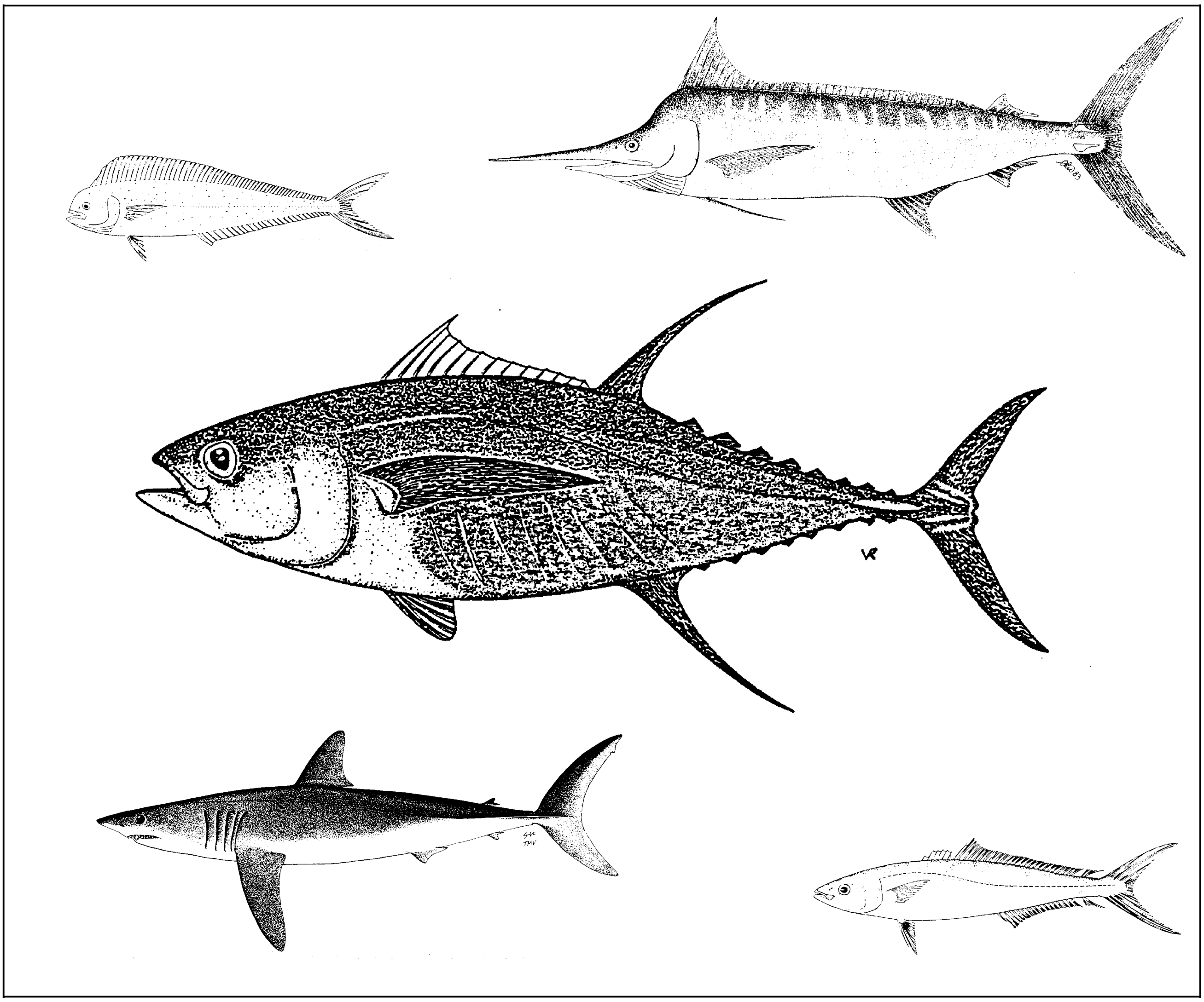
SOUTH PACIFIC COMMISSION
NOUMEA, NEW CALEDONIA

BY-CATCH AND DISCARDS IN WESTERN PACIFIC TUNA FISHERIES: A REVIEW OF SPC DATA HOLDINGS AND LITERATURE



Oceanic Fisheries Programme
Technical Report No. 34

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ABSTRACT

The western and central Pacific Ocean (WPO) currently supports the largest industrial tuna fishery in the world, with total annual catches from 1991 to 1994 of approximately 1,000,000 mt. The three gear types accounting for most of the catch in the area are longline, purse seine and pole-and-line. Large-mesh drift-net, handline and trolling gear have been utilised in some areas, but not to the extent of the above-mentioned gear types. The primary target species are skipjack, yellowfin, bigeye and albacore.

All of these fisheries invariably have some level of (i) discards of target species, (ii) retained by-catch, and (iii) discards of by-catch. This report attempts to document by-catch and discard practices in the fisheries through review of catch logsheet data, observer information, and published and unpublished reports. The catch logsheets available for this review generally cover the period 1978–1992, but the coverage is variable; data for some fleets/areas are considered near complete, while for other fleets logsheet data are seriously incomplete. Observer activity during this period was very low, and it has only been recently that some effort has been made to increase observer activity and standardise observer data collection. For this reason, some observer data collected in recent years (i.e. 1993 and 1994) have been included in this review.

In the **purse-seine** fishery, the catch logsheet reporting of target species discards, retained by-catch and discarded by-catch is poor. Observer estimates provide some indications, although the coverage is low. According to available observer data, an estimated 0.35–0.77 per cent of the total catch (by weight) for school sets is by-catch; for log sets, the level is higher at an estimated 3.0–7.3 per cent. The most common by-catch species observed in purse seine log sets are amberjack (*Seriola rivoliana*), mackerel scad (*Decapterus macarellus*), rainbow runner (*Elagatis bipinnulata*), drummer (*Kyphosus cinerascens*), mahimahi (*Coryphaena hippurus*) and ocean triggerfish (*Canthidermis maculatus*). Observer records show that blue marlin (*Makaira mazara*) is the most common billfish species taken in purse-seine sets. Marine turtles are taken occasionally, but there is evidence that these are usually released alive. While the reasons for the discard of target tuna species are well documented, tuna discard is an irregular and unpredictable feature of the purse-seine fishery, thus it is difficult to provide indicative estimates.

In the **longline** fishery, the catch logsheet reporting of target species discard and discarded by-catch is very poor. Observer activity on longline vessels has only recently increased; however, the coverage remains low and is not considered adequate to provide overall indications of the levels of by-catch and discards in the tropical waters of the WPO. The by-catch of over 50 fish species has been observed in the tropical and sub-tropical waters of the WPO; these are categorised into shark (21 species), non-target scombrids (7 species), billfish (6 species) and other fish (21 species).

Longline catch logsheets provide some indication of the catch of billfish species, but the reporting of other fish by-catch species is poor. The distribution of nominal catch rates, and annual and seasonal trends in nominal catch rates, of billfish species are presented in this review. There is no logsheet reporting of shark catch, by species, in the tropical waters of the WPO, and observer data show that the total shark catch is grossly under-reported on logsheets. The catch of shark, according to observer data, is sometimes at a similar level to target tuna catch, and the blue shark (*Prionace glauca*) was observed as the most common shark species taken throughout the WPO. Marine turtles appear to be taken occasionally on longline vessels in the tropical waters of the WPO; however, there are insufficient data to determine the extent of exploitation.

The reasons for the discard of by-catch on longline vessels are documented in the report, although overall estimates could not be determined due to the poor coverage. As in the purse-seine fishery, the reasons for tuna discards are well documented, but tuna discard is an irregular and unpredictable feature of the fishery and thus difficult to estimate.

Observer data provide good indications of the levels of by-catch and discard in the large-mesh **drift-net** fishery in the South Pacific. Due to mounting pressure regarding the impacts on the albacore stock and by-catch species, the use of this gear type has now been banned and this fishery therefore no longer exists.

Tuna discards and by-catch in the **hand-line**, **pole-and-line** and **troll** fisheries are relatively minor and it is suggested that emphasis be focused on the future monitoring of the purse-seine and longline fisheries.

Suggestions for the future monitoring of the purse-seine and longline fisheries are provided. Increasing observer coverage was identified as the main solution to obtaining better estimates of by-catch and discards in the industrial tuna fisheries.

RÉSUMÉ

C'est dans le Pacifique occidental et central que la production thonière est la plus importante du monde à l'heure actuelle, les prises réalisées ayant atteint 1 million de tonnes par an environ de 1991 à 1994. L'essentiel des captures est réalisé à l'aide de trois types d'engins, la palangre, la senne et la canne. Les filets maillants dérivants, la palangrotte et la traîne ont été utilisés dans certaines zones, mais dans une moindre mesure que les autres engins. Les principales espèces ciblées sont la bonite, le thon jaune, le thon obèse et le germon.

Il existe pour tous les engins un certain nombre de rejets des espèces visées, de prises accessoires conservées et de prises accessoires rejetées. Le présent document étudie la situation en matière de prises accessoires et de rejets, sur la base des données fournies par les fiches de pêche, des informations communiquées par les observateurs, et de rapports publiés ou non. Les fiches de pêche utilisées couvrent généralement la période comprise entre 1978 et 1992, mais cette couverture est de qualité variable; les données sont en effet considérées comme presque complètes pour certaines flottilles ou certaines zones, mais très incomplètes dans d'autres cas. Les activités d'observation étaient très rares durant cette période et ce n'est que récemment qu'on s'est efforcé de les intensifier et d'harmoniser la collecte de données par les observateurs. Certaines données d'observation recueillies ces dernières années (en 1993 et en 1994) ont donc été incluses dans ce travail.

En ce qui concerne la **pêche à la senne**, il est rare que les espèces visées rejetées, les prises accessoires conservées et les prises accessoires rejetées soient mentionnées dans les fiches de pêche. Les estimations des observateurs donnent quelques rares indications à cet égard : 0,35 à 0,77 pour cent des prises totales (en volume) par calée sur des bancs simples seraient constitués de prises accessoires; en ce qui concerne les calées sur épaves, ce niveau est plus élevé puisqu'il se situerait entre 3 et 7,3 pour cent. Les prises accessoires le plus souvent réalisées sur épaves concernent les espèces suivantes : carangue amoureuse (*Seriola rivoliana*), maquereau (*Decapterus macarellus*), coureur arc-en-ciel (*Elagatis bipinnulata*), saupe (*Kyphosus cinerascens*), mahi-mahi (*Coryphaena hippurus*) et baliste du large (*Canthidermis maculatus*). D'après les observateurs, le marlin bleu

(*Makaira mazara*) est le marlin le plus souvent capturé par les senneurs. Il arrive que des tortues soient prises, mais elles sont généralement relâchées vivantes, d'après les données dont on dispose. Les causes des rejets des thons ciblés sont expliquées, mais la pratique du rejet lors de la pêche à la senne est irrégulière et imprévisible, de sorte qu'il est difficile de fournir des estimations.

Les données fournies par les fiches de pêche en ce qui concerne les rejets des espèces visées et des prises accessoires par les **palangriers** sont très rares. Les activités d'observation sur les palangriers ne se sont développées que récemment; la couverture reste faible et ne paraît pas suffisante pour tirer des conclusions générales sur les niveaux de prises accessoires et de rejets dans les eaux tropicales du Pacifique occidental et central. Il a été constaté que les prises accessoires concernaient plus de 50 espèces de poissons dans les parties tropicale et subtropicale de cette région; il s'agit de requins (21 espèces), de scombridés non ciblés (7 espèces), de marlins et alliés (6 espèces) et d'autres poissons (21 espèces).

Les fiches de pêche fournissent quelques indications sur les prises à la palangre de marlins et alliés, mais les captures des autres espèces de poissons sont rarement consignées. La présente étude indique la répartition des taux de prise nominale de marlins et alliés, ainsi que les tendances enregistrées à cet égard par année et par campagne. Les fiches de pêche n'indiquent pas les prises de requins par espèce dans les eaux tropicales du Pacifique occidental et central, et les informations fournies par les observateurs montrent que les prises totales de requins déclarées dans les fiches de pêche sont très en-deça de la réalité. En fait, elles sont parfois aussi importantes que les prises des thons ciblés, le requin bleu (*Prionace glauca*) étant le plus fréquemment capturé dans l'ensemble de la région étudiée. Des tortues de mer sont parfois prises par des palangriers dans les eaux tropicales du Pacifique occidental et central, mais les données sont insuffisantes pour permettre d'établir l'ampleur de l'exploitation.

Les causes de rejets des prises accessoires par les palangriers sont expliquées dans le présent rapport, mais il n'est pas possible de donner des estimations globales en raison de la médiocrité de la couverture. De même que pour la pêche à la senne, les causes des rejets de thons sont bien connues, mais cette pratique est irrégulière et imprévisible, de sorte qu'il est difficile de procéder à des estimations.

Les données d'observation donnent une bonne indication des niveaux de prises accessoires et de rejets des navires de **pêche au filet maillant dérivant** dans le Pacifique Sud. Des pressions de plus en plus fortes se sont exercées afin de protéger les stocks de germons et les espèces constituant des prises accessoires, de sorte que cet engin est maintenant interdit et que ce type de pêche n'existe plus.

Les rejets de thons et les prises accessoires des navires pêchant **à la palangrotte**, **à la canne** et **à la traîne** sont relativement peu importants; il est donc proposé de mettre l'accent à l'avenir sur le suivi de la pêche à la senne et à la palangre.

Des propositions sont formulées dans cette optique. L'amélioration de la couverture assurée par les observateurs semble être la solution à adopter en priorité pour améliorer les estimations de prises accessoires et de rejets des navires thoniers.

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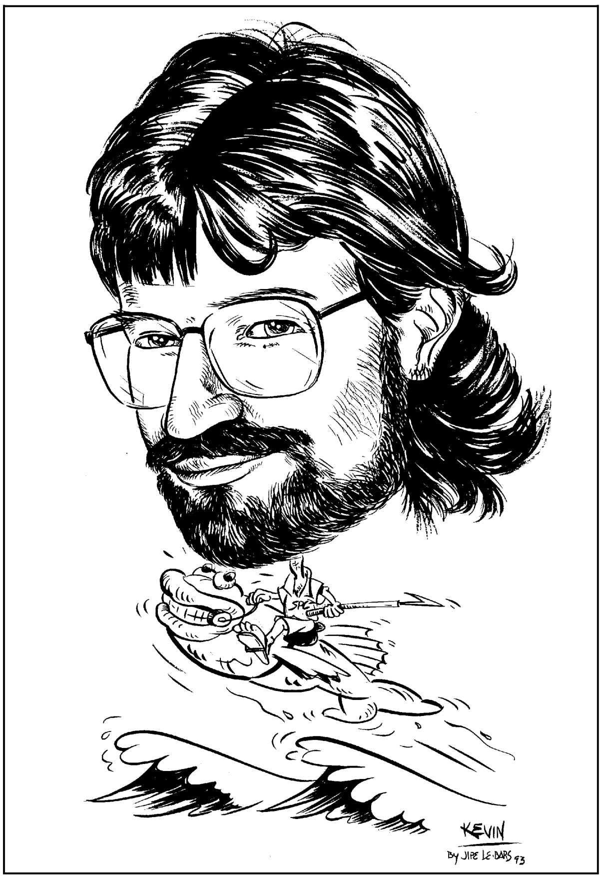
DEDICATION



Kevin Neil Bailey

This technical report is dedicated to the memory of Kevin Bailey, who was tragically taken from us close to the completion of the work for this review.

It was Kevin's experience, interest and determination that provided the impetus for this project. We have lost a dear friend, and the fisheries world has lost a valuable scientist.

Section 1

INTRODUCTION

The western and central Pacific Ocean currently supports the largest industrial tuna fishery in the world, with an estimated catch in 1992 of 1,089,607 mt in the SPC statistical area alone (Lawson 1993). Skipjack is the most important of the four major tuna species in the fishery, accounting for 67 per cent of the catch by weight in 1992, followed by yellowfin (24.5%), bigeye (5%) and albacore (3%). Purse seine gear was responsible for 80 per cent of the total catch, with pole-and-line gear accounting for 7 per cent, longline gear 12 per cent and troll gear 1 per cent.

All of these fisheries invariably have some level of catch of non-target species (termed 'by-catch'). A portion of this by-catch is discarded because it has little or no economic value, and, if retained, would take up storage capacity best used for the more valuable tuna species. A portion of the target catch is also often discarded for economic reasons, or because it is damaged, physically too small for efficient processing, or lost because of gear failures during fishing operations.

Recently, widespread attention fell on the large-mesh driftnet fishery operating in the South Pacific and its alleged high levels of by-catch of dolphins and numerous species of fish, as well as its effect on the stock size of the target species, albacore. This attention, most obviously manifested in statements in the media about the 'wall of death', eventually resulted in an arbitrarily-imposed world-wide moratorium on using large-mesh driftnets. The moratorium is one product of a growing perception amongst government agencies and environmental interest groups of the potential waste in the world's fisheries. A second example is the recent decision by US canneries not to purchase, process or sell any tuna caught in association with dolphins. This decision, made under mounting pressure from environmental groups, has had far-reaching repercussions in the tuna industry, the least of which has been a displacement of US purse seiners to the western Pacific (e.g. Kronman 1990).

As attention will almost certainly fall on the industrial tuna fisheries in the western and central Pacific, it is timely that an objective review of their levels of by-catch and discards be undertaken. Thus, the Fourth Standing Committee on Tuna and Billfish requested the South Pacific Commission to 'evaluate and report available information on by-catch and discards in western and central Pacific tuna and billfish fisheries and advise on the need for further action' (SPC 1991). The Fifth Standing Committee on Tuna and Billfish considered the preliminary report and the draft was formally presented to the Sixth Standing Committee on Tuna and Billfish; recommendations from this meeting and revisions suggested by the Seventh Standing Committee on Tuna and Billfish have been included in this, the final version.

The Oceanic Fisheries Programme (OFP) of the SPC is well placed to carry out such a review, as it maintains a database of daily catch-and-effort logsheet data from the major tuna fisheries in the region, and has in its employ fisheries scientists with considerable practical experience of these fisheries. The review will also aid in providing some direction for the scientific observer work being undertaken by the OFP during the five-year South Pacific Regional Tuna Resource Assessment and Monitoring Project (SPRTRAMP).

Section 2

OBJECTIVES AND DEFINITIONS

The main objective of this report is to carry out a review of the by-catch and discard practices of the industrial tuna fisheries operating in the western and central Pacific, using logsheet data provided to the member countries of SPC, observer information, and published and unpublished reports. As stated above, the second objective is to advise the Standing Committee on Tuna and Billfish (SCTB) on areas where the monitoring of by-catch and discard levels is insufficient and, thereby, suggest where action is required.

The following definitions, based on those determined by the Fourth Standing Committee on Tuna and Billfish, are used throughout this report:

Target catch: Catch of target species, i.e. skipjack, yellowfin, bigeye, albacore and southern bluefin tuna, and, in some instances, billfish. The actual target species vary depending on the gear used and the location. A fishing operation need not be restricted to a single target species, although one might be preferred over others (e.g. bigeye tuna preferred to yellowfin in longline operations).

By-catch: Any catch of species (fish, sharks, marine mammals, turtles, seabirds, etc.) other than the target species. 'Incidental catch' can be regarded as synonymous. For example, bluefin tuna (*Thunnus thynnus*) are taken incidentally by some longline vessels fishing in the western tropical Pacific, even though they are a valued part of the catch; in this report they have been included as part of the by-catch as they are not the normal target species.

Total catch: Sum of target catch and by-catch.

Discards: The portion of the total catch that is discarded. This includes discards of target species ('Tuna discards') and 'By-catch discards'.

Target tuna discards include catches that are deliberately discarded because the fish are too small or damaged to be retained, are excess to storage capacity, and catches that are unintentionally discarded through gear failure (e.g. ripped purse seine sacks, driftnet drop-out). By-catch discards usually consist of species that have little or no economic value and are deliberately discarded.

The western and central Pacific is defined for this review as the SPC statistical area, shown in Figure 2.1, that is covered by the South Pacific Commission/Forum Fisheries Agency Regional Tuna Fisheries Database (RTFD). The approximate boundaries of this area are the 25°N and 45°S lines of latitude, and the 125°E and 120°W lines of longitude, reflecting the 200-mile limits of the SPC member countries and territories. For convenience, the statistical area is called the western and central Pacific Ocean (WPO) in this report and subdivided, because of the various fisheries involved, into the western tropical Pacific (WTP, 10°N–10°S), the western subtropical Pacific (WSP, 10°S–35°S, and the area to the north of 15°N designated WSPn) and the western temperate Pacific (WTeP, 35°–45°S).

The industrial fisheries covered include six gear types: purse seine, longline, pole-and-line, troll line, handline and driftnet. All of these gears, except for the driftnet, are currently in use. Table 2.1 summarises the various tuna (and billfish) fisheries in the WPO that are reviewed in this report. Artisanal fisheries, although widespread in the Pacific and incorporating varying degrees of commercial enterprise, are not reviewed because few data are available. The six gear types are covered in individual sections, with each section including an overview of the fishery or fisheries involved, a description of data sources used, followed by specific discussion of species and quantities involved and special attributes of the fisheries that influence by-catch and discards. Particular attention is given to species of by-catch that are undesirable captures in various other situations or have been perceived to be under threat, e.g. billfish, seabirds, marine reptiles (particularly sea turtles) and marine mammals. Estimates of by-catch and discards are made only when considered realistic given the available data. Brief comparisons of by-catch and discard levels with similar fisheries in other oceans are made. Each section concludes with a summary of the essential by-catch and discard aspects of the specific fisheries; recommendations for further action are made where appropriate.

Recognised common names of species are used throughout the text; species names are mentioned only if they have not been included in the tables of by-catch provided for each fishery.

Table 2.1: Industrial tuna and billfish fisheries operating in the SPC statistical area of the western Pacific Ocean

Gear	Target species	Area	Season	Countries involved
Purse seine	Skipjack, yellowfin (bigeye)	WTP	All year	Australia, Federated States of Micronesia (FSM), Japan, Korea, Marshall Is., Mexico, Philippines, Russia, Solomon Is., Taiwan, USA
	Skipjack	WSP	Oct. – Jun.	Australia, New Zealand, Philippines, USA
	Southern bluefin, skipjack	WTeP	Oct. – Apr.	Australia
Longline	Yellowfin, bigeye (albacore,billfish)	WTP	All year	China, FSM, Marshall Is., Japan, Korea, Solomon Is., Taiwan, USA
	Yellowfin, bigeye, albacore (swordfish,striped marlin)	WSP	All year	Australia, Fiji, French Polynesia, Japan, Korea, New Caledonia, Taiwan, Tonga (Korea and Taiwan extend into WTeP from Mar. – Jun.)
	Southern bluefin, yellowfin (albacore,bigeye,swordfish)	WTeP	All year	Australia, Japan, New Zealand
Pole-and-line	Skipjack (yellowfin,bigeye)	WTP	All year	Japan, Kiribati, Palau, Papua New Guinea, Solomon Is., Tuvalu
	Skipjack (yellowfin)	WSP	Nov. – Aug. Dec. – Mar. All year	Fiji Australia French Polynesia
Troll	Albacore	WTeP	Nov. – Apr.	Australia, Canada, Fiji, French Polynesia, New Zealand, USA
Handline	Yellowfin,bigeye	WSP	Oct. – Nov.	Australia, Japan
	Southern bluefin	WTeP	May. – Aug.	Australia, New Zealand
Driftnet	Albacore (skipjack)	WTeP	Nov. – Apr.	Japan, Taiwan, Korea

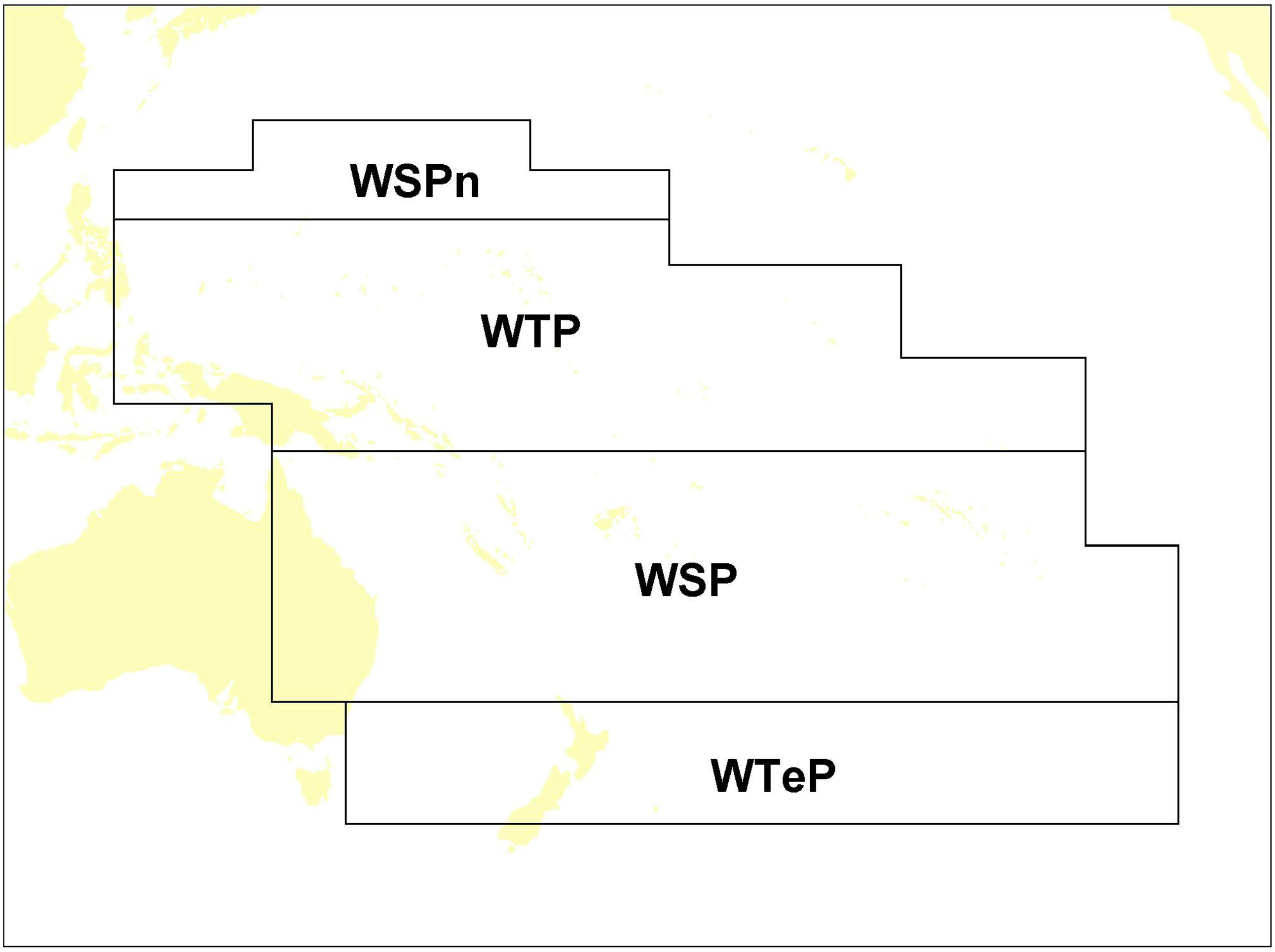


Figure 2.1: The SPC Statistical Area, showing tropical (WTP), subtropical (WSP, WSPn) and temperate (WTeP) subdivisions used in this report.

Section 3

PURSE-SEINE FISHERIES

3.1 OVERVIEW OF THE WESTERN PACIFIC PURSE-SEINE FISHERIES

3.1.1 Summary of the fishery

The purse-seine fisheries in the WPO can be divided into two main components: a tropical component, that operates throughout the year in calm equatorial waters and provides the bulk of the tuna catch, made up of skipjack, yellowfin, and, to a lesser extent, bigeye; and a subtropical component that yields much smaller catches, is highly seasonal and consists almost entirely of skipjack. The tropical component, or WTP fishery, is located in the area bounded by 10°N and 10°S between eastern Indonesia (about 120°E) and the Phoenix and Line Islands of Kiribati (170°W–150°W). The subtropical component has in the past extended to the waters of eastern Australia, northern New Zealand and Fiji. Part of this component extends into the temperate waters of eastern Australia, targeting skipjack at present and southern bluefin prior to 1983. A large fleet of Japanese seiners targeting northern bluefin and skipjack to the north of the statistical area is not covered in this report. The WTP component is dominated by US-style single purse-seine vessels with a smaller number of group seiners working in the region. Most of the WTP seiners utilize boom-mounted power blocks, with a small number of vessels using deck-mounted hauling gear, while the WSP and WTeP components have a greater mix of the two hauling systems. Itano (1990) summarises the development of purse-seine activity in the WTP and details the gear and fishing techniques by school type utilised by the various fleets.

In 1992, the WPO purse-seine fishery yielded an estimated 659,201 t of skipjack and 217,664 t of yellowfin (the latter including up to 10% bigeye, by weight), taken by 199 seiners from ten countries: Australia, Federated States of Micronesia, Japan, Korea, New Zealand, Philippines, Russia, Solomon Islands, Taiwan and USA. Most of these catches came from the WTP, and primarily from the large fleets operated by Japan, Korea, Taiwan and USA. A detailed breakdown of catches by the individual fleets is given in Lawson (1993). Much of the following discussion centres on the fishery in the WTP.

3.1.2 Fishing method by school association

Purse seiners set on a variety of school types or ‘associations’, ranging from schools associated with floating objects, such as logs and other naturally occurring debris, man-made fish aggregating devices (FADs), and dead whales, to schools swimming with live animals such as whales and whale sharks. 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. Such sets are collectively termed school sets. Hampton and Bailey (1993) provide a detailed description of the principal school associations encountered in the WPO purse seine fishery. A summary of this description is given below because the associations largely determine the quantity and kinds of by-catch and discards in the fishery.

Figure 3.1 shows the breakdown of reported effort and by-catch by school association and fleet for 1992, according to logsheet data (RTFD).

3.1.2.1 Log associations

Logs and other floating debris are found throughout the WPO, often concentrating along productive current or water mass interfaces. Schools of tuna aggregate around them for a variety of possible reasons (e.g. feeding, shelter, orientation) and a viable purse-seine fishery in the WTP was initially based on seining tuna schools associated with drifting objects (Doulman 1987). Logs can consist of sections of trunk, groups of branches or entire trees. Other debris includes almost any floating object that is washed or drifts out to sea or is jettisoned from ships, e.g. canoes and boats, drums, cable spools, polystyrene floats, discarded mooring lines, and wooden pallets. Most occurrences within this association type, however, involve logs. Log sets are usually made immediately before dawn, at a time when tuna are most vulnerable to purse seining as they are concentrated close to the log and cannot see and avoid the encircling net.

Apart from tuna, logs aggregate a considerable number of other fish species, ranging from typically reef-associated species such as sergeant major, rainbow runner and barracuda, to the truly pelagic species such as ocean triggerfish, oceanic whitetip shark and blue marlin. Some of these species, particularly the small schooling pelagics such as the rainbow runner, mackerel scad, frigate tuna and kawakawa, can occur in quantity, often in terms of tonnes. To US purse-seine fishermen, these species are collectively known as 'bait fish', although they may variously compete with or prey on tuna.

There is strong evidence of stratification of the bait fish and tuna species beneath logs, with many of the small or typically reef-associated species (eg. ocean triggerfish, drummer, jacks and sergeant major) maintaining a close relationship with the object, while the larger species (eg. rainbow runner, wahoo, mahimahi, mackerel scad) range further away. The bait fish generally stay in the upper part of the water column, with the tuna species aggregated below. Skipjack tend to aggregate in the upper 20–40 m, with yellowfin further below, and bigeye below 100 m. Seiners often use the ascent of these schools in the early morning as a signal to begin setting. Bigeye appear to form the strongest association underneath logs throughout the day and night, while skipjack and yellowfin tend to forage away from the log during daylight hours.

This fishing association accounts for 34 per cent of the 1992 sets on the RTFD database.

3.1.2.2 FAD associations

FADs in the WPO appear to operate very much like logs in terms of fish aggregation, how the tuna behave in their vicinity, and the general strategies used by seiners to set on them. Two basic types of FAD association are recognised. The first involves FADs that are anchored in place, usually within a network of similar units, and the second occurs with FADs that have broken loose from their mooring lines and drifted away, or have been deliberately deployed without mooring lines. Within the second category, the Japanese appear to include associations with logs and debris that have been roped together (Tanaka 1989). The Japanese are also known to anchor FADs near small islands and release them to drift after a suitable 'ageing' period has resulted in the accumulation of encrusting life and a population of baitfish (D.G. Itano pers. comm.). A large volume of literature exists on the types and designs of FADs in use in the WPO (e.g. Preston 1982; Malig et al. 1991).

Anchored and drifting FAD sets make up two and three per cent, respectively, of the 1992 sets recorded on the RTFD.

3.1.2.3 Animal associations

Animal associations commonly consist of two distinct association types: tuna aggregating and feeding with sei whales (*Balaenoptera borealis*) and, to a lesser extent, minke whales (*B. acutorostrata*); and schools associated with the slow-moving whale shark. Tuna schools found with live whales do not appear to form long-term associations with the whales; they seem only to come together to feed on pelagic baitfish schools and separate once the feeding activity is finished. In this sense, these schools are similar to the unassociated schools described below, and are set on in the same way. The seiner will, however, attempt to encircle the whale during the setting operation, as the tuna will tend to remain close to the whale, thus improving the chance for a successful set. Once pursed, the whale escapes by punching a hole through the net.

Micronesian Maritime Authority (MMA) observers have recorded 39 whale-associated purse-seine sets on DWFN purse seine vessels in Micronesian waters between 1984 and 1993. Of these, 34 were made during February, March and April, agreeing with anecdotal accounts which indicate that the Japanese purse-seine fleet operates on whale-associated schools mostly during the first quarter of the year.

Whale-shark associations appear to be intermediate between live whales and logs in that the shark and tuna often come together to feed on anchovy but can maintain the association for some time in the absence of feeding behaviour, much like tuna aggregating under a slow-moving log. Whale sharks are set on during the day, as it is impractical to mark them with buoys and therefore difficult to locate them in the dark. The amount of bycatch associated with these categories is typically low.

In comparison, schools found associated with floating whale carcasses are similar to log associations, with large attendant schools of bait-fish species. Dead whales are rarely encountered but when so, are treated like logs, marked with radio and light buoys for tracking and set on before dawn.

In the eastern Pacific, large yellowfin frequently associate with porpoise (*Stenella attenuata, S. longirostris, Delphinus delphis*) . This association is extremely rare in the western Pacific because of the low abundance of porpoise schools in the main fishing grounds, and it appears that the oceanographic and biological conditions that may promote the association between dolphin and yellowfin in the eastern Pacific (e.g. shallow thermocline, abundance of ommastrephid squid) are not usually present in the WPO. In addition, successful purse seining on porpoise-associated schools is a technically complicated procedure that requires a crew experienced with this type of fishing and a modified net. Consequently, there is no evidence of purse seiners deliberately setting on dolphin-associated tuna schools in the western Pacific.

Animal sets make up one per cent of the 1992 sets on the RTFD database.

3.1.2.4 Unassociated schools

Unassociated schools are typically surface schools that range in activity from fast moving ‘breezers’ that appear like a breeze blowing across the sea surface to stationary ‘boilers’ and ‘foamers’ consisting of tuna churning the surface into a white froth while feeding on pelagic bait fish and other forage. The latter types of schools are most preferred for seining as the tuna are distracted by their feeding frenzy and easier to encircle with the seine. In comparison, breezing schools are more erratic in behaviour and are often moving at speed, making them difficult to encircle and catch. School fishing in the WTP has required that nets be lengthened to effectively encircle the fast-moving schools and deepened to extend below the depth of the WTP thermocline. A typical US net currently measures over 1,500 m long by 220 m deep. Along with these developments, there have been increases in mesh size and reductions in twine size to allow the net to sink faster with reduced water resistance during pursing and net retrieval, and increases in purse winch power allowing net pursing to be conducted in less than 15 minutes.

Unassociated sets make up 50 per cent of the 1992 sets on the RTFD database.

3.2 SOURCES AND COVERAGE OF DATA

3.2.1 Logsheet data

Catch-and-effort logsheet data from foreign purse seiners operating in the Exclusive Economic Zones of SPC member countries are provided to those countries as part of the reporting requirements of access agreements. Since June 1988, the Forum Fisheries Agency (FFA) has managed the data collection for the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America (USMLTF); these data are provided to SPC on a regular basis and have been included in this review. Data from domestic seiners are also provided. These data are forwarded to SPC for computer storage and used for reporting back to the countries on the condition of the tuna stocks in their waters and the WPO as a whole.

Table 3.1 details the fleets and periods for which catch-and-effort data are stored in the RTFD and used in this review; for the WTP fishery, the data cover the period from 1979 to the end of 1991. To provide an indication of recent tendencies in reporting levels of by-catch and discards, data for 1992 have been included separately; data for 1993 were incomplete at the time of completing this review and have been used in the figures only. Figure 3.2 shows the distribution of reported effort, by-catch and tuna discard for purse seine fleets operating in the WPO for 1975–1992.

The various access agreements in effect between member countries and purse-seine operators or associations require that logsheets be completed, and instructions are provided with the forms to assist the vessel captains. While by-catch and discards are usually defined in the instructions, there are no legal obligations to include this information and no penalties are imposed on non-reporters. Thus, the information at hand is extremely patchy and largely unvalidated. In most cases, however, it is the only information provided on logsheet forms at present.

Coverage of individual fleets in the RTFD is extremely variable, for example, the catches of Korean and Taiwanese vessels are estimated to be under-reported by a factor of three for the period 1980–1989 and by a factor of five in 1990 (Lawson 1992b). The estimated levels of non-reporting of catch for the two fleets in 1990 are quite different: 75 per cent for the Korean fleet and 5 per cent for the Taiwanese fleet. Coverage of the US fleet is poor for most years up until mid-June 1988, when the USMLTF came into affect and all US flag tuna vessels were required to provide catch data within a large treaty area stretching from the Line Islands of Kiribati to Palau. The coverage of the Japanese fleet is good for most of the period (70% for 1980–1989), while the smaller fleets have variable and often unknown coverage.

Various logsheet forms have been used by the purse-seine fleets for the recording of catch-and-effort data. Although the information on the forms had been largely standardised by the mid-1980s, many forms used in the early years of the fishery by Japanese and Solomon Islands vessels had no provision for the recording of by-catch and/or discards.

As there is a limited number of set types identified on most catch forms used on seiners, it is not possible in the present analysis to divide the data into the variety of associations described in the previous section. Thus, sets made on live and dead whales and whale sharks, all of which are different in terms of setting strategy, by-catch species, and often the target species, have been combined into a single category, the animal set. Similarly, it is not possible to determine what proportion of school sets are made on geographic or oceanographic features. As a number of these features tend to concentrate logs and other floating debris, it is probable that data on log sets include sets made on schools that have formed a geographic or oceanographic association.

In the database there are two further categories of set type: 'Other' and 'Unspecified', The former involves such set types as boat-associated schools (Itano 1991; Suzuki 1992), early morning sets on schools that have temporarily moved away from logs, and subsurface schools set on with sonar; these are are difficult to assign to specific set types.

These two set types together comprise five per cent of the data in the RTFD for the period 1975–1991 and ten per cent for 1992.

As the Philippine fleet deploys the largest number of FADs in the WPO, it is likely that many of the drifting FAD sets recorded in the database for this fleet are in fact on FADs or their underwater appendages that have been disconnected from their mooring lines rather than having broken loose naturally. Thus many of these sets should be considered as anchored FAD sets, but cannot be easily separated in the database. Similarly, drifting FAD sets made by New Zealand vessels operating in Fiji waters were probably all on anchored FAD rafts that were unhooked prior to setting and then rehooked after the set (G. Preston pers. comm.)

3.2.2 Observer data

The available literature on by-catch and discards in the fishery is sparse, and the present review relies on a series of SPC reports describing observer trips on Japanese, US and New Zealand seiners from 1984 to 1990, and Pacific Tuna Development Foundation (PTDF) reports generated from exploratory fishing by US seiners in the WPO between 1976 and 1983.

The review has also benefitted recently from the work of the MMA observer programme which has collected standardised by-catch and discard data from purse-seine vessels fishing in and around FSM waters since January 1993. These data have been provided to SPC in the form of an unpublished report (Heberer, 1994b).

The South Pacific Forum Fisheries Agency (FFA) observer programme on US vessels has also provided a limited amount of data, although the programme is primarily aimed at compliance and enforcement of the Multilateral Treaty rather than scientific data collection. In the last year, data collection forms for recording by-catch and discard information from US purse seine vessels have been developed; however the few data that have been collected since were not available for this review.

3.2.3 Other sources of data

Data and experiences from the SPC Regional Tuna Tagging Project (RTTP) and Philippines Tuna Research Project (PTRP) have been referred to. Although these projects employed a pole-and-line vessel as the principal fishing and tagging platform, the vessel concentrated its efforts in the main purse seine area in the WTP and essentially fished on the surface and subsurface schools available to seiners, as evidenced by the high proportion of recoveries of tagged fish from the purse-seine vessels.

The experiences and private log books of two SPC staff members (D.G. Itano and K. Bailey), who have worked on US seiners in the WTP and New Zealand fisheries for a number of years, have also been incorporated in this report.

3.3 BY-CATCH AND DISCARDS OF BY-CATCH

3.3.1 By-catch by school association

An indication of the various levels of by-catch and discards resulting from fishing on different types of schools, and by inference the extent of non-reporting amongst the fleets, is given in Table 3.2. It is important to note that the calculations made for this table only include sets **where by-catch has been recorded**, and thus take no account of either the non-reporting of sets with by-catch or legitimate sets of zero by-catch. Figure 3.3 indicates the frequency of reported by-catch by school association, and clearly illustrates the skewed distribution, with most values falling below two or three tonnes and a long tail extending along the X axis which represents a few sets with large quantities of by-catch. A frequency distribution of this kind is not well characterised by an arithmetic mean, and median values for by-catch per set were substituted in Table 3.2.

No matter what value is used to describe by-catch quantities, it is clear that the level of by-catch reporting is extremely low, with for instance only 0.2 per cent of the 28,791 school sets and 1.5 per cent of the 41,524 log sets on the database reporting by-catch for the period 1975-1991. In comparison, observer reports show that most if not all log and FAD sets and a considerable proportion of school sets have some level of by-catch.

Table 3.3 compares mean by-catch per set calculated from MMA observer data with median by-catch per set from the RTFD (Table 3.2) and mean by-catch per set calculated from all sets of vessel trips which report at least one set of by-catch (RTFD).

3.3.1.1 By-catch from log sets

Log schools produce an overall median of 1.0 mt per set from the 682 sets in which by-catch is declared, with a range of 0.5 to 5.0 mt per set reported from the individual fleets (Table 3.2 : RTFD, 1975–1991). Available observer data provide a similar mean value for by-catch from log sets of 1.3 mt per set (Table 3.3). For anyone who has witnessed WTP log-associated sets, this level of catch is not surprising. Not only do most logs have a large attendant population of fish (a possible total of at least 45 species, as listed in Table 3.4, also Table 3.5), dominated by rainbow runner, mahimahi, ocean triggerfish, mackerel scad, and silky shark, but the purse-seine operation does not allow for an easy escape for most species. Earnest attempts are made to reduce by-catch levels because of the extra work involved in cleaning the net of 'gillers' and sorting the catch during brailing in the limited time available before the tuna begin to spoil in the tropical climate. Most fishermen also believe that removing the 'bait' species from a log will detract from its productivity (i.e. ability to aggregate tuna schools). Thus, when pursing is complete and before net hauling commences, the main boom is lowered on the net side so that a gap forms between the vessel and the end of the net through which the log can be slowly towed, allowing the bait to escape. While this operation can be successful, most log sets end with the species that swim furthest from the log turning back into the net and becoming mixed with the catch that is brailed aboard.

Much of the by-catch from log sets is of low economic value and is discarded at sea. This is particularly apparent for US and Korean vessels, which discard 88.9 and 84.2 per cent of their respective by-catches. Discarding usually takes place on the working deck after the catch is brailed to a sorting receiver or 'hopper'. Some of the hardier species, such as rainbow runner and ocean triggerfish, are known to survive this ordeal, but the majority of purse seine by-catch is discarded dead or fatally injured (Itano pers. obs). On most vessels, small quantities of mahimahi, wahoo and other edible species are kept for crew consumption and barter or gifts in port.

3.3.1.2 By-catch from FAD sets

FAD by-catch reported from the individual fleets ranges from medians of 1.0 mt (210 sets; Table 3.2 : 1975–1991) to 3.0 mt per set (171 sets with declared by-catch). In comparison, non-MMA observers report a mean of 0.3 mt per set from log and FAD sets (81 observed sets), while MMA observers report 0.1 mt per set from only 10 drifting FAD sets, highlighting the current lack of coverage from observer data for this particular set type. It is possible that the higher reporting rate for Solomon Islands seiners may be due to an active domestic observer programme conducted by the Solomon Islands Fisheries Division. The 1992 median value for the Philippine fleet (6.3 mt per set) may be attributed to improved reporting in recent years; it is noteworthy that no discard of by-catch was apparent in this instance.

FADs produce a similar range of by-catch species to logs, dominated by the same five or six species (Table 3.4) and drifting FADs are essentially identical to logs. The slightly higher by-catch rates between anchored FADs and logs indicated in Table 3.2 is possibly related to the fact that FADs are usually anchored near islands and land masses, where by-catch species may be more abundant. Also, FADs are usually set in a network allowing a seiner to set on a different FAD every day, thus permitting the associated tuna (and by-catch) populations to rebuild between visits. In contrast, logs are often set repeatedly or within a short time period until they become unproductive, which does not allow time for by-catch to recruit to the log.

Two medium-sized New Zealand purse seiners operated in Fiji from 1981 to 1985, fishing almost exclusively on a large network of anchored FADs. During the 1984–1985 season, one of these vessels recorded a by-catch of 1.7 mt per set for one year of operation (Itano 1989). Most of the catch consisted of rainbow runner, but mahimahi and kawakawa were other common by-catch species. Farman (1984) notes that all by-catch from FAD sets made by the New Zealand vessels in Fiji was sold locally, except for sharks, where only the fins were marketed. It also appears that a large part of the by-catch in the Solomon Islands is retained; most probably goes for local sale and consumption.

The New Zealand purse seiners operating in Fiji during the early 1980s noted definite seasonal fluctuations in FAD-associated by-catch. The occurrence of mahimahi and rainbow runner increased noticeably during the winter months, and mahimahi disappeared completely during the summer (Itano 1989).

The highest level of by-catch reporting occurs in anchored FAD sets, at 14.4 per cent of all anchored FAD sets.

3.3.1.3 By-catch from animal sets

By-catch information on animal sets from the RTFD is limited to two sets made by Korean seiners that produced an average of 1.0 mt of by-catch per set with declared by-catch; as live whale sets produce a similar range of species to school sets it is possible that the two Korean sets were of this type. MMA observers reported 42 sets on animal-associated schools between January 1993 and June 1994 which yielded a mean by-catch of less than 0.1 mt per set.

Dead whale sets are similar to log and FAD sets, with the same predominant species present (Hampton & Bailey 1993). Sharks are very abundant around floating whale carcasses, probably in higher densities than around logs or FADs. Information on the species taken in dead whale sets is limited, with only nine species recorded (Table 3.4). It is probable that most of the species found with logs and FADs also occur with this association type. There is also little information for whale-shark sets; RTTP records list three species; however it is likely that many of the species found with schools and logs (eg. silky sharks, rainbow runner, mahimahi) are common with whale sharks.

The position, school type and catch of every set (n = 92) made by one Japanese group seine vessel during its 1991 season was recorded by Itano (1991). Four whale- and one whale shark-associated sets were made, all of them during March and April, with no by-catch reported.

Occurrences of large animal (whales, whale shark) capture during purse-seine operations related to this set type are dealt with in Section 3.4.

3.3.1.4 By-catch from sets on unassociated schools

MMA observers reported a mean by-catch of 0.1 mt per set (261 observed sets) for unassociated schools. The mode for all school sets where by-catch was reported in the RTFD is 0.1 mt per set, compared with a median and geometric mean of 0.5 and 0.6 mt per set, respectively. The apparent high median value for by-catch from unassociated schools in 1992 (5.0 mt/set: Table 3.2) is attributed to the majority of the reported by-catch (41 of the 71 sets with reported by-catch) coming from Taiwanese purse-seine vessels, who appear to report by-catch only when taken in considerable quantities (i.e. 5 and 10 mt). It is also significant to note the improvement in recent by-catch reporting for unassociated school sets (the figure of 71 sets with by-catch reported for 1992 is the same as that for the entire 1975–1991 period), particularly from Taiwanese vessels.

By-catch reported from the RTFD for school sets is very low: 0.2 per cent of all school sets. Observer reports show that school sets often have some degree of by-catch (12.9% of 287 sets for Bailey & Souter 1982; Gillett 1986a,b; Itano 1991; FFA observer programme), but the by-catch is usually limited to a small number of apex predators taken per set. Common by-catch species from school sets include blue marlin, black marlin, and silky and oceanic whitetip sharks (Table 3.4) that may approach 0.2–0.5 mt per set. On rare occasions, sets may be made on schools, particularly those near reefs or seamounts, where rainbow runner, mackerel or small tunas (frigate, bullet, kawakawa) are common, and such sets may produce relatively large amounts of by-catch (Table 3.5). In addition, unsuccessful school sets (‘skunks’) often result in catches of sharks and billfish, although such catches are unlikely to be recorded unless an observer is on board.

It is difficult to estimate the amount of by-catch from school sets using the data from the RTFD because of both the questionable catch rates and the proportions of sets with by-catch. Much of the data pertaining to the 287 sets mentioned above includes only few numbers of fish as by-catch.

Both the literature and RTFD data show that most of the by-catch in school sets is discarded, primarily because the species caught have a much lower value than the target species when stored frozen using the technology employed by most WTP purse seiners. For the US fleet, with the largest number of reported by-catch sets, over 90 per cent of the by-catch is discarded. On some seiners, sharks’ fins are retained for sale in landing ports and the carcasses are discarded. Occasionally, the teeth or jaws are retained for souvenirs or sale. Billfish are a special case, and depending on the amount of catch and school activity, are either discarded, retained for consumption or, occasionally, stored for sale. Billfish by-catch is disc-ussed in Section 3.3.2.1.

The seasonal New Zealand purse seine fishery of the WTeP is based entirely on setting on unassociated schools of skipjack. However, the seasonality of the fishery, its proximity to a large land mass and extensive continental shelf, and location in temperate seas result in an unique mix of by-catch species, including pelagic and benthic resident species, tropical migrants and species found in all oceans. Habib et al. (unpublished) provide a detailed list of the 68 species of sharks, rays and bony fishes that have been recorded by MAF observers during the period from 1975 to 1982 when US super-seiners dominated the fishery. However, because of the inconsistent nature of these recordings, it is not possible to use this information to determine the relative occurrence of species in the by-catch. A subset of the data, using records of observers who consistently reported by-catch, is presented in Table 3.6. A total of 904 sets by US and New Zealand super-seiners was examined; 47.9 per cent of these sets contained some by-catch. Of the 46 species of sharks, rays and fish listed, the most common species were the sunfish (15.5% of all sets), manta ray (8.2%), albacore (7.3%), and porcupine fish (5.8%). Although it is not possible to convert these occurrences to weights, observer records and personal experience indicate that the by-catch of this fishery rarely exceeded 0.5–1 mt per set. In terms of the limited data held on the RTFD for the New Zealand fishery, it appears that US vessels have not included by-catch in their reporting. For the period 1976 to 1983, super-seiners made a total of 2,924 sets in the fishery (West 1991).

Most of this by-catch was discarded because of its low economic value; a small but unquantifiable amount was retained for crew consumption, particularly the marlins, albacore and yellowfin tuna (K. Bailey pers. obs.).

Apart from a single super-seiner operating from 1976 to 1982, New Zealand flag vessels are small (23–36 m LOA, carrying capacity 90–350 mt) and unable to compete effectively with the larger, faster US-style seiners. Thus, much of their effort has been limited to continental shelf waters, particularly in the Bay of Plenty, and their by-catch has differed accordingly, with a higher percentage of coastal species. Unfortunately, observer activity on these vessels was limited and no useful information is readily available. The RTFD has records of 1,829 sets by these vessels, resulting in the capture of 2,170 individual by-catch fish. An unusual feature of this fishery is the high percentage of mako shark in the by-catch (73.7 per cent of records) and high numbers in individual sets (averaging 33 sharks per set catching mako), which again suggests that by-catch is only reported when numbers are substantial.

No information is available on the by-catch of the purse seine fisheries in eastern Australian waters. Similarly, there is very little data available on the by-catch of the small number of sets made in New Caledonian waters by US seiners. Hoffschir (1981) reported the presence of considerable numbers of sharks taken as by-catch during three school fish sets near the Chesterfield Reefs during an observer trip on one US vessel.

3.3.1.5 By-catch from 'Other' and 'Unspecified' set types

'Other' and 'Unspecified' set types produce a variety of by-catch species (Table 3.5) and quantities that suggest that many of these sets are made on floating objects. For the sets with by-catch, 60.3 per cent of 'Other' sets and 95.3 per cent of 'Unspecified' sets were made before 0600 hours, at a time when most floating-object sets are made in the WTP (Hampton & Bailey 1993). The respective percentages for all sets within these categories made before 0600 are 26.3 per cent and 67.4 per cent.

3.3.2 By-catch by fleet

In terms of individual fleets, the Philippines and Solomon Islands fleets provide the highest level of by-catch reporting, ranging from 14.5 to 16.3 per cent of anchored FAD sets and 19.2 to 50.0 per cent of log sets (Table 3.2). Both fleets are based on fishing on anchored FADs. Reporting levels from the Philippine fleet appear to be higher than those of other Asian fleets operating in the region, and the Solomon Islands purse seine fishery is intermittently monitored by a domestic observer programme, which improves reporting considerably. The lowest levels of reporting are seen in the Japanese, Korean and Taiwanese fleets, most of which have not been subject to regular observer programmes and seldom entered regional ports prior to 1993. The US reporting level for school sets is comparable to that of the above three fleets but an order of magnitude higher than either Japan or Taiwan for log sets. This discrepancy is compounded by the fact that the proportion of log to school sets made by Japanese and Taiwanese vessels is far higher than that of the US Reporting on US boats may be better, due to the presence of FFA observers on many of the vessels and the fact that the logsheet form used by the US vessels provides more definition for the recording of by-catch and discards.

The Philippines fleet exhibits the lowest by-catch discard rate (21.9% for the fleet), primarily because one of the companies involved (Company 2 in Table 3.7) retains and processes both tuna and by-catch species for sale. The high by-catch and proportion of recorded sets for the company (4.0 mt per set, 21.7% of sets) may also relate in part to this retention. In comparison, Company 1, which fishes in a similar fashion to Company 2, records extremely low levels of by-catch and discards. According to an executive of Company 1, its vessels keep by-catch to a minimum by using a mesh size of 12 in (30 cm) in the main body of the seine net, through which they claim bait fish can swim without becoming entangled. In comparison, US and Japanese nets typically have a mesh size of 4–6 in (10–15 cm) and 4–9 in (10–23 cm), respectively. The mesh size in Company 2 nets measures about 1–2 in (2.5–5 cm). The mesh size in the sack of Company 1 nets is similar to that of other fleets, averaging 3.5 in (9 cm), but the company is considering increasing this to 6 in to reduce gilling of small tuna and mackerel scad. In addition, these vessels purse the net at maximum speed so that bait fish can escape over the corkline as it sinks, although this can result in tuna escaping as well.

These practices should certainly reduce the amount of by-catch, even if it does not eliminate it entirely. The large mesh size in the Company 1 nets and the possibility of increasing the mesh size in the sack are innovations that may be worth investigating if there is a movement towards reducing or controlling by-catch in the fishery.

Retention and subsequent sale of by-catch has caused problems for some purse-seine fleets operating in the region. Sale of by-catch (and tuna discards) has lead to intense conflict between seiner crews and local fishermen in the Solomons and Fiji (A.D. Lewis pers. comm.) The same is true in American Samoa, where inexpensive and readily available purse-seine and longline by-catch has long been a constraint on the development of local artisanal fisheries (Itano 1991). Since the recent ban on high seas transshipment (June 1993), problems relating to the influx of by-catch from Taiwanese and Korean purse-seine vessels have been addressed to some extent by regulations restricting local trade of rejected by-catch in the ports of Kosrae and Chuuk (Heberer pers. comm.).

3.3.3 By-catch by species

3.3.3.1 Billfish

Six species of billfish are known to occur as by-catch of the purse-seine fishery in the WTP (Table 3.4). Billfish by-catch data on the RTFD is very sparse and therefore of little value (Table 3.5), apart from highlighting the extent of non-reporting. The introduction to the US fleet in mid-1991 of a new log form that includes a column specifically for billfish catch has only slightly improved the quantity of data. In comparison, observer reports, summarised in Tables 3.8 and 3.9, show that billfish are a common by-catch item in log sets (42.5% of 108 sets and 14.3% of 98 sets from MMA observers) and to a lesser extent in unassociated school sets (9.2% of 163 sets and 5.2% of 170 sets from MMA observers). Marlin species dominate this by-catch, particularly the blue marlin which occurs in at least 72.1 per cent and 33.3 per cent of those observed log and school sets, respectively, with billfish catch (Table 3.8). It is curious, however, to notice the billfish species composition of the by-catch recorded on logsheets (RTFD) from US purse seine vessels (Table 3.8) which show a higher proportion of black marlin than blue marlin in both log and school sets, a situation thought to be the reverse in the WTP (Nakamura 1985). No information was found to indicate whether a preference for reporting black marlin by-catch exists for this fleet, some degree of misidentification has occurred, or if there is any other explanation for this occurrence.

An extrapolation from the figures in Table 3.8 gives an estimated catch of 27,686 billfish over the period investigated (3,068 from school sets, 24,618 from log sets), and 6,959 in 1990 (1,012 from school sets, 5,947 from log sets) after scaling the set number for coverage. Taking an average weight of 66 kg per billfish, the estimated catch in 1990 may represent 459 mt of billfish. Japanese participants at Billfish Symposium II mentioned that Japanese seiners operating in the WTP caught between 114 and 139 mt of marlin per year over the period 1985 to 1987 (Bailey 1988), which suggests that the estimate for 1990 is of the correct order of magnitude.

As the fishery has developed, there has been a gradual shift, involving the larger and more technologically advanced fleets, from fishing on logs to setting on free schools. As the proportion of school sets with accompanying marlin is substantially less than that of log sets, this shift may have resulted in a decrease in marlin by-catch, offset to an unknown degree, however, by fleet expansion.

In the New Zealand skipjack fishery, the billfish by-catch is dominated by striped marlin in terms of numbers (Habib et al. 1982) and occurrence in sets (Table 3.6), followed by the blue marlin and black marlin. Swordfish occur in relatively small numbers. The predominance of striped marlin in the catch is not surprising, considering that the species prefers subtropical and temperate waters (Nakamura 1985) and supports a sport fishery along the north-east coast of New Zealand.

The proportion of billfish by-catch that is discarded is not known, although from observer reports and personal experience, it is probably high. Billfish are normally discarded from US seiners when they hinder the sacking-up and brailing processes, but are brought on board for crew consumption if time permits and the catch of tuna in the particular set is small (Bailey pers. obs.). Special efforts are made to retain swordfish on the rare occasions they are caught, because of their superior eating quality. On Japanese vessels, billfish are also usually discarded, although Gillett (1986b) reports that one single seiner retained billfish for sale in Japan. It is not known how widespread this practice is, although it is probably dependent on current prices on the Japanese market and the species involved.

Amongst the remaining fleets, billfish are probably retained for consumption whenever practical, and for sale in some instances, for example Philippines vessels, and New Zealand vessels operating in Fiji waters (Farman 1984).

3.3.3.2 Seabirds

There are no records in either the RTFD or in the literature of seabirds occurring as by-catch of purse seiners operating in the WPO.

3.3.3.3 Marine reptiles

There are no data on the by-catch of marine reptiles in the RTFD. SPC staff have noted the occurrence of three species of turtle and a single species of sea snake in the vicinity of logs and FADs and in purse-seine sets on logs. Of the 116 logs investigated by the RTTP in 1991, individual turtles were associated with six (5.2%).

Since January 1993, turtle by-catch data have been collected by MMA observers active on purse-seine vessels operating in the WTP (Heberer 1994b). Of the 493 sets observed during the period January 1993 to April 1994, 10 turtles (5 hawksbill, 2 olive ridley, 1 leatherback, 2 unidentified) were taken; at least 6 of these were alive when released. Most of this by-catch was taken in log sets (7) and the remainder (i.e. 1 olive ridley, 1 hawksbill and 1 unidentified turtle) were accidentally taken in separate school sets. The catch rate by school association calculated for these data (where observed sets can be broken down by school association) is 1.34 turtles per 100 school sets and 1.92 turtles per 100 log sets, although the 95 per cent confidence intervals of ±1.85 and ±2.65, respectively, highlight the small sample sizes currently available and thus the inadvisability of extrapolation.

The fate of turtle by-catch is unknown, although, as mentioned, most of the recent turtle by-catch reported by MMA observers was released alive. One US seiner, owned and operated by Americans of Japanese descent, is known to release any turtles caught because it is considered bad luck to hurt them. It is not known, however, whether turtles are also released by Japanese flag vessels, although it is possible that vessels operated by some of the older Japanese fishermen may follow this belief.
Marine reptiles are also known to occur in association with drifting and anchored FADs and current lines of floating debris.

3.3.3.4 Marine mammals

There is no evidence to suggest that purse seiners make dolphin-associated sets in the WPO. The dolphin species that form associations with large yellowfin tuna in the eastern Pacific, primarily the spotted dolphin (*Stenella attenuata*) and to a lesser extent the spinner (*S. longirostris*) and common (*Delphinus delphis*) dolphins (Wild 1991), are present in the WPO, but appear to be rare in the main area of purse seine activity and do not form large aggregations similar to those found in the ETP. In a series of exploratory charters between 1974 and 1984, ten US seiners experienced in tuna/porpoise fishing recorded 190 dolphin pods over a period of 772 searching/fishing days, of which 61 were of the preferred three species (PTDF 1977, 1978; Souter & Broadhead 1978; Burns & Souter 1980; Salomons & Souter 1980; Souter & Salomons 1980a,b;

Bailey & Souter 1982; Lambert 1984). In two instances dolphin–tuna associations were encountered but not set on (PTDF 1977). More recent reports on Japanese and U.S. vessels support this evidence, with none of the authors recording dolphin sets (Gillett 1986a,b; Farman 1987; Tanaka 1989; Itano 1991; Suzuki 1992; MMA observer reports: Heberer 1994b). In addition, of the 1,794 tuna schools sighted and fished by the SPC tagging vessel, *Te Tautai*, in the WPO (excluding Indonesia and the Philippines) during 1992–1993 only one school, found in northern Papua New Guinea waters, was associated with dolphins. These dolphins were tentatively identified as spinners. However, this vessel has fished on six dolphin-associated tuna schools (out of 264 schools) in the archipelagic waters of Indonesia and the Philippines, suggesting that the association may be more common in these areas. It should be noted that none of these associations involved the large yellowfin typical of the eastern Pacific association, but involved either skipjack or mixed schools of skipjack and small to medium-sized yellowfin. The tightness of this association was also unknown.

The WTeP provides the only recorded instances of dolphin by-catch; these reports come from the seasonal purse-seine fishery for skipjack in northern New Zealand waters which was routinely monitored by a MAF Fisheries scientific observer programme. Of the 2,924 sets made in the fishery between 1976 and 1983, only two are known to have resulted in the capture of dolphin (MAF Fisheries records). One set, made at dusk, resulted in the drowning of 11 common dolphin, while the second set resulted in the capture of 15 common dolphin, of which 13 were released alive. In both instances, the catch was purely accidental as dolphin do not form an association with skipjack in New Zealand waters. The first author was an observer on the vessel that made the dusk set, and noticed a group of dolphin riding on the bow wave on the port side of the vessel. By the time the circle was complete it was dark, the dolphin were unable to evade the net or dive under it, and it was impossible to rescue them. Near the end of retrieval, the net 'collapsed' and the dolphin were caught in the webbing and drowned. The second set was made in mid-afternoon, and there was sufficient time for a 'backing-down' operation and the release of most of the trapped dolphin. It is worth noting that the common dolphin is abundant in New Zealand waters and not shy of approaching fishing vessels (Gaskin 1972); the low incidence of their capture noted here therefore suggests that in most cases they are capable of evading purse-seine nets.

Pilot whales (*Globicephala* spp.), or 'blackfish' as they are known to US fishermen, are often seen in the vicinity of logs. These whales are readily observed in the early hours of the morning because they produce a characteristic signal on the sonar equipment that is used to check the logs for tuna. Their presence tends to disrupt the usual aggregation pattern at this time of day, resulting in the tuna schools dispersing rather than forming fishable concentrations. Because of this, few, if any sets, are made on logs with pilot whales in attendance and no records in the RTFD or literature exist of these whales being caught.

Baleen whales, most commonly the sei whale, are occasionally encircled during purse seine operations on tuna schools that are usually feeding on pelagic baitfish. These animals generally punch through the net, usually close to the surface, or are aided in their release by submerging a portion of the corkline. In some cases, whales have been observed to return to feeding after being set on (D.G. Itano pers. obs.), which suggests that their encounters with the purse-seine operation are not overly traumatic.

3.3.3.5 Whale shark

There have been observer reports of the incidental capture of whale shark by purse-seine vessels operating in the WTP and some accounts of injuries being sustained during subsequent release from the net (Heberer, 1994b).

Logsheets (and hence the RTFD) do not provide a breakdown of whale-shark sets for all purse-seine fleets; when they do, there is no indication of capture, size of animal or subsequent fate. As mentioned, whale-shark sets have been grouped with animal sets, of which there were 115 during 1992 (1% of all sets; RTFD), most of which were reported from the Korean (53) and Japanese (46) fleets; from observer accounts, whale-shark sets are expected to make up the smaller proportion of these. While whale-shark capture is known to occur, it is generally avoided due to the time wasted in attempting to release the animal. An unsuccessful release technique for a whale shark encircled in the net on one Taiwanese vessel has been described (Heberer 1994b), although no information was found on the methods of release employed by other vessels in this or other fleets in cases where whale-shark capture is encountered.

MMA observer reports list three whale shark-associated sets during the period January 1993 to April 1994 (< 1% of all sets observed), of which one set was reported as causing injuries to the whale shark.

3.3.4 Overall levels of by-catch

The geographical distributions of reported by-catch (mt) are shown in Figure 3.2 (middle). Reported by-catch is mostly concentrated in the equatorial WTP, particularly to the south of the Equator. By-catch was reported to the north of Papua New Guinea (an area of high effort), north-east of the Solomon Islands, in Kiribati waters and in the Solomon Sea, areas of relatively low effort.

During the period 1975 to 1991, data stored on the RTFD represent 2.2 million mt of fish caught by purse seiners operating in the WPO. Of this reported catch, 99.79 per cent consisted of target catch, i.e. skipjack, yellowfin and bigeye tuna (and a small percentage of southern bluefin tuna in eastern Australia), while only 0.21 per cent consisted of by-catch (Table 3.1). This reported by-catch represents 4,703 mt of fish.

For the main fishery in the WTP, the levels of by-catch reported by the fleets varies by one or two orders of magnitude. Although some of this variation can be explained by the types of schools that are targeted by various fleets (e.g. Philippine and Solomon Islands vessels concentrate on FAD-associated schools, which would be expected to result in relatively high levels of by-catch), it appears from this gross view of the available data that there is considerable non-reporting of by-catch. This is particularly apparent amongst the main fleets of Japan, Korea, Taiwan and US which fish the same areas and use the same basic strategies and gear, yet have levels of by-catch that vary by an order of magnitude.

The reported by-catch in 1992 was 0.92 per cent of the total catch. The increase, when compared to levels for the period 1975–1991, is believed to be primarily due to improved by-catch reporting by some of the WPO purse seine fleets.

Due to the paucity of the data currently available and the considerable degree of irregularity in reporting by-catch which exists, the estimation of definitive by-catch levels was not attempted. Instead, comparative statistics of available data have been provided in Table 3.3. It has already been mentioned that the median value from the RTFD for school sets (0.5 mt per set) is probably inflated due to the tendency for purse-seine vessels to report by-catch only when taken in significant quantities; the level calculated from observers (0.1 mt per set) is therefore accepted as a more realistic representation. Using the observer-reported by-catch level and based on CPUE rates (by fleet) for school sets in 1992, it is likely that by-catch constituted between 0.35 and 0.77 per cent of the total catch, by weight, for unassociated school sets. The values for by-catch per log and drifting FAD set reported by observers are somewhat closer to those calculated from the RTFD. Using the observer-reported by-catch level and 1992 CPUE rates (for log sets), it is likely that by-catch constituted between 3.0 and 7.3 per cent of the total catch for log sets.

3.4 TUNA DISCARDS

3.4.1 Tuna discards by school association

Tuna discard levels recorded on the RTFD, and by observers and in the literature are summarised in Tables 3.10 and 3.11, respectively. As with reported by-catch from logsheet data, the calculations made in Table 3.10 include only sets where tuna discards have been recorded and, as such, take no account of either non-reporting of sets with tuna discards or legitimate sets of zero discards. Considerable variation is apparent in this information, particularly in the proportions of each type of set that have tuna discards and the quantities discarded.

The frequency of reported tuna discards is shown in Figure 3.4. The frequency distribution for tuna discards, as with the frequency distribution of reported by-catch (Figure 3.3), is not well characterised by an arithmetic mean and hence has been replaced in Table 3.10 with median values. Table 3.3 compares mean tuna discards per set calculated from MMA observer data with median tuna discards per set from the RTFD (Table 3.2) and mean tuna discards per set calculated from all sets of vessel trips which report at least one set of tuna discards (RTFD).

One trend apparent in the data is that tuna discards are more common in sets on floating objects than on unassociated schools. For the RTFD data during the period 1975–1991, 1.5 per cent of log sets and 20.0 per cent of anchored FAD sets had tuna discards, compared with 0.3 per cent of school sets; levels of tuna discards for these set types were similar for 1992. Similarly, at least 23.2 per cent of log sets in observer (excluding the MMA observer programme) and literature records had tuna discards, compared with 5.4 per cent of school sets; for MMA observer records (Table 3.9), these values were 66.4 per cent and 26.8 per cent, respectively.

By school association, the amounts of discards per set reported from logsheet data are similar, with median values of 1.8 mt for school and log sets and 2.0 mt for anchored FAD and unspecified sets (Table 3.10). Comparisons with MMA observer data are only possible for school and log sets. The mean value of tuna discards for school sets according to observer reports (0.3 mt per set) is considerably less than the median value calculated from the RTFD, as is the mean value reported from the RTFD vessel trips where at least one set with tuna discards was reported (0.2 mt per set). This is probably due to the fact that some US vessels have the tendency to report tuna discards only when considerable amounts are involved (i.e. 5, 10 and 20 short tonnes : Figure 3.4). The mean by-catch for log sets reported by MMA observers (0.9 mt per set) is also noticeably less than the level calculated from logsheet data (1.8 mt per set).

3.4.2 Reasons for discarding tuna

An examination of the reasons given on logsheets for discarding tuna provides a clearer picture of the nature of tuna discards and of the apparent trends. A summary of these reasons is given in Table 3.12, while Table 3.13 and Figure 3.5 show the RTFD discards data subdivided by reason. Tuna can be discarded accidentally through gear failure, such as a ripped sack during sacking-up or brailing, or intentionally due to storage problems that affect the quality of the catch and may result in the loss of a well of fish or the entire load. Tuna can also be discarded deliberately because the fish are too small for canning (typically < 3–4 lb or < 1.4–1.8 kg), are soft or smashed, or the vessel is fully loaded. The RTFD also includes discards of undesirable tuna species, presumably of frigate tuna and kawakawa, that should in fact be considered as by-catch.

3.4.2.1 Small tuna

Seventy-five per cent of all reported tuna discards were discarded because they were too small for canning (Table 3.13). The set types with the highest reported discards of small tuna were log and anchored FAD sets (67.1% and 92%, respectively: Figure 3.5), presumably because the associations tend to aggregate a wide size range of tuna that often includes a large proportion of small fish (e.g. Hampton & Bailey 1993). As these sets are made before dawn, there is little chance of avoiding the small tuna if they are present. Some vessels, particularly in the US fleet, attempt to reduce this incidence by trolling around the floating object during the day in order to determine what size of tuna is present and whether a set is worthwhile. Vessels in the Philippine fleet take this one step further by often setting only when the tuna school is clearly separated vertically from the bait under the log or FAD, in the belief that small tuna are usually mixed with the bait.

One of the Philippine companies that operate purse-seine vessels in the WPO claims to keep the catch of small tuna (and hence, tuna discards) to a minimum by careful gauging of the size of the tuna around the FADs. If all fish signs on the sonar are within 15 m of the surface, the FAD is usually not set on, as the tuna are thought to be too small for canning (for this company, < 1.2 kg). This is verified by observing surface activity. If large tuna are mixed with the spot, however, they are usually seen jumping, and in this case a set is made. If there is a separate sonar target below the bait and small tuna, then a set is also made. This is a routine method used by most fleets to determine whether logs or FADs are chosen for a set.

Trials with larger than the standard 3.5 in (9 cm) mesh sizes in the sack have also been conducted recently by this company over a period of nearly 4 months resulting in mixed success (Abao pers. comm.). The use of the larger mesh (5.0 in) was observed to result in a definite drop of small tuna catch (<3 lb: 0.743% of the total catch) compared to the control vessel (6.13%) which fished in the same operating period and area with the standard 3.5 in mesh size in the sack. However, the trial net did not appear to significantly reduce the number of 'gillers' caught in the net, as larger fish had a tendency to get caught in the larger mesh. Recommendations on the placement of 3.5 in and 5 in (mesh size) sections at strategic positions and the maneuvering of the last 20 fathoms of net were subsequently viewed as positive steps in reducing the gilling problem with the trial net. Further trials were to be conducted.

In comparison, unassociated schools largely consist of uniformly-sized fish. As school sets are made during the day on visible schools, experienced fishermen are usually able to judge tuna size and avoid setting if they appear too small. As a result, the amount of tuna discarded in school sets is smaller because of size (7.6% of all small tuna discards; 30.0% by association). It should be noted, however, that this is still the principal reason for reported discarding of tuna from unassociated schools, in terms of both weight and occurrence (44.1% of school sets with tuna discards).

On a fleet basis, both the Korean and US fleets reported discarding greater quantities of small tuna in log sets than in school sets, while the Japanese fleet reported no small tuna discards in either set type. This category accounts for all reported tuna discards in the Solomon Islands FAD-based fishery, and the largest part of the discards in the Philippines fleet. The latter fleet reported no small tuna discards from the 72 school sets or 2,444 drifting FAD sets made. The New Zealand fishery is dominated by medium-sized skipjack (Habib et al, 1981), so that discards of small tuna are unknown.

3.4.2.2 Damaged tuna

Soft and smashed tuna are discarded because they are too damaged for processing at the cannery. Tuna in this category have either been crushed by the power block after becoming entangled in the net or have been at the bottom of the sack for too long during sacking-up and brailing, have consequently softened because of high temperature, and have been crushed against the webbing by the weight of the tuna above. In the logsheets used by the fleets, this category has to be entered under 'Other reason' and the reason specified by the person filling in the form. Only US vessels have recorded soft and smashed discards, and this is reflected in Table 3.13. Not surprisingly, this category is common in sets with catches of over 100 mt (5 of the 9 occurrences of smashed tuna discards in 1992), where sacking-up can take 1–2 hours and brailing a similar period. However, the actual volume of discards is not positively correlated with catch, and in most cases is either reported as 1 or 2 short tons (0.9 or 1.8 t), irrespective of the catch (Figure 3.4). One school set of 180 mt resulted in 58 mt of discards, probably because of mechanical problems (e.g. burst hydraulic line, damaged brailer or burnt-out winch motor) that prolonged the sacking-up and brailing times.

It is likely that most sets in the WTP that yield over 100 mt have some volume of soft and smashed tuna discards. The RTFD records a total of 756 such sets (4% of all sets in 1992), which is an indication of the occurrence of this discard type. The large quantity of tuna discards under the 'Other' category of Philippine log sets (Table 3.13: 292.8 mt) came from sets with catches below 100 mt, which suggests that most of these discards were not soft or smashed.

It should be noted that one factor contributing to this discard category is the high water temperature experienced in the WTP, and that similar problems do not exist in the New Zealand fishery, where catches often exceed 100 mt per set but temperatures are typically 10°C lower.

Tuna become entangled in the net in most sets, irrespective of association, but usually in low numbers. In most cases, the fish can be shaken out of the net and back into the water inside the encircling net by momentarily changing the direction of pull of the power block. Most seiners in the fishery use boom-mounted power blocks and are able to shake 'gillers' out of the net. Those vessels with deck-mounted net haulers (7 Japanese group seiners, 1 Australian single seiner, and possibly 1 Japanese single seiner) are unable to do this, and as a consequence all gillers are dragged through the hauler, then the power block, and are crushed. Itano (1991), for instance, notes that one Japanese group seiner discarded 3 mt of smashed tuna during the course of 15 sets. The relatively small number of these vessels, however, means that the quantity of such discards is overall very low. Occasionally, a large part of the catch may become entangled if the net collapses because of strong currents, poor setting practice, or mechanical problems that delay net retrieval. Japanese vessels are best suited to counter this because they utilise two or three small towboats to keep the net 'open'; US-style seiners typically employ one towboat, making the task potentially more difficult.

Gillers often occur in school sets that are made in the late afternoon or early evening, simply because the fish blunder into the net in the encroaching dark. While the power block operator will usually try to shake the gillers out of at least the first half of the net, much time is lost and a point reached where this is detrimental to the condition of the remaining catch. Thus, net retrieval may proceed at full speed, and all remaining gillers run through the power block and are crushed. The actual quantity of these discards is impossible to estimate because they are controlled by the practices of individual fishing masters, conditions at the time of each set and the amount of catch. However, an indication of their occurrence can be seen in the number of successful school sets that began after 1700 hours. For the RTFD in 1992, this figure was 30 school sets (0.3 %) and 2 log sets (0.03%). It is said to be possible to reduce the incidence of gillers during night sets by shining a spotlight into the center of the net, in the hope that the tuna will be attracted to the light and away from the net.

3.4.2.3 Gear failure

Fishing gear failure that results in accidental tuna discards usually occurs as a result of a sack ripping, which mostly happens with large catches (>100 mt) that prove too heavy for the webbing. This occurs because of worn webbing; burrs or sharp edges on the stem or hull of the vessel that rip the net during setting or sacking-up; or improper sacking-up technique. In the latter case, if the netting is not retrieved evenly, pockets can develop in the sack; these are not supported by the vessel and the catch can suddenly shift into such a pocket and cause the net to rip. The rip can occur during sacking-up and result in the loss of the entire catch, or during brailing so that at least part of the catch may have already been lifted aboard. Ripped sacks appear to be a rare event in the fishery because of the care usually taken in sacking-up and in maintenance of the webbing. Only two such events are recorded in the RTFD: a school set that resulted in the loss of an estimated 227 mt after 110 mt had been successfully brailed on board and a log set that lost 9.1 mt (Table 3.13). The observer data and literature list three school sets that resulted in losses of 150, 200 and 272 mt. The first two losses occurred during an early PTDF exploratory charter to the WTP using a modified eastern Pacific-style purse-seine net and relatively old vessel (Souter & Broadhead 1978). Since that time, net and hauling technology have improved considerably. The third loss was reported by a FFA observer, but neither the set nor the loss was recorded on the logsheet for the vessel (US purse-seine vessel, 6 May 1991, set started at 1930 hours). It is therefore possible that ripped sacks occur more often than reported.

3.4.2.4 Vessel fully loaded

Tuna discarded because the seiner has filled all her wells but caught more than her requirements on the last set is known to occur in the fishery and is considered largely uncontrollable. The 'Vessel loaded' category on the standard Catch Report Form is reported in four of the six fleets declaring tuna discards and makes up 7.0 per cent of discards by weight. The actual discard amount is impossible to determine because it depends on how much tuna is on board when the set is made and the size of the school set on. If a vessel is almost fully loaded and encounters a group of schools, the fishing master may select a school that is sufficient to fill the remaining capacity and avoid those that are too large. However, his decision will probably be driven more by which school appears to be the most catchable, and this may prove to be far more than is required.

If another seiner is nearby, transshipment of the excess may occur, as happened with 59 mt from a school set in the US fleet. Once again this is an unpredictable feature of the fishery, as seiners often fish in groups, particularly when areas of school fish or logs have been located, but also operate alone, when there is little chance of transshipping excess catch. Japanese, Korean and US seiners are known to operate in groups, searching areas *en masse* and passing on daily intelligence to members of the group by coded radio messages (hence the term 'code group'). It is unlikely, however, that transshipment will occur between vessels belonging to different fleets or different code groups of vessels within a fleet. The transshipment mentioned above, for example, was made between two US vessels belonging to the same code group (and owned by the same company). The recent ban on high-seas transshipments (June, 1993) and regulations prohibiting the dumping of discards in the waters of regional ports may also restrict some fleets in options for distributing excess catch.

Another problem with transshipping excess catch is that it is a difficult and time-consuming operation with US-style single seiners. The catch has to be brailed onto the vessel that originally caught the fish and transferred by shutes to a net belonging to the second vessel. Then it is a matter of either lifting this net or brailing the fish onto the second vessel. Thus, there is a good chance that much of the excess catch will be too damaged or soft to be retained.

Transshipment of excess catch is a common practice with group seiners, because they regularly operate with two or more carrier vessels and are configured to brail directly to the carrier. Group seine vessels have the advantage of calling in another carrier if the catch is excess to the capacity of one ship. On one Japanese group seiner, Itano (1991) reported that a 60 mt catch was kept alive in the net for several hours until a second carrier vessel arrrived on the scene and brailing commenced. Fifteen tonnes were required to fill the first carrier, after which she exchanged places with the second vessel which took the remaining 45 tonnes. However, approximately three tonnes of skipjack were discarded on the first carrier one day after the holds were filled, as the fish had expanded during freezing to over-fill the holds. On some carrier vessels, this is probably a standard practice that assures that the carrier is completely filled with high-quality catch that is not crushed or smashed during freezing.

3.4.2.5 Storage problems

Even though discards of tuna at sea from storage wells and rejection of tuna at canneries are termed 'wast-age', they are not considered to be a part of the fishing operation *per se* and, thus, only brief mention of them has been made in this review.

Storage problems relate to the refrigeration and storage of the catch. One problem that occurs at sea, albeit rarely, is the contamination of a well of fish because of burst ammonia coils. There are no observer or literature records covering such an incident, and only one record on the RTFD, resulting in the loss of 54 mt (Table 3.13). Wells of tuna or entire catches of a vessel have been known to be rejected at the canneries in Pago Pago, American Samoa, if fish quality is poor, (e.g. not frozen properly, high histamine or salt levels, or 'honeycombing' of the meat). Burns (1985) reviews procedures for the handling and refrigeration of tuna on US purse seiners and lists causes of quality loss. There are no records of such events in the literature or on the RTFD.

3.4.3 Overall levels of tuna discards

The distribution of tuna discards (mt) for the period is shown in Figure 3.2 (bottom). As with by-catch, almost all discards occur in the WTP between 5°N and 10°S, which is effectively where nearly all the effort occurs.

During the period 1975–1991, the RTFD shows that 0.24 per cent of the total catch of the purse seine fishery consisted of tuna discards. This percentage amounts to 5,594 mt of tuna. As with by-catch, the reporting of tuna discards by the various fleets can vary by one or two orders of magnitude (e.g. Japan and Korea reported tuna discards of 0.01 and 0.29% of their total catches in the WTP, respectively). The highest levels of tuna discards are seen in the FAD-based fisheries of the Solomon Islands and Philippines fleets (3.31% and 1.05%, respectively). The Australian, Mexican, Russian and Taiwanese fleets did not report tuna discards for the period, and neither did the US fleet operating outside the WTP nor the New Zealand fleet working in its home waters. Similar levels for reported tuna discards were maintained during 1992 (i.e. 0.30 % of the total catch).

Due to the irregular nature of tuna discards in purse-seine fisheries, an estimate of the extent of such discards is neither possible nor realistic with the available information. Table 3.3 provides some indication of the level of tuna discards, with comparative statistics derived from logsheet and observer data. The median value of tuna discards calculated for school sets (1.8 mt per set) from the RTFD is inflated when compared to the trip average (RTFD: 0.2 mt per set) and the observed level (0.3 mt per set) (as was apparent in the calculated levels of by-catch presented in this table). This is also evident for tuna discards for log sets where the RTFD median value (1.8 mt per set) is double the observed level (0.9 mt per set).

3.5 COMPARISONS WITH OTHER PURSE-SEINE FISHERIES

As many of the by-catch species found in the various school associations in the WPO are cosmopolitan and occur in similar associations throughout the world's oceans (e.g. Arenas et al. 1992, for eastern Pacific), it is likely that they, or related species, also occur as purse-seine by-catch. This is particularly so for the most abundant species encountered around logs and FADs, notably the rainbow runner, silky shark, mackerel scad, ocean triggerfish and mahimahi. Little published information is available, however, on the actual levels of by-catch and discards in other purse-seine fisheries. Au (1991) presents detailed information on the proportions of by-catch species in school, log- and porpoise-associated schools in the eastern Pacific fishery. Although there are differences between the two areas (e.g. billfish occurrence was similar for all set types in the EPO, with sailfish and striped marlin the predominant species c.f. blue and black marlin in the WPO), the essential point remains that most by-catch occurs with log sets. Hallier and Parajua (1992) make a similar point with the Indian Ocean purse-seine fishery, where 87 per cent of by-catch observations came from log schools.

By-catch levels of US purse seiners operating in the eastern tropical Atlantic from 1967 to 1975 are summarised by Sakagawa (1976). Reported by-catch consisted entirely of scombrids (albacore, little tunny (*Euthynnus alleteratus*) and frigate and bullet tunas (*Auxis thazard* and *A. rochei* respectively)) and was usually recorded when 'about a ton or more' was caught in a set. Albacore were usually retained because of their high value; catch levels of the less valuable species (little tunny, *Auxis* spp.) were considered to be under-estimates because of non-reporting of discards. Rainbow runner were rarely caught and never reported. No breakdown of by-catch by school type is provided, although length-frequency information for little tunny and bigeye is given.

3.6 CONCLUSIONS

The main conclusions and recommendations to come out of this investigation of purse seine by-catch and discard practices are as follows:

(a) A summary of data held on RTFD and in reports of observers' trips, private log books and personal experience of the purse seine fishery in the WPO indicates that there is an extremely low incidence of reporting of by-catch and discards of by-catch and target catch. For the period 1975–1991, the data stored in the RTFD show that the total reported catch of this fishery exceeded 2.2 million mt, of which 0.21 per cent was listed as by-catch, 0.06 per cent as discarded by-catch and 0.24 per cent as tuna discards; for 1992, these values were 0.92 per cent, < 0.01 per cent and 0.3 per cent, respectively.

(b) Due to the poor reporting of by-catch and discards available from logsheet data and the fact that observer coverage has only recently improved, definitive estimates of by-catch have not been attempted. However, using observer-reported by-catch rates to explain and verify discrepancies with by-catch rates calculated from logsheet data, some indication of by-catch levels in the WTP is possible. For 1992, the by-catch level was determined, from observer data and ranges of CPUE by fleet, to be between 0.35 and 0.77 per cent of the total catch for school sets and between 3.0 and 7.3 per cent for log sets.

(c) In terms of set types, floating object sets produce the largest amounts, highest incidences and greatest variety of fish and other species. Log sets clearly account for more by-catch than school sets, according to observer and logsheet data (Table 3.3). The most common species in log sets, by frequency of occurrence, are the silky shark, mackerel scad, rainbow runner, mahimahi and ocean triggerfish. However, there is a trend in the larger and more technologically advanced fleets to move away from log sets and concentrate on school fish. As the by-catch of school sets is less, it is likely that by-catch levels per vessel and set may have decreased over the last 5–6 years and will continue to decrease in the future.

(d) There is no evidence to suggest that dolphins are deliberately set on or caught by the purse-seine fishery in the WTP. Large baleen whales are occasionally set on in the WTP, but are easily able to escape alive and unharmed.

(e) There is no evidence of seabirds being taken in purse seines. Marine turtles are occasionally caught, and there is some evidence that the majority may be released alive by purse-seine fleets of the WTP. Marlin are uncommon in school sets, but relatively common in log sets. However, the overall catch is minor compared to the marlin catch of longliners operating in the same area. Whale shark are occasionally set on in the WTP and there are reports of injuries inflicted on these animals when certain release techniques are attempted; it is therefore quite urgent to determine the frequency of these occurrences.

(f) Tuna discards are an irregular and unpredictable feature of the fishery. Their levels often depend on setting practices of individual fishing masters, size of the catch, conditions during the set and condition of fishing gear. An estimate of such discards for the period investigated is not possible, particularly as it is obvious that considerable non-reporting occurs. Three-quarters of reported tuna discards were made because the tuna were too small (< 3–4 lb or < 1.4–1.8 kg) for canning. Similarly, 76 per cent of reported tuna discards came from log and FAD sets.

(g) Improvements can be made to logsheet forms to ensure that the provision for recording by-catch and discard data is clearer in the future, although it is not possible to fully counter the problem of non-reporting of by-catch and discards, as this type of information is provided on a voluntary basis. It is difficult to envisage that any form of enforcement would overcome such problems.

As with many fisheries, the only practical solution is to mount a scientific observer programme aimed at collecting accurate and representative data from all fleets involved. Only with this information will it be possible to determine the true extent of the occurrence.

Suggestions for future monitoring of by-catch and discard levels in the WPO purse seine fishery are provided in Table 3.14.

Table 3.1: By-catch and discards as a percentage of the total catch of purse-seine fleets operating in the WPO, based on logbook data held in the SPC Regional Tuna Fisheries Database, 1975–1991 and 1992 (shaded)

Fleet	Area	Period	Total sets	Total catch (mt)	Target catch (%)	By-catch (%)	Tuna disc.(%)	other discards (%)
Australia	WTP	1988–1991	584	10,117	100.00	0.00	0.00	0.00
		1992	78	1,065	99.70	0.30	0.00	0.00
	WSP/WTeP	1975–1990	424	8,851	100.00	0.00	0.00	0.00
		1992	220	7,156	100.00	0.00	0.00	0.00
FSM	WTP	1991	105	627	100.00	0.00	0.00	0.00
		1992	574	14,444	99.70	0.30	0.30	0.00
Indonesia	WTP	1986–1990	433	11,471	99.98	0.02	0.39	0.00
Japan	WTP	1979–1991	45,823	1,039,476	99.93	0.07	0.01	0.01
		1992	2,887	93,827	99.50	0.50	0.00	0.00
Korea	WTP	1980–1991	7,877	153,307	99.93	0.07	0.29	0.06
		1992	2,096	31,163	99.50	0.50	0.20	0.30
Mexico	WTP	1984	164	3,191	100.00	0.00	0.00	0.00
New Zealand	WSP	1983–1985	165	1,940	96.34	3.66	0.36	0.10
	WSP (NZ)	1983–1988	1,829	22,612	100.00	2,170	0.00	0.00
Philippines	WTP	1982–1991	6,454	105,876	98.24	1.76	1.05	0.38
		1992	1,608	33,790	96.30	3.70	0.50	0.00
	WSP	1989	20	292	98.63	1.37	0.00	0.00
		1992	55	942	84.00	16.0	6.10	0.00
Russia	WTP	1985–1986	529	5,539	99.49	0.51	0.00	0.00
Solomon Islands	WTP	1984–1991	1,750	56,105	98.38	1.62	3.31	0.00
		1992	402	11,547	96.00	4.00	3.20	0.00
Taiwan	WTP	1983–1991	10,311	155,640	99.98	0.02	0.00	0.00
		1992	3,610	90,438	99.60	0.40	0.00	0.00
USA	WTP	1983–1991	27,058	659,790	99.86	0.14	0.27	0.11
		1992	7,208	204,575	99.20	0.80	0.40	0.00
	WSP	1984–1991	234	4,929	100.00	0.00	0.00	0.00
		1992	64	165	100.00	0.00	0.00	0.00
Totals	WTP	1979–1991	101,088	2,201,139	99.79	0.21	0.24	0.06
		1992	18,468	480,874	99.10	0.90	0.30	0.00
	WSP/WTeP	1975–1990	424	8,851	100.00	0.00	0.00	0.00
		1992	222	7,166	100.00	0.00	0.00	0.00
	WSP	1983–1991	419	7,157	98.95	1.05	0.10	0.03
		1992	121	1,162	86.10	13.9	4.90	0.00
	WSP(NZ)	1983–1988	1,829	22,612	100.00	2,170	0.00	0.00
Grand total	all areas	1975–1991	103,760	2,239,759	99.79	0.21	0.24	0.06
		1992	18,811	489,192	99.08	0.92	0.30	0.00

Notes

1. **% Target catch** includes tuna catches retained and discarded.
   % By-catch includes by-catch retained and discarded.
   The sum of % Target and % By-catch equals 100%.

2. New Zealand by-catch in NZ waters has been provided in numbers only.

Table 3.2: Median by-catch per set (mt) by school association for purse-seine fleets operating in the WTP, for the periods 1975–1991 and 1992 (shaded), with descriptive statistics for all fleets combined

Fleet		Unassociated school		Log		Drifting FAD		Anchored FAD		Animal		Other		Unspec.	
Indonesia	By-catch/set	–	–	1.0	–	–	–	–	–	–	–	–	–	–	–
	# by-catch sets	–	–	2.0	–	–	–	–	–	–	–	–	–	–	–
	% by-catch sets	–	–	0.6	–	–	–	–	–	–	–	–	–	–	–
	% by-catch disc.	–	–	0.0	–	–	–	–	–	–	–	–	–	–	–
Japan	By-catch/set	2.0	3.5	2.0	2.0	0.1	–	2.0	–	–	–	2.0	–	1.0	–
	# by-catch sets	3.0	2.0	89.0	6.0	2.0	–	1.0	–	–	–	133.0	–	4.0	–
	% by-catch sets	+	0.1	0.3	0.5	1.0	–	0.8	–	–	–	3.6	–	0.9	–
	% by-catch disc.	11.1	71.4	24.3	0.0	100	–	0.0	–	–	–	0.0	–	0.0	–
Korea	By-catch/set	1.0	–	1.0	5.0	–	–	–	–	1.0	–	–	–	3.0	–
	# by-catch sets	6.0	–	37.0	14.0	–	–	–	–	2.0	–	–	–	1.0	–
	% by-catch sets	0.2	–	0.9	1.6	–	–	–	–	0.6	–	–	–	0.3	–
	% by-catch disc.	100.0	–	84.2	100.0	–	–	–	–	100.0	–	–	–	100.0	–
Philippines	By-catch/set	1.8	–	1.1	4.5	1.0	5.4	1.0	6.3	–	–	2.0	–	1.0	3.0
	# by-catch sets	4.0	–	286.0	16.0	14.0	2.0	210.0	34.0	–	–	46.0	–	52.0	37.0
	% by-catch sets	5.6	–	19.1	2.6	0.6	0.5	14.5	10.6	–	–	7.8	–	13.0	12.5
	% by-catch disc.	100	–	21.9	0.0	0.0	0.0	37.2	0.0	–	–	0.0	–	0.1	0.0
Russia	By-catch/set	9.5	–	4.5	–	–	–	–	–	–	–	–	–	–	–
	# by-catch sets	2.0	–	2.0	–	–	–	–	–	–	–	–	–	–	–
	% by-catch sets	0.4	–	9.1	–	–	–	–	–	–	–	–	–	–	–
	% by-catch disc.	0.0	–	0.0	–	–	–	–	–	–	–	–	–	–	–
Solomon Islands	By-catch/set	–	–	3.0	–	–	–	3.0	3.0	–	–	3.0	–	1.0	–
	# by-catch sets	–	–	11.0	–	–	–	171.0	7.0	–	–	5.0	–	30.0	–
	% by-catch sets	–	–	50.0	–	–	–	16.3	5.6	–	–	4.0	–	5.5	–
	% by-catch disc.	–	–	0.0	–	–	–	0	0.0	–	–	0.0	–	0.0	–
Taiwan	By-catch/set	10.0	10.0	5.0	–	–	5.0	–	–	–	–	–	–	10.0	–
	# by-catch sets	1.0	41.0	3.0	–	–	3.0	–	–	–	–	–	–	1.0	–
	% by-catch sets	0.2	3.9	+	–	–	5.9	–	–	–	–	–	–	0.1	–
	% by-catch disc.	0.0	0.0	0.0	–	–	0.0	–	–	–	–	–	–	0.0	–
USA	By-catch/set	0.2	0.2	0.5	0.2	–	–	–	–	–	–	–	–	0.2	–
	# by-catch sets	55.0	28.0	252.0	140.0	–	–	–	–	–	–	–	–	3.0	–
	% by-catch sets	0.3	0.5	5.0	8.6	–	–	–	–	–	–	–	–	0.8	–
	% by-catch disc.	36.5	88.8	88.9	100.0	–	–	–	–	–	–	–	–	8.2	–
Totals	By-catch/set	0.5	5.0	1.0	0.2	1.0	5.0	1.2	5.7	1.0	–	2.0	–	1.0	3.0
	# by-catch sets	71.0	71.0	682.0	176.0	16.0	5.0	382.0	41.0	2.0	–	184.0	–	91.0	37.0
	% by-catch sets	0.2	0.8	1.5	2.7	0.6	0.9	14.4	9.1	0.1	–	3.8	–	3.1	12.5
	% by-catch disc.	40.8	3.2	44.8	53.8	0.8	0.0	12.8	0.0	100	–	0.0	–	1.5	0.0
Descriptive statistics	Minimum	0.1	+	0.1	+	0.1	4.1	0.1	1.0	1.0	–	1.0	–	0.1	1.0
	Maximum	90.7	20.0	64.0	24.0	7.0	10.0	55.0	55.0	1.0	–	46.0	–	18.0	13.0
	Mean	3.8	5.3	3.3	1.4	1.9	6.2	2.9	8.9	1.0	–	3.2	–	2.4	4.1
	Std. deviation	11.8	5.2	6.5	3.0	1.8	2.4	4.7	10.3	0	–	5.1	–	3.0	3.3
	Median	0.5	5.0	1.0	0.2	1.0	5.0	1.2	5.7	1.0	–	2.0	–	1.0	3.0
	Mode	0.1	10.0	1.0	0.1	1.0	5.0	1.0	1.0	1.0	–	1.0	–	1.0	1.0
	Geometric mean	0.6	1.7	1.1	0.2	1.3	5.9	1.6	5.3	1.0	–	2.0	–	1.0	2.9

Notes

1. Figures are median tonnes of by-catch per set for sets on the SPC Regional Tuna Fisheries Database that contain records of by-catch, total number of sets, number of sets with by-catch recorded, the percentage of by-catch sets against all sets for each association type, and the percentage of by-catch that was discarded. (+ = < 0.1%).

Table 3.3: Summary of by-catch and discard levels reported in the RTFD and MMA observer programme by school association for the major purse-seine fleets operating in the WTP

		By-catch / Set			% By-catch discarded			Tuna discarded / Set		
Fleet	**Set type**	**RTFD Day[3]**	**RTFD Trip[4]**	**MMA observer trips[5]**	**RTFD Day[3]**	**RTFD Trip[4]**	**MMA observer trips[5]**	**RTFD Day[3]**	**RTFD Trip[4]**	**MMA observer trips[5]**
Japan	School	2.0	0.1	0.2	11.1	28	N/A	2.0	0.1	+
	Log	2.0	0.5	1.5	24.3	22.3	N/A	3.0	0.5	0.2
	Drifting FAD	0.1	+	+	100	100	N/A	–	0	–
	Anchored FAD	2.0	0.2	–	0	0	N/A	–	–	–
	Other	2.0	0.7	–	0	0	N/A	–	0	–
	Unspec.	1.0	0.4	–	0	0	N/A	–	1.5	–
Korea	School	1.0	+	0.1	100	100	N/A	2.5	0.1	0.7
	Log	1.0	0.5	1.3	84.2	93	N/A	2.0	1.6	0.9
	Raft	–	–	1.0	–	–	–	–	–	0
	Animal	1.0	+	+	100	100	N/A	4.5	0.2	0.1
	Unspec.	3.0	+	–	100	100	N/A	1.5	4.1	–
Philippines	School	1.8	+	–	100	100	–	20.1	20.1	–
	Log	1.1	1.7	–	21.9	20.4	–	1.0	0.8	–
	Drifting FAD	1.0	0.2	–	0	0	–	–	+	–
	Anchored FAD	1.0	0.7	–	37.2	21.6	–	0.9	1.6	–
	Other	2.0	0.4	–	0	–	–	–	–	–
	Unspec.	1.0	1.1	–	0.1	1.1	–	2.0	1.7	–
Taiwan	School	10.0	2.1	+	0	0	N/A	–	1.7	0.1
	Log	5.0	1.0	0.9	0	0	N/A	–	0	1.9
	Drifting FAD	–	1.2	0.1	–	–	N/A	–	–	0
	Animal	–	–	0.0	–	–	N/A	–	–	0.3
	Unspec.	10.0	–	–	0	0	N/A	–	–	–
USA	School	0.2	0.2	–	36.5	39.7	–	1.8	0.2	–
	Log	0.5	0.3	–	88.9	89.3	–	2.0	1.0	–
	Drifting FAD	–	+	–	–	–	–	1.4	0.4	–
	Other	–	+	–	–	100	–	1.8	+	–
	Unspec.	0.2	0.1	–	8.2	8.3	–	28.4	+	–
Totals	School	0.5	0.2	0.1	40.8	19.4	N/A	1.8	0.2	0.3
	Log	1.0	0.3	1.3	44.8	46.1	N/A	1.8	1.0	0.9
	Drifting FAD	1.0	1.2	0.1	0.8	0.3	N/A	1.4	0.2	0.0
	Anchored FAD	1.2	0.7	–	12.8	21.5	N/A	2.0	1.2	–
	Animal	1.0	–	+	100	100	N/A	4.5	0.1	0.2
	Other	2.0	+	–	0	0.1	N/A	1.8	0.1	–
	Unspec.	1.0	0.1	–	1.5	2.2	N/A	2.0	1.4	–

Notes

1. 'School' indicates unassociated school
2. '+' indicates < 0.1 mt/set
3. Only for sets where by-catch/discards were recorded (see Tables 3.2, 3.9); *median* by-catch per set and *median* tuna discard per set calculated.
4. For vessel trips (i.e. all sets of the trip) where by-catch/discards were recorded; *mean* by-catch per set and *mean* tuna discard per set calculated.
5. For vessel trips where by-catch/discards were observed (i.e. all observed sets of the trip); *mean* by-catch per set and *mean* tuna discard per set calculated. MMA observer trips were conducted during August 1993 – April 1994 (Heberer, 1994b): Japanese vessels (50 school sets, 67 log, 7 drifting raft observed); Korea (109 school, 54 log, 1 raft, 14 animal); Taiwan (102 school, 49 log, 2 raft, 28 animal). Estimated catch for by-catch species was calculated from expected average weights where numbers only were provided.

Table 3.4: By-catch species from purse-seine sets on different school assocations in the WTP

Species	Unassoc. school	Log	Drifting FAD	Anchor–ored FAD	Animal associations: Live whales	Dead whales	Whale shark
Sharks and rays							
Blue shark (*Prionace glauca*)	–	R	–	–	–	–	–
Oceanic whitetip (*Carcharhinus longimanus*)	S	S	S	S	S	S	–
Silky shark (*C. falciformis*)	S	M	M	M	M	M	–
Tiger shark (*Galeocerdo cuvier*)	–	R	–	–	–	–	–
Whale shark (*Rhincodon typus*)	–	R	–	–	R	–	S
Manta ray (*Mobula japanica, Manta* spp.)	S	S	–	–	S	–	–
Pelagic stingray (*Dasyatis* sp.)	–	R	–	–	–	–	–
Scombrids							
Frigate tuna (*Auxis thazard*)	S	S	S	S	–	–	–
Kawakawa (*Euthynnus affinis*)	S	S	S	S	–	–	–
Wahoo (*Acanthocybium solandri*)	S	M	M	M	–	–	–
Billfish							
Black marlin (*Makaira indica*)	R	R	R	R	–	–	–
Blue marlin (*M. mazara*)	S	S	S	S	–	–	–
Broadbill swordfish (*Xiphias gladius*)	–	R	–	–	–	–	–
Sailfish (*Istiophorus platypterus*)	R	R	–	R	–	–	–
Shortbill spearfish (*Tetrapturus angustirostris*)	–	–	–	R	–	–	–
Striped marlin (*T. audax*)	R	–	–	–	–	–	–
Carangids							
Amberjack (*Seriola rivoliana*)	–	L	L	L	–	–	–
Bar jack (*Carangoides ferdau*)	–	R	–	–	–	–	–
Bigeye trevally (*Caranx sexfasciatus*)	–	M	M	M	–	–	–
Bigeye scad (*Selar crumenophthalmus*)	–	–	–	L	–	–	–
Caranx spp. (*ignobilis, lugubris, melampygus*)	–	R	R	R	–	–	–
Golden trevally (*Gnathanodon speciosus*)	–	S	–	–	–	–	–
Greater amberjack (*Seriola dumerili*)	–	S	S	S	–	–	–
Mackerel scad (*Decapterus macarellus*)	–	L	L	L	–	–	–
Pilotfish (*Naucrates ductor*)	S	S	S	S	S	S	S
Rainbow runner (*Elagatis bipinnulata*)	S	L	L	L	–	L	–
Other fish							
Batfish (*Platax teira*)	–	S	S	S	–	–	–
Bramid (*Brama* sp.)	–	R	–	–	–	–	–
Drummer (*Kyphosus cinerascens*)	–	L	L	L	–	L	–
Filefish (*Aluterus monoceros*)	–	M	M	M	–	–	–
Filefish (*A. scriptus*)	–	S	–	–	–	–	–
Flutemouth (*Fistularia* sp.)	–	R	–	–	–	–	–
Great barracuda (*Sphyraena barracuda*)	–	S	S	S	–	–	–
Mahimahi (*Coryphaena hippurus*)	S	L	L	L	–	L	–
Man-o-war fish (*Psenes cyanophrys*)	–	M	M	M	–	–	–
Ocean anchovy (*Stolephorus punctifer*)	L	–	–	–	L	–	L
Ocean triggerfish (*Canthidermis maculatus*)	–	L	L	L	–	L	–
Porcupine fish (*Diodon hystrix*)	–	R	–	–	–	–	–
Porcupine fish (*Cyclichthys echinatus*)	–	R	–	–	–	–	–
Rudderfish (*Centrolophus niger*)	–	?	?	–	–	–	–
Sergeant major (*Abudefduf saxatilis*)	–	M	M	M	–	–	–
Sea bream (*Rhadosargus sarba*)	–	R	–	–	–	–	–
Seahorse (*Hippocampus* sp.)	–	R	–	–	–	–	–
Sharksucker (*Remora remora*)	S	S	S	S	S	S	S
Therapon perch (*Therapon* sp.)	–	R	–	–	–	–	–
Tripletail (*Lobotes surinamensis*)	–	S	S	S	–	S	–
Marine reptiles							
Green turtle (*Chelonia mydas*)	–	R	R	R	–	–	–
Hawksbill turtle (*Eretmochelys imbricata*)	–	R	R	R	–	–	–
Olive ridley turtle (*Lepidochelys olivacea*)	–	R	–	–	–	–	–
Sea snake (*Pelamis platurus*)	–	R	–	–	–	–	–

Notes

1. R : rare, <1/set; S : common in small numbers, 1–10/set; M : common in moderate numbers, 10–100/set; L : common in large numbers, > 100/set; – : not present. Sources of data include various observer reports/data reviewed and pers. obsv. by authors.

Table 3.5: Purse seine catches of by-catch species recorded in the RTFD, 1975–1992

Fleet	By-catch species	Unassoc. School		Log		Drifting FAD		Anchored FAD		Other		Unspec.	
Japan	Blue marlin	–	–	1.0	1	–	–	–	–	–	–	–	–
	Frigate tuna	–	–	6.5	2	–	–	–	–	–	–	–	–
	Mahimahi	15.0	1	–	–	–	–	–	–	–	–	–	–
	Ocean triggerfish	–	–	–	–	–	–	–	–	1.8	26	–	–
	Rainbow runner	–	–	3.0	3	–	–	–	–	1.2	22	–	–
	Tuna – mixed	–	–	–	–	–	–	–	–	4.8	56	–	–
New Zealand	Broadbill swordfish	–	–	–	–	1.0	1	–	–	–	–	–	–
	Mahimahi	–	–	–	–	–	–	–	–	–	–	1.0	3
	Mako shark	(2170)	N/A	–	–	–	–	–	–	–	–	–	–
	Rainbow runner	–	–	–	–	3.0	2	–	–	–	–	1.8	15
Philippines	Albacore	–	–	–	–	–	–	–	–	–	–	1.0	1
	Blue marlin	–	–	7.5	2	–	–	1.5	2	–	–	1.0	1
	Kawakawa	–	–	13.7	3	1.7	10	6.4	7	2.8	40	–	–
	Mackerel	–	–	1.8	23	–	–	4.0	15	–	–	2.4	5
	Rainbow runner	–	–	5.7	54	1.0	1	1.6	46	1.0	1	2.2	16
	Tuna – mixed	–	–	1.6	29	–	–	0.8	20	27.0	1	3.0	1
	Tuna – unspec.	–	–	1.4	5	–	–	1.5	14	–	–	–	–
Russia	Mackerel	10.0	1	4.5	2	–	–	–	–	–	–	–	–
Solomon Is	Rainbow runner	–	–	–	–	–	–	1.7	3	1.0	1	1.2	20
	Tuna-mixed	–	–	–	–	–	–	–	–	5.0	2	–	–
USA	Albacore	–	–	1.8	1	–	–	–	–	–	–	–	–
	Billfish – unspec.	0.1	1	0.9	1	–	–	–	–	–	–	–	–
	Mackerel	–	–	0.1	11	–	–	–	–	–	–	–	–
	Ocean triggerfish	–	–	0.05	2	–	–	–	–	–	–	–	–
	Pelagic ray	0.6	5	–	–	–	–	–	–	0.2	1	–	–
	Rainbow runner	0.1	4	0.6	124	–	–	–	–	–	–	–	–
	Shark – unspec.	0.3	64	0.2	43	–	–	–	–	0.2	2	–	–
Totals	Albacore	–	–	1.8	1	–	–	–	–	–	–	1.0	1
	Billfish – unspec.	0.1	1	0.9	1	–	–	–	–	–	–	–	–
	Blue marlin	–	–	5.3	3	–	–	1.5	2	–	–	1.0	1
	Broadbill swordfish	–	–	–	–	1.0	1	–	–	–	–	–	–
	Frigate tuna	–	–	6.5	2	–	–	–	–	–	–	–	–
	Kawakawa	–	–	13.7	3	1.7	10	6.4	7	2.8	40	–	–
	Mackerel	10.0	1	1.5	36	–	–	4.0	15	–	–	2.4	5
	Mahimahi	15.0	1	–	–	–	–	–	–	–	–	1.0	3
	Mako shark	(2170)	N/A	–	–	–	–	–	–	–	–	–	–
	Ocean triggerfish	–	–	0.05	2	–	–	–	–	1.8	26	–	–
	Pelagic ray	0.6	5	–	–	–	–	–	–	0.2	1	–	–
	Rainbow runner	0.1	4	1.4	181	2.3	3	1.6	51	1.0	24	1.8	51
	Shark – unspec.	0.3	64	0.2	43	–	–	–	–	0.2	2	–	–
	Tuna – unspec.	–	–	1.4	5	–	–	1.5	14	–	–	–	–

Notes

1. Number of mako shark for NZ purse-seine fishery only.
2. Units are average metric tonnes per set. Number of sets is shaded.

Table 3.6: By-catch of US and NZ purse seiners operating in the New Zealand EEZ, 1976–1982, based on observer data supplied by the NZ Ministry of Agriculture and Fisheries

Species	Occurrence (No. of sets)	% occurrence to all sets	Average number per occurrence
Cephalopods			
Arrow squid (*Notodarus sloanii*)	22	2.4	3.5
Octopus (*Octopus* sp.)	17	1.9	1.4
Paper Nautilus (*Argonauta argo*)	7	0.8	1.2
Sharks and rays			
Blue shark (*Prionace glauca*)	18	2.0	1.2
Bronze-whaler shark (*Carcharhinus brachyurus*)	4	0.4	1.8
Hammerhead shark (*Sphyrna zygaena*)	2	0.2	1.0
Mako shark (*Isurus oxyrinchus*)	17	1.9	1.1
Spiny dogfish (*Squalis acanthias*)	1	0.1	1.0
Thresher shark (*Alopias vulpinus*)	7	0.8	1.0
Unidentified sharks	7	0.8	1.7
Eagle ray (*Myliobatis tenuicaudatus*)	3	0.3	1.3
Electric ray (*Torpedo fairchildi*)	12	1.3	2.4
Long-tailed stingray (*Dasyatis thetidis*)	20	2.2	1.7
Manta ray (*Mobula japonica*)	74	8.2	2.2
Short-tailed stingray (*D. brevicaudatus*)	5	0.6	1.4
Unidentified stingray (*Dasyatis* spp.)	10	1.1	2.0
Scombrids			
Albacore (*Thunnus alalunga*)	66	7.3	8.9
Blue mackerel (*Scomber australasicus*)	18	2.0	28.8
Frigate tuna (*Auxis thazard*)	26	2.9	6.1
Slender tuna (*Allothunnus fallai*)	2	0.2	1.5
Yellowfin tuna (*T. albacares*)	12	1.3	1.8
Billfish			
Black marlin (*Makaira indica*)	10	1.1	1.5
Blue marlin (*M. mazara*)	11	1.2	1.1
Broadbill swordfish (*Xiphias gladius*)	3	0.3	1.0
Striped marlin (*Tetrapturus audax*)	16	1.8	1.1
Unidentified marlin	3	0.3	1.0
Other fish			
Blue maomao (*Scorpis violaceus*)	1	0.1	50.0
Blue warehou (*Seriolella brama*)	1	0.1	1.0
Dealfish (*Trachipterus trachypterus*)	3	0.3	1.0
Flying fish (*Cheilopogon melanocercus*)	35	3.9	1.4
Frostfish (*Lepidopus caudatus*)	8	0.9	6.5
Hapuku (*Polyprion oxygeneios*)	1	0.1	1.0
Jack mackerel (*Trachurus* spp.)	13	1.4	11.5
John dory (*Zeus faber*)	4	0.4	2.3
Lamprey (*Geotria australis*)	1	0.1	1.0
Monkfish (*Kathetostoma giganteum*)	1	0.1	1.0
Pilchard (*Sardinops neopilchardus*)	2	0.2	22.5
Pilotfish (*Naucrates ductor*)	20	2.2	2.9
Porcupine fish (*Allomycterus jaculiferus*)	52	5.8	125.9
Pufferfish (*Lagocephalus cheesemanii*)	1	0.1	1.0
Ray's bream (*Brama brama*)	13	1.4	1.6
Red cod (*Pseudophycis bachus*)	1	0.1	1.0
Remora (*Remora remora, R. brachyptera*)	22	2.4	2.3
Rudderfish (*Centrolophus niger*)	3	0.3	1.0
Saury (*Scomberesox saurus*)	12	1.3	9.6
Silver dory (*Cyttus novaezelandiae*)	3	0.3	1.3
Starry toado (*Arothron firmamentum*)	35	3.9	16.8
Sunfish (*Mola mola*)	140	15.5	1.3
Tarakihi (*Nemadactylus macropterus*)	1	0.1	1.0
Witch (*Arnoglossus scapha*)	2	0.2	1.0
Yellowtail kingfish (*Seriola lalandi*)	1	0.1	1.0
Marine mammals			
Common dolphin (*Delphinus delphis*)	2	0.2	13.0

Note

Total number of observed sets = 904; number with by-catch = 433 (47.9%)

Table 3.7: By-catch and discards (mt per set) of Philippine purse seiners operating in the WPO, 1982–1991 and 1992 (shaded)

Philippine company		Unassoc. School		Log		Drifting FAD		Anchored FAD		Animal		Other		Unspec.	
By-catch and discards															
#1	By-catch/set	–	–	14.0	–	1.6	–	1.0	–	0.0	–	2.8	–	1.0	–
	# by-catch sets	–	–	1.0	–	12.0	–	1.0	–	0.0	–	45.0	–	4.0	–
	% by-catch sets	–	–	0.7	–	0.5	–	0.3	–	–	–	7.7	–	2.1	–
	% by-catch discarded	–	–	0.0	–	0.0	–	0.0	–	–	–	0.0	–	75.0	–
#2	By-catch/set	2.1	–	4.0	5.9	2.5	5.5	1.6	8.0	–	–	3.9	–	0.6	4.0
	# by-catch sets	4.0	–	293.0	16.0	2.0	2.0	224.0	34.0	–	–	7.0	–	225.0	37.0
	% by-catch sets	7.5	–	21.7	2.6	1.5	4.2	20.8	10.6	–	–	14.3	–	20.9	14.8
	% by-catch discarded	100.0	–	22.3	0.0	0.0	0.0	37.8	0.0	–	–	0.0	–	0.0	0.0
Tuna discards															
# 1	Tuna discards/set	–	–	–	–	–	–	–	–	–	–	–	–	–	–
# 2	Tuna discards/set	10.6	–	1.5	–	–	–	2.3	6.4	–	–	–	–	–	4.4
	# tuna disc. sets	–	–	187.0	–	–	1.0	126.0	20.0	–	–	–	–	–	25.0
	% tuna disc. sets	–	–	19.7	–	–	2.1	15.9	6.3	–	–	–	–	8.1	10.0

Notes

1. **By-catch/set** – for sets where by-catch have been reported only.
2. **Tuna discards/set** – for sets where tuna discards have been reported only.

Table 3.8: Observer and RTFD records of billfish catches from purse seiners operating in the WTP, 1982–1993

Vessel flag and type	Period and area	No. of sets observed		No. of sets with billfish	Billfish species and nos. caught	
Observer records						
US single	Jan.–Apr. 1982	Sch.	26	2	2 marlin	K. Bailey pers. obs.
	North PNG	Log	27	0	–	
US single	Jul.–Aug. 1982	Sch.	20	6	3 blue marlin, 3 marlin, 1 sailfish	Bailey & Souter 1982
	FSM–Kiribati	Log	7	0	–	
Japan single	Jun.–Jul. 1982	Sch.	1	1	1 blue marlin	Gillett 1986b
	FSM	Log	22	15	15 blue marlin, 1 black marlin	
Japan group	Feb. 1983	Sch.	2	0	–	Gillett 1986b
	North-west PNG	Log	3	2	4 blue marlin	
Japan group	Apr. 1984	Sch.	7	0	–	Farman 1987
	FSM	Log	7	7	8 billfish	
US single	Nov.–Dec. 1984	Sch.	7	0	–	Gillett 1986a
	North-west PNG	Log	7	7	10 blue marlin	
US single	Jul.–Oct. 1988 North PNG, FSM	Log	7	1	2 black marlin	FFA observer programme
US single	Aug.–Oct.1988	Sch.	13	2	2 marlin	FFA observer
	FSM	Log	9	5	9 blue marlin	programme
US single	Jan.–Mar. 1989	Sch.	41	3	1 blue marlin, 2 marlin	FFA observer
	North PNG	Log	9	5	4 blue marlin, 5 marlin, 1 sailfish	programme
Japan group	Apr.1990	Sch.	10	0	–	Itano 1991
	FSM	Log	5	1	2 blue marlin	
US single	Jul.–Aug. 1991 East of Kiribati	Sch.	32	1	2 marlin	FFA observer programme
US single	Mar. 1993	Sch.	3	–	–	Ward pers.
	Kiribati/Nauru	Log	5	3	4 blue marlin	comm.
Observer totals 1982–1993		Sch.	163	15	17 billfish (11 marlin, 5 blue marlin, 1 sailfish)	9.2%
		Log	108	47	61 billfish (8 billfish, 5 marlin, 48 blue marlin, 3 black marlin, 1 sailfish)	43.5%
RTFD records: US single	Jun.–Dec. 1991	Sch.	5415	42	51 billfish (18 billfish, 26 black marlin, 6 blue marlin, 1 striped marlin)	0.78%
	WTP, mostly east of 170° E	Log	306	7	7 billfish (2 billfish, 4 black marlin, 1 striped marlin)	2.3%
	1992	Sch.	5508	14	14 billfish (10 black marlin, 4 blue marlin)	0.25%
	WTP, mostly east of 160° E	Log	1633	17	22 billfish (2 billfish, 17 black marlin, 3 striped marlin)	1.0%

Note

Sch. = unassociated school sets

Table 3.9: Observer records of billfish catches from purse seiners operating in FSM waters, August 1993 – April 1994

Vessel flag	No. of sets observed		No. of sets with billfish		Billfish species and nos. caught	No. of sets with other by-catch	No. of sets with tuna discards
Korea	Sch.	2	1		1 sailfish	4	7
	Log	11	–		–	2	1
Japan	Sch.	17	1		1 marlin	4	6
	Log	19	7		7 marlin	19	12
Taiwan	Sch.	14	2		3 black marlin	3	8
	Log	4	–		–	3	3
Taiwan	Sch.	7	1		2 blue marlin	1	1
	Log	2	–		–	1	1
Korea	Sch.	4	1		1 striped marlin	2	2
	Log	6	–		–	1	1
	Whl.	1	–		–	–	–
Taiwan	Sch.	12	–		–	–	2
	Log	2	1		1 black marlin	3	3
	Whl.	4	–		–	1	2
Taiwan	Sch.	6	–		–	–	–
	Log	3	–		–	3	3
	Raft	1	1		1 blue marlin	1	1
	Whl.	20	–		–	2	1
Taiwan	Sch.	32	–		–	–	2
	Log	1	–		–	–	–
Korea	Sch	9	1		1 striped marlin	3	3
	Log	2	–		–	–	–
	Whl.	2	–		–	–	–
Japan	Sch.	5	–		–	–	–
	Log	16	3		4 marlin	15	10
Korea	Sch.	13	1		1 blue marlin	6	4
	Log	3	–		–	3	3
	Whl.	6	1		1 blue marlin	5	3
Korea	Sch.	16	1		2 sailfish	5	3
	Log	10	1		2 black marlin	9	8
	Whl.	1	1		1 sailfish	–	–
Korea	Sch.	15	–		–	2	2
	Log	8	1		2 blue marlin	8	8
	Whl.	3					
	Raft	1	–		–	1	1
FSM	Sch.	18	–		–	–	–
	Log	11	1		1 blue marlin	16	16
	Whl.	1	–		–	–	–
Totals	Sch.	170	9	5.2%	3 blue marlin, 3 black marlin, 2 striped marlin, 3 sailfish, 1 marlin	30	40
	Log	98	14	14.3%	3 blue marlin, 3 black marlin, 11 marlin	83	69
	Raft	2	1	50.0%	1 blue marlin	2	2
	Whl.	38	2	5.3%	1 blue marlin, 1 sailfish	8	5

Notes

1. Observer trips are in chronological order.
2. **Sch. -** School sets; **Log -** Log sets; **Raft -** Raft sets; **Whl. -** Whale-shark sets.
3. Data derived from Heberer, 1994b.

Table 3.10: Median discards of tuna per set (mt) by school association for purse-seine fleets operating in the WTP, 1979–1991 and 1992 (shaded)

Fleet		Unassoc. School		Log		Drifting FAD		Anchored FAD		Animal		Other		Unspec.	
Indonesia	Tuna discards/set	10.0	–	10.0	–	–	–	–	–	–	–	–	–	–	–
	No. of tuna discard sets	1	–	3	–	–	–	–	–	–	–	–	–	–	–
	% tuna discard sets	2.7	–	0.9	–	–	–	–	–	–	–	–	–	–	–
Japan	Tuna discards/set	2.0	5.0	3.0	–	–	–	–	–	–	–	–	–	1.0	–
	No. of tuna discard sets	1	1	11	–	–	–	–	–	–	–	–	–	15	–
	% tuna discard sets	+	+	+	–	–	–	–	–	–	–	–	–	3.2	–
Korea	Tuna discards/set	2.5	10.0	2.0	5.0	–	–	–	–	4.5	–	–	–	1.5	–
	No. of tuna discard sets	12	1	101	10	–	–	–	–	2	–	–	–	6	–
	% tuna discard sets	0.4	+	2.5	1.0	–	–	–	–	0.6	–	–	–	1.8	–
Philippines	Tuna discards/set	20.1	–	1.0	–	–	0.1	0.9	2.0	–	–	–	–	2.0	3.0
	No. of tuna discard sets	1	–	251	–	–	1	186	20	–	–	–	–	24	25
	% tuna discard sets	1.4	–	16.7	–	–	0.2	7.6	6.3	–	–	–	–	6.0	8.4
Solomon Islands	Tuna discards/set	–	–	–	–	–	–	3.0	3.0	–	–	–	–	3.0	3.0
	No. of tuna discard sets	–	–	–	–	–	–	340	70	–	–	–	–	87	1
	% tuna discard sets	–	–	–	–	–	–	32.4	56	–	–	–	–	15.9	0.4
USA	Tuna discards/set	1.8	2.7	2.0	2.7	1.4	–	–	–	–	–	1.8	–	28.4	–
	No. of tuna discard sets	95	14	206	81	2	–	–	–	–	–	3	–	2	–
	% tuna discard sets	0.4	0.3	4.1	5.0	7.4	–	–	–	–	–	1.4	–	0.5	–
Totals	Tuna discards/set	1.8	3.6	1.8	2.7	1.4	0.1	2.0	3.0	4.5	–	1.8	–	2.0	3.0
	No. of tuna discard sets	110	16	572	91	2	1	526	90	2	–	2	–	134	26
	% tuna discard sets	0.3	0.2	1.5	1.5	7.4	+	20.0	20.2	0.6	–	1.4	–	6.0	1.9

Note

Figures are median tonnes per set for sets on the SPC Regional Tuna Fisheries Database that contain records of tuna discards, number of sets with tuna discards, and the percentage of tuna discard sets against all sets for each association (+ = < 0.1%).

Table 3.11: Observer and literature records of tuna discards by purse seiners operating in the WTP, 1977–1993

Vessel flag and type	Period		No. of sets observed	Sets with tuna discards	Tuna discards (mt)	Discard reason
US single	Aug.1977–Apr.1978	Sch.	55	2	350.0	Sack ripped
		Log	59	1	4.0	Tuna too small
US single	Jan.–Apr. 1982	Sch.	26	1	0.25	Tuna damaged
		Log	27	0	–	–
	Jul.–Aug.1982	Sch.	20	0	–	–
		Log	7	0	–	–
Japan single	Jun.–Jul.1982	Sch.	1	0	–	–
		Log	22	?	80.2	0.2 mt: too small or damaged; 80 mt: 1 log set gear failure
Japan group	Feb.1983	Sch.	2	?	1.5	Tuna too small or damaged
		Log	3	?		
Japan group	Apr. 1984	Sch.	7	?	0.5	Tuna too small
		Log	7	?		
US single	Nov.–Dec. 1984	Sch.	7	0	–	–
		Log	7	7	37.0	Tuna too small.
US single	Jan.–Mar.1989	Sch.	41	0	–	–
		Log	9	3	8.2	Tuna too small (<4 lb/1.8 kg)
Japan group	Apr.1990	Sch.	10	?	3.0	Tuna gilled and crushed by power block
		Log	5	?		
US single	Oct.1990–Jan.1991	Sch.	25	6	0.2	Tuna damaged, 0.02 mt too small, 0.04 mt no reason.
		Log	19	18	12.9	10.0 too small, 0.1 mt damaged, 1.4 mt undesirable, 1.4 mt no reason.
US single	Dec.1990–Mar.1991	Sch.	57	1	0.1	Tuna too small
		Log	7	0	–	–
US single	Apr.–May 1991	Sch.	4	0	–	–
		Log	11	6	10.5	Tuna too small, 1.9 mt no reason.
US single	Apr.–May 1991	Sch.	30	1	0.9	Tuna smashed
		Log	8	2	10.9	Tuna too small (<3 lb/1.4 kg).
US single	May 1991	Sch.	24	1	272.4	Sack ripped
US single	Jun.–Jul.1991	Sch.	21	2	0.1	Tuna too small or damaged
		Log	9	6	5.9	Tuna too small
US single	Jun.–Jul. 1991	Sch.	48	3	33.1	Vessel fully loaded, 1.3 mt damaged.
US single	Jun.–Jul. 1991	Sch.	67	6	4.3	Vessel fully loaded, 1.6 mt damaged.
US single	Mar. 1993	Sch.	3	–	–	–
		Log	5	5	1.9	Tuna too small or damaged
Totals	1977–1993	Sch.	429	23	661.4	622.4 mt sack ripped, 34.5 mt vessel loaded, 4.2 mt damaged, 0.1 mt too small, 0.1 mt damaged or too small, 0.1 mt too small or no reason
		Log	190	48+?	171.5	80.6 mt too small, 4.1 m damaged, 2.1 mt too small or damaged, 80.0 mt gear failure, 1.4 mt undesirable, 3.3 mt no reason
		Log & Sch.	34	?	5.0	3.0 mt damaged, 1.5 mt too small or damaged, 0.5 mt too small.

Note

Refer to Table 3.8 for sources of information.

Table 3.12: Reasons for discarding tuna in the WTP purse-seine fishery

Discard	Reason	Comments	Occurrence
Accidental	Gear failure	Sack rips during sacking-up or brailing, part of or entire catch is lost.	Rare, occurs with large catches (>100mt) if sack worn or sacking-up technique poor.
	Storage problem	Refrigeration problem, e.g. ammonia coil rupture in fish well, catch contaminated.	Rare
		Poor-quality product delivered to cannery because of inadequate freezing, high salt or histamine levels and 'honeycombing' in meat. Can result in rejection of one well of fish or entire catch of vessel.	Unknown, but probably very rare. Unlikely to be recorded on logsheets. One occasion in 1982 when 850 mt load of old US seiner was rejected in 1982 because of high salt content.
Deliberate	Tuna too small	Tuna < 3–4 lb (1.4–1.8 kg), too small for most canneries	Common with log & FAD sets, less common with school sets as able to target on larger fish. Some discarding at canneries.
	Tuna soft or smashed	Tuna at bottom of sack and last to be brailed aboard are softened by weight of catch above and high sea temperature (commonly > 28°C). Also, tuna gilled in net and crushed as net is pulled through power block and haulers. (Tuna discard has also been observed during the transfer of fish between brine wells at sea, well after any fishing operation).	Common in large sets (> 100 mt) where sacking–up and brailing may take over 3–4 hours to complete. Gillers common in sets made at dusk and when breakdowns delay net retrieval. Also some discarding at canneries after fish crushed in wells.
	Vessel fully loaded	Last set of trip exceeds carrying capacity, well coamings and food freezers also filled. Excess is transshipped to other seiners, if any are nearby.	Common
	Undesirable species	Tuna species of little or no economic value, such as frigate tuna and kawakawa.	Uncommon, mostly in log and FAD sets.

Table 3.13: Discards of tuna (mt) and numbers of tuna discard sets (shaded) in the WTP purse-seine fishery by school association and reason for discarding, 1979–1991

Fleet	Discard reason	Unassoc. school		Log		Drifting FAD		Anchored FAD		Animal		Other		Unspec.	
Indonesia	Vessel loaded	10.0	1	35.0	3	–	–	–	–	–	–	–	–	–	–
Japan	Undesirable spp.	–	–	2.0	1	–	–	–	–	–	–	–	–	–	–
	Tuna too small	–	–	–	–	–	–	–	–	–	–	–	–	29.0	14
	Vessel loaded	2.0	1	25.0	3	–	–	–	–	–	–	–	–	10.0	1
	Other	–	–	15.0	4	–	–	–	–	–	–	–	–	–	–
	Unknown	–	–	5.0	3	–	–	–	–	–	–	–	–	–	–
Korea	Undesirable spp.	–	–	3.0	2	–	–	–	–	–	–	–	–	–	–
	Tuna too small	62.0	12	361.0	99	–	–	–	–	9.0	2	–	–	12.0	6
Philippines	Undesirable spp.	–	–	34.1	23	–	–	47.7	32	–	–	–	–	–	–
	Tuna too small	–	–	28.2	14	–	–	312.3	38	–	–	–	–	178.0	22
	Vessel loaded	–	–	3.9	2	–	–	–	–	–	–	–	–	–	–
	Other	–	–	292.8	124	–	–	92.5	39	–	–	–	–	–	–
	Unknown	20.1	1	49.6	88	–	–	50.6	77	–	–	–	–	0.3	2
Solomon Is.	Tuna too small	–	–	–	–	–	–	1525	340	–	–	–	–	334.0	87
USA	Undesirable spp.	0.9	1	78.3	22	–	–	–	–	–	–	–	–	–	–
	Tuna too small	237.3	40	838.9	157	2.7	2	–	–	–	–	4.8	3	2.7	1
	Vessel loaded	202.5	11	104.8	9	–	–	–	–	–	–	–	–	–	–
	Tuna smashed	98.4	33	10.0	5	–	–	–	–	–	–	–	–	–	–
	Sack ripped	227.0	1	9.1	1	–	–	–	–	–	–	–	–	–	–
	Storage prob.	–	–	–	–	–	–	–	–	–	–	–	–	54.0	1
	Other	136.7	8	18.9	8	–	–	–	–	–	–	–	–	–	–
	Unknown	19.0	1	10.8	4	–	–	–	–	–	–	–	–	–	–
Totals	Undesirable spp.	0.9	1	117.4	48	–	–	47.7	32	–	–	–	–	–	–
	Tuna too small	299.3	52	1228.1	270	2.7	2	1837.3	378	9.0	2	4.8	3	555.7	130
	Vessel loaded	214.5	13	168.7	17	–	–	–	–	–	–	–	–	10.0	1
	Tuna smashed	98.4	33	10.0	5	–	–	–	–	–	–	–	–	–	–
	Sack ripped	227.0	1	9.1	1	–	–	–	–	–	–	–	–	–	–
	Storage prob.	–	–	–	–	–	–	–	–	–	–	–	–	54.0	1
	Other	136.7	8	326.7	136	–	–	92.5	39	–	–	–	–	–	–
	Unknown	20.6	2	65.4	95	–	–	50.6	77	–	–	–	–	0.3	2
Grand total	All reasons	997.4	110	1925.4	572	2.7	2	2028.1	526	9.0	2	4.8	3	620.0	134

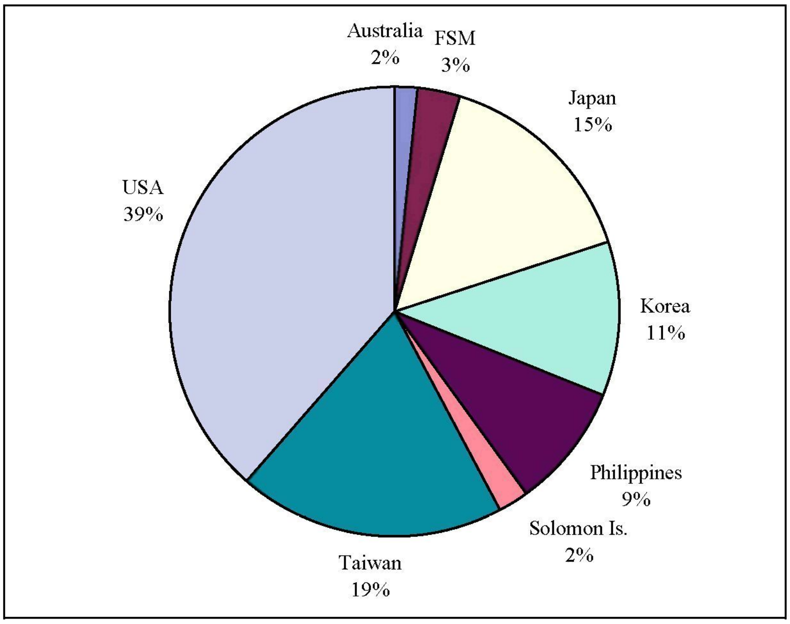
Table 3.14: Suggestions for future monitoring of by-catch and discard levels in the WPO purse-seine fishery

Category	Current knowledge / coverage	Mechanisms for improving knowledge / necessary action	Required coverage (in order of importance)	Priority[1]
Levels of by-catch by species				
• General	Logsheet data provide poor indications of the frequency of by-catch and by-catch species breakdown. Observer data provide species identification. However, the coverage is currently insufficient for frequency of by-catch.	1. Improve observer coverage, with biological sampling where possible	Observer coverage by 1. school association 2. area 3. fleet 4. month	**High**
• Billfish	Some indications (species breakdown/catch in numbers) from logsheets (US fleet), although non- and under-reporting suspected. Observer data provide better indication. The total (numbers) caught is lower than longline fisheries.	1. Maintain/improve observer data collection 2. Verify (with observers) species identification and billfish catch levels of logsheet recording	Observer coverage by 1. school association 2. area 3. fleet	**Low**
• Seabirds	According to observer data , there is no by-catch.	—	—	—
• Marine reptiles	No indication from logsheets (no provision for recording this type of catch). Observer data provide some indication. However, coverage is currently lacking.	1. Improve observer coverage, ensuring correct species identification	Observer coverage by 1. school association 2. area	**Medium–High**
• Marine mammals	Sets on whales occur; no reports of dolphin sets in WTP. No indication of capture from logsheets. However, few indications of encounters (i.e. whale associations with tuna schools). Observer reports list few encounters; none warrant concern.	1. Maintain/improve observer coverage	Observer coverage by 1. fleet 2. month 3. area	**Low**
• Whale shark	No indication of capture from logsheets. However, indication of encounters (i.e. associations with tuna schools). Observer reports list some encounters of capture.	1. Monitor practices that unnecessarily harm the animal 2. Maintain/improve observer coverage	Observer coverage by 1. fleet 2. area	**Medium**
Levels of by-catch by school association	Generally known that there is usually more by-catch from associated than unassociated schools; some indication of species composition of by-catch is also known. Some indications from logsheet data, although observer data provide better detail.	Due to variability it will be difficult to provide definitive estimates. 1. Improve observer coverage 2. Verify logsheet data from observer data, where possible	Observer coverage by 1. school association	**Low**
Levels of discard of by-catch species	Some indication of by-catch species normally discarded and fleet discard practices are available from observer data. Little or no indication from logsheet data (no species identification).	1. Maintain / improve observer coverage	Observer coverage by 1. fleet 2. school association 3. area	**Medium**
Spatio-temporal variations	Logsheet data provide a poor indication as species identification usually not provided. Observer data coverage not adequate to determine at the species level.	1. Improve observer coverage, ensuring species identification	Observer coverage by 1. month and area 2. school association 3. fleet	**Low**
Levels of tuna discard	Levels known to be highly irregular (observer data) and thus difficult to obtain overall estimates. Some indication from logsheets (species identification provided on some forms).	1. Maintain/improve observer coverage, with biological sampling where possible 2. Verify levels in logsheet data with observer data, where	Observer coverage by 1. fleet (varying practices) 2. school association 3. area 4. month	**Medium–High**

Category	Current knowledge / coverage	Mechanisms for improving knowledge / necessary action	Required coverage (in order of importance)	Priority[1]
		possible		
Levels of tuna discard by school association	General breakdown known to some extent from observer data. Some indication (with reasons provided) from logsheets, although difficult to determine overall estimates due to irregular nature.	1. Maintain/improve observer coverage 2. Verify levels in logsheet data with observer data, where possible	Observer coverage by 1. school association 2. fleet	**Medium**
Reasons for tuna discard	Reasons are well documented in observer reports, literature. Some indications of frequency provided from logsheet data; better indications from observer data, however, currently lacking in coverage.	1. Maintain/improve observer coverage 2. Verify levels in logsheet data with observer data, where possible	Observer coverage by 1. (dependent on reason) 2. fleet 3. school association	**Low–Medium**
Spatio-temporal variations of tuna discards	Some indication from logsheet data, although non–reporting will always affect these data. Observer data coverage not currently adequate to determine.	1. Maintain/improve observer coverage 2. Verify levels in logsheet data with observer data, where possible	Observer coverage by 1. month and area 2. fleet 3. school assocation	**Low**

Note

This refers to the priority of data collection and subsequent analyses between the abovementioned categories only.



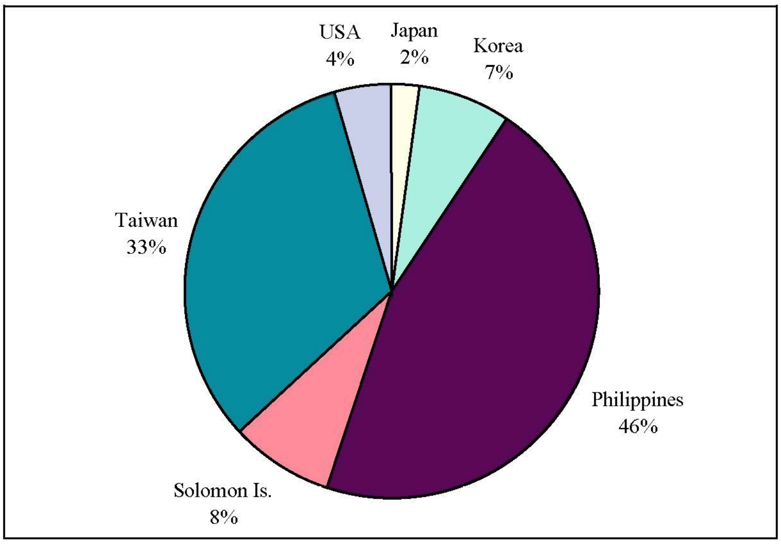
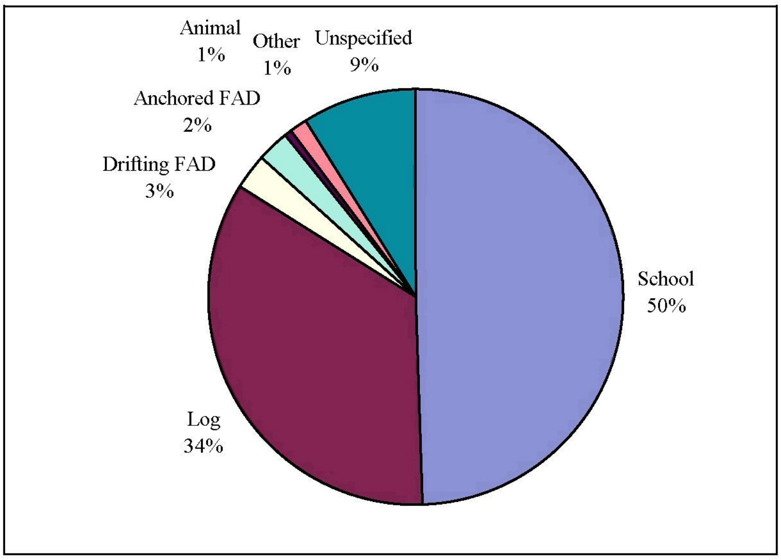


Figure 3.1 (a): Reported effort (above, in sets), and by-catch levels (below, in mt), by vessel nationality, for the WTP purse-seine fishery, 1992



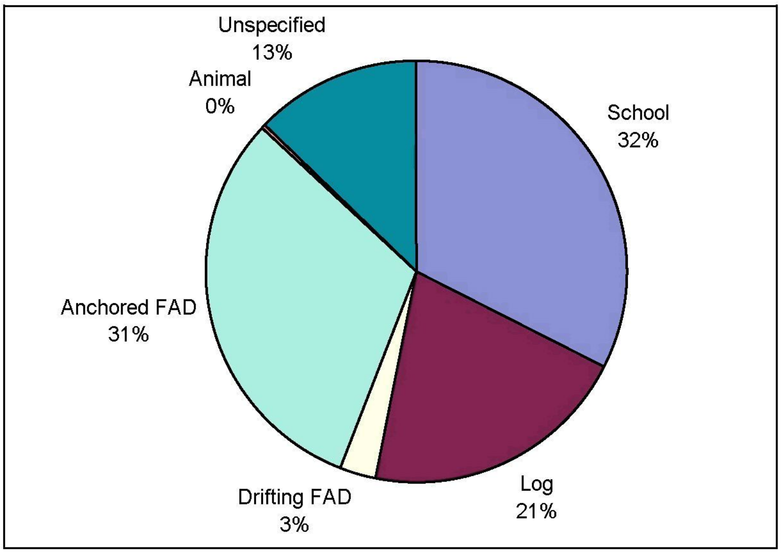


Figure 3.1 (b): Reported effort (above, in sets), and by-catch levels (below, in mt), by school association, for the WTP purse-seine fishery, 1992

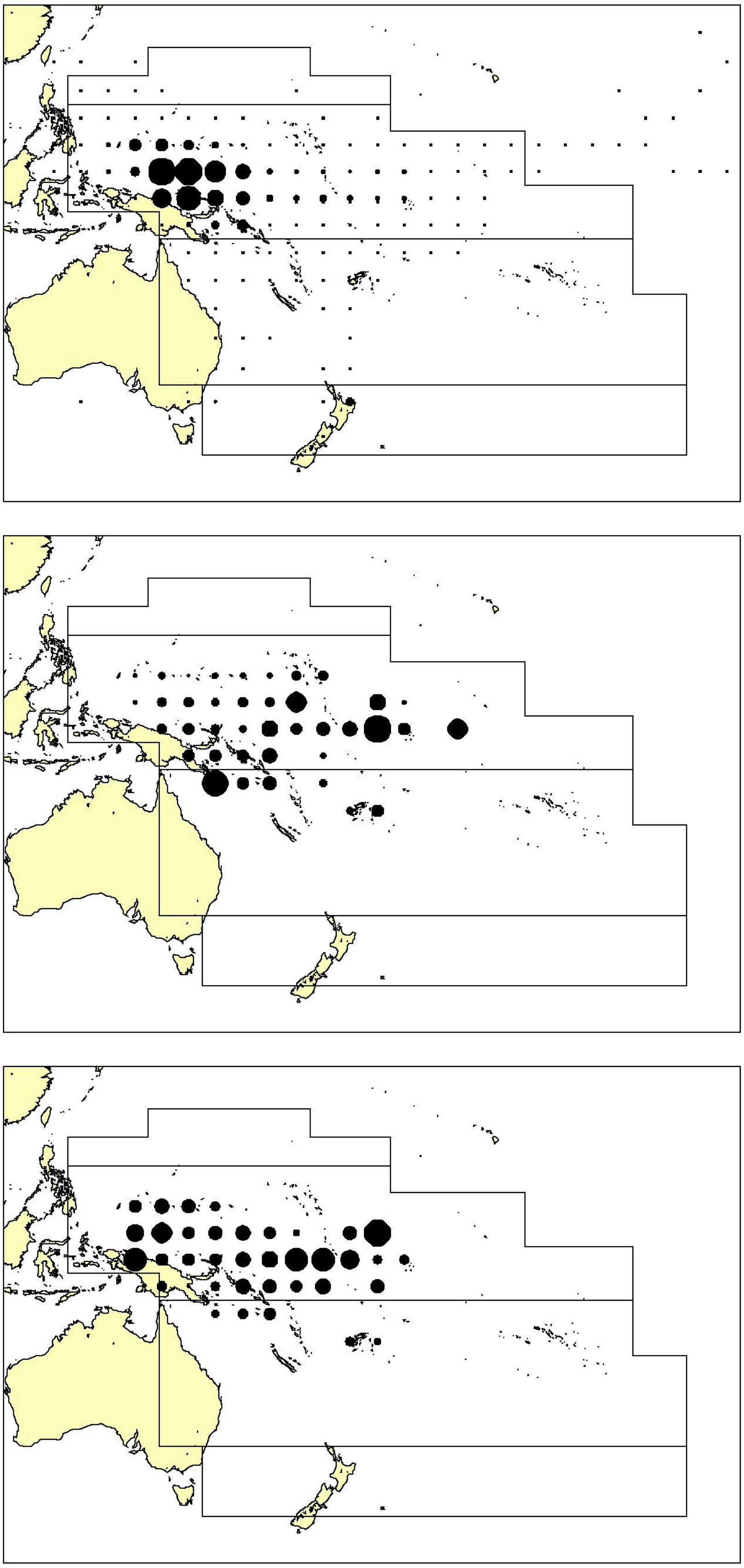


Figure 3.2: Distribution of sets (top), tonnes of by-catch (middle) and tuna discards (bottom) in the WPO purse seine fisheries, 1975–1992

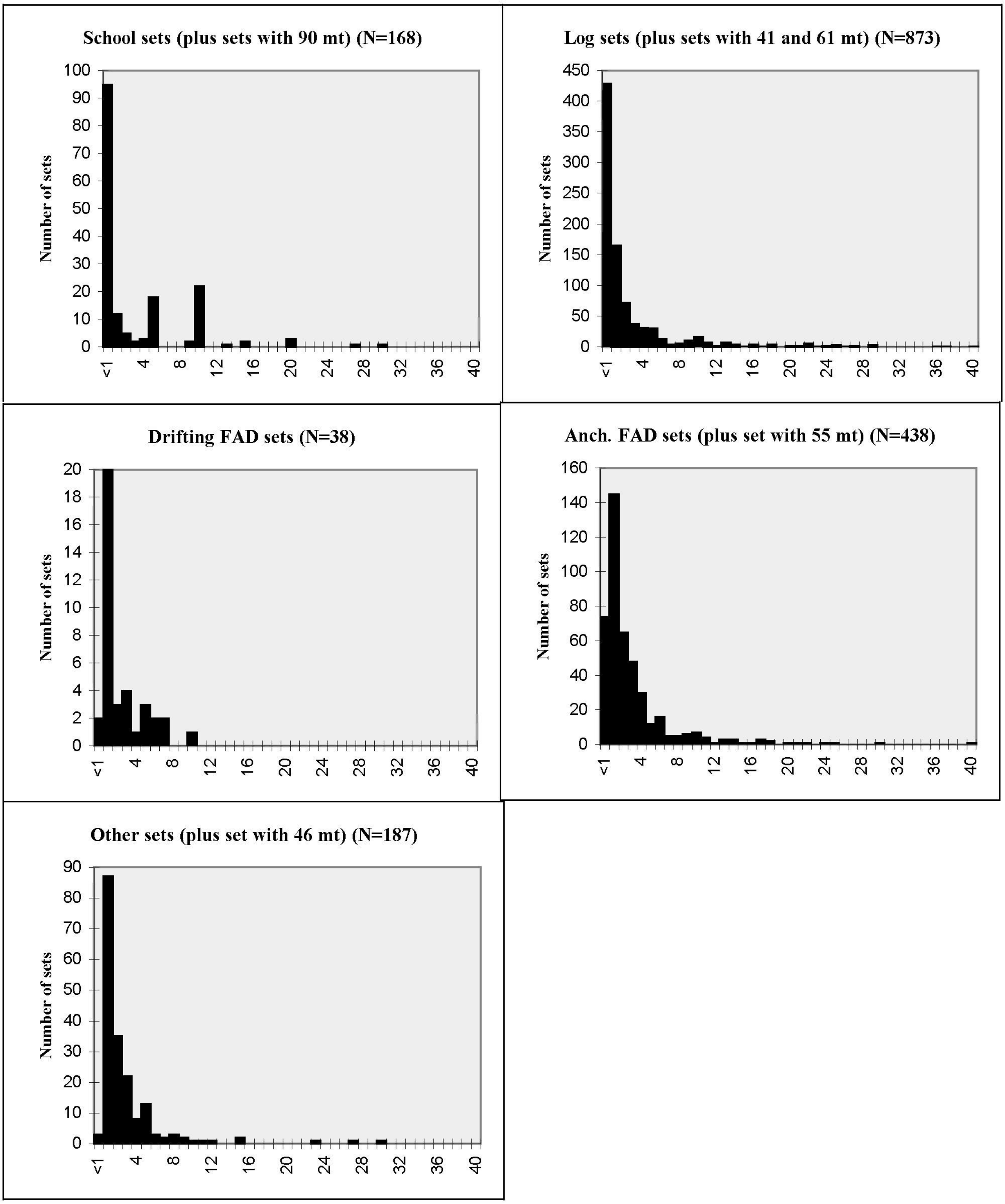


Figure 3.3: Frequency of by-catch by school association, based on data held in the RTFD, 1975–1993

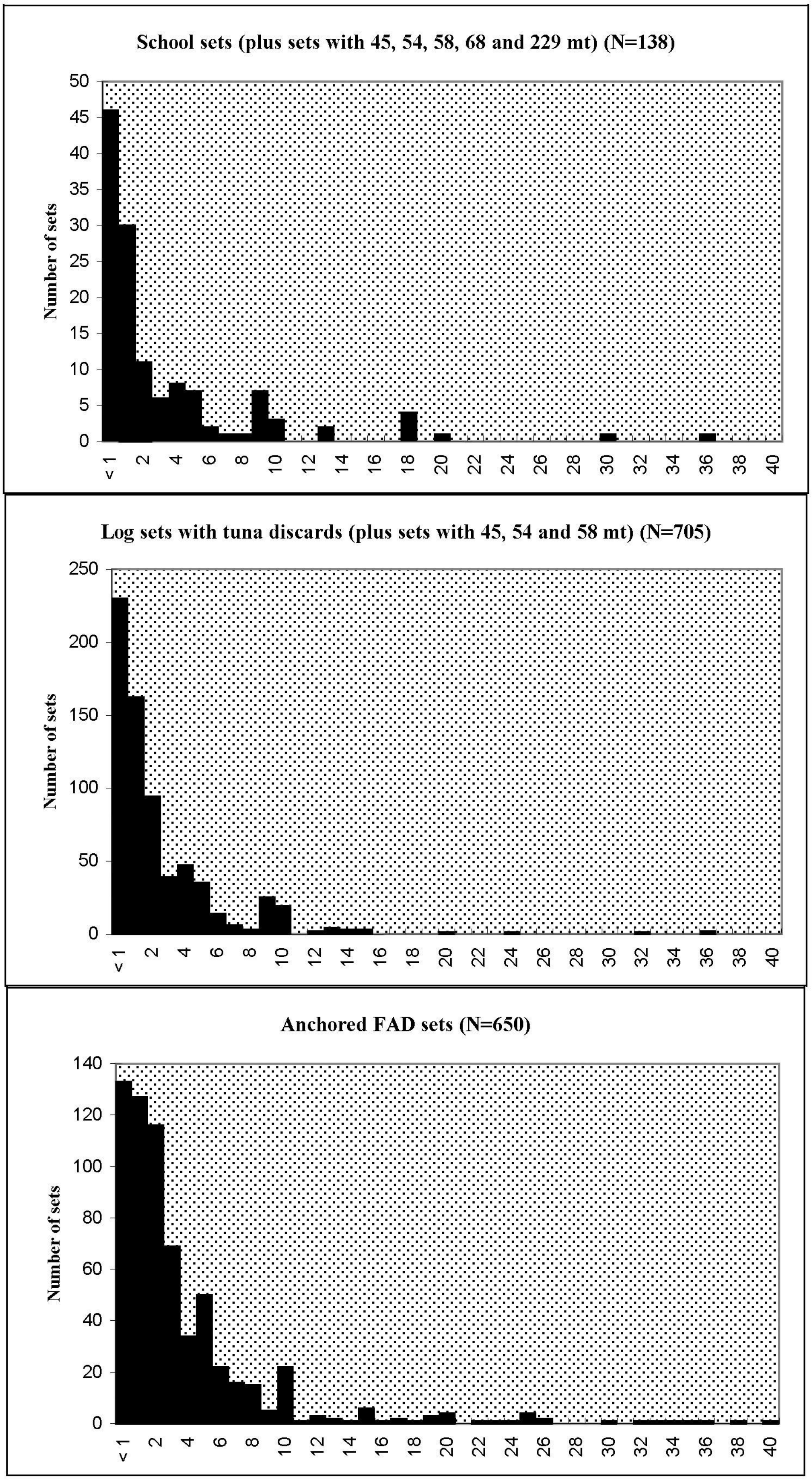
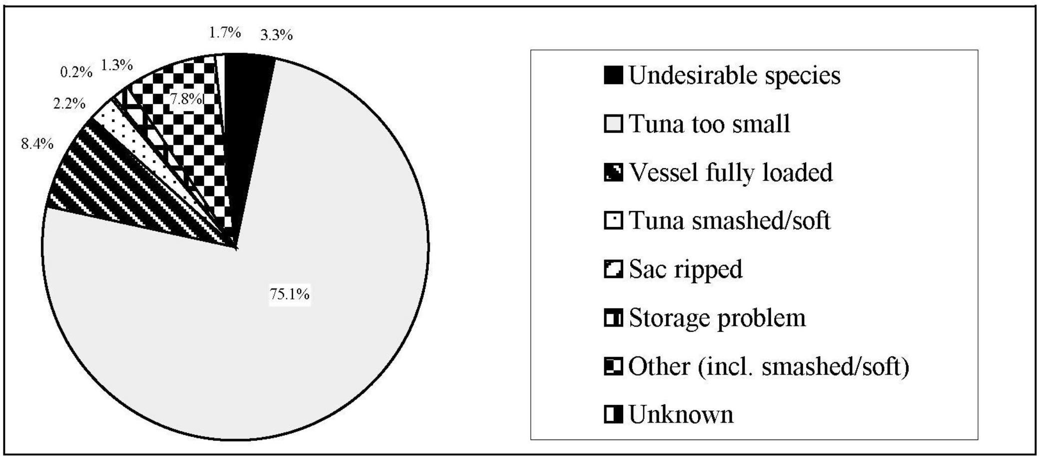
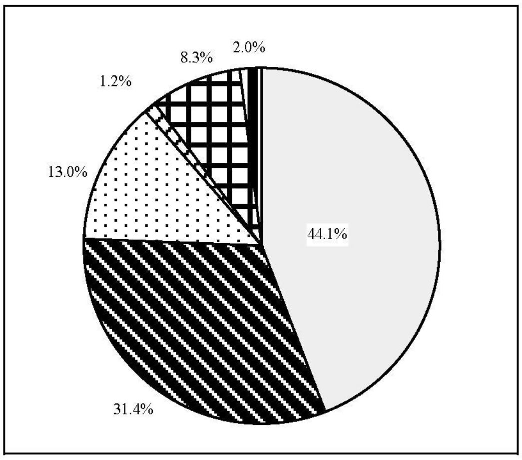


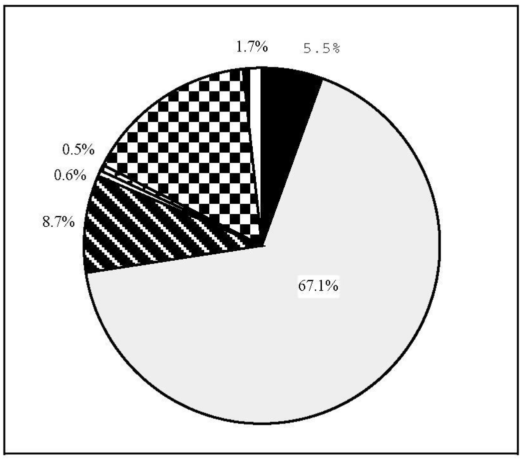
Figure 3.4: Frequency of tuna discards by school association, based on data held in the RTFD, 1975–1993



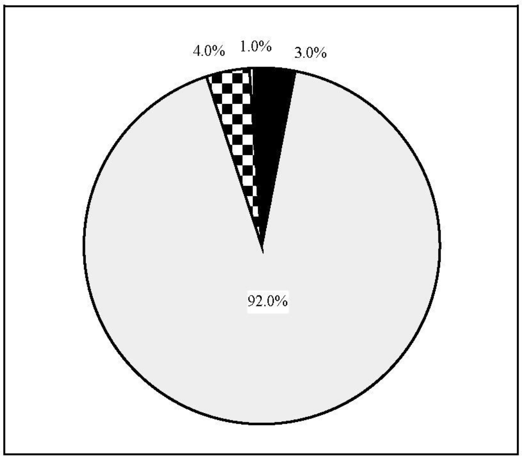
Total tuna discards



Tuna discards from schools



Tuna discards from logs



Tuna discards from anchored FADS

Figure 3.5: Tuna discard levels (mt) by reasons for discarding and school association, 1975–1993

Section 4

LONGLINE FISHERIES

4.1 OVERVIEW OF THE WESTERN PACIFIC LONGLINE FISHERIES

4.1.1 Summary of the fishery

For 1992, the RTFD contains daily fishing information for a total of 881 longline vessels from 12 countries (Australia, People's Republic of China, FSM, Fiji, French Polynesia, Japan, Korea, Marshall Islands, New Caledonia, New Zealand, Taiwan and Tonga), with a total declared catch of 42,366 mt in the WPO. Due mainly to the unavailability of data for vessels fishing in international waters, the actual number of vessels and total catch for the longline fishery in the WPO is not known, although a catch of 129,542 t for the three target tuna species (albacore, bigeye and yellowfin) has been estimated by Lawson (1993) for the area. Using this value, the estimated coverage for the WPO longline fishery by the RTFD is well below 50 per cent. A detailed breakdown of catches and levels of RTFD coverage by the individual fleets is given in Lawson (1993).

There are basically two categories of longline vessel fishing in the WPO. The first category contains the large distant-water vessels (typically > 100 GT) from Japan, Korea and Taiwan; these vessels are capable of fishing far from their home ports, with trips usually ranging from more than one month to up to one year for vessels that take advantage of at-sea transshipment. The second category consists of vessels that are generally smaller and used specifically for shorter fishing trips, basing themselves in proximity to the fishing areas, with trips from a few days to two weeks in duration. These vessels have established home ports in SPC member countries and territories (e.g. FSM, Guam, Marshall Islands, Palau) and fish under the nationalities of China, Japan, Taiwan, Korea or the country where fishing activity takes place (i.e. domestic fleets). They typically use ice only to supply fresh/chilled fish for sashimi markets as opposed to the larger distant-water vessels, which supply frozen fish for normally lower-priced markets. The general decline in the numbers of large distant-water vessels and the increase in activities involving the smaller vessels working out of SPC member countries in the past 5–10 years is seen primarily as a development to capitalise on higher sashimi prices for fresh/chilled fish and related improvements in airfreight availability.

4.1.2 Distribution of effort

Maps showing longline effort by fleet for 1992 are described in Lawson (1993) and for combined fleet effort in the Fourth Quarter *SPC Regional Tuna Bulletin* (1993). Figure 4.1 (top) shows the distribution of longline effort in the WPO for the years 1978–1992 combined, and the distribution of seasonal effort for this period is described in Figure 4.2. Figure 4.3 shows annual trends in longline effort by fleet for the WPO areas, based on data available in the RTFD.

The following is a brief description of the geographical distribution of longline fisheries throughout the WPO by area, based on data available in the RTFD for 1992.

Seasonal longline activity in the Western Temperate Pacific (WTeP) occurs primarily in the waters around south-eastern Australia and southern waters of New Zealand. Fishing by the Taiwanese and Korean fleets, primarily in the Subtropical Convergence Zone (STCZ), is strictly seasonal and has been treated as an extension of their Western Subtropical Pacific (WSP) activities in this report. RTFD coverage of these fleets in the WTeP is very poor as the STCZ covers international waters and there is no obligation to provide logsheet data; however, some indications are available from data provided by the national fisheries agencies of these countries.

Between 10° and 35°S, in the area defined in this report as the Western Subtropical Pacific (WSP), longline activity is not as confined as in the WTeP. Daily information for 1992 is available for fishing off the east coast of Australia, the northern waters of New Zealand, New Caledonia, Fiji, Tonga, Cook Islands and French Polynesia, and in the international waters bordering these areas. As would be expected, seasonality of operations in the WSP longline fisheries is less pronounced than in the WTeP. It should be noted that the choice of the 35°S line to divide the WSP and WTeP is purely for convenience; in fact, the WSP and WTeP longline fisheries of New Zealand and Australia, as defined in this report, do extend above and below this line depending on season. As with the WTeP, there is very little RTFD daily fishing information for Taiwanese and Korean vessels fishing in parts of the WSP.

The tropical waters of the WPO north of 10°S, the Western Tropical Pacific (WTP), contain the majority of longline activity, even though activity has been almost completely absent from Papua New Guinea (PNG) since Japanese vessels last fished there in 1987. In the warm waters of the WTP, the seasonal changes in the fishery are not as pronounced as in the more temperate waters, and the target species are almost exclusively yellowfin and bigeye tuna. In 1992, distant-water Japanese vessels were active in FSM, Solomon Islands, Marshall Islands, Kiribati and the northern waters of French Polynesia, while distant-water Korean vessel effort was concentrated in and around the economic zones of the three island groups of Kiribati, and, to a lesser extent, in French Polynesia. The smaller vessels that operated out of SPC member countries unloaded at ports in FSM, Guam, Marshall Islands and Palau.

There are virtually no data in the RTFD for the area north of the WTP (the WPO north of 15°N, called the WTPN), as it constitutes mostly international waters; reference to the WTPN has been largely omitted from this report.

While the area covered by this report includes part of the southern bluefin longline fishery in Australia and New Zealand, for which there is a substantial amount of information available, more emphasis is given to the WTP and WSP fisheries, where possible, as these are of primary interest to the mandate of the OFP.

4.1.3 Factors affecting catch and discard

Observer reports made available to SPC from programmes in Australia, FSM, Kiribati and New Zealand provide detailed descriptions of the longline operation and the various fishing techniques employed.

In the three areas of the WPO, there are a number of considerations in the fishing strategy when attempting to attain the optimum catch level of target species. These include the depth of the gear in relation to knowledge of the preferred temperature range for target species, real-time information from other vessels in the vicinity (here termed 'group fishing'), types of bait used, setting strategies involving diel and lunar cycles, knowledge of geographic and oceanographic features (e.g. current, ocean-floor topography), and environmental factors that might affect the fishing conditions.

Developments in gear technology, for example the use of monofilament and wire traces, are believed to have some effect on the success of target catch and the incidence of by-catch, for example, the retention of shark on lines with wire traces. No information on the extent of these effects is available from logsheet data and although observer data provide some indications, the coverage is not sufficient to provide quantitative descriptions for this review.

Temporal variations in setting and hauling are believed to have some effect on the success of target catch and, indirectly, by-catch. Reports from Australian observers active in the Australian Fisheries Zone (AFZ) indicate that some Japanese longline vessels set their gear shallower and earlier than normal around the full-moon period in order to maximise their catches of bigeye tuna and swordfish. This practice is also used by some vessels in the WTP; however, no information on the extent by fleet and area is currently available.

The availability of various types of electronic equipment has also made it possible to concentrate activities in the vicinity of oceanographic (e.g. current lines) and geographic features thought to enhance the success of catch. Some of these features, for example sea mounts, may have associated populations of by-catch species not normally encountered in the catch of pelagic longline fisheries. For example, an SPC observer (Labelle pers. comm.) reported the catch of a number of an unidentified serranid species from a longline vessel operating in French Polynesian waters; this catch was taken on only one day of the trip and constituted the majority of the overall catch for that day. No information was found on longline activities directly associated with geographic and oceanographic features, although this appears to have some influence on the amount of by-catch taken.

Clearly, the horizontal and vertical attributes of the longline gear contribute to a generally broader species range in the catch than in the surface fisheries (purse-seine and pole-and-line) in this area. Variations in some factors of the fishing strategy exist between areas; this occurs, for example, in the comparison of the seasonal fluctuations in the thermocline structure in more temperate waters of the WPO, with the more permanent nature of the thermocline structure in tropical waters. As data for most of the above-mentioned factors are limited or non-existent in the RTFD (even though it is apparent that some of these have some bearing on by-catch and discard levels), this report attempts to deal only with the effect that ranges of gear depth (and by inference, vertical temperature profile) have on by-catch from longline vessels.

4.1.3.1 Depth

The higher price demanded for bigeye tuna than for yellowfin has seen a change in targeting methods in the WTP longline fisheries since the late 1970s. References indicate that bigeye tuna are generally taken at greater depth than yellowfin (e.g. Suzuki et al. 1977), with one of the prime factors being a bigeye preference for a lower temperature range of 10°–15°C. Figure 4.4 shows the distribution of the mean depth of the 15° isotherm throughout the WTP and WSP and thus provides some indication of the depth required for longline gear to target bigeye in these areas.

Suzuki et al. (1977) use the value of hooks per basket as a relative measure for depth of fishing; two broad categories of vessels in the Japanese longline fleet were identified: those that set their gear 'deep', and those with 'conventional' setting. Figure 4.5 shows combined annual frequency of hooks per basket used by longline vessels fishing in the WTP and WSP for the years 1981–1992, based on data held in the RTFD. In both areas, there are distinct groups which represent conventional gear utilisation (WTP: 3–6 hooks per basket; WSP: 5–8 hooks per basket) and deep gear utilisation (WTP and WSP: >= 10 hooks per basket), with very little activity coming from the intermediate group (WTP: 7–9 hooks per basket; WSP: 9 hooks per basket). It is evident that the trend for recent years has been towards nearly 100 per cent deployment of deep gear and thus some preference for targeting bigeye tuna. However, it should be noted that practices such as shallow-set targeting of bigeye around the full-moon period also occur.

In contrast to the WTP situation, there are no obvious annual trend between the utilisation of conventional and deep gear in the WSP. This is probably due to the need to have varied gear configurations to cater for more pronounced temporal and spatial differences throughout this broad area.

4.1.3.2 Vessel category

There are differences between the operations of the distant-water vessels producing for the frozen market and the smaller vessels conducting shorter trips targeting for the sashimi market. One obvious difference is the discard level, which is expected to be less on the distant-water vessels as adequate freezer storage is normally available for most of their catch; in contrast, species that are normally retained on these vessels may normally be discarded during trips of the smaller vessels which have limited ice supply to chill their target catch. Little information was available to provide comparative descriptions by vessel category; nonetheless, this distinction should be a consideration in any future monitoring.

4.2 SOURCES AND COVERAGE OF DATA

4.2.1 Logsheet data

Table 4.1 summarises, by fleet, the daily longline catch-and-effort data available from the RTFD for the period 1978 to the end of 1992; as indicated for the purse-seine fishery, data for 1993 were not considered because they were incomplete at the time of writing. Numbers of fish, instead of weight, were used throughout. Since the average weights of the 11 most common species of the catch on logsheet forms in the WPO (yellowfin, bigeye, albacore, southern bluefin, skipjack, striped marlin, black marlin, blue marlin, swordfish, sailfish and shark) vary markedly, sometimes by a factor of 10, using total weights by species would tend to give a misleading impression in comparisons of catch levels. Catch-and-effort data in aggregated form that have been made available to SPC by DWFNs (Japan, Taiwan and Korea) were used in this report only when comparing annual trends in the CPUE of certain species of by-catch and in an attempt to estimate total catches of the billfish species in the WPO.

The main source of longline daily catch data in the RTFD is logsheet forms completed by longline vessels as a requirement for fishing in the economic zones of SPC member countries. Since the inception of data processing, 21 different form types have been received, in addition to data provided on magnetic media from Australia and New Zealand. As the prime aim of the logsheet (and hence the RTFD) is to obtain catch levels of the commercially important species of the longline fishery, quite often the less important by-catch and discarded species were ignored. This was the case not only in the design of the various logsheets used and in the subsequent design of the RTFD, but also in the recording of the catch, even though provision for this breakdown may have existed both on the logsheet and in the RTFD. In comparisons between observer and logsheet data, Michael et al. (1989) found that the level of under-reporting increased when relative importance of species decreased.

In reviewing the levels of by-catch and discards in the WPO from data held in the RTFD, the following inconsistencies were encountered due to the variation in format of the data available:

(a) Some forms have provision for recording numbers only (20% of WTP trips);

(b) Some forms omit or group certain by-catch species (for example, some forms provide a column for 'Billfish' instead of the individual billfish species);

(c) Some forms have no provision for recording discard information (this was also the case with the New Zealand magnetic media data);

(d) Some forms require discards to be entered in numbers only, some as weights only;

(e) No forms provide an identification or breakdown of the tuna or other species discarded;

(f) No forms provide reasons for discarding;

(g) Though not strictly important to this report, information on the structure of the gear and bait used was often lacking or incorrectly recorded, and time of set is provided for on less than 0.01 per cent of longline vessel logsheet trips and thus not catered for in the RTFD.

The extent to which logsheet data entered into the RTFD have provision to record billfish species is generally good (around 90% of recorded trip logsheets had the provision for recording billfish by species). There is no provision for recording individual shark species on logsheets provided to SPC, although a generic shark column exists for over 90 per cent of the recorded trip logsheets. Introduction of logsheets recording the variety of shark species taken in WPO longline fisheries would obviously cause problems in both form design and subsequent mis-identification of species, although this has been attempted for the most important shark species in the AFZ logbook data collection programme. There is usually no provision on logsheets (due to difficulties in logsheet form design) for recording catch of individual species other than the billfish and shark; these catches are usually lumped together as 'Other catch' on most logsheet forms (90% of WTP trips).

The extent to which logsheet data entered into the RTFD have provision for recording discards is shown in Table 4.2.

In order to get some indications of the success of suggested modifications to catch logsheet forms, the Micronesian Maritime Authority (MMA) asked a co-operative fishing fleet, based out of Pohnpei (FSM), to record information on the occurrence of shark finning and the frequency of target discards due to shark and marine mammal damage. While there are no means of verification, these data are assumed to be representative and have been included in this review.

4.2.2 Observer data

References to observer reports made available from programmes operating out of Australia, FSM, Kiribati, New Zealand and SPC, were relied upon to give more indications of the levels of by-catch and discards from the longline catch. Observer programmes that have operated out of Australia (since 1979) and New Zealand (since 1986) provide good indications of the level of by-catch and discards. In contrast, the observer programme of the Micronesian Maritime Authority (since 1979) provides the only monitoring of WTP longline activity for an area containing considerably more effort. The data collected by MMA observers have been made available to SPC in the form of unpublished reports (Heberer, 1993; Heberer, 1994a).

It is considered that observer coverage of the WTP is not currently adequate to provide indications of the levels of by-catch and discards. An attempt has been made in this report to highlight where non- and under-reporting of by-catch and discards exist, by comparing RTFD data with percentage target, by-catch and discard of the total catch from the observer reports available (Tables 4.2 and 4.3, and Figure 4.6). It is evident that the discard reporting for vessel trips in the RTFD was in most cases either non- or under-reported, and, therefore, specific information on discards is restricted to average values of discards and their percentages of the total catch (only where discards were recorded).

It is hoped, however, that further data from the observer programmes will provide a better indication of the levels and breakdown of longline catch and further highlight where discrepancies exist in what is reported by the logsheet data (RTFD). As longline vessel trips outnumber purse-seine trips in the WTP by a factor of more than 10, ensuring that representative coverage with observer data collection is achieved will be difficult.

A variety of anecdotal information from observers is available and, where appropriate, has been included in this review.

4.2.3 Other sources of data

There are a number of publications that specifically review aspects of the more common by-catch (i.e. **billfish**) of longline vessels. The most relevant is an (as yet) unpublished synopsis of marlin species, with particular emphasis on the area of the WPO fisheries (Williams unpublished manuscript). Other sources with detailed information on billfish are Nakamura (1985), proceedings from various international billfish symposiums, the last held in 1988 (Stroud 1990), and reports from workshops/meetings conducted by the Western Pacific Regional Fisheries Management Council (WPFMC). The latest works found to review species of marlin stocks in the area of interest were by Suzuki et al. (1977) and Sakagawa (1987).

Very little information is available on the exploitation levels of the individual species of shark in the WPO longline fisheries, the most relevant literature reference being a review of the Japanese longline catch of blue (*P. glauca*) and mako (*I. oxyrinchus*) sharks off south-eastern Australia (Stevens, 1992). There are some descriptions and quantitative information on turtle by-catch from longline fisheries in the Atlantic and Pacific oceans; where appropriate, references to these reports (provided by WPRFMC) have been made in this review.

Nothing was available in the literature to specifically review stocks of any of the other by-catch species mentioned for this area, except the non-target tuna species, for example skipjack, which are target species of surface fisheries in the WPO. No literature specifically addressing discards from the longline fishery was found; however, several observer reports give descriptive accounts of methods and reasons for discards, which are useful in comparison to what can be discerned about the WPO longline fishery from the RTFD.

4.3 BY-CATCH AND DISCARDS OF BY-CATCH

Table 4.4 describes the species composition of the most common by-catch by fleet and area for the WPO, for which specific mention is provided below.

4.3.1 Billfish

Even though some billfish (e.g. swordfish and striped marlin) are among the target species of some longline vessels in parts of WSP waters, all billfish catches have been included as by-catch in this report. In the tabulated data presented in this report, target species for each area have been defined as the tuna species of prime commercial interest in that area (Table 2.1).

While billfish form the most readily recognised part of the by-catch of longline vessels in the WPO, it is not the intention of this report to give an in-depth review of the exploitation of billfish stocks in the WPO. The information compiled from the logsheet data (RTFD) provides some insights into the distribution and relative abundance of the individual billfish species in the WPO; however, further information (e.g., reliable size-composition data) and analyses would be required to ascertain the impact of longlining on individual stocks, for example. A comparison of billfish species composition shown in logbook data (Table 4.4; Figure 4.6) with observer data (Table 4.5; Figure 4.6) in the WTP reveal that the logbook reporting appears to provide a reasonable indication of catch levels in this fishery, although there remain deficiencies in the RTFD, some of which are discussed below.

In the presentation of nominal catch rates for billfish throughout this report, no provision has been made to account for the factors listed below. These factors, while not catered for quantitatively, should be considered in light of the information that follows.

(a) The seasonal patterns in longline fishing effort in Australia and New Zealand;

(b) The legislative action by the local governing bodies to prohibit the catch of billfish, as is the case in New Zealand with the establishment of a billfish moratorium in the northern fishery since 1988 (Murray & Burgess 1992), in order to prevent competition with growing recreational fisheries;

(c) The seasonal closure of an area off the north coast of New South Wales (NSW) where domestic fishermen were prohibited from landing live striped marlin (*T. audax*). This practice was also adopted by Japanese longliners fishing in this area. (Australian Fisheries Management Authority (AFMA): Ward, pers. comm.);

(d) The agreement by Japanese vessels, licensed to fish in the AFZ, to release all black (*M. indica*) and blue marlin (*M. mazara*) that were alive at the time of landing. This agreement was voluntary on the part of the Japanese, who accepted the perceived importance of the developing recreational fishery for marlins off the east Australian coast. These practices have occurred since 1986/87 and apply to all areas of the AFZ (AFMA: Ward, pers. comm.);

(e) The agreement by Australian domestic vessels in 1987 to release all black and blue marlin, whether alive or dead. Striped marlin can be retained for export; however landing and selling any marlin and swordfish in NSW is prohibited (AFMA: Ward, pers. comm.);

(f) Area closures off the north-east coast of Australia (since 1980/81: the AFZ 12°S–18°43'16"S; since 1990/91: the AFZ 12°S–20°28'49"S), prohibiting foreign longline fishing in order to reduce competition with the recreational fishery for black marlin and sailfish (AFMA: Ward, pers. comm.).

4.3.1.1 Striped marlin

Figure 4.7 (top left) shows the distribution of nominal CPUE for striped marlin throughout the WPO. Figure 4.8 (top left) shows annual trends in striped marlin CPUE in the three areas of the WPO and Figure 4.9 shows seasonality of striped marlin catch rates by WPO area and categories of hooks per basket, which is used in this review as a relative measure of fishing depth.

Striped marlin are taken by longline vessels throughout the WPO. However, it is noticeable that catch rates are highest in the eastern and western areas of the WSP. High catch rates in the eastern areas of the WSP are attributed to pre-spawning and spawning aggregations that form in the latter part of each year (Williams unpublished). Pre-spawning aggregations appear to be associated with cooler waters surrounding elevated bottom topography, which may explain the slight peak in CPUE for intermediate depth gear during August–September in the WSP (Figure 4.9). The high catch rates experienced during spawning occur in warmer waters further to the north during October–December with no apparent association with bottom topography, as in pre-spawning. Examination of gonad indices of striped marlin caught in the Coral Sea (WSP) indicate a primary spawning season in the months of November and December (Hanamoto 1977). This is also demonstrated by the fact that of the longline sets where striped marlin were taken for this season in the WSP, over 30 per cent contained 6 or more individuals; this compares to less than half this percentage for any other season, for catches of 6 or more individuals.

The strong feeding behaviour associated with spawning appears to be restricted to relatively shallow waters, as there is a near absence of striped marlin in the catch of deep-geared vessels in the WSP, as measured by CPUE (Figure 4.9). This is confirmed by the belief that striped marlin have some preference for a temperature range between the 20° and 25° isotherms (Nakamura 1985) which is normally apparent in the shallower waters of this area. Similar conclusions on the preferred depth range of striped marlin in the EPO have been made via observations on vertical movement patterns from tracking experiments (Holland et al. 1990) and experiments using time-depth recorders (Boggs 1992).

Striped marlin have been one of the target species for some Japanese longliners fishing in and around the waters of north-east Australia, New Caledonia and the northern waters of New Zealand, although in the latter case, the retention of billfish caught by foreign longline vessels has been prohibited since 1987.

Suzuki (1977) refers to two different stocks of striped marlin for the Pacific Ocean, with the majority of the WPO-caught striped marlin taken from the hypothetical southern stock. The occurrence of generally smaller striped marlin in the WTP (Figure 4.10; Table 4.6), which is adjacent to major spawning areas, corresponds to the hypothesis that these fish may stay in the warmer waters as juveniles and only move to higher latitudes after maturity. Annual trends in CPUE for the WTP and WSP fluctuate during the last 10 years, although it is noticeable that in some years, CPUE have risen in the WTP with a corresponding decrease in the WSP, and vice-versa; this could be attributed to variations in currents and the thermal structure of ocean in these areas brought about by ENSO (El Nino Southern Oscillation) events.

Striped marlin, with swordfish, appear to be one of the hardier species of the billfish, on the basis of estimated survival rates (Table 4.8).

In regards to the marketing, striped marlin as sashimi is considered the best among the billfish (Nakamura 1985).

4.3.1.2 Black marlin

Figure 4.7 (top right) shows the distribution of nominal CPUE for black marlin throughout the WPO. Figure 4.8 (top right) shows annual trends in black marlin CPUE in the three areas of the WPO and Figure 4.9 shows seasonality of black marlin catch rates by WPO area and categories of hooks per basket, which is used in this review as a relative measure of fishing depth.

There has been some concern that black marlin species misidentification occurs throughout the WPO longline fishery (Farman 1986). Taiwanese fleets operating in the WTP consistently report high catches of black marlin even though other fleets operating in the same area usually report very few black marlin caught compared with the more abundant blue marlin apparent in this area. The confusion may also stem from Japanese names of marlin species, for example, black marlin (*shirokajiki*) is referred to in japanese as ‘white’ marlin and blue marlin (*kurokajiki*) as ‘black’ marlin. The level to which misidentification occurs is currently unknown, although it should be noted that observer programmes offer a mechanism for determining this. In any event, any review of black marlin catch from logsheet data presented here should take into account some degree of mis-identification.

Longline catches of black marlin are distributed throughout the WPO, although they are aligned more to coastal areas than the other two marlin species reviewed here and the catch is not as high. There has been some evidence that targeting of this species by Japanese longline vessels may have occurred off the north-east coast of Australia prior to the early 1980s (Ward pers. comm.). This particular area has historically reported high catch rates as a result of seasonal spawning aggregations. Management measures have recently been introduced in order to restrict the catch of black marlin, and thus reduce possible direct competition with the sports fishery established there.

Black marlin catches have been recorded in the three areas of the WPO, with the highest catch rates occurring in the WSP areas off the north-eastern coast of Australia and eastward, in and around the waters of New Caledonia, Fiji and Tonga. Since 1976, catch rates in the WSP have been fairly consistent at around 1–2 fish per 10,000 hooks. In the WTP, annual catch rates rarely exceed 1 fish per 10,000 hooks, although it is worth noting that the WTP CPUE was similar to the WSP level in 1989, possibly due in part to restrictions placed on the landing of this species in parts of the WSP and also to the misidentification problem described above.

A seasonal pattern for catch rates of black marlin exists in the WSP. The increase in catch rates in certain areas of the WSP (Coral Sea) for the last quarter of the year coincides with denser distributions of spawning schools occurring in this area at the time (Nakamura 1985). There is apparently little difference in the modal size of black marlin caught by longline vessels in the WTP and the WSP (Figure 4.11), although there appears to be a higher tendency for larger fish to be taken in the WSP. Catch rates for deep-geared vessels in the WSP and WTP generally match those of the conventional geared vessels for most of the year, although there are noted higher rates experienced for vessels setting fewer hooks per basket in the fourth quarter for the WSP and also a possible preference for deeper waters in the WTP; the changes in gear utilisation in the WTP during the last 10–15 years and recent regulations restricting catch should, however, be taken into account when considering these data.

There is some information available on the movement patterns of this species from tagging conducted in Australia. Recaptures of tagged black marlin far from their position of release indicate that they are highly mobile fish, although it was noted that there appears to be a greater tendency for long-distance travel by individuals less than 100 kg (Williams, 1994).

No evidence of black marlin discard was found in the data available and post-harvest treatment of this species is primarily for the sashimi market; low-quality black marlin are primarily used for fish sausage (Izumi pers. comm.).

4.3.1.3 Blue marlin

Figure 4.7 (middle left) shows the distribution of nominal CPUE for blue marlin throughout the WPO. Figure 4.8 (bottom left) shows annual trends in blue marlin CPUE in the three areas of the WPO and Figure 4.9 shows seasonality of blue marlin catch rates by WPO area and categories of hooks per basket, which is used in this review as a relative measure of fishing depth.

The distribution of catch rates for blue marlin shows the highest values in and around the northern waters of the Marshall Islands, although, given the distribution of effort in the WTP, the catch volume of blue marlin taken is fairly consistent throughout. Preference for the warmer offshore waters of the WTP and northern areas of the WSP is apparent, contrary to the mainly WSP distribution exhibited by the striped marlin (oceanic) and, to a lesser extent, the black marlin (more coastal). Annual blue marlin CPUE has displayed no apparent trend of increase or decline in the years leading up to 1989, after a noticeable decline during the earlier to mid-1960s. The drop in CPUE in the WTP for 1989 and 1990 coincides with a higher-than-normal CPUE for the WSP, an interesting trend that may be explained by variations in currents and thermal structure of the ocean brought about by ENSO events.

It is also suggested that the variable nature of the blue marlin CPUE in the WTP (particularly for the period 1984–1989) may be related to migratory behaviour of (smaller) males away from the equator (Williams 1994); when this occurs, good catch rates are experienced in more temperate waters. This is consistent with size-frequency data for blue marlin in the WSP (Figure 4.12). It is noticeable that there is a high proportion of fish less than 50 kg taken in the WSP (compared with the WTP), an occurrence that is in contrast with the other two marlin species, although (as with the other marlin species discussed in this report) the largest individuals are more prevalent in the longline catch of the WSP. Blue marlin CPUE for the WTP has generally fluctuated between 4 and 7 fish per 10,000 hooks since the early 1970s, while for the same period in the WSP, values of between 2 and 4 fish per 10,000 hooks existed; catch of blue marlin in the WTeP were practically non-existent.

The slightly higher blue marlin catch rate for deep-geared longline vessels in the WTP and the WSP (Figure 4.9) highlights a different depth-range preference for feeding from the other marlins. Evidence of feeding at greater depths is mentioned in Nakamura (1985), with the occurrence of the deep-dwelling squirrel fish (*Holocentrus lacteoguttatus*) in the stomachs of this species. It is interesting to compare this with the depth range preferences in observations on the short-term vertical movement of sonic-tagged blue marlin in the waters off Hawaii (Holland et al. 1990), and comparable data on blue marlin CPUE breakdown for these gear types, described in Suzuki et al. (1977). There is a slight seasonal pattern for catch rates of blue marlin in the WTP; a more pronounced pattern appears for the WSP, which is similar to that of the other marlin species in this area, although no information was available to indicate mechanisms for this seasonality.

It is generally considered that due to the historic pattern of effort, blue marlin stocks would be the most vulnerable to over-exploitation of the marlin species. The results from analyses of available longline data (1952–1975) on the catch of blue marlin in the Pacific by Yuen and Miyake (1980) indicated that the stock was probably over-exploited as catch rates diminished and the catch level fell below the estimated maximum sustainable yield (MSY = 22,000 metric tonnes) even though fishing effort remained very high. Sakagawa (1987), however, suggested a reappraisal of this earlier work, as changes in gear depth utilisation since the late 1970s are believed to affect the vulnerability of blue marlin to longline gear.

It is not known whether blue marlin are targeted anywhere in the WPO; however, it is assumed they are generally retained and primarily processed for the sashimi market.

4.3.1.4 Swordfish

Figure 4.7 (middle right) shows the distribution of nominal CPUE for swordfish throughout the WPO. Figure 4.8 (bottom right) shows annual trends in swordfish CPUE in the three areas of the WPO and Figure 4.9 shows seasonality of swordfish catch rates by WPO area and categories of hooks per basket, which is used in this review as a relative measure of fishing depth.

Swordfish are the target species for some Japanese and New Zealand longline vessels fishing in the waters off the east coast of Australia and in the waters of New Zealand; studies on the diel behaviour patterns of swordfish, and experience in the fishery, have determined that the night is the best time to catch this species using light sticks in the surface ocean layers. The lack of 'time of set' information in the RTFD, however, prevents a quantitative description of this fishing practice. This species of billfish is different from the others mentioned above in that fecundity is lower and longevity is higher, both important factors in management considerations.

The WSP produces the highest catch rates and catch volume in the WPO, according to the RTFD. Annual values of CPUE show no trend in the overall catch rates for swordfish in the WSP and the WTeP; these areas, in reality, should be considered as one for this species. Since the late 1960s, CPUE for these areas has generally fluctuated between 5 and 12 fish per 10,000 hooks, although it appears more consistent in the WSP. CPUE for the WTP has remained somewhat constant over the 29 years, with a value of about 1–2 fish per 10,000 hooks. No definitive work was found on the status of swordfish stocks in the WPO, and recent interest in targeting this species in parts of the WPO, may warrant further attention in the future. As an indication of what may be possible in areas of the WPO, 61,000 swordfish were taken by the longline target fishery in Hawaii during 1991 at an average CPUE of 5.0 fish per 1,000 hooks (WPRFMC, 1994).

A strong seasonal pattern exists for swordfish CPUE in the WSP for conventional-geared vessels, which is in contrast to the situation for marlins. It shows an increase in CPUE for the months leading up to the austral winter, a sharp decline during winter and another slight increase towards the beginning of spring. Observations elsewhere (Atlantic Ocean: Carey & Robinson 1981), have shown swordfish making ventures into colder, deeper water than marlin and they are also known to favour surface waters at night when the temperature is of the range of 18° to 22° C. It is interesting to compare these findings with the fact that deep-geared vessels in this area consistently catch less than 1 fish per 10,000 hooks, a fact which no doubt highlights the methods employed in targeting this species. Desurmont (pers. comm.) mentioned that when targeting swordfish in New Caledonia, the gear of the first set of a trip was structured in a way that would find the preferred depth (and thus temperature) range for swordfish in that area; catch rates, stratified by hook number, identified this depth range as being very narrow. Swordfish appear to be more prevalent in the catch of deep-geared vessels in the WTP; this is consistent with the steady increase in CPUE during the early 1980s at a time when the trend was towards fishing at greater depths. The fact that specific techniques (i.e. the use of light sticks) may be used to target confounds the presentation of swordfish CPUE by gear depth. It is, therefore, important that this practice (for which there are no data available on the RTFD) be considered in future monitoring of this catch.

At the moment, the marketing of swordfish in Australia is restricted by regulations prohibiting the sale of this species where greater than 0.5 ppm mercury content is encountered; however, there have been recent efforts to try and have this minimum level increased, which may lead to an increase in interest for this species in the future. Similar regulations exist in the US and Japan.

From a marketing standpoint, in Japan, swordfish are primarily sold as steaks in the preparation of *Teriyaki* (Nakamura 1985); however, it is known to be available for sashimi as well. In the US, swordfish is popular and normally grilled/broiled using barbecues.

4.3.1.5 Sailfish

Figure 4.7 (bottom left) shows the distribution of nominal CPUE for sailfish throughout the WPO. Figure 4.8 (second page) shows annual trends in sailfish CPUE in the three areas of the WPO and Figure 4.9 shows seasonality of sailfish catch rates by WPO area and categories of hooks per basket, which is used in this review as a relative measure of fishing depth.

Sailfish catch rates are highest in the areas off the north-east coast of Australia, in the waters around New Guinea, Solomon Islands and New Caledonia. While the distribution of this species is widespread, higher levels of catch are known to occur in coastal waters, close to islands and reefs. Historical catch rates for sailfish are limited to the RTFD since the historical Japanese data for sailfish are not available. Annual CPUE in the WSP during the 1980s was generally between 1–2 fish per 10,000 hooks, compared to a level never exceeding 1 fish per 10,000 hooks in the WTP. Sailfish catch rates in the WSP show little seasonal pattern, other than for the intermediate gear, which make up a very small proportion of the effort. Sailfish tend to remain in one area (more so than the marlin species) and they are known to form feeding aggregations, which is not as evident with the other billfish (Nakamura 1985). There have been observer reports of relatively high species composition of sailfish for some longline sets in the WTP (Heberer 1994a) and this is also demonstrated by the high percentage of total catch exhibited in the WTP for days where sailfish catches were encountered. For example, more than 7 per cent of trips where sailfish were encountered in the WTP contained 6 or more individuals; this compares with approximately 4 per cent of the trips where 6 or more blue marlin were taken, even though blue marlin are considered the more abundant billfish species overall in this area. Contrary to some of the marlin species, it appears as though larger sailfish are taken in the WTP longline catch than in the WSP (Figure 4.14).

It is not expected that sailfish would be included in the target species of any longline vessel fishing in the WPO and it is more likely that under-reporting of this species would occur due to its relative lesser importance when compared with the other billfish (the tendency to group this species with short-billed spearfish is an example: Farman 1988). No information on stock status was found or is suggested; however, some action may be necessary to improve coverage and distinction in the catch from short-billed spearfish.

Sailfish are retained catch, although not as highly valued as the other billfish; increasing utilisation of sailfish as sashimi, by smaller vessels, has been mentioned (Lewis pers. comm.).

4.3.2 By-catch of non-fish species of particular interest

No RTFD record exists of seabird, turtle or marine mammal capture by the longline vessels in the WPO. The following describes what is found in observer reports and the literature on these animals.

4.3.2.1 Seabirds

Due to the nature of baiting and setting longline gear, seabirds have for some time caused a problem for longline vessels in some areas. When baited hooks are flung from the vessel, birds in the vicinity of the vessel will try and take the bait before there is time for the line to sink; there have also been reports of birds taking baits in the hauling process, although the frequency of birds caught in this manner is nowhere near that of bird catch during the setting process. The catch rates of bird are typically at their highest in the WSP and WTeP, where vessels are in proximity to the major land masses of Australia and New Zealand. The genera mostly taken in these areas are *Diomedea* spp. (albatrosses) and *Procellaria* spp. (petrels). Until recently, catch rates of 0.9 birds per 1000 hooks for the southern bluefin longline fishery in New Zealand (Murray et al. 1991) and 0.41 birds per 1000 hooks in the Australian southern bluefin fishery (Brothers 1991) have been recorded by observers. Concern related to the decline in the population of these birds, in particular the albatross species, prompted initiatives on both sides of the Tasman Sea to try and reduce this catch. There was also keen interest from the fishermen, as bait loss from birds (one estimate was 5 baits lost per hooked bird; Murray et al. 1991) meant the reduced efficiency of their gear. The implementation of what is referred to as a *tori* (bird) pole, consisting of a boom and trailing streamer line, has seen a substantial reduction in the bird catch rate to 88 per cent of the level in previous years when this device was not used (Brothers 1991). Other mechanisms that have been suggested are (i) the possibility of setting longlines at night when bird activity is at a minimum; and (ii) the closure of areas known to be localities which birds frequent and where they are likely to be a problem to the longline vessel (Murray 1992). A mechanical bait-throwing device to reduce slack in the branch line and speed bait sinking is also showing promising results.

No references were found to the catch of birds by longline vessels in the WTP, where a large proportion of the effort occurs. As the populations of the above-mentioned genera are prevalent in the higher latitudes, the problems encountered in the WTeP would not be expected to occur in the WTP.

4.3.2.2 Marine reptiles

While there are no records of turtle catch in the RTFD, observer reports suggest that turtles are caught by longline vessels in the WTP (and WSP) from time to time. There are references to the catch of some turtle species by longline vessels in the WPO from observers (Table 4.7), and in nearly all cases, they were released alive, with no mention of commercial interest in turtles nor of them being retained for consumption on-board or on return to port.

A recent estimate for turtle by-catch of 0.020 per 1,000 hooks in FSM waters has been provided from MMA observer data (Heberer, 1994a), although admittedly, current coverage is only a very small percentage of overall effort. Witzell (1984) calculated a CPUE of 0.073 turtles per 10,000 hooks for Japanese longline vessels fishing in US waters in the Atlantic Ocean and 0.18 per 10,000 hooks in the Gulf of Mexico. For two areas, the percentage of turtles (leatherback, green, Kemp's ridley and loggerhead) released alive was 70.4 per cent and 93.3 per cent, suggesting a good survival rate which could be applied to WPO occurrences.

Two important considerations for future monitoring are (i) the expected abundance of turtle species in the WPO using, for example, knowledge of the proximity to spawning areas and (ii) whether turtle by-catch has occurred by the animal taking the bait, accidental hooking elsewhere on the body/carapace or line entanglement.

A good reference document detailing current concerns, knowledge of the levels of turtle by-catch and future directions for monitoring by-catch levels is *Research plan to assess marine turtle hooking mortality: results of* *an expert workshop* (Balazs & Pooley, ed.) held in Honolulu recently (December, 1993). The guidelines from this workshop will no doubt be a useful reference for future monitoring of this by-catch in the WPO.

4.3.2.3 Marine mammals

There are very few reports of marine mammal capture in WPO longline fisheries. One observer account describes the accidental capture of two common dolphins (*Delphinus delphis*) by a foreign longline vessel in New Zealand waters (Michael et al. 1987) and gives another account of the hooking of a porpoise (species not known), also in New Zealand waters. Evidence of the capture of a killer whale (*Orcinus orca*) by a longline vessel in New Caledonian waters was witnessed by one of the authors and there is a report of the same species being taken in the southern waters of New Zealand by a Japanese longliner. MMA observers list the capture of only one unidentified marine mammal during more than 10 years of observations.

Given the somewhat frequent accounts by fishermen and observers of tuna damaged by killer whale, false killer whale (*Pseudorca crassidens*) and pilot whale (*Globicephala* spp.) in the longline fishery, it is possible that there may be occasional hook-ups or tangles as a result of these species 'playing' with or attacking tuna already on the line. However, reported instances of their catch is very rare and as they are regarded as a serious 'pest', fishermen endeavour to avoid operations in areas where they may occur in order to reduce major catch losses. Normally, these species will leave only the head or lips of the catch and the frequency of damage in the total catch is almost always far greater than that caused by sharks. As an example, there were two days out of nine observed where at least half of the target catch from a Japanese longline vessel fishing in the north-eastern AFZ was damaged by false killer whales (AFZ observer report) and it was necessary to shift operations on the subsequent days to avoid such incidents; false killer whale-damaged tuna were observed on three other days of this observation period, but not to the same extent as mentioned above.

Observers in New Zealand have reported the incidental catch of seal (Pinnipedia) by Japanese longline fishing vessels targeting southern bluefin tuna; however, further information on their fate and the frequency of this type of catch was not available. As the WPO longline area has little overlap with areas where seal populations are abundant, it is perceived that this by-catch is extremely low in comparison to the overall effort.

4.3.3 Shark by-catch

Various species of shark are taken throughout the WPO (Figure 4.7 bottom right). Table 4.7 describes the species of shark caught and their broad distribution in the WPO, based primarily on observer data; detailed descriptions of the biology and geographic distribution can be found in Compagno (1984).

Observer data collected by some SPC member countries provide the only indication of by-catch levels for the individual species of shark vulnerable to WPO longline fisheries, as logsheets (RTFD) do not provide for a breakdown of shark species. Available observer data show that the proportion of the shark by-catch to total catch in the WPO longline fisheries is regularly at a similar level as target species catch (Tables 4.5, 4.10), although coverage in the WTP is currently lacking and thus it is not advisable to use these few data to provide overall estimates of this by-catch. It is obvious, however, that there is a lack of reports on shark by-catch on logsheets (Table 4.4, Figure 4.6).

There has been some effort in Australia to gain more information through the recent introduction of a shark logbook supplement for the Japanese longline fleet (P. Ward, pers. comm.), requiring the breakdown of shark by-catch into numbers/weight/discards of the most important species in AFZ, that is, blue shark (*Prionace glauca*), mako (*Isuris oxyrinchus*), porbeagle (*Lamna nasus*) and bronze whaler (*Carcharinus brachyurus*). While there has been no quantitative assessment of the success of this supplement (for example, comparisons between logbook data from vessels with observers present), there appears to have been a conscious effort by some of the vessels to complete the form; it is noteworthy, however, that there have been some problems in species identification.

One of the predominant species taken throughout the WPO appear to be the blue shark (*P. glauca*), although significant catches of mako (*I. oxyrhinchus*), thresher (*Alopias* sp.) and *Carcharhinus* species have been observed in the WPO. While there are not enough quantitative data for the WPO, Sivasubramaniam (1964) described the shift in a higher species composition from blue shark to *Carcharhinus* species as one moved from temperate to tropical waters in the Indian Ocean. Stevens (1992) estimated that the average Japanese catch rate for landed blue shark taken off south-eastern Australia is around 1–2 fish per 100 hooks. However, he noted that considerable variations in catch levels were experienced between periods of sampling. In comparison, he describes Japanese catch rates for the New Zealand longline fisheries which, after raising to account for under-reporting, are estimated to be in the range 1–4 fish per 100 hooks for the period from 1980 to 1989; catch rates (1.0 and 0.9) calculated from data collected on two observer trips (Michael et al. 1989) on Japanese vessels in New Zealand waters tend to agree with the lower end of this range. The main concern with the level of catch of this species in the south-eastern Australian longline fishery was the high incidence of immature and adolescent females. The few observer data and accounts available for the WTP suggest that this species may be the predominant one in the longline catch in this area (MMA observer programme: Heberer, 1994a).

Blue shark are not a valued by-catch and in most cases only the fins are retained for additional crew revenue, with the remaining trunk usually discarded. In contrast, the other more common shark by-catch species (mako shark, for example) tend to be retained in entirety, although it appears that practices in retaining the trunks of shark may vary between vessel nationalities (for example the Taiwanese seem to catch and retain more shark than the other fleets (Table 4.10)); the levels to which this occurs can only be validated by further observer data collection and analyses.

Due to concerns relating to the practice on foreign longline vessels of removing the fins from shark (primarily blue shark) and discarding the trunk, Australia recently (1991/92) introduced regulations to prohibit this type of processing (AFMA: Ward, pers. comm.). While there are obvious problems in enforcing this requirement, it has nonetheless been reported that the market for blue shark trunks has improved. The high rate of survival of shark species taken by this gear (Table 4.9) suggests that this may be a viable management option for other countries where this is seen to be a problem.

As mentioned, levels of shark by-catch in the WTP based on information contained in the RTFD are seriously under-reported. As an indication, the average species composition of shark reported in the RTFD between 1985 and 1990 for Taiwanese vessels fishing in one area of the WTP was 25 per cent; this compares to 0.09 per cent for the same period and area for Japanese vessels. For this period, a subset of 60 trips by Taiwanese vessels had over 50 per cent of the total recorded catch (in numbers) as shark, compared to none by the Japanese (although, prior to 1985 there were 4 Japanese trips where shark by-catch exceeded 50% of the total catch, perhaps highlighting the decline in shark by-catch reporting in recent years). The species composition of shark in the catch by Taiwanese vessels in the WTP from logsheet data is in the same order of magnitude as that reported by observers in this area and may be indicative of the real catch of the other fleets operating in the area. However, it is difficult to accept this broad assumption without taking into account the range of activities of all fleets. While shark by-catch by Japanese vessels in the WTP appears to be under-reported, it is interesting to note the contrast in the apparent consistent reporting level of shark by-catch by Japanese vessels in the WTeP (Table 4.4), possibly highlighting more interest placed on some shark species in this area. It is hard to imagine these differences are valid; they more likely occur because the various vessels/fleets have a tendency not to report catch of no commercial value, or are not obliged to do so. The fact that Taiwanese vessels in the WTP appear to provide better shark by-catch reporting may be related to their interest in this catch. For example, some vessels purposely set their gear shallower in order to target shark towards the end of a trip when suitable transportation back to Taiwan is available (Heberer pers. comm.). In regards to shark by-catch in related fisheries, the Hawaiian longline fishery reported a catch of 71,000 sharks during 1991 at a catch rate of about 6.0 per 1,000 hooks, although only 4,500 (6%) were retained (NMFS 1992).

Table 4.10 provides an interesting trend in the comparison of catch rates of shark with those of target species for Japanese and Taiwanese fleets operating in the FSM. There appears to be some correlation between the proportion of bigeye to yellowfin catch rates and shark catch rates per vessel trip. When bigeye catch is greater than yellowfin, the shark by-catch is also generally greater than yellowfin; when there are higher catches of yellowfin (compared with bigeye), shark by-catch is generally lower than yellowfin. This relationship is also consistent with information on shark-damaged target species from logbook data provided to MMA by Taiwanese vessels operating out of Pohnpei, FSM. Out of the 71 target individuals listed as damaged by shark during vessel trips of 1993, only 2 were yellowfin (i.e. 69 bigeye), even though yellowfin made up more than a third of the target catch. There was no further information available to explain whether this relationship was due to increased shark catch around the full-moon (when some vessels catch bigeye with shallow sets), or to the fact that particular shark species are more abundant at depth (where bigeye targeting also occurs), or to differences in fishing techniques between the fleets, a combination of the above, or any other reason. Nonetheless, the relationship is worthy of further investigation if any management of this by-catch is required in the future.

It would be of some concern if the overall shark catch rate in the WTP is anything close to that reported for the WTeP, although it is more likely to be closer to the level reported by the Taiwanese for this area. If it was considered necessary to introduce species-specific recording on catch logsheets, one of the problems envisaged would be correct species identification. In addition to ensuring that reliable catch data are collected, some knowledge of fecundity, natural mortality and longevity of the species of shark in question would be required in order to review the status of individual species stocks for the areas of interest.

4.3.4 Non-target tuna species

4.3.4.1 Skipjack

Skipjack (*Katsuwonus pelamis*) are considered by-catch for the longline fishery in the WPO, as there is no documented evidence of any targeting in the areas of interest. The distribution of skipjack vulnerable to the longline gear is widespread and extends beyond the main area of activity of the surface fishery fleets, which is primarily the WTP. An indication of the exploitation levels by longline vessels in the WTP is difficult due to inconsistent reporting from longline vessels of catch of this species, and it is expected that the species composition (Table 4.4: 0.03% in the WTP), even after raising to account for non-provision on logsheets (logsheet coverage 23%), is below the real level. Data available in observer reports from the WTP indicate that 14 out of 21 trips reviewed had some skipjack catch (species composition ranging to 5% for one trip, averaging about 1%), most of which was discarded (Heberer 1993). This proportion is far above what has been reported on logsheets but also differs considerably from the proportion for trips where tuna discards were reported in the RTFD (Table 4.2 : 0.53%), assuming the normal practice is to discard this species in this area. In the WSP, there is also evidence of some degree of under-reporting of skipjack catch, as two per cent of the catch (by weight) unloaded in 1990 from longline vessels in Fiji were skipjack; this highlights the fact that there are some areas where this species is always retained, thus it would be difficult to provide broad indications of the fate of this species.

It is apparent that when there is sufficient freezer space and/or vessels make short trips from SPC member-country ports, skipjack are sometimes retained and then sold or given away on return to port; in some instances skipjack have been also retained for on-board crew consumption. The levels of under-reporting seem to stem primarily from the fact that skipjack are of lesser importance in the catch of these vessels and very rarely, if at all, contribute to the commercial catch.

The longline fishery operating in the equatorial regions in the Indian Ocean has reported consistently high hooking rates (> 2 per 1,000 hooks) for skipjack; it is also evident that the skipjack taken by this gear are generally larger than those taken by the surface fisheries in that area (Marcille & Suzuki 1974), a fact also prevalent in the WTP. From the few data in the RTFD where vessel trips recorded skipjack catch the following average CPUE values are available for the period 1978–1991 where the frequency of trips is greater than 10 : Japanese vessels fishing in Australia (0.4 fish per 1000 hooks; 399 trips), Korean vessels in Cook Islands (1.1; 22 trips), Taiwanese in Fiji (0.7; 41 trips), Japanese in FSM (0.2; 13 trips), Koreans in Kiribati (0.4; 23 trips, Japanese in the Marshall Islands (0.7; 17 trips), Japanese in Papua New Guinea (0.4; 13 trips), Japanese in Solomon Islands (0.3; 49 trips) and the domestic Tongan longliner (0.7 for 49 trips). It is assumed that these were retained catches and it is unknown whether there were further discards of skipjack not included in these reports. There was not enough information available to compare the catch levels of skipjack for conventional against deep-setting vessels.

There have been only two skipjack releases reported as longline recoveries, one skipjack released during the Skipjack Survey and Assessment Programme (SSAP) conducted by SPC from 1977 to 1981, and one release from the Regional Tuna Tagging Project (RTTP), conducted by the TBAP from 1988 to 1992.

4.3.4.2 Incidental catch of albacore

Albacore (*Thunnus alalunga*) are usually the target species for longline vessels operating in the WSP, although there are also incidental catches taken by longline vessels in the WTP; the fate of this by-catch is largely unknown, but it is considered to be kept for crew consumption or gifts on return to port. Only one individual has been reported from WTP observer trips available for this report. Albacore longline catch data are available in the RTFD for activities in the WTP waters of FSM (where CPUE have ranged from about 0.1 to 1 fish per 10,000 hooks annually by the Japanese fleet since 1982 and from 1.7 to 2.4 fish per 1000 hooks annually by the Taiwanese fleet during 1987–1989), Kiribati (0.2 to 1.1 fish per 1000 hooks by the Japanese fleet since 1981; 0.1 to 1.5 per 1000 hooks annually for the Korean fleet since 1985); the Marshall Islands (CPUE range from about 0.1 to 2 fish per 10,000 hooks for the Japanese fleet since 1982); Papua New Guinea (1 to 7 fish per 10,000 hooks annually for the Japanese during 1980 to 1987); Palau (1 to 12 fish per 10,000 hooks annually for the Japanese since 1980) and the Solomon Islands (0.2 to 5.1 fish per 1,000 hooks annually for the Japanese since 1978). The average weight of albacore taken in the WTP tends to be larger than that of the more temperate waters (i.e. spawning), with very few records of individuals less than 15 kilograms appearing in the RTFD.

4.3.4.3 Incidental catch of northern and southern bluefin

Northern bluefin (*Thunnus thynnus orientalis*) and southern bluefin (*Thunnus maccoyii*) are the valuable target species of longline fisheries bordering parts of the northern and southern areas of the WPO, respectively. Incidental catches of bluefin in the WTP are available in the RTFD, although some uncertainty surrounds the exact species identification; the assumption that they are *T. thynnus orientalis* is based upon the proximity to this species' target fishery and perceived movements of this species from spawning grounds near the Philippines. Examples of outstanding catches in the WTP are (i) during 1991–1992, 9 individuals averaging over 200 kg were taken by Taiwanese vessels in FSM waters; (ii) during 1990–1991, 4 individuals averaging over 250 kg each were taken by Chinese vessels fishing in Palau waters; (iii) 3 individuals, each weighing over 100 kg, were taken by Japanese vessels fishing in Solomon Island waters north of 10°S during 1985–1990; and (iv) several individuals were taken in Fijian waters weighing over 150 kg.

None of the available observer data contain occurrences of catch of either bluefin species in the WTP.

4.3.5 By-catch of other species

For reasons described in the 'sources and coverage of data' section above, information on the by-catch of the 'other' species contained in the RTFD is lacking. Tabulated data are provided in an attempt to give some representation of the levels of by-catch in the WPO; the seasonal catch for each retained species reported on logsheets is shown in Table 4.11, and Table 4.7 describes the species that have been caught by longline vessels in the WPO according to observations. Table 4.6 gives some indication of the broad distribution and size composition of the some of the individual 'other' species by-catch. No attempt has been made to show annual CPUE trends by species, detailed geographic distribution or quantitative estimates of other species by-catch for the WPO due to the paucity and inconsistent reporting in data available.

Domestic fleets operating in the WTP and WSP generally retain more by-catch species than the DWFN fleets; by-catch from locally-based vessels is usually sold in local markets or retained by crew for personal consumption or gifts to family and friends, although, in Fiji for example, up to 90 per cent of the retained by-catch is exported and it has been reported that, when appropriate, some by-catch unloaded at ports in FSM by Taiwanese vessels is shipped back to Taiwan.

Of the species catch contained in the RTFD, only moonfish (*Lampris* sp.) have been reported regularly in the three areas of the WPO. The fate of these fish, considered a delicacy, seems to vary. Some are exclusively kept for crew consumption, whether on-board or on return to port, while there are other reports of the commercial sale of this fish; for example, moonfish (as well as short-billed spearfish and escolar) have been exported from Fiji (Viala pers. comm.).

4.3.5.1 Mahi mahi and wahoo

In some areas of the WTP and the WSP, wahoo (*Acanthocybium solandri*) and mahi mahi (*Coryphaena* sp.) are the common by-catch of longline vessels. Catch of these species is more seasonal in the WSP and they are not normally discarded as they are generally used for crew consumption or commercially important enough to provide local markets, although this may not be the case for vessels making long trips where freezer space is at a premium.

The RTFD contains catch data for wahoo from Fiji (vessel trip CPUE ranging from 1–2 fish per trip to 0.4 per 1000 hooks for the trip); New Caledonia (CPUE up to 0.9 fish per 1000 hooks for the trip); and PNG (CPUE up to 0.3 fish per 1000 hooks for the trip). Consistent wahoo catch has been reported by observers on foreign longline vessels fishing in FSM waters (vessel trip CPUE up to 1.4 fish per 1000 hooks; an average of 0.27 per 1,000 hooks for all observed trips since January 1993; Heberer 1994a).

The catch of mahi mahi has been reported (in the RTFD) from Fiji (vessel trip CPUE up to 0.8 fish per 1000 hooks); FSM (to 13.3 fish per 1000 hooks); Marshall Islands (to 4.7 fish per 1000 hooks); PNG (to 0.03 fish per 1000 hooks); and Tonga (to 0.2 fish per 1000 hooks). FSM observers also reported consistent catches for mahi mahi, with CPUE up to 2.7 fish per 1000 hooks for the observed trips (0.1 per 1,000 hooks for all observed trips since January 1993). The Hawaiian longline fishery reported an average catch rate for mahi mahi of 3.1 per 1,000 hooks during 1991.

Some of the logsheets received by SPC contain specific columns for these two species, indicating their importance in the catch of those areas (for example, New Caledonia). The importance of these species as part of the overall longline catch is highlighted also in the actions taken by WPRFMC to specifically include them in its Pelagics Fisheries Management Plan (FMP) for the longline fisheries of its area of jurisdiction (some of which includes areas of the WPO, for example Guam). The FMP also contains summarised information on the biology and geographic distribution of these species in the Pacific Ocean, which is relevant to the WPO fisheries described in this review.

No indication of overall levels of exploitation for the WPO are suggested or were found due to the current paucity of data.

4.3.5.2 Others

There are some by-catch species which are very seldom considered commercially valuable or kept for crew consumption. The most common of these species are the oilfish (*Ruvettus pretiosus*), snake mackerel/escolar (Gempylidae), lancet fish (Alepisauridae) and the barracudas (Sphyraenidae). As an example, there was only one trip out of 21 reviewed by Heberer (1993) where any of these species were retained, even though reasonable catches were observed (at least 75% of trips contained by-catch of this nature). According to observers on foreign longline vessels in Australian waters, less than one per cent of the observed catch of these species was retained. In regards to the ability of these species to survive after discard, the oilfish (81% encountered alive on landing) and snake mackerel (78%) appear to be the hardier species (AFMA observer data: Ward, pers. comm.).

Of the species not already mentioned, it appears that sunfish (*Mola* sp.) and pomfrets (Bramidae) are regular by-catch of longline vessels and, thus should warrant further attention. There are few observer data available that describe the catch levels of these species; in the WTP, catch rates of 0.15 and 0.223 per 1,000 hooks, respectively, have been reported (Heberer 1993).

4.3.6 Discards of by-catch

Reasons for the discards of by-catch in the WPO fall into the following six categories :

Undesirable species. This is probably the most common reason for the discard of by-catch, as the species in question has no commercial value. These fish may be discarded after landing, or, if they are identified before landing, they may be struck off (flicked off) the line by the crew before the gear reaches the vessel. The latter method of discarding has caused some observers concern when trying to monitor the entire catch composition of a set or a continuous hauling period of a set, as they are usually not in a good position to observe these occurrences. As mentioned already, oilfish, snake mackerel, lancet fish and barracudas are the most common in this category. The species of by-catch that are normally discarded are considered a nuisance, as they lower the effective fishing power, i.e. the number of hooks available. No strategy to counter the hooking of these undesirable species, other than the sea birds, was found in the literature, and it seems likely that the economics of investigations and subsequent implementation of such strategies far outweigh the simple discarding practices now performed.

Non-target tuna species of no commercial value to the longline vessel may be discarded if there is no interest in on-board consumption or the lack of freezer space means that they cannot be retained for consumption on return to port. The most common species that falls into this category is skipjack (*K. pelamis*). While specific references were not found, it is also possible that species that are target in other parts of the WPO (for example albacore (*T. alalunga*) are target species in areas of the WSP) may be discarded in areas where they are not kept for personal consumption or as part of the commercial catch.

No available space. The species of by-catch is one that is normally retained. However, when freezer space is limited due to success in taking target catch, these fish (for example mahi mahi and wahoo) are discarded. This is more likely to occur on the larger longline vessels making longer trips further away from offloading ports than on the vessels that operate out of SPC member-country ports. It is possible that these species may be retained during the early part of a trip and discarded later as the more valuable species are taken and freezer space becomes limited.

Damaged by-catch. The by-catch species is one that is normally retained. However, they have been mauled by killer whales, false killer whales or sharks and are not worth retaining (billfish would normally fall into this category). If the damage has been caused by a marine mammal, normally only the head remains.

Shark fins. For certain species of shark (e.g. blue shark), the dorsal, ventral, tail, and pectoral fins are removed and the remainder of the carcass discarded. This is a common practice throughout the WPO. Efforts have been made recently in Australia to try and reduce the incidence of this type of discard.

Difficult to land. There have been instances reported by observers where very large fish (e.g. shark) have been difficult to process or land, and discarding was necessary (Ward, pers.comm.).

Protected species. There are requirements in certain areas of the WPO that billfish that are still alive at the time of landing must be released. The fate of these species after enduring the stress of hooking is unknown, although sonic tagging experiments on billfish that have undergone similar stress levels (Holland et al., 1990) and observer-reported survival rates provide encouraging findings. Discarding marine reptiles would also fall into this category.

Discarding practices may vary from fleet to fleet and often from vessel to vessel within a fleet. The determinants for retaining or discarding fish sometimes come down to the captain/fishing master's personal preferences. Table 4.3 gives the best available indication of the variability of levels of by-catch discarded in areas of the WPO. The amount of by-catch taken has some relationship to the amount that is considered for discard, although it is apparent that by-catch alone can not be used as an indicator for subsequent levels of discard, as some fleets (and vessels) tend to retain by-catch more than others.

Very little information on by-catch discarded is available from the RTFD, as no species identification nor reason for discard is provided for on logsheets. This is compounded by the inconsistencies in by-catch discard reporting throughout the WPO.

An aspect of discards important in conservation issues is the number of species that are likely to be alive at the time of landing. Some data have been collected by observers and other sources indicating the survival rates of some by-catch species from longline vessels (Tables 4.8 and 4.9) and it would be expected that data of this type would be important in discussions and implementations of future management plans in this fishery. No information was found on the survival rates of by-catch tuna species, although with knowledge of the biology of these species, it is expected that high mortality would occur, especially for skipjack.

4.3.7 Overall levels of by-catch and discard

Figure 4.1 (bottom) describes the distribution of the discards of by-catch in the WPO. This distribution clearly does not correspond to that of effort for the area and perhaps merely indicates the operating locations of vessels which reliably report discards. Table 4.1 shows levels of by-catch by fleet and area for longline vessels fishing in the WPO, as reported in the RTFD. For comparison, Table 4.3 provides a breakdown of total catch into target and by-catch for data available in observer reports; it should be noted that due to the few data available from observer cruises at this stage, the approach taken in summarising this information is simply to give an indication of the possible non- and under-reporting of the RTFD data.

Several observations can be drawn from these data. In the RTFD, there is a distinct trend in the proportion of target to by-catch between the three areas of interest (target:by-catch; WTP—93.5%:6.5%; WSP—87%:13%; WTeP—49%:51%). This trend is also evident when considering the few observer data available, although it is apparent that the catch composition from individual trips can vary markedly. The variation in catch composition between fleets in the RTFD and the observer data is also noticeable (Tables 4.3, 4.6, 4.10). For example, the Japanese fleet appear to have a better ability to target than the other fleets in the WTP, although it is evident that the proportion of by-catch in the overall catch as reported in the logsheets is lower than that reported by observers, indicating some degree of under-reporting.

The most noteworthy comparison between levels of by-catch reported by logsheets (RTFD) and observer data is the degree of non- and under-reporting of the discards of by-catch species. Considering the information presented in Table 4.2, it is apparent that the problem is more one of non-reporting than under-reporting, as the proportion of discard (by weight) for days when there were discards reported on the logsheet is in the order of that reported by observers. The notable exception is that the level of by-catch discarded in the WTeP as reported by observers is far greater than the level determined from the logsheet data (RTFD).

As mentioned, comparisons of the billfish catch composition as reported by observers indicate some consistency in the logbook reporting (Figure 4.6), however, the same cannot be said for shark and other species. An attempt has been made to estimate the catch of billfish species by longline vessels operating in the WPO from logbook data (Table 4.12). The trend in the reduction of overall catch for most of the billfish species is difficult to explain, however, it is thought that differences in the level in effort between years and fleets, the changes in areas fished by some fleets and the recent introduction of regulations prohibiting the landing of certain species of billfish in areas of the WPO may have some bearing on the reporting for some of these species. If further investigations on billfish stocks are to be made, it is worth noting the points raised by Farman (1988), who warns about using solely catch-and-effort statistics in reviewing stock status of billfish without taking into consideration other forms of data, such as size-composition data.

4.4 TUNA DISCARDS

4.4.1 Reasons for target tuna discards

The following, in no particular order, are the reasons why target tuna species are discarded in the WPO.

Target species that are too small. In the WTP, there have been reports from observers that the standard practice on some vessels is to discard target species that are smaller than a size considered marketable (this has been reported by some observers to be 15 kilograms for some vessels, 95 cm for others). The minimum size limit appears to differ from vessel to vessel and fleet to fleet and seems to vary depending on whether the trip is long or short (freezer space being a constraint). There are also reports of certain preferences for target species below the minimum size for crew consumption. For example, Heberer (1993) mentions, in his review of one observer trip, that small bigeye were preferred for crew consumption/gifts over small yellowfin, which were mostly discarded. Towards the end of a successful trip, discarding of the target catch of a higher-than-standard minimum weight may also occur if freezer space is limited. No information was available to indicate whether foreign vessels that are based out of SPC member-country ports show a lesser tendency to discard in this manner than the distant-water/larger longline vessels.

Consideration of this practice should be particularly noted in analyses of length and weight data collected at ports of unloading.

Shark- or marine mammal-damaged target species. The incidence of shark- and killer whale-damaged tuna has been observed in the more warmer waters of the WPO and appears to be one of the most common reasons why target species of tuna are discarded. Of the 9 observer trips in the WTP where target tuna damage information is available, there are 6 trips where tuna damage accounts for approximately 50 per cent or more of the number of target tuna discarded. Hooked tuna become easy prey for shark and killer whale/false killer whale/pilot whale, although the latter are considered the more dangerous to the commercial catch as they will work along the line once they have encountered their first prey. There are numerous accounts of hauling a line littered with bodiless heads of tunas after attacks by these species of marine mammals. Shark damage, in contrast, is usually restricted to isolated attacks per shark. The undamaged sections of the tuna are sometimes retained for crew consumption (in some instances even the heads), with the remainder discarded. Sivasubramaniam (1964) estimated that an average of 11 per cent of tuna catches may be susceptible to shark damage in the Indian Ocean and that attacks were more frequent in warmer waters in areas where *C. longimanus* and *C. brachyurus* are abundant; this level appears to be in the order of that experienced during observer trips in the WTP. No reports of billfish-damaged tuna were found.

The high incidence of damaged target tuna in the WTP is evident in the proportion of the total catch that falls into this category as reported by observers (Table 4.3), although few data of this nature exist at this point and it is hoped more accurate levels will be known as a result of appropriate changes to logsheet and observer data collection procedures.

There are also observer reports of slight damage of target tuna by the cookie cutter shark (*Isistius brasiliensis*); in the instances where this was reported, it did not result in spoiling the fish. This is in contrast to a report by an observer (AFZ observer report: Staisch, 1993), where tuna with minor puncture marks, caused by the teeth of false killer whales ‘playing’ with their prey, were apparently discarded as it was thought the bacteria from the predator’s teeth had contaminated the flesh of the tuna and thus would soon make it unfit for human consumption.

Target of poor quality. On some vessels it is a requirement that the target tuna be landed alive and tuna may be discarded when they have been on the line too long and hence are not of the quality suitable enough for the sashimi market. Discard may also occur due to the failure of the freezing equipment on-board, as fish that have thawed to a level beyond the optimum range for storage, become unsuitable for sale.

No available space on-board. Discarding practices for target species may occur towards the end of a successful trip when freezer storage capacity has been reached.

4.4.2 Overall levels of tuna discards

Table 2.1 shows levels of tuna discard by fleet and area for longline vessels fishing in the WPO and Figure 4.1 shows the distribution of tuna discards, both sourced from data available in the RTFD. Table 4.3 shows the proportion of target tuna discarded from the total catch as reported by observers.

As tuna discards reported in the RTFD are inconsistent, Figure 4.1 (bottom) showing distribution of tuna discarded can only be seen to represent cases where reliable reporting has occurred. The small amount of information available from observers suggests that tuna discards should be more prevalent in the lower latitudes (i.e. WTP and WSP), as there is a higher frequency of marine mammal and shark damage to target species and small tuna are more abundant in these areas.

Comparative reporting of tuna discards is provided in Tables 4.2 and 4.3. It is interesting to note the comparison between the average proportion of tuna discards for days where it was reported in the RTFD (8.2% for WTP; 7.1% for WSP) and the proportion of total catch reported discarded by observers (average 11.3% for WTP prior to 1993, 0–4% for 1993; 0–5% for WSP). This is in stark contrast to the value of less than 0.2 per cent reported for the WTP and WSP for all RTFD data, where there was provision for entering tuna discard information.

No attempt was made to estimate WPO values of tuna discards from the observer data available, as it appears that reasons for discarding are highly variable between vessels and even for successive days for one vessel (for example, discards resulting from marine mammal damage). It is believed that, due to the irregular nature of tuna discards in the WPO longline fisheries, the coverage of observer-collected data would need to be substantial to accurately gauge overall levels. Some thought is needed on the design of future observer data collection if monitoring of tuna discards is considered of importance.

4.5 CONCLUSIONS

The main conclusions and recommendations to come out of this investigation of longline by-catch and discard practices are as follows :

(a) For the period 1978 to 1992, the RTFD contains a total WTP catch for the longline fishery of over 14,000,000 fish, of which 7 per cent was listed as by-catch, less than 0.1 per cent as discarded by-catch and less than 0.1 per cent as target tuna discards.

No attempt has been made in this report to estimate the amount of total by-catch and discard of by-catch and target tuna due to obvious problems of non- and under-reporting. (Some instances of non-reporting were due to the lack of provision to record necessary information on catch logsheets; while in time this has been largely remedied, there remain some suggestions that may improve the provision for this type of reporting.)

Instead, reference is made to available observer data to give some indication of the degree of non- and under-reporting that exists in the RTFD and, thus, the likely levels of by-catch and discards.

(b) The ability of the RTFD to give indications of by-catch and discard levels for the longline fishery in the WPO can only be applied to the reporting of billfish catch, for which descriptions of distribution, annual and seasonal catch rates by area, indications of size frequency by area and catch estimates have been provided.

Management measures for releasing live billfish in order to restrict the catch of billfish in Australia and New Zealand have been in force since the early 1980s. Data on survival rates of marlin taken by longline vessels suggest that releasing live billfish is a viable option for other countries where interaction between recreational and longline fisheries is perceived to be a potential problem, although there is still some concern in regard to the enforcement of this practice. The collection of finer detail on the survival rates of billfish taken by longline vessels (the AFZ observer programme has introduced a scale of life status on landing, rather than just dead/alive) and some more knowledge on the degree of interaction between recreational and longline fisheries would no doubt benefit decisions to be made in the future.

Misidentification of billfish species appears to occur in some WTP fleets. Some work is thus required to ensure that species identification is correctly recorded on logsheets.

(c) Reporting of shark in the WTP longline fisheries via logsheets is lacking. The few observer data available provide a better indication of species breakdown; however, coverage is currently poor. The catch of shark in the WPO constitutes a large proportion of the total catch, but it is not a part of the commercial catch and hence is rarely recorded on the logsheets.

According to observer accounts, blue shark (*P. glauca*) appears to be the most common shark species taken in the WPO longline fisheries, although oceanic white-tip and other *Carcharhinus* species are also prevalent in WTP catches.

Some efforts have been made in Australia to increase the reporting of shark by providing a shark logsheet supplement to foreign fishing vessels; this is an initiative that could be applied to other areas of the WPO, although it is thought that problems of misidentification of species and non- and under-reporting would have to be overcome. The observed high survival rates of shark are encouraging and, if there is believed to be a potential problem, management measures involving the (live) discard of these species (as currently occurs in Australia) may be appropriate elsewhere.

(d) Of the by-catch species of particular interest, the observer monitoring of marine reptile catch appears to be of some importance. Little information currently exists to give indications of the overall catch of turtles by longline vessels in the WPO. On the other hand, levels of seabird exploitation by temperate-water longline fleets have been well-documented and management measures already suggested. There ise no reported by-catch of seabirds in the WTP.

There are very few accounts of marine mammal capture in the WPO longline fisheries.

(e) Incidental catches of skipjack and other non-target tuna species occur throughout the WTP. Discarding of skipjack may occur and varies between area and fleet. However, the level of this by-catch is very minor compared, for example, with the exploitation of skipjack by surface gears.

Little is known about the exploitation levels of the other by-catch species (i.e. other than billfish, shark and non-target tuna species). It appears that the best mechanism for obtaining more definite species-specific data is observer programmes, although the reporting of catch of the more commercially-important species, such as wahoo and mahi mahi, could be improved by suitable changes in the format of catch logsheets.

(f) As in the purse-seine fishery, target tuna discards are an irregular and unpredictable feature of the longline fishery. The two major reasons for tuna discard are (i) small size and (ii) damage by shark or marine mammals. As target species have been discarded in both cases, it is important to know the degree of this occurrence in order to obtain true CPUE values. Damaged-tuna discards are more irregular and unpredictable than the discards of small tuna, which appear to be determined by fleet and could be extrapolated from adequate observer coverage. The damage by large predators is unavoidable and should not normally present the fishermen with any reason for not providing accurate data on logsheets; trials in FSM specifying that damaged tuna discards must be recorded on logsheets appear to have been successful.

Knowledge of tuna discard levels, particularly due to size, is important for analyses that deal with size-composition data collected at ports of unloading.

Suggestions for future monitoring of by-catch and discard levels in the WPO longline fisheries have been provided in Table 4.13. One of the major problems faced in observer monitoring of the WPO longline fisheries is ensuring that representative coverage for the large number of vessels operating is achieved, particularly for the distant-water longline fleets.

Table 4.1: By-catch and discards of longline fleets operating in the WPO, based on logbook data held in the RTFD, 1978–1992

Fleet	Area	Period	Total catch (number)	Target catch (%)	By-catch (%)	Tuna discards (%)	Other discards (%)
Australia	WSP	1986–1992	177,150	80.62	19.38	N/A	N/A
	WTeP	1985–1992	111,378	87.69	12.31	N/A	N/A
China	WTP	1989–1992	96,318	89.25	10.75	+	1.19
FSM	WTP	1991–1992	3,978	91.53	8.47	+	0.01
Fiji	WSP (Fiji)	1989–1992	69,563	76.01	23.99	0.00	0.00
French Polynesia	WTP	1992	2,556	84.94	15.06	0.00	4.93
	WSP	1992	5,216	75.13	24.87	0.00	3.07
Japan	WTP	1978–1992	12,544,311	94.26	5.74	{ 0.02}	{ 0.02}
	WSP	1978–1992	5,074,963	85.00	15.00	{ 0.09}	{ 0.02}
	WTeP	1979–1992	2,152,588	54.68	45.32	0.00	0.00
Korea	WTP	1978–1992	1,342,468	92.67	7.33	{ 0.40}	{ 0.14}
	WSP (& WTeP)	1980–1992	638,789	92.94	7.06	{ 3.06}	{ 1.27}
Marshall Is.	WTP	1992	196	97.45	2.55	0.00	4.96
New Caledonia	WSP (N.C.)	1983–1992	245,662	84.91	15.09	{ 0.22}	{ 6.40}
New Zealand	WSP	1990–1992	213	76.06	23.94	0.00	0.00
	WTeP	1980,89–92	21,609	18.38	81.62	0.00	0.00
Solomon Is.	WTP (& WSP)	1981–1985	58,406	88.83	11.17	0.00	0.00
Taiwan	WTP	1980–1992	330,096	74.22	25.77	0.09	0.01
	WSP (& WTeP)	1980–1992	727,659	96.92	2.89	0.06	0.40
Tonga	WSP	1982–1992	123,054	83.55	16.45	1.19	8.29
USA	WTP	1992	3,670	88.23	11.77	0.71	5.98
Totals	WTP	1978–1992	14,381,464	93.51	6.49	{ 0.05}	{ 0.03}
	WSP	1978–1992	7,062,018	86.95	13.05	{ 0.19}	{ 0.29}
	WTeP	1978–1992	2,285,575	49.09	50.91	–	–

Notes

1. % Target catch includes tuna catches retained and discarded; % By-catch includes by-catch retained and discarded; the sum of target and by-catch equals 100%.
2. All calculations are based on numbers, except where only weight of discards were available. Where this occurs, the % discards represent the proportion of discard (in kilograms) to the total weight of catch in kilograms and have been put in brackets {}.
3. % tuna and other discards are for logsheet forms where there has been provision to record this information only.

Table 4.2: Coverage of tuna and other species discards by the RTFD, 1978–1991

	Units	WTP	WSP
Fishing days with provision for recording discards	days	302,309	85,572
Trips with provision for recording discards	trips	16,701	3,457
Days with tuna discards recorded	days	584 .00	867.00
	%	0.19	1.01
Trips with tuna discard recorded	trips	89.00	62.00
	%	0.53	1.79
Days with other species discard recorded	days	817.00	2,441.00
	%	0.27	3.35
Trips with other species discard recorded	trips	119.00	90.00
	%	0.71	5.00
Average tuna discard, where recorded	no./day	2.41	7.78
	(sd)[2]	1.14	10.54
	kgs/day	118.15	151.57
	(sd)	387.46	461.94
Average other species discard, where recorded	no./day	50.52	13.22
	(sd)	60.47	19.55
	kgs/day	79.01	82.98
	(sd)	97.16	305.50
Tuna discard as % of total catch, where recorded	%no.	3.50	8.01
	(sd)	1.18	10.01
	%kgs	8.20	7.17
	(sd)	13.57	10.21
Other discard as % of total catch, where recorded	%no.	54.05	13.24
	(sd)	31.19	14.87
	%kgs	10.95	6.18
	(sd)	13.61	9.86

Notes

1. Some logsheet forms require discards to be recorded in numbers, others in kilograms; both have been calculated where relevant.
2. ‘sd’: Standard deviation.

Table 4.3. Summary of longline observer data available to SPC

Area	Year	Vessel nation	Hooks	Total catch (no.)	Target %	By-catch %	Target discard %	Tuna damaged %	By-catch disc. %	Source
WTP	1993	China	7200	77	62	38	0	N/A	18	Heberer, 1994a
	1993	China	4000	21	47	53	0	N/A	18	Heberer, 1994a
	1993	China	4760	58	37	63	N/A	N/A	N/A	Heberer, 1994a
	1994	China	9000	112	57	43	1	N/A	20	Heberer, 1994a
		China			51	49	+	N/A	19	(see note 5.)
	1992	FSM	5400	72	10	90	4	N/A	75	MMA Observer report
	1980	Japan	49690	2240	76	24	32	10	22	PNG report (Wright, 1980)
	1980	Japan	78000	2373+	84+	16-	N/A	N/A	11+	MMA Observer report (FSM)
	1985	Japan	60000	1125+	60-	40+	13	N/A	26+	MMA Observer report (FSM)
	1985	Japan	16770	379	76	24	4	4	20	Kiribati Fisheries report
	1985	Japan	58000	1142	73	27	6	N/A	23	MMA Observer report (FSM)
	1985	Japan	49500	823	78	22	34	27	18	MMA Observer report (FSM)
	1986	Japan	54000	1766	79	21	24	9	11+	MMA Observer report (FSM)
	1986	Japan	72500	1694	74	26	13	N/A	21	MMA Observer report (FSM)
	1986	Japan	56000	1960	88	12	14	7	3+	Kiribati Fisheries report
	1987	Japan	21600	341	73	17	9	4	5	MMA Observer report (see note 1.)
	1987	Japan	42000	1071	59	41	20	N/A	5	MMA Observer report (see note 1.)
	1987	Japan	70200	1213	96	4	4	N/A	3	MMA Observer report
	1988	Japan	70200	425	78	22	22	N/A	17	MMA Observer report
	1988	Japan	29900	802	89	11	8	N/A	9	MMA Observer report
	1988	Japan	40800	1048+	89-	11+	11	10	4	MMA Observer report
	1989	Japan	47500	1229+	96-	4+	17	11	4+	MMA Observer report
	1989	Japan	55200	1298	77	23	5	N/A	20	MMA Observer report
	1993	Japan	44460	900	79	21	3	N/A	20	Heberer, 1994a
	1993	Japan	29400	185	44	56	2	N/A	38	Heberer, 1994a
	1993	Japan	84000	2887	83	17	4	N/A	13	Heberer, 1994a
	1993	Japan	34776	320	70	30	1	N/A	17	Heberer, 1994a
	1993	Japan	35000	261	73	27	8	N/A	16	Heberer, 1994a
	1994	Japan	46550	586	55	45	2	N/A	26	Heberer, 1994a
	1994	Japan	45866	670	65	35	8	N/A	20	Heberer, 1994a
		Japan			73	27	4	N/A	21	(see note 5.)
	1992	Korea	18200	372	29	71	3	N/A	38	MMA Observer report
	1992	Korea	22500	343	43	57	6	N/A	46	MMA Observer report
	1992	Taiwan	9600	218	44	56	6	N/A	48	MMA Observer report
	1992	Taiwan	5600	314	16	84	4	N/A	45	MMA Observer report
	1992	Taiwan	4000	202	65	35	1	N/A	4	MMA Observer report (see note 1.)
	1993	Taiwan	5500	67	34	66	2	N/A	15	Heberer, 1994a
	1993	Taiwan	12100	122	58	42	1	N/A	22	Heberer, 1994a
	1993	Taiwan	8550	68	23	77	2	N/A	32	Heberer, 1994a
	1993	Taiwan	6000	57	42	58	1	N/A	6	Heberer, 1994a
	1993	Taiwan	5760	95	52	48	0	N/A	4	Heberer, 1994a
	1994	Taiwan	2880	18	23	77	0	N/A	11	Heberer, 1994a
		Taiwan			39	61	1	N/A	19	(see note 5.)
WSP	1986	Tonga	37488	1025	64	36	5+	+	+	SPC Observer report (Farman, 1986)
	1991	Japan	?	13239	65	35	2	N/A	20	AFMA observer data (pers. comm. Ward; see note 4.)
	1992	New Caledonia	5758	136	58	42	1	1	9	SPC Observer report (Palu, 1992)
	1993	French Polynesia	4200	80	41	59	0	0	37	SPC Observer report (Labelle, 1993)
	1994	Fiji	6146	242	38	62	1	1	12	SPC Observer report (Ward, 1994)
WTeP	1985	Japan	?	813	77	23	N/A	–	16	Australian observer report
	1985	Japan	?	98	83	17	N/A	–	11	Australian observer report
	1987	Japan	74784	1304	54	46	N/A	–	22	Ministrtry of Fisheries NZ (MAF) report (Michael et al., 1987; see note 4.)
	1988	Japan	116880	4128	28	72	N/A	N/A	55	MAF report (Michael et al., 1988, see note 4.)
	1989	Japan	39120	976	4	96	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1989	Japan	57510	1786	2	98	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1989	Japan	35634	968	5	95	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1989	Japan	56280	646	10	90	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1989	Japan	58008	893	10	90	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1990	Japan	47892	578	31	69	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1990	Japan	26350	557	6	94	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1990	Japan	42240	683	11	89	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1990	Japan	57330	1725	11	89	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1990	Japan	168680	5627	7	93	N/A	N/A	N/A	MAF (Burgess, pers. comm.)
	1990	Japan	104962	2306	2	98	N/A	N/A	N/A	MAF (Burgess, pers. comm.)

Notes

1. Data from these observer trips have been raised from 4 x 100 hook samples.
2. All percentages are calculated from the total catch in numbers. 'Tuna damaged' represents tuna damaged by sharks or killer whale and is included in 'Target discards'.
3. '+' and '–' indicate that accurate quantities were not available.
4. Data are from more than one observer trip. Data from Australia include some activity in WTeP. Data from New Zealand include some activity in WSP.
5. Fleet averages from MMA observer trips since January 1993.

Table 4.4: Species composition of by-catch taken by longline fleets in the WPO, based on logbook data held in the SPC Regional Tuna Fisheries Database, 1978–1992

Fleet	Area		Striped marlin	Blue marlin	Black marlin	Swordfish	Sailfish	Shark	Skipjack	Other
Australia	WSP	%	1.44	0.52	0.55	0.55	0.20	1.73	3.42	10.97
		no.	*2,548*	*927*	*982*	*967*	*359*	*3,062*	*6,052*	*19,428*
	WTeP	%	0.37	0.09	0.04	1.61	0.01	1.51	5.18	3.52
		no.	*407*	*98*	*45*	*1788*	*9*	*1,680*	*5,765*	*3,923*
China	WTP	%	0	0.22	0.68	2.40	2.46	2.20	0.01	2.78
		no.	*0*	*207*	*647*	*2,281*	*2,340*	*2,091*	*6*	*2,642*
FSM	WTP	%	0.03	4.88	0.00	1.11	0.35	0.40	0.00	1.17
		no.	*1*	*194*	*0*	*44*	*14*	*16*	*0*	*68*
Fiji	WSP (Fiji)	%	0.43	1.04	0.07	0.29	1.09	2.96	0.00	18.10
		no.	*301*	*724*	*48*	*205*	*755*	*2060*	*2*	*12,594*
Japan	WTP	%	0.11	2.77	0.17	0.46	0.21	0.54	0.01	1.47
		no.	*14,381*	*347,269*	*21,054*	*57,522*	*26,280*	*67,820*	*1,869*	*184,369*
	WSP	%	2.42	1.09	0.53	4.40	0.57	2.45	1.85	1.68
		no.	*123,051*	*55,123*	*27,051*	*223,483*	*28,941*	*124,467*	*93,644*	*85,371*
	WTeP	%	0.38	0.01	0.01	3.02	0.00	30.90	1.07	9.92
		no.	*8,275*	*290*	*168*	*65,061*	*101*	*665,047*	*23,070*	*213,571*
Korea	WTP	%	0.54	2.11	0.46	0.89	0.08	0.60	0.12	2.52
		no.	*7,302*	*28,379*	*6,174*	*11,950*	*1,122*	*8,018*	*1,630*	*33,838*
	WSP/WTeP	%	0.50	0.85	0.26	0.35	0.04	2.92	0.11	2.03
		no.	*3,217*	*5,459*	*1,661*	*2,219*	*266*	*18,623*	*699*	*12,968*
Marshall Is.	WTP	%	0.00	2.55	0.00	0.00	0.00	0.00	0.00	0.00
		no.	*0*	*5*	*0*	*0*	*0*	*0*	*0*	*0*
New Caledonia	WSP (N.C.)	%	3.24	0.52	1.77	0.49	0.79	1.62	0.00	6.66
		no.	*7,962*	*1,277*	*4,340*	*1,212*	*1,945*	*3,968*	*0*	*16,370*
New Zealand	WSP	%	0.00	0	0	0.00	0	1.41	0	22.54
		no.	*0*	*0*	*0*	*0*	*0*	*3*	*0*	*48*
	WTeP	%	0.00	0	0	0.69	0	62.86	0	18.07
		no.	*0*	*0*	*0*	*149*	*0*	*13,583*	*0*	*3,905*
Solomon Is.	WTP/WSP	%	0.13	2.62	1.55	0.22	6.12	0.00	0.00	0.54
		no.	*74*	*1,529*	*906*	*126*	*3,576*	*0*	*0*	*315*
Taiwan	WTP	%	0.36	1.44	6.19	2.50	0.72	13.04	0.04	1.47
		no.	*1,202*	*4,751*	*20,436*	*8,265*	*2,388*	*43,054*	*128*	*4,847*
	WSP/WTeP	%	0.30	0.41	0.13	0.19	0.11	0.38	0.59	0.79
		no.	*2,188*	*2,978*	*933*	*1,349*	*805*	*2,751*	*4,280*	*5,732*
Tonga	WSP	%	0.22	0.20	1.86	0.42	0.35	1.58	1.60	10.22
		no.	*278*	*252*	*2,310*	*517*	*434*	*1,957*	*1,985*	*12,688*
USA	WTP	%	0.19	1.06	0.30	1.77	0.25	7.44	0.00	0.65
		no.	*7*	*39*	*11*	*69*	*9*	*273*	*0*	*24*
Totals	WTP	%	0.16	2.66	0.34	0.56	0.25	0.84	0.03	1.57
		no.	*22,967*	*382,373*	*49,228*	*80,257*	*35,729*	*121,272*	*3,633*	*226,103*
	WSP	%	1.97	0.94	0.53	3.26	0.50	2.19	1.51	2.30
		no.	*139,146*	*66,640*	*37,112*	*229,889*	*35,307*	*154,749*	*106,662*	*162,301*
	WTeP	%	0.38	0.02	0.01	2.93	0.00	29.77	1.26	9.69
		no.	*8,682*	*388*	*231*	*66,998*	*110*	*680,310*	*28,835*	*221,399*

Notes

1. Percentages are the proportion of numbers to the total catch (described in Table 4.1).

Table 4.5: Species composition and nominal catch rates of billfish and shark taken by longline fleets operating in FSM waters since January 1993, based on MMA observer data

Fleet		Striped marlin	Blue marlin	Black marlin	Swordfish	Sailfish	Marlin (unspec.)	Shark
China	%	2.10	2.48	1.71	5.91	0.57	3.81	20.00
	no.	*11*	*13*	*9*	*31*	*3*	*20*	*105*
	CPUE	0.44	0.52	0.36	1.24	0.12	0.80	4.21
Japan	%	0.15	1.85	0.30	0.73	0.39	0.06	6.43
	no.	*12*	*147*	*24*	*58*	*31*	*5*	*510*
	CPUE	0.04	0.46	0.08	0.18	0.10	0.02	1.59
Taiwan	%	2.28	3.73	1.37	6.28	1.18	1.73	37.80
	no.	*25*	*41*	*15*	*69*	*13*	*19*	*415*
	CPUE	0.61	1.01	0.37	1.69	0.32	0.47	10.17

Note

1. Derived from Heberer, 1994a. CPUE – number per 1,000 hooks.

Table 4.6: Average weight and CPUE range data for by-catch species from longline vessels, based on data held in the RTFD, 1978–1992

	Units	WTP	WSP	WTeP
Striped marlin				
Average weight (weighted)	kg	39.0	74.8	77.4
Maximum CPUE - month/5° square[2]	CPUE	0.23	1.93	0.36
Black marlin				
Average weight (weighted)	kg	51.5	86.2	100.2
Maximum CPUE - month/5° square	CPUE	0.67	3.11	0.10
Blue marlin				
Average weight (weighted)	kg	50.7	72.6	120.3
Maximum CPUE - month/5° square	CPUE	1.26	1.00	0.21
Swordfish				
Average weight (weighted)	kg	43.1	66.4	60.7
Maximum CPUE - month/5° square	CPUE	0.66	2.60	1.52
Sailfish				
Average weight (weighted)	kg	25.2	21.7	15.2
Maximum CPUE - month/5° square	CPUE	1.46	0.74	0.04
Shark				
Average weight (weighted)	kg	25.4	22.7	8.6
Maximum CPUE - month/5° square	CPUE	4.43	3.00	15.65
Skipjack				
Average weight (weighted)	kg	6.6	6.8	6.6
Maximum CPUE - month/5° square	CPUE	0.66	7.41	1.91
Butterfly tuna				
Average weight (weighted)	kg	–	35.3	32.9
Maximum CPUE - month/5° square	CPUE	–	0.22	0.74
Mahi mahi				
Average weight (weighted)	kg	9.8	4	–
Maximum CPUE - month/5° square	CPUE	0.44	0.08	–
Moonfish				
Average weight (weighted)	kg	9.7	12.2	19.7
Maximum CPUE - month/5° square	CPUE	0.08	0.20	0.44
Oilfish				
Average weight (weighted)	kg	–	8.4	25.8
Maximum CPUE - month/5° square	CPUE	–	0.48	0.73
Sunfish				
Average weight (weighted)	kg	–	16	25.1
Maximum CPUE - month/5° square	CPUE	–	0.49	0.64
Wahoo				
Average weight (weighted)	kg	11.6	9.6	–
Maximum CPUE - month/5° square	CPUE	0.28	0.30	–

Notes

1. CPUE is numbers of fish per hundred hooks.
2. The highest CPUE value for month/5° stratification in this area.

Table 4.7: Target and by-catch species taken by longline vessels fishing in the WPO

Species	WTP	WSP	WTeP	Retained[1]
Sharks and rays				
Black-tip reef shark (*Carcharhinus melanopterus*)	–	–	–	–
Black-tip shark (*Carcharhinus limbatus*)	R	–	–	–
Blue shark (*Prionace glauca*)	A	A	A	N
Crocodile shark (*Pseudocarcharais kamoharai*)	C	S	–	N
Dogfish (*Symnodon* sp.; Squalidae)	–	R	R	N
Great white shark (*Carcharodon carcharias*)	–	R	R	Y
Grey reef shark (*Carcharhinus amblyrhynchos*)	R	C	–	–
Hammerhead shark (*Sphyrinus* sp.)	S	S	–	–
Mako shark (*Isurus oxyrhinchus*)	S	C	C	Y
Manta rays (Mobulidae)	–	R	–	N
Oceanic white tip (*Carcharinus longimanus*)	C	C	–	Y
Porbeagle shark (*Lamna nasus*)	–	C	C	N
School shark (*Galeorhinus galeus*)	–	S	S	Y
Silky shark (*Carcharhinus falciformis*)	A	S	–	Y
Silvertip shark (*Carcharinus albimarginatus*)	C	R	–	Y
Smooth lanternshark (*Etmopterus pusillus*)	–	R	–	N
Stingray (*Dasyatis* sp.)	A	S	–	N
Thresher shark (*Alopias* sp)	C	C	C	Y
Tiger shark (*Galeocerdo cuvier*)	R	R	–	N
White-tip reef shark (*Triaenodon obesus*)	–	–	–	–
Scombrids				
Albacore tuna (*Thunnus alalunga*)	S	T	T	Y
Bigeye tuna (*Thunnus obesus*)	T	T	S	Y
Butterfly tuna (*Gasterochisma melampus*)	–	S	C	Y
Frigate tuna (*Auxis thazard*)	–	R	–	N
Kawakawa (*Euthynnus affinis*)	S	A	–	N
Longtail tuna (*Thunnus tonggol*)	–	S	R	Y
(Northern) bluefin tuna (*Thunnus thynnus*)	R	R	S	Y
Skipjack tuna (*Katsuwonus pelamis*)	A	C	S	N
Slender tuna (*Allothunnus fallai*)	–	R	S	N
Southern bluefin tuna (*Thunnus maccoyii*)	–	S	T	Y
Wahoo (*Acanthocybium solandri*)	C	A	–	Y
Yellowfin tuna (*Thunnus albacares*)	T	T	S	Y
Billfish				
Black marlin (*Makaira indica*)	A	A	S	Y[3]
Blue marlin (*Makaira mazara*)	A	A	S	Y[3]
Broadbill swordfish (*Xiphias gladius*)	A	A	S	Y
Sailfish (*Istiophorus platypterus*)	A	A	S	Y
Shortbill spearfish (*Tetrapturus angustirostris*)	A	A	S	Y
Striped marlin (*Tetrapturus audax*)	A	T	S	Y[3]
Other fish				
Barracuda (*Agrioposphyraena barracuda*)	S	S	R	N
Barracouta (*Thyrsites atun*)	–	R	R	N
Bass, Hapuka (*Polyprion* sp.)	–	–	R	Y
Blue eyes (Pseudomugilidae)	–	R	R	–
Bluenose (*Hyperoglyphe antarctica*)	–	–	R	N
Bramids, Ray's bream, pomfrets (Bramidae)	A	A	C	N
Dealfish (*Trachipterus* sp.)	R	R	R	N
Gemfish (*Rexea solandri*)	–	R	R	Y
Globefish, porcupine fish (Diodontidae)	R	R	R	N
Hake (*Merluccius australis*)	–	–	S	Y
Hoki, blue grenadier (*Macruronus novaezelandiae*)	–	S	S	Y
Kingfish (*Seriola* sp.)	S	S	R	Y
Lancetfish (*Alepisaurus* sp.)	C	C	S	N
Lantern fish (Myctophidae)	–	–	R	N
Mahimahi (*Coryphaena hippurus*)	C	C	R	Y
Oarfish (*Regalecus glesne*)	–	R	R	N
Oilfish (*Ruvettus pretiosus*)	A	A	S	N
Ragfish (*Icichthys australis*)	–	–	R	N
Rainbow runner (*Elagatis bipinnulata*)	S	S	–	Y

Species	WTP	WSP	WTeP	Retained[1]
Remora (*Remora* sp.)	R	R	R	N
Rudderfish (*Centrolophus niger*)	–	R	R	N
Sea perches, gropers (Serranidae)	–	S	–	N
Snake mackerel, Escolar (*Lepidocybium flavobrunneum*)	A	A	S	N
Sunfish (*Mola* sp.)	R	C	S	N
Moonfish / opah / mambo (*Lampris* sp.)	A	A	S	Y
Warehou (*Seriolella brama*)	–	R	R	Y
Marine reptiles				
Green turtle (*Chelonia mydas*)	S	–	–	N
Hawksbill turtle (*Eretmochelys imbricata*)	S	–	–	N
Leatherback (*Dermochelys coriacea*)	–	–	–	N
Olive ridley (*Lepidochelys olivacea*)	S	–	–	N
Turtles (unidentified)	S	S	R	N
Marine mammals				
Common dolphin (*Dephinus delphis*)	–	R	–	N
False killer whale (*Pseudorca crassidens*)	–	?	–	N
Killer whale (*Orcinus orca*)	–	–	R	N
Marine mammal (unidentified)	R	R	–	N
Pilot whale (*Globicephala* spp.)	–	–	–	N
Seal (Pinnipedia)	–	–	S	?
Birds				
Albatross (*Diomedea* sp.)	–	–	C	N
Petrels (*Procellaria* sp.)	–	–	C	N
Other seabirds	–	S	S	N

Notes

1. 'Y' - normally retained; 'N' - not retained, i.e. normally discarded/released. This does not take into account the differences in discarding practices that may exist between fleets or even vessels of the same fleet. The species retained may be sold commercially, kept for crew consumption or given away on return to port. For shark species, the trunks are often discarded after the fins have been removed. Most observations of turtles caught by longline vessels indicate that they were released alive (FSM observer reports).

2. Moonfish (*Lampris guttatus*) is sometimes referred to as **MANDAI**, which is the Japanese Okinawan common name for this species. Oilfish (*Ruvettus pretiosus*) is sometimes referred to as **BARAMUTSU**, which is the Japanese common name for this species (Izumi pers. comm.).

3. There are restrictions on the landing of certain billfish species in some areas of Australian and New Zealand waters.

LEGEND

A: Usually abundant in the longline catch for this area; at least 1 per set on average.
C: Commonly taken; usually it would be expected that at least 1 of this species would be taken every 10 sets.
R: Rarely taken; there may be only one taken per year for that area or, for some species, only one occurrence ever.
S: Seldom caught; taken on few occasions but not considered common or rare in the catch; typically it would be expected that at least 1 of this species would be taken every few months, or may only be taken at certain times of the year for that area (i.e. seasonal), or only in specific parts of that area.
T: Usually a target species for fleets in this area; if not the target for all vessels, it is usually abundant in the longline catch; at least 1 per set on average.
–: No evidence of longline catch of this species found.

SOURCES

SPC RTFD records; Observer data made available to SPC by FSM (MMA Observer reports; Heberer 1993; Heberer 1994a), Kiribati, PNG (Wright 1980), Australia (AFMA observer programme: Ward pers. com.; Stevens pers. comm.), New Zealand (MAF observer programme: Michael et al. 1987 and 1989; Burgess pers. comm.); SPC observer reports (Farman 1986; Palu 1992; Labelle 1993); various anectodal information from observers/others and personal observations by authors at unloading sites.

Table 4.8: Survival rates of billfish species taken by longline vessels

Species	Number of observations (N) (AFZ)	% alive at time of landing (AFZ)	% alive at time of landing (NMFS)	% alive at time of landing (Japan)
Black marlin (*Makaira indica*)	**13**	30.8	25.7	54.1
Blue marlin (*Makaira mazara*)	**30**	40.0	29.1	55.6
Broadbill swordfish (*Xiphias gladius*)	**139**	59.0	40.0	54.4
Sailfish (*Istiophorus platypterus*)	**42**	33.3	25.0[1]	42.2[1]
Shortbill spearfish (*Tetrapturus angustirostris*)	**34**	38.2	25.0[1]	42.2[1]
Striped marlin (*Tetrapturus audax*)	**67**	49.3	54.5	76.7

Notes

1. Only percentage for sailfish and short-billed spearfish combined was available.
2. Sources of data are (i) AFZ observer data for the years 1979–1990 and the area of the AFZ north of 40°S and east of 140°E (derived from AFMA observer data : Ward, pers. comm.); (ii) Mortality rates of billfish determined by the NMFS Honolulu laboratory (WPRFMC 1986); (iii) Far Seas Fisheries Research Laboratory Data (Japan).

Table 4.9: Survival rates of shark species caught by Japanese longliners in Australian waters, based on observer data for the years 1979–1990 and the area of the Australian fishing zone north of 40°S and east of 140°E

Species of shark	Number of observations (N)	% alive at time of landing	Status[1]
Blue shark (*Prionace glauca*)	**2,611**	90	F
Bronze whaler (*Carcharinus brachyurus*)	**3**	100	R
Crocodile shark (*Pseudocarcharais kamoharai*)	**7**	100	D
Dogfish (*Scymnodon* sp.; Squalidae)	**33**	94	D
Great white shark (*Carcharodon carcharias*)	**1**	100	R
Hammerhead shark (*Sphyrinus* sp.)	**2**	50	R
Mako shark (*Isurus oxyrhinchus*)	**237**	68	R
Oceanic white tip (*Carcharinus longimanus*)	**7**	86	R
Porbeagle shark (*Lamna nasus*)	**11**	64	F
School shark (*Galeorhinus galeus*)	**17**	100	R
Silky shark (*Carcharhinus falciformis*)	**28**	96	R
Silvertip shark (*Carcharinus albimarginatus*)	**1**	100	R
Smooth lanternshark (*Etmopterus pusillus*)	**1**	100	D
Thresher shark (*Alopias* sp.)	**22**	91	R
Tiger shark (*Galeocerdo cuvier*)	**2**	100	F

Notes

1. Observed landed status. 'R': retained for commercial sale or crew consumption; 'F': fins only retained; 'D': entire shark discarded.
2. Derived from AFMA observer data : Ward pers. comm.

Table 4.10: Comparisons of target and shark catch rates from observed longline vessel trips in the WTP, 1988–1993

Vessel nation	Trip	YFT CPUE	BET CPUE	SHK CPUE	Comments
China	(1)	0.3	0.8	0.2	Breakdown of shark species not available
	(2)	0.1	0.5	0.2	Breakdown of shark species not available
	(3)	0.7	0.5	0.4	Breakdown of shark species not available
	(4)	0.9	0.3	1.0	Breakdown of shark species not available
FSM	(1)	0.0	0.1	0.5	Breakdown of shark species not available
Japan	(1)	0.4	0.1	0.1	Breakdown of shark species not available
	(2)	2.0	0.3	0.2	Breakdown of shark species not available
	(3)	0.6	0.8	0.3	Breakdown of shark species not available
	(4)	1.1	0.9	0.1	Breakdown of shark species not available
	(5)	0.3	0.3	0.2	Breakdown of shark species not available
	(6)	3.0	0.5	0.3	Breakdown of shark species not available
	(7)	0.5	0.5	0.1	Breakdown of shark species not available
	(8)	0.1	0.6	0.1	Breakdown of shark species not available
	(9)	0.8	0.4	0.2	Breakdown of shark species not available
	(10)	0.9	0.6	0.1	Breakdown of shark species not available
Korea	(1)	0.1	0.5	0.8	Blue shark (*P. glauca*) – 0.4 Thresher (*Alopias* sp.) – 0.2 Silky shark (*C. falciformis*) – 0.1
	(2)	0.3	0.3	0.4	Breakdown of shark species not available
Taiwan	(1)	2.1	1.2	1.1	Breakdown of shark species not available
	(2)	0.8	0.2	3.0	Blue shark (*P. glauca*) – 2.1 Silky shark (*C. falciformis*) – 0.7 Oceanic white-tip (*C. longimanus*) – 0.2
	(3)	0.6	0.4	0.4	Breakdown of shark species not available
	(4)	0.3	0.1	1.8	Breakdown of shark species not available
	(5)	0.5	0.7	1.9	Breakdown of shark species not available
	(6)	0.7	0.3	0.2	Breakdown of shark species not available
	(7)	0.1	0.7	1.8	Breakdown of shark species not available
	(8)	0.4	0.6	0.7	Breakdown of shark species not available
	(9)	0.4	1.3	0.9	Breakdown of shark species not available
	(10)	0.4	0.2	1.1	Breakdown of shark species not available

Notes

1. Derived from MMA observer data : Heberer 1994a.
2. YFT: Yellowfin; BET: Bigeye; SHK: Shark.
3. Units : CPUE - number of fish per 100 hooks.

Table 4.11: Common incidental species (number of fish) caught by longline vessels in the WPO, stratified by quarter and area, based on logbook data held in the SPC RTFD, 1978–1992

	WTP					WSP					WTeP				
Species	**1**	**2**	**3**	**4**	**Total**	**1**	**2**	**3**	**4**	**Total**	**1**	**2**	**3**	**4**	**Total**
Butterfly tuna	–	–	–	–	–	–	9	224	–	233	442	4,889	491	–	5,822
Hoki	–	–	–	–	–	–	–	–	–	–	14	87	–	–	101
Mahi mahi	1,289	542	64	7	1,902	1	–	20	96	117	–	–	–	–	–
Moonfish (Opah)	121	94	273	102	590	763	618	3,188	251	4,820	360	2,619	1,317	–	4,296
Oilfish	–	–	–	–	–	9	485	2,473	–	2,967	62	5,050	6,240	–	11,352
Rainbow runner	4	19	25	5	53	9	1	–	9	19	–	–	–	–	–
Slender tuna	–	–	–	–	–	2	1	–	–	3	–	330	27	–	357
Shortbill spearfish	11	6	33	–	50	32	8	20	6	66	11	–	–	–	11
Sunfish	–	–	–	–	–	221	536	1,015	–	1,772	133	3,420	1,822	–	5,375
Wahoo	1,459	842	642	432	3,375	93	54	5	136	288	–	–	–	–	–
Not specified or mixed species	12,387	10,232	17,078	9,752	49,449	3,817	11,135	18,072	3,811	36,835	5,640	102,548	57,393	–	165,581
Billfish not specified	313	142	607	670	1,732	485	577	2	68	1,132	–	–	–	–	–
Tuna not specified	305	382	923	735	2,345	–	75	44	130	249	–	9	–	–	9

Notes

1. On some logsheet forms, there is no provision for entering species name for 'other' catch; these have been included in 'Not specified or mixed species'.

2. Due to the data storage requirements of the RTFD, there is no provision for storing individual 'other' by-catch species data where more than one occur for the day; in these cases (less than 0.1% of the SPC processed logsheet forms cater for this type of recording), the species catch are added and assigned a species code: 'Not specified or mixed species'. Data provided by NZ (MAF) and Australian data (AFMA) allow for a breakdown of 'other' species catch in the datasets provided to SPC.

3. Moonfish (*Lampris guttatus*) is sometimes referred to on logsheets as **MANDAI**, which is the Japanese Okinawan common name for this species. Oilfish (*Ruvettus pretiosus*) is sometimes referred to as **BARAMUTSU**, which is the Japanese common name for this species (Izumi, pers. comm.).

Table 4.12: Estimates of billfish catch from longline vessels fishing in the WPO, 1989–1992

	Number				Metric tonnes			
Species	**1989**	**1990**	**1991**	**1992**	**1989**	**1990**	**1991**	**1992**
Black marlin	29,068	23,650	22,988	20,147	1,300	1,265	1,132	1,131
Blue marlin	84,721	87,563	72,347	85,961	4,685	4,749	3,776	4,297
Sailfish	10,314	19,377	4,573	3,445	235	535	146	103
Striped marlin	39,923	36,078	24,075	30,533	2,337	2,216	1,298	1,511
Swordfish	57,190	82,235	52,568	59,270	3,043	4,364	2,712	3,213

Notes

1. Estimates have been determined in the following manner :

   (i) Japanese billfish catch (in number) was made available to SPC from the Japanese Fisheries Agency (JFA). Catches in metric tonnes have been determined using the average weight for each species in each area (i.e. WTP, WSP and WTeP); the average weights were calculated from the RTFD (i.e. weighted average of daily logsheet data).

   (ii) Taiwanese (vessels < 100 GRT and >=100 GRT) and Korean billfish catches were raised, by area, from the RTFD catches for these fleets by applying the proportion of RTFD catch to total catch estimates for yellowfin and bigeye catch (provided in Lawson, 1993).

   (iii) The billfish catch reported in the RTFD for the remaining fleets was assumed to have 100% coverage.

Table 4.13 Suggestions for future monitoring of by-catch and discard levels in the WPO longline fisheries

Category	Current knowledge / coverage	Mechanisms for improving knowledge / necessary action	Required coverage (in order of importance)	Priority[1]
Factors affecting catch	Very little information is available to adequately determine the effects of various fishing techniques/strategies/practices on levels of by-catch. Logsheet data provide some indications e.g. depth of fishing using the relative measure of hooks per basket.	1. Determine, through observer work, what factors affect levels of by-catch. 2. Improve observer data collection to adequately monitor these factors.	Observer coverage (dependent on factor)	**Low**
Levels of by-catch by species				
• General	Logsheet data provide good indications of billfish catch, however, the catch of other species, particularly shark, is not representative. Observer data provide species identification. However, the coverage is currently insufficient for frequency of by-catch.	1. Improve observer coverage, with biological sampling where possible.	Observer coverage 1. (area) 2. (fleet) 3. (month)	**High**
• Billfish	Good indication of species breakdown and catch from logsheet data; however, problems of misidentification. Observer data currently used to verify levels of billfish catch from logsheet reporting.	1. Ensure the problem of billfish misidentification on logsheets is addressed. 2. Improve/maintain observer coverage to verify logsheet reporting. 3. Biological sampling.	Observer coverage 1. by area 2. by fleet	**Low–Medium**
• Seabirds	Based on observer data, there appears to be no seabird by-catch in the WTP. However, observers from the more temperate waters off Australia and New Zealand report high catch rates.	(This has been addressed by monitoring programmes in Australia and New Zealand.)	Observer coverage 1. by area	**Low (WTP) High (WteP)**
• Marine reptiles	No indication from logsheet data. Observer data provide species identification, size data and frequency of catch. However, coverage is currently lacking.	1. Improve observer coverage 2. Guidelines suggested in the marine turtle workshop (Balaz & Pooley 1993). 3. Tagging ?	Observer coverage 1. by area 2. by fleet	**High**
• Marine mammals	Based on observer data, there are very few marine mammal captures in the WPO longline fisheries.	1. Maintain observer coverage	Observer coverage 1. by area	**Low**
• Shark species	Logsheet data provide very poor indications. Observer data provide species identification and frequency of catch. However, coverage is currently poor.	1. Improve observer coverage with species identification. 2. Biological sampling where appropriate.	Observer coverage 1. by area 2. by factor (i.e. depth, fleet practices, etc.)	**Medium–High**
• Non-target tuna species	Logsheet data provide reasonable indications for the incidental catches of albacore and bluefin tuna in the WTP. However, skipjack catch is generally not reported. Observer data provide better indications of skipjack catch. However, coverage is currently poor.	1. Improve observer coverage. 2. Biological sampling where appropriate.	Observer coverage 1. by area 2. by factor (i.e. depth, fleet practices, etc.)	**Low**
• Other species	Logsheet data provide poor indications. Observer data provide species identification and frequency of catch. However, coverage is currently poor.	1. Improve observer coverage with species identification. 2. Introduce columns for mahi mahi and wahoo on catch logsheets 3. Biological sampling where appropriate.	Observer coverage 1. by area 2. by factor (i.e. depth, fleet practices, etc.)	**Low**
Reasons and levels of discard of by-catch species	Reasons are well documented in observer reports. Poor indications of frequency provided from logsheet data; better indications from observer data. However, currently lacking in coverage.	1. Improve observer coverage.	Observer coverage 1. (dependent on reason) 2. by fleet 3. by area 4. by factor	**Low**

Category	Current knowledge / coverage	Mechanisms for improving knowledge / necessary action	Required coverage (in order of importance)	Priority[1]
Spatio-temporal variations	Logsheet data provide a good indication for billfish species. However, poor indications for other by-catch as species identification is generally lacking. Observer data coverage not adequate to determine at species level.	1. Improve observer coverage. 2. Verification of billfish catch. 3. Relevant biological sampling	Observer coverage 1. by month and area 2. by factor	**Low–Medium**
Levels of tuna discard	Some levels known to be highly irregular (e.g. shark, marine mammal damage) and thus difficult to obtain overall estimates. Poor indication from logsheets.	1. Improve observer coverage, with biological sampling where possible, 2. Introduce reporting of damaged tuna discard (by target species) on logsheets.	Observer coverage 1. by fleet 2. by area 3. by month	**Medium**
Reasons for tuna discard	Reasons are well documented in observer reports. Poor indications of frequency provided from logsheet data; better indications from observer data. However, currently lacking in coverage.	1. Improve observer coverage	Observer coverage 1. (dependent on reason) 2. by fleet	**Low**
Spatio-temporal variations of tuna discard	Poor indications from logsheet data. Observer data coverage not adequate.	1. Improve observer coverage	Observer coverage 1. by month and area 2. by factor	**Low–Medium**

Note

This refers to the priority of data collection and subsequent analyses between the above-mentioned categories only.

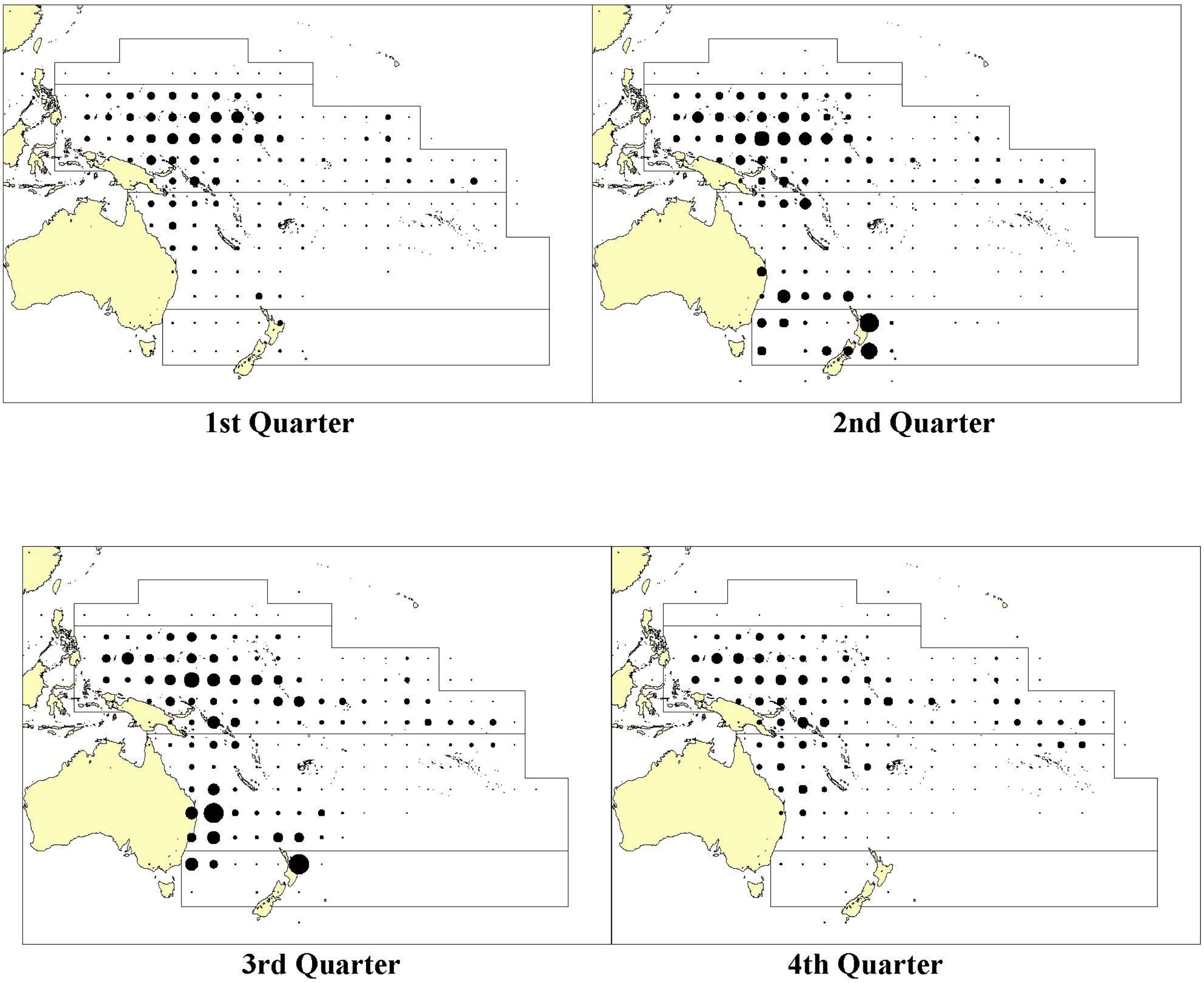
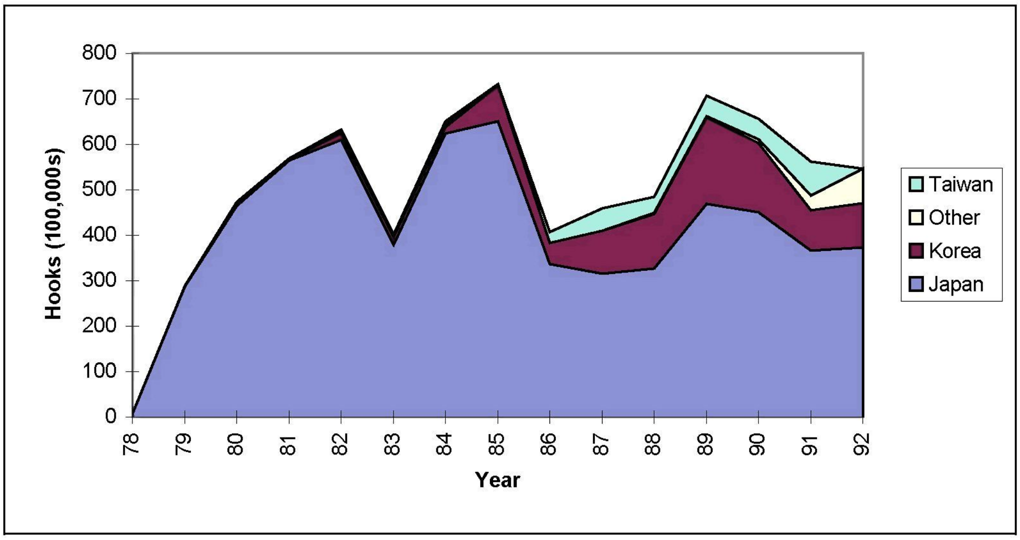
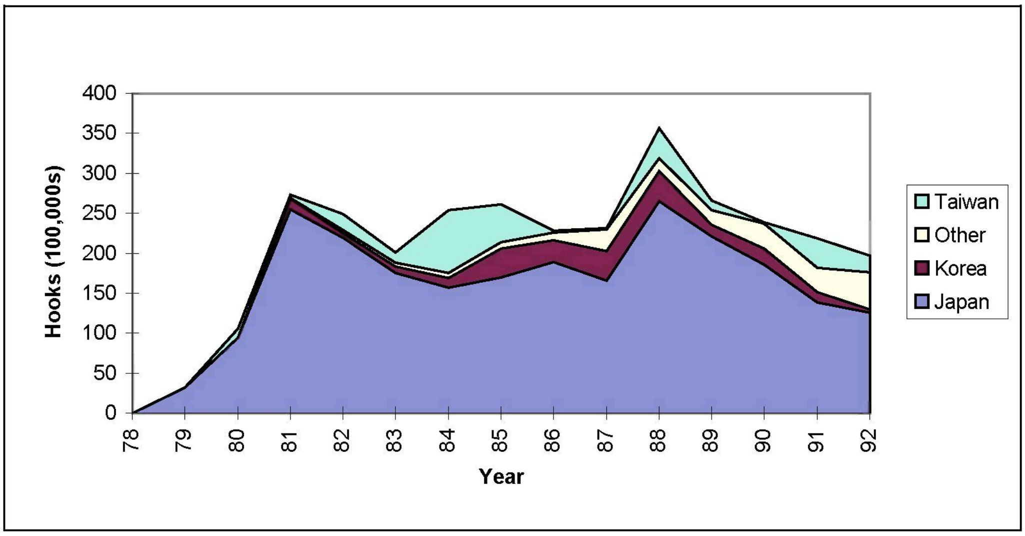


Figure 4.2: Distribution of seasonal longline effort for the WPO, based on data held in the RTFD, 1978–1992





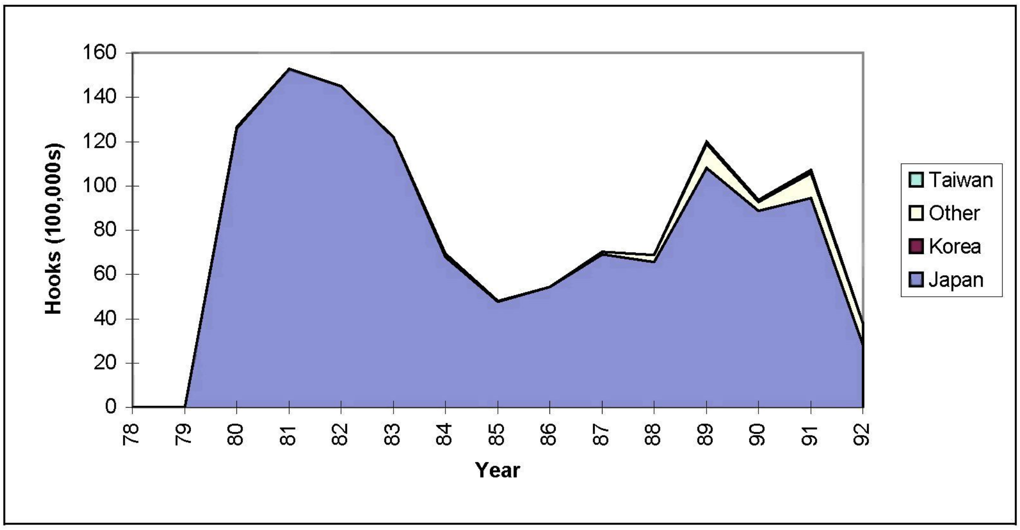


Figure 4.3: Annual longline effort by fleet for the WTP (top), WSP (middle) and WTeP (bottom), based on data held in the RTFD, 1979–1992

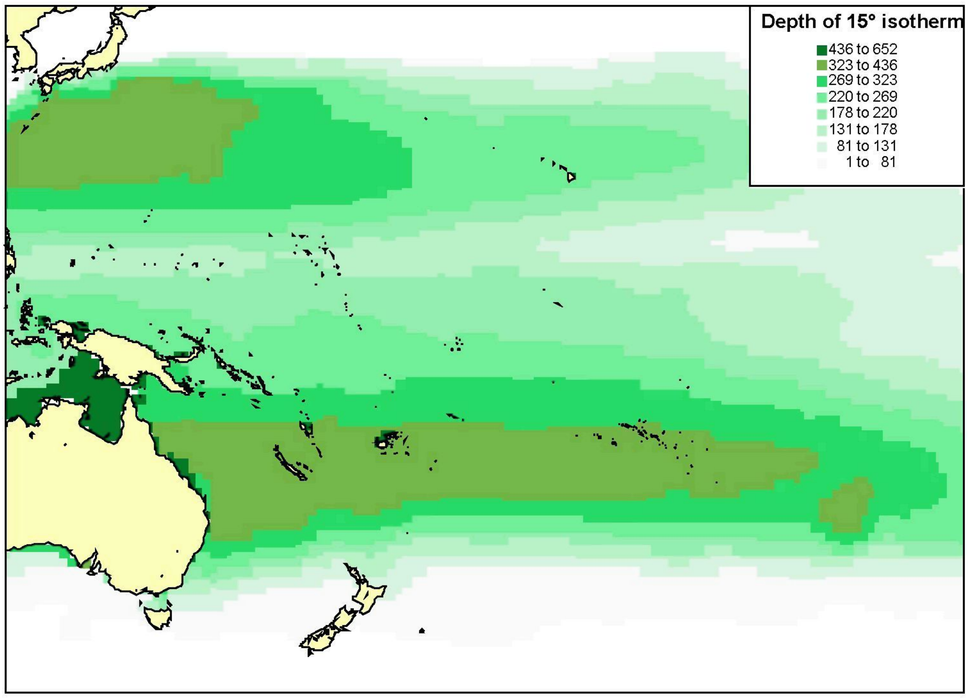
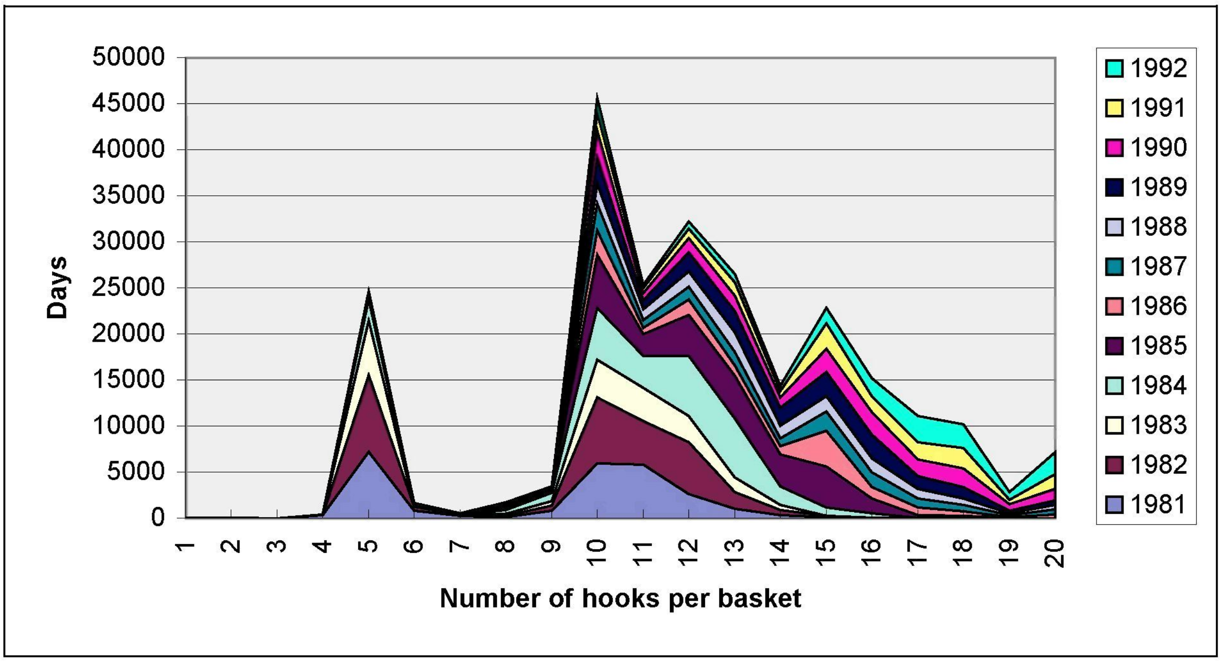


Figure 4.4: Mean depth (metres) of 15° isotherm throughout the Pacific Ocean, 1935–1994.

Source : Levitus & Boyer (1994)



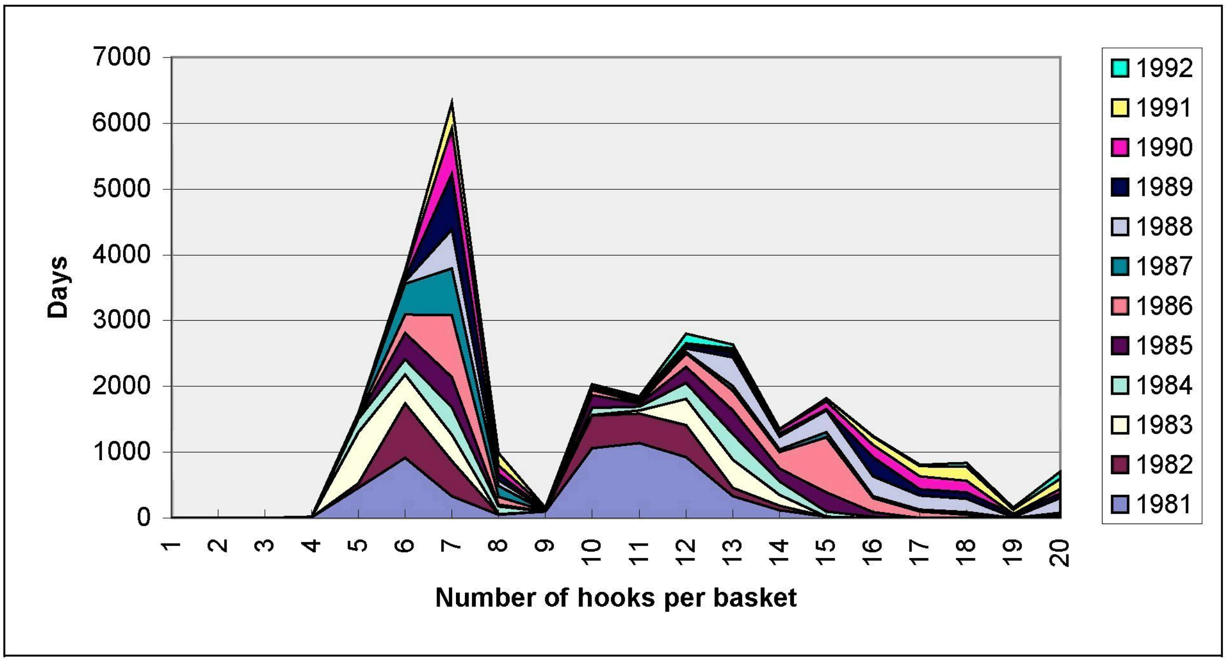


Figure 4.5: Annual frequency of hooks per basket used by longline vessels fishing for the WTP (top) and WSP (bottom), 1981–1992

Source : RTFD; only those data which include hooks per basket have been used.

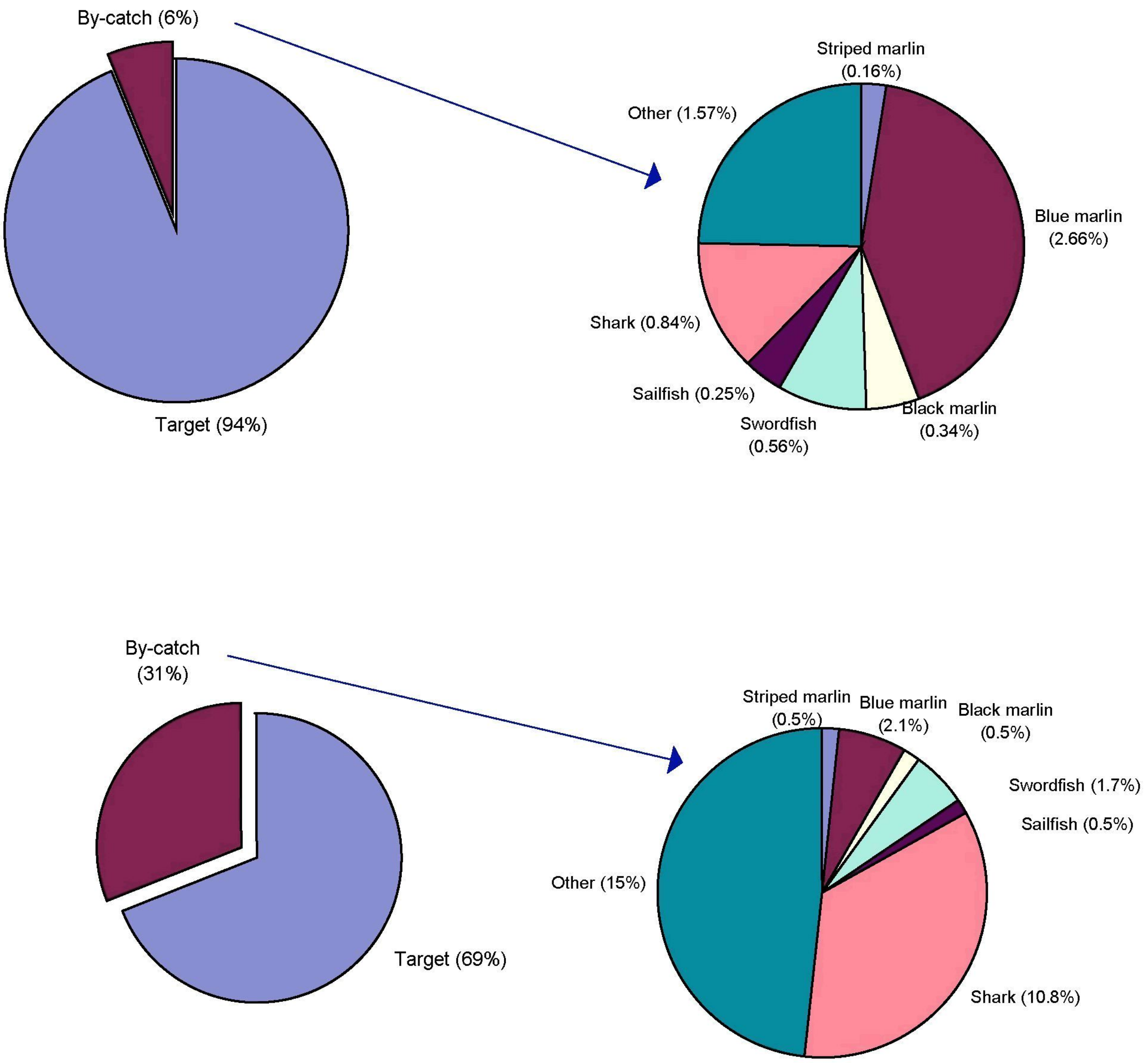
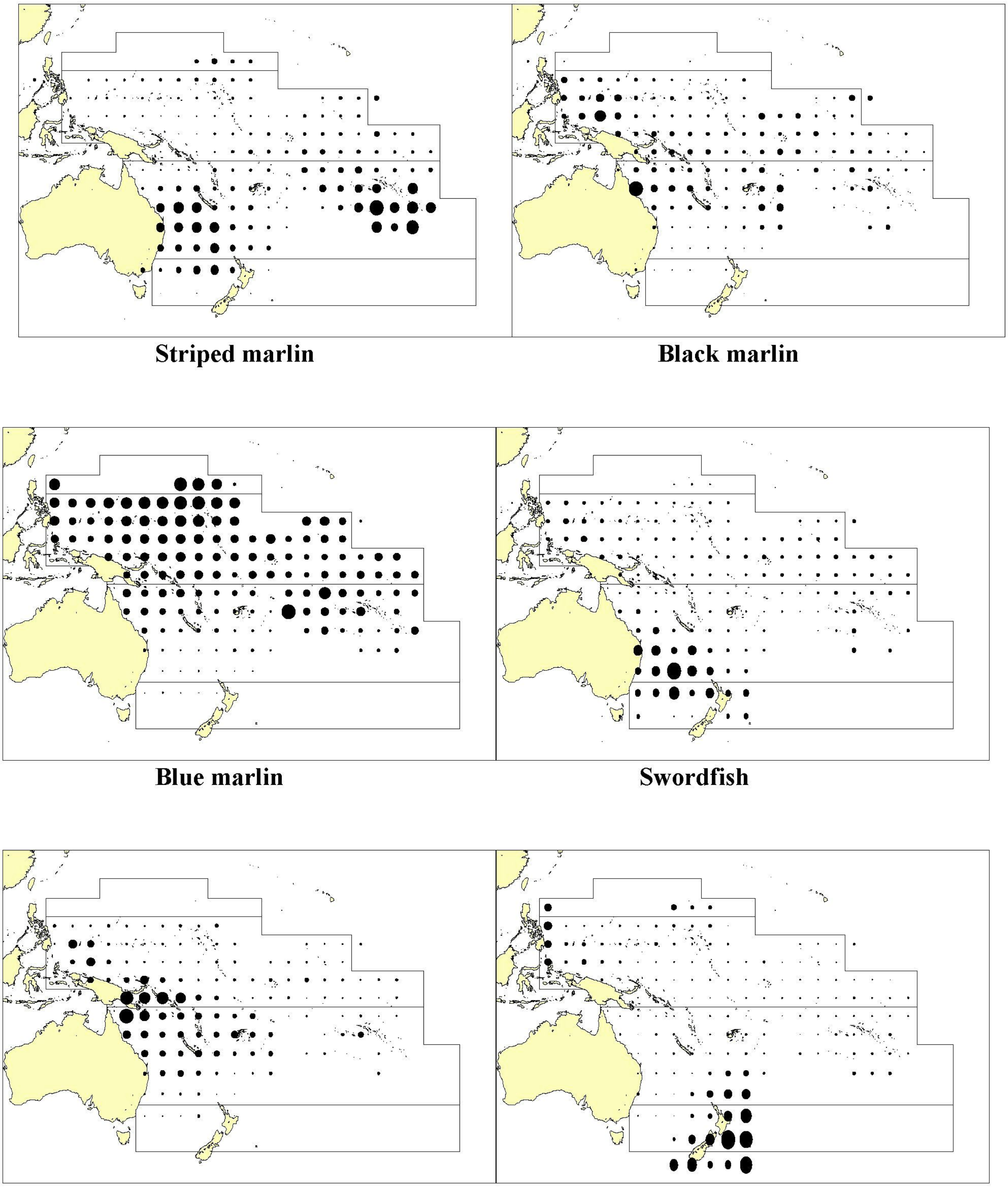


Figure 4.6: Breakdown of reported (top left) and observed (bottom left) longline catch, and reported (top right) and observed (bottom right) longline by-catch in the WTP

(Catch and bycatch expressed in numbers. Reported catch and by-catch are based on data held in the RTFD for 1978–1992; observed data were provided by MMA observers for 1993–1994.)



Striped marlin | Black marlin

Blue marlin | Swordfish

Sailfish | Shark

Figure 4.7: Distribution of nominal CPUE for common by-catch species taken by longline vessels in the WPO, based on data held in the RTFD, 1978–1992
(The unit of effort is number of fish per hundred hooks; only five degree square grids with more than 50,000 hooks effort are shown.)

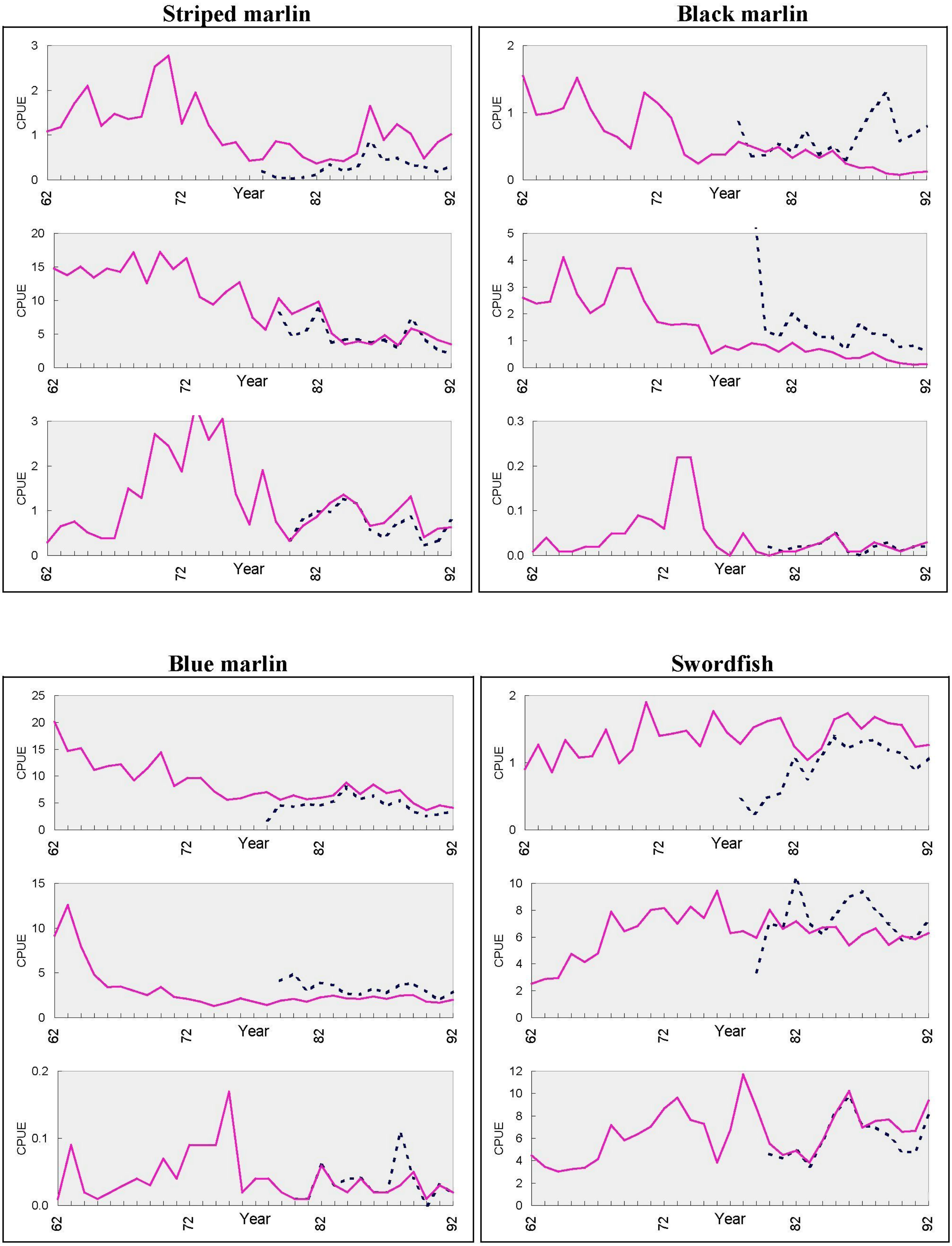


Figure 4.8: Annual longline CPUE, in numbers per 10,000 hooks, for common by-catch species in the WTP (top), WSP (middle) and WTeP (bottom)

(Sources are data provided to SPC by the Japanese Fisheries Agency (JFA: thick line) and the RTFD (dotted line).)

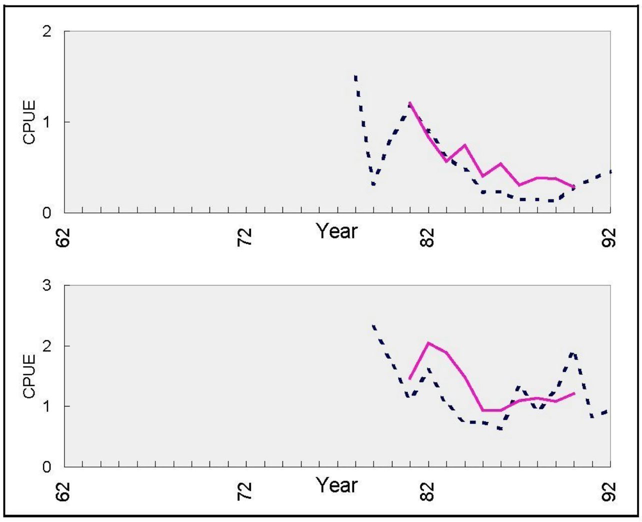


Figure 4.8 (continued)

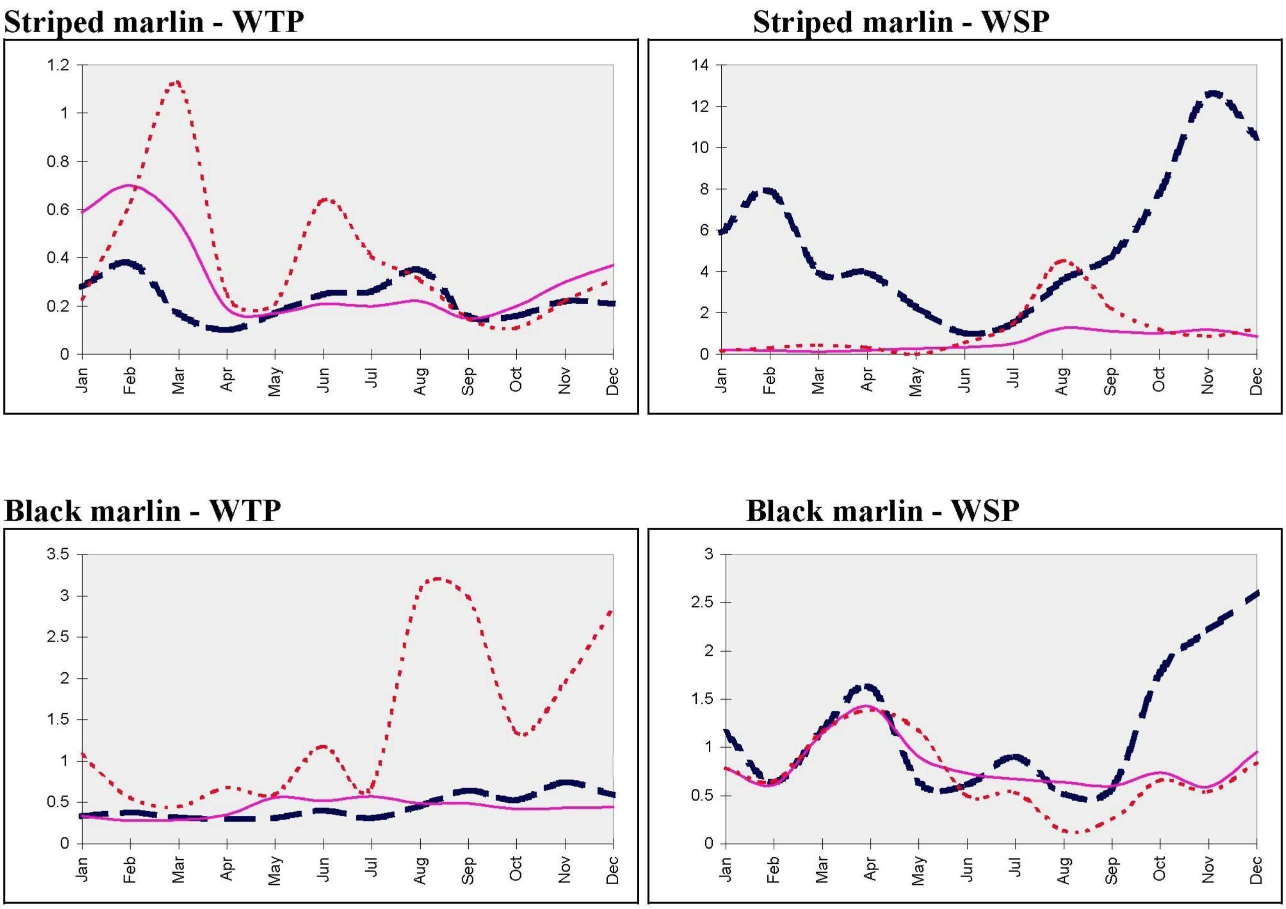
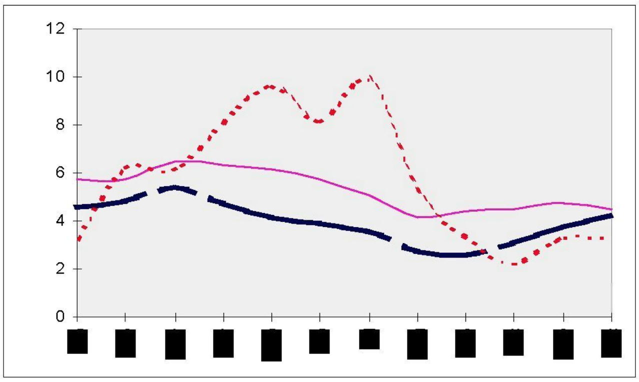


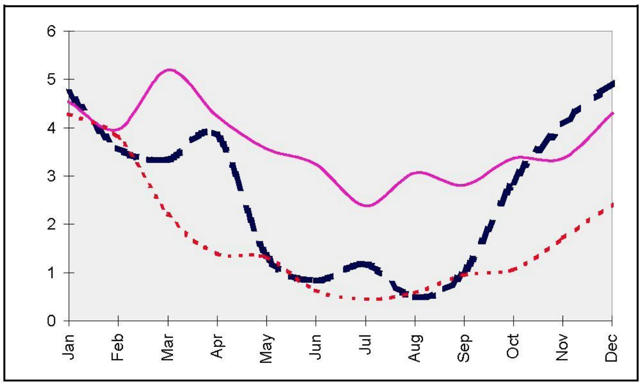
Figure 4.9 : Seasonal longline CPUE, in numbers per 10,000 hooks, for common by-catch species in the WPO, stratified by categories of number of hooks / basket

(WTP: Thick-dashed line: 3–6 hooks / basket; Solid line: >=10 hooks / basket; Dashed line: 7–9 hooks / basket
WSP: Thick-dashed line: 5–8 hooks / basket; Solid line: >=10 hooks / basket; Dashed line: 9 hooks / basket)

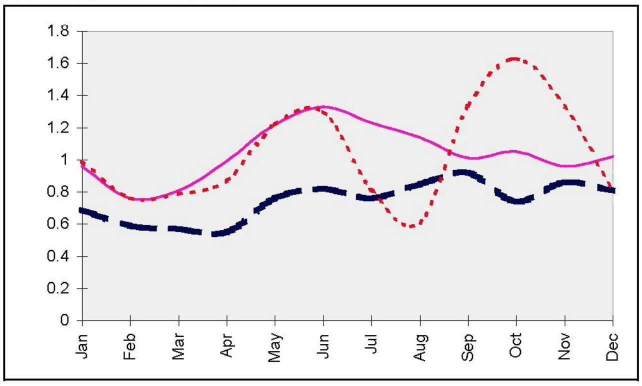
Blue marlin - WTP



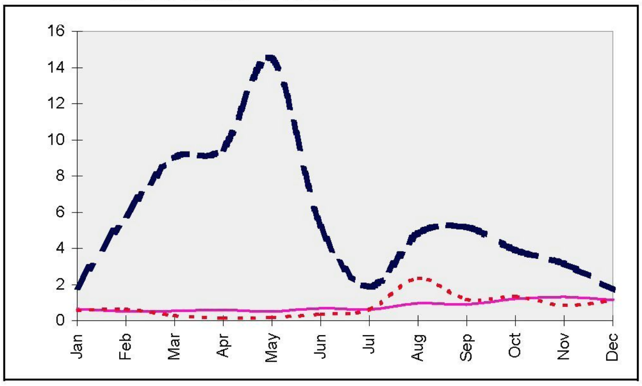
Blue marlin - WSP



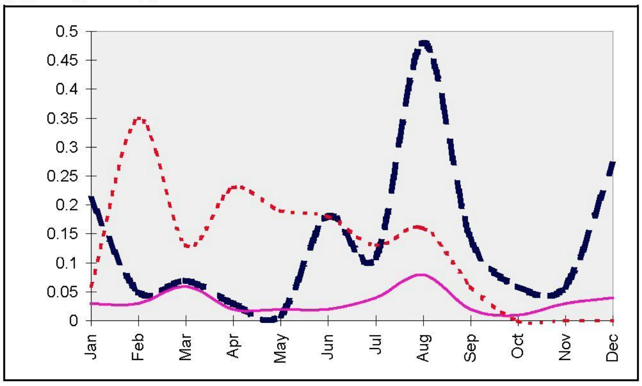
Swordfish - WTP



Swordfish - WSP



Sailfish - WTP



Sailfish - WSP

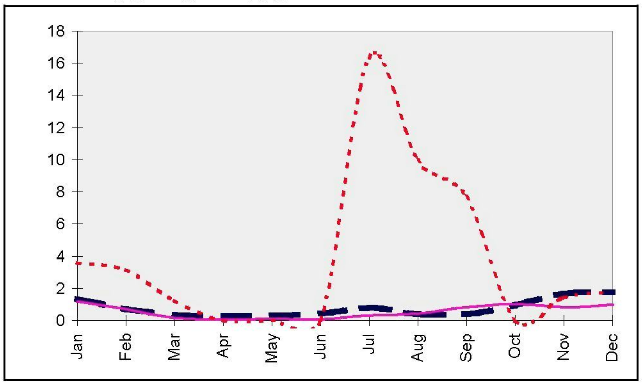


Figure 4.9 (continued)

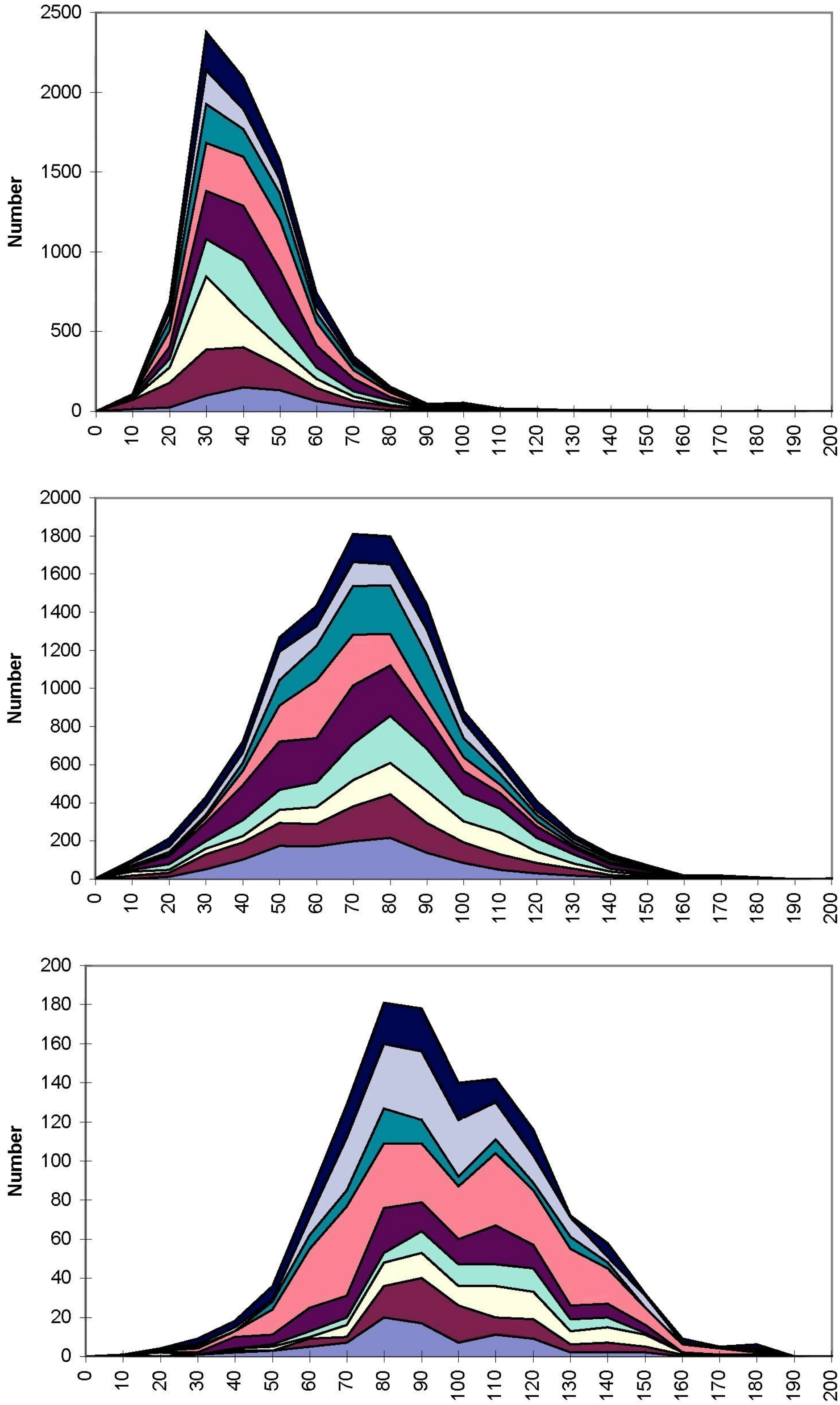


Figure 4.10 : Size composition (kg) of striped marlin in the WTP (top), WSP (middle) and WTeP (bottom) for 1984 (lowest category) to 1992 (highest category)

(Source : RTFD for days where only one striped marlin was recorded on the logsheet; weights have been rounded to the nearest 10 kg; no allowance has been made for weight loss due to processing.)

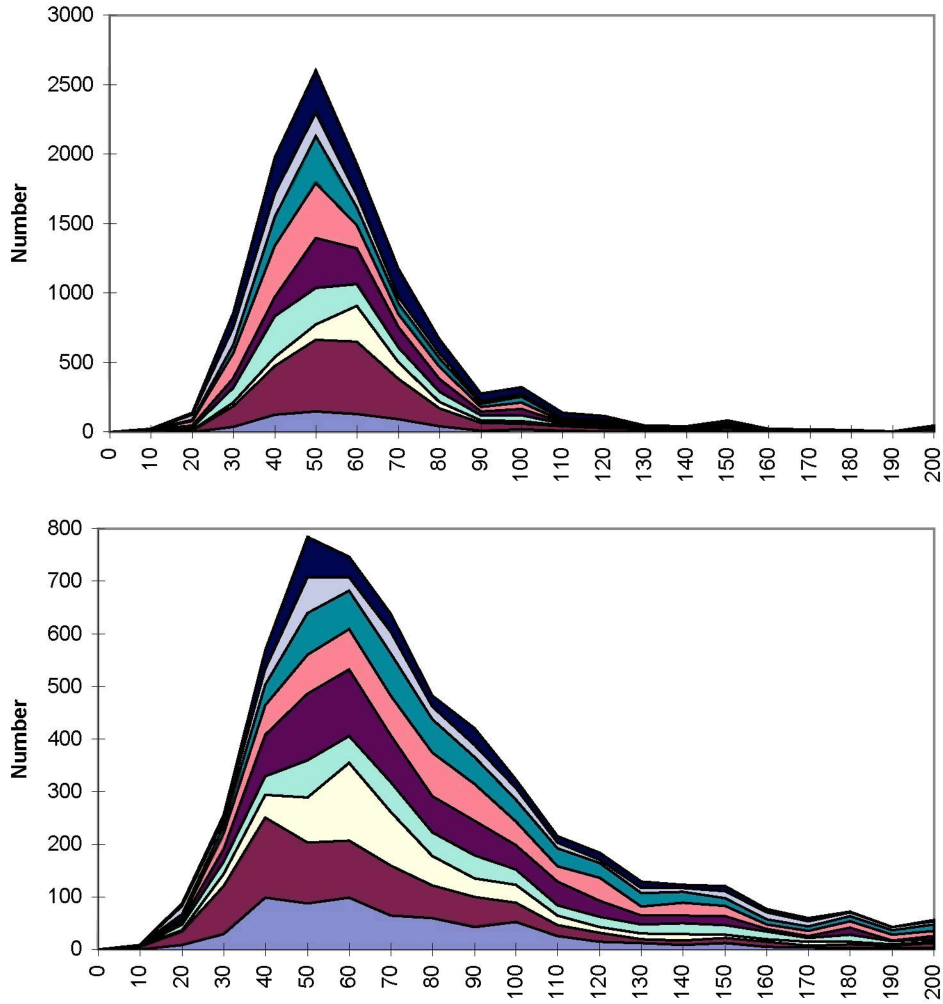


Figure 4.11 : Size composition (kg) of black marlin in the WTP (top) and WSP (bottom) for 1984 (lowest category) to 1992 (highest category)

(Source : RTFD for days where only one black marlin was recorded on the logsheet; weights have been rounded to the nearest 10 kg; no allowance has been made for weight loss due to processing.)

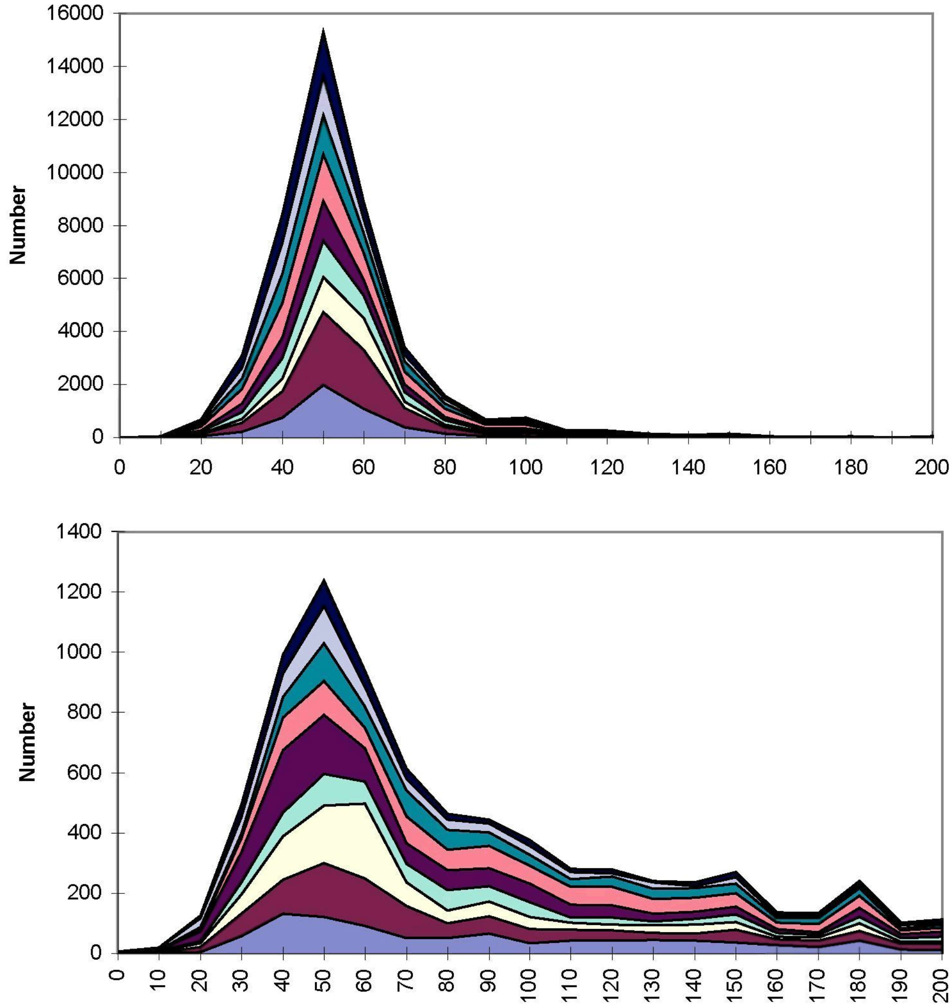


Figure 4.12 : Size composition (kg) of blue marlin in the WTP (top) and WSP (bottom) for 1984 (lowest category) to 1992 (highest category)

(Source : RTFD for days where only one blue marlin was recorded on the logsheet; weights have been rounded to the nearest 10 kg; no allowance has been made for weight loss due to processing.)

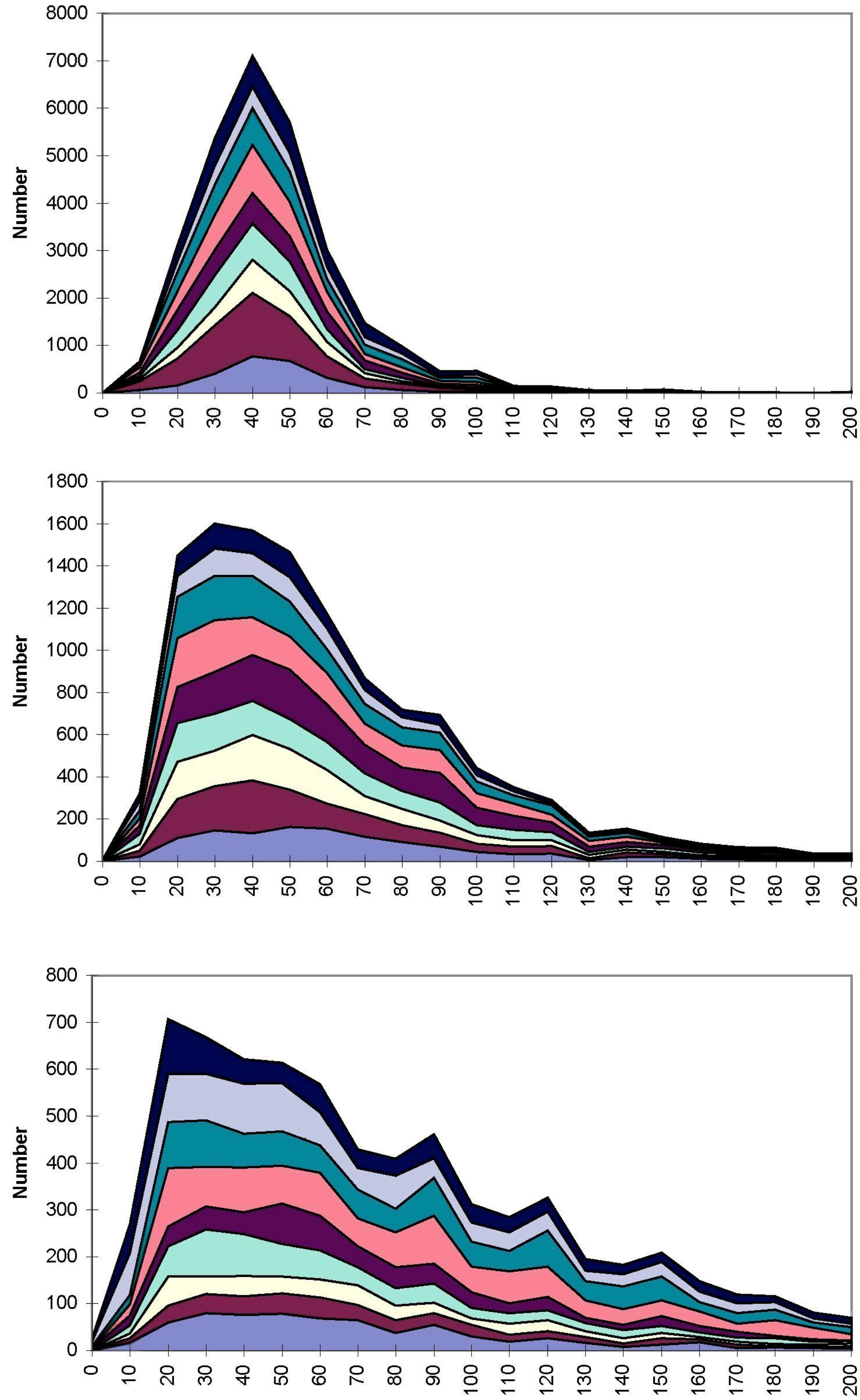


Figure 4.13 : Size composition (kg) of swordfish in the WTP (top), WSP (middle) and WTeP (bottom) for 1984 (lowest category) to 1992 (highest category)

(Source : RTFD for days where only one swordfish was recorded on the logsheet; weights have been rounded to the nearest 10 kg; no allowance has been made for weight loss due to processing.)

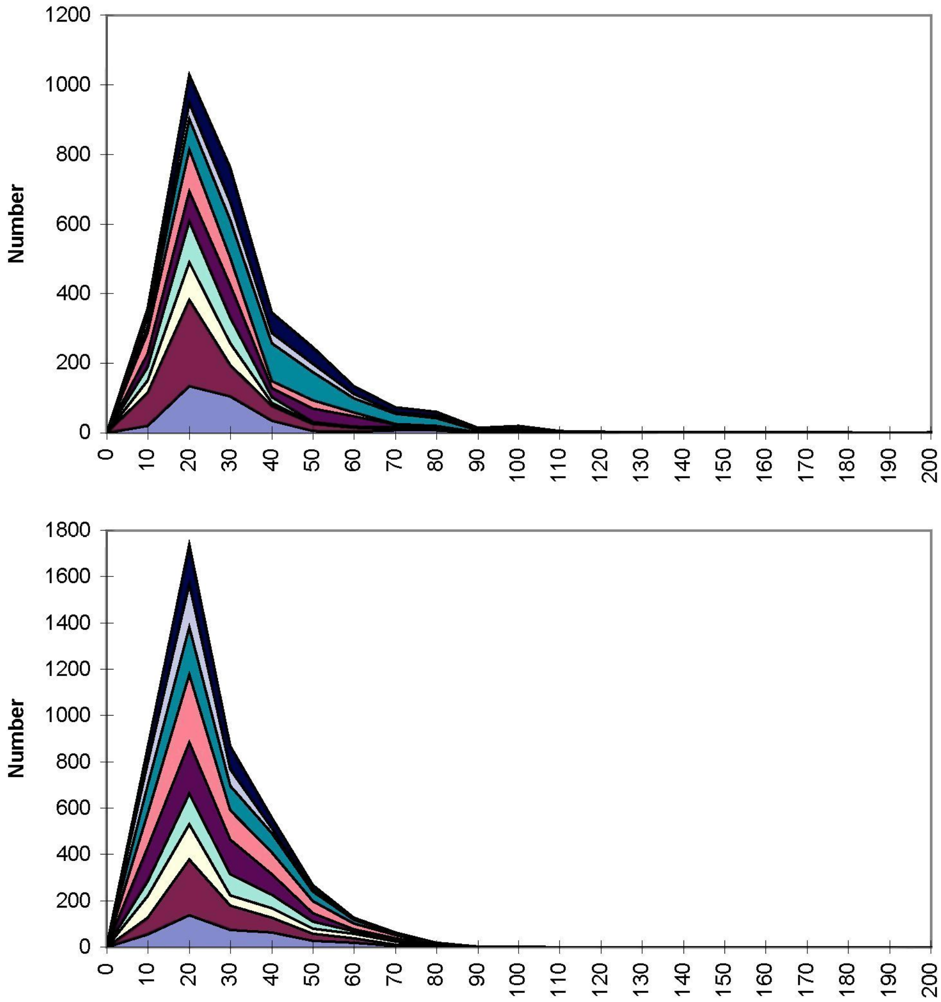


Figure 4.14 : Size composition (kg) of sailfish in the WTP (top) and WSP (bottom) for 1984 (lowest category) to 1992 (highest category)
(Source : RTFD for days where only one sailfish was recorded on the logsheet; weights have been rounded to the nearest 10 kg; no allowance has been made for weight loss due to processing.)

Section 5

POLE-AND-LINE FISHERIES

5.1 OVERVIEW OF THE WESTERN PACIFIC POLE-AND-LINE FISHERIES

5.1.1 Summary of the fishery

Pole-and-line tuna fisheries of the WPO can be divided into three general categories: large vessels from DWFNs landing their catch outside the region; domestic fleets operating on a smaller scale and unloading within the region; and artisanal-scale pole fisheries that supply fresh tuna to local markets. Japan is the only DWFN currently operating pole-and-line tuna vessels in the WPO, targeting high-quality skipjack destined for a variety of Japanese domestic tuna products. The Japanese southern-water (WTP) and *higashi oki* (WSPn, WSP and WTeP) skipjack fleet shrank from 317 vessels in 1980 to 38 in 1992, which included six vessels engaged in survey and experimental fishing during the 1992 season. Fleet reduction occurred in response to increased operational costs, reduced access to fishing grounds and the rapid development of the Japanese tropical purse-seine fishery. The southern-water fleet has operated mostly in the WTP, in the EEZs of the Federated States of Micronesia, Marshall Islands and Kiribati, including the Phoenix and Line Island groups and adjacent international waters. The *higashi oki* grounds are located east and south-east of Japan, mostly between Japan and Wake Island. However, a productive fishing ground for *toro katsuo*, or high-quality fatty skipjack, was discovered in the international waters of the Tasman Sea between Australia and New Zealand during 1991. In recent years, a considerable amount of effort has been directed to this area, where Japanese pole-and-line vessels harvested approximately 1300 mt of tuna during the 1992 season. Figure 5.1 shows the distribution of effort for all pole-and-line vessels for which daily logsheet data have been provided (RTFD) and Figure 5.2 shows the distribution of effort for Japanese pole-and-line vessels only, highlighting activity of the southern water fleet and in international waters (*higashi oki*), for which daily logsheet data are not available.

Vessels engaged in the Japanese distant-water fishery are large, modern, highly-sophisticated craft up to 499 GRT, equipped to carry live bait from Japan to tropical fishing grounds in temperature-controlled, chemically stabilised and filtered bait wells. Skipjack is the target species, but juvenile bigeye, yellowfin, bluefin and albacore are also poled and retained for sale. Fishing operations concentrate on unassociated schools of skipjack or log-associated mixed tuna schools.

Domestic pole-and-line fleets are restricted to island groups with reliable sources of baitfish suitable for live-bait-assisted tuna-poling operations. Sizable domestic fleets of small to medium-sized, Japanese-style pole-and-line vessels have operated in many countries of the WTP and WSP. Currently, active fleets are based in Fiji and the Solomon Islands and are similar to pole-and-line fisheries that operated in Palau and Papua New Guinea until 1982 and 1985 respectively. Between one and three large Japanese pole-and-line boats operated under a joint-venture arrangement in New Caledonia and Wallis until 1983.

The Fiji fleet in 1992 consisted of nine Fiji-owned and two Japanese chartered vessels while the Solomon Islands fishery consists of joint-venture or chartered Okinawan pole boats operated by Solomon Taiyo Ltd and British Columbia Packers Ltd. Both fleets supply iced or brine-frozen tuna to nearby canneries. The Solomon Islands fishery is based on an extensive FAD network around the main archipelago that also entrains significant quantities of by-catch species. A single, 25 GRT Japanese-style vessel currently operates in Palau, supplying fresh fish to local markets.

Kiribati and Tuvalu have small and medium-sized Japanese-style pole-and-line vessels run by national fishing corporations. Kiribati has operated up to five vessels since 1988 in Kiribati, Fiji and the Solomon Islands, while Tuvalu has a single 173 GRT vessel that has fished in Fiji and the Solomon Islands. This vessel was chartered by the South Pacific Commission from December 1989 to the end of 1992 as a research/tagging platform for the SPC Regional Tuna Tagging Project.
New Zealand and Australia have seasonal pole-and-line tuna fisheries in the WTeP around New Zealand and off the south-east Australian coast. Three vessels operated in New Zealand waters during 1991, taking one

tonne of albacore, with another New Zealand flag vessel landing skipjack and yellowfin in the Solomon Islands (Lawson 1992a).

Australian pole-and-line vessels targeted southern bluefin tuna from ports in South Australia until 1984. A small degree of pole effort has continued on bluefin for the Japanese sashimi market, but the bulk of catches now consist of skipjack and a small quantity of yellowfin and bigeye. The skipjack pole and purse-seine fishery operates mostly in the waters of New South Wales from January to May and has expanded rapidly after the decline in effort on southern bluefin tuna. Ten boats engaged in the Australian skipjack fishery during 1992, taking over 800 mt (Lawson 1993).

Small-scale pole-and-line fisheries that do not depend on chumming live bait exist in French Polynesia and Kiribati. A fleet of *bonitier* vessels has operated around Tahiti since 1975 on unassociated schools, logs and FADs. These vessels pole skipjack using traditional-style pearl shell lures from moving motorised vessels. In 1991, the *bonitier* fleet consisted of 31 vessels and caught over 700 mt (Lawson 1993).

Over 60 artisanal pole/troll skiffs operate from south Tarawa in Kiribati, fishing mostly on local banks. Both fisheries supply fresh skipjack and a small quantity of yellowfin to their respective domestic markets.

Japanese-style pole-and-line vessels that capture tuna baitfish take a wide variety of fish and invertebrate species in their lift and surround nets. The most desirable tuna baitfish in the WTP are various species of anchovies (Engraulidae), herrings and sardines (Clupeidae) and sprats (Dussumieriidae). However, a tremendous variety of juvenile and adult tropical reef fish are taken in pole-and-line baiting operations. The baiting operation is considered to be separate from the actual tuna fishing operation and, as such, has not been described in this review.

5.2 SOURCES AND COVERAGE OF DATA

Table 5.1 summarises daily pole-and-line catch and effort data by fleet available from the RTFD (1970–1993) and aggregated statistics by month and 1° square grid provided by the Fisheries Agency of Japan (1972–1990). The main source of daily pole-and-line data in the RTFD is the provision of logsheet forms by vessels as a requirement for fishing in the economic zones of SPC member countries and territories. The pole-and-line logsheet forms were not designed to provide detailed recording of by-catch and discards; few data are therefore available on the species of by-catch taken and no information on discards of either target or by-catch species. There is also no provision for recording the school association on any of the pole-and-line forms received at SPC, so no comparison at this level has been possible.

Data are available for species other than skipjack, yellowfin and bigeye (i.e. bluefin, frigate and albacore tuna) in the aggregated statistics provided by the Fisheries Agency of Japan (Table 5.2). However, as with the logsheet forms provided to SPC, there is no information on the level of discards of either the target or by-catch species, nor a breakdown of catch by school association. Estimates of target catch of the pole-and-line fleets operating in the WPO are summarised in Lawson (1992a) and Lawson (1993).

Data from the Skipjack Survey and Assessment Programme (SSAP) and the Regional Tuna Tagging Project (RTTP), where a breakdown of by-catch species and school association are available, have also been used.

The available literature on the pole-and-line fishery is sparse; the current review therefore relies on cruise reports from the tagging projects conducted by SPC and information from annual reports produced by fisheries divisions of SPC member countries and territories.

5.3 BY-CATCH AND DISCARDS OF BY-CATCH

5.3.1 Gross levels of by-catch and reporting

During the period 1970 to 1993, data stored on the RTFD indicate a reported catch of 1,191,809 mt taken by pole-and-line vessels in the WPO (Table 5.1). Of this catch, 99.2 % consisted of target catch or commercially-valuable tunas that were retained for sale. Skipjack is the main target species in the WTP, WSP and WSPn, but juvenile yellowfin and bigeye are significant in the catch, with albacore and small quantities of bluefin tuna taken in temperate-water pole-and-line fisheries. The reported by-catch during this period amounts to 9,473 mt of fish (i.e. 0.8% of the total catch). The reported levels of by-catch and species composition (Table 5.2) from similar pole fisheries in the WPO vary widely, while the relative levels of target catch are quite similar. This observation supports an assumption that some degree of under- and non-reporting exists for by-catch and discards in WPO pole-and-line fisheries.

5.3.2 Levels of by-catch and discards

Despite the problems of under-reporting in this fishery, gross levels of by-catch and discards are thought to be relatively low due to the nature of the fishery. The pole-and-line fishery is one of the most targeted and controllable industrial tuna fisheries in the WPO in terms of species composition, and harvested fish size and total harvest levels are far lower than those of the purse-seine catch. These factors result in low by-catch and discard levels due to the nature of the fishing operation and the fact that each fish is individually hooked and landed from a surface school.

Schools are carefully assessed according to species composition and individual fish size prior to the commencement of chumming. If a positive biting response is established, the fishing operation can be halted immediately if the school contains a high proportion of undesirable species or target species of an unmarketable size. The careful targeting of desirable catch is especially important on Japanese-style pole-and-line vessels that are dependent on limited supplies of live chum. Baitfish conservation is of paramount importance to these vessels, which carry their entire baitfish supply for one trip from Japan in temperature-controlled tanks.

Retained by-catch levels are also reduced in pole-and-line fisheries through a selection process done during the fishing operation. When a mix of species is present in a school, it is common for fishermen to flick the undesirable species off their barbless hooks in mid-air. The survival rates for live fish discarded in this manner are not known, but are presumed to be high for most species.

5.3.3 By-catch species

5.3.3.1 Common species

Significant data sets for WPO pole-and-line fisheries exist in the RTFD for fleets from Australia, Fiji, Japan, Kiribati, New Caledonia, Papua New Guinea (PNG), the Solomon Islands and Tuvalu. Table 5.1 summarises reported catch data from these fleets.

The catch composition of the WTP and WSP fleets from Fiji, Kiribati and the Solomon Islands are very similar, with skipjack rarely exceeding 95 per cent of the total annual catch (Lawson 1993). The reported catch from the Japanese fleet indicates a higher proportion of skipjack, between 96 and 99 per cent of the catch for the years 1972 to 1992 (Lawson 1993). These figures are consistent with the targeting by this fleet on large skipjack for speciality markets in Japan and their perception that yellowfin, bigeye and albacore are an incidental by-catch species to their fishery.

Catch statistics available for the single Palauan pole-and-line vessel show that for 1990, 81 per cent of the total catch was skipjack, 3 per cent yellowfin, 15 per cent frigate mackerel/kawakawa, and the remainder (<1%) made up of rainbow runner and mahi-mahi (Anon. 1991). This vessel retains by-catch species that are normally discarded by regional pole-and-line fleets, as they have local market value or can be used for bait (Watt pers. comm.). The reported level of by-catch from this vessel is particularly noticeable when compared with the catch composition from other fleets (Table 5.2), which report a zero or less than 0.01 per cent catch for these species. Figure 5.3 shows the distribution of by-catch composition of the total catch reported by Japanese pole-and-line vessels. It is noticeable that by-catch appears to constitute a higher proportion of the total catch in the

WSPn and Solomon Islands pole-and-line fisheries than elsewhere. Probable reasons include (i) the higher proportion of by-catch to target species (i.e. skipjack) in more temperate waters; (ii) the proximity of these fisheries to ports of landing, where, for example, storage space/subsequent marketing may not be as critical as with distant-water (*higashi oki*) vessels; (iii) the distant-water vessels typically discard by-catch and thus it is not reported; and (iv) some by-catch species, for example frigate mackerel and kawakawa, appear to be more prevalent in the waters around oceanic islands and the archipelagic waters of the WPO (Collette & Nauen 1983); this also explains the general reduction in the proportion of by-catch taken from west to east in the WTP (Figure 5.3).

Regardless of the problems of non- and under-reporting, it is evident that common by-catch species in the WTP and WSP include kawakawa, frigate mackerel, mahi mahi and rainbow runner. Table 5.3 lists common by-catch species taken by pole-and-line vessels in the WPO; the by-catch species for WPO purse-seine fisheries (Table 3.4) that are vulnerable to surface-deployed hook-and-line gear would essentially provide additions to Table 5.3. In a few instances, by-catch species can become a targeted catch, such as the harvest of mahi mahi by the *bonitier* fleet of French Polynesia.

5.3.3.2 Billfish by-catch

Only one instance of billfish catch by pole-and-line vessels was found in this review. Approximately 0.1 metric tonnes of broadbill swordfish were taken (presumably from one school) by a Japanese pole-and-line vessel in Kiribati waters in November 1990. The reported average weight of 2 kg is consistent with information on the expected spawning period (March to July) in the central Pacific Ocean and observations of the appearance of juvenile swordfish at a similar interval since spawning in other fisheries (Nakamura 1985).

There are no other instances of billfish being caught in the pole-and-line fisheries of the WPO.

5.3.3.3 By-catch of seabirds, marine reptiles and marine mammals

There are no records of seabirds, marine reptiles or marine mammals being caught in the pole-and-line fisheries of the WPO.

5.3.4 By-catch by school association

School sightings and fishing logs from the tagging cruises of the SSAP and RTTP provide detailed information on pole-and-line by-catch by area and school association. During the SSAP, 4179 tuna schools were sighted and categorised to association type during tagging cruises. Of these, 3838 schools were classified as unassociated, while 145 schools were found in association with logs, FADs or flotsam. Table 5.3 shows the relative frequency of different by-catch species taken by school association. Table 5.4 shows the frequency of common by-catch species poled from unassociated and log-FAD-associated schools during the SSAP. By-catch species, such as mahi-mahi and rainbow runner, were very common on log- and FAD-associated schools. This pattern is supported by similar data collected on the *Te Tautai* during the RTTP, as indicated in Table 5.5. Table 5.6 lists the actual numbers of by-catch by species taken by school association type on the *Te Tautai* during the RTTP. Rainbow runner and mahi mahi were the most common by-catch species taken during the project, being caught mostly from log-, drifting FAD- and anchored FAD-associated schools. Another trend evident in the raw data is that many by-catch species, such as kawakawa, frigate mackerel and rainbow runner, are more abundant near land masses and large archipelagoes, i.e. the Solomon Islands, Indonesia and the Philippines.

5.3.5 Seasonality of by-catch

By-catch in WPO pole-and-line fisheries is highest for fishing operations based on FAD- and log-associated schools. Any seasonal trend that brings more logs, debris and flotsam-associated schools to an area will increase the by-catch levels. Annual variability in recruitment of some by-catch species will also have a direct effect on by-catch levels on FADs, seamounts and drifting objects.

Data from the RTFD which appear to contain consistent by-catch reporting by fleet have been used to provide seasonal trends of some by-catch species. Figure 5.4 shows the seasonality of frigate mackerel by-catch, which appears to be more prevalent in the months December to April (except January), although it should be noted that the Fijian pole-and-line fleet is largely inactive from July to October. The pole-and-line by-catch of mahi mahi (Figure 5.5) shows similar seasonal trends to the reported catch of this species by longline vessels in the WTP (Table 4.11), which is essentially higher in the first two quarters of the year. Rainbow runners (Figure 5.6) appear to be taken during most months of the year and more frequently (i.e. a better catch rate) than frigate mackerel and mahi mahi, particularly in the Solomon Islands.

5.3.6 Estimates of by-catch and discards

Information from the purse-seine fisheries of the WPO and tagging experiments using pole-and-line vessels provide some indications on the frequency of encountering by-catch species by school association. However, it is difficult to provide estimates of by-catch and discards of by-catch for the pole-and-line fishery when it is evident that fishermen can easily flip or throw off their undesirable catch, a practice that can vary from vessel to vessel.

5.4 TUNA DISCARDS

5.4.1 Tuna discard levels

There is no information in the RTFD or Japanese aggregated data on tuna discards in pole-and-line fisheries. As mentioned above, this method of fishing is one of the most controllable and targeted in the WPO in terms of the species and size of fish landed.

Where schools include a variety of sizes of target catch, it is possible for the fishermen to throw the undesirable fish off their hooks rather than land them on deck, as described in Section 5.3.2 for by-catch species. Many of these rejects land back in the water after being airborne for a few seconds. The fate of these fish is unknown, but mortality is presumed low in light of the estimated high survival rates of releases for pole-and-line tagging experiments.

It is possible that a small quantity of catch is routinely discarded by Japanese distant-water pole-and-line vessels if they completely fill their holds. There have been reports of some discards from the daily catch of pole-and-line vessels operating in Papua New Guinea; this occurred when no space for storage was available and fish lying on the deck had become spoiled in the warm temperatures (Lewis pers. comm.).

5.4.2 Seasonality of tuna discards

A common reason for discarding target tuna species is if the catch is too small to market or to receive an economically-viable ex-vessel price. An area that receives a large influx of under-sized juvenile tuna will most likely have temporarily-elevated tuna discard levels. This is noticeable in the Solomon Islands fishery, where small skipjack and yellowfin are common on FADs from December to June (Hampton & Bailey 1993).

5.4.3 Estimates of tuna discards

No estimates of tuna discards were possible in this review.

5.5 COMPARISONS WITH OTHER POLE-AND-LINE FISHERIES

A large FAD-based pole-and-line tuna fishery is active in eastern Indonesia, utilising vessels ranging from very small artisanal craft to large Japanese-style pole vessels. In 1989, a total of 616 pole-and-line vessels of 3 to 300 GRT operated mostly from bases in Irian Jaya, Sulawesi and Nusa Tenggara (Naamin & Bahar 1990). Literature reviewed was not sufficiently detailed to indicate levels of by-catch in this fishery. However, it is estimated that skipjack and yellowfin accounted for approximately 95 and 5 per cent, respectively, of the target catch, making it similar to other WTP domestic pole-and-line fisheries. It can be assumed that by-catch levels are significant, as the fishery is based on FAD-associated schools that hold large populations of frigate mackerel, bullet tuna, kawakawa, mahi mahi and rainbow runner. In addition, the Indonesian pole-and-line fishery makes incidental catches of longtail tuna, dogtooth tuna, double-lined mackerel (*Grammatorcynus bicarinatus*) and striped bonito (*Sarda orientalis*).

5.6 CONCLUSIONS

The major conclusions of this investigation of by-catch and discards in the WPO pole-and-line fisheries are as follows:

(a) Due to the ability to control the pole-and-line catch and the incentive pole-and-line boats have to conserve chum during fishing operations, it is likely that tuna discard levels in the various pole-and-line fisheries in the WPO are relatively minor.

(b) By-catch from the pole-and-line fisheries in the WPO according to the RTFD is less than one per cent, although it is expected that the real level may be slightly higher, and varies with the type of school association. By-catch levels are higher for pole-and-line fisheries based on FAD networks or in areas close to islands, reefs or archipelagic waters, as in the Solomon Islands, Indonesia and Fiji. High seas pole-and-line fisheries, such as the Japanese *higashi oki* fishery, seem to have lower levels of by-catch and possibly quite low levels of tuna discards (under-size) as this fishery targets premium skipjack and directs effort away from non-target species to conserve limited live baitfish supplies.

Future monitoring of the pole-and-line fisheries of the WPO using scientific observers could be directed to gaining more information on the by-catch levels and discard practices by fleet and school association. However, as the proportion of by-catch taken by commercial pole-and-line vessels is very small and observer coverage would need to be substantial, it is thought that observer effort would be best directed to the other more important fisheries of the WPO.

Table 5.1: By-catch and discards of pole-and-line vessels in the WPO, based on logbook data held in the RTFD, 1970–1993 and data provided by the Fisheries Agency of Japan, 1972–1990 (shaded)

Fleet	Area	Period	Total catch (mt)	Target catch (%)	By-catch (%)	Target discards (%)	Other discards (%)
Australia	WSP	1989–1993	7,370	100.0	0.0	N/A	N/A
Fiji	WTP/WSP	1976–1991	41,335	99.9	0.1	N/A	N/A
Japan	WTP	1978–1993	472,594	99.3	0.7	N/A	N/A
		1972–1990	1,791,972	99.6	0.4	N/A	N/A
	WSP	1978–1992	10,735	99.7	0.3	N/A	N/A
		1972–1990	50,640	99.6	0.4	N/A	N/A
	WSPn	1979–1992	2,418	99.9	0.1	N/A	N/A
		1972–1990	366,045	99.2	0.8	N/A	N/A
Kiribati	WTP/WSP	1986–1993	4,390	99.0	1.0	N/A	N/A
New Caledonia	WTP/WSP	1981–1983	1,717	89.4	10.6	N/A	N/A
Papua New Guinea	WTP/WSP	1970–1979 1984–1985	322,925	99.6	0.4	N/A	N/A
Solomon Islands	WTP/WSP	1981–1993	325,538	98.6	1.4	N/A	N/A
Tuvalu	WTP/WSP	1982–1988	2,787	99.5	0.5	N/A	N/A
Total			1,191,809	99.2	0.8	N/A	N/A

Table 5.2: Species composition of by-catch taken by pole-and-line vessels in the WPO, based on logbook data held in the RTFD, 1970–1993 and data provided by the Fisheries Agency of Japan, 1981–1990 (shaded)

Fleet	Area		Alba-core	Bluefin	Frigate tuna	Sword-fish	Rainbow runner	Mahi mahi	Trigger fish	Others
Australia	WSP	mt	–	–	–	–	–	–	–	–
		%	–	–	–	–	–	–	–	–
Fiji	WTP/WSP	mt	–	–	1.6	–	0.2	–	–	48.8
		%	–	–	<0.01	–	<0.01	–	–	0.14
Japan	WTP	mt	–	2.2	13.5	0.1	31.1	7.1	0.1	3,216.8
		%	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.73
		mt	32.4	9.0	–	–	–	–	–	1,436.4
		%	<0.01	<0.01	–	–	–	–	–	0.20
	WSP	mt	–	–	–	–	1.0	0.5	–	27.9
		%	–	–	–	–	<0.01	<0.01	–	0.26
		mt	2.3	–	0.1	–	–	–	–	6.0
		%	0.02	–	<0.01	–	–	–	–	0.05
	WSPn	mt	–	–	–	–	–	–	–	1.3
		%	–	–	–	–	–	–	–	0.05
		mt	111.1	11	6.2	–	–	–	–	2,078.8
		%	0.3	<0.01	<0.01	–	–	–	–	0.63
Kiribati	WTP/WSP	mt	–	–	–	–	–	–	–	30.2
		%	–	–	–	–	–	–	–	1.0
New Caledonia	WTP/WSP	mt	–	–	–	–	–	–	–	183.0
		%	–	–	–	–	–	–	–	10.6
Papua New Guinea	WTP/WSP	mt	–	–	–	–	–	–	–	1332.6
		%	–	–	–	–	–	–	–	0.4
Solomon Islands	WTP/WSP	mt	–	–	–	–	167.4	–	–	3,034.8
		%	–	–	–	–	0.5	–	–	0.9
Tuvalu	WTP/WSP	mt	–	–	–	–	3.1	–	–	6.4
		%	–	–	–	–	0.16	–	–	0.3

Note

Albacore and bluefin are normally considered part of the target catch.

Table 5.3: By-catch species of pole-and-line fisheries by school associations

Species (common name)	Scientific name	Unassociated	Anchored FAD	Log	Current line	Reef/ seamount	Whale	Whale shark
Sharks	**Carcharhinidae**							
Grey reef	*Carcharhinus amblyrhynchos*	R	R	R	R	R	R	R
Oceanic whitetip	*C. longimanus*	R	R	R	R	R	R	R
Silky shark	*C. falciformis*	R	R	R	R	R	R	R
Silvertip	*C. albimarginatus*	R	R	R	R	R	R	R
Tuna and tuna-like fishes	**Scombridae**							
Bullet tuna	*Auxis rochei*	R	R	R	R	R	R	R
Dogtooth tuna	*Gymnosarda unicolor*	R	R	R	R	R	R	R
Double-lined mackerel	*Grammatorcynus bicarinatus*	R	R	R	R	R	R	R
Frigate tuna	*Auxis thazard*	O	C	O	R	R	R	R
Kawakawa	*Euthynnus affinis*	O	C	C	O	O	R	R
Longtail tuna	*Thunnus tonggol*	R	R	R	R	R	R	R
Spanish mackerel	*Scomberomorus commerson*	R	R	R	R	R	R	R
Wahoo	*Acanthocybium solandri*	R	R	R	R	R	R	R
Jacks	**Carangidae**							
Amberjack	*Seriola rivoliana*	R	R	O	R	R	R	R
Bigeye trevally	*Caranx sexfasciatus*	R	O	O	R	R	R	R
Leatherskin jack	*Scomberoides* spp.	R	R	R	R	R	R	R
Rainbow runner	*Elegatis bipinnulata*	R	C	C	O	C	R	R
Miscellaneous								
Mahi mahi	*Coryphaena hippurus*	R	C	C	O	O	R	R
Ocean triggerfish	*Canthidermis maculatus*	R	O	O	R	R	R	R
Tripletail	*Lobotes surinamensis*	R	R	O	R	R	R	R

Notes

1. Sources: Regional Tuna Tagging Project (RTTP), Skipjack Survey and Assessment Programme (SSAP), RTFD.
2. R = rare, O = occasional, C = common.

Table 5.4: Frequency of occurrence of by-catch species taken from unassociated (n = 3838) and log-associated (n = 148) schools during the Skipjack Survey and Assessment Programme

Species	Unassociated schools			Log-associated schools		
	Frequency	No. poled	% frequency	Frequency	No. poled	% frequency
Dogtooth tuna	4	9	0.1	–	–	–
Frigate tuna	65	162	1.7	6	63	4.1
Kawakawa	58	278	1.5	8	147	5.4
Mahi mahi	20	12	0.5	21	44	14.2
Rainbow runner	109	563	2.8	32	244	21.6

Notes

1. 'Unassociated' category includes SSAP categories for bird, shark, turtle, marlin/billfish, anchovy/baitfish and no association.

2. 'Log-associated' category includes SSAP categories for log, debris/flotsam, floats/balls/buoys and FAD-associated schools.

Table 5.5: Frequency of occurrence of by-catch species taken from unassociated, anchored FAD and log-associated schools by the *Te Tautai* during the Regional Tuna Tagging Project

Species	Unassociated		Anchored FAD		Log	
	Frequency	% frequency	Frequency	% frequency	Frequency	% frequency
Frigate tuna	12	1.9	22	8.7	5	3.4
Kawakawa	26	4.0	8	3.2	6	4.0
Mahi mahi	2	0.3	49	19.3	19	12.8
Ocean triggerfish	–	–	1	0.4	13	8.7
Rainbow runner	18	2.8	55	21.7	47	31.5

Table 5.6: Number of by-catch species poled from the *Te Tautai* during the Regional Tuna Tagging Project, by school association

Species	Unassociated	Seamount	Island/ reef	Current line	Whale/ whale shark	Vessel	Log	Drifting FAD	Anchored FAD
Amberjack	2	–	–	–	–	–	4	–	–
Bigeye trevally	–	–	–	–	–	–	52	–	–
Frigate tuna	69	7	1	–	–	–	9	1	94
Kawakawa	453	13	18	20	1	–	45	–	34
Longtail tuna	82	–	–	–	–	–	–	–	–
Mackerel scad	3	–	–	–	–	–	–	–	–
Mahimahi	–	–	5	–	2	–	190	10	327
Ocean triggerfish	–	–	–	–	–	–	65	1	11
Rainbow runner	170	83	15	4	–	–	679	130	584
Shark (*Carcharhinus* spp.)	–	–	–	–	–	–	1	–	3
Wahoo	–	–	–	–	–	–	1	–	–

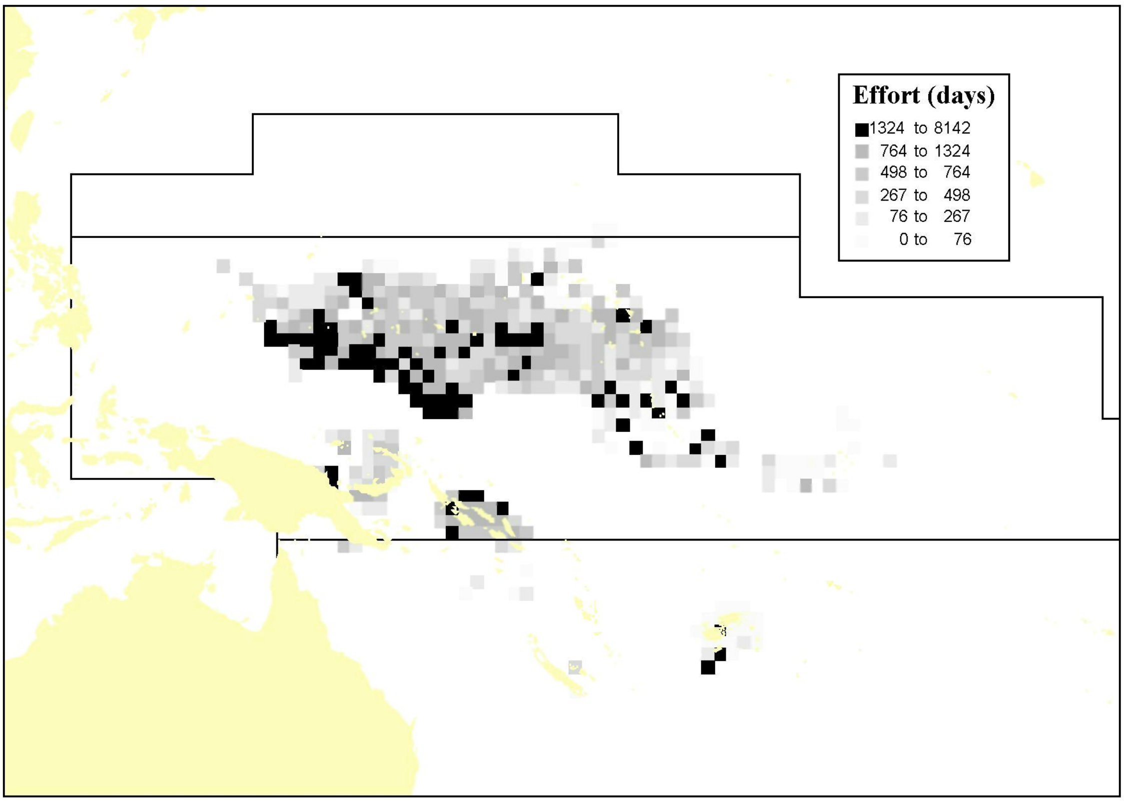


Figure 5.1: Distribution of effort (in days fishing and searching) reported for commercial pole-and-line vessels, 1979–1993

(Source : SPC/FFA Regional Tuna Fisheries Database (RTFD))

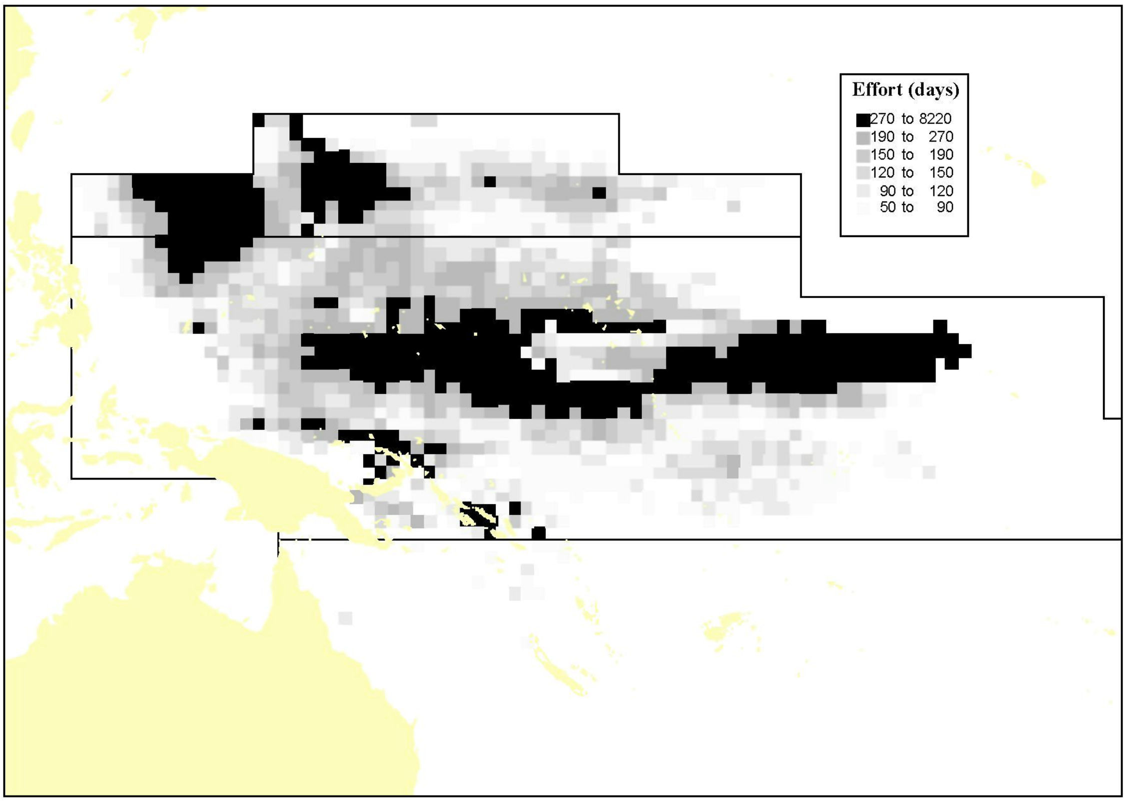


Figure 5.2: Distribution of effort (in days fishing and searching) for Japanese pole-and-line vessels operating in the WTP, WSP and WSPn, 1972–1990

(Source : Aggregated statistics provided by the Fisheries Agency of Japan)

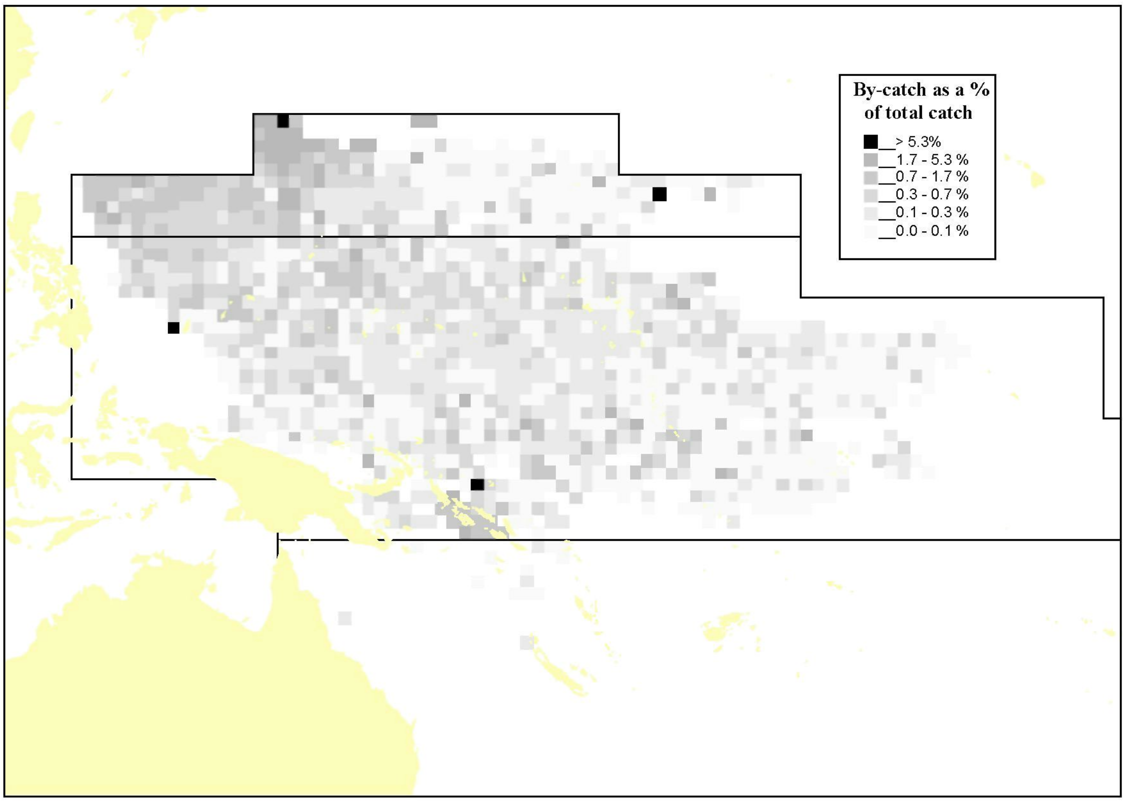


Figure 5.3: Distribution of by-catch (as percentage of total catch) reported by Japanese pole-and-line vessels operating in the WTP, WSP and WSPn, 1972–1990

(Source of data : Aggregated statistics provided by the Fisheries Agency of Japan)

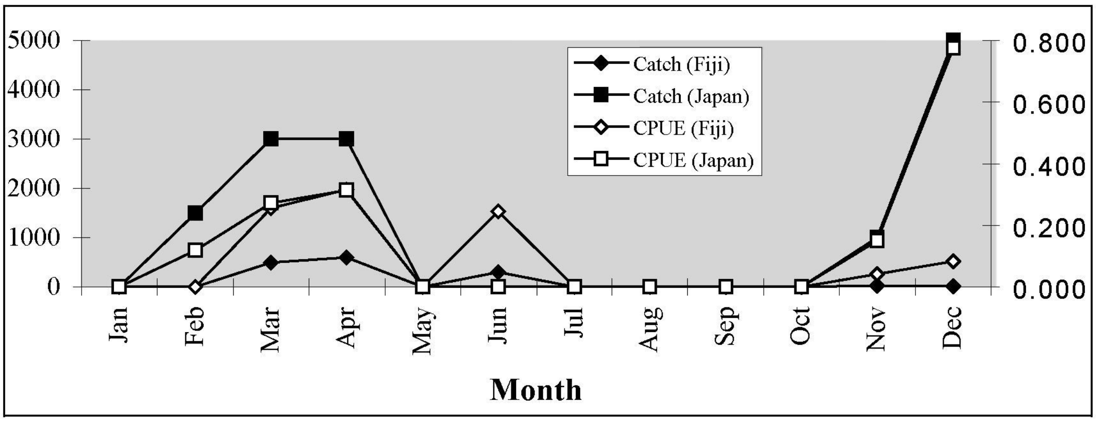


Figure 5.4: Seasonal pole-and-line catch (left axis) and CPUE (right axis) for frigate tuna in the WPO, 1979–1993
(Source of data: RTFD)

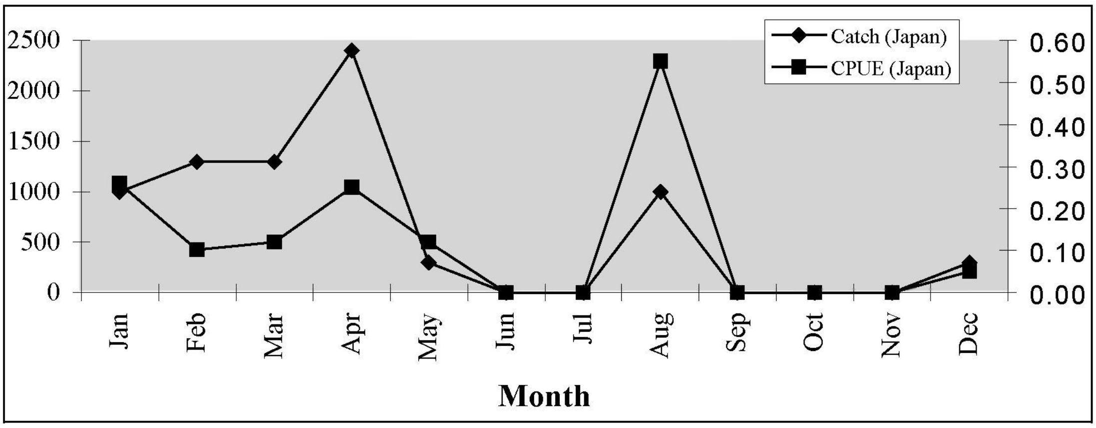


Figure 5.5: Seasonal pole-and-line catch (left axis) and CPUE (right axis) for mahi mahi in the WPO, 1979–1993
(Source of data: RTFD)

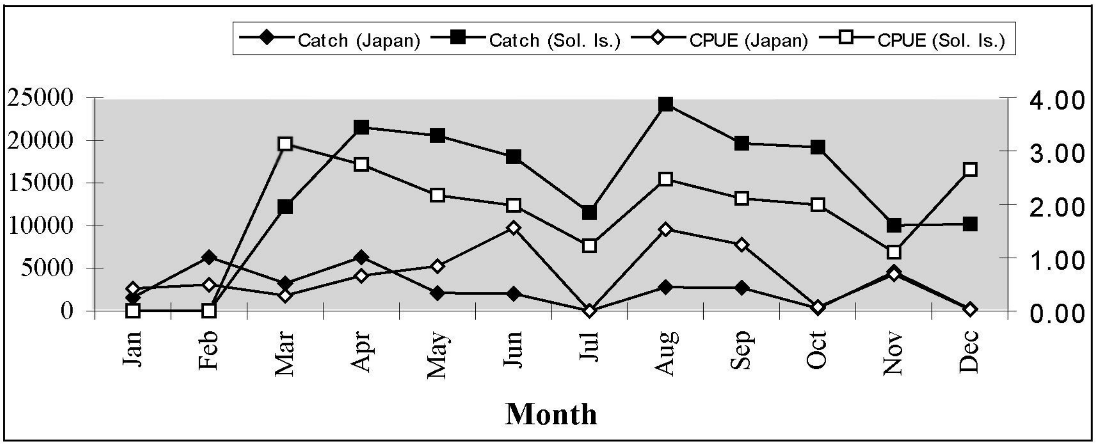


Figure 5.6: Seasonal pole-and-line catch (left axis) and CPUE (right axis) for rainbow runner in the WPO, 1979–1993
(Source of data: RTFD)

Section 6

TROLL FISHERY

6.1 OVERVIEW OF THE WESTERN PACIFIC TROLL FISHERY

6.1.1 Summary of the fishery

A single troll fishery targets juvenile albacore (< about 90 cm fork length) in the WTeP from November to May. Two principal grounds are fished: the coastal waters of New Zealand, particularly along the west coast of the South Island, and the Subtropical Convergence Zone (STCZ) to the east of New Zealand; to a lesser extent, there is some activity in the Tasman Sea off the south-east coast of Australia. Most fishing is concentrated in the latitudinal band of 35°–45°S, where sea-surface temperatures and the formation of temperature fronts during the summer months tend to concentrate albacore (Figure 6.1). The fishery employs standard US North Pacific troll gear and consists largely of New Zealand and US vessels. Small numbers of vessels from Canada, French Polynesia and Fiji also participate. The New Zealand grounds have been fished since the late 1960s and provide annual catches of 2,000–4,000 mt during warm, calm seasons, dropping to less than 1,000 mt during cold and windy seasons (Murray 1990). Vessels from the United States first operated in the STCZ during the 1985–86 season; since then the fishery has greatly expanded, with many vessels moving south from the depressed North Pacific albacore troll fishery. Catches from the STCZ exceeded 3,000 mt per season from 1987–88 to 1991–92. A noticeable drop in effort by the US fleet operating in the STCZ during the 1992–93 season, and again in the 1993–94 season, indicates that the catch levels of previous seasons have not been maintained (Coan pers. comm.). In the 1990–91 season, the total troll fleet numbered more than 280 vessels, of which 229 were from New Zealand and 58 from the United States; the estimated catch of albacore was 8,437 mt, of which 30 per cent was taken by NZ vessels, mostly working in NZ waters, and 65 per cent by US vessels, concentrating in the STCZ (Lawson 1992a; Lawson 1993).

6.2 SOURCES AND COVERAGE OF DATA

As there are no data in the Regional Tuna Fisheries Database or in the associated South Pacific Albacore Research (SPAR) database on by-catches and discards of the troll fishery, the following description has relied on data collected by SPC and NZ observers over the period 1988–1992; a series of published reports from that observer programme (Hampton et al. 1989, 1991; Labelle & Murray 1992; Labelle 1993a) and unpublished cruise reports of the NZ MAF research vessel *Kaharoa*. Catch-and-effort data from the New Zealand fishery are not readily available, and although there is provision for recording of by-catch and discards on the logsheets in use, these sections are very rarely completed by the fishermen (T. Murray pers. comm.). US fishermen involved in the STCZ fishery complete logbooks for the National Marine Fisheries Service (NMFS) on a voluntary basis but by-catch and discard entries are very limited and inconsistent (A. Coan pers. comm.).

During the 1991–92 season, an exploratory survey of albacore resources present in south-east Australian waters was carried out by two Australian troll vessels (Chapman et al. 1992). The results of this survey are incorporated here.

6.3 BY-CATCH AND DISCARDS OF BY-CATCH

6.3.1 Gross levels of by-catch and reporting

Levels of by-catch in the troll fishery are typically very low, in most recorded instances comprising less than 5 per cent of the total catch and often less than 1 per cent (Table 6.1). By-catch levels appear to be higher in the coastal waters of New Zealand and Australia than in the oceanic expanse of the STCZ, with levels in New Zealand ranging from 0.2–94.1 per cent of the total catch, in number, compared with 0.1–5.0 per cent in the STCZ. The by-catch levels attributed to NZ MAF and Laurs et al. (1986) should be treated with caution because they are derived from research vessels that often used different gear from the commercial vessels (e.g. single hooks rather than standard double barbless hooks), fished in areas and times on the periphery of the main grounds and most productive months (January–March), had inexperienced crews, and rigid schedules that did not allow for extensive searching and fishing activity. In this sense, the by-catch levels recorded by SPC observers on commercial vessels are probably most representative of the fishery, particularly in the latter years of the programme as observer coverage increased. In the 1989–90, 1990–91 and 1991–92 STCZ seasons (seasons run from September to May, the following year), by-catch levels ranged from 0.1–0.4 per cent of the observed catch. The peak of 0.4 per cent recorded for the 1991–92 season can be attributed partly to increased coverage but also to the fact that albacore catches were poor, thereby forcing vessels to search further to the north and east than in previous seasons (P. Sharples, pers. comm.). In the New Zealand fishery, by-catch equalled 1.7 per cent of the total observed catch to the north of the main (west coast of the South Island) ground at the start of the season and 0.2 per cent on this ground near the end of the season (Table 6.1).

The relatively high by-catch level reported during the south-east Australian survey (30.6%) is indicative of the areas and periods in which the vessels operated, with considerable proportions of the by-catch occurring in New South Wales waters in the early and late months of the survey (Chapman et al. 1992).

6.3.2 Species of by-catch

6.3.2.1 General

A variety of coastal and oceanic pelagic fish species are taken as by-catch, including three species of shark, six species of scombrid and two species of billfish (Table 6.2). Skipjack are by far the most common species of by-catch on all three grounds, often comprising over 70 per cent of the by-catch items (SPC and NZ MAF data). Much of the skipjack catch occurs to the north of the main albacore grounds, usually during transits to and from home or unloading ports or while searching for albacore, presumably because of this species' preference for slightly warmer water than albacore (≥20°C rather than 17°–19°C). As mentioned above, the 1991–92 STCZ season saw vessels searching further afield than in previous seasons and resulted in substantial increases in the levels of by-catch and skipjack by-catch.

A number of other warm-water species are caught to the north of the main grounds, albeit in small numbers; these include mahi mahi, yellowfin tuna and wahoo.

The yellowtail kingfish is the most frequently occurring by-catch species after skipjack, being common in the coastal waters of New Zealand, particularly over seamounts and banks. This species is also taken in the STCZ, but in much smaller numbers. Ray's bream can be a common by-catch species on the west coast South Island ground, being caught in the early morning and late afternoon as they rise to the sea surface; during one research cruise in this area, 95 per cent of the 159 by-catch items consisted of this species (NZ MAF data).

A number of the unusual catches in the STCZ came from fishing around floating logs; these include the bluenose, juvenile hapuku and violet warehou. Juvenile hapuku have also been caught while trolling over the Chatham Rise to the east of the South Island (NZ MAF data).

Few of the by-catch species taken in New Zealand or the STCZ are of sufficient value to retain. Thus, most by-catch is discarded. Relatively valuable species, such as yellowfin tuna caught to the north of the STCZ ground during transit, may be retained for sale if the vessel is heading to port for unloading, e.g. Yen and Wrobel (1988) note that one vessel travelling to Papeete at the end of the 1987–88 STCZ season caught substantial numbers of yellowfin in low latitudes (18°–28°S). Some of the more palatable by-catch species, such as shortbill spearfish, juvenile hapuku and mahi mahi may be kept for crew consumption. Skipjack are largely discarded. In the Australian fishery, significant by-catches of skipjack and yellowfin were made in the northern part of the survey area and retained for sale.

6.3.2.2 Billfish

Billfish are known to strike trolling gear occasionally. This can be a relatively common occurrence in New Zealand during warm summers when sea-surface temperatures on the albacore ground exceed 19°C. During the 1988–89 season, for example, there were numerous sightings of 'marlin' on the west coast South Island ground

(K. Bailey pers. obs.). There are few recorded instances of marlin being landed by troll vessels because they usually break the gear before the vessel can be slowed or more line attached to play the fish (Labelle 1993a, K. Bailey pers. obs.). In the 1988–89 STCZ fishery, a 'small' blue marlin was landed and two others brought alongside the vessel before they were able to break the lines and escape (P. Sharples pers. comm.). There are also instances of shortbill spearfish being landed; three specimens were caught in the STCZ in the 1989–90 season, two of which weighed 20 kg each (SPC data). This species is also caught in the New Zealand fishery, although rarely (T. Murray pers. comm.). An SPC observer who has participated in the STCZ fishery for four seasons (1988–89 to 1991–92) considers that between 5 and 10 hook-ups of billfish occur each season, of which 1 or 2 may be landed (P. Sharples, pers. comm.).

6.3.2.3 Seabirds

Seabirds, particularly Australasian gannets, mollymawks and wandering albatrosses, often show an interest in troll lures and on rare occasions are capable of catching the lures and becoming hooked. Over the four seasons covered by the SPC observer programme (>4,000 observed days), five mollymawks were caught in the STCZ fishery, three of which were retrieved, unhooked and released alive with little apparent damage apart from punctures in the bill. The other two birds had swallowed the hooks and died (SPC data; P. Sharples pers. comm.). A sixth bird, an albatross, was caught by one of the Australian survey vessels and released alive (M. Labelle, pers. comm.). Surveys by the *Kaharoa* in New Zealand waters caught similar low numbers of seabirds, all of which were released alive (K. Bailey pers. obs.).

6.3.2.4 Marine reptiles

There are no records of marine reptiles being caught by trolling gear (P. Sharples pers. comm.). Most sea turtles are tropical and sub-tropical dwellers and are unlikely to venture into water below about 20°C (Márquez 1990). The leatherback turtle is known to move into higher latitudes and colder water, but its apparent preference for jellyfish, tunicates and other slow-moving invertebrates probably means that it will not respond to troll lures.

6.3.2.5 Marine mammals

There are no records of marine mammals being caught by trolling gear in either the New Zealand or the STCZ fisheries (Labelle 1993a). Common dolphin have been observed swimming close to deployed gear in New Zealand but on no occasions were the lures attacked (K. Bailey pers. obs.). Marine mammals appear to be rare in the STCZ (Hampton et al. 1989; Sharples et al. 1991), so that the chances of them being caught are probably even less than on the New Zealand grounds.

6.3.3 Seasonality of by-catch

Since the troll fishery in New Zealand and the STCZ is seasonal, so too is the by-catch. Within-season effects on by-catch are largely dependent on where and at what time vessels are operating. For example, the survey of the Australian south-east coast yielded high by-catches of yellowfin and skipjack in New South Wales waters from September to November, but these declined in favour of the target species in December (Chapman et al. 1992). Similarly, skipjack by-catch in northern New Zealand can be high in relation to albacore catch in November and December (NZ MAF data). Much of the by-catch of skipjack around New Zealand and in the STCZ occurs at the beginning and end of each fishing season, as the troll vessels pass through warmer water than those preferred by albacore, and also during the season while transiting to and from unloading ports. Coastal species are usually taken when vessels fish close to shore, which may be in response to temperature fronts or influxes of oceanic water that are seasonal in nature.

The possible effect of the 1991–92 El Nino/Southern Oscillation event on by-catch levels in the 1991–92 season cannot be discounted; lower-than-normal temperatures were experienced in the latitudes usually fished in the STCZ; albacore catches were poor and vessels expanded their searching area. As mentioned above, this resulted in an increase in by-catch levels over earlier seasons.

6.3.4 Estimates of by-catch

No estimates of the by-catch of the troll fishery are attempted because of the limited data available.

6.4 TUNA DISCARDS

6.4.1 Tuna discard levels

Albacore are discarded by accident during hauling or deliberately because they are too small for canning or damaged by sharks. The troll fishery is unique in that many of the discarded fish are alive when they escape or are shaken off the hooks, although the extent of their injuries and chances of survival after the encounter are unknown. Labelle (1993a) noted that less than 0.1 per cent of albacore examined for mouth damage had healed injuries that might have resulted from previous encounters with troll gear.

Accidental drop-offs or escapement occur within seconds of a fish being hooked if the vessel is trolling too fast, as the fish is hauled to the boat, or as it is lifted out of the water and onto the deck. Labelle and Murray (1992) and Labelle (1993a) provide some information of the level of escapement in the WPO troll fishery. Even though accidental drop-offs occur frequently in this fishery and it has been possible to quantify these to some extent, they would normally be considered as retained target catch, so the level of escapement in the troll fishery has not been included in this review.

Albacore below 9 lb in weight (i.e. ~4 kg and <57 cm fork length) are often discarded in New Zealand and the STCZ in favour of larger fish because of price differentials set by the canneries. These small fish, known as 'cokes' or 'shakers' amongst most fishermen, are shaken off the hooks at the end of hauling. While they are usually alive at this point, the extent of their injuries and effect on survival are unknown. In the 1988–89 STCZ season, 5.5 per cent of the observed catch measured <57 cm, however, only 1.2 per cent were recorded as being discarded (SPC data). The observed discard rate of small fish in the 1990–91 season amounted to 1.7 per cent (Labelle & Murray 1992). During the following season the discard rates on two vessels were closely monitored and revealed daily rates of up to 47 per cent and an overall rate for the two vessels combined of 7 per cent (Labelle 1993a). This rate may not be representative of that season as observers noted that small albacore were often retained simply because the catches were poor (P. Sharples pers. comm.).

Small numbers of albacore are discarded because of damage caused by large pelagic sharks, such as the blue shark, during hauling. In the 1989–90 season, 0.02 per cent of albacore examined by SPC observers were discarded because of such damage, with the highest rejection rate occurring in northern New Zealand (0.17% of examined albacore) and the lowest (0%) in the Tasman Sea (Hampton et al. 1991). The rejection rate in the STCZ was 0.01 per cent. Damage inflicted by cookie cutter sharks occurred in the Tasman Sea and around New Zealand (0.48 and 0.39 per cent of examined albacore respectively) but not in the STCZ. In all recorded cases the damage was sufficiently minor for the albacore to be retained (Hampton et al. 1991). Labelle (1993a) noted that the occurrence of shark damage had not exceeded 0.2 per cent of examined albacore in any season since 1988–89.

6.4.2 Seasonality of tuna discards

Observer recorded drop-off rates for the 1990–91 and 1991–92 seasons both show a steady decline over the January–March period, followed by an increase, most pronounced in the latter season, in April and a second decline in May as the seasons come to an end (SPC data). This trend is interesting in that it tends to parallel the presence of small albacore in the fishery (e.g. Murray and Bailey 1986, Hampton et al. 1991) and lends support to the view that small albacore are more likely to drop-off the hooks than larger fish. One vessel monitored in the 1991–92 STCZ season had a small-albacore discard rate of 21.2 per cent in January; it dropped to 12.3 per cent in February and 0.5 per cent in March (SPC data). This particular vessel did not have an observer on board in April.

6.4.3 Estimates of tuna discards

No estimates are made of tuna discards in the fishery.

6.5 COMPARISONS WITH OTHER TROLL FISHERIES

A seasonal troll fishery for albacore, using identical gear and similar vessels to the South Pacific fishery, has existed in the North Pacific since the early 1900s. Although this fishery has been extensively researched and documented there appears to be no substantive literature on by-catch and discards. It appears from a NMFS observer programme that the fishery has a similar range of by-catch species to the South Pacific, including skipjack, yellowfin, shortbill spearfish, striped marlin, rainbow runner, and mahi mahi, and discarding of small albacore is known to occur (Rensink & Miller 1992).

6.6 CONCLUSIONS

The major conclusions of this investigation of by-catch and discards in the WTeP albacore troll fishery are as follows:

(a) By-catch in the fishery is low, typically less than five per cent of the total catch on New Zealand grounds and less than one per cent in the STCZ. Much of the by-catch is taken to the north of the main fishing grounds as vessels move to and from ports at the beginning and end of seasons and during unloading calls.

(b) A total of 25 species of by-catch has been recorded in the fishery, including three species of shark, six species of scombrid, and two billfish species. Skipjack is the most common species on both grounds, often comprising over 70 per cent of by-catch. Yellowtail kingfish and Ray's bream can be common on the New Zealand grounds, the former species close to shore and the latter beyond the continental shelf in the early morning and late afternoon. Unusual species such as violet warehou, hapuku and bluenose have been caught in association with drifting logs in the STCZ. Most by-catch species are discarded because of low market value in comparison with albacore. Valuable species such as yellowfin tuna may be retained.

(c) Billfish are rarely caught and in most cases are able to escape by breaking the troll gear; small billfish such as shortbill spearfish appear to be the only ones capable of being landed with the gear. Seabirds often show an interest in troll lures but few are ever caught; of those that are, most are released alive with little apparent damage. There are no records of marine reptiles or mammals being taken with troll gear.

(d) Albacore weighing less than about 4 kg (57 cm) are often shaken off the hooks and returned to the sea alive. The limited information available on this deliberate 'high grading' of catch suggests that less than two per cent of a season's catch is discarded because of size. The extent of the injuries suffered by the drop-offs and small discarded fish and their chances of survival are unknown. Negligible numbers of albacore are discarded because of shark damage.

Table 6.1: Levels of target catch and by-catch in the WTeP albacore troll fishery

Area	Period	Total catch (no.)	Target catch (%)	By-catch (%)	Source
Australia					
South-east	Sep. 1991 – Jul. 1992	11779	69.4	30.6	Chapman et al. 1992
South-east	Jan. 1992	223	49.8	50.2	NZ MAF (*Kaharoa*)[1]
New Zealand					
North North I.	Nov.–Dec. 1984	611	32.2	67.8	NZ MAF (*Kaharoa*)
West South I.	Feb.–Mar. 1985	760	79.1	20.9	NZ MAF (*Kaharoa*)
East North I.	Apr. 1985	659	5.9	94.1	NZ MAF (*Kaharoa*)
North North I.	Oct. 1985	39	41.0	59.0	NZ MAF (*Kaharoa*)
Chatham Rise	Feb. 1986	193	95.5	4.5	NZ MAF (*Kaharoa*)
North-west North I.	Mar. 1986	397	25.4	74.6	NZ MAF (*Kaharoa*)
North-west North I.	Nov.–Dec. 1986	514	89.1	10.9	NZ MAF (*Kaharoa*)[1]
Chatham Rise	Feb. 1987	602	94.4	5.6	NZ MAF (*Kaharoa*)[1]
South-east North I.	Jan. 1988	430	95.6	4.4	NZ MAF (*Kaharoa*)[1]
North-west North I.	Feb. 1988	584	99.8	0.2	NZ MAF (*Kaharoa*)[1]
Chatham Rise	Feb.–Mar. 1988	107	100.0	0.0	NZ MAF (*Kaharoa*)[1]
West South I.	Jan.–Feb. 1989	1735	96.8	3.2	NZ MAF (*Kaharoa*)[1]
West North I.	Nov.–Dec. 1989	6889	98.3	1.7	SPC
Central Tasman	Feb.–Mar. 1991	920	95.4	4.6	NZ MAF (*Kaharoa*)[1]
West South I.	Mar. 1992	479	99.8	0.2	SPC
STCZ	Feb. 1986	181	95.0	5.0	Laurs et al. 1986
	Mar.–Apr. 1988	22646	99.3	0.7	Yen & Wrobel 1988
	Mar.–Apr. 1989	2940	98.6	1.4	SPC
	Jan.–Apr. 1990	47063	99.8	0.2	SPC
	Dec. 1990 – Apr. 1991	41785	99.9	0.1	SPC
	Dec. 1991 – Apr. 1992	54839	99.6	0.4	SPC

Notes

1. Single barbless hooks were used for tagging purposes during these cruises.

Table 6.2: By-catch species from the WTeP albacore troll fishery

Species	Australia	New Zealand	STCZ
Cephalopods			
Arrow squid (*Nototodarus sloani*)	–	R	R
Unidentified squid	–	–	R
Sharks			
Blue shark (*Prionace glauca*)	–	–	R
Mako shark (*Isurus oxyrhinchus*)	–	R	–
Thresher shark (*Alopias vulpinus*)	–	–	R
Scombrids			
Blue mackerel (*Scomber australasicus*)	–	R	–
Skipjack (*Katsuwonus pelamis*)	C	C	C
Slender tuna (*Allothunnus fallai*)	–	R	–
Southern bluefin tuna (*Thunnus maccoyii*)	R	–	–
Wahoo (*Acanthocybium solandri*)	–	–	R
Yellowfin (*T. albacares*)	C	R	–
Billfish			
Blue marlin (*Makaira mazara*)	–	–	R
Shortbill spearfish (*Tetrapturus angustirostris*)	–	R	R
Other fish	–	C	–
Barracouta (*Thyrsites atun*)	–	–	R
Bluenose (*Hyperoglyphe antarctica*)[1]	–	R	R
Hapuku (*Polyprion oxygeneios* juvenile)	–	C	–
Kahawai (*Arripis trutta*)	–	R	R
Mahi mahi (*Coryphaena hippurus*)	–	C	–
Ray's bream (*Brama brama*)	–	–	R
Violet warehou (*Seriolella labyrinthica*)	–	C	R
Yellowtail kingfish (*Seriola lalandi*)			
Seabirds	–	R	–
Australasian gannet (*Sula serrator*)	–	R	R
Mollymawks (unid. *Diomedea* spp.)	–	R	–
Sooty shearwater (*Puffinus griseus*)	R	R	R
Wandering albatross (*Diomedea exulans*)			

Notes

1. Identification not positive.

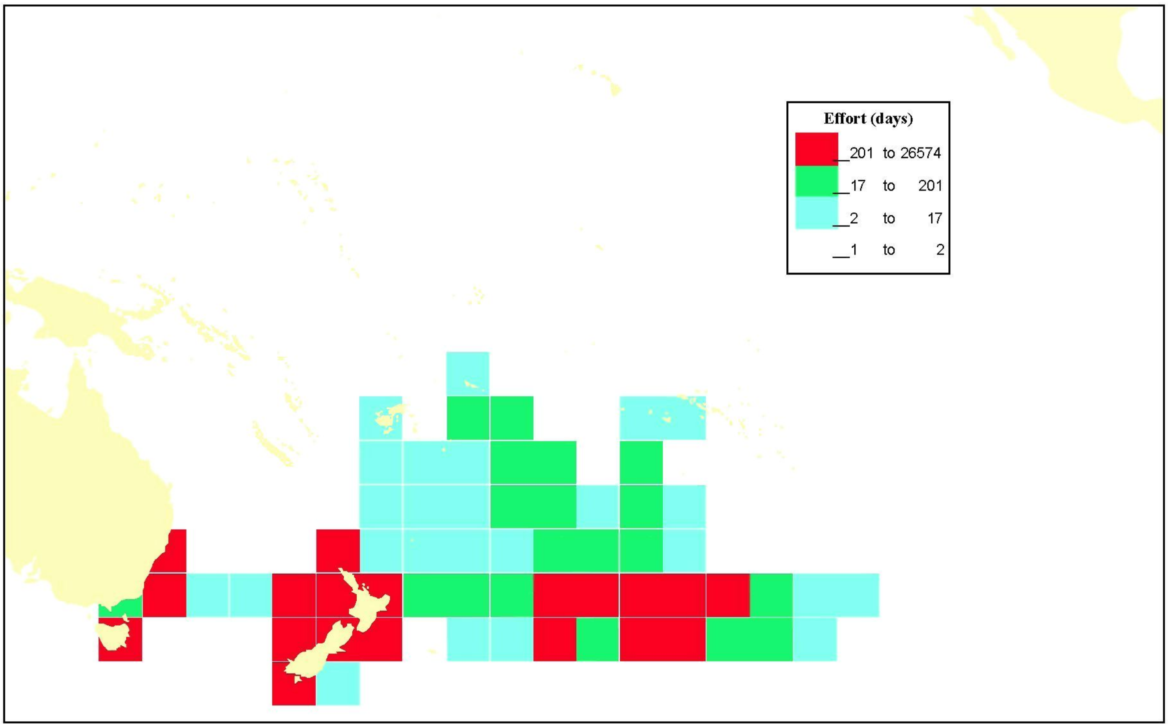


Figure 6.1: Distribution of effort (in days fishing and searching) reported for commercial troll vessels, 1982–1992

(Source : South Pacific Albacore Research Group (SPAR) database)

Section 7

DRIFTNET FISHERIES

7.1 OVERVIEW OF THE WESTERN PACIFIC DRIFTNET FISHERY

A large-scale, large-mesh driftnet fishery targeted albacore in the western temperate Pacific (WTeP) from 1983 to its closure in 1991 following a UN resolution banning the use of such nets in all oceans. The fishery was initiated by Japanese vessels, many of which had been displaced from North Pacific fisheries for squid and salmon, and joined by Taiwanese vessels in the 1987–88 season. Driftnets were typically 30–40 km long with stretched-mesh sizes of 165–220 mm. The fishing season lasted from November to April, with highest catches in January and February and effort concentrated in the mid-Tasman Sea and the Subtropical Convergence Zone (STCZ) east of New Zealand (Figure 7.1). During the peak season of 1988–89, 65 Japanese, 71 Taiwanese and one Korean vessel caught an estimated 21,955 mt of albacore (Lawson 1992a).

Mounting pressure from FFA member countries regarding the effects of this fishery on the albacore stock and by-catch species, followed by the drive at the United Nations to ban the use of large-mesh driftnets, resulted in Korea withdrawing from the fishery at the end of the 1988–89 season, followed by the Japanese after the 1989–90 season and the Taiwanese by mid-1991. This effectively brought the fishery to a close. It should be noted, however, that UN Resolution 44/225 states that the moratorium on this fishery can be lifted 'should effective conservation and management measures be taken ... to prevent the unacceptable impact of such fishing practices on the region and to ensure the conservation of the living marine resources of that region' (Hey et al. 1991).

In addition to the commercial driftnet fishery, there have been a number of Japanese driftnet surveys in the WPO, including a series of Japan Marine Resource Research Center (JAMARC) surveys targeting slender tuna and bramids (or pomfret, *Brama* spp.) in the WTeP from 1982 to 1987 and albacore in the WTep from 1987 to 1990 (JAMARC 1989; Watanabe et al. 1989); a trial operation in the tropical waters of the Federated States of Micronesia in 1989 (Goldblatt 1989); and exploratory fishing in the western Northern Marianas Islands, southern FSM and eastern Solomon Islands from 1984 to 1986 by the Tohoku Regional Fisheries Research Laboratory (Iizuka et al. 1989). The slender tuna and bramid surveys used a variety of large-mesh nets, ranging in mesh size from 118 to 200 mm. The WTP operations were overall resource surveys rather than being specifically aimed at tuna, and this is reflected in the smaller mesh sizes used (38 mm—Goldblatt; mostly 33–121 mm—Iizuka et al.).

7.2 SOURCES AND COVERAGE OF DATA

Neither the RTFD nor South Pacific Albacore Research (SPAR) databases contain data on by-catch or discard levels of the albacore driftnet fishery. The following description is therefore limited to published and unpublished reports, particularly that describing SPC observer work on the JAMARC driftnet survey vessel *Shinhoyo Maru* during the 1989–90 season (Sharples et al. 1991); a Greenpeace campaign carried out in the Tasman Sea in the same season (Coffey & Grace 1990); and working papers presented at SPAR workshops on commercial and survey catches of Japanese vessels (e.g. Nakano et al. 1989; Watanabe et al. 1989). No information is available on the by-catch of the Taiwanese and Korean fleets, although Greenpeace inspected the catches of one Taiwanese vessel during its Tasman Sea campaign. Brief mention is made of the various JAMARC and WTP surveys listed above.

7.3 BY-CATCH AND DISCARDS OF BY-CATCH

7.3.1 Gross levels of by-catch and discards

Available information on the catches of Japanese commercial driftnet vessels is summarised in Table 7.1, along with the results of JAMARC surveys. Commercial vessels were not required to report their catch to the Japanese Government; the commercial catches in Table 7.1 were taken from a sub-sample of 26 vessels that supplied data to the National Research Institute of Far Seas Fisheries and as such appear to only include those species that were retained for sale. Over a period of five fishing seasons, the monitored vessels achieved a target catch of 83.8 per cent of the total catch, with season ranges of 61.9–92.6 per cent. The by-catch consisted of skipjack (12.2%, with seasonal ranges of 3.3–30.7%), sharks (1.3%), billfish (0.3%) and other unspecified species (2.4%).

The 1987 and 1988 JAMARC albacore surveys are not directly comparable with the commercial fishery because the high percentages of slender tuna achieved during the surveys are not representative of the fishery. Thus, the *Shinhoyo Maru* survey of 1989–90 is probably the most comparable, although reservations have been voiced about the catching efficiency of this vessel (Anon. 1991). The *Shinhoyo Maru* had an overall target catch of 50.5 per cent of the total catch, and by-catch of 49.5 per cent. In the Tasman Sea area the target catch amounted to 29.1 per cent, with high by-catches of skipjack (35.1%) and bramids (32.9%). The latter species do not appear in the commercial catch in any great numbers (maximum of 2.4% of total catch) and appear to be discarded because of their low value (P. Sharples pers. comm.); removing them from the *Shinhoyo Maru* data raises the Tasman Sea target catch to 43.3 per cent. Bramids and skipjack were largely absent in the STCZ and target catch amounted to 97.4 per cent and by-catch to 2.6 per cent. The information collected on the *Shinhoyo Maru* suggests that by-catch was considerably higher in the Tasman Sea fishing area than in the STCZ. In this regard, it is unfortunate that the commercial data presented in Nakano et al. (1989) were not separated by fishing area.

The slender tuna and bramid surveys detailed in Table 7.1 show that slender tunas can be effectively targeted and bramids less so. By-catch levels can be considerable, although often containing a relatively high proportion of target species of other surveys. Albacore and skipjack by-catches were usually less than 10 per cent, while shark by-catch typically exceeded this level. Billfish levels were comparable to those in the albacore surveys and the commercial fishery.

Over half of the catch of the *Monju Maru* in FSM waters was tuna (55.3%), followed by sharks (20.4%), mahi mahi (5.9%) and billfish (4.6%); the vessel also had a significant catch of marine mammals (6.2%) (Goldblatt 1989). Sixteen per cent of the catch was discarded because of low market values, spoilage due to high water temperature and long soak-time, and shark-inflicted damage. Squid, coryphaenids, and flying fish dominated the catch of the Tohoku Laboratory surveys in the WTP, with tuna, particularly skipjack juveniles, comprising a minor part of the catch (Iizuka et al. 1989).

The term 'ghost-fishing' has been coined to describe the phenomenon of lost or discarded pieces of driftnet continuing to catch fish and other species for an indefinite period of time before disintegrating, sinking or being washed ashore. Little information is available on the frequency with which nets are lost or discarded or, in fact, if they continue to catch fish. US and New Zealand troll fishermen have reported sightings of such nets, and beach clean-ups in northern New Zealand have yielded large numbers of driftnet floats (Anon. 1991). SPC observer data list a number of occasions when nets set by the *Shinhoyo Maru* were almost lost during night-time hauling, particularly when adjacent nets became tangled and when first approaching nets for retrieval. That no nets were lost was a tribute to the skills and experience of the vessel's fishing master and crew. Damage to nets appeared to be a regular occurrence during the observer cruises and sections of net were often put to one side for untangling or repair.

7.3.2 By-catch species

7.3.2.1 General

Driftnets in the WTep caught a broad spectrum of epipelagic and mesopelagic species consistent with a fishing method that operated in the upper 10–12 m of the sea from mid-afternoon to early morning.

Sharples et al. (1991) and Coffey & Grace (1990) list a total of 48 species caught in the WTeP, consisting of five species of cephalopods, eight species of sharks and rays, six species of scombrid (including albacore), four billfish species, 18 other fish species, one species each of marine reptile and seabird and five species of marine mammals (Table 7.2). The variety of species caught in the two main fishing areas, the Tasman Sea and the

STCZ to the east of New Zealand was markedly different, with the absence in the STCZ sample of 29 species found in the Tasman Sea presumably reflecting the distance this ground is from productive continental waters. Five species present in the STCZ were absent from the Tasman Sea catches.

Goldblatt (1989) lists at least 21 species taken in FSM waters, including three species of tuna and at least three species of billfish (Table 7.3). Iizuka et al (1989) provide a comprehensive list of 75 species taken in the Tohoku Laboratory surveys (including about 24 species of flying fish) that appears consistent with the small-mesh nets that were used.

7.3.2.2 Tunas

Skipjack dominated the tuna by-catch in both areas, but especially so in the Tasman Sea where it made up 35.1 per cent of the total catch at a rate of 11 fish per km of net observed on the *Shinhoyo Maru*. High catches were also recorded in the commercial fishery (3.3–30.7% per season). Bigeye, yellowfin, slender tuna and butterfly tuna were rarely taken. Southern bluefin did not occur in the *Shinhoyo Maru* catch but comprised a small part of the commercial catch; in one season 457 southern bluefin were caught by nine vessels (0.2% of season's catch), but it appears that the catch of this species was usually much lower.

Most tuna landed on the *Shinhoyo Maru* and commercial vessels were retained, although some commercial vessels are known to have discarded skipjack (P. Sharples pers. comm.). The lack of slender tuna records in the commercial catch suggests that this species was probably discarded.

An experimental net, designed to fish from 2 to 14 m below the surface rather than the standard surface-to-12 m, was deployed during 19 of the 22 sets made by the *Shinhoyo Maru* in the Tasman Sea. The net was used to test whether catches of skipjack and by-catch, particularly marine mammals, could be reduced without affecting the catch of albacore. The results of this admittedly limited experiment (Table 7.4, from Sharples et al. 1991) showed that the net caught significantly fewer skipjack than adjacent standard nets, without prejudicing albacore catch. In addition, no marine mammals, cephalopods, turtles or seabirds were caught in the net. The experimental net was also deployed in the STCZ, but catch data were not collected by the observer apart from the fact that no marine mammals were caught in it.

7.3.2.3 Sharks and rays

Sharks and rays comprised 0.6 per cent of the *Shinhoyo Maru* catch and 1.3 per cent of the commercial catch, with the dominant species being the blue shark (1.2% commercial, 0.3% *Shinhoyo Maru*) and the mako shark (0.2% *Shinhoyo Maru*). From the *Shinhoyo Maru* data, it appears that blue sharks are more common in the STCZ area than in the Tasman, with the opposite being the case for mako sharks. Commercial data include a small catch of salmon shark (seasonal range of 0.02–0.1% of catch) but this is presumably a mis-identification (possibly of the con-generic porbeagle shark) since the species is known only from to the northern North Pacific (Compagno 1984). Sharples et al. (1991) recorded the capture of one basking shark in the Tasman Sea; this particular animal broke free from the driftnet and swam away entangled in webbing. A Japanese scientist on the *Shinhoyo Maru* at the time said that this had been his first experience of basking sharks being caught in the fishery (P. Sharples pers. comm.). Sharks were usually finned and the bodies discarded; large mako sharks (>1.5 m) were retained, as is common in longline operations. Cookie cutter sharks and rays were discarded.

Sharks were a relatively common part of the *Monju Maru* catches in FSM waters (20.4% of total catch) but rare in the Tohoku Laboratory surveys. Goldblatt (1989) noted that shark catches increased noticeably the longer the nets were in the water, and suggested that this was evidence, along with the presence of numerous shark-damaged fish, that sharks were removing fish from the net.

7.3.2.4 Billfish

Billfish comprised 0.3 per cent of the commercial catch and 0.2 per cent of the *Shinhoyo Maru* catch, and were dominated by swordfish (0.1% commercial, 0.2% *Shinhoyo Maru*) and striped marlin (0.1% commercial, 0.1%

Shinhoyo Maru). Swordfish appeared to be a consistent part of the catch in both fishing areas, whereas striped marlin were more common in the Tasman Sea. Rarer catches included the blue and black marlins, and shortbill spearfish. Sailfish were also mentioned in Nakano et al. (1990), but no catch details were provided. All billfish were apparently retained for sale.

The WTP catches consisted of swordfish, sailfish, blue marlin and 'marlin', and made up 6.4 per cent of the *Monju Maru* catch and 0.2 per cent of the catch of the Tohoku Laboratory surveys.

7.3.2.5 Other fish species

A wide range of other fish species was caught in the WTeP. The majority (32.9% of *Shinhoyo Maru* catch) consisted of bramids belonging to the *Brama* genus, most of which were probably the Ray's bream (*Brama brama*). Bramids were usually kept on the *Shinhoyo Maru*, but appear to have been discarded on commercial vessels (Sharples et al. 1991). The remaining species were released or discarded, although small numbers of squid, sunfish and other fish species were kept for crew consumption.

In the WTP, Goldblatt (1989) recorded 7 species or groups of species that fall into the 'other fish' category, including jacks, triggerfish, flying fish, rainbow runner and barracuda. All of these groups contributed less than 0.5 per cent of the total catch. The Tohoku Laboratory surveys yielded 55 species of other fish, of which 24 were flying fish.

7.3.2.6 Seabirds

Seabirds appear to be rarely caught by driftnets. Two Westland black petrels were caught and drowned in the 22 driftnet sets made by the *Shinhoyo Maru* in the Tasman Sea, while no seabirds were observed in the 14 sets made in the STCZ or in the 25 nets observed by Greenpeace in the Tasman Sea (Sharples et al. 1991; Coffey & Grace 1990). The latter authors suggest that this absence may be due to the fact that the fish and squid caught in such large-mesh nets are too big for seabirds to feed on. No seabirds were recorded in the small- to large-mesh driftnets used in the WTP (Goldblatt 1989; Iizuka et al. 1989).

7.3.2.7 Marine reptiles

Sharples et al. (1991) reported three leatherback turtles caught during the *Shinhoyo Maru* operations in the Tasman Sea, two of which broke away from the driftnet during hauling while the third was landed, freed of netting and released. No turtles were caught in the STCZ or in nets observed by Greenpeace in the Tasman Sea (Coffey & Grace 1990). It is not possible to determine whether the turtle freed on the *Shinhoyo Maru* would have been retained if an observer had not been on board, although there are indications in other tuna fisheries that turtles are often released by Japanese fishermen (see Sections 3.3.3 and 4.3.2).

Goldblatt (1989) recorded a catch of 10 unidentified turtles in the 24 driftnet sets made by the *Monju Maru* in FSM waters, all of which were apparently retained on board, although there is no mention of whether the turtles were kept for sale or crew consumption. One hawksbill and one olive ridley turtle were caught in the eastern Solomon Islands during 16 sets made by the Tohoku Laboratory vessel; no turtles were caught in the other two areas (western Northern Marianas Islands and southern FSM) surveyed by this ship (Iizuka et al. 1989).

7.3.2.8 Marine mammals

Marine mammals taken in the WTeP driftnet fishery included 3 species of dolphins (the common, striped and Risso's dolphins), and 2 species of small whale (the short-finned pilot whale and the southern bottlenose whale). In the Tasman Sea, 45 common dolphins were caught by the *Shinhoyo Maru*, at an average rate of 2.1 per set and 0.064 per km of net (Sharples et al. 1991). The striped dolphin, a relatively rare visitor to the Tasman Sea, was the next most common capture, with 10 in the observer period at an average rate of 0.5 per set and 0.014 per km. Coffey & Grace (1990) reported an identical 'dolphin' catch rate to that of the common dolphin, although these authors appear to have miscalculated the rate, which should in fact be 0.055 dolphin per km (7 dolphins in 126 km of observed net). All the dolphin were dead on landing and on the *Shinhoyo Maru*, at least, were discarded.

Single specimens of short-finned pilot whale and southern bottlenose whale were caught in the Tasman Sea. The pilot whale was landed and discarded before the observer had a chance to examine it. However, it appeared that the whale was dead, otherwise there would have been some struggle in landing and releasing it. The bottlenose whale was released from the net while still in the water, and drifted off in an apparently exhausted state with 100–200 m of net wrapped around it.

The marine mammal catch observed in the STCZ consisted of 8 common dolphins (0.5 per set and 0.020 per km) and 1 Risso's dolphin, which suggests that marine mammals are less common in this area than in the Tasman Sea. This is supported by the low sightings made by SPC observers during four seasons of the albacore troll fishery. All specimens were dead on landing.

In the WTP, Goldblatt (1989) reported catches of 97 dolphins and 11 whales, none of which were identified to species. One whale was estimated to weigh several tons. These catches represent catch rates of 4.0 individuals per set and 0.167 per km of net for dolphins, and 0.5 individuals per set and 0.019 per km for whales. One set caught 9 of the 11 whales. The Tohoku Laboratory surveys yielded low catches of dolphins, including one rough-toothed dolphin (*Steno bredanensis*), but no whales (Iizuka et al. 1989).

7.3.3 Seasonality of by-catch

As there appears to have been some movement of vessels from the Tasman Sea to the STCZ as the season progresses, particularly in February and March, it is possible, based on *Shinhoyo Maru* data, that the varieties and quantities of by-catch declined with this movement. Such a decline cannot be quantified with the available data.

7.3.4 Estimates of by-catch

It is not realistic to estimate by-catch of the WTeP driftnet fishery with the available catch-and-effort data, although Coffey and Grace (1990) attempt to provide estimates based on few observer data.

7.4 TUNA DISCARDS

7.4.1 Tuna discard levels and reasons for discarding

Tuna discards in the driftnet fishery consisted of tuna escaping from the net during the soaking phase of the fishing operation, tuna 'dropping out' as the net was hauled from the water, and discards of net- and shark-damaged fish and small tuna that had little or no commercial value. Sharples et al (1991) noted that tuna caught in driftnets were all dead on landing, while those observed to drop from the net either floated on the surface or sank and were probably dead.

Observation of troll-caught fish with visible striations and cuts on their bodies that probably came from encounters with driftnets provide an indication of escapement. As in the other fisheries of the WPO, escapement is not considered as discard and therefore has been not described in this review. Hampton et al. (1989) provide some information of the possible levels of escapement.

During the peak driftnet season of 1988–89, 14.5 per cent of observed albacore caught in the STCZ troll fishery had driftnet marks, with unverified rates of 40–50 per cent and up to 90 per cent occurring during periods when troll and driftnet vessels operated in close proximity (Hampton et al. 1989). As driftnet effort decreased over the following seasons, the percentage of marked fish in the STCZ dropped from 12.3 per cent in 1989–90 to 2.5 per cent in 1990–91 and 1 per cent in 1991–92. The rates observed in the first two seasons suggest that escapement from driftnets and subsequent survival can be high, although it is apparent from the data that the size selectivity of the net can cause severe damage to fish of 63–71 cm fork length and that survival of these fish after escapement was considerably less than that of fish with minor damage (Hampton et al. 1989).

Drop-out rates of tuna from driftnets used by the *Shinhoyo Maru* in the Tasman Sea and STCZ are shown in Tables 7.5 and 7.6 respectively. These drop-out rates were observed at night and represent only those fish that were visible as the net left the water; thus they do not account for drop-outs outside the range of the lights or in the water as the nets were hauled. The observed drop-out rate for albacore in the Tasman Sea was 8.7 per cent, with a range for individual nets of 0–20.8 per cent. These rates include a small number of albacore that were subsequently recovered with gaffs. As there is no information on whether drop-out recovery is a common exercise on commercial driftnet boats, the calculated rates include the numbers recovered. The observed drop-out rate for skipjack was 4.9 per cent, with a range of 0–15 per cent. Coffey & Grace (1990) reported drop-out rates for tuna of 6–20 per cent from the catches of three nets observed by Greenpeace in the Tasman Sea.

The observed albacore drop-out rate for the *Shinhoyo Maru* in the STZC was 3.7 per cent of the observed catch, with a range of 0–8.1 per cent per net. The substantially lower drop-out rate experienced in the STCZ may have been related to the size of fish being caught, as the proportion of large fish (>70 cm) in the STCZ catch was much lower than in the Tasman Sea. Sharples et al. (1991) noted, however, that there appeared to be no obvious relationship between the average size of albacore caught in specific sets and the proportion of albacore dropping from nets deployed during those sets.

Sharples et al. (1991) suggested that drop-out rates may increase with deteriorating weather and sea conditions, but were unable to quantify this relationship with the limited data available. Another factor that may have influenced drop-outs was the direction of travel of albacore in relation to the lay and hauling direction of the net. On at least one occasion during the Tasman Sea operations of the *Shinhoyo Maru*, a high drop-out was thought to be due to a large number of fish entering the net from the side that faced down during hauling.

Small amounts of albacore and skipjack were deliberately discarded because of shark- and net-damage or because they were too small. Sharples et al (1991) found that 2.1 per cent of both albacore and skipjack landed and observed on the *Shinhoyo Maru* over seven sets were discarded because of damage, with shark damage accounting for 29 and 27 per cent of the discards of albacore and skipjack respectively and net damage the remaining percentages. These authors did not quantify the amount of small-tuna discards, although they noted that it was extremely low (and presumably related to the size selectivity of the net). As the *Shinhoyo Maru* was operating as a survey vessel with Japanese and SPC observers, it is not possible to determine whether the discard practices on board were typical of the commercial fleet. Coffey and Grace (1990) noted, for instance, that 15 out of 22 tuna (i.e. albacore and skipjack) landed on one commercial vessel in the Tasman Sea were discarded, although no mention was made of fish size or why the discards occurred.

No mention is made of the numbers of tuna that were discarded because of size, spoilage or shark damage, or dropped out of the net during hauling in the WTP surveys. Goldblatt (1989) noted that spoilage was high and suggested that an appreciable part of the stored catch was discarded before reaching the market because of this.

7.4.2 Seasonality of tuna discards

Sharples et al. (1991) noted that the drop-out rate of albacore declined markedly between fishing in the Tasman Sea from November to December and operations in the STCZ in February and March (see Section 7.4.2), and suggested that this may have been due to the lower proportion of large albacore (>70 cm) in the latter area.

7.4.3 Estimates of tuna discards

Estimates of tuna discards are not possible with the available data.

7.5 COMPARISONS WITH OTHER DRIFTNET FISHERIES

There is a considerable body of information available on driftnet fisheries outside the SPC statistical area, all of which is summarised in detail by Northridge (1991). Large-mesh driftnet fisheries similar to the WTeP fishery and targeting albacore, other tunas and billfish were carried out by Taiwanese vessels in the Indian Ocean, by Japanese, Taiwanese and US vessels in the North Pacific, by French vessels in the North Atlantic and by Italian vessels in the Mediterranean Sea. There is also evidence that Taiwanese vessels targeted tuna in the Atlantic Ocean on an opportunistic basis, particularly in the south-east Atlantic in the vicinity of the Tristan da Cunha group of islands (Northridge 1991; Ryan & Cooper 1991). There are also a large number of small-scale large-mesh fisheries, as in the Cote d'Ivoire and Ghana, and along the north-east coast of the United States. All of these fisheries report considerable amounts and varieties of by-catch of fish, seabirds, turtles and marine mammals.

The fisheries most comparable to the WTeP fishery, because of target species, gear used and latitudes fished, are those in the Indian Ocean and North Pacific. Unfortunately, information on the by-catch of these fisheries is extremely limited. In the Indian Ocean fishery, available information appears to be limited to retained species; thus over a four-season period, the catch comprised 90.7 per cent albacore (the target), 8.8 per cent other tuna and 0.5 per cent billfish (Northridge 1991). Sharks made up a large part of the catch in one season (24%) but were negligible in the following season (0.5%). No data are available on seabird, turtle and marine mammal by-catches.

No information is available on by-catch of the Taiwanese fishery in the North Pacific. From figures presented by Northridge, it appears that the Japanese fishery targeting albacore had a substantially lower target catch than the South Pacific (14–36% of total catch over 8 seasons c.f. 62–93% over 6 seasons), with higher by-catches of skipjack, tunas, and billfish. A total of 79 marine mammals belonging to at least 9 species were caught in 66 research sets made in the Japanese fishery, giving a catch rate of 1.2 per set; this compares to a catch rate of 1.8 for all marine mammals taken by the *Shinhoyo Maru*. A US fishery targeting swordfish and shark has been known to operate outside US waters and target albacore, but no information is available on by-catch during this targeting (Northridge 1991). Since 1990 the use of large-scale driftnets by US fishermen has been prohibited.

Other driftnet fisheries targeting albacore include the French fishery, which had an observed target catch of 90.5 per cent and by-catch of bluefin tuna (3.5%) and swordfish and sharks (6.0%) in 1989, and the Mediterranean fishery, which also targeted swordfish and had a by-catch of up to 44 species, although catch rates are unavailable (Northridge 1991). Both fisheries reported catches of marine mammals, but the incidence appears to have been much higher in the Mediterranean, where the annual cetacean catch was estimated at 3,000–5,000 animals (Di Natale 1989 cited in Northridge 1991). The Mediterranean fishery was closed in 1990.

A Taiwanese large-mesh driftnet fishery operated in the Timor and Arafura Seas, north of Australia, from 1974 and targeted sharks, spanish mackerel (*Scomberomorus* spp.) and longtail tuna (*T. tonggol*). The fishery was prohibited from operating in the Australian Fishing Zone (AFZ) in 1986 after reports of what were considered unacceptable levels of dolphin by-catch (0.033–0.088 dolphin per km of net, Northridge 1991). After that time the fishery operated to the north of the AFZ, but no information is available on by-catch, although Northridge (1991) suggests that the dolphin by-catch rate was probably similar to that achieved in Australian waters because of similar oceanographic conditions.

7.6 CONCLUSIONS

The major conclusions of this investigation of by-catch and discards in the WTeP large-mesh driftnet fishery are as follows:

(a) SPC observer coverage and Greenpeace surveys of Tasman Sea driftnet activity yielded similar catch rates for dolphin (0.078 animals per km of net observed by SPC, 0.064 or 0.055 per km by Greenpeace, depending on how the calculation was performed). SPC observers also noted the capture of two small whales, one of which may be rare. Dolphin catch rates in the STCZ were considerably less than in the Tasman Sea, at 0.022 animals per km. All dolphins were dead on landing. The small whales were released but both appeared to be in poor health. The marine mammal catch rates in the WTeP fishery are slightly higher than that of the Japanese fishery targeting albacore in the North Pacific and comparable to the catch rate of the Taiwanese fishery targeting shark, spanish mackerel and longtail tuna in the Timor and Arafura Seas.

(b) Drop-out rates of albacore during hauling amounted to 8.7 per cent of the observed catch on the *Shinhoyo Maru* in the Tasman Sea and 3.7 per cent in the STCZ; the difference between the two areas may have been related to the lower proportion of large fish in the STCZ. These drop-outs appeared to be dead. Various factors may influence drop-out rates, including weather conditions, the side of the net that fish swim into and orientation of that side during hauling. Unknown quantities of albacore (and other species) escape from the net during the soaking period and drop out during hauling but while the net is still in the water. An indication of albacore escapement can be seen in the presence of driftnet-marked fish in the adjacent troll fishery; at the peak of the driftnet fishery in 1988–89, 14.5 per cent of albacore observed in the troll fishery had such marks, with unverified rates of 40–50 per cent during periods when the two fisheries operated in close proximity.

(c) A number of driftnet surveys have been carried out in the WTP by Japanese vessels using small- to medium-mesh nets. One survey in FSM waters yielded a moderate catch rate of tuna (55.3% of total catch, 1.755 tuna per km of net) and relatively high catch rates of sharks (20.4%, 0.615 per km) and marine mammals (6.2%, 0.186 per km). This survey also had a discard rate rate of 16 per cent, much of which was due to spoilage in the high water temperatures of the tropics and shark damage. A group of surveys by the Tohoku Regional Fisheries Research Laboratory yielded high catches of squid, coryphaenids and flying fish and low catches of tuna and billfish.

Table 7.1: Target catch and by-catch of the large-mesh driftnet fishery of the WTeP and driftnet surveys of the WTP and WTeP

Fishery	Area	Total catch	Targetc atch (%)	By-catch (%)	Alba-core (%)	Skipjack (%)	Slender tuna (%)	Pomfret (%)	Billfish (%)	Shark (%)	Other (%)
Commercial albacore		**No.**									
1983–84 to 1987–88	33°–43°S, 155°–165°E & 37°–45°S, 170°–155°W	644367	83.8	16.2	–	12.2	0.0	?	0.3	1.3	2.4
Albacore surveys		**No.**									
Nov. – Oct. 1987	10°–30°S, 150°–120°W	7050	0.1	99.9	–	4.2	92.5	0.0	1.6	0.2	1.4
Dec. 1987–Jan. 1988	20°–40°S, 175°E–150°W	3255	26.9	73.1	–	3.1	48.5	6.5	1.2	9.8	4.0
Jan.–Apr. 1988	35°–45°S, 175°E–160°W	7681	48.5	51.5	–	1.0	36.6	3.2	1.0	0.0	9.7
Nov.–Dec. 1989	36°–39°S, 156°–163°E	22153	29.1	70.1	–	35.1	0.4	32.9	0.2	0.5	1.8
Feb.–Mar. 1990	38°–39°S, 151°–144°W	10749	94.7	5.3	–	2.7	0.0	0.0	0.3	0.8	1.5
Slender tuna surveys		**mt**									
Oct. 1982–Feb. 1983	)	231.3	63.5	36.5	13.8	1.5	–	0.7	4.8	12.4	3.3
Oct. 1983–Feb. 1984	) 25°–60°S	265.4	67.4	32.6	6.8	5.4	–	3.2	4.2	9.4	3.6
Sep. 1984–Feb. 1985	) 175°–75°W	366.5	71.7	28.3	2.5	0.4	–	9.2	1.6	13.8	0.8
Oct. 1985–Mar. 1986	)	309.3	74.3	25.7	0.8	0.4	–	13.5	1.5	8.5	1.0
Oct. 1986–Feb. 1987	)	281.4	73.3	26.7	1.4	0.2	–	11.4	1.1	10.6	2.0
Pomfret surveys		**mt**									
Jul. 1984–Mar. 1985	) 25°–60°S	487.1	16.8	83.2	2.9	2.0	60.7	–	0.6	15.1	1.9
Aug. 1985–May 1986	) 175°–75°W	826.6	23.9	76.1	1.9	0.1	60.4	–	0.3	12.4	1.0
Oct. 1986–Mar. 1987	)	509.0	39.6	60.4	3.9	+	37.6	–	0.2	16.1	2.6

Notes

1. Sources: Nakano et al. (1989), Sharples et al. (1991), Watanabe et al. (1989).
2. + = less than 0.1; – = percentage catches listed in % target catch column; ? = no information but probably included in % others.

Table 7.2: Target and by-catch species caught by driftnet vessels operating in the WTeP, 1989–1990

Species	Tasman Sea				STCZ	
	No.	No./km	No.	No./km	No.	No./km
Cephalopods						
Cuttlefish (unidentified)	1	0.001			–	–
Flying squid (*Ommastrephes bartrami*)	103	0.147			–	–
Octopus (unidentified)	–	–			2	0.005
Paper nautilus (*Argonauta argo*)	1	0.001			–	–
Squid (unidentified)	8	0.011	1	0.008	127	0.311
Sharks and rays						
Basking shark (*Cetorhinus maximus*)	1	0.001	5 unid.	0.040	–	–
Blue shark (*Prionace glauca*)	22	0.032	sharks		70	0.171
Cookie cutter shark (*Isistius brasiliensis*)	10	0.014			–	–
Hammerhead shark (*Sphyrna zygaena*)	3	0.004			–	–
Mako shark (*Isurus oxyrhincus*)	66	0.095			10	0.024
Oceanic whitetip shark (*Carcharhinus longimanus*)	–	–	1	0.008	–	–
Porbeagle shark (*Lamna nasus*)	3	0.004			–	–
Pelagic stingray (*Dasyatis guileri*)	16	0.023			4	0.001
Scombrids						
Albacore (*Thunnus alalunga*)	6445	9.228	1419	11.262	10185	24.951
Bigeye tuna (*Thunnus obesus*)	4	0.006	tuna		–	–
Butterfly tuna (*Gasterochisma melampus*)	–	–			1	0.002
Skipjack tuna (*Katsuwonus pelamis*)	7768	11.123			294	0.720
Slender tuna (*Allothunnus fallai*)	94	0.135			–	–
Yellowfin tuna (*Thunnus albacares*)	5	0.007			–	–
Billfish						
Blue marlin (*Makaira mazara*)	1	0.001			–	–
Broadbill swordfish (*Xiphias gladius*)	32	0.046	1	0.008	23	0.056
Shortbill spearfish (*Tetrapturus angustirostris*)	5	0.007	1	0.008	3	0.007
Striped marlin (*Tetrapturus audax*)	13	0.019	4	0.037	5	0.012
Other fish						
Barracudina (Paralepididae)	19	0.027	9 unid.	0.071	–	–
Baxter's cubehead (*Cubiceps baxteri*)	37	0.053	fish		–	–
Bramids (*Brama* spp.)	7292	10.441	21	0.167	–	–
Cubehead (*Cubiceps caeruleus*)	1	0.001			–	–
Dealfish (Trachipteridae)	4	0.006			–	–
Escolar (*Lepidocybium flavobrunneum*)	1	0.001			–	–
Flying fish (Exocoetidae)	38	0.054			2	0.005
Mahi mahi (*Coryphaena hippurus*)	+	–			–	–
Pelagic butterfish (*Schedophilus maculatus*)	4	0.006			–	–
Pilotfish (*Naucrates ductor*)	~41	0.059			3	0.007
Pufferfish (Tetraodontidae)	1	0.001			–	–
Raftfish (Centrolophidae)	~16	0.023			–	–
Ragfish (*Icichthys australis*)	–	–			3	0.007
Rainbow runner (*Elagatis bipinnulata*)[2]	–	–			3	0.007
Remora (*Remora albescens, Rhombochirus osteochir*)	7	0.010			–	–
Rudderfish (*Centrolophus niger*)	11	0.016			–	–
Sunfish (*Mola mola*)	~18	0.026	5	0.040	5	0.012
Marine reptiles						
Leatherback turtle (*Dermochelys coriacea*)	3	0.004			–	–
Seabirds						
Westland black petrel (*Procellaria westlandica*)	2	0.003			–	–
Marine mammals						
Common dolphin (*Delphinus delphis*)	45	0.064	7 unid.	0.055	8	0.020
Risso's Dolphin (*Grampus gracilis*)	–	–	dolphin		1	0.002
Short-finned pilot whale (*Globicephala macrorhynchus*)[2]	1	0.001			–	–
Southern bottlenose whale (*Hyperoodon planifrons*)[2]	1	0.001			–	–
Striped dolphin (*Stenella caeruleoabla*)	10	0.014			–	–
Totals	**22153**	**31.720**	**1474**	**11.698**	**10749**	**26.330**

Notes

1. Sources: Sharples et al. (1991) and Coffey & Grace (1990) for the Tasman Sea, and Sharples et al. for the STCZ.
2. Identification not positive.
3. + = present but not counted; – = absent.

Table 7.3: Target and by-catch species caught by MV *Monju Maru* in the waters of the Federated States of Micronesia, 1989

Species	No.	No./km
Sharks and rays		
Unidentified shark	356	0.615
Unidentified manta ray	21	0.036
Scombrids		
Island bonito (*Euthynnus affinis*)	51	0.088
Skipjack tuna (*Katsuwonus pelamis*)	909	1.569
Wahoo (*Acanthocybium solandri*)	2	0.003
Yellowfin tuna (*Thunnus albacares*)	55	0.095
Billfish		
Broadbill swordfish (*Xiphias gladius*)	8	0.014
Sailfish (*Istiophorus platypterus*)	24	0.041
Unidentified marlin	48	0.083
Carangids		
Rainbow runner (*Elagatis bipinnulata*)	4	0.007
Unidentified jack	8	0.014
Other fish	1	0.002
Barracuda (*Sphyraena* sp.)	8	0.014
Flying fish (Exocoetidae)	102	0.176
Mahi mahi (*Coryphaena hippurus*)	4	0.007
Needlefish (Belonidae)	1	0.002
Pufferfish (Tetraodontidae)	5	0.009
Triggerfish (Balistidae)		
Marine reptiles	10	0.017
Unidentified turtle		
Marine mammals	97	0.167
Unidentified dolphin	11	0.019
Unidentified whale		
	17	0.029
Other (unspecified)		
Totals	1742	3.008

Table 7.4: Catch of albacore, skipjack and other species in experimental driftnets used by RV *Shinhoyo Maru* in the Tasman Sea

Set no.	Experimental net no.	Alb. in expt. net	Ave. no. alb. per std. net	Skj. in expt. net	Ave. no. skj. per std. net	Other species in expt. net
1	7	21	5.6	7	27.6	None
2	2	62	26.4	120	157.7	Mako shark (1)
5	9	24	7.3	19	57.8	Swordfish (1)
6	1	11	26.1	1	42.6	None
7	4	126	39.9	61	99.8	None
8	7	69	19.9	70	72.2	Swordfish (1), yellowfin (2)
9	4	60	27.1	0	20.1	None
10	6	62	24.8	6	7.0	Mako shark (2)
11	5	62	67.1	0	2.3	Mako shark (1)
12	6	53	64.7	24	44.4	Mako shark (1)
13	3	34	35.3	1	57.9	None
14	7	21	50.0	0	1.0	None
15	4	22	35.3	0	4.3	Blue shark (1), dealfish (1)
16	5	33	81.0	6	10.9	Mako shark (1)
18	4	34	33.2	0	25.2	None
19	7	13	40.2	7	18.9	None
20	4	12	3.1	0	2.7	None
21	7	16	22.1	0	0.0	Mako shark (1)
22	4	37	45.3	0	0.0	None
Average		40.6	34.0	18.9	39.3	
std. dev.		28.5	31.7	32.6	48.6	
n		19	158	17	142	

Note

1. ‘std. net’ = standard net; ‘expt. net’ = experimental net.

Table 7.5: Drop-out rates of albacore and skipjack from driftnets used by RV *Shinhoyo Maru* in the Tasman Sea

Set no.	Net no.	Albacore caught	Albacore drop-out	%Albacore drop-out	Skipjack caught	Skipjack drop-out	%Skipjack drop-out
4	3	16	0	0.0	174	4	2.3
6	5	100	(1) 6	6.0	65	4	6.2
7	7	66	4	6.1	121	5	4.1
8	9	45	(3) 8	17.8	92	11	12.0
9	3	15	2	13.3	12	1	8.3
10	6	71	9	12.7	6	0	0
11	1	21	1	4.8	0	0	0
12	4	55	0	0.0	52	0	0
13	3	39	5	12.8	1	0	0
14	5	53	7	13.2	0	0	0
15	7	40	3	7.5	0	0	0
16	1	16	1	6.3	0	0	0
	2	37	2	5.4	0	0	0
17	1	3	0	0.0	0	0	0
	2	24	(1)5	20.8	0	0	0
	3	29	3	10.3	1	0	0
18	4	38	4	10.5	0	0	0
	5	41	5	12.2	19	0	0
19	6	42	(1) 2	4.8	20	3	15.0
	7	14	1	7.1	7	0	0
21	8	20	1	5.0	0	0	0
	9	22	2	9.1	0	0	0
22	1	1	0	0.0	0	0	0
	2	10	0	0.0	0	0	0
Overall	24 nets	818	(6) 71	8.7	570	28	4.9

Note

1. Numbers in brackets are albacore that are included in drop-out numbers but were subsequently recovered with a gaff.

Table 7.6: Drop-out rates of albacore from driftnets used by RV *Shinhoyo Maru* in the STCZ

Set no.	No. of nets observed	Albacore caught	Albacore drop-out	% Albacore drop-out
1	4	1149	40	3.5
3	1	176	6	3.4
4	3	336	10	3.0
5	2	130	1	0.8
6	3	85	2	2.4
7	4	9	0	0.0
8	3	75	3	4.0
9	4	262	10	3.8
10	4	123	10	8.1
11	4	167	10	6.0
12	5	227	11	4.8
13	5	257	7	2.7
14	2	234	9	3.8
15	5	615	24	3.9
Total	49	3845	143	3.7

Note

1. Albacore recovered by gaff were not counted or included as drop-outs.

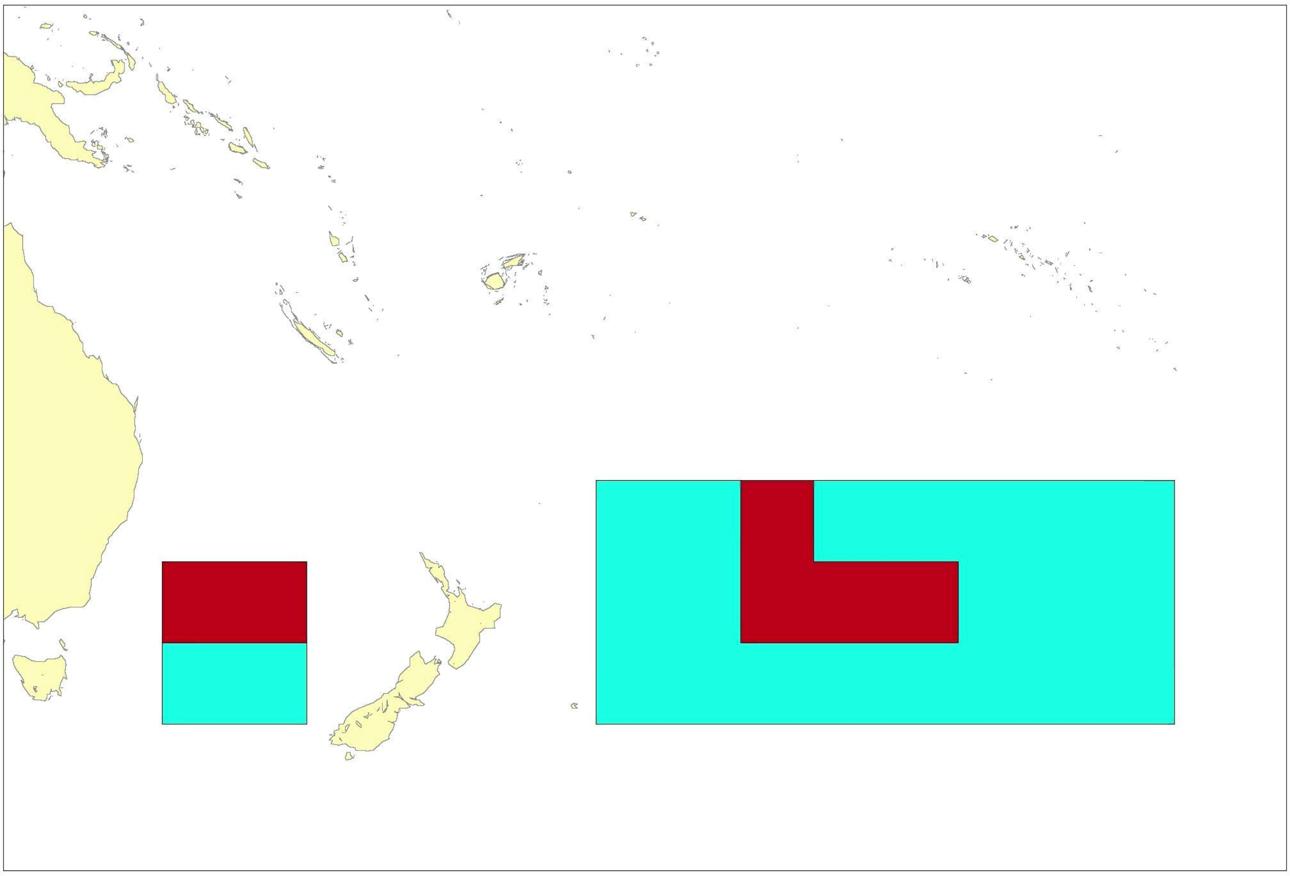


Figure 7.1: Distribution of effort reported for commercial driftnet vessels, 1988–1990

(Effort is described by five degree grid squares where fishing occurred.
Darker shading represents areas of more concentrated effort.
Source : South Pacific Albacore Research Group (SPAR) database.)

Section 8

HANDLINE FISHERIES

8.1 OVERVIEW OF THE WESTERN PACIFIC HANDLINE FISHERIES

8.1.1 Summary of the fishery

A specialised handline fishery for yellowfin and bigeye was developed by Japanese longline fishermen in the Coral Sea off the north-east coast of Australia during the 1960s (Hisada 1973). During the months of October to early December, vessels fish in an area bounded by latitudes 14° and 18°S, and longitudes 145° and 148°E, targeting aggregations of yellowfin and bigeye tuna feeding off spawning lanternfish (*Diaphus* sp.) (Figure 8.1). The area fished overlaps with the established recreational billfish fishery off Cairns and thus has some importance for monitoring; it is thought that, for this reason, logbook coverage of the target catch is reasonably high (Table 8.1). Annual effort has fluctuated throughout the last decade, ranging to >100 days (5–8 vessels) for the years 1984, 1985 and 1987, from <30 days (1–6 vessels) for the other years. CPUE for most years exceeded 200 fish per boat day, with a peak in 1992 of 713.5 fish per boat day; the largest annual catch (259.7 mt) was taken during 1987. Australian vessels have been known to participate in this fishery in recent years.

Multi-purpose Australian troll vessels have handlined schools of albacore (*Thunnus alalunga*), yellowtail kingfish (*Seriola lalandi*) and blue mackerel (*Scomber australasicus*) off the south-east coast of New South Wales (Australia) since 1989 (source: RTFD). Handlined catch has been taken in an area between latitudes 34° and 36°S, even though the range of fishing for these vessels normally extends north and south beyond this area. Yellowtail kingfish and blue mackerel are the predominant species taken by this method and have been encountered all year round except during the months of July and August; Yellowtail kingfish are considered target catch and blue mackerel are probably caught for longline bait (Caton pers. comm.). No information was available on the searching and handlining strategies employed by these vessels. Logbook records show that handlining in this area has increased throughout the last few years, with more than 100 boat days (with handlined catch) for 1993 compared with <10 days recorded for 1989 and 1990.

There is one record in the RTFD of a Japanese vessel handlining 13 southern bluefin tuna (*Thunnus maccoyii*) south of Tasmania in 1985; no other species were caught by that vessel during the operation and no further information was available to indicate the likelihood of similar practices by other vessels in this fleet.

A winter handline/troll fishery operates off the west coast of the South Island of New Zealand, targeting southern bluefin tuna. Vessels fish between latitudes 41° and 44°30'S from June to September, with effort peaking during a seasonal trawl fishery for hoki (*Macruronus novaezelandiae*). Tuna vessels fish close to large factory trawlers and use the discarded trawl and processing wastes as groundbait. Southern bluefin are caught with baited single-hook handlines. Most fish are landed to a freezer vessel, with a small number being air-freighted fresh-chilled to Japan. The fishery peaked in 1982 with a catch of 265 mt, but has since declined to between 70 and 120 mt per year (Murray & Burgess 1990).

8.2 SOURCES AND COVERAGE OF DATA

Table 8.1 summarises, by fleet, the daily logsheet catch-and-effort data available for handlining operations in Australian waters for the period 1979 to 1993; unfortunately, there are no data available for Australian vessels active in the Coral Sea handline fishery, although it is expected that the information provided in this review for the Japanese fleet in this area would be representative. There are a number of published and unpublished reports describing aspects of the Coral Sea handline fishery (for example Hisada 1973; Williams 1981; McPherson 1988; 1992). However, no information was found in the literature regarding handlining elsewhere in Australian waters.

The Regional Tuna Tagging Project, conducted by the South Pacific Commission during 1989–1992, used handlining techniques to tag quantities of large yellowfin and bigeye in the Coral Sea (Itano & Bailey 1991; Itano & Bailey 1992). Relevant information from cruise logs has been extracted for this report.

There are no data in the RTFD on the New Zealand southern bluefin handline/troll fishery. The limited information presented here is given courtesy of New Zealand MAF and former SPC Fisheries Education and Training Adviser Hugh Walton, who participated in the fishery for two seasons.

8.3 BY-CATCH AND DISCARDS OF BY-CATCH

8.3.1 Gross levels of by-catch and discards

Table 8.1 shows levels of by-catch and discards of by-catch from handline fisheries operating in Australian waters according to RTFD records. Very little by-catch has been taken from these fisheries. Skipjack tuna appears to have been the most common by-catch species from the Coral Sea handline fishery (Table 8.2). However, RTTP accounts indicate that the catch of shark may have been under-reported. Handline operations off the south-east coast of New South Wales catch yellowtail kingfish and blue mackerel in some quantities; for this reason, these species, with albacore, are considered as target and only the few 'other species, not specified' have been considered as by-catch in this report.

Data from cruises conducted by the RTTP where handlining occurred show similar levels of by-catch (1.2%: 1991; 0.6%: 1992) to those reported by commercial handline vessels fishing in the Coral Sea area; the two by-catch species encountered during the tagging of handlined yellowfin and bigeye tuna were skipjack (predominant) and oceanic white-tip shark (*C. longimanus*).

Small amounts of albacore, skipjack, swordfish, bronze whaler sharks and moonfish are taken as by-catch in the southern bluefin handline/troll fishery in New Zealand (T. Murray, H. Walton pers. comm.). The sharks are probably the most common part of the by-catch but typically either escape after biting through the monofilament traces or are discarded. The remaining species are retained. Actual levels of by-catch are not available.

8.3.2 Species and levels of by-catch

8.3.2.1 Tunas

Skipjack tuna have been the primary by-catch species reported for the Coral Sea handline fishery throughout the last decade (0.08% for all years: RTFD); the average size of skipjack taken over this period is calculated to be around 3.4 kg and it is presumed that this species is normally retained by the commercial fleet operating in this area. During the handline fishing of tuna aggregations by the RTTP in 1991 and 1992, skipjack schools were notably present and in close association with the yellowfin/bigeye schools but typically distant from the tagging vessel. It was believed that the skipjack schools were not attracted by the dead bait used in the handline operation and that the very large hook size used was inappropriate for catching the smaller skipjack present. The catch of skipjack by the tagging vessel using handline technique was 1.2 per cent and 0.6 per cent of the total catch, by number, in 1991 and 1992, respectively.

Some albacore have been taken by vessels operating in the New Zealand southern bluefin handline fishery. Elsewhere close to this latitude, albacore catch by handline has been considered as target catch; 13 albacore were handlined by the multi-purpose troll vessels fishing off the south-east coast of New South Wales during 1989, presumably after a school with a strong biting response was encountered during troll operations.

8.3.2.2 Billfish

There are only three records of billfish being taken by vessels operating in the Coral Sea handline fishery, according to the RTFD. A 73 kg. black marlin was taken in 1984; in the same year a 120 kg blue marlin was taken; and in 1985 a 74 kg blue marlin was landed. It is not surprising that billfish are in the vicinity of the tuna aggregations exploited by these vessels; due to their relatively small numbers, the level of by-catch described from logbook data is expected to be representative. The recent introduction of measures to discourage the landing of billfish in this area would also limit the retention of this type of by-catch. No other records of billfish catch exist for vessels using handline techniques in Australian waters.

Swordfish are occasionally caught in the southern bluefin fishery (T. Murray pers. comm.).

8.3.2.3 Seabirds, marine reptiles and marine mammals

There are no records of seabird, marine reptile or marine mammal catch from the handline fisheries operating in Australian waters. There are no records of marine reptile or marine mammal associations with tuna aggregations targeted by vessels operating in the Coral Sea handline fishery, although seabird associations (i.e. shearwaters, petrels and frigate birds) have been observed (Itano & Bailey 1991). Due to the methods employed in the handline fishery (Williams 1981; Itano & Bailey 1991), it is highly unlikely that seabird catch would occur.

There appears to be no by-catch of seabirds, marine reptiles or marine mammals in the southern bluefin handline/troll fishery. New Zealand fur seals (*Arctocephalus forsteri*) are common in the area and are attracted to the hoki and southern bluefin fisheries. There are no records, however, of seals being caught by handline or trolling gear.

8.3.2.4 Sharks

During the 1991 RTTP cruise of the Coral Sea, about 10 oceanic white-tip shark were hooked but subsequently shaken off rather than landed; this by-catch constituted less than 0.3 per cent of the total catch by number. No species identification was provided for the catch of 3 sharks reported by commercial vessels in this area.

Bronze whaler sharks have been taken by vessels of the southern bluefin/troll fishery in New Zealand; while no quantitative data are available, incidence of this by-catch is believed to be rare; when encountered, these sharks are usually discarded (H. Walton pers. comm).

8.3.3 Discards of by-catch

Discards of by-catch from handline fisheries in the WPO appear to be mainly shark species (H. Walton pers. comm.; RTTP cruise logs). As the time between hooking and subsequent discard is minimal, it is expected that the survival rate for any discard of by-catch would be high, although it is also likely that shark damage of hooked by-catch would occur. The fact that barbless hooks are typically used in the Coral Sea handline fishery would also enhance the survival rate of any by-catch taken.

8.4 TUNA AND OTHER TARGET SPECIES DISCARDS

There are no records of discards of yellowfin or bigeye tuna from the Coral Sea handline fishery. Presumably, there could be instances where shark damage would result in the discard of tuna; however, no account of such occurrences was found. When a large number of tuna are landed on deck in a short period, there are problems in processing and storing individual tuna in the allotted time before the quality deteriorates, although there are accounts (Williams 1981) of the fishing master temporarily halting fishing operations so that the fish can be processed/refrigerated and thus minimising/preventing possible discard; there is no information available on occurrences of discard for this reason.

Small amounts of discards of yellowtail kingfish and blue mackerel have been reported by vessels after handline operations off the south-east coast of New South Wales (source: RTFD). While no information is available on the reasons for discard, possible causes are poor quality of some of the catch when large numbers have been landed; undesirability of species compared with other (trolled) catch on-board; and problems related to the lack of storage space. The discard level of target species taken by these vessels (Table 8.1: 8.2%) is inflated due to two occurrences when most of the catch was apparently discarded; when these are omitted, the discard level is less than three per cent.

Discarding of handlined southern bluefin in the New Zealand fishery appears to be rare; small tuna are not usually encountered in the fishery and those that are caught are typically in undamaged condition (H. Walton pers. comm). It is possible, however, that sharks and fur seal may inflict some damage on unwary tuna and that such fish, if caught, would have to be discarded.

8.5 ESTIMATES OF BY-CATCH AND TUNA DISCARDS

Since no information was found on the level of discards of yellowfin and bigeye by vessels using handlining techniques in Australian waters, no estimate is provided. Given the experiences of the RTTP, the apparent under-reporting of shark by-catch by vessels handlining in the Coral Sea should not alter the estimate of <1% of the total catch. The by-catch taken by the multi-purpose troll vessels using handlines off the south-east coast of New South Wales appears to be of a similar level (<1%).

Estimates of by-catch and tuna discards in the southern bluefin handline/troll fishery cannot be made with the available information.

8.6 CONCLUSIONS

The major conclusions of this investigation of by-catch and discards in the WPO handline fisheries are as follows:

(a) By-catch is low, typically less than one per cent of the total catch.

(b) Shark species appear to be the predominant by-catch discarded; due to the nature of this fishing method, the survival rate of any discarded by-catch is expected to be high. There are no reports of seabirds, marine mammals or marine reptiles being taken by handline fisheries in the WPO.

(c) There is not enough information available to determine the level of tuna discards (due to poor quality) in the Coral Sea handline fishery, however, as there is some control on the rate of catch landed on deck (and hence the rate of subsequent processing/storage before deterioration), it is expected that this would be minimal. There are no quantitative data available on the level of tuna discards due to shark damage, although these are expected to occur from time to time.

Increased monitoring of the handline fisheries using scientific observers may be worthwhile in gaining more insight into, for example, the reasons for and the level of tuna discard, and the relationships between non-tuna species and the tuna aggregations of the Coral Sea. However, it is thought that observer effort would be best concentrated on data collection in other more important tuna fisheries of the WPO.

Table 8.1: By-catch and discards of vessels handlining in the WPO, based on logbook data held in the RTFD, 1979–1993

Fleet	Area[1]	Period	Total catch (number)	Target catch (%)	By-catch (%)	Target discards (%)	Other discards (%)
Australia (multi-purpose gear)	S.E. Australia	1989–1993	9,391	99.27	0.73	8.21	0.00
Japan (longline)	Coral Sea	1979–1992	136,139	99.91	0.09	0.00	0.00
	South of Tasmania	1985	13	100.00	0.00	0.00	0.00
New Zealand	Off west coast of South Island	1975–1992	N/A	N/A	N/A	N/A	N/A

Note

1. See Figure 8.1.

Table 8.2: Species composition and average weights of by-catch taken by vessels handlining in the WPO, based on logbook data held in the RTFD, 1979–1993

Fleet	Area[1]		Skipjack	Black marlin	Blue marlin	Shark	Other
Australia	S.E. Australia	%[3]	–	–	–	–	0.73
		no.	–	–	–	–	69
		avg. wt.	–	–	–	–	N/A
Japan	Coral Sea	%	0.08	0.00	0.00	0.00	0.01
		no.	107	1	2	3	10
		avg. wt.	3.4	73.0	97.0	20.0	N/A
	South of Tasmania	%	–	–	–	–	–
		no.	–	–	–	–	–
		avg. wt.	–	–	–	–	–
New Zealand	Off west coast of South Island		N/A	N/A	N/A	N/A	N/A

Notes

1. See Figure 8.1.
2. Target catch made up of albacore, yellowtail kingfish and blue mackerel.
3. Percentages in Table 8.2 are the proportion of numbers to the total catch (see Table 8.1).

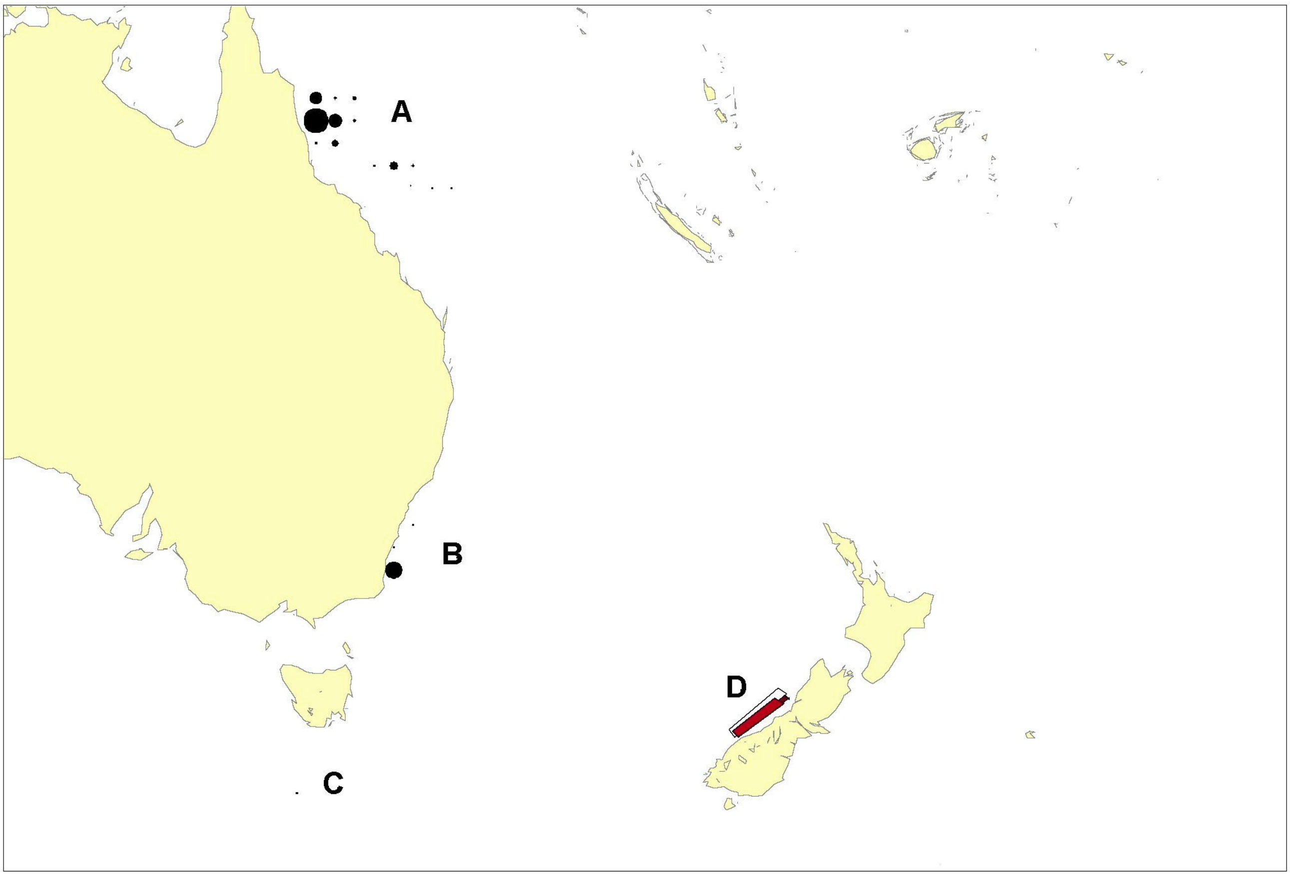


Figure 8.1: Distribution of effort (in fishing days) reported for tuna handline fisheries in the WPO, 1979–1993

Notes

1. Largest circle represents 330 boat days.
2. Areas are defined as follows:

A. Japanese longline vessels targeting yellowfin and bigeye in the Coral Sea;

B. Opportunistic handlining by multi-purpose Australian troll vessels off the south-east coast of New South Wales (1989–1993);

C. Japanese longline vessel handlining southern bluefin (1 day only; 1985);

D. New Zealand vessels targeting southern bluefin tuna off the west coast of the South Island (no effort data available; general area shown).

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