Tuna Fisheries Status and Management in the Western and Central Pacific Ocean

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1 Introduction

This paper provides an overview of tuna fisheries in the western and central Pacific Ocean (WCPO), including a description of the fisheries (section 2), a summary of the biology and ecology of the key species (section 3), and their stock status (section 4). This is followed by a description of the management systems in place at the national, sub-regional and regional levels (section 5). Section 6 discusses the current challenges of tuna management and possible solutions.

2 Tuna Fisheries of the WCPO: an Overview

The tuna fishery in the Western and Central Pacific Ocean is diverse, ranging from small-scale artisanal operations in the coastal waters of Pacific states, to large-scale, industrial purse-seine, pole-and-line and longline operations in both the exclusive economic zones of Pacific states and on the high seas. The main species targeted by these fisheries are skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*) and albacore tuna (*T. alalunga*). Artisanal and larger-scale commercial fisheries exploiting the same stocks of these species also occur in the Pacific Ocean waters of adjacent south-east Asian countries, particularly Indonesia, Philippines and Vietnam.

The statistics presented in this section refer to the commercial tuna-targeting fisheries operating in the Convention Area of the Western and Central Pacific Fisheries Commission (WCPFC). The statistical area used for compilation of catches by the WCPFC is shown in Figure 1.

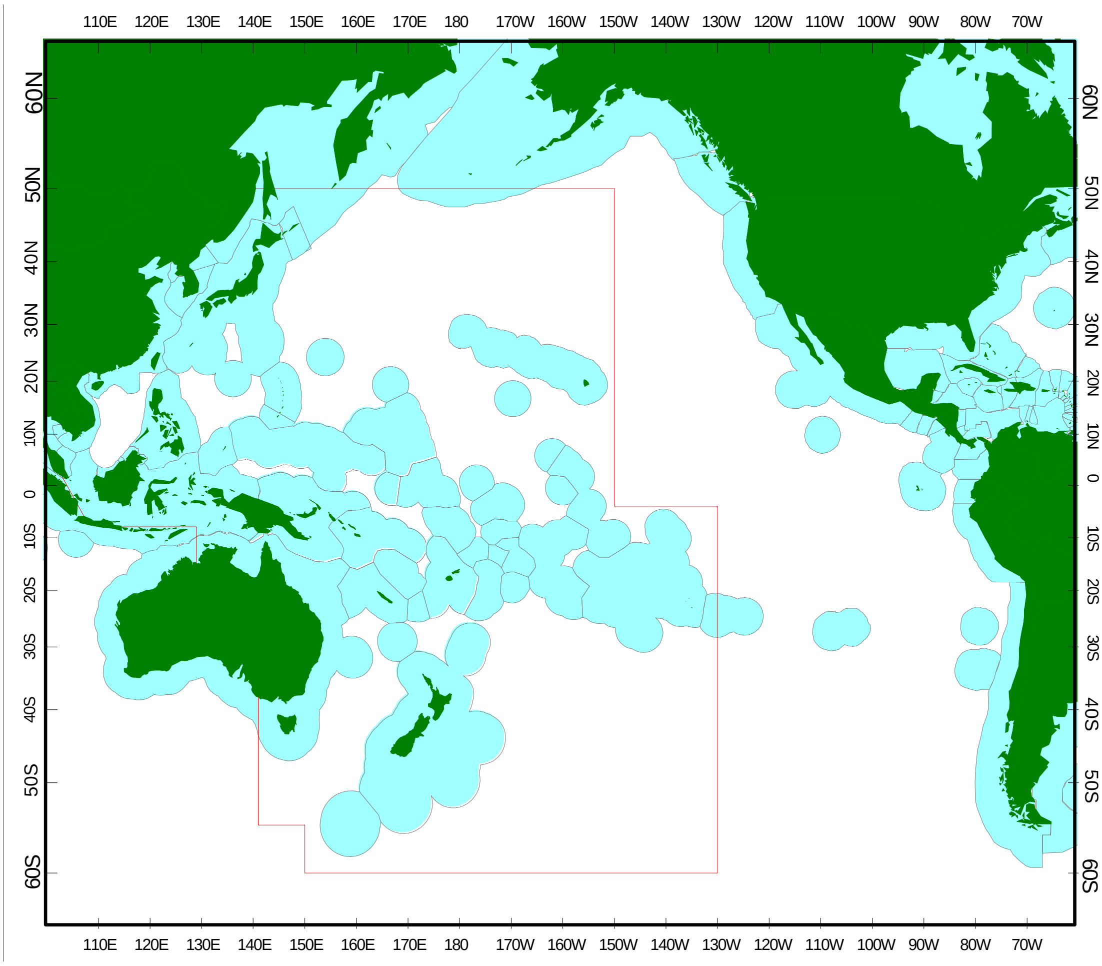

Figure 1. The Pacific Ocean, showing the boundaries of the WCPFC statistical area.

2.1 Total Catches

Annual catches of the four main tuna species (skipjack, yellowfin, bigeye and albacore tunas) in the WCPFC-CA have increased continuously since the beginning of significant commercial exploitation in the early 1950s (Figure 2). In 2009, the highest ever catch of 2.46 million tonnes was recorded (Williams and Terawasi, 2010). The expansion in the total catch over the past 30 years has been due primarily to the development of purse seine fishing in the region. As a result, catches of skipjack, the main target of the purse seine fishery, and yellowfin, a secondary target species, have been the main source of catch increases. The value of the landed catch has also grown, and has been USD 4-5 billion in recent years.

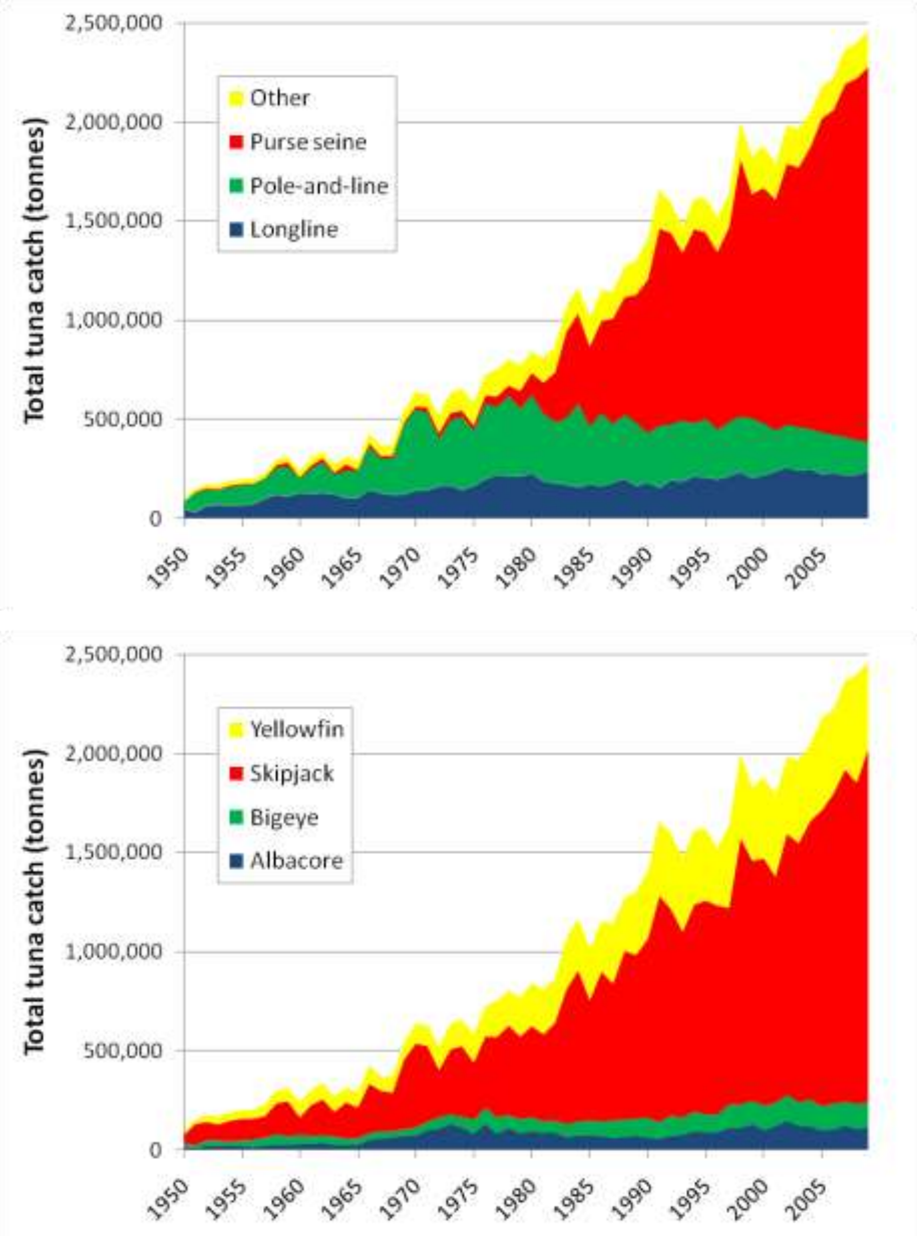

Figure 2. Total catch of the main tuna species in the WCPFC-CA by gear type (top) and by species (bottom).

