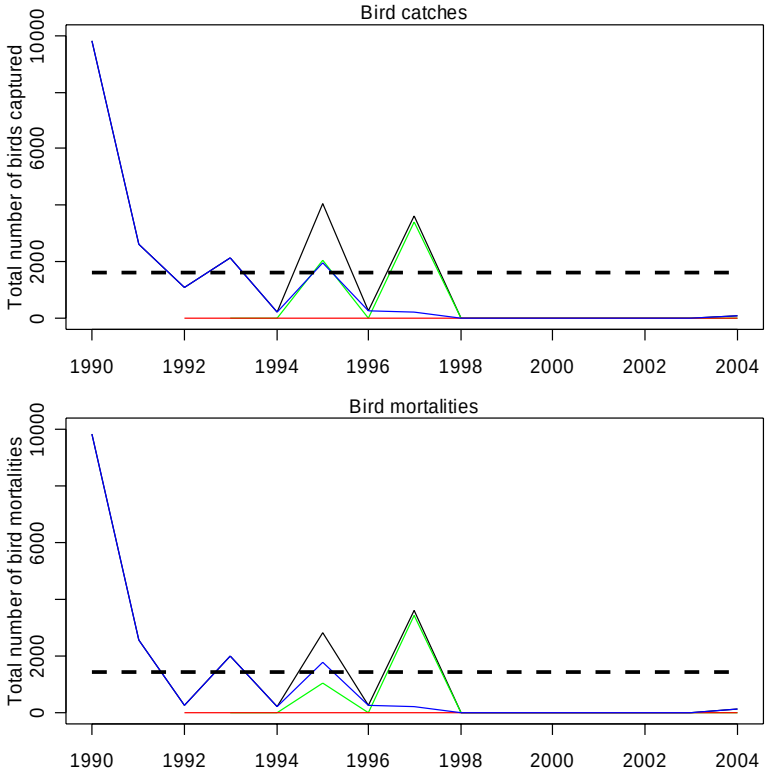

Figure 14. Annual point estimates of total bird catches (upper figure) and mortalities (lower figure) by the longline fisheries of the WCPO, 1990–2004. Source, raised observer data held at SPC. Line codes: green, TSL fishery; red, TDL fishery; blue, TAL fishery, solid black, all longline fisheries combined; dashed black, mean 1990–2004.

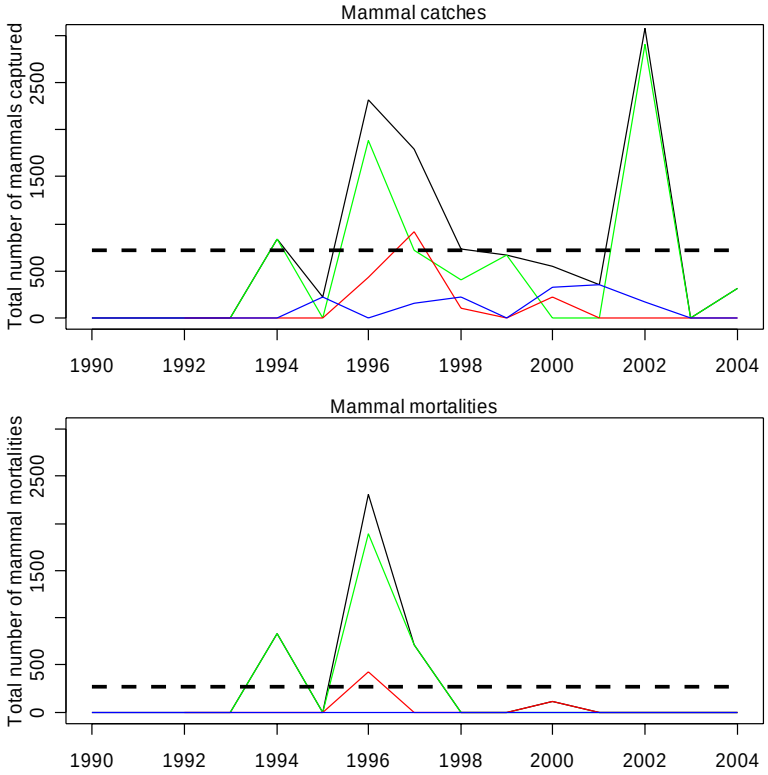

Figure 15. Annual point estimates of total mammal catches (upper figure) and mortalities (lower figure) by the longline fisheries of the WCPO, 1990–2004. Source, observer data held at SPC. Line codes: green, TSL fishery; red, TDL fishery; blue, TAL fishery, solid black, all longline fisheries combined; dashed black, mean 1990–2004.

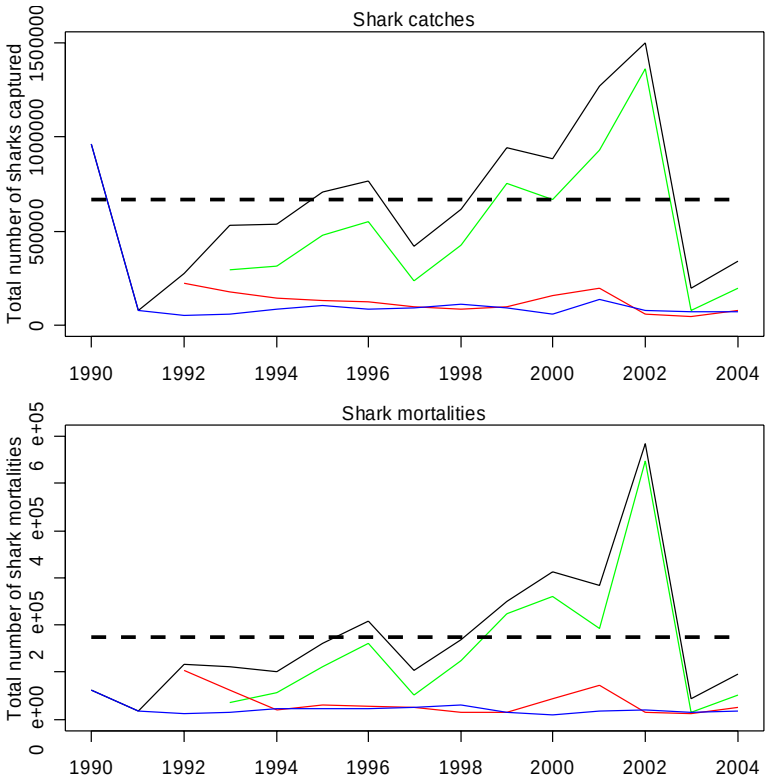

Figure 16. Annual point estimates of total shark catches (upper figure) and mortalities (lower figure) by the longline fisheries of the WCPO, 1990–2004. Source, observer data held at SPC. Line codes: green, TSL fishery; red, TDL fishery; blue, TAL fishery, solid black, all longline fisheries combined; dashed black, mean 1990–2004. Ranges of the y-axes vary between the two figures.

