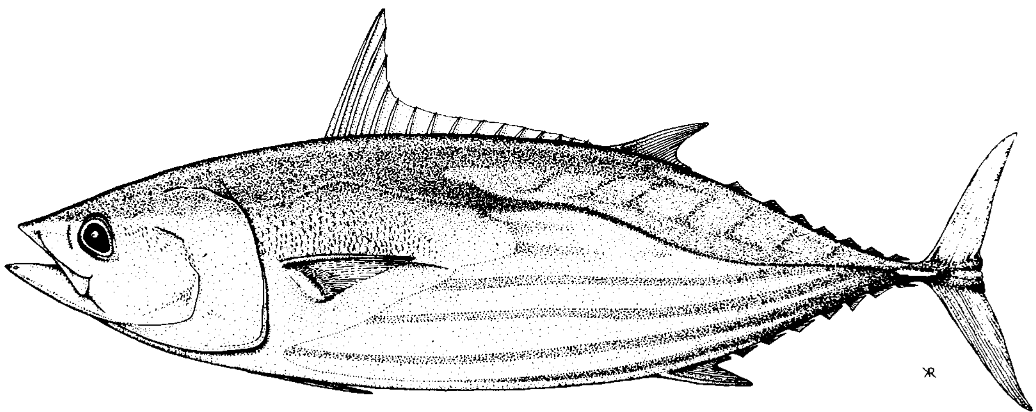
THE WESTERN AND CENTRAL PACIFIC TUNA FISHERY: 2002 OVERVIEW AND STATUS OF STOCKS

Adam Langley, John Hampton and Peter Williams



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Preface

Tuna Fisheries Assessment Reports provide current information on the tuna fishery of the western and central Pacific Ocean and the fish stocks, mainly tuna, which are impacted by them. This report focuses on the main tuna stocks targeted by the fishery — skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*) and South Pacific albacore tuna (*T. alalunga*).

The report is in two main parts, the first providing an overview of the fishery, with emphasis on developments during the past few years, and the second providing the most recent information on the status of the stocks. The data used in compiling the report are those which were available to the Oceanic Fisheries Programme (OFP) at the time of publication. The fisheries statistics presented will usually be complete to the end of the year prior to publication; however, some minor revisions to statistics may be made for recent years from time to time. The stock assessment information presented is the most recent available, and is updated periodically for each species as new analyses are completed.

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Préface

Les rapports d'évaluation de la pêche thonière donnent des informations d'actualité sur la pêche thonière dans le Pacifique occidental et central et ses répercussions sur les stocks de poisson, principalement de thon. Le présent rapport braque le projecteur sur les principaux stocks de thon ciblés par cette activité : bonite (*Katsuwonus pelamis*), thon jaune (*Thunnus albacares*), thon obèse (*T. obesus*) et germon (*T. alalunga*).

Ce rapport comprend deux parties. La première fait un tour d'horizon de la pêche thonière et met l'accent sur l'évolution intervenue ces dernières années, et la seconde fait le point sur l'état des stocks. Les données utilisées pour établir ce rapport sont celles dont le programme Pêche hauturière avait connaissance au moment de la publication. Les statistiques halieutiques présentées sont généralement complétées à la fin de l'année qui précède la publication. Quelques modifications mineures peuvent parfois être apportées aux statistiques pour les années récentes. Les informations concernant l'évaluation des stocks qui sont présentées ici sont les plus récentes dont on dispose et sont actualisées périodiquement pour chaque espèce, au fur et à mesure que l'on procède à des analyses.

Pour toute question concernant ce rapport ou d'autres aspects des activités du programme Pêche hauturière, veuillez vous adresser au:

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Des informations complémentaires, notamment une version française intégrale de ce rapport, peuvent être consultées sur le site Web du programme Pêche hauturière: http://www.spc.int/oceanfish/.

Abstract

Overview of the Western and Central Pacific Tuna Fishery

The tuna fishery in the western and central Pacific Ocean (WCPO, west of 150°W) 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 both in 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*).

Annual tuna catches, after being relatively stable since 1991, increased significantly in 1998. The 2002 catch is estimated at 2,004,836 mt, the second highest annual catch recorded after 1998 (2,040,593 mt). The purse-seine fishery accounted for an estimated 58% of the total catch, pole-and-line 17%, and longline 11%, with the remainder (14%) taken by troll gear and a variety of artisanal gears, mostly in eastern Indonesia and the Philippines. The WCPO tuna catch represented 75% of the total estimated Pacific Ocean catch of 2,679,608 mt, and 50% of the provisional estimate of world tuna catch (3,988,181 mt).

The 2002 catch by species featured a continuation of high skipjack tuna catches (1,320,692 mt; 66% of the total) and was the highest annual catch ever recorded. The yellowfin tuna catch (446,122 mt; 22%) was below the record 1998 level, but represented the sixth successive year that catches have exceeded 400,000 mt. The bigeye tuna catch (124,107 mt; 6%) was the highest recorded annual catch. The albacore tuna (North and South Pacific) catch in 2002 (113,916 mt; 6%) was slightly less than the 2001 level.

The 2002 **purse-seine** catch of 1,160,104 mt was the fifth consecutive annual catch in excess of 1,000,000 mt. Skipjack tuna (962,233 mt; 83%) continued to be the basis of the fishery and the 2002 catch was a record annual catch for the fishery. The yellowfin tuna catch (176,175 mt; 15%) was the lowest recorded over the previous six years and the bigeye tuna catch (21,696 mt; 2%) declined for the third successive year as a result of reduced FAD fishing. Catches for the Korean and Taiwanese fleets increased in 2002, while Japanese catches declined. A significant component of the 2002 catch was taken by the Papua New Guinea domestic fleet.

