CASE STUDY[1]

SHARK AND RELATED SPECIES CATCH IN TUNA FISHERIES OF THE TROPICAL WESTERN AND CENTRAL PACIFIC OCEAN

Peter G. Williams
Oceanic Fisheries Programme
South Pacific Commission
B.P. D5, Noumea CEDEX
New Caledonia

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Abstract

The tropical waters of the western and central Pacific Ocean currently support the largest industrial tuna fishery in the world with an annual catch approaching one million metric tonnes. The two main gear types, longline and purse seine, currently account for over ninety percent of the target tuna catch in this area.

A variety of elasmobranch species is taken as by-catch in these two fisheries, with at least 16 species of sharks and rays regularly encountered in longline sets and at least 10 species of sharks and rays encountered in purse seine sets, according to recent observer-collected data. The most prevalent species found in longline sets are blue shark (*Prionace glauca*), silky shark (*Carcharhinus falciformis*), pelagic stingray (*Dasyatis violacea*), and the oceanic whitetip (*C. longimanus*). The most prevalent species found in purse seine sets are silky shark (*Carcharhinus falciformis*) and the oceanic whitetip (*C. longimanus*).

Some indication of the exploitation of shark in these tuna fisheries is available from observer data, but the observer coverage is presently too low to be able to apply any robust stock assessment procedures. Shark catch reporting via logsheets suffers from the inevitable problems of non-reporting and species mis-identification, and therefore this form of data collection is not a viable option at this stage. Estimates of nominal catch rates, distribution, survival rates and size composition of the shark species taken in these fisheries have been summarised from observer data and are presented. Observer and anecdotal data provide some indication of market preferences and the economics of shark products.

There has yet to be consideration of shark management in tropical tuna fisheries of the western and central Pacific Ocean, as economic factors have primarily dictated the management of the tuna fishery to this point in time. The information and procedures that are likely to be used in any future management planning process are described, and some suggestions that may be considered in any future review of shark by-catch management are also offered.

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Contents

1. INTRODUCTION

The western and central Pacific Ocean (WCPO) currently supports the largest industrial tuna fishery in the world, with an estimated catch in 1996 of 873,699 t in the SPC statistical area alone (Figure 1; Lawson 1997a); most of the catch volume is taken by the purse seine gear (around 80%), but purse seine (44%) and longline (48%) share a similar portion of the landed catch value (FFA, 1997). The bulk of the fishing effort is undertaken in the tropical areas of the WCPO, an area referred to in this study as the tropical western and central Pacific (WTP).

The WCPO tuna fisheries are described in detail in a number of documents produced by the Oceanic Fisheries Programme (OFP) of the South Pacific Commission (SPC), for example, Bailey et al. (1996) and Lawson (1997a).

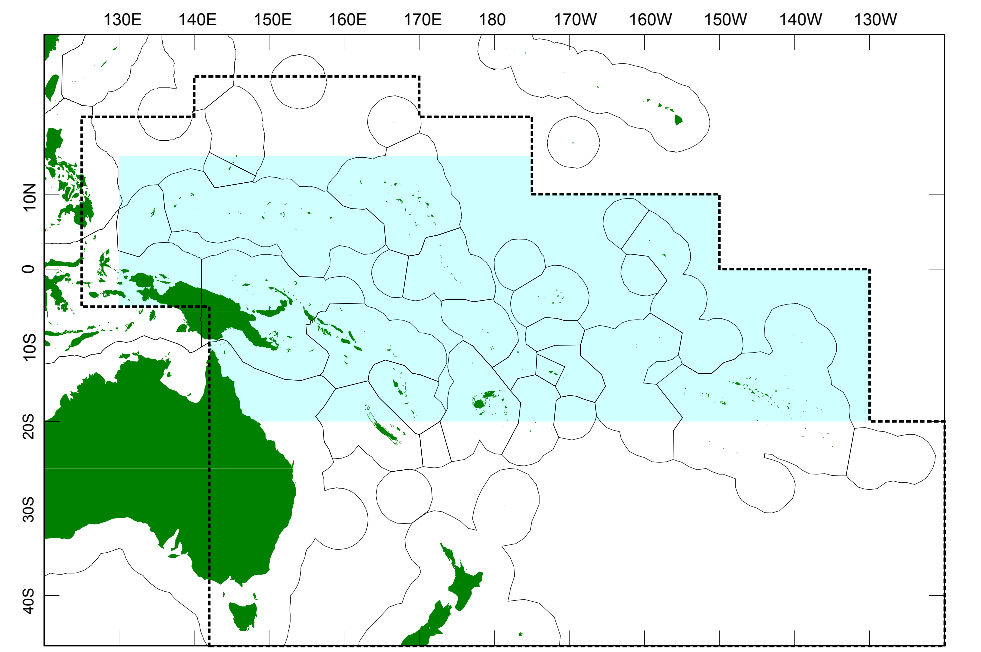

Figure 1. The western and central Pacific Ocean, showing the SPC statistical area (dashed line) and the tropical western and central Pacific (shaded), which is referred to in this study as the 'WTP'.

Elasmobranch species (sharks and related forms) are invariably taken as by-catch in the WCPO tuna fisheries. The need for more reliable information on the amount of elasmobranch by-catch in these fisheries has only recently grown in importance with, for example, the specific mention of by-catch monitoring in the *Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stock*. Unfortunately, most of the information on shark by-catch in the tuna longline fishery, which dates back to the 1950s, is only available from recent data collection.

As a consequence of concern expressed on the lack of knowledge of the exploitation of all by-catch species in the WCPO tuna fisheries, the OFP conducted a review of by-catch based on data holdings and literature (SPC 1991). The results of this study were peer reviewed at successive annual meetings of the SCTB (Standing Committee on Tuna and Billfish) held in 1993, 1994 and 1995, and the report was recently published (Bailey et al. 1996).

The general conclusions of this review were that insufficient information was available to accurately determine the levels of any by-catch species in the WCPO tuna fisheries. However, the review did conclude that sharks were one of the main by-catch categories in the WCPO longline fisheries, according to observer data collection. The review further outlined the problems encountered in the logbook reporting (i.e. widespread non-reporting of shark catch) and suggested that, due to difficulties in enforcing the reporting of shark catch on logbooks and inevitable problems with species misidentification, observer data collection would be the only reliable means of obtaining indications of the shark by-catch at the species level in the future.

Observer programmes have only recently gained prominence in the WCPO tuna fisheries. Prior to 1990, only two compliance-related observer programmes were operational in the tropical waters of the WCPO (i.e. the WTP); both programmes have since become more involved in scientific data collection.

The establishment in 1995 of a five year European Union (EU)-funded project operating in association with the work programme of the OFP, the *South Pacific Regional Tuna Resource Assessment and Monitoring Project (SPRTRAMP)*, has seen an increase in observer activities throughout the region. With assistance from SPRTRAMP, national observer programmes have been established in Fiji, Marshall Islands, Papua New Guinea, Palau and the Solomon Islands in recent years and further national programmes are expected in the future.

There is currently no regional management regime that brings together the coastal states and fishing nations involved in the WTP tuna fisheries, although discussions related to the establishment of such an arrangement are currently taking place in ongoing multi-lateral high-level and related technical consultations. Nevertheless, much research on the status of WTP tuna stocks has been undertaken and the consensus that the WTP tuna stocks are generally in a healthy state (SPC, 1997) has meant that there has yet to be any biologically-driven management measures introduced in these fisheries. However, with the growing importance of by-catch monitoring in the WCPO tuna fisheries, some consideration of management measures may occur in the future, as provided for in the United Nations Implementing Agreement (UNIA).