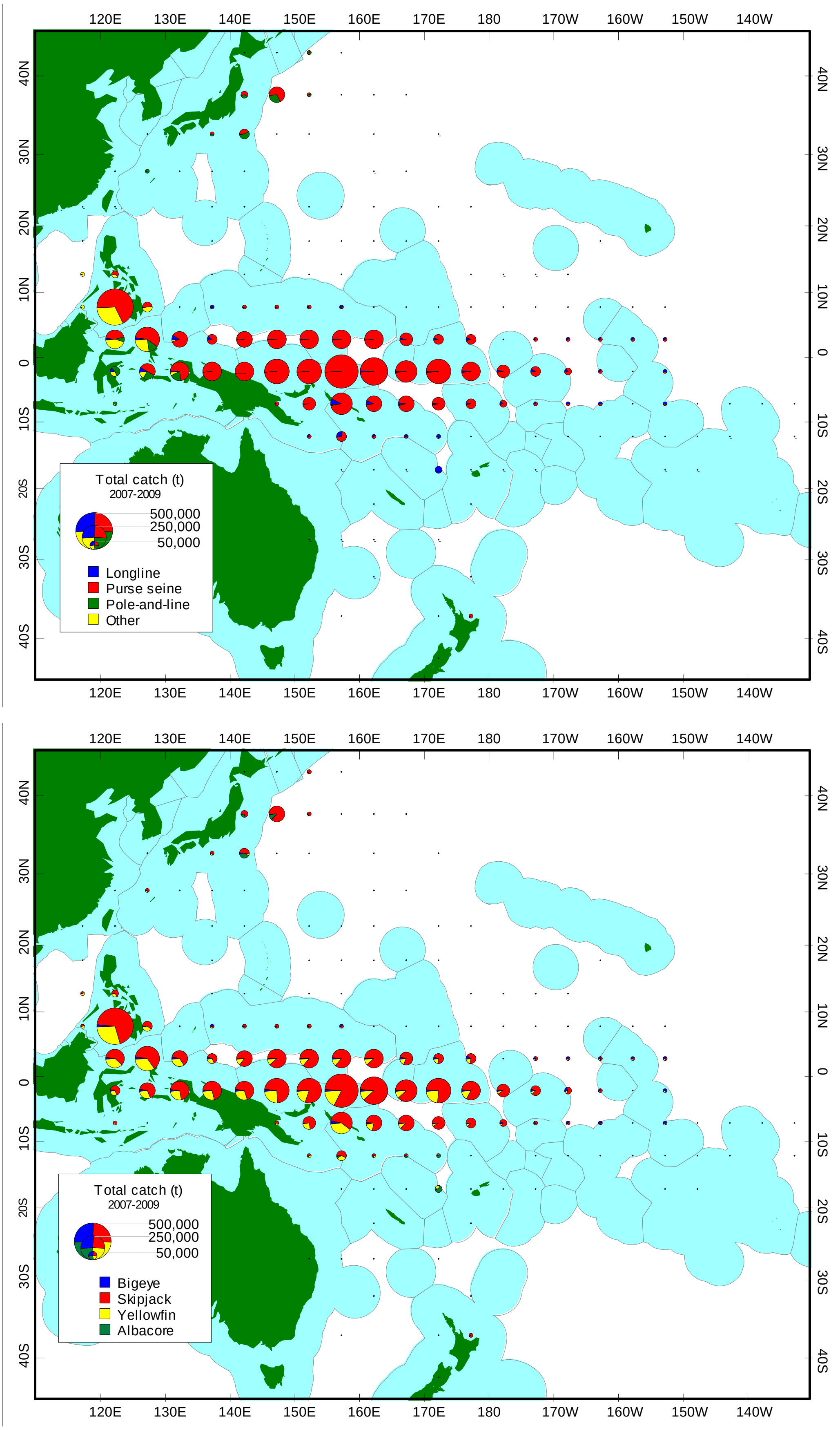

Figure 3. Total catch by gear type (top) and by species (bottom) for 2007-2009.

The catch is highly concentrated in the equatorial zone, due to the concentration of the purse seine fishery, and skipjack catches, in this area (Figure 3). This also results in a concentration of catch in the equatorial EEZs of Federated States of Micronesia, Indonesia, Kiribati, Philippines, PNG and Solomon Islands, and in international waters (Figure 4).

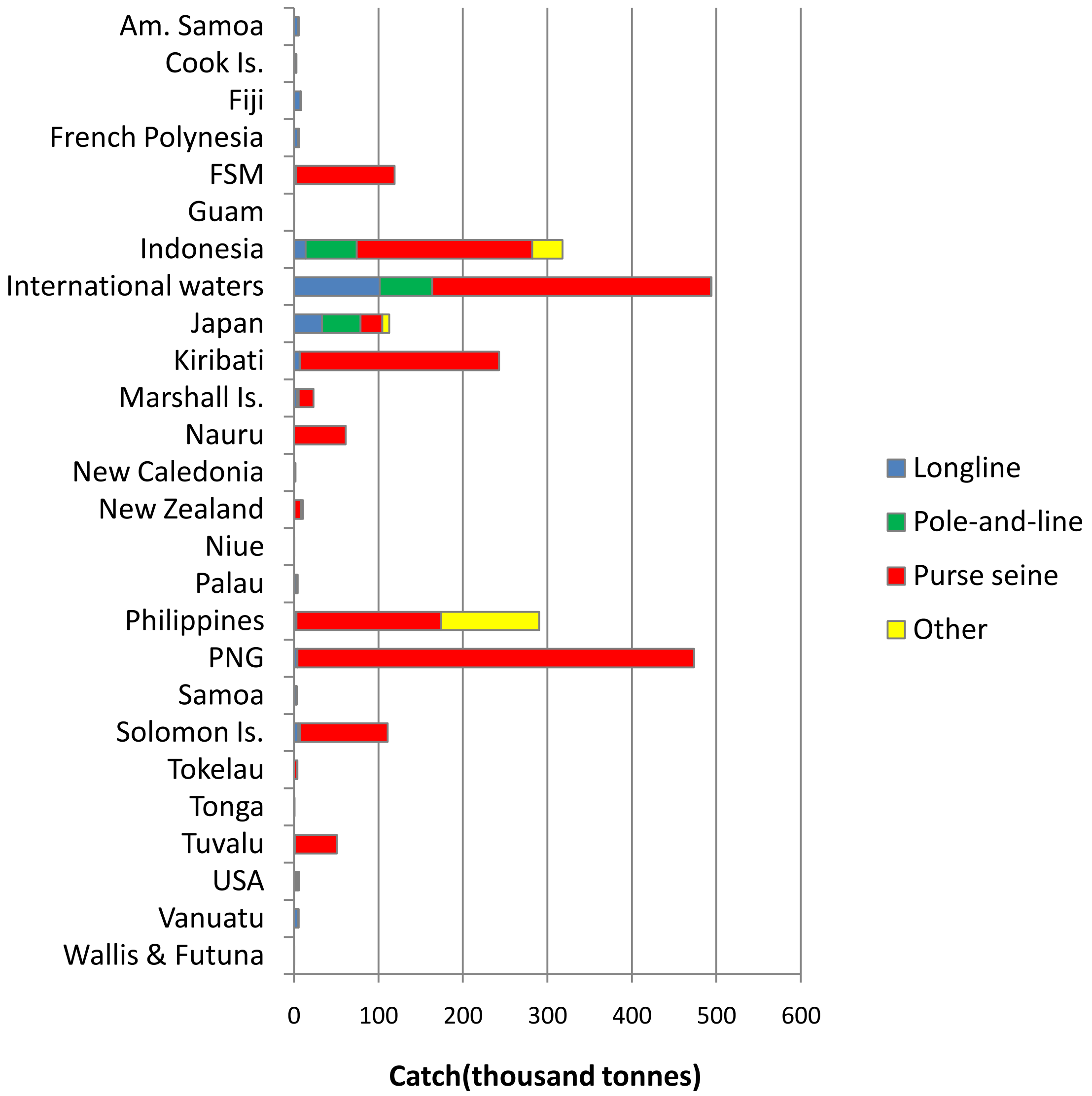

Figure 4. Average annual catch of tunas in 2007-2009, by EEZ.

2.2 Purse seine

The purse seine fishery in the western and central Pacific is essentially a skipjack fishery, unlike those of other ocean areas. Skipjack generally account for 70–85% of the purse seine catch, with yellowfin accounting for 15–30% and bigeye accounting for only a small proportion (Figure 5). Small amounts of albacore tuna are also taken in temperate water purse seine fisheries in the North Pacific.

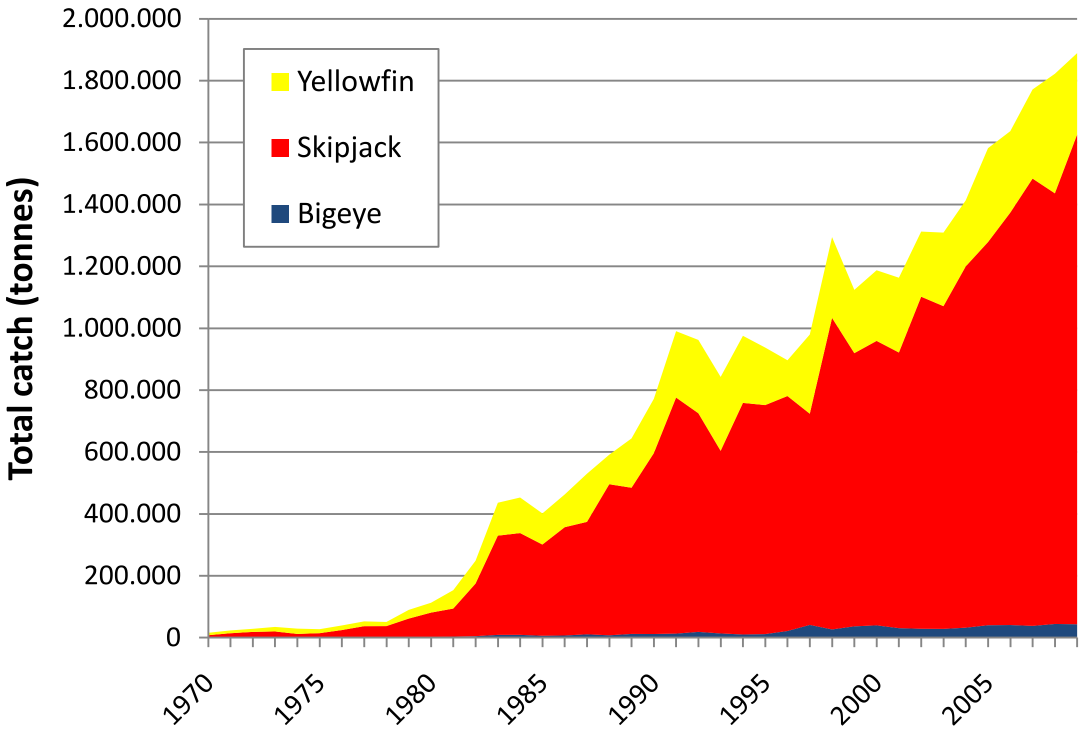

Figure 5. Purse seine catch, by species.

Features of the purse seine catch by species during the past decade include:

- Annual skipjack catches fluctuating between 600,000 and 800,000 tonnes prior to 1998, a significant increase in the catch during 1998, with catches now maintained well above 1,000,000 tonnes. The provisional catch of skipjack for 2009 of 1,889,966 tonnes is the record high;

- Annual yellowfin catches fluctuating considerably between 115,000 and 270,000 tonnes. The proportion of yellowfin in the catch is generally higher during *El Niño* years and lower during *La Niña* years (for example, 1995/96 and to a lesser extent 1999/2000). The 2008 yellowfin catch (386,293 tonnes) was easily the highest on record and remains an outlier, with the provisional 2009 catch falling back to 263,015 tonnes;

- Increased bigeye tuna purse seine catches, (e.g. 41,628 tonnes in 1997 and 37,775 tonnes in 2000) coinciding with the introduction of drifting FADs (since 1996). In the period 2001–2006, bigeye catches were generally lower, but the catch estimate for bigeye in 2008 (44,457 tonnes) is the highest on record and the 2009 catch the second highest.

The geographical distribution of the purse seine fishery is tightly concentrated in the equatorial band, with the highest catches in the zone 5°N - 10°S (Figure 6).