The 2002 **pole-and-line** catch of 330,968 mt (preliminary estimate) constituted 17% of the total WCPO catch. Annual catches have remained relatively stable at this level for the last five years. Skipjack tuna comprised the vast majority of the catch (85%); albacore tuna taken by the Japanese coastal and offshore fleets in the temperate waters of the North Pacific (9%), yellowfin tuna (5%) and a small component of bigeye tuna (1%) made up the remainder of the catch. By fleet, the Japanese distant-water and offshore fleet (130,497 mt in 2001) and the Indonesian fleet (182,545 mt in 2002) are again expected to account for most of the catch; the Solomon Islands fleet (9,652 mt) continues to recover from low catch levels experienced in recent years.

The 2002 **longline** catch of 241,917 mt accounted for 11% of the total western and central Pacific catch, but rivals the much larger purse-seine catch in terms of catch value. Since 1992, annual catches have steadily increased and the 2002 catch was the highest on record. The species composition of the 2002 longline catch was 34% yellowfin tuna, 32% albacore tuna and 34% bigeye tuna. As in previous years, most of the 2002 catch was taken by the large-vessel, distant-water fleets of Japan, Korea and Taiwan, although this proportion is declining. Effort by these fleets is widespread as they target bigeye and yellowfin tuna for the frozen sashimi market, and albacore tuna in the more temperate waters for canning. The developing domestic longline fisheries of Pacific Island countries now provide approximately 15% of the WCPO longline catch.

The 2002 **troll** catch of South Pacific albacore tuna (4,477 mt) was considerably less than from 2001, mainly due to lower effort by the USA fleet. As in previous years, catch and effort were

concentrated in two main areas — in coastal waters around New Zealand, and in the south central Pacific in the vicinity of the Sub-Tropical Convergence Zone.

Status of Tuna Stocks

Skipjack Tuna

The available fishery indicators suggest that, while skipjack tuna stock biomass in the WCPO shows considerable inter-annual variation, the fisheries have had little measurable impact on the stock. The application of the MULTIFAN-CL assessment model gave results generally consistent with the fishery indicators and previous tag-based assessments. While fishing mortality has increased significantly over time, the overall estimates of recent fishing mortality-at-age remain considerably less than the corresponding estimates of natural mortality-at-age. The percentage reduction in stock biomass attributable to the fishery has been 20–25% in recent years. Current levels of stock biomass are high and recent catch levels are easily sustainable under current stock productivity conditions.

Yellowfin Tuna

The assessment reaffirms the result of the previous assessment that the yellowfin stock in the WCPO is presently not being overfished (ie. $F_{CURRENT} < F_{MSY}$) and that it is not in an overfished state ($B_{CURRENT} > B_{MSY}$). However, the stock is likely to be nearing full exploitation and any future increases in fishing mortality would not result in any long-term increase in yield and may move the yellowfin stock to an overfished state. The assessment indicates that the equatorial regions are likely to be fully exploited, while the temperate regions are likely to be under-exploited. While these spatial patterns of exploitation remain uncertain, if true, this may indicate the potential need for different management in different regions. Furthermore, the attribution of depletion to various fisheries or groups of fisheries indicates that the Indonesian fishery has the greatest impact, particularly in its home region. The purse seine fishery also has high impact, particularly in the equatorial regions.

Bigeye Tuna

The current bigeye assessment indicates the stock is not in an overfished state ($B_{CURRENT} > B_{MSY}$) although overfishing is occurring ($F_{CURRENT} > F_{MSY}$) and the current level of exploitation appears not to be sustainable in the long term, unless the high recent recruitment is maintained in the future.

The current assessment differs considerably from the previous assessment, largely due to differences in the methodology used to standardize the longline effort data. The stock status of the bigeye fishery is sensitive to these inputs and, consequently, the validity of alternative approaches needs to be investigated to determine the true status of the bigeye stock. On this basis, the SCTB concluded that, caution should be exercised in applying the current results for management purposes. Further work is being undertaken to improve the assessment, however, in the interim the SCTB recommended that there be no further increase in the fishing mortality rate of bigeye tuna.

South Pacific Albacore Tuna

Fishery indicators and the MULTIFAN-CL analysis both suggest that the South Pacific albacore tuna stock declined moderately since the early 1980s. This decline in stock biomass was mainly recruitment driven, as was the slight recovery in the mid-1990s. One hypothesis concerning the relationship between recruitment and oceanographic conditions predicts that recruitment may have been low in 1999–2000 but may increase over the next few years due to recent La Niña conditions. The impact of the fishery on the overall stock is estimated to be small, and higher levels of catch could likely be sustained.

Résumé

Tour d'horizon de la pêche thonière dans le Pacifique occidental et central

La pêche thonière dans l'océan Pacifique occidental et central (à l'ouest du 150° O) est très diversifiée; on y trouve à la fois de petites entreprises artisanales dans les eaux côtières des États et Territoires océaniens et de grandes entreprises industrielles de pêche à la senne, à la canne et à la palangre, tant dans les zones économiques exclusives des États et Territoires océaniens que dans les eaux internationales. Les principales espèces ciblées par ces pêcheries sont la bonite (*Katsuwonus pelamis*), le thon jaune (*Thunnus albacares*), le thon obèse (*T. obesus*) et le germon (*T. alalunga*).

Après être demeurées relativement stables depuis 1991, les prises annuelles ont accusé une augmentation importante en 1998. Les prises pour 2002 sont estimées à 2 004 836 tonnes, deuxième chiffre le plus élevé après celui de 1998 (2 040 593 tonnes). La pêche à la senne représente environ 58 pour cent du total des prises, celle à la canne 17 pour cent et celle à la palangre 11 pour cent, les 14 pour cent restants étant les produits de la pêche à la traîne et de divers types de pêche artisanale, principalement en Indonésie orientale et aux Philippines. Les prises de thon dans le Pacifique occidental et central constituent 75 pour cent du total estimé des prises dans l'océan Pacifique, qui atteignent 2 679 608 tonnes, et 50 pour cent des prises mondiales de thon, estimées provisoirement à 3 988 181 tonnes.