2. THE RESOURCE

The target species of the tropical western and central Pacific Ocean (WTP) tuna fisheries are skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*) and bigeye (*Thunnus obesus*). Skipjack tuna comprise the bulk of the WCPO tuna catch, and the largest component of the resource. The smallest of the four main tuna species, they are fished as surface schools by pole-and-line and purse seine gears, year-round in equatorial areas and seasonally in more temperate waters. Yellowfin tuna also occur with skipjack as juveniles in surface schools, where they are also taken by purse seine and pole-and-line gear. Larger yellowfin (>20 kg) inhabit both surface and deeper waters, down to the thermocline, and are captured by both longline and purse seine gears. Bigeye tuna have a similar distribution to yellowfin, occurring to some extent as juveniles at the surface with skipjack and yellowfin, but deep-swimming as adults, and with the lowest water temperature preference (11–15°C) of the three species considered.

Pelagic sharks and rays are a common by-catch of the WTP longline and purse seine fisheries, but very few data have been collected at the species level to enable insights into their distribution and abundance to the level that has been achieved for the target tuna species in the WTP. Observer data collection has provided a breakdown of elasmobranch species taken in these fisheries, with at least 16 species observed in the longline fishery (Table 1) and at least 10 species observed in the purse seine fishery (Table 2).

Table 1: Sharks and rays encountered in WTP longline sets, based on observer data.

Common name	*Scientific name*
Pelagic thresher shark	*Alopias pelagicus*
Bigeye thresher shark	*A. superciliosus*
Silvertip shark	*Carcharhinus albimarginatus*
Grey reef shark	*C. amblyrhynchos*
Silky shark	*C. falciformis*
Oceanic whitetip	*C. longimanus*
Blacktip shark	*C. limbatus*
Whip stingray	*Dasyatis akajei*
Pelagic stingray	*D. violacea*
Tiger shark	*Galeocerdo cuvier*
Short-finned mako	*Isurus oxyrinchus*
Long-finned mako	*I. paucus*
Manta rays	Mobulidae
Blue shark	*Prionace glauca*
Crocodile shark	*Pseudocarcharias kamoharai*
Hammerhead shark	*Sphyrna* spp.

Table 2: Sharks and rays encountered in WTP purse seine sets, based on observer data.

Common name	*Scientific name*
Pelagic thresher shark	*Alopias pelagicus*
Silvertip shark	*Carcharhinus albimarginatus*
Oceanic whitetip	*C. longimanus*
Silky shark	*C. falciformis*
Tiger shark	*Galeocerdo cuvier*
Short-finned mako	*Isurus oxyrinchus*
Long-finned mako	*I. paucus*
Manta rays	Mobulidae
Blue shark	*Prionace glauca*
Crocodile shark	*Pseudocarcharias kamoharai*

2.1 Species composition

Catch logsheet reporting of shark has several problems and cannot be considered as a reliable source of shark catch data to the species level at this stage (Bailey et al. 1996). As such, the only reliable information currently available on the species composition of shark taken in WTP tuna fisheries is data collected by observers. The level of observer coverage is currently limited, but some indications of species composition are nonetheless apparent.

Figures 2 and 3 show the species composition of sharks and rays encountered in the WTP longline and purse seine fisheries, respectively.

The available data suggest that the catch rates of the main shark and ray species (blue shark, silky shark, pelagic stingray and oceanic whitetip) are substantially less than the rates of target tuna species taken in the WTP longline fishery.

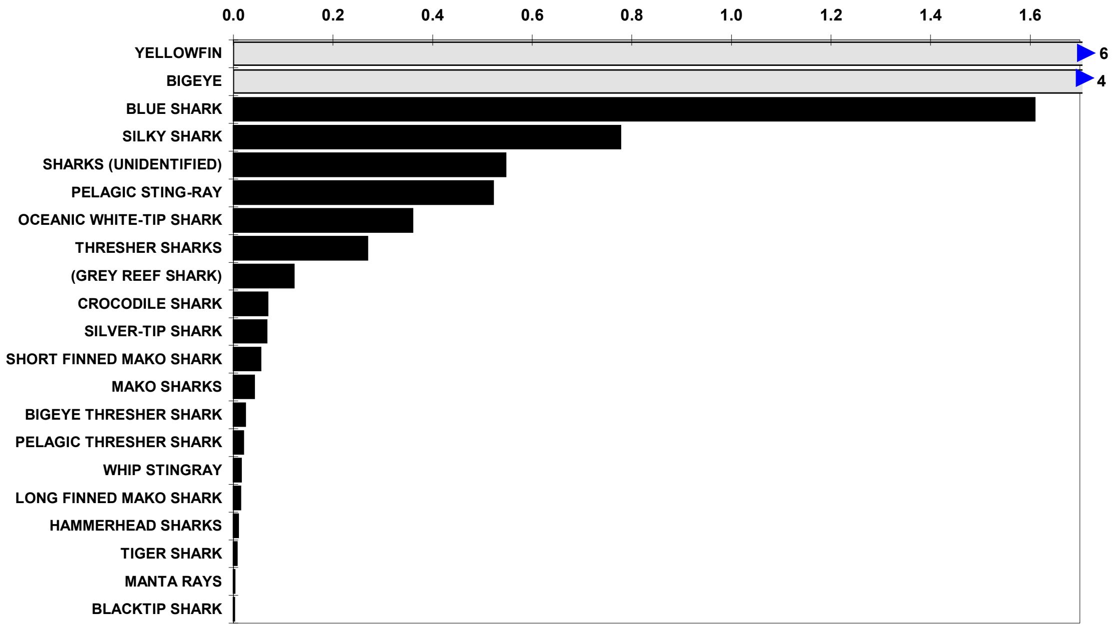

Figure 2. Nominal catch rates (fish per 1,000 hooks) of sharks and rays taken in the WTP longline fishery based on available observer data (1993–1997).

Notes

1. Nominal catch rates of target tuna species have been included;
2. Sharks and rays observed but not identified to the genus or species level have been included;
3. The coverage of observer data is less than 1% of longline activity in the WTP.
4. The observations of the grey reef shark (*C. amblyrhynchos*) are believed to be misidentification of the silky shark (*C. falciformis*) in most cases, but are yet to be confirmed.

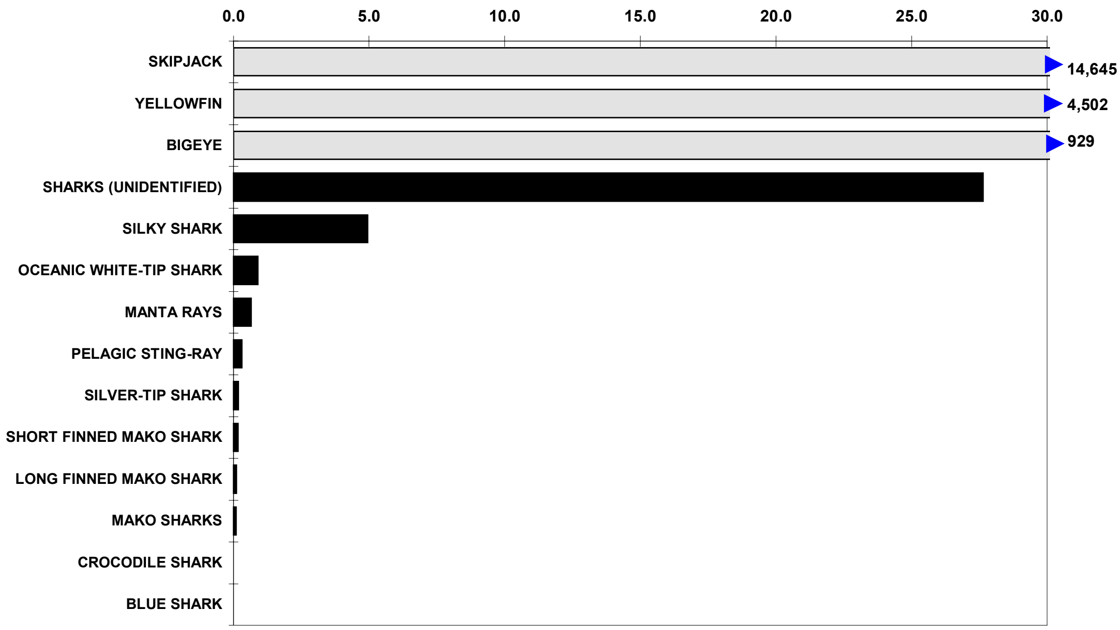

Figure 3. Nominal catch rates (kg of fish per set) of sharks and rays taken in the WTP purse seine fishery based on available observer data (1994–1997).