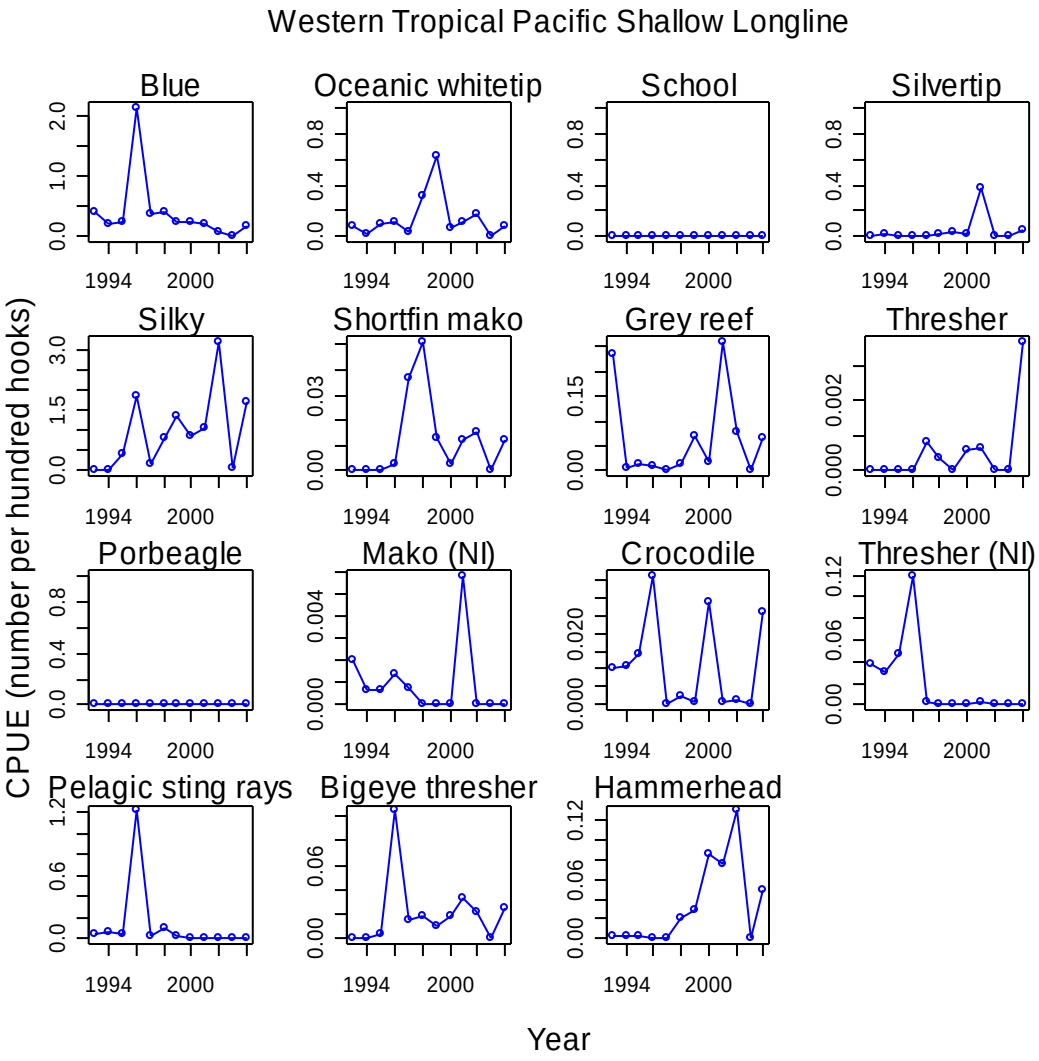

Figure 17. Estimated catch per unit effort (number per hundred hooks) of common shark taxa by the tropical shallow Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. (NI), indicates an taxa not identified to species level.

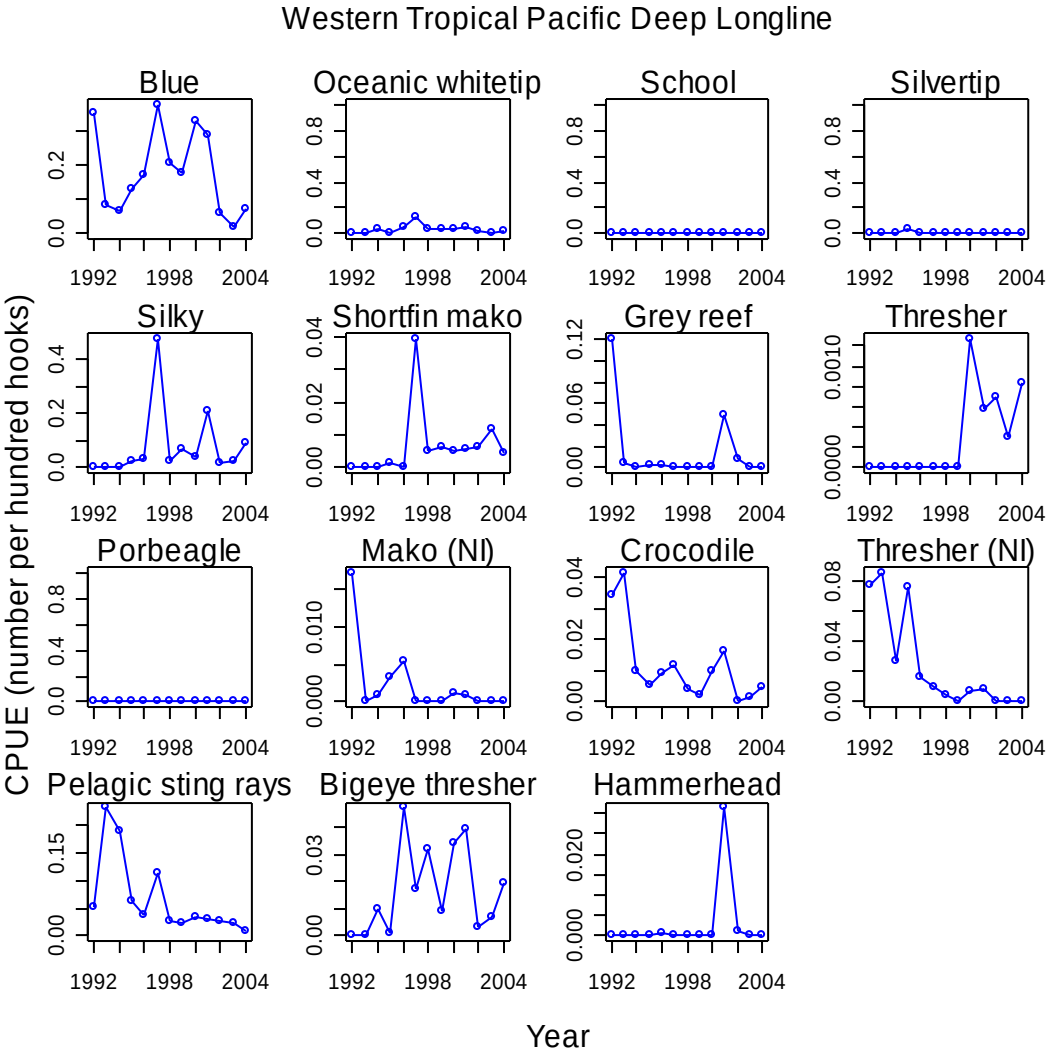

Figure 18. Estimated catch per unit effort (number per hundred hooks) of common shark taxa by the tropical deep Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. (NI), indicates an taxa not identified to species level.