Si l'on ventile les prises par espèce, on observe que les prises de bonite en 2002 demeurent à un niveau élevé et atteignent 1 320 692 tonnes, soit 66 pour cent du total des prises, ce qui constitue un record. Les prises de thon jaune (446 122 tonnes, 22%) accusent un léger recul par rapport au record de 1998 tout en se maintenant au-dessus de la barre des 400 000 tonnes depuis six ans, tandis que les prises de thon obèse sont de 124 107 tonnes (6 %), soit les plus élevées jamais enregistrées. Les prises de germon (Pacifique Nord et Sud) en 2002 (113 916 tonnes, soit 6%) sont légèrement moins importantes que celles réalisées en 2001.

En 2002, les prises des **senneurs** se sont élevées à 1 160 104 tonnes; c'est la cinquième année consécutive que les prises annuelles dépassent le million de tonnes. Cette pêcherie reste axée sur la bonite (962 233 tonnes, 83%), dont les prises ont atteint un niveau record en 2002. Les prises de thon jaune (176 175 tonnes, 15%) sont les moins importantes enregistrées au cours des six dernières années, et celles de thon obèse (21 696 tonnes, 2%) accusent une baisse pour la troisième année consécutive en raison de la diminution de l’effort de pêche autour de DCP. Les prises des flottilles coréenne et taiwanaise ont augmenté en 2002, tandis que celles du Japon ont baissé. Une part importante des prises de 2002 ont été effectuées par la flottille nationale de Papouasie-Nouvelle-Guinée.

Les prises à la **canne** de 2002 sont estimées provisoirement à 330 968 tonnes, soit 17 pour cent des prises totales dans le Pacifique occidental et central. Les prises annuelles sont demeurées relativement stables au cours des cinq dernières années. La bonite a représenté la grande majorité des prises (85%), le germon pris par les flottilles côtières et hauturières japonaises dans les eaux tempérées du Pacifique Nord (9%), le thon jaune (5%) et une faible proportion de thon obèse (1%) représentant le reste. Si l'on effectue la ventilation par flottille, ce sont la flottille japonaise pratiquant la pêche hauturière et au large (130 497 tonnes en 2001) et la flottille indonésienne (182 545 tonnes en 2002) qui devraient encore une fois réaliser la majorité des prises; la flottille des Îles Salomon (9 652 tonnes) poursuit son redressement après les faibles prises enregistrées ces dernières années.

Les prises de 2002 réalisées par les flottilles de **palangriers**, soit 241 917 tonnes, ne représentent que 11 pour cent du total des prises réalisées dans le Pacifique occidental et central, mais, sur le plan de la valeur marchande, elles rivalisent avec celles des senneurs, pourtant bien plus importantes. Depuis 1992, les prises ont augmenté graduellement, et celles de 2002 sont les plus importantes jamais enregistrées. La composition par espèce des prises réalisées à la palangre en 2002 a été de 34 pour cent de thon jaune, 32 pour cent de germon et 34 pour cent de thon obèse. Comme les années passées, la majeure partie des prises de 2002 a été réalisée par les gros bateaux du Japon, de la Corée et de Taiwan pratiquant la pêche hauturière, bien que cette proportion soit en baisse. Ces flottilles font porter leur effort de pêche sur une vaste zone car elles ciblent le thon obèse et le thon jaune pour le marché du sashimi congelé et le germon dans les eaux plus tempérées pour la

conserverie. Les flottilles nationales des États et territoires océaniens représentent maintenant environ 15 pour cent des prises à la palangre dans le Pacifique occidental et central.

En 2002, les prises **à la traîne** de germon du sud (4 477 tonnes) ont été beaucoup moins importantes qu'en 2001, principalement en raison de la diminution de l'effort de pêche de la flottille des États-Unis d'Amérique. Comme les années précédentes, les prises et l'effort se sont concentrés sur deux principales zones : les eaux côtières entourant la Nouvelle-Zélande et le Pacifique central du sud, aux abords de la zone de convergence subtropicale.

État des stocks de thonidés

Bonite

Les indicateurs de pêche dont nous disposons laissent à penser que, même si la biomasse des stocks de bonite dans le Pacifique occidental et central présente une variation interannuelle considérable, la pêche n'a qu'une faible incidence mesurable sur ces stocks. L'évaluation réalisée à l'aide du modèle MULTIFAN-CL a donné des résultats qui confirment généralement les indicateurs et les évaluations faites auparavant au moyen des marques. Si la mortalité due à la pêche a beaucoup augmenté au fil du temps, les estimations globales récentes de la mortalité par âge due à la pêche sont de loin inférieures aux estimations correspondantes de la mortalité naturelle par âge. Le pourcentage de diminution de la biomasse des stocks imputable à la pêche a été de 20 à 25 % ces dernières années. Les niveaux actuels de biomasse des stocks sont élevés, et les taux de prise atteints récemment peuvent se maintenir aisément, dans les conditions actuelles de productivité des stocks.

Thon jaune

La présente évaluation confirme l'évaluation précédente, à savoir que le stock de thon jaune du Pacifique central et occidental n'est pas actuellement surexploité (mortalité due à la pêche actuelle > mortalité due à la pêche correspondant à la production maximale équilibrée) et ne se trouve pas dans un état découlant d'une surpêche (biomasse actuelle < biomasse nécessaire à la production maximale équilibrée). Toutefois, il est probable qu'il approche du seuil maximal d'exploitation, et que toute future augmentation de la mortalité due à la pêche risque de compromettre les rendements à long terme et mener à la surexploitation du stock. L'évaluation montre aussi que les stocks des régions équatoriales sont susceptibles d'être exploités au maximum, et ceux des régions tempérées sous-exploités. Bien que la répartition spatiale de cette exploitation demeure incertaine, si cette hypothèse s'avère, cette situation pourrait justifier le besoin d'adopter des stratégies de gestion différentes selon la région. Qui plus est, en examinant le rôle joué par des pêcheries ou groupes de pêcheries dans l'appauvrissement des stocks, on constate que les pêcheries indonésiennes ont l'impact le plus grand, en particulier dans leurs eaux nationales. La pêche à la senne a également une forte incidence, en particulier dans les régions équatoriales.