Notes

1. Nominal catch rates of target tuna species have been included;
2. Sharks and rays observed but not identified to the genus or species level have been included;
3. The coverage of observer data is considered to be less than 3% of overall purse seine activity.

Blue shark were by far the predominant shark species observed throughout the WTP longline tuna fishery, but the level of catch (Figure 2: 1.6 blue shark per 1,000 hooks) is significantly less than that reported in temperate longline fisheries. For example, a catch rate of 10.4 blue shark per 1,000 hooks was calculated from data collected by observers monitoring vessels in the southern bluefin tuna (*Thunnus maccoyii*) fishery off the south-east coast of Australia (Stevens 1992).

Catch rates from observer data suggest that, for the WTP longline fisheries, silky shark are taken at about half the rate as blue shark, and oceanic whitetip are taken at about one quarter the rate of the blue shark.

The predominant shark species observed in the WTP purse seine fishery were the silky shark and the oceanic whitetip shark. However, earlier observer work did not give priority to shark species identification and hence the shark species breakdown in the purse seine fishery is less clear than in the longline fishery at this stage. Nonetheless, it is apparent that only a very small percentage of the purse seine catch is made up of shark (around 0.15% by weight, according to observer data), which is a much lower rate per operation than for longline gear. The breakdown of shark species taken in the WTP purse seine fishery provides an interesting comparison with shark taken in the eastern Pacific Ocean (EPO) purse seine tuna fishery (Hall and Williams 1997). There are no observer reports of the blacktip shark (*Carcharhinus limbatus*) in WTP purse seine fisheries, but this species is by far the most commonly encountered shark in the EPO purse seine fishery. The catch rate for sharks, in general, appear to be higher in the EPO than in the WTP purse seine fishery.

2.2 Distribution of fishery

2.2.1 Distribution of WTP tuna fisheries effort

The WTP longline fishery (Figure 4) forms the major part of the WCPO longline fishery, with a tendency for the more temperate longline fisheries south of the WTP to target albacore (*Thunnus alalunga*) and, south of 30°S, southern bluefin tuna (*Thunnus maccoyii*). These temperate fisheries include the waters of Australia and New Zealand, where more control over fishery data collection has been exerted; available information on shark by-catch from the temperate-water longline fisheries (e.g. Stevens, 1992) offers interesting and useful comparisons to the shark by-catch in the adjacent WTP longline fisheries (see section '4.3.1 Measures of abundance').

The WCPO purse seine fishery is almost exclusively confined to warmer waters of the WTP (Figure 5).

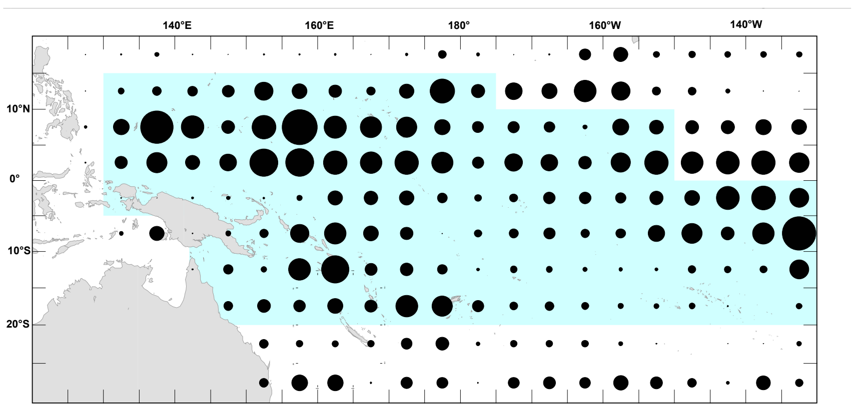

Figure 4. Distribution of longline effort throughout the western and central Pacific Ocean (1993–1997), showing the WTP area (shaded) referred to in this study.

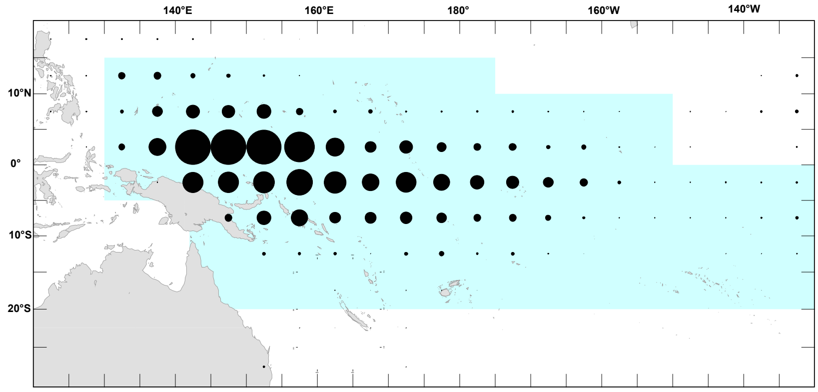

Figure 5. Distribution of purse seine effort throughout the western and central Pacific Ocean (1993–1997), showing the WTP area (shaded) referred to in this study.

2.2.2 Distribution of shark taken in WTP tuna fisheries

Observer data provide some indication of the distribution of the main pelagic shark species encountered in the WTP tuna fisheries, despite a poor coverage of overall fishing effort. Figure 6 shows the incidence of blue shark, silky shark, oceanic whitetip, the two species of thresher and the two species of mako sharks encountered in the WTP tuna fisheries. The three main pelagic species (blue shark, silky and oceanic whitetip) appear to be prevalent in most areas where observer activities have covered the fisheries to this point in time. Observer data collection in the future will undoubtedly shed more light on the relative distributions of the two species of thresher and the two species of mako shark, for which there is insufficient information at present.

It is expected that this type of information will eventually provide an update to authoritative works (i.e. Compagno 1984; Last and Stevens 1994) which deal with, *inter alia*, the distribution of shark species throughout the Pacific Ocean.

2.3 Characteristics of the WTP tuna fisheries

2.3.1 The harvesting process

The **longline** tuna fisheries are spread over most of the WCPO (Figure 4), and consist of two basic categories of fishing vessel: the larger *distant-water* vessels that fish far from home ports for periods typically from 3–6 months, but often longer, and the smaller *offshore* vessels, which have established base ports in Pacific island countries and undertake trips which are usually 1–2 weeks. The main distinction between these two categories is the method of catch storage: the *distant-water* vessels supply frozen fish for the normally lower-priced markets, while the *offshore* fleets supply fresh/chilled fish for the higher-priced sashimi markets. In the tropical waters, bigeye and yellowfin tuna are the target species; while in the sub-tropical waters, albacore are an important additional or primary target catch.