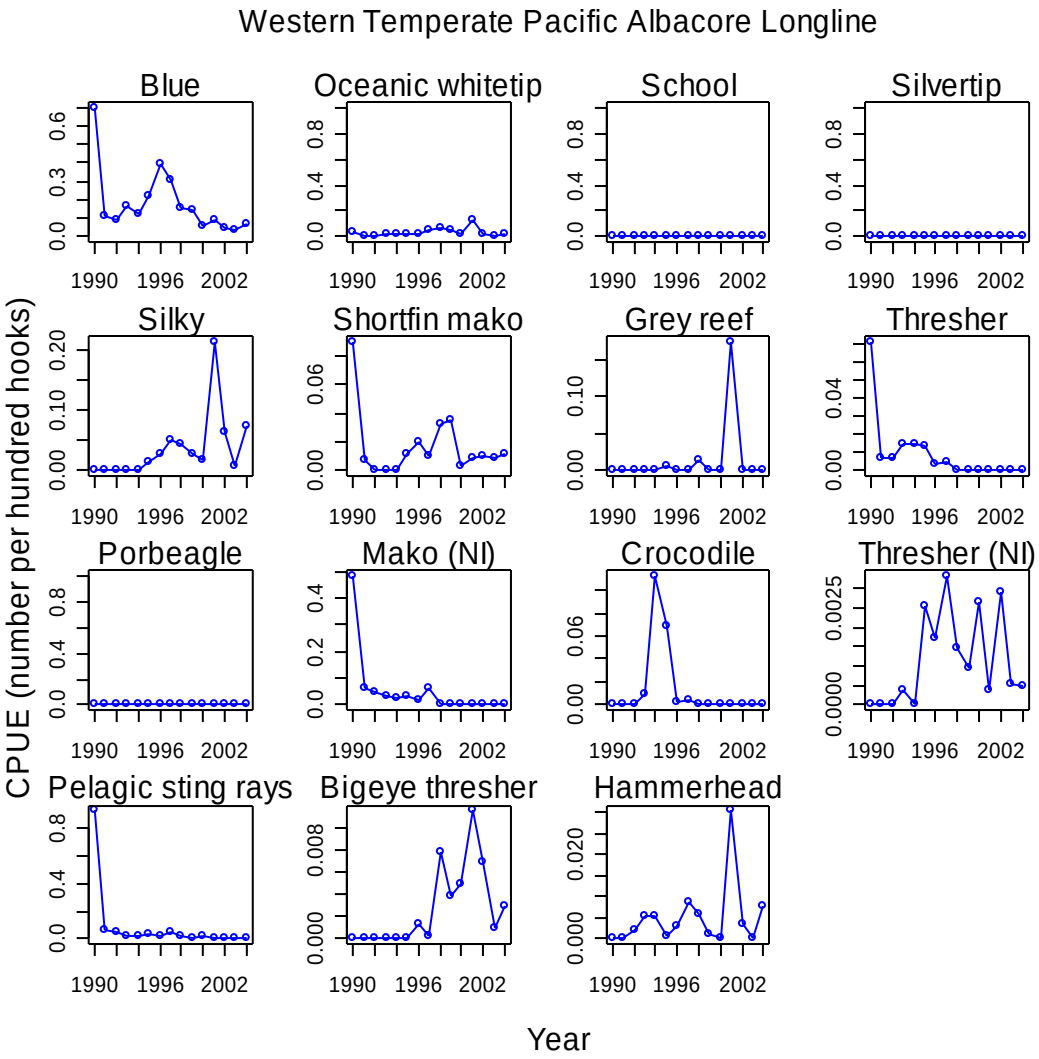

Figure 19. Estimated catch per unit effort (number per hundred hooks) of common shark taxa by the temperate Pacific albacore longline fishery, 1990–2004. Source: observer database maintained by SPC. (NI), indicates an taxa not identified to species level.

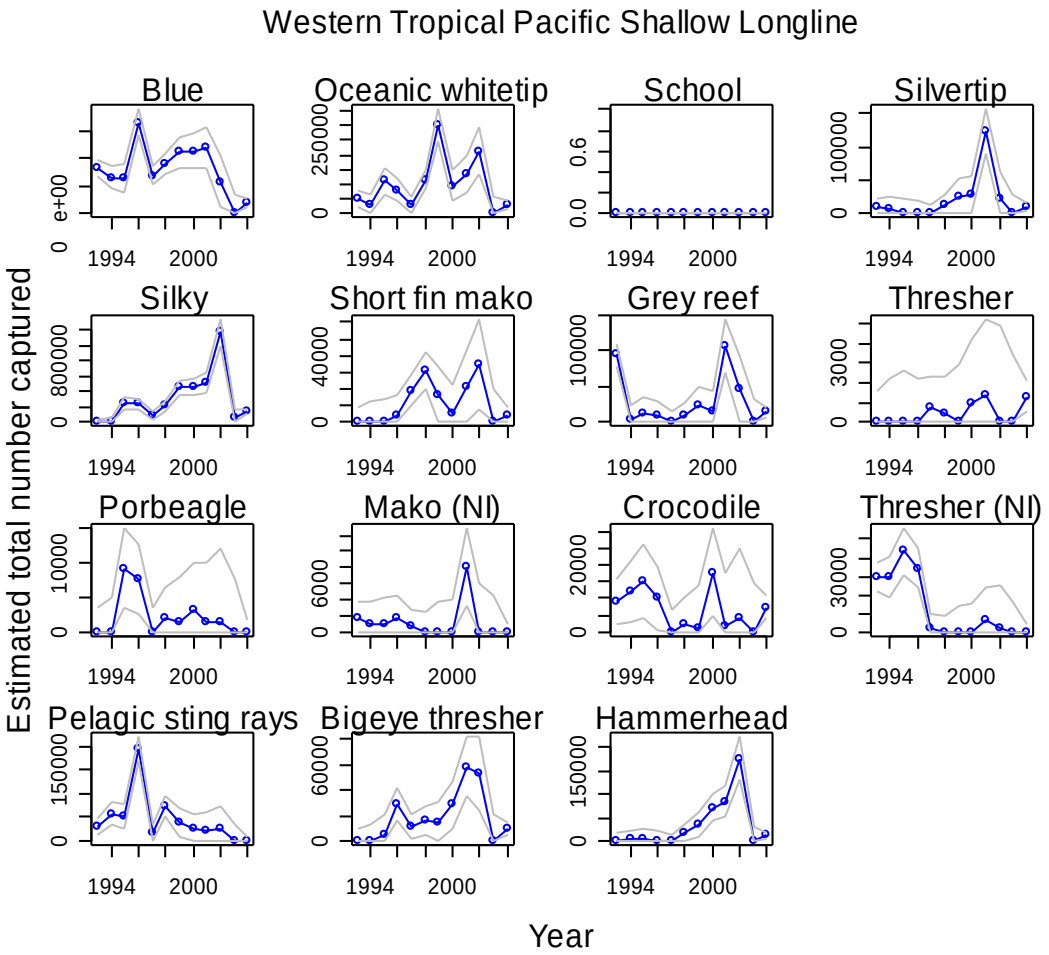

Figure 20. Estimated total catches (numbers, blue lines) of common shark taxa by the tropical shallow Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Grey lines represent 95% confidence intervals generated from global standard deviations for each taxa. (NI), indicates an taxa not identified to species level.