Thon obèse

La présente évaluation révèle que le stock de thon obèse ne se trouve pas dans un état de surexploitation (biomasse actuelle > biomasse nécessaire à la production maximale équilibrée), bien qu'il fasse actuellement l'objet d'une surpêche (mortalité par pêche actuelle > mortalité due à la pêche correspondant à la production maximale équilibrée). Le degré actuel d'exploitation ne semble pas pouvoir être soutenu à long terme, sauf si le taux élevé de recrutement récemment observé se maintient.

L'évaluation actuelle diffère considérablement de l'évaluation précédente, principalement en raison de l'emploi de méthodes différentes pour uniformiser les données relatives à l'effort de pêche à la palangre. Les résultats de l'évaluation varient sensiblement en fonction des hypothèses associées aux données et, par conséquent, il convient d'étudier la validité des différentes méthodes pour déterminer le véritable état du stock de thon obèse. Ainsi, les participants à la réunion du Comité permanent sur les thonidés et marlins ont conclu qu'il importe de se montrer prudent lorsqu'on utilise ces résultats à des fins de gestion. D'autres travaux sont en cours pour améliorer ces résultats ; toutefois, le Comité permanent sur les thonidés et marlins a recommandé qu'en attendant, il faudrait éviter toute augmentation du taux de mortalité du thon obèse due à la pêche.

Germon du sud

Les indicateurs de l'état de cette pêche et les résultats de l'analyse MULTIFAN-CL donnent à penser que le stock de germon du sud a modérément décliné à partir du début des années 80. Cette diminution de la biomasse du stock est à lier principalement au recrutement, tout comme la légère reconstitution du stock au milieu des années 90. Selon une hypothèse concernant les liens entre le recrutement et les conditions océanographiques, le recrutement, encore faible en 1999-2000, pourrait augmenter au cours des prochaines années sous l'effet du récent épisode La Niña. On estime que l'impact de la pêche sur le stock est faible et que l’on pourrait probablement continuer à viser des rendements des captures élevés.

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List of Abbreviations

CPUE	catch per unit of fishing effort
ENSO	El Niño Southern Oscillation
EPO	eastern Pacific Ocean
FAD	fish aggregation device
GRT	gross registered tonnes
MSY	maximum sustainable yield
MULTIFAN-CL	a length-based, age-structured computer model used for fish stock assessment
OFP	Oceanic Fisheries Programme of the Secretariat of the Pacific Community
RTTP	Regional Tuna Tagging Project
SCTB	Standing Committee on Tuna and Billfish
SPC	Secretariat of the Pacific Community
STCZ	Sub-Tropical Convergence Zone
WCPFC	Western and Central Pacific Fisheries Commission
WCPO	western and central Pacific Ocean

Introduction

The tuna fishery in the western and central Pacific Ocean (WCPO) 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 both in 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*); a range of other species is taken incidentally in these fisheries but those species, including billfish, are not considered here.

In this report, we provide an overview of the tuna fisheries, with an emphasis on the year 2002, and current information on the status of the stocks of the target tuna species. The report draws on data and research results obtained by the SPC's Oceanic Fisheries Programme (OFP), particularly the 2002 Tuna Fishery Yearbook (Lawson 2003), and on material presented at the July 2003, 16th meeting of the Standing Committee on Tuna and Billfish (SCTB), held in Mooloolaba, Queensland, Australia (see the SCTB homepage at http://www.spc.int/OceanFish).

1 Total Catch in the Western and Central Pacific Ocean

Each of the four tuna stocks is distributed throughout the tropical and temperate waters of the Pacific Ocean, although the tropical surface fisheries, which target skipjack, yellowfin and bigeye tuna, dominate the total catch and tend to be concentrated in the western and eastern parts of the Pacific. Also, in the case of skipjack and yellowfin tuna, mixing of stocks between the western and eastern Pacific is believed to be low. For these reasons, when describing the tuna fisheries of the Pacific, we normally define the western and central Pacific Ocean and the eastern Pacific Ocean (EPO) as being separated by 150°W longitude (Figure 1).

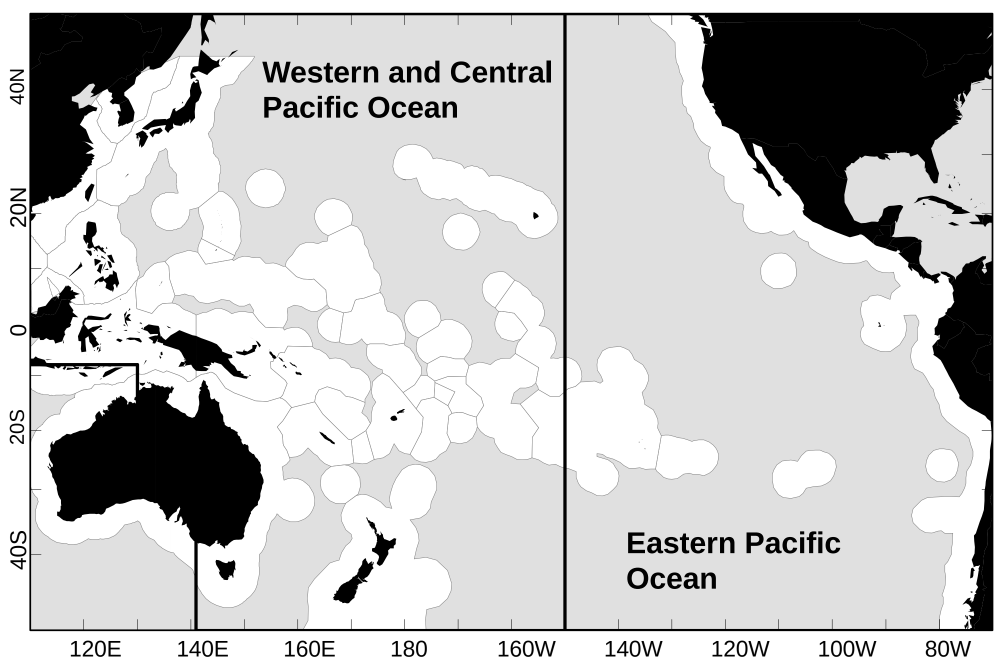

Figure 1. The western and central Pacific Ocean and the eastern Pacific Ocean.