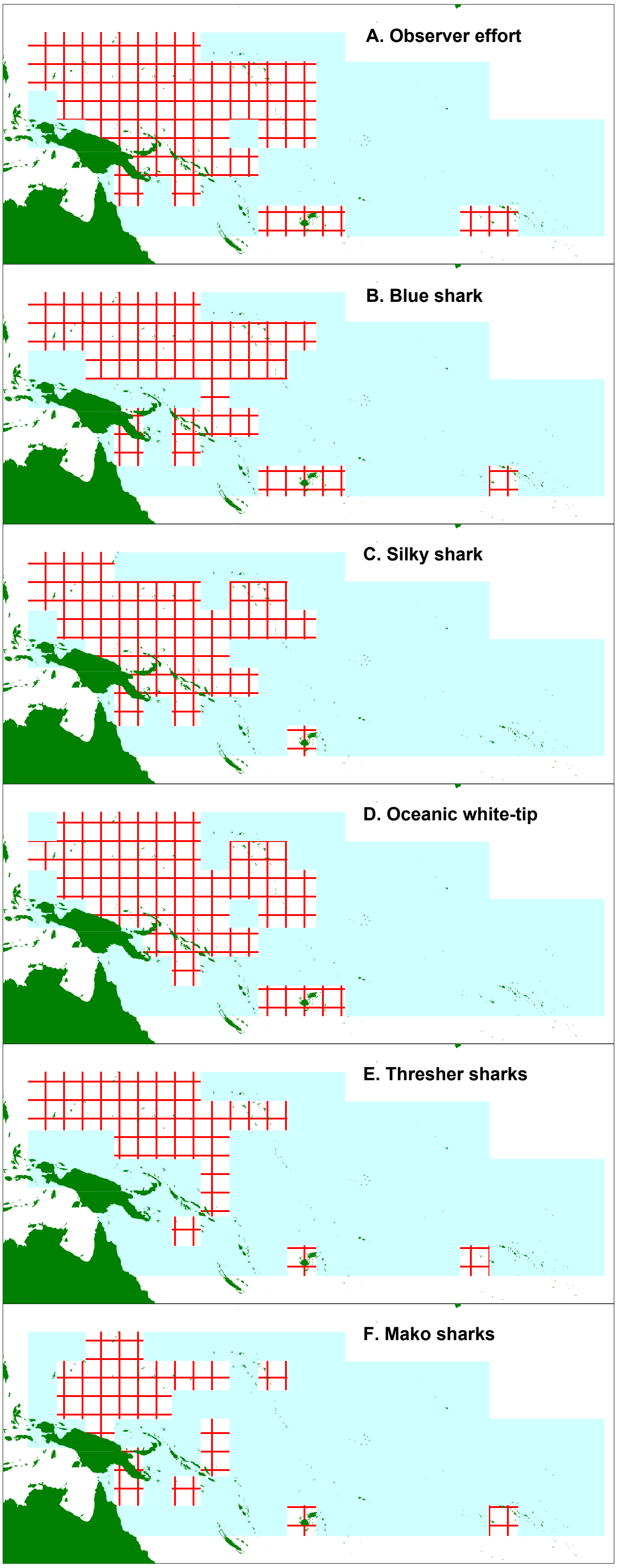

Figure 6. Incidence of (a) observer effort, (b) blue shark, (c) silky shark, (d) oceanic whitetip shark, (e) thresher shark and (f) mako shark catch in WTP tuna fisheries, based on observer data.

The **purse seine** tuna fishery operates almost exclusively in the tropical waters (WTP) of the WCPO, from approximately 120°E to about 155°W (Figure 5). Purse seine vessels set on skipjack and yellowfin schools that have formed 'associations' with floating objects, such as logs and other naturally occuring debris, man-made Fish Aggregation Devices (FADs), and dead whales; tuna schools swimming with live animals, such as whales and whale sharks, also occur. Sets are also made on tuna schools not associated with floating objects or other animals; these may be unassociated or free-swimming schools that are usually feeding on baitfish or schools associated with geographic features such as seamounts and islands, or with oceanographic features such as current interfaces and areas of upwelling. The breakdown of purse seine sets by school type based on catch logsheet data across all fleets for 1996 is: unassociated–50%; log associated–34%; FAD associated–14%; animal associated–1%; other and unspecified associations–1%.

Sharks, as with other by-catch species, are taken in both fisheries in the same manner as the target tuna species. However, there has been one recent observer account of a longline vessel that set specially baited lines tied to the floats in order to catch shark. The extent of this practice is currently not known, but is considered to be a rare event given the additional effort involved and the economics when compared to the return expected from target tuna catch.

2.3.2 Evolution of the catch

Figure 5 shows a time series of the total tuna catch in the SPC statistical area providing some indication of the evolution of the WCPO tuna fisheries. Prior to 1970, the longline fishery was prominent with the highest historical longline catches taken during the late 1950s and early 1960s (Lawson 1997a). Few historical data are available on the catch of shark in the WCPO tuna fisheries and the data that are available were not broken down into shark catch by species due the lack of provision for shark species catch on past logbook formats (Bailey et al. 1996). As such, there is no indication of the historical exploitation of shark at the species level.

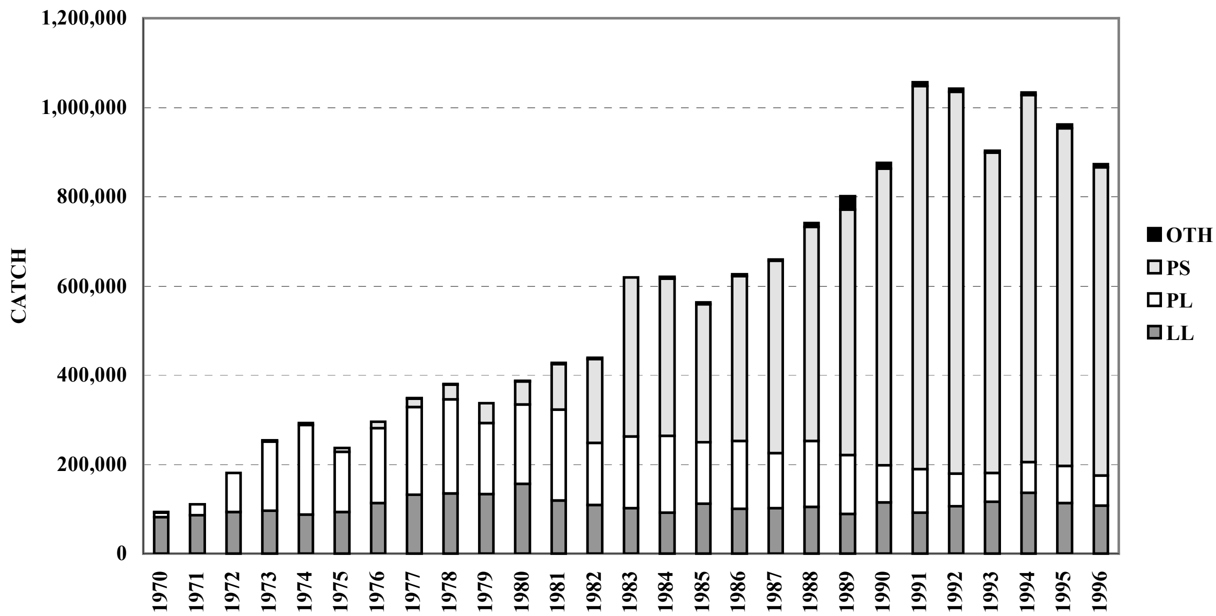

Figure 5. Annual tuna catches (metric tonnes) by longline (LL), pole-and-line (PL), purse seine (PS) and other gear types (OTH) in the SPC statistical area (Lawson 1997a)

2.3.3 Fleet characteristics, evolution of the fleet and fishing effort

Several OFP publications (e.g. Lawson 1997a; Bailey et al. 1996) provide a background to the evolution of WTP longline and purse seine fisheries. Japanese longline vessels have been active in the WTP since the early 1950s and were the dominant fleet of all WTP tuna fisheries well into the 1970s. During the 1970s, Korean and Taiwanese fleets became established in the longline fishery, and pole-and-line activities became more pronounced throughout the region. The late 1970s and early 1980s saw the start of a dramatic increase in the purse seine fishery, which continued until the early 1990s. By contrast, in the years since the establishment of the purse seine fishery, there has been a gradual decline in the number of Japanese freezer vessels active in the WTP longline fishery. In more recent years, however, several new fleets (i.e. Taiwanese, mainland Chinese and domestic vessels), utilising smaller vessels and supplying the fresh sashimi tuna market, have entered the WTP longline fishery.