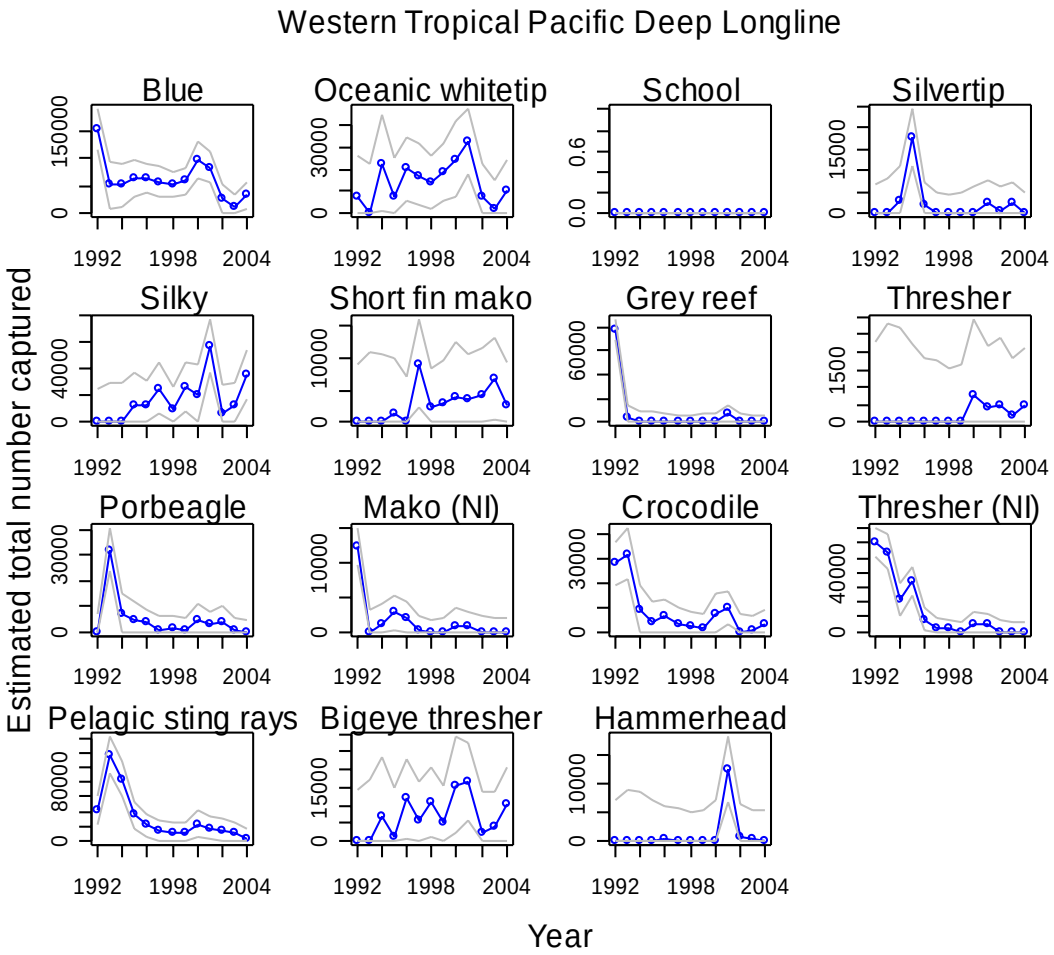

Figure 21. Estimated total catches (numbers, blue lines) of common shark taxa by the tropical deep Pacific longline fishery, 1990–2004. Source: observer database maintained by SPC. Grey lines represent ± two times the global standard deviations for each taxa. (NI), indicates an taxa not identified to species level.

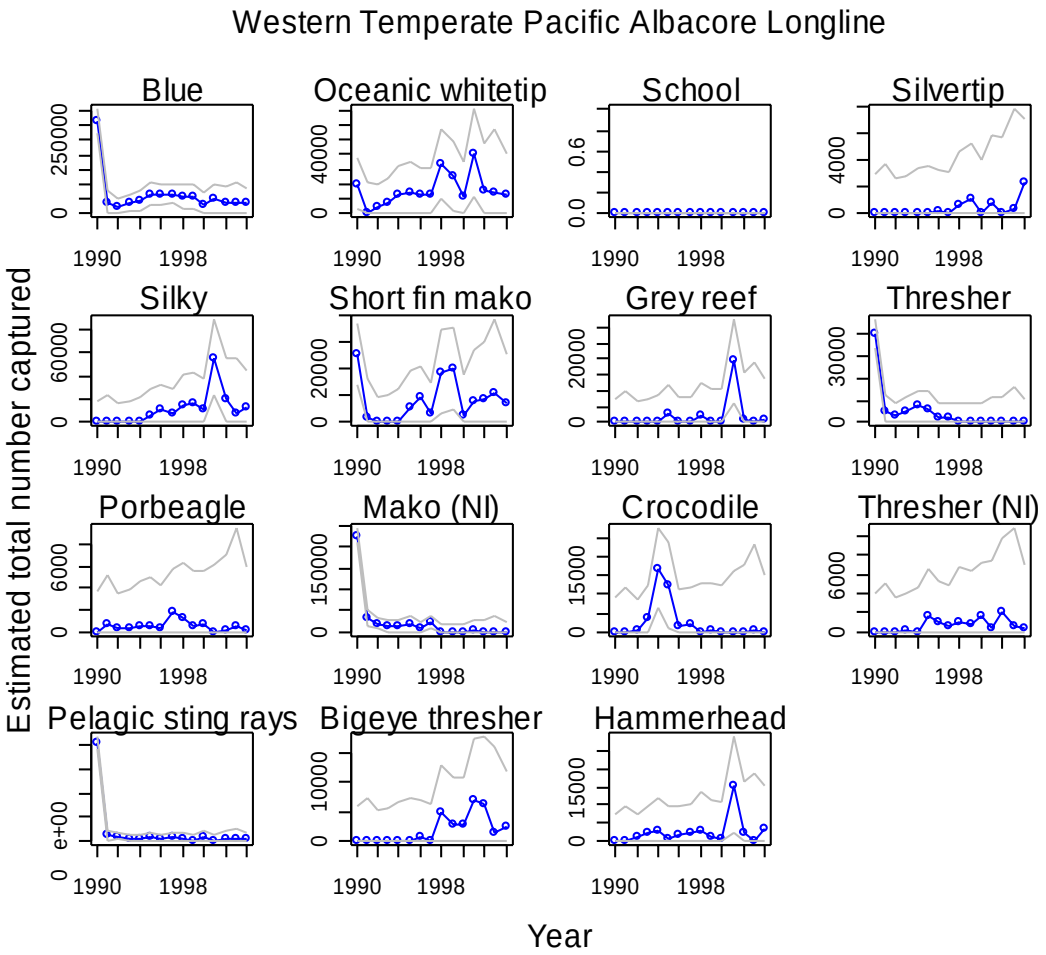

Figure 22. Estimated total catches (numbers, blue lines) of common shark taxa by the temperate Pacific albacore longline fishery, 1990–2004. Source: observer database maintained by SPC. Grey lines represent ± two times the global standard deviations for each taxa. (NI), indicates an taxa not identified to species level.

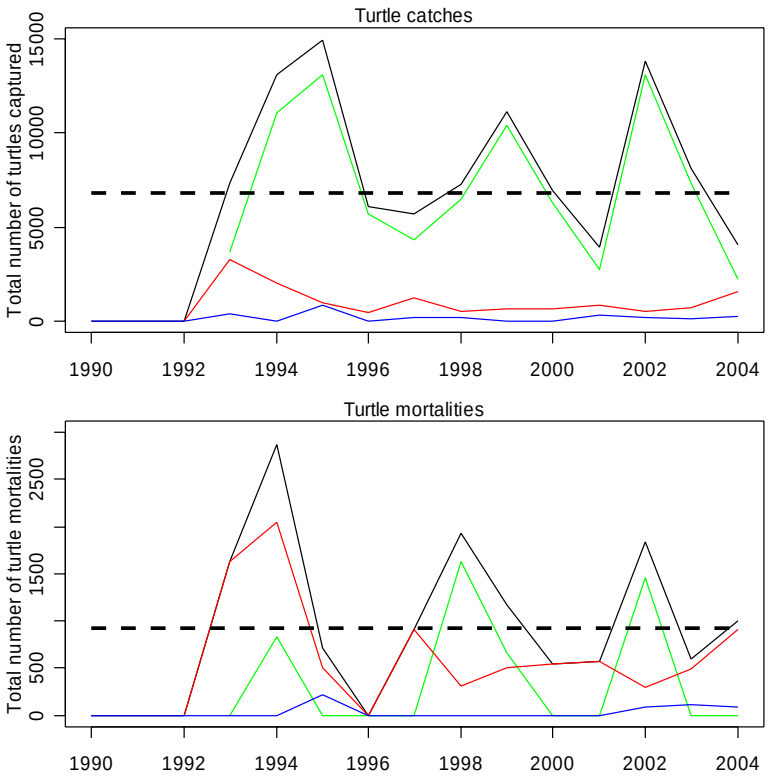

Figure 23. Annual point estimates of total turtle catches (upper figure) and mortalities (lower figure) by the longline fisheries of the WCPO, 1990–2004. Source, observer data held at SPC. Line codes: green, TSL fishery; red, TDL fishery; blue, TAL fishery, solid black, total for all longline fisheries combined; dashed black, mean 1990–2004. Ranges of the y-axes vary between the two figures.

9. Appendices

Appendix 1. Formula used to calculate CPUEs for total catches and total mortalities, standard deviations, confidence intervals and total estimates.

$$\text{Annual CPUE of total numbers per taxa} = \frac{\Sigma(\text{number of individuals observed per year})}{\Sigma(\text{total observed effort per year})}$$

$$\text{Annual CPUE of mortality per taxa} = \frac{\Sigma(\text{number of mortalities observed per year})}{\Sigma(\text{total observed effort per year})}$$

A unit of effort was defined as one hundred hooks for each of the longline fisheries.