Annual total catches of the four main tuna species (skipjack, yellowfin, bigeye and albacore) remained relatively stable during most of the 1990s, increased sharply in 1998 and have remained at this elevated level since (Figures 2 and 3). The total WCPO tuna catch during 2002 was estimated at 2,004,836 mt, only the second time over two million metric tonnes, and the second highest annual catch recorded after 1998 (2,040,593 mt). During 2002, the purse seine fishery accounted for an estimated 1,160,104 mt (58% of the total catch), with pole-and-line taking an estimated 330,968 mt (17%), the longline fishery an estimated 241,917 mt (11%), and the remainder (14%) taken by troll gear and a variety of artisanal gears, mostly in eastern Indonesia and the Philippines. The WCPO longline catch for 2002 was the highest on record.

The WCPO tuna catch represented 75% of the total estimated Pacific Ocean catch of 2,679,608 mt in 2002, and 50% of the provisional global catch estimate (3,988,181 mt) for these four species. As for the WCPO, EPO catch in 2002 (674,771 mt) was the second highest ever (after 2001), and contributed to producing a record total tuna catch for the whole Pacific Ocean (2,679,608 mt). The provisional global catch of the four main species for 2002 was also the highest ever.

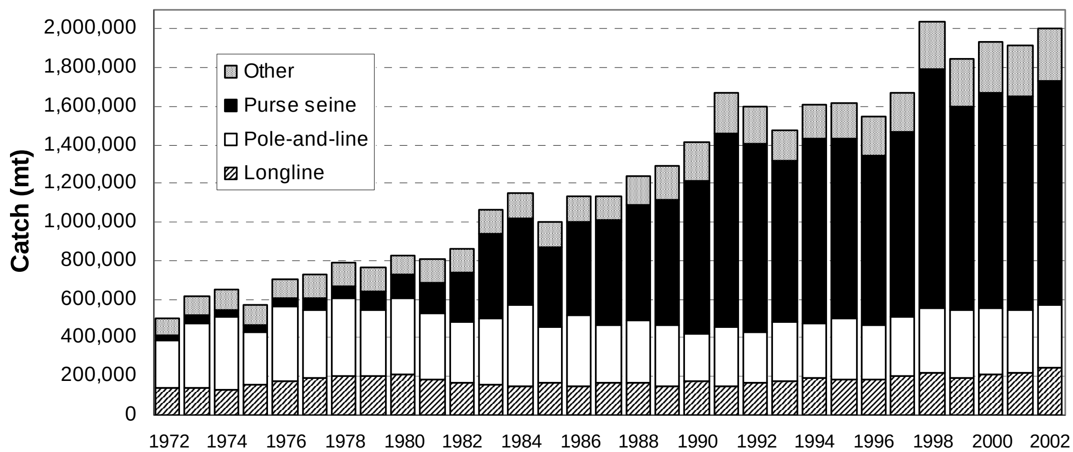

Figure 2. Annual total catch of skipjack, yellowfin, bigeye and albacore tuna, by fishing method, in the WCPO.

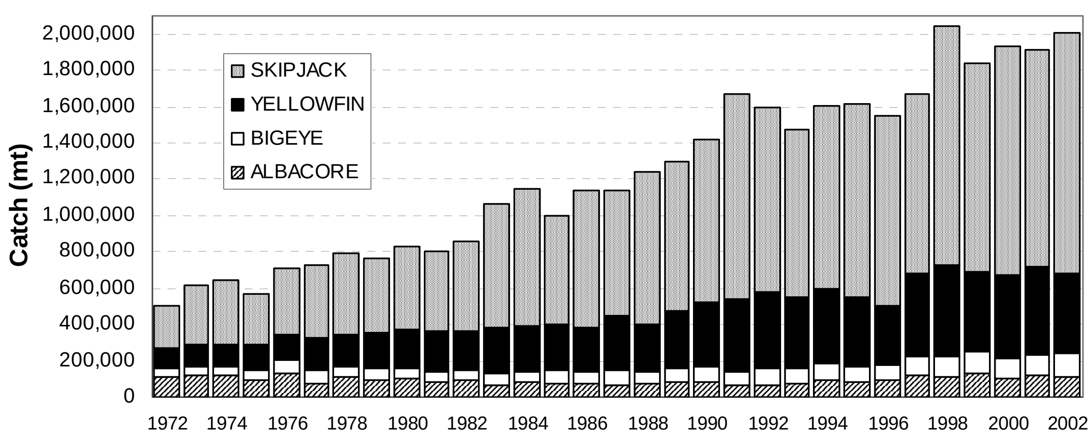

Figure 3. Annual total catch, by species, in the WCPO.

The WCPO catch by species has always been dominated by skipjack (66% in 2002). The 2002 WCPO catch of skipjack (1,320,692 mt) was the highest ever, eclipsing the previous record catch attained in 1998 (1,314,247 mt). The WCPO yellowfin catch (446,122 mt; 22%) continued the recent trend of catches above 400,000 mt, but was more than 50,000 mt lower than the record catch in 1998 (501,438 mt). The WCPO bigeye catch for 2002 (124,107 mt; 6%) was clearly the highest ever, and the WCPO albacore[1] catch (113,916 mt; 6%) was down slightly on the 2001 level. In contrast to the WCPO, the EPO yellowfin catch for 2002 was the highest ever (427,664 mt), but the EPO bigeye catch was the lowest since 1984.

2 Tuna Fishery by Gear Type

2.1 Purse Seine

2.1.1 Historical Overview

The purse-seine fishery has accounted for around 55–60% of the WCPO total catch since the early 1990s, with annual catches in the range 790,000–1,200,000 mt. The majority of the WCPO purse-seine catch is taken by the four main distant-water fishing fleets (Japan, Korea, Taiwan and USA), which currently number around 140 vessels.

There has been an increasing contribution from the growing number of Pacific Island domestic vessels (Figure 4) in recent years (41 vessels in 2002), with the balance from Philippines fisheries and a variety of other fleets, including a small seasonally active Spanish fleet.

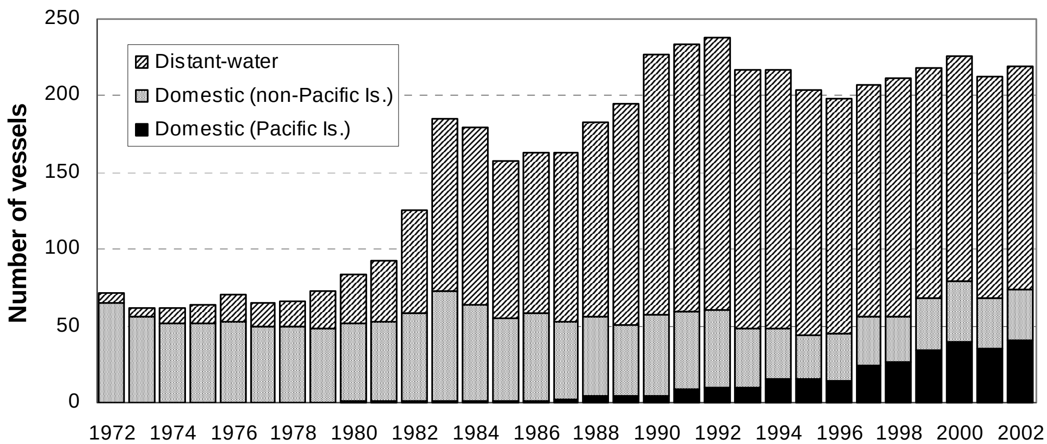

Figure 4. Number of purse-seine vessels operating in the WCPO. Domestic (non-Pacific Is.) includes vessels based in Australia, Japan and New Zealand, but not Philippines domestic vessels.

The WCPO purse-seine fishery is essentially a skipjack fishery, unlike those of other ocean areas. Skipjack tuna regularly account for 70–80% of the purse-seine catch, with yellowfin accounting for 20-25% and bigeye accounting for only a small proportion (Figure 5). Purse-seine catches in recent years have been the highest ever — the WCPO historical high catch was in 1998 (1,238,389 mt), and catches have been over 1 million mt since, despite the unfavourable economic conditions in the fishery in recent years.

Features of the purse-seine fishery during the past decade include:

- Annual skipjack catches fluctuating between 600,000 and 700,000 mt p.a. until the sharp increase with the 1998 catch which has since been maintained at around 800,000 mt and above;
- Annual yellowfin catches fluctuating considerably between 120,000 and 270,000 mt; increases in the proportion of yellowfin in the catch are often noted during El Niño years (Figure 5), with sharp reductions during La Niña years (1995/96 and to a lesser extent 1999/2000);

[1] Includes catches of North and South Pacific albacore tuna west of 150°W, which comprised 84% of the total Pacific Ocean albacore tuna catch of 137,292 mt in 2002.

- Increased bigeye tuna purse seine catches, first in 1997 (35,172 mt) and then a peak in 1999 (38,367 mt), were viewed as a result of increased use of drifting FADs since 1996. In recent years, there has been a gradual decline in both the use of drifting FADs and the bigeye catch.

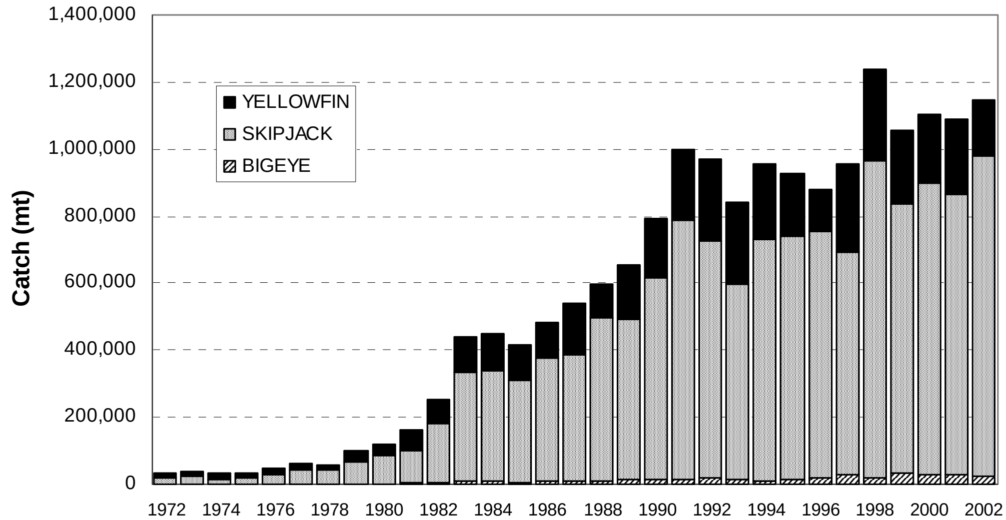

Figure 5. Purse-seine catch of skipjack, yellowfin and bigeye tuna in the WCPO.

2.1.2 The Year 2002 Fishery

Catch estimates and fleet sizes

The provisional 2002 purse-seine catch of 1,160,104 mt was the second highest on record and maintained the catch in excess of 1,000,000 mt since the record year attained in 1998. A general absence of the restrictions placed on effort in the purse seine fishery in previous two years (as a result of falling prices) no doubt contributed to this higher catch level.

The purse seine skipjack catch for 2002 (962,233 mt – 83%) was a record for this fishery (slightly higher than the previous record in 1998 – 947,149 mt). In contrast, the purse seine yellowfin catch for 2002 (176,175 mt – 15%) was the lowest for six years, and considered unusual for an El Nino period. The estimated purse seine bigeye catch for 2002 (21,696 mt – 2%) continues the declining trend in catches since the record 1999 catch (38,367 mt), primarily due to the gradual reduction in fishing effort on drifting FADs over recent years.

Catches for all distant-water fleets except Japan increased in 2002, with Taiwan continuing the trend as the highest producer for at least five years now (the 2002 catch of 258,126 mt for this fleet was marginally less than the record catch in 1998). The steady increase in catch by the PNG fleet in recent years is also noteworthy – the catch by this fleet was on par with the US fleet during 2002 (both just under 120,000 mt).

The number of Pacific-island domestic vessels continued to increase in 2002 (Figure 4). The PNG purse seine fleet constitutes the largest Pacific-island domestic fleet and is made up of 19 domestically-based vessels fishing in joint-venture arrangements in PNG waters and another eight vessels that fish over a wider area under the FSM Arrangement. The number of vessels in the FSM and Kiribati fleets remained stable into 2002, while the Marshall Islands fleet (5 vessels re-flagged from Vanuatu during 2000), were well established and fished consistently throughout 2002. The Solomon Island fleet comprised only two active vessels during 2002.

The distant-water Philippine fleet, which operates almost exclusively in PNG waters, comprises 11 vessels and accounted for close to 30,000 mt during 2002. The domestic Philippine purse-seine and ringnet fleets operate in Philippine and northern Indonesian waters, and catch close to 100,000 mt annually (Lawson, 2003). The recently-established New Zealand (4 vessels in the tropical fishery) and Chinese (3 vessels) purse seine fleets continued to expand their activities in the WCPO during 2002. There was only five days fishing by the Spanish fleet in the WCPO during 2002.

Sets on unassociated schools were the predominant fishing method during 2002 except for the PNG purse seine fleet, the domestic component of which predominantly sets on anchored FADs (Figure 6). The percentage of sets on drifting FADs dropped during 2002, continuing the trend seen since 2000. For the first time since 1998 (the most recent El Nino year prior to 2002), the proportion of log sets for all fleets, except the US, was more than for drifting FAD-associated sets.

Geographical distribution

Catch distribution in tropical areas of the WCPO is strongly influenced by ENSO events. Figure 7 demonstrates the effect of ENSO events on the spatial distribution of the purse-seine catch, with fishing effort distributed further to the east during El Nino years and a contraction westwards during La Nina periods, with considerable variation over years and areas. In general, fishing effort is distributed farther to the east during El Niño years and contracting westward during La Niña periods.

There is, however, some indication that the use of drifting FADs has dampened these effects. During El Nino periods, the WCPO equatorial waters experience a regime of westerly winds, with the resulting wind-generated (east-flowing) currents transporting natural debris (logs) further east than usual and extending the range beyond the waters where they are usually found (e.g. FSM, Indonesia and Papua New Guinea). During recent La Nina periods, it is known that purse seine fleets (predominantly US vessels) adopted a strategy of using drifting FADs well east of 160°E in order to target tuna more efficiently and reduce time in transit to their port of unloading (Pago Pago). This strategy appears to have been a successful substitute for logs, which are not as readily available in the eastern areas of the WCPO in La Nina periods compared to El Nino periods.

The WCPO experienced an ENSO-transitional (or normal) period during 2001, and an El Nino period during 2002. This resulted in a gradual shift of activities eastwards during 2001 and 2002 compared to activities during 2000. During 2002, there was less fishing activity west of 160°E longitude by the distant-water fleets compared to 2001, with effort extending eastwards and beyond the Kiribati Line Group (around 150°W) for three of the four fleets (Williams, 2003). Significantly, there was hardly any overlap in the general area fished by the US fleet during 2002 (i.e. further east and mostly south of the equator) with the general area fished by the other three distant-water purse-seine fleets.

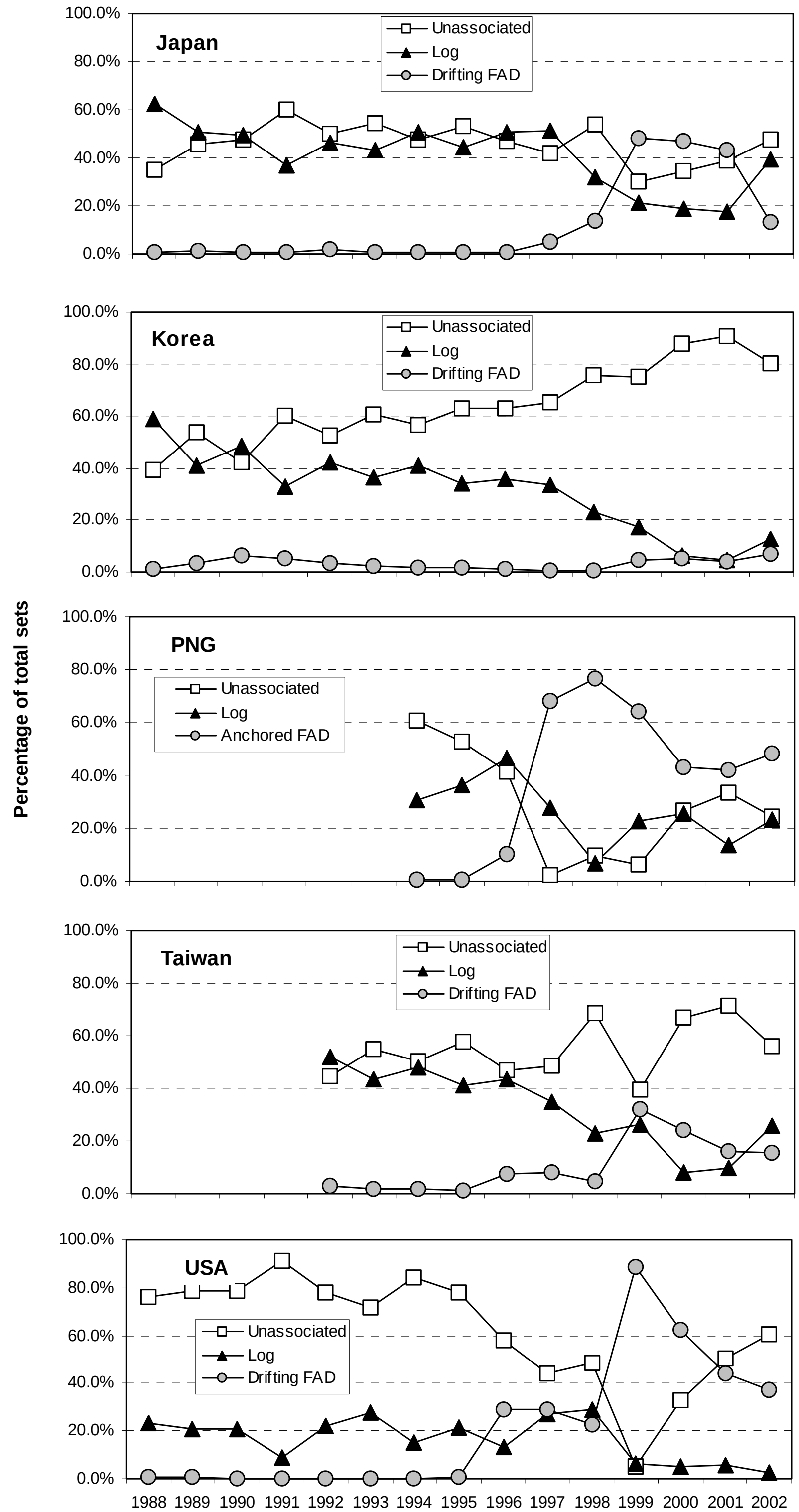

Figure 6. The percentage of total sets by set type for the major purse-seine fleets operating in the WCPO.

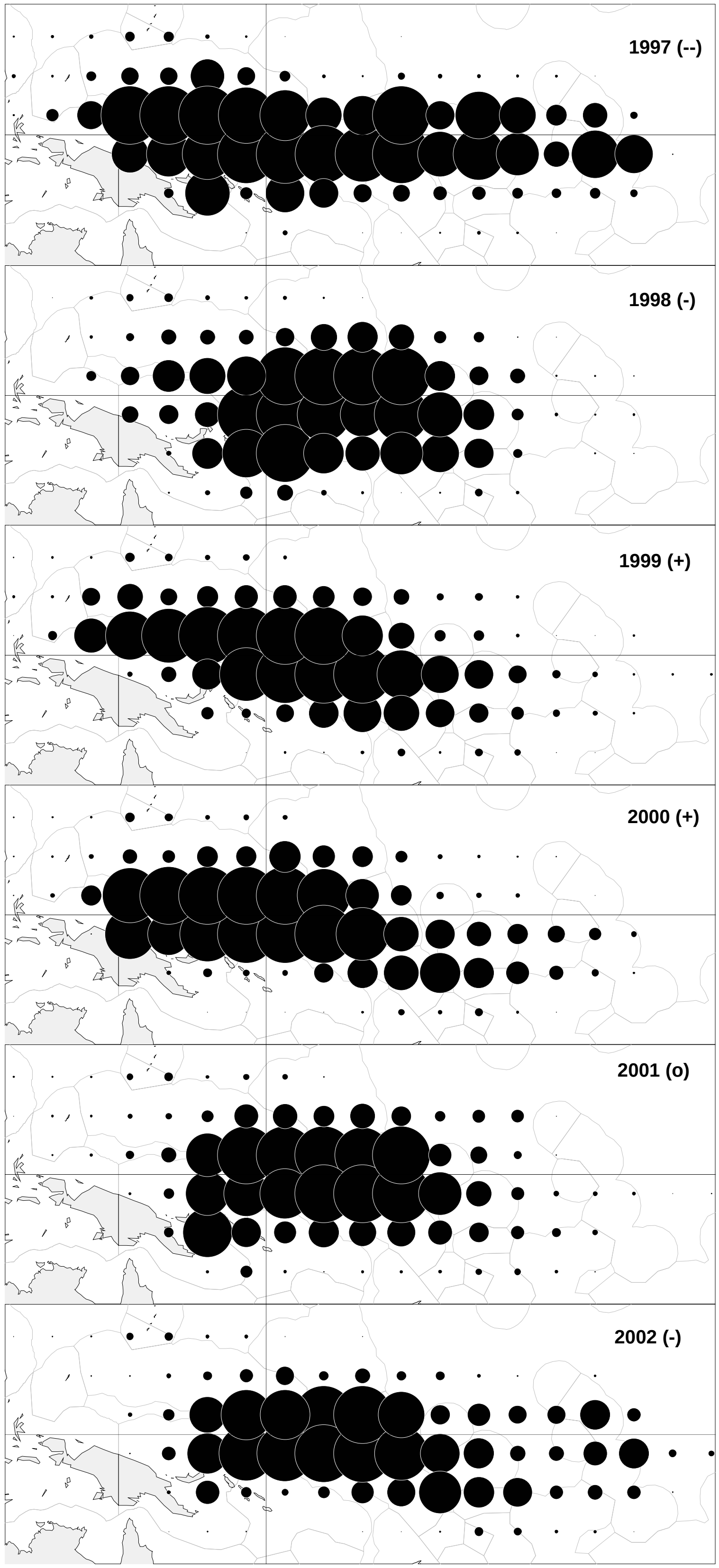

Figure 7. Distribution of purse-seine effort (days fishing and searching), 1997–2002. **ENSO periods are denoted by: '+' = La Niña; '-' = El Niño; '--' = strong El Niño; '0' = transition period. The vertical line is the 160°E longitude.**

2.2 *Pole and Line*

2.2.1 Historical Overview

The WCPO pole-and-line fishery includes:

- the year-round tropical skipjack tuna fishery, mainly involving the domestic fleets of Indonesia, Solomon Islands and French Polynesia, and the distant-water fleet of Japan;
- seasonal subtropical skipjack tuna fisheries in the home waters of Japan and Australia;
- a seasonal albacore/skipjack tuna 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 (Figure 8) and stabilisation in the annual pole-and-line catch during the past decade (Figure 9; note that distinction between troll and pole-and-line gears in the Japanese coastal fleet was not possible for years prior to 1995). 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 or two vessels are now operating in Fiji, and there have been problems in the Solomons fishery over the past 3 years. Several vessels continue to fish in Hawai'i, and the French Polynesian *bonitier* fleet remains active, but