2.3.4 Factors affecting the catch of shark

Factors that are believed to have some bearing on the shark catch rate and shark species composition have been described in Bailey et al. (1996) and Hampton and Bailey (1993). In the longline fishery, various developments in gear technology and other targetting strategies are believed to play an important role in the level of shark catch. For example, the retention of shark taken with wire traces is understood to far outweigh the retention of shark by gear utilising monofilament traces; unfortunately, there is not enough information currently available to provide a quantitative description of this example. The type of bait used may also have some bearing on the level of shark catch.

A factor that appears to be significant to the amount of shark by-catch in the WTP longline fisheries is the depth of fishing. Suzuki et al. (1977) describes how the number of hooks set between floats can be used as a relative measure of depth of fishing. The late 1970s saw the beginnings of a gradual change in targetting methods in the WTP longline fisheries in order to capitalise on the higher price demanded for bigeye tuna, which are taken at a greater depth, over yellowfin tuna (Bailey et al. 1996). Table 3 shows the nominal catch rates for sharks and rays taken in the WTP longline fisheries, stratified by relative depth of fishing. These data clearly show that the main pelagic shark species tend to be taken at a higher rate by the

Table 3. Nominal CPUE of sharks and rays, by depth of fishing, taken in the WTP longline fisheries, based on observer data (1993-1997).

	DEEP		SHALLOW		Ratio of CPUE
Species	**N**	**CPUE**	**N**	**CPUE**	**Shallow vs Deep**
BIGEYE THRESHER SHARK	3	0.003	31	0.067	**21.2**
(GREY REEF SHARK)	41	0.043	128	0.278	**6.4**
SILKY SHARK	271	0.287	841	1.829	**6.4**
PELAGIC THRESHER SHARK	7	0.007	21	0.046	**6.2**
HAMMERHEAD SHARKS	5	0.005	10	0.022	**4.1**
OCEANIC WHITETIP SHARK	221	0.234	301	0.654	**2.8**
BLUE SHARK	989	1.047	1296	2.818	**2.7**
CROCODILE SHARK	47	0.050	53	0.115	**2.3**
PELAGIC STINGRAY	497	0.526	255	0.554	**1.1**
SILVER-TIP SHARK	69	0.073	29	0.063	**0.9**
MANTA RAYS	3	0.003	1	0.002	**0.7**
TIGER SHARK	8	0.008	2	0.004	**0.5**
SHORT FINNED MAKO SHARK	68	0.072	11	0.024	**0.3**
LONG FINNED MAKO SHARK	19	0.020	2	0.004	**0.2**
WHIP STINGRAY	23	0.024			

Notes

1. CPUE is expressed in number per 1,000 hooks.
2. Depth of fishing is determined from the number of hooks between floats, where available : "Shallow" – 1-9 hooks between floats; "Deep' – >= 10 hooks between floats.
3. The observations of the grey reef shark (*C. amblyrhynchos*) are believed to be misidentification of the silky shark (*C. falciformis*) in most cases, but are yet to be confirmed.

shallow-geared longline vessels than the deep-geared vessels.

There are factors in the WTP purse seine fishery that are also significant to the level of shark by-catch (Bailey et al. 1996), the most obvious being the type of school association that targeted tuna have established prior to any fishing activity. Table 4 shows that several shark species, as with other large pelagic predators (e.g. billfish), are more prevalent in the vicinity of logs and other floating objects that have 'aggregated' communities of baitfish and predatory tuna schools, than around schools of tuna that are 'free-swimming' and not associated with floating objects (i.e. 'unassociated schools'). Based on these preliminary data, it appears that oceanic whitetip shark, manta ray, pelagic stingray (and probably blue shark) are less common around associated schools than the other shark species encountered in purse seine sets.

Table 4. Nominal CPUE of sharks and rays, by tuna school association, in the WTP purse seine fishery, based on observer data (1995-1997).

Species	Unassociated schools CPUE (N=700 sets)	Associated schools CPUE (N=688 sets)	Ratio of CPUE Assoc. vs Unassoc
SHORT FINNED MAKO SHARK	0.000	0.498	+
LONG FINNED MAKO SHARK	0.000	0.309	+
MAKO SHARKS	0.000	0.260	+
CROCODILE SHARK	0.000	0.031	+
BLUE SHARK	0.000	0.004	+
SILVER-TIP SHARK	0.006	0.497	85.2
SILKY SHARK	1.230	11.882	9.7
OCEANIC WHITETIP SHARK	0.980	0.806	0.8
MANTA RAYS	0.740	0.423	0.6
PELAGIC STINGRAY	0.493	0.102	0.2

Notes

1. CPUE is expressed in kilograms per set.
2. '+' indicates that this species was taken in associated sets, but not encountered in unassociated sets.
3. This table uses only data collected by observers who could reliably identify sharks to the species level.

2.3.5 Fate of shark taken in the WTP longline fisheries

Observer accounts show that the fate of sharks and rays varies from fleet to fleet, from vessel to vessel within the same fleet, and may even vary within the same vessel trip. The fate of shark taken in WTP longline fisheries is certainly more complicated that the common belief that all sharks have their fins removed and the trunks discarded. Table 5 provides some indication of the fate of sharks and rays encountered in the WTP longline fishery, according to observer data. Certain species (e.g. pelagic stingray) clearly have no economic value at all and hence are discarded whole. The fate of other shark species provides some insight into their economic value, with, for example, the trunk of the silky shark (retained in 45.8% of observed catches) apparently more valuable than the trunk of blue shark (retained in only 5.4% of observed catches). However, there have been reports that discarding practices may not be related to the species of shark taken and may change from day to day, for example, when storage space becomes critical towards the end of a trip.

Anecdotes from observers suggest a variety of uses for the retained shark trunks. Several accounts describe how the trunks of shark were retained and prepared for crew consumption. Two extreme examples of this were one report that described the preparation of a pelagic stingray as sashimi for crew consumption, and another account describing how the skins of oceanic whitetip shark and silky sharks were retained and prepared as a delicacy for the crew. On longline vessels carrying live bait (i.e. milkfish, *Chanos chanos*), some of the retained shark trunks were prepared as a food supplement for the bait, and there were a number of accounts of shark being stripped and salted, and used for bait later in the trip. These reports suggest that there are a variety of on-board uses for retained shark trunks which appear to be fleet- and even vessel-dependent; an indicative breakdown for the entire fishery would be difficult at this stage.

Table 5. The fate of the sharks and rays taken in the WTP longline fisheries, based on observer data (N = 946 sets).

Species	Number of observations	% Shark / ray retained	% Escape d	% Fins only retained	% Discarded undesirable species	% Struck off before landing	% Discarded shark damage	% Discarde d difficult to land	% Discarded other reason
BLUE SHARK	2359	5.4	0.7	84.1	0.9	3.9	0.1	2.2	2.7
SILKY SHARK	1140	45.8	1.2	47.5	0.4	0.4	0.1	1.0	3.5
PELAGIC STINGRAY	765	1.4	0.0	0.1	60.0	36.9	0.0	0.1	1.4
OCEANIC WHITETIP SHARK	527	32.8	0.2	61.7	1.3	2.3	0.2	0.2	1.3
CROCODILE SHARK	101	2.0	0.0	5.0	69.3	18.8	2.0	1.0	2.0
SILVER-TIP SHARK	98	21.4	0.0	11.2	56.1	10.2	0.0	0.0	1.0
SHORT FINNED MAKO SHARK	80	26.3	1.3	70.0	1.3	0.0	0.0	1.3	0.0
BIGEYE THRESHER SHARK	35	31.4	0.0	62.9	0.0	0.0	0.0	5.7	0.0
PELAGIC THRESHER SHARK	29	27.6	0.0	62.1	6.9	0.0	3.5	0.0	0.0
WHIP STINGRAY	23	0.0	0.0	0.0	8.7	82.6	4.4	4.4	0.0
LONG FINNED MAKO SHARK	21	0.0	0.0	85.7	14.3	0.0	0.0	0.0	0.0
HAMMERHEAD SHARKS	15	20.0	13.3	60.0	6.7	0.0	0.0	0.0	0.0
TIGER SHARK	10	0.0	0.0	70.0	30.0	0.0	0.0	0.0	0.0
MANTA RAYS	4	0.0	0.0	0.0	75.0	25.0	0.0	0.0	0.0
BLACKTIP SHARK	3	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0

2.4 Markets for shark taken in WTP tuna fisheries

Several documents provide information on the markets of shark fins sourced from the Pacific Islands (e.g. Ferdouse 1997). It is presumed that shark fins have been utilised since the inception of the longline fishery, with the south-east Asian markets the predominant recipients of the shark-fin product. In contrast, there are very few data available on the marketing of shark trunks, a fact related no doubt to their very low economic value relative to the shark fin product.

Shark fin exports from the WTP tuna fisheries eventually end up in the lucrative markets of Hong Kong, Singapore and Malaysia. No information was found to suggest any end-user market in the Pacific Islands, and it is understood that the product is either sent on to these market centres through agents based in ports of Pacific Island countries, or offloaded from Asian fishing vessels on return to their home country.

Recent efforts have been made to increase awareness throughout the Pacific Islands of quality control in processing and handling, and market background of the shark fin product in the hope that the coastal states may become more involved in this area in the future.

The fins of several shark species are known to be more valuable than those of other species–the fins from hammerhead shark, for example, are highly valued (Ferdouse 1997). Some indication of the relative market importance of shark fins and trunks can be gained from the fate of shark species at time of landing (Table 5). This information also shows clearly that the trunks of some shark species (e.g. silky shark) are obviously more valuable than others (e.g. blue shark). The market for shark trunks, when retained, is not that well known. One account described how shark trunks were held in on-shore cold storage in one Pacific Island port prior to shipment to Korea, but no information was available on the processing and end-product (S. Roberts pers. comm.).

Observers have reported instances where the jaws of tiger and mako sharks have been extracted and prepared for local markets, but this practice is believed to be rare. Observers have also reported the skinning of certain shark species, but no information on a market for the skins was forthcoming. As expected with pelagic shark species, there were no observer reports of shark liver utilisation.

2.5 Economics related to shark by-catch in the WTP tuna fisheries

Some anecdotal information on the revenue obtained from shark fins taken in WTP tuna fisheries are available from observers. Ferdouse (1997) provides a good breakdown of reference and retail prices for shark fins in the south-east Asian markets.

The prices paid to crews for shark fins, according to observers, vary depending on the species of shark, but more importantly, seem to relate to the degree of care taken in removing, processing and storage of the fins prior to sale. For example, the 'moon' cut (Trachet et al. 1990) and well dried shark fins command higher prices than the shark fins that have been merely sliced off the trunk without further processing or have not been sufficiently dried.

Several observer reports highlight the gap between prices paid for shark fins and shark trunks. One observer reported that shark trunks had netted the vessel US$300 per tonne (mainly silky and oceanic whitetip shark) which is more than two orders of magnitude lower than the price paid for an equivalent weight of shark fins. It was reported that the crew of another vessel had shared only 15% of the proceeds gained from the marketing of shark trunks while they shared 100% of the proceeds from shark fins. Some reports suggest that shark fin revenue can double the normal wage of some crews.

3. MANAGEMENT OBJECTIVES

Several international fora have identified the requirement for management of highly migratory fish stocks and straddling fish stocks to be conducted at the international level (UNIA). A management structure, similar to that of international organisations dealing with tuna fisheries in other oceans of the world, does not exist for the western and central Pacific Ocean, but steps are currently being taken to develop an international conservation and management arrangement for highly migratory fish stocks (tunas in the first instance) in the WCPO.

To date, regional coordination of WCPO tuna fisheries management has been confined to the Pacific Island countries in whose waters most of the fishing takes place, and who constitute the membership of the Forum Fisheries Agency (FFA), the regional body given the task of providing advice on economic, legal, and surveillance monitoring aspects of the WCPO tuna fisheries. The OFP of SPC, with its mandate to provide technical advice and assistance to the Pacific Island member countries, is responsible for the collection, processing and analyses of data from the WCPO tuna fisheries, and for the provision of scientific advice regarding the status of the target tuna and related stocks.

Analyses conducted by SPC scientists over the past 20 years suggest that target tuna stocks remain in a generally healthy state (OFP 1997b). As such, there have yet to be any management measures restricting WTP tuna fisheries based on biological factors. In contrast, there has been some reduction in fleet numbers in recent years, driven by more economic-related constraints (e.g. see FFA 1997).

Management objectives in the WTP tuna fisheries to date have been primarily involved with maximising the economic benefits of the tuna fisheries to Pacific Island countries. There has yet to be any consideration of specific objectives relating to the management of the shark taken in WTP tuna fisheries.

4. MANAGEMENT PLANNING PROCESS

4.1 Provision of resource management advice

For the past ten years, information on the resources exploited in the WCPO tuna fisheries has been compiled by the Standing Committee on Tuna and Billfish (SCTB) and other related sub-committees. This group brings together representatives from the Pacific Islands and distant-water fishing nations for an informal scientific meeting every year to discuss various scientific aspects of the WCPO tuna fisheries. Topics of the SCTB primarily concern the status of the target tuna stocks, but more recently have included issues related to by-catch in the fishery. Research deemed necessary by the group is usually undertaken by, or on a collaborative basis with, OFP research scientists. The scientific advice based on research work conducted by the OFP is then usually made available to the Forum Fisheries Agency, or directly to national fisheries offices, for subsequent consideration.

4.2 Fisheries Statistics

The collection of appropriate data from the WCPO tuna fisheries has been a long-term priority of the OFP. Since the its inception in 1981, the OFP has maintained catch and effort, tagging, size composition and, more recently, observer databases; these databases have been used extensively by research scientists conducting tuna stock assessment analyses, and have been made available for other related activities, for example economic analyses of the fisheries.

In recent years, a dedicated effort has been made to standardise tuna fisheries data collections forms throughout the region (SPC 1997a).

4.2.1 Methods used for collection of catch and effort data

Two methods of data collection cover the monitoring of shark by-catch in WTP tuna fisheries: catch logsheets submitted by the fishing vessel, and data collected by observers.

The regional standardised catch logsheet forms for both longline and purse seine include provision for recording shark catch, by species, in numbers and weight, and the number of shark discarded at the fishing operation level. Catch logsheets are issued by the coastal states which form bilateral arrangements with fishing nations for access to their exclusive economic zones; there is also one multilateral arrangement currently in force that allows US purse seine vessels to fish throughout the region. However, while there is a requirement to provide accurate details for the target tuna catch, it has been difficult to enforce the reporting of shark catch, and with major problems such as the inevitable grouping of shark species under the one heading ‘shark’, it is considered that shark catch data collected from logsheets, at this stage, are unusable.

Scientific observers are trained to collect catch and effort data from longline and purse seine vessels operating in the region. Unlike logbook data collection, observers collect very detailed information on the components of fishing effort and individual catch from each fishing operation. Table 6 shows the type of effort and catch information collected by observers onboard longline vessels and Table 7 shows the type of information collected onboard purse seine vessels. In order to gain adequate information to perform necessary stock assessment of shark species in the future, some work will be involved in determining, and then achieving, representative observer coverage of the WTP tuna fisheries.

Table 6. Observer data collected for each longline fishing operation

Effort information	Catch information
Detail of gear used by the vessel in the setting process. For example, all dimensions of the longline gear used in the set, bait species used and setting speed parameters.	Time when individual catch is taken and the hook number between successive floats that this catch was encountered.
Detailed positional and temporal information of the setting and hauling process.	Name of species (target and by-catch) encountered
Environmental conditions (e.g. sea temperature, sea condition, etc.) during the set and haul.	Length and weight of individual catch. Note that different length and weight measurements are taken depending on the species and the processing (fate) undertaken onboard.
	The fate of the catch. That is, whether the catch, or part of the catch, was retained or discarded, and the reasons for retaining or discarding the species catch.
	Life status (condition) of the individual catch at the time of landing.
	Sex of the individual catch.

Table 7. Observer data collected for each purse seine fishing operation

Effort information	Catch information
Detail of gear used by the vessel in the setting process	Name of species (target and by-catch) encountered
Detail of searching activity leading up to the fishing set.	Number and weight of species taken (methods are employed to estimate weight for catch which is typically measured in the metric tonnes for target tuna species)
Location of and time of the set	The fate of the catch. That is, whether the catch, or part of the catch, was retained or discarded, and the reasons for retaining or discarding the species catch.
Tuna school association information	Weight range of individuals in that species catch / fate combination. (for example, target catch may be discarded due to being too small).
Environmental conditions (e.g. sea temperature, sea condition, etc.)	Life status (condition) of the species catch. This is relevant for protected species, for example, marine reptiles and marine mammals.
Time taken for each sub-activity in the setting process	Size composition sample of the catch (Target and by-catch).

4.2.2 Evaluation of data collection process

There are inherent problems in the reliability of shark by-catch data collected via logsheets. Other than problems relating to difficulties in enforcing the reliable reporting shark catch on logsheets and the inevitable problems with species misidentification, there is another fundamental problem that prevents the appropriate collection of useful shark catch data on a major scale. Unlike the target tuna species, for which unloadings data are collected and used to verify catch logsheet data, the transfer of shark fins and trunks from vessel to the market and/or processing place is usually done on an informal basis and is neither regulated nor monitored to the degree that useful information has yet been obtained. It remains to be seen whether improvements in this area will eventuate in the future.

The observer data collection process is more controlled, and can readily be reviewed and modified as appropriate. Ongoing training, the provision of observer data collection forms, manuals and species identification guides are provided to national observer programmes by the OFP, fostering regional standardisation of the data collection. Ongoing review of national observer programmes throughout the region has been achieved by the placement of scientific observers employed by the OFP through SPRTRAMP in countries for the purpose of reviewing and advising on observer data collection matters. A distinct improvement in the identification of shark species by national observers in recent years has been the result of such initiatives. To ensure the integrity of the data collected, data from each observer trip are carefully screened and data quality indicators for fishing activity, target catch, by-catch and size composition are assigned as appropriate.

The centralisation of data collection and processing for the region at the OFP has tended to ensure better data quality control, although the timeliness in the provision of logsheet and, to a lesser extent, observer data has often been thwarted by delays in postal services throughout the region. Plans to utilise data transmission via satellite and internet services will no doubt solve these problems in the future.

Peer review of observer data collection protocols has been undertaken by organisations outside the region (e.g. the Inter–American Tropical Tuna Commission [I–ATTC] observer programme) and the benefits of this work is recognised and likely to be considered by the OFP in the future.

4.2.3 Data processing, storage and accessibility

All fisheries data are processed and stored in a state-of-the-art Relational Database Management System (RDBMS) named Microsoft Visual Foxpro (version 5.0). Fisheries data are generally processed at the OFP, but increasingly some data are also being processed in the national fisheries departments. Where data are processed in the fisheries departments of coastal states, the same data quality control checks used by the OFP have been implemented to ensure the integrity of the regional databases.

The policy regarding ownership of data provided to the OFP is straightforward: data provided to the OFP for research purposes are owned by the provider. As an example, the logsheet and observer data provided by coastal states of the region are owned by the coastal states, and unless prior authorisation has been given, release of their data by the OFP to third parties is not permitted. The situation is much the same when aggregated data are provided to the OFP by fishing nations, although there are a few examples where aggregated data from coastal states and fishing nations have been declared as public domain. A level of aggregation that normally satisfies release to third parties, without seeking prior authorisation from owners of the data, has been established at 5°x5° latitude/longitude grids by month.

4.3 Stock Assessment

There has yet to be any stock assessment conducted on shark species taken in the WTP tuna fisheries. Related assessment work conducted to date include Nakano and Watanabe (1992), who provide an assessment of the impact of high-seas drift-net fisheries on blue shark in an area adjacent to the WTP. Several documents provide preliminary catch estimates of the major shark species taken in Pacific Ocean tuna fisheries (e.g. Lawson 1997b; Stevens 1996), but have been based on the very few shark catch data collected to date.

4.3.1 Measures of stock abundance

Lawson (1997b) has developed procedures that provide catch estimates of shark species taken in the WTP tuna fisheries using observer data. However, the current low coverage of observer data mean that these estimates can only be considered preliminary and the results have therefore been retained in a confidential OFP Internal Report. Stevens (1996) provides estimates of pelagic shark catch for major species in the Pacific Ocean, and, while these appear to be the best information at hand, were based on limited data available on shark catches.

Matsunaga and Nakano (1996) looked at the species composition and catch rates of pelagic sharks taken by longline gear deployed from research vessels in, and adjacent to, the waters of the WTP. This study compared catch rates of certain pelagic shark species taken from two periods, 1967–1970 and 1992–1995, and found that the blue shark proportion did not vary significantly between the two periods. The increase in the thresher shark proportion and decline in oceanic whitetip proportion was thought to be related to the different depths of the gear used between the two periods. Their investigations further found that total shark catch rates have showed no trend over the period 1973–1993, inferring that blue shark, as the most abundant shark, has showed no trend between these two time periods.

Future consideration of measures of stock abundance will no doubt focus on the need for stock boundaries for the main pelagic shark species. Blue shark appear to be the widest ranging species (Compagno 1984; Stevens 1996), while recent observer data collected in the WTP tuna fisheries (Figure 5) suggest a need to review and update the ranges of silky shark, pelagic thresher and bigeye thresher, as described in Compagno (1984) and Last and Stevens (1994).

In further measuring abundance, consideration of factors that affect the catch of shark must also be taken into account. Bailey et al. (1996) lists depth of fishing, time of fishing (i.e. day versus night), oceanographic features, environmental factors and setting strategies as among some of the factors that should be considered in analyses of by-catch stock abundance. As an example, Table 3 shows the nominal CPUE of shark species by depth of fishing, clearly showing the apparent changes in abundance of some shark species with depth. This information tends to confirm the notion that most of the pelagic sharks species in the WTP longline tuna fisheries are more prone to shallow-geared vessels; the main exception being the mako sharks. Another factor that must be considered when standardising shark catch rates in measuring abundance is the use of wire or monofilament traces.

Various information relating to population assessments of shark species collected to date show that they typically exhibit relatively low fecundity, low natural mortality, slow growth and delayed sexual maturity compared to tropical tuna species. It is expected that these parameters will be applied with size composition data collected by observers to assess the state of shark species populations vulnerable to the tuna fisheries in the future. Figure 6 shows the current size composition data, collected by observers, available for the three main species of pelagic shark taken in the WTP longline fisheries. Table 8 shows the sex ratio of shark species taken by longline vessels in the WTP tuna fisheries. Without going into detail, these data offer an interesting comparison to similar data collected on blue shark catch from the longline fisheries operating in temperate waters adjacent to the WTP (i.e. off the south-east coast of Australia; Stevens 1992).

4.3.2 Biological advice review process

The biological advice review process for target tuna species is achieved through the work of the Standing Committee on Tuna and Billfish (SCTB), which meets on an annual basis, and through regular contact and review of the work conducted by scientists in other organisations dealing with tuna fisheries, both in the region and in other areas.

There has yet to be any consideration given to a biological review process for shark in WTP tuna fisheries, although it is likely to be included in the work of the SCTB Billfish and By-catch Research Group, to be established in June 1998.

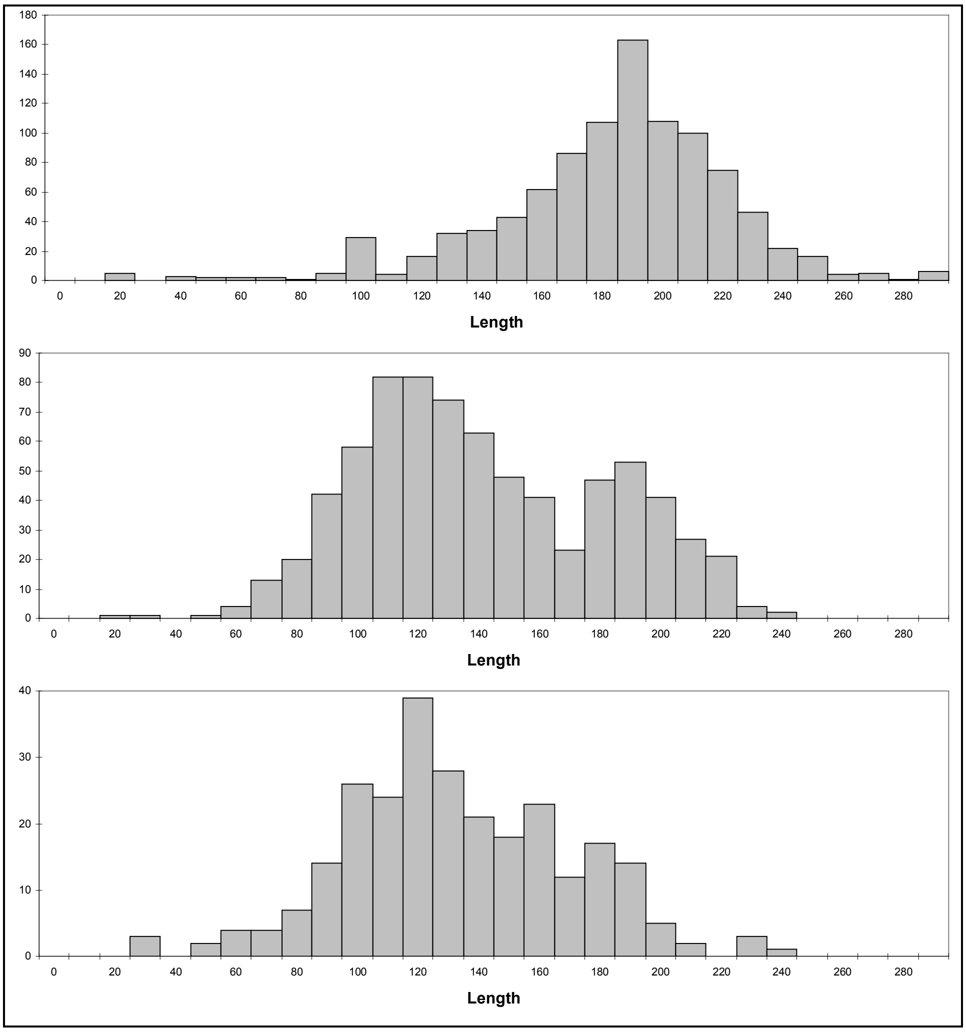

Figure 6. Size composition of BLUE SHARK (top), SILKY SHARK (middle) and OCEANIC WHITETIP SHARK sampled by observers active in the WTP longline fishery.

(Length is in 10cm size classes and was measured from the tip of snout to the end of the tail, i.e. "Total length").

4.3.3 Biological management reference points

Biological reference points for shark species taken in the WTP tuna fisheries have not yet been established.

4.3.4 Sustainability of the resource

There is currently insufficient information to determine the resource status of the shark species taken in the WTP tuna fisheries. The lack of historical shark catch data and the paucity of other relevant data (i.e. observer and tagging data) suggests that it will be some time before a good indication of the status of shark stocks in this area is available.

Table 8. Sex ratio of shark species taken in the WTP longline fisheries, based on observer data.

Species	Number of observations	% Male	% Female
BLUE SHARK	2359	42	27
SILKY SHARK	1140	39	44
OCEANIC WHITETIP SHARK	527	38	46
CROCODILE SHARK	101	24	5
SILVER-TIP SHARK	98	79	14
SHORT FINNED MAKO SHARK	80	30	45
BIGEYE THRESHER SHARK	35	11	63
PELAGIC THRESHER SHARK	29	28	55
LONG FINNED MAKO SHARK	21	24	48
HAMMERHEAD SHARKS	15	27	53
TIGER SHARK	10	70	0
BLACKTIP SHARK	3	100	0

Notes

1. Observations include instances where sex was not determined and/or not recorded.

5. FUTURE MANAGEMENT CONSIDERATIONS

It is likely that management objectives for the WTP tuna fisheries in the short–mid term will continue to focus on the target tuna stocks. However, increasing attention is likely to be given to by-catch (including shark) data collection and assessment. A sound basis for monitoring shark catch in the WTP tuna fisheries has now been established through observer data collection, but coverage needs to be increased to levels where reliable catch estimates for the major species can be determined. Also, reliable stock assessment will require further information on the population dynamics of most species.

Some suggestions that may be considered in future objective-setting processes for shark management in WTP tuna fisheries are offered :

- Given that shark taken in the WTP tuna fisheries are primarily pelagic species, international cooperation in management and research will be required, as is the case with the target tuna species;
- Enhance and sustain shark by-catch monitoring by observers, where necessary;
- Attempts should be made to gain more knowledge on the shark (fins and trunks) product-flow, that is, from the point of landing to the market place. This may involve introducing standardised data collection via observers;
- The Pacific Islands may seek to secure more of the commercial benefits derived from shark by-catch;
- There should be some investigation of the impacts that the introduction of certain measures to restrict the landing of shark in tuna fisheries are likely to have, before their implementation. For example, shark appear to be one of the more robust categories of fish taken in WTP longline fisheries (Table 9), but what are the ramifications of introducing measures that recommend the live-release of sharks taken in this fishery ? Also, what might be the

ramifications of recommending that longline vessels use monofilament traces instead of wire traces ?

Table 9. Survival rates of shark species taken in the WTP longline fisheries, based on observer data.

Species	Number of Observations	% Alive	% Dead
BLUE SHARK	2359	92	7
SILKY SHARK	1140	81	18
PELAGIC STINGRAY	765	87	7
OCEANIC WHITETIP SHARK	527	86	14
CROCODILE SHARK	101	74	26
SILVER-TIP SHARK	98	88	11
SHORT FINNED MAKO SHARK	80	78	21
BIGEYE THRESHER SHARK	35	66	34
PELAGIC THRESHER SHARK	29	83	14
WHIP STINGRAY	23	83	13
LONG FINNED MAKO SHARK	21	86	14
HAMMERHEAD SHARKS	15	87	13
TIGER SHARK	10	70	10
MANTA RAYS	4	75	25
BLACKTIP SHARK	3	100	0

Notes

1. Observations include instances where fish condition was not recorded.

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