Due to the low number of observations, global standard deviations (SDs) were used to provide more robust estimates of confidence intervals around for each estimated CPUE. Global SDs (i.e. for the entire dataset for each taxa) were used as the number of records per taxa were relatively low. Global standard deviations provide more robust estimates of uncertainties around each calculated CPUE. SDs were calculated for each taxa examined, both for total estimated catches and total estimated mortalities per taxa, via;

$$\text{SD of total number per taxa} = \sqrt{\frac{\Sigma(\text{number of individuals observed}^2)}{\text{Number of records}}}$$

$$\text{SD of total mortality per taxa} = \sqrt{\frac{\Sigma(\text{number of mortalities observed}^2)}{\text{Number of records}}}$$

Ninety-five percent (95%) confidence intervals (CIs) were calculated by adding and subtracting 1.96 times the estimated SD from the mean for each taxa;

$$CI = CPUE \pm 1.96(SD*\text{total effort})$$

Total catches and mortalities per taxa for each fishery were calculated by multiplying the annual CPUEs by the annual estimated total effort for each fishery;

Total catch = CPUE x annual estimated total effort.

Similarly, total CIs were constructed by multiplying the CI by the total annual effort for each fishery;

Total CI = CI x annual estimated total effort.

Appendix 2. Estimated annual catches and mortalities of species of sharks commonly recorded by observers in the three fisheries examined. Only species with more than 1,000 records in the longline fisheries were analysed. Only sharks identified to species are presented.

Table A1. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

a). Silky sharks (*Carcharhinus falciformis*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													0	0	18,456	0	0	8,328
1991													0	0	23,520	0	0	5,415
1992							0	0	24,535	0	0	14,311	0	0	8,388	0	0	3,785
1993	0	0	45,091	0	0	24,609	0	0	29,996	0	0	17,496	0	0	8,917	0	0	4,024
1994	0	0	62,139	0	0	33,913	0	0	28,713	0	0	16,748	0	0	10,802	0	0	4,874
1995	242,384	169,465	315,303	49,843	10,047	89,640	12,609	0	36,406	6,271	0	20,152	6,033	0	11,573	861	0	5,222
1996	241,140	178,157	304,123	52,601	18,228	86,975	12,182	0	31,495	3,149	0	14,413	11,603	0	10,007	1,364	0	4,515
1997	82,183	37,123	127,244	26,521	1,928	51,113	24,859	6,204	43,514	10,444	0	21,325	8,578	0	10,007	2,730	0	4,515
1998	211,739	158,009	265,469	61,500	32,176	90,824	9,268	0	25,759	2,756	0	12,375	15,407	0	13,122	6,744	0	5,921
1999	451,486	369,091	533,881	135,563	90,594	180,531	26,007	8,337	43,678	2,749	0	13,056	16,441	0	13,098	2,342	0	5,910
2000	454,686	366,788	542,585	169,786	121,814	217,758	20,270	0	43,419	7,697	0	21,199	12,043	0	12,861	2,503	0	5,803
2001	514,666	406,739	622,592	100,546	41,644	159,448	56,912	37,872	75,951	24,092	12,986	35,197	55,438	23,633	16,227	7,416	0	7,322
2002	1,162,580	1,026,451	1,298,710	449,065	374,771	523,360	7,448	0	27,644	3,093	0	14,873	19,843	0	18,001	5,786	0	8,122
2003	72,123	0	170,250	14,278	0	67,832	12,082	0	29,430	4,485	0	14,603	8,423	0	23,684	3,329	0	10,686
2004	137,644	116,074	159,214	31,917	20,145	43,689	35,959	18,333	53,585	11,069	788	21,350	13,341	0	15,250	5,196	0	6,881
Mean	*297,553*	*235,658*	*370,550*	*90,968*	*59,279*	*130,808*	*16,738*	*5,442*	*38,010*	*5,831*	*1,060*	*18,238*	*11,143*	*1,576*	*14,261*	*2,551*	*0*	*6,088*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

b). Oceanic whitetip sharks (*Carcharhinus longimanus*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													19,770	3,011	36,530	0	0	7,062
1991													0	0	21,358	0	0	9,000
1992							7,766	0	25,876	0	0	9,628	3,906	0	18,835	401	0	6,692
1993	50,088	24,091	76,086	1,834	0	11,913	0	0	22,141	0	0	11,772	6,985	0	22,856	521	0	7,209
1994	27,944	0	63,771	3,341	0	17,231	22,783	1,589	43,977	5,114	0	16,382	13,129	0	32,354	2,357	0	10,458
1995	110,841	68,799	152,883	18,595	2,296	34,894	7,192	0	24,758	2,506	0	11,845	13,633	0	34,232	2,191	0	10,871
1996	78,567	42,254	114,880	17,242	3,164	31,320	20,065	5,810	34,320	3,972	0	11,551	12,109	0	29,920	2,130	0	9,636
1997	27,251	1,271	53,231	4,298	0	14,370	17,230	3,460	31,000	4,827	0	12,148	12,850	0	30,661	2,459	0	9,965
1998	116,234	85,256	147,213	16,063	4,053	28,073	14,095	1,924	26,267	1,108	0	7,580	33,264	9,908	56,619	9,775	0	19,617
1999	300,757	253,252	348,263	52,692	34,275	71,109	18,401	5,358	31,444	1,262	0	8,197	25,046	1,733	48,358	3,810	0	13,634
2000	92,912	42,233	143,591	21,314	1,667	40,962	24,634	7,548	41,720	5,324	0	14,409	10,962	0	33,853	2,696	0	12,342
2001	133,807	71,581	196,033	7,728	0	31,852	32,442	18,389	46,496	10,643	3,171	18,115	40,457	11,576	69,338	2,860	0	15,031
2002	213,897	135,410	292,383	83,105	52,677	113,533	7,410	0	22,317	3,549	0	11,474	15,231	0	47,269	4,555	0	18,055
2003	0	0	56,575	0	0	21,933	1,618	0	14,422	487	0	7,295	14,341	0	56,494	4,512	0	22,275
2004	26,854	14,418	39,290	4,587	0	9,408	10,554	0	23,565	3,312	0	10,229	12,739	0	39,882	1,878	0	13,316
Mean	*98,263*	*61,547*	*140,350*	*19,233*	*8,178*	*35,550*	*14,169*	*3,391*	*29,870*	*3,239*	*244*	*11,587*	*15,628*	*1,749*	*38,571*	*2,676*	*0*	*12,344*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

c). Blue sharks (*Prionace glauca*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													314,293	285,199	343,387	0	0	9,120
1991													38,519	1,442	75,596	3,036	0	14,658
1992							150,679	117,654	183,704	43,970	31,243	56,698	25,276	0	51,192	1,940	0	10,064
1993	164,573	135,012	194,133	13,975	0	25,706	50,561	10,185	90,938	13,369	0	28,929	37,787	10,235	65,338	4,144	0	12,780
1994	130,951	90,214	171,687	11,025	0	27,190	50,940	12,291	89,590	2,044	0	16,938	42,486	9,112	75,860	4,542	0	15,003
1995	127,228	79,424	175,032	22,771	3,801	41,741	64,567	32,535	96,600	4,809	0	17,154	65,698	29,939	101,456	5,411	0	16,619
1996	328,242	286,952	369,532	71,282	54,898	87,667	63,199	37,204	89,195	4,512	0	14,530	63,022	32,103	93,940	11,059	1,367	20,750
1997	138,314	108,774	167,854	19,369	7,647	31,092	57,849	32,739	82,960	7,822	0	17,499	65,877	34,957	96,797	9,078	0	18,770
1998	177,943	142,719	213,166	38,496	24,518	52,473	51,801	29,604	73,998	2,329	0	10,883	59,041	18,497	99,586	4,795	0	17,504
1999	220,507	166,491	274,523	42,140	20,705	63,575	58,082	34,296	81,868	4,541	0	13,708	54,063	13,594	94,532	1,954	0	14,639
2000	225,050	167,426	282,674	45,792	22,925	68,659	96,708	65,549	127,867	18,809	6,801	30,817	30,330	0	70,068	2,309	0	14,765
2001	237,461	166,708	308,214	34,270	6,194	62,347	82,882	57,254	108,511	14,708	4,832	24,585	48,967	0	99,103	2,860	0	18,576
2002	114,796	25,554	204,038	12,503	0	47,917	25,610	0	52,794	1,539	0	12,015	32,955	0	88,572	3,786	0	21,219
2003	0	0	64,329	0	0	25,527	11,092	0	34,443	1,640	0	10,639	33,680	0	106,857	2,423	0	25,361
2004	38,426	24,286	52,567	3,926	0	9,538	32,500	8,774	56,226	3,891	0	13,034	37,079	0	84,199	4,271	0	19,040
Mean	158,624	116,130	206,479	26,296	11,724	45,286	61,267	33,699	89,899	9,537	3,298	20,572	63,271	29,005	103,099	4,107	91	16,591

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

d). Porbeagle sharks (*Lamna nasus*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													0	0	3,593	0	0	3,593
1991													661	0	5,240	661	0	5,240
1992							0	0	6,863	0	0	6,863	262	0	3,462	262	0	3,462
1993	0	0	3,549	0	0	3,549	31,956	23,566	40,346	31,956	23,566	40,346	403	0	3,805	403	0	3,805
1994	0	0	4,891	0	0	4,891	6,739	0	14,770	6,739	0	14,770	428	0	4,549	428	0	4,549
1995	9,228	3,489	14,968	9,228	3,489	14,968	4,809	0	11,465	4,809	0	11,465	556	0	4,972	556	0	4,972
1996	7,621	2,664	12,579	7,621	2,664	12,579	3,408	0	8,810	3,408	0	8,810	372	0	4,190	372	0	4,190
1997	0	0	3,547	0	0	3,547	656	0	5,874	656	0	5,874	1,844	0	5,663	1,844	0	5,663
1998	2,098	0	6,328	2,098	0	6,328	1,194	0	5,806	1,194	0	5,806	1,229	0	6,236	1,229	0	6,236
1999	1,335	0	7,821	1,335	0	7,821	665	0	5,608	665	0	5,608	488	0	5,486	488	0	5,486
2000	3,045	0	9,964	3,045	0	9,964	4,595	0	11,070	4,595	0	11,070	659	0	5,566	659	0	5,566
2001	1,382	0	9,878	1,382	0	9,878	2,627	0	7,952	2,627	0	7,952	0	0	6,191	0	0	6,191
2002	1,454	0	12,170	1,454	0	12,170	4,099	0	9,748	4,099	0	9,748	165	0	7,033	165	0	7,033
2003	0	0	7,724	0	0	7,724	487	0	5,340	487	0	5,340	426	0	9,462	426	0	9,462
2004	0	0	1,698	0	0	1,698	0	0	4,930	0	0	4,930	90	0	5,909	90	0	5,909
Mean	*2,180*	*513*	*7,926*	*2,180*	*513*	*7,926*	*4,710*	*1,813*	*10,660*	*4,710*	*1,813*	*10,660*	*506*	*0*	*5,424*	*506*	*0*	*5,424*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

e). Pelagic string rays (*Dasyatis violacea*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													412,406	397,029	427,783	0	0	3,593
1991													22,693	3,097	42,289	661	0	5,240
1992							40,652	21,996	59,309	0	0	6,863	18,683	4,985	32,381	262	0	3,462
1993	32,172	15,413	48,931	0	0	3,549	116,174	93,365	138,983	31,956	23,566	40,346	8,276	0	22,838	403	0	3,805
1994	57,163	34,068	80,259	0	0	4,891	84,453	62,620	106,287	6,739	0	14,770	9,123	0	26,762	428	0	4,549
1995	51,818	24,716	78,920	9,228	3,489	14,968	35,342	17,247	53,438	4,809	0	11,465	14,367	0	33,266	556	0	4,972
1996	192,635	169,226	216,044	7,621	2,664	12,579	21,266	6,581	35,952	3,408	0	8,810	8,184	0	24,526	372	0	4,190
1997	17,647	899	34,395	0	0	3,547	14,079	0	28,264	656	0	5,874	14,044	0	30,386	1,844	0	5,663
1998	72,290	52,320	92,260	2,098	0	6,328	12,337	0	24,876	1,194	0	5,806	11,191	0	32,620	1,229	0	6,236
1999	38,245	7,621	68,869	1,335	0	7,821	11,299	0	24,736	665	0	5,608	3,931	0	25,320	488	0	5,486
2000	25,061	0	57,731	3,045	0	9,964	23,338	5,736	40,940	4,595	0	11,070	17,775	0	38,778	659	0	5,566
2001	21,035	0	61,149	1,382	0	9,878	17,850	3,373	32,328	2,627	0	7,952	2,100	0	28,599	0	0	6,191
2002	24,244	0	74,840	1,454	0	12,170	13,680	0	29,036	4,099	0	9,748	10,254	0	39,649	165	0	7,033
2003	0	0	36,471	0	0	7,724	10,885	0	24,076	487	0	5,340	11,791	0	50,467	426	0	9,462
2004	941	0	8,958	0	0	1,698	3,843	0	17,246	0	0	4,930	8,838	0	33,742	90	0	5,909
Mean	*44,438*	*25,355*	*71,569*	*2,180*	*513*	*7,926*	*31,169*	*16,224*	*47,344*	*4,710*	*1,813*	*10,660*	*38,244*	*27,007*	*59,294*	*506*	*0*	*5,424*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

f). Shortfin mako sharks (*Isurus oxyrhinchus*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													25,646	14,653	36,638	0	0	5,266
1991													2,159	0	16,168	0	0	6,710
1992							0	0	9,059	0	0	4,394	0	0	9,792	0	0	4,690
1993	0	0	8,984	0	0	3,493	0	0	11,075	0	0	5,372	0	0	10,410	0	0	4,986
1994	0	0	12,381	0	0	4,814	0	0	10,601	0	0	5,143	0	0	12,610	0	0	6,040
1995	0	0	14,529	0	0	5,649	1,295	0	10,081	0	0	4,262	5,607	0	19,118	2,317	0	8,789
1996	3,584	0	16,134	1,791	0	6,670	0	0	7,130	0	0	3,459	9,336	0	21,019	2,627	0	8,223
1997	19,293	10,315	28,272	1,431	0	4,922	9,228	2,340	16,115	1,726	0	5,068	3,076	0	14,759	1,462	0	7,058
1998	30,893	20,187	41,599	6,503	2,341	10,665	2,450	0	8,538	495	0	3,449	19,076	3,757	34,396	7,078	0	14,416
1999	16,418	1	32,835	3,731	0	10,114	3,091	0	9,615	264	0	3,428	19,957	4,666	35,247	3,954	0	11,278
2000	5,077	0	22,591	0	0	6,809	4,010	0	12,557	711	0	4,857	2,503	0	17,517	1,512	0	8,704
2001	21,483	0	42,988	7,728	0	16,088	3,723	0	10,753	638	0	4,048	7,689	0	26,633	2,100	0	11,174
2002	34,559	7,436	61,683	11,898	1,353	22,443	4,231	0	11,687	1,957	0	5,574	8,962	0	29,976	1,750	0	11,816
2003	0	0	19,552	0	0	7,601	6,791	386	13,196	1,423	0	4,530	10,941	0	38,590	2,468	0	15,711
2004	4,771	474	9,069	1,255	0	2,925	2,764	0	9,272	910	0	4,067	7,541	0	25,345	2,097	0	10,625
Mean	*11,340*	*3,201*	*25,885*	*2,861*	*308*	*8,516*	*2,891*	*210*	*10,745*	*625*	*0*	*4,435*	*8,166*	*1,538*	*23,215*	*1,824*	*0*	*9,032*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

g). Bigeye thresher sharks (*Alopias superciliosus*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													0	0	5,808	0	0	2,025
1991													0	0	7,402	0	0	46
1992							0	0	14,085	0	0	4,544	0	0	5,174	0	0	18
1993	0	0	9,315	0	0	998	0	0	17,221	0	0	956	0	0	5,500	0	0	42
1994	0	0	12,837	0	0	454	7,069	0	23,553	2,044	1,445	2,642	0	0	6,663	0	0	44
1995	5,175	0	20,240	2,069	1,506	2,632	1,002	0	14,664	501	207	794	0	0	7,139	0	0	45
1996	28,948	15,936	41,959	24,251	23,276	25,227	11,933	846	23,021	6,930	6,681	7,180	692	0	6,865	0	0	26
1997	11,139	1,830	20,448	3,581	3,191	3,970	5,859	0	16,568	545	449	641	161	0	6,334	0	0	17
1998	15,483	4,383	26,583	6,980	6,759	7,200	10,788	1,322	20,255	2,394	2,334	2,454	4,808	0	12,903	660	614	706
1999	14,174	0	31,196	4,400	4,036	4,763	5,209	0	15,354	333	235	430	2,730	0	10,809	244	194	295
2000	28,215	10,056	46,374	15,858	15,306	16,410	15,600	2,311	28,890	2,789	2,726	2,852	2,833	0	10,766	330	261	398
2001	58,454	36,157	80,750	20,458	19,706	21,211	16,530	5,599	27,460	5,614	5,555	5,673	7,088	0	17,097	1,862	1,790	1,935
2002	52,841	24,718	80,964	17,130	16,339	17,922	2,406	0	14,000	268	224	312	6,404	0	17,508	1,584	1,567	1,602
2003	0	0	20,272	0	0	3,879	3,948	0	13,907	1,342	1,284	1,399	1,278	0	15,887	213	191	235
2004	9,496	5,040	13,952	1,569	1,398	1,739	10,214	95	20,334	3,312	3,205	3,419	2,369	0	11,776	415	396	433
Mean	*18,661*	*8,177*	*33,741*	*8,025*	*7,626*	*8,867*	*6,966*	*783*	*19,178*	*2,005*	*1,873*	*2,561*	*1,891*	*0*	*9,842*	*354*	*334*	*524*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

h). Grey reef sharks (*Carcharhinus amblyrhynchos*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													0	0	7,650	0	0	2,198
1991													0	0	9,749	0	0	2,801
1992							77,766	69,302	86,229	56,717	49,771	63,663	0	0	6,815	0	0	1,958
1993	94,950	80,037	109,864	6,587	0	13,175	4,218	0	14,565	0	0	8,493	0	0	7,245	0	0	2,081
1994	4,320	0	24,872	1,670	0	10,750	0	0	9,905	0	0	8,129	0	0	8,776	0	0	2,521
1995	11,325	0	35,443	2,402	0	13,057	1,503	0	9,712	501	0	7,238	2,617	0	12,020	861	0	3,562
1996	8,974	0	29,806	1,791	0	10,994	1,526	0	8,188	0	0	5,468	0	0	8,130	0	0	2,336
1997	0	0	14,904	0	0	6,584	0	0	6,435	0	0	5,282	0	0	8,130	0	0	2,336
1998	8,880	0	26,652	3,079	0	10,931	0	0	5,688	0	0	4,669	2,021	0	12,682	569	0	3,632
1999	23,232	0	50,484	5,200	0	17,240	929	0	7,025	763	0	5,766	244	0	10,886	0	0	3,057
2000	15,438	0	44,511	4,655	0	17,499	0	0	7,985	0	0	6,554	0	0	10,449	0	0	3,002
2001	107,796	72,100	143,493	23,658	7,888	39,429	7,136	568	13,703	5,489	98	10,879	19,340	6,156	32,523	0	0	3,788
2002	46,888	1,863	91,913	29,599	9,707	49,491	1,303	0	8,270	1,155	0	6,873	1,129	0	15,754	675	0	4,877
2003	0	0	32,455	0	0	14,339	0	0	5,984	0	0	4,911	0	0	19,242	0	0	5,528
2004	14,372	7,238	21,506	1,255	0	4,406	364	0	6,444	0	0	4,990	1,101	0	13,491	391	0	3,951
Mean	*28,015*	*13,436*	*52,159*	*6,658*	*1,466*	*17,325*	*7,288*	*5,375*	*14,626*	*4,971*	*3,836*	*10,993*	*1,763*	*410*	*12,236*	*166*	*0*	*3,175*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

i). Crocodile sharks (*Pseudocarcharias kamoharai*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													0	0	9,179	0	0	2,469
1991													0	0	11,697	0	0	3,147
1992							28,056	19,499	36,614	0	0	4,362	525	0	8,701	0	0	2,200
1993	9,196	2,470	15,921	1,834	0	6,444	31,926	21,464	42,388	15,696	10,363	21,028	3,567	0	12,259	605	0	2,943
1994	12,007	2,739	21,276	835	0	7,188	8,966	0	18,980	0	0	5,104	16,733	6,204	27,262	2,555	0	5,388
1995	15,267	4,391	26,144	5,782	0	13,238	3,889	0	12,189	1,503	0	5,734	12,275	994	23,557	1,418	0	4,453
1996	10,133	739	19,527	8,333	1,893	14,773	6,294	0	13,030	1,703	0	5,136	1,458	0	11,212	248	0	2,872
1997	0	0	6,721	0	0	4,607	3,552	0	10,058	492	0	3,808	1,909	0	11,664	241	0	2,866
1998	2,160	0	10,174	0	0	5,494	2,261	0	8,012	575	0	3,507	0	0	12,791	0	0	3,441
1999	1,335	0	13,625	0	0	8,425	1,193	0	7,356	264	0	3,405	244	0	13,012	0	0	3,435
2000	17,884	4,773	30,994	11,106	2,118	20,093	7,370	0	15,444	2,738	0	6,853	0	0	12,537	0	0	3,373
2001	1,382	0	17,480	0	0	11,035	9,506	2,866	16,147	2,281	0	5,666	0	0	15,818	0	0	4,255
2002	4,365	0	24,669	4,365	0	18,284	75	0	7,118	0	0	3,590	83	0	17,629	0	0	4,720
2003	0	0	14,636	0	0	10,033	576	0	6,626	226	0	3,310	213	0	23,299	0	0	6,211
2004	7,500	4,282	10,717	2,482	277	4,688	2,764	0	8,912	1,381	0	4,515	0	0	14,866	0	0	3,999
Mean	*6,769*	*1,616*	*17,657*	*2,895*	*357*	*10,359*	*8,187*	*3,371*	*15,606*	*2,066*	*797*	*5,848*	*2,467*	*480*	*15,032*	*338*	*0*	*3,718*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

j). Silvertip sharks (*Carcharhinus albimarginatus*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													0	0	2,959	0	0	1,917
1991													0	0	3,771	0	0	2,443
1992							0	0	6,622	0	0	4,354	0	0	2,636	0	0	1,707
1993	8,430	0	21,970	1,834	0	5,908	0	0	8,096	0	0	5,323	0	0	2,802	0	0	1,815
1994	6,121	0	24,780	1,670	0	7,285	3,066	0	10,816	1,619	0	6,715	0	0	3,395	0	0	2,199
1995	0	0	21,897	0	0	6,589	17,689	11,266	24,112	1,503	0	5,726	0	0	3,637	0	0	2,356
1996	0	0	18,913	0	0	5,691	1,952	0	7,164	1,277	0	4,704	124	0	3,269	124	0	2,161
1997	0	0	13,531	0	0	4,072	0	0	5,035	0	0	3,311	0	0	3,145	0	0	2,037
1998	12,477	0	28,612	4,299	0	9,154	0	0	4,451	0	0	2,927	569	0	4,693	440	0	3,111
1999	26,349	1,607	51,092	6,685	0	14,130	0	0	4,769	0	0	3,136	1,120	0	5,236	244	0	2,910
2000	28,215	1,820	54,610	11,778	3,836	19,721	108	0	6,355	108	0	4,216	0	0	4,042	0	0	2,618
2001	121,971	89,562	154,380	15,686	5,934	25,438	2,502	0	7,640	1,800	0	5,179	812	0	5,912	0	0	3,303
2002	22,062	0	62,940	0	0	12,300	598	0	6,048	149	0	3,733	0	0	5,657	0	0	3,664
2003	0	0	29,466	0	0	8,866	2,475	0	7,157	1,843	0	4,922	382	0	7,825	275	0	5,096
2004	8,508	2,031	14,985	1,255	0	3,204	0	0	4,757	0	0	3,128	2,309	0	7,102	1,055	0	4,159
Mean	*19,511*	*7,918*	*41,431*	*3,601*	*814*	*10,196*	*2,184*	*867*	*7,925*	*638*	*0*	*4,413*	*354*	*0*	*4,405*	*143*	*0*	*2,766*

Table A1, continued. Final estimated total catches (Total, in numbers), mortalities (Mort.) and approximate 95% confidence intervals (CI) of commonly reported species of sharks of the three fisheries examined, 1990–2004. Ratio: the proportion of each taxa reported as dead by observers; *Mean*, mean of estimates for each fishery for the year range examined; *Total*, total estimated annual average for all fisheries combined. Blank cells indicate no records for individual fishery and year combinations.

k). Thresher sharks (*Alopias vulpinus*)

	Fishery																	
	Tropical shallow longline						Tropical deep longline						Temperate albacore longline					
Year	Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI		Total	95% CI		Mort.	95% CI	
		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.		Low.	Upp.
1990													40,036	33,846	46,225	0	0	3,952
1991													4,585	0	12,472	1,452	0	6,489
1992							0	0	2,294	0	0	1,311	3,007	0	8,521	1,590	0	5,110
1993	0	0	1,608	0	0	509	0	0	2,805	0	0	1,603	5,149	0	11,010	1,328	0	5,071
1994	0	0	2,216	0	0	701	0	0	2,685	0	0	1,535	7,284	184	14,384	4,396	0	8,930
1995	0	0	2,600	0	0	822	0	0	2,225	0	0	1,272	6,075	0	13,682	2,975	0	7,833
1996	0	0	2,246	0	0	710	0	0	1,806	0	0	1,032	2,027	0	8,605	784	0	4,984
1997	715	0	2,322	0	0	508	0	0	1,744	0	0	997	2,409	0	8,986	899	0	5,099
1998	406	0	2,322	0	0	606	0	0	1,542	0	0	881	0	0	8,625	0	0	5,508
1999	0	0	2,938	0	0	929	0	0	1,652	0	0	944	244	0	8,853	0	0	5,497
2000	1,015	0	4,149	0	0	991	774	0	2,939	216	0	1,453	0	0	8,454	0	0	5,398
2001	1,382	0	5,231	0	0	1,217	404	0	2,184	0	0	1,018	350	0	11,016	350	0	7,161
2002	0	0	4,854	0	0	1,535	492	0	2,381	193	0	1,273	0	0	11,832	0	0	7,555
2003	0	0	3,499	0	0	1,107	195	0	1,817	0	0	927	0	0	15,567	0	0	9,941
2004	1,308	539	2,077	313	70	557	470	0	2,119	364	0	1,306	90	0	10,115	90	0	6,491
Mean	*402*	*45*	*3,005*	*26*	*6*	*849*	*180*	*0*	*2,169*	*59*	*0*	*1,196*	*4,750*	*2,269*	*13,223*	*924*	*0*	*6,335*

Appendix 3. Summaries of the observer data used in the analyses within the current report.

Table A2. Pooled number of observed longline sets by flag for the longline fisheries used in the analyses, 1990–2004 Source, SPC observer database. Flag codes: AS, American Samoa; CK, Cook Islands; CN, China; FJ, Fiji; FM, Federated States of Micronesia; FR, France; JP, Japan; KR, Korea; NC, New Caledonia; NZ, New Zealand; PF, French Polynesia; PG, Papua New Guinea; PW, Palau; SB, Solomon Islands; TO, Tonga; TW, Taiwan; US, United States; WS, Western Samoa.

	Flag																		
Year	**AS**	**CK**	**CN**	**FJ**	**FM**	**FR**	**JP**	**KR**	**NC**	**NZ**	**PF**	**PG**	**PW**	**SB**	**TO**	**TW**	**US**	**VU**	**WS**	**Total**
1990							47													47
1991							173													173
1992							254	8	4	1										267
1993			18				149	5			3					36				211
1994			29	6	7		180									95	24			341
1995		6	107	34	4		170			8					18	75	49	1		472
1996		2	76	12	12		178		59			10			3	63	48			463
1997			87	23	42		312				64			67		70	46			711
1998	2		87		42		124	54	26					50	71	255	102		7	820
1999			82	60	19		101	24	22			76		60	18	95	53		2	612
2000			71		50		59					60	10	94	23	118	340		10	835
2001			111		27		55		20			262		74		24	411		14	998
2002	60	22	6	45	22		56	163	50		66	285		551		54				1,380
2003		2	24	151	10			1	79	9	164	107		280		82				909
2004			160	76	46	43	3		49		124	166		12	31	90		2		802
Total	*62*	*32*	*858*	*407*	*281*	*43*	*1,861*	*255*	*309*	*18*	*421*	*966*	*10*	*1188*	*164*	*1,057*	*1,073*	*3*	*33*	*9,041*

Appendix 4. Distribution of observer and logsheet records of starting times of longline sets used in the analyses within the current report.

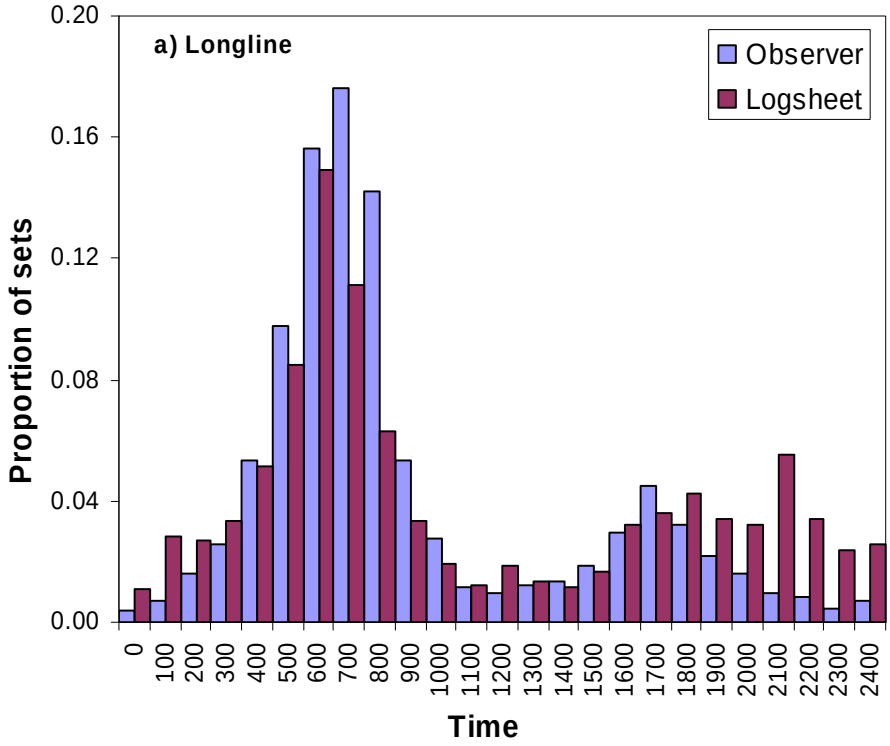

Figure A1. Proportion of observed and logsheet set start times for all longline fisheries used in the analyses. Source, SPC observer and logsheet data.