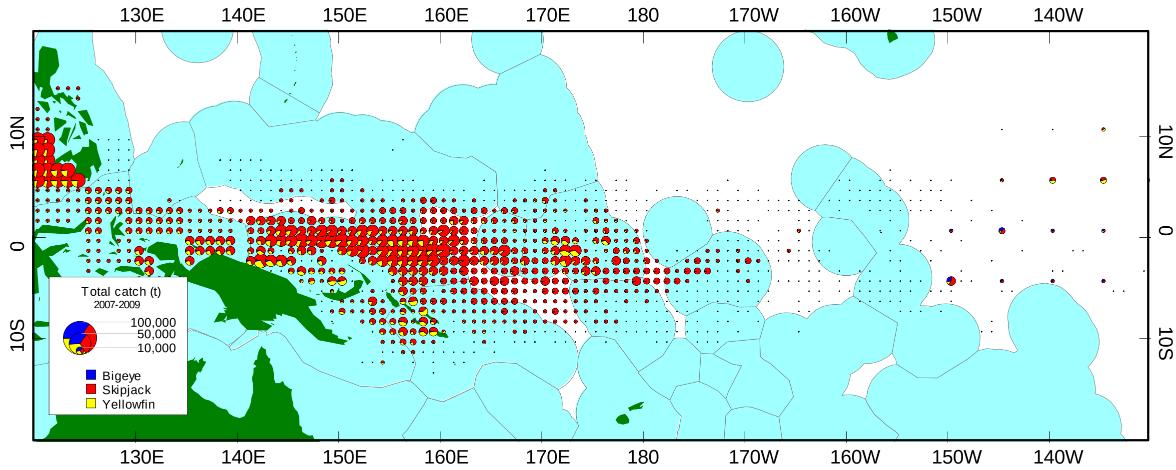

Figure 6. Purse seine catch by species, 2007-2009.

2.3 Pole-and-line

The WCP–CA pole-and-line fishery has several components:

a) The year-round tropical skipjack fishery, mainly involving the domestic fleets of Indonesia, Solomon Islands and French Polynesia, and the distant water fleet of Japan

b) Seasonal sub-tropical skipjack fisheries in the home waters of Japan, Australia, Hawaii and Fiji

c) A seasonal albacore/skipjack fishery east of Japan (largely an extension of the Japan home-water fishery).

Economic factors and technological advances in the purse seine fishery (primarily targeting the same species, skipjack) have seen a gradual decline in the number of vessels in the pole-and-line fishery and in the annual pole-and-line catch during the past 15–20 years (Figure 7). The gradual reduction in numbers of vessels has occurred in all pole-and-line fleets over the past decade. Pacific Island domestic fleets have declined in recent years – fisheries formerly operating in Palau, Papua New Guinea and Kiribati are no longer active, only one vessel is now operating (seasonally) in Fiji, and fishing activity in the Solomon Islands fishery has reduced significantly from the level experienced during the 1990s. Several vessels continue to fish in Hawai'i, and the French Polynesian *bonitier* fleet remains active, but more vessels have turned to longline fishing. Provisional statistics also suggest that the Indonesian pole-and-line has also declined over the past decade. Most of the current pole-and-line catch occurs in the waters around Japan and Indonesia, with a now reducred level of catch by Japanese distant-water vessels in the tropical WCPO between 20^{o}N and 10^{o}S (Figure 8).

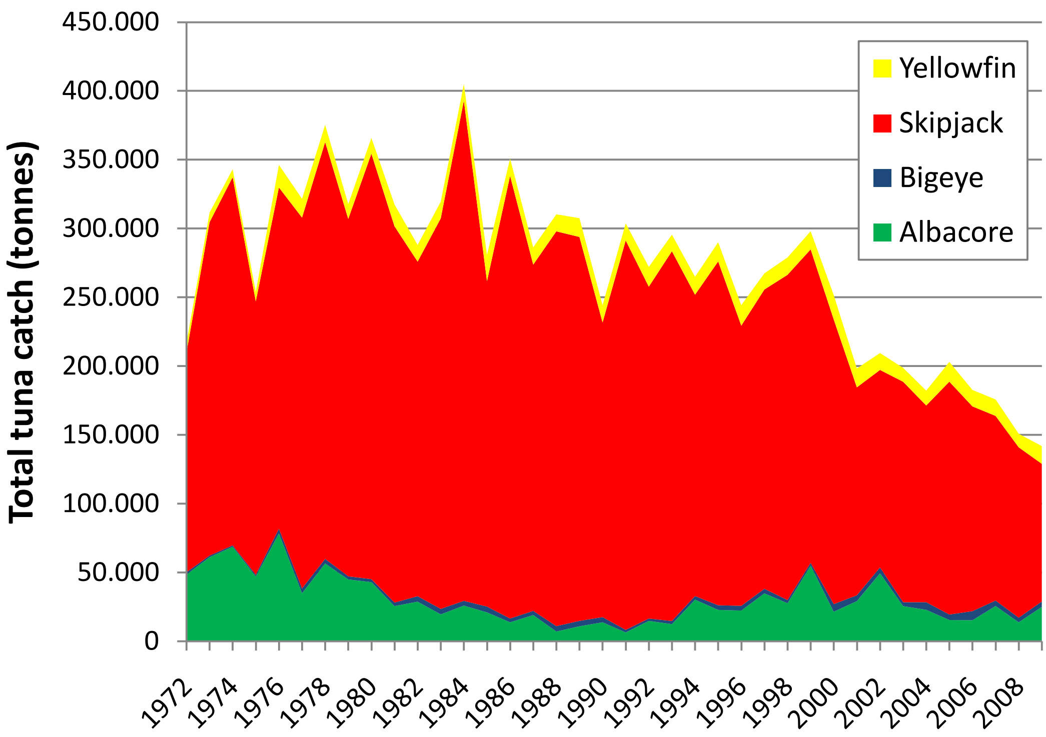

Figure 7. Pole-and-line catch by species.

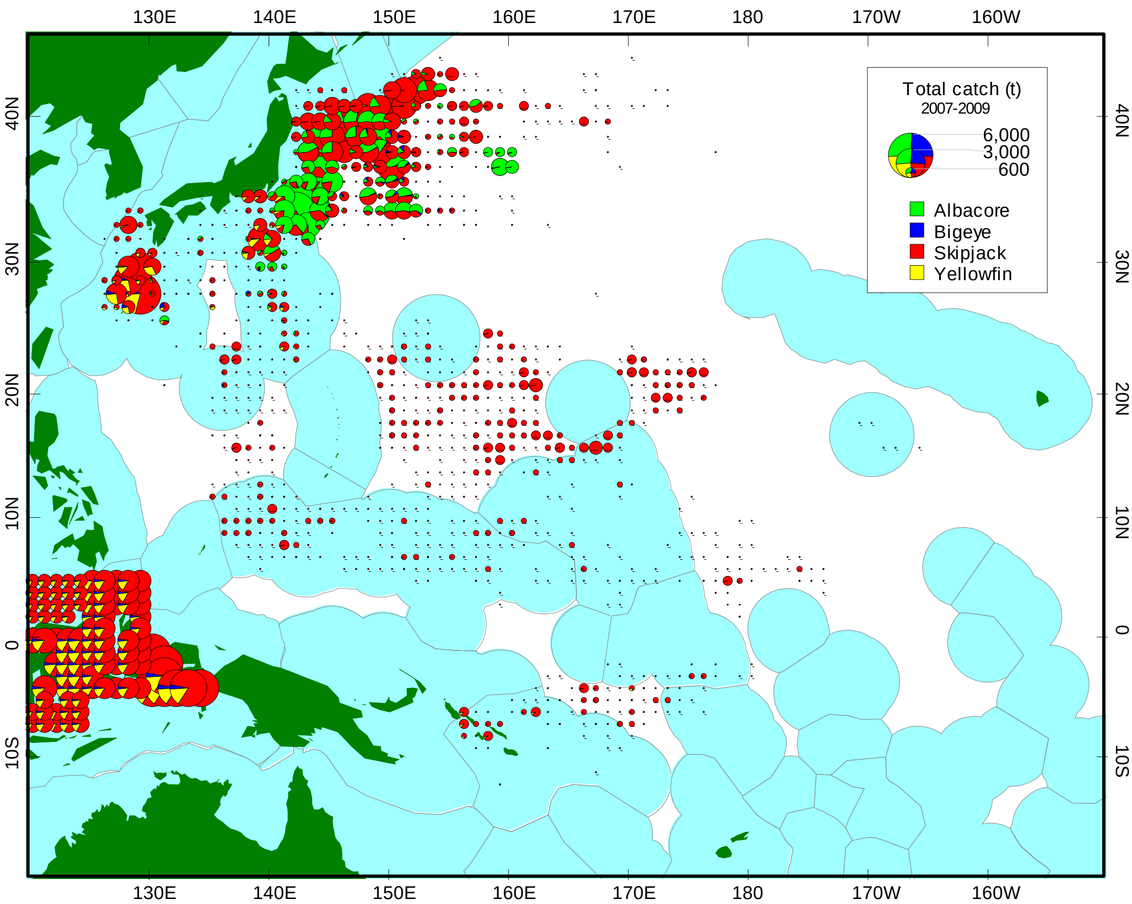

Figure 8. Pole-and-line catch by species, 2007-2009.

2.4 Longline

The longline fishery continues to account for around 10–13% of the total WCPFC–CA catch, but rivals the much larger purse seine catch in landed value. It provides the longest time series of catch estimates for the WCP–CA, with estimates available since the early 1950s. The total number of vessels involved in the fishery has generally fluctuated between 3,500 and 5,500 for the last 30 years.

The fishery involves two main types of operation –

a) Large (typically >250 GRT) **distant-water** freezer vessels which undertake long voyages (months) and operate over large areas of the region. These vessels may target either tropical (yellowfin, bigeye tuna) or subtropical (albacore tuna) species. Voluntary reduction in vessel numbers by at least one fleet has occurred in recent years;

b) Smaller (typically <100 GRT) **offshore** vessels which are usually **domestically-based**, undertaking trips less than one month, with ice or chill capacity, and serving fresh or air-freight sashimi markets, or [albacore] canneries.

The following broad categories of longline fishery, based on type of operation, area fished and target species, are currently active in the WCPFC–CA:

- **South Pacific offshore albacore fishery** comprises Pacific-Islands domestic "offshore" vessels, such as those from American Samoa, Cook Islands, Fiji, French Polynesia, New Caledonia, Samoa, Solomon Islands, Tonga and Vanuatu; these fleets mainly operate in subtropical waters, with **albacore** the main species taken.
- **Tropical offshore bigeye/yellowfin-target fishery** includes "offshore" sashimi longliners from Chinese-Taipei, based in Micronesia, Guam, Philippines and Chinese-Taipei, mainland Chinese vessels based in Micronesia, and domestic fleets based in Indonesia, Micronesian countries, Philippines, PNG, the Solomon Islands and Vietnam.
- **Tropical distant-water bigeye/yellowfin-target fishery** comprises "distant-water" vessels from Japan, Korea, Chinese-Taipei, mainland China and Vanuatu. These vessels primarily operate in the eastern tropical waters of the WCP–CA (and into the EPO), targeting bigeye and yellowfin tuna for the frozen sashimi market.
- **South Pacific distant-water albacore fishery** comprises "distant-water" vessels from Chinese-Taipei, mainland China and Vanuatu operating in the south Pacific, generally below 20°S, targeting albacore tuna destined for canneries.
- **Domestic fisheries in the sub-tropical and temperate WCP–CA** comprise vessels targeting different species within the same fleet depending on market, season and/or area. These fleets include the domestic fisheries of Australia, Japan, New Zealand and Hawaii. For example, the Hawaiian longline fleet has a component that targets swordfish and another that targets bigeye tuna.
- **South Pacific distant-water swordfish fishery** is a relatively new fishery and comprises "distant-water" vessels from Spain.
- **North Pacific distant-water albacore and swordfish fisheries** mainly comprise "distant-water" vessels from Japan (swordfish and albacore), Chinese-Taipei (albacore only) and Vanuatu (albacore only).

Additionally, small vessels in Indonesia, Philippines and more recently in Papua New Guinea target yellowfin by handlining and small vertical longlines, usually around the numerous arrays of anchored FADs in home waters . The commercial handline fleets target large yellowfin tuna which comprise the majority of the overall catch (> 90%).

The WCPFC–CA longline tuna catch steadily increased from the early years of the fishery (i.e. the early 1950s) to 1980, but declined in the five years after (Figure 9). Since 1984, catches steadily increased over the next 15 years until the late 1990s, when catch levels were again similar to 1980. Annual catches in the longline fishery since 2000 have been amongst the highest ever, but the composition of the catch in recent years (e.g. ALB–30%; BET–38%; YFT–30%; SKJ–2% in 2008) differs considerably from the period of the late 1970s and early 1980s, when yellowfin tuna were the main target species (e.g. ALB–19%; BET–27%; YFT–54% in 1980).

Longline catches since the record catch in 2004 have declined somewhat, due to a combination of reduced effort and catch-per-unit-effort (Figure 9). The distribution of catches is widespread throughout the tropical and sub-tropical Pacific, which yellowfin and bigeye dominating catches in the equatorial zone, and albacore dominating at higher latitudes (Figure 10).

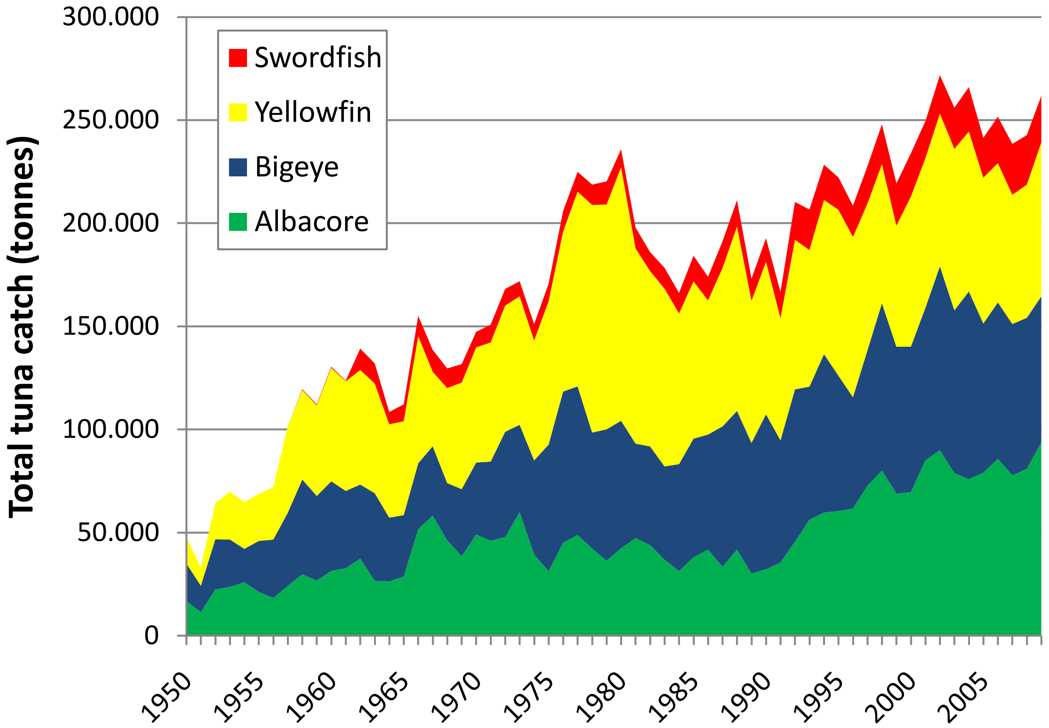

Figure 9. Longline catch by species.

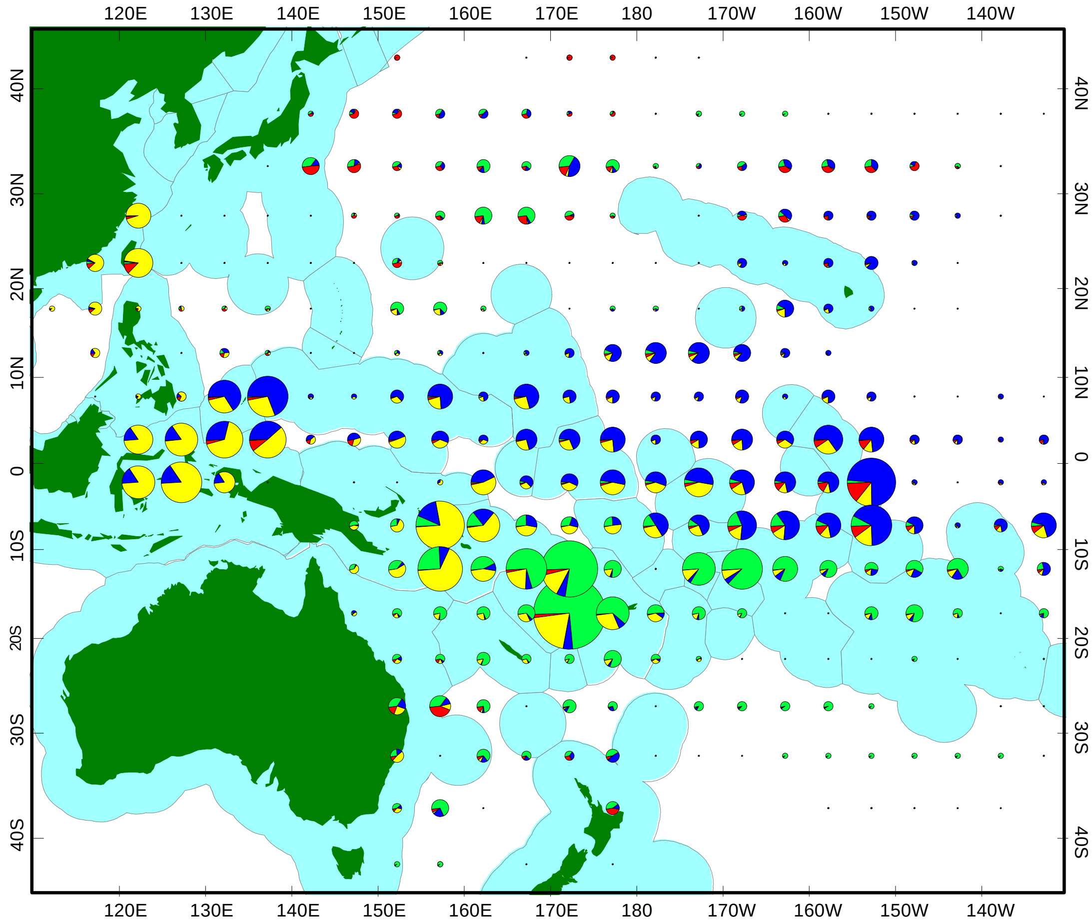

Figure 10. Longline catch by species, 2007-2009.

3 Tuna Biology and Ecology

Contrary to common portrayal in the media, tuna are not a single species of fish, but rather several species. Scientists often use the term “tuna and tuna-like fish” which includes a total of 61 species, fourteen of which are considered “true tuna”. Four species are of major commercial importance in the WCPO: skipjack, yellowfin, bigeye, and albacore. These four species of tuna are quite distinct with respect to many properties, such as how they are captured, the amount presently captured, the size and productivity of the populations, and the end use of the product.

3.1 Skipjack

Skipjack are a surface–schooling tuna which are easily distinguished from other species of tuna due to their small size, small dark pectoral fins and three to six distinct dark longitudinal lines (stripes). It is found year-round concentrated in warmer tropical waters of the WCPO, with that distribution expanding seasonally into subtropical waters to the north and south, particularly on the western side of the WCPO. Skipjack are caught mainly on the surface by purse seine and pole-and-line gear and are used for producing canned tuna.

The typical capture size for skipjack is between 40 and 70 cm, corresponding to fish between one and three years of age, with very few captured fish exceeding 80 cm. However, rare records of skipjack over 100 cm and weighing more than 30 kg have been reported historically.

Skipjack tuna is a fast growing species (reaching 42-45 cm within its first year), are relatively short-lived (few live longer than 3 - 4 years) and mature early (~ 1 years of age). These biological characteristics promote rapid productivity and turnover in skipjack populations.

Skipjack are also highly fecund and can spawn year round over a wide area of the tropical and subtropical Pacific. Environmental conditions are believed to significantly influence recruitment and can produce widely varying recruitment levels between years.

In the WCPO, the biomass of skipjack tuna is very large and estimated to exceed that of the other three main tuna species combined. It is assumed that skipjack in the WCPO is a separate population (for stock assessment and management purposes) to those in the eastern Pacific.

3.2 Yellowfin

Yellowfin tuna are a relatively large tuna, easily distinguished as adults by their large second dorsal and anal fins which, along with finlets, are typically bright yellow. However, they can be less easy to distinguish from other tuna (like bigeye) as juveniles (<70cm).

Yellowfin tuna are distributed throughout the tropical and sub-equatorial waters of the WCPO, and typically spend most of their time in the warmer mixed surface waters (above the thermocline). Small yellowfin are caught on the surface by a range of gears including handline, ringnet, purse seine and pole/line gear and are used mainly for canning, while the majority of larger/older fish are caught by both purse seine and longline fisheries, with the longline catch often shipped fresh to overseas markets.

The typical capture size for yellowfin shows two distinct modes in the WCPO, being 20 to 70cm (ringnet, handline, purse seine, pole and line) which corresponds to fish between approximately 3 months and 1.5 years of age, and between 90 and 160cm (purse seine, longline), corresponding to fish mostly between 1.5 and 6-7 years of age. Very few captured fish exceed 180cm or 80 kg.

Yellowfin tuna is a fast growing species (reaching > 45cm within its first year), have a life span of up to ~7 years of age and mature around 2-3 years of age. These biological characteristics promote moderate turnover in yellowfin populations.

Yellowfin are highly fecund and can spawn year round over a wide area of the tropical and subtropical Pacific, providing environmental conditions (such as water temperature and forage availability) are suitable. As with many tropical tuna species, environmental conditions are believed to significantly influence recruitment levels over time.

For stock assessment purposes, yellowfin tuna are believed to constitute a single stock in the WCPO.

3.3 Bigeye

Bigeye tuna are among the largest of tuna species and are distinguished as adults by their body depth, colouring (iridescent blue longitudinal band) and smaller anal and dorsal fins (relative to yellowfin). However, they are more difficult to distinguish from yellowfin tuna as small juveniles (<50cm).

In the WCPO, bigeye tuna have a relatively broad distribution, both geographically between 40°N and 40°S, and vertically between the surface and 500 m deep (occasionally to 1000 m) due to their tolerance of low oxygen levels and low temperatures. In the tropical and subtropical waters or the WCPO, adult bigeye migrate from cooler deeper waters (beneath the thermocline) where they live during the day to shallower warmer waters (above the thermocline) at night. Juvenile bigeye tend to inhabit shallower waters and can form mixed schools with skipjack and yellowfin, which results in catches by the surface fishery, particularly in association with floating objects.

In the WCPO, smaller bigeye are caught on the surface by a range of gears including handline, ringnet and purse seine and are used mainly for canning, while the majority of larger/older fish are caught by longline fisheries. While bigeye tuna account for a relatively small proportion of the total tuna catch in the region, adult bigeye tuna are extremely valuable (particularly as fresh fish in the Japanese market); their economic value probably exceeds US$1 billion annually.

The typical capture size for bigeye shows two distinct modes in the WCPO, being 20 to 75cm (ringnet, handline, purse seine) which corresponds to fish between 3 months and 1.7 years of age, and between 100 and 180cm (mostly caught by longline) , corresponding to fish between 2 and 10 years of age. Very few captured fish exceed 200 cm or 120 kg.

Bigeye tuna grow more slowly than either yellowfin or skipjack, reaching around 40cm after one year, have a longer potential lifespan (at least 15 years) and mature later (around 3-4 years of age). Natural mortality is estimated to be relatively low compared with other tropical species. These biological characteristics promote only moderate turnover in bigeye populations, and, in combination with their susceptibility to multiple gear types throughout their lifespan, make bigeye tuna less resilient to exploitation than more productive species like skipjack. The bigeye biomass is estimated to be significantly smaller than those of yellowfin and skipjack in the WCPO.

Like yellowfin, bigeye tuna are highly fecund and can spawn year round over a wide area of the tropical and subtropical Pacific, providing environmental conditions (such as water temperature) are suitable. As with many tropical tuna species, environmental conditions are believed to significantly influence recruitment levels over time.

For stock assessment purposes, bigeye tuna are assumed to constitute a single stock in the WCPO. However, the distribution is continuous across the tropical Pacific, and appears to increase from the western to the central and eastern Pacific.

3.4 Albacore

Although colour and shape can be similar to other species of tuna, adult albacore are distinguished by their very long pectoral fins. Albacore are segregated into two discrete stocks in the WCPO, with the equatorial area (where albacore are rare) separating the southern component from those of the north. Mature albacore (age at first maturity is about 5 years) spawn in tropical and sub-tropical waters between 10 to 25 degrees from the equator, with individual fish becoming available to surface fishing about 40 degrees from the equator approximately one to two years later, at a size of 45-50 cm. From this area, albacore gradually disperse towards lower latitudes, but may make seasonal migrations between tropical and sub-tropical waters.

Small albacore are caught by trolling at the surface in cool water outside the tropics, while larger fish are caught deeper and mainly at lower latitudes (subtropical) using longline gear. Most of the catch is used for producing “white meat” canned tuna. Fish caught are typically from 1.5 to ten years old.

Albacore are relatively slow growing, and have a maximum fork length of about 130 cm. Natural mortality is low compared to tropical tunas, with significant numbers of fish reaching an age of 10 years or more.

4 Stock Status

4.1 Skipjack

The most recent assessment of skipjack tuna was undertaken in August 2010 and reported to the 2010 meeting of the WCPFC Scientific Committee (Hoyle et al. 2010). Despite greatly increased catches now reaching approximately 1.7 million tonnes (Figure 11A), estimated biomass is relatively stable (Figure 11B), fishery impacts are moderate (Figure 11C) and the stock is neither over-fished nor is it experiencing over-fishing (Figure 11D). However, while current catch levels appear to be sustainable, the assessment suggests that there is not much scope for further long-term catch increase.

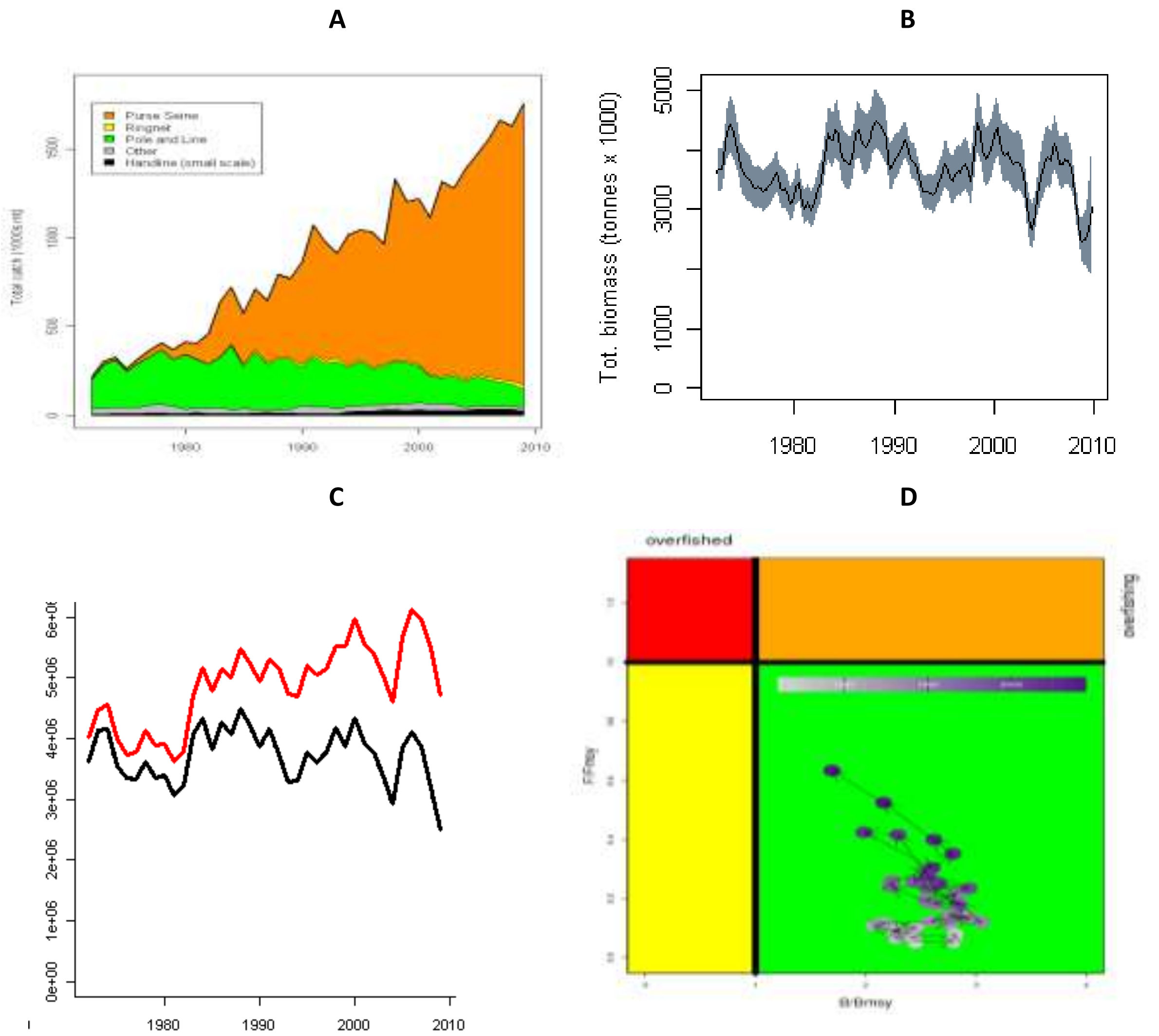

Figure 11. Stock status of skipjack tuna. A. Catch by gear type; B. Estimated time series of stock biomass; C. Comparison of estimated biomass (black line) with biomass that would have occurred in the absence of fishing (red line); and D. Kobe plot showing the relationship between the ratios of estimated biomass and fishing mortality to their respective MSY-based reference points.

4.2 Yellowfin

The most recent assessment of yellowfin tuna was undertaken in August 2009 and reported to the 2009 meeting of the WCPFC Scientific Committee (Langley et al. 2009). Catches have been fairly stable since the mid-1990's at 400,000 – 450,000 tonnes annually (Figure 12A) (although there was an abnormally high catch in 2008, not considered in the 2009 assessment, of >500,000 tonnes). For the WCPO as a whole, both total and spawning biomass are estimated to be declining (Figure 12B) with moderate overall fishery impacts (Figure 12C). Fishing mortality and biomass are estimated to be within their MSY-based reference points (Figure 12D). While this is a fairly optimistic outlook, more severe biomass declines (Figure 12E) and fishery impacts (Figure 12F) are estimated for the western equatorial sub-region, where >90% of the WCPO yellowfin catch is taken. This warrants a more cautious approach to management than is suggested by the overall stock status indicators. The 2009 meeting of the WCPFC Scientific Committee therefore recommended that fishing mortality rates not be increased beyond the 2001-2004 average levels.

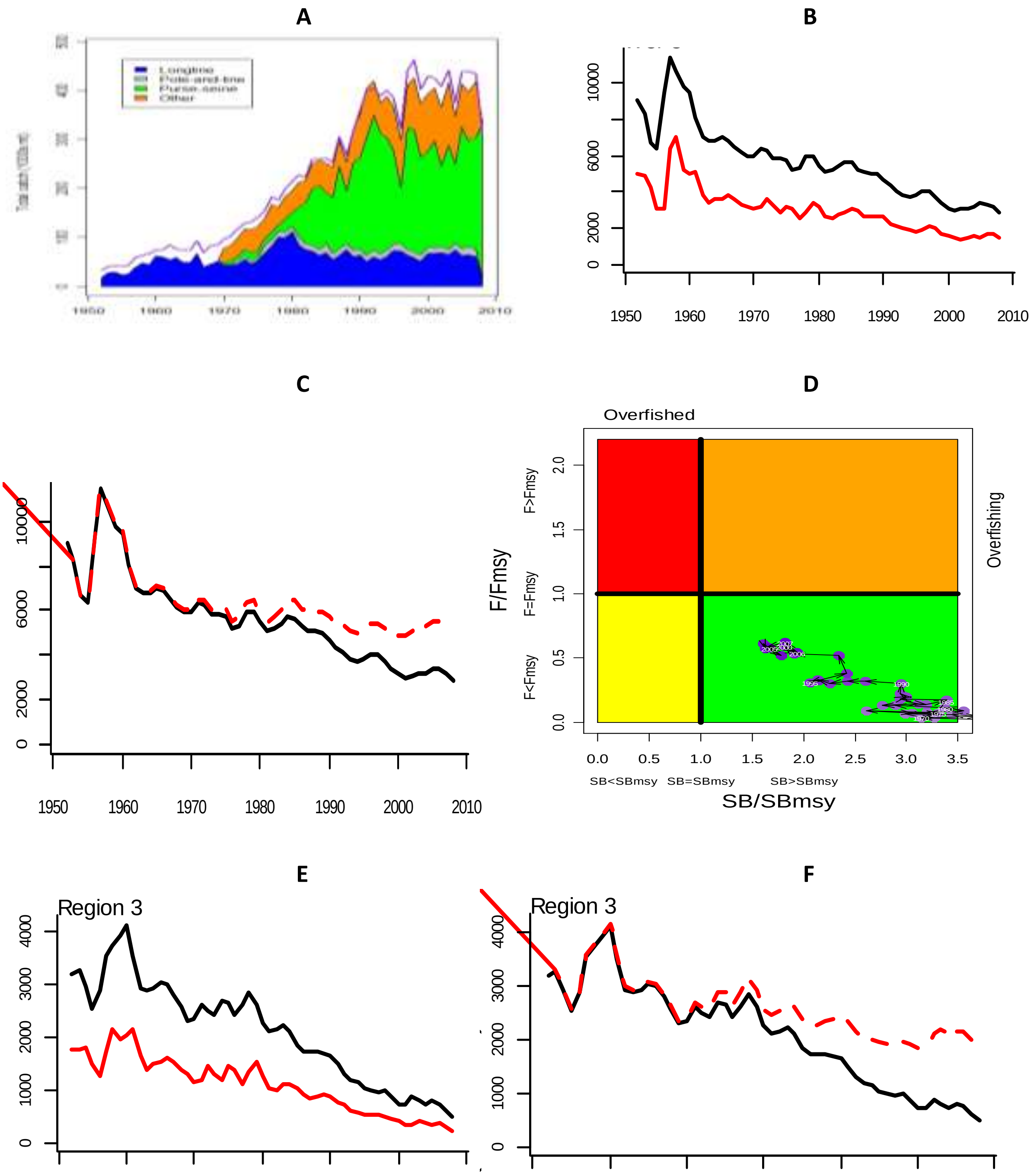

Figure 12. Stock status of yellowfin tuna. A. Catch by gear type; B. Estimated time series of stock biomass (black = total biomass, red = adult biomass); C. Comparison of estimated biomass (black line) with biomass that would have occurred in the absence of fishing (red dashed line); D. Kobe plot showing the relationship between the ratios of estimated biomass and fishing mortality to their respective MSY-based reference points; E. Estimated stock biomass (black = total biomass, red = adult biomass) for the western equatorial sub-region; and F. Comparison of estimated biomass (black line) with biomass that would have occurred in the absence of fishing (red dashed line) for the western equatorial sub-region.

4.3 Bigeye

The most recent assessment of bigeye tuna was undertaken in August 2010 and reported to the 2010 meeting of the WCPFC Scientific Committee (Harley et al. 2010a). A serious source of uncertainty in the assessment is the catch of bigeye tuna by purse seine. It is becoming apparent that previous estimates of bigeye purse seine catch are under-estimated, and higher, but still preliminary, estimates were used in the 2010 assessment (Figure 13A). Catches of bigeye peaked in the late 1990s at around 180,000 tonnes and have since declined. Spawning biomass has been in a long-term decline (Figure 13B), but greatly mitigated by an estimated increase in recruitment since the mid-1980s. Fishery impacts on spawning biomass are high (Figure 13C) and fishing mortality rates since the late 1990s are estimated to have exceeded the MSY-based reference point; however, spawning biomass, elevated by the above-average recent recruitment, remains above the MSY-based reference level (Figure 13D). Therefore, over-fishing is occurring, but the stock is not yet in an over-fished state. The 2010 WCPFC Scientific Committee recommended that measures be taken to achieve a 29% reduction in fishing mortality from the 2005-2008 average levels.

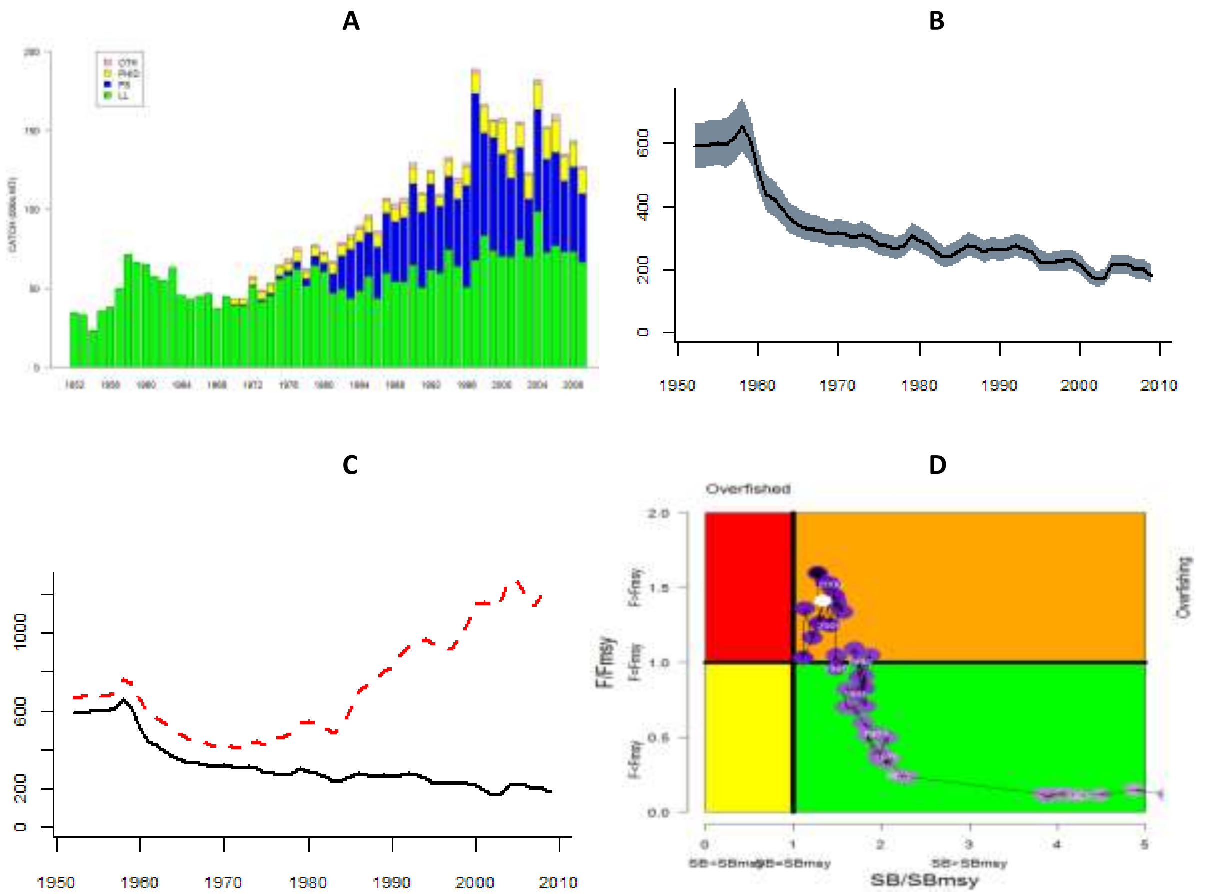

Figure 13. Stock status of bigeye tuna. A. Catch by gear type; B. Estimated time series of spawning biomass; C. Comparison of estimated spawning biomass (black line) with biomass that would have occurred in the absence of fishing (red dashed line); and D. Kobe plot showing the relationship between the ratios of estimated spawning biomass and fishing mortality to their respective MSY-based reference points.

4.4 South Pacific Albacore

The most recent assessment of South Pacific albacore tuna was undertaken in August 2009 and reported to the 2009 meeting of the WCPFC Scientific Committee (Hoyle and Davies 2009). Catches are predominantly of larger adult albacore taken by longline and have reached around 65,000 tonnes in recent years (Figure 14A). Biomass has declined to some extent since the late 1980s

(Figure 14B) while the impacts of fishing on the older portion of the stock (spawning biomass and biomass vulnerable to longline fishing) have increased to 30 – 50% depletion from unexploited levels (Figure 14C). However, both fishing mortality and biomass remain well within their respective MSY-based reference levels.

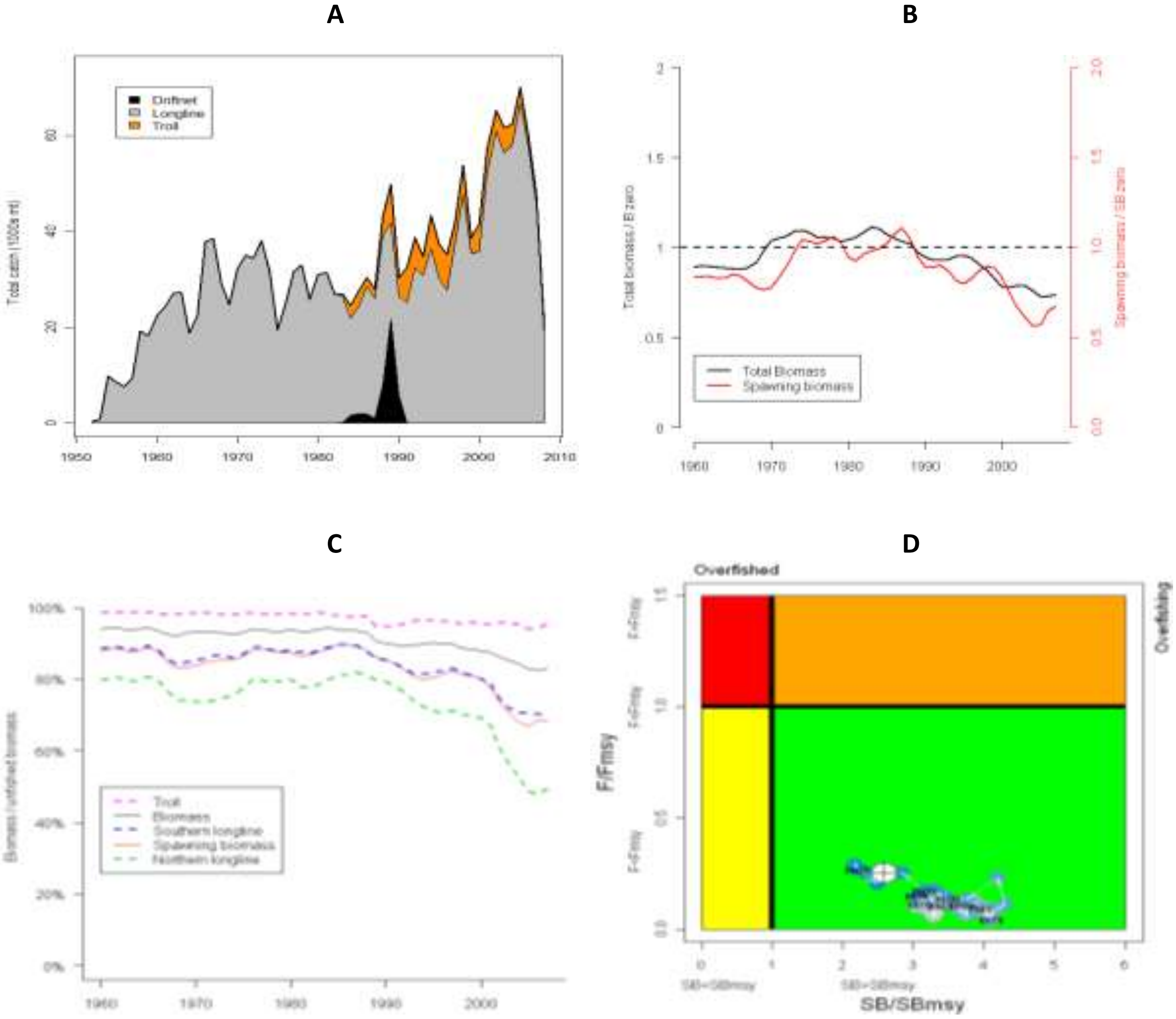

Figure 14. Stock status of South Pacific albacore tuna. A. Catch by gear type; B. Estimated time series of total and spawning biomass scaled to their respective initial values; C. Ratios of total and spawning biomass, and the biomass vulnerable to key fisheries to their respective values in the absence of fishing; and D. Kobe plot showing the relationship between the ratios of estimated spawning biomass and fishing mortality to their respective MSY-based reference points.

5 Management Frameworks

There are existing management arrangements for tuna fisheries in the WCPO at three levels – national, sub-regional and regional. These are described below.

5.1 National

Most of the island members of the Forum Fisheries Agency (FFA)[1] have national tuna management plans that provide guidelines for catch and/or effort levels for the various fisheries operating in their EEZs. These plans usually articulate aspirations for domestic tuna fisheries development, and, through a process coordinated by FFA and assisted by SPC at a technical level, incorporate the

[1] Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu and Vanuatu.

ecosystem approach to fisheries management. Some national plans provide for limits on EEZ-based catch and/or effort, but most do not. Where they do exist, they are not generally applied in terms of hard limits. One reason for this is that the tuna are not particularly amenable to unilateral management action at the EEZ level because of their wide distribution and potential for large-scale movement. Effective national catch and/or effort limits would necessarily need to be coordinated among coastal states so that the sum of such limits was consistent with stock-wide sustainable exploitation. This implies a need for a top-down allocation process, which is yet to be done comprehensively for all species and gear types. However, there are specific examples of where this is being attempted or considered at the sub-regional level, and these are described in the next section.

5.2 Sub-regional

Certain groups of FFA members have been proactive in developing coordinated management measures at the sub-regional level. One such group is the **Parties to the Nauru Agreement (PNA)**, which is a group of eight coastal states[2] located near the equator in whose EEZs nearly half of the WCPO tuna catch is taken (Figure 15).

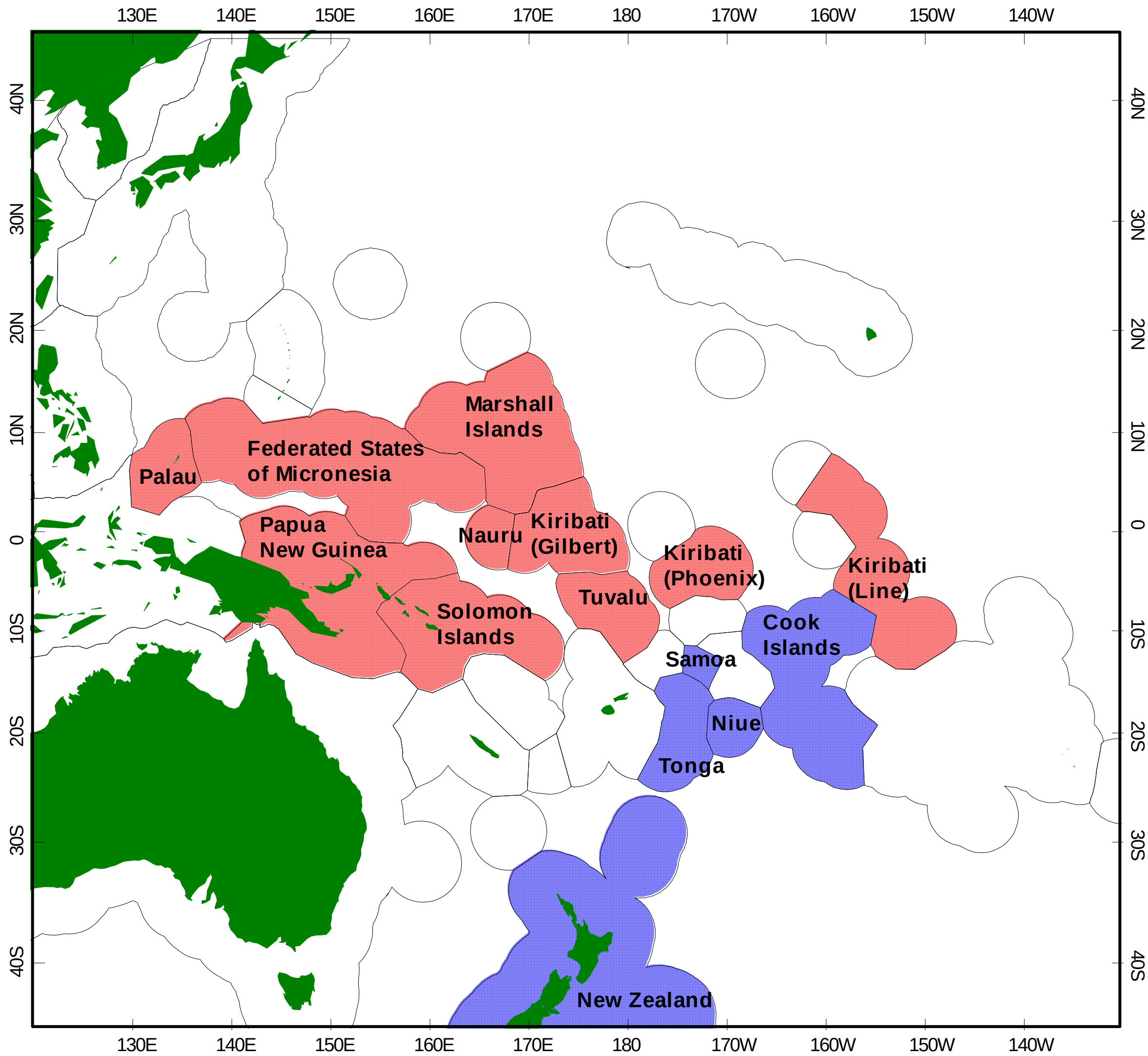

Figure 15. EEZs of the Parties to the Nauru Agreement (red) and *Te Vaka Moana* (blue).

[2] Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands, Tuvalu.

The PNA have implemented a number of important management measures, the most notable of which has been the Vessel Days Scheme (VDS) for purse seiners fishing in their EEZs. The important elements of the VDS are:

- The designation of a Total Allowable Effort (TAE) for the combined PNA EEZs, expressed as a number of days fishing or searching for fish;
- The allocation of a portion of the TAE to the United Stated purse seine fleet, which is licenced to fish throughout the EEZs of PNA and other FFA members, and on the high seas under the US Tuna Treaty;
- The allocation of the remainder of the TAE to the PNA EEZs (termed Party Allowable Effort or PAE) according to agreed criteria; and
- Provisions for the transfer of PAE among years within a three-year management period for an individual Party, and among Parties in any given year.

Currently, the TAE is arbitrarily specified and not related to the status of the main stocks taken by the purse seine fishery (skipjack, yellowfin and bigeye tuna). It does, however, provide a cap on the level of purse seine effort for the combined PNA EEZs. The PNA are currently considering a similar VDS for longline fishing in their EEZs.

In addition to managing total purse seine effort, the PNA have introduced other measures, effective 1 January 2010, as part of their Third Implementing Arrangement:

- A prohibition on purse seine sets on floating objects (commonly termed FAD sets) during the period 1 July – 30 September;
- A requirement for all licensed purse seiners to carry observers;
- A requirement that all purse seine caught tuna be retained on board and not discarded (unless unfit for human consumption and with an exemption for excess catch from the final set of a trip that cannot be carried); and
- A requirement that licensed purse seine vessels do not fish in the two high seas pockets bounded by PNA EEZs.

The FAD closure is designed to mitigate the purse seine catch of juvenile bigeye tuna, which are captured mainly in sets on floating objects. The full catch retention measure is intended to encourage vessel operators to avoid setting on aggregations of tuna that they know in advance to contain large amounts of small fish. The 100% observer coverage is to monitor compliance with these measures. Closure of the high seas pockets is intended mainly to simplify the detection of unlicensed, i.e. illegal, fishing in the EEZs, but also potentially removes effort from the fishery. An additional high seas measure, covering the high seas between 10°N and 20°S, and 170°E and 150°W, has recently been announced. The intent of this additional closure is to limit purse seine effort in the eastern portion of the WCPO, where the vulnerability of bigeye tuna to capture by purse seine appears to be particularly high.

The PNA has recently established a secretariat based in Majuro, Marshall Islands, to pursue their goal of increasing the flow of economic benefits from the tuna resource to PNA members.

Two sub-regional arrangements that deal with licensing of purse seiners operate in the WCPO – the US Tuna Treaty, which provides for access of up to 40 US-flagged purse seiners to FFA EEZs and the adjacent high seas, and the FSM arrangement, which provides for access of vessels flagged (or otherwise sponsored) by PNA members to each others' EEZs. These two arrangements deal primarily with licensing and, while they provide for certain data collection, do not operate as management arrangements in the usual sense.

A new grouping of a sub-set of FFA members, called *Te Vaka Moana* (TVM) has recently been established. TVM has a limited membership (Cook Islands, New Zealand, Niue, Samoa and Tonga – Figure 15) and is currently considering coordinated management of longline fishing for albacore in their EEZs. However, no specific management measures have been agreed at this time.

5.3 Regional

The development and implementation of stock-wide management measures for WCPO tuna fisheries is the responsibility of the Western and Central Pacific Fisheries Commission (WCPFC). Conservation and Management Measures (CMMs) are agreed at the annual sessions of the Commission and are listed at http://www.wcpfc.int/conservation-and-management-measures. A key CMM is CMM 2008-01, which applies to bigeye and yellowfin tuna. This CMM has the objectives of achieving a 30% reduction in bigeye tuna fishing mortality from the 2001-2004 average and restricting yellowfin tuna fishing mortality to the 2001-2004 average so as to maintain stocks at levels capable of producing the maximum sustainable yield (MSY). These objectives are pursued though a combination of measures involving longline catch limits, purse seine effort limits, a closure relating to purse seine fishing using fish aggregation devices (FADs) and a closure of two high-seas pockets to purse seine fishing. Most of these measures have various exemptions or alternatives built in and are phased in over the period 2009 – 2011. The CMM includes several provisions of the PNA's Third Implementing Arrangement, i.e. the FAD closure, closure of the high seas pockets and full tuna catch retention. Additionally, CMM 2008-01 specifically adopts the PNA VDS as its main tool for limiting purse seine effort in PNA EEZs. Compatible measures for non-PNA EEZs and the high seas are also specified.

An evaluation of CMM 2008-01 has been carried out by Hampton and Harley (2009a, b; 2010). The evaluation showed that CMM2008-01 is unlikely to meet its objectives of a 30% reduction in bigeye tuna fishing mortality from the 2001-2004 level, or maintenance of the bigeye tuna stock at a level capable of producing MSY over the long term. However, the evaluation concluded that the CMM should achieve its objectives with respect to yellowfin tuna.

The main reasons for the lack of effectiveness of the measure regarding bigeye tuna are (i) the reductions in longline catch do not result in the required reduction in fishing mortality on adult bigeye tuna; (ii) the increase in purse seine effort potentially allowed under the measure, and the increase in purse seine catchability (fishing mortality per unit effort) that has occurred since 2001-2004, is not sufficiently offset by the FAD and high seas pockets closures to reduce purse seine fishing mortality below 2001-2004 average levels; and (iii) the exclusion of archipelagic waters, which encompass most of the fishing activity of the Indonesian and Philippines domestic fleets and significant amounts of purse seine effort in Papua New Guinea and Solomon Islands, from the measure effectively quarantines an important source of fishing mortality on juvenile bigeye tuna. The Commission will need to consider additional measures if bigeye tuna fishing mortality is to be reduced to levels consistent with achievement of MSY.

The other CMM of relevance to the four main tuna stocks covered in this paper is CMM 2005-02, which relates to South Pacific albacore. The measure is restricted in scope, limiting the number of vessels fishing for South Pacific albacore south of 20°S to 2005 or 2001-2004 average levels. The limitation in geographic scope of the measure is intended to restrict it to largely the high seas, with the presumption that coastal states would take responsibility for the area between the Equator and 20°S, which is largely comprised of EEZs.

A range of other CMMs have been agreed by WCPFC covering pelagic species in the North Pacific, south-west Pacific swordfish, south-west Pacific striped marlin, sharks, sea turtles, sea birds and others.

6 Challenges and Solutions

Tuna fisheries in the WCPO are mostly in good condition. The species comprising around 70% of the total catch, skipjack, is being exploited well within internationally accepted guidelines. Yellowfin is more heavily exploited, particularly in the western equatorial area, but its overall status is estimated to be within MSY-based reference points. South Pacific albacore, with a predominantly longline catch of larger-sized fish, is also estimated to be well within MSY-based reference points. Bigeye tuna is the one species for which over-fishing is estimated to be occurring in the WCPO. However, even though fishing mortality for bigeye tuna is considered to be too high, stock levels appear to not yet have declined significantly below MSY-based reference levels. While the issue of high fishing mortality for bigeye needs to be addressed by management, there is no evidence that the bigeye tuna, or any other tuna stock in the WCPO, is at imminent risk of irreversible damage due to overfishing.

It is clear from the work undertaken to date that reductions in fishing mortality of bigeye tuna are needed from all major fishery sectors. This includes both the tropical longline fishery which targets adult bigeye, and the purse seine and other fisheries targeting primarily skipjack and yellowfin, while also taking quantities of juvenile bigeye that are small in the context of the overall catch by those fisheries, but are significant in terms of their impact on the bigeye stock.

To date, WCPFC have attempted to control bigeye fishing mortality in the longline fishery through catch limitation. Given the multispecies nature of the longline catch (see Figure 9), this is a reasonable approach. However, the catch limits need to be set such that they are truly limiting and result in a real reduction in fishing mortality. If this is not the case, the catch limits may not be achieved and actual catches will simply decline as the stock declines. There is some evidence that the current longline catch limits may not in fact be limiting (Hampton and Harley 2009a, b).

Achieving reductions in bigeye tuna fishing mortality in the purse seine fishery, and other fisheries targeting skipjack and yellowfin tuna, is somewhat more complicated for two main reasons. First, the economies of several small-island developing states in the Pacific, particularly PNA members, are highly dependent on skipjack tuna and the purse seine fishery. Bigeye tuna is a relatively minor part of the tuna fisheries equation for these countries and comprise <5% of the purse seine catch. Therefore, to have the support of PNA members (and other countries such as Philippines and Indonesia), any reduction in fishing mortality on bigeye tuna in the purse seine fishery must not result in significantly reduced catches of skipjack. Second, the main beneficiaries in fishery terms of reduced juvenile bigeye fishing mortality would be the distant-water longline fleets targeting adult bigeye. PNA members and purse seine operators therefore see few tangible benefits to them of any sacrifices that they might make in terms of management measures to reduce juvenile bigeye tuna fishing mortality.

These complications effectively rule out total purse seine effort or capacity controls as a means of limiting bigeye fishing mortality. To date, the PNA and the WCPFC have relied on controls on purse seine sets on floating objects (FADs) through an annual three-month closure of this form of purse seine fishing. In theory, such limits can be effective because most of the purse seine catch of bigeye is taken in sets on floating objects; relatively little bigeye is taken in the other major purse seine operational mode, sets on free-swimming or unassociated schools. Of all of the purse seine provisions of CMM 2008-01, the FAD closure is the only one that differentially targets bigeye tuna. Also, limits on floating object sets may not overly impact catches of skipjack as most purse seiners can continue to fish on free-swimming schools. However, there are some downsides: (i) searching for and setting on free-swimming schools of skipjack is more variable in terms of fishing success and tends to have a lower average catch-per-unit-effort than sets on floating objects; and (ii) free-school fishing is more costly because of increased fuel consumption, use of helicopters necessary for free-school searching and increased wear and tear on the gear because of the greater number of sets that need to be undertaken to achieve acceptable catch rates. In short, purse seine fishing for free-swimming schools is less profitable than fishing on floating objects. Therefore, there is industry resistance to the FAD closure as it is perceived as a measure that negtively impacts their efficiency and profitability.

A comprehensive evaluation of the initial two-month FAD closure that occurred in August – September 2009 has not yet been undertaken due to delays in the availability of observer data.

However, initial indications are mixed (Harley et al. 2010b). On the positive side, most vessels were able to focus on free-school sets during the FAD closure with reasonable success, and the 2009 purse seine catch of skipjack was an all-time record. On the downside, there was a higher than average focus on FAD sets during the unregulated ten months of 2009, with the result that the percentage of the overall 2009 purse seine effort that was based on FAD sets was the highest since 2005. Therefore, purse seine bigeye catch overall in 2009 is likely to have remained high. This will be further evaluated when observer data are available for analysis.

The uncertain effectiveness of the FAD closure and industry resistance to it are major issues that need to be addressed if it is to be an effective measure for limiting bigeye tuna fishing mortality in the purse seine fishery. One possible approach is the creation of market incentives to encourage the industry to voluntarily shift their operations from FAD-based to free-school based fishing. This might be achieved, for example, by a certification scheme for free-school catches whereby such catches, appropriately validated, attract a price premium in the market place. The PNA has recently commissioned an assessment by the Marine Stewardship Council (MSC) with a view to MSC certification of the purse seine catches of skipjack caught in free-school and natural floating log sets in PNA EEZs. If successful and it is capable of being effectively implemented, MSC certification of free-school-caught skipjack may create an incentive for the use of this type of operation.

FADs and natural floating objects such as logs typically aggregate schools of smaller-sized skipjack, yellowfin and bigeye tuna. In recent years, it has been common for individual purse seiners to deploy in excess of 100 FADs equipped with satellite transmitters so that their positions can be remotely monitored. FADs may also now be equipped with echo sounders that can transmit information to the owner vessel on the abundance and species composition of tuna aggregated beneath them. This technology has greatly increased the effectiveness of purse seine fishing because it allows informed choices to be made by operators to achieve their prime objective of catch maximization. Unfortunately, because of the differential propensity of bigeye tuna to aggregate beneath FADs, the catch and fishing mortality of bigeye is likely to increase as this new technology is adopted and improved.

However, the availability of new FAD technology could also be part of the solution. If there were appropriate incentives for bigeye tuna avoidance, operators could select FADs having a lower proportion of bigeye. Research to investigate this and other potential bigeye catch mitigation measures is currently being planned on a global basis by the International Seafood Sustainability Foundation (ISSF). ISSF are currently organizing workshops of tuna purse seine skippers to formulate ideas for bigeye and other by-catch mitigation. The more promising of these ideas will be evaluated in the field using one or more chartered purse seine vessels during a series of cruises scheduled for 2011 and 2012 (Restrepo 2010). Other agencies (e.g., Hasegawa et al. 2010) are also conducting trials that will hopefully provide purse seine operators with options for bigeye tuna avoidance.

If technical solutions can be found to reduce bigeye tuna catch in purse seine FAD sets, incentives may still be required to encourage operators to use them. Market incentives such as MSC certification are a possibility (e.g., for vessels which are able to reduce their bigeye by-catch to a specified level), but direct regulation of bigeye catch by WCPFC through vessel- or fleet-specific bigeye catch quotas may also be feasible. Either possibility would require near-real-time monitoring of bigeye catch by observers[3].

The preceding discussion has appropriately focused on bigeye tuna, as the main management problem currently facing WCPO tuna fisheries. While skipjack, yellowfin and South Pacific albacore do not yet face problems of over-fishing or over-depletion, it is important that frameworks be established for the control of fishing mortality for these stocks through total catch and/or effort

[3] Due to the similar visual appearance of juvenile bigeye and yellowfin tuna, reliable estimation of bigeye catch by purse seine requires the catch to be randomly sampled, ideally set-by-set, by trained observers.

controls. Ultimately, stock-wide controls will be required through WCPFC; however, a prerequisite for this is for WCPFC to agree on explicit management objectives, and limit and target reference points consistent with these objectives. This fundamental work should be an immediate priority for WCPFC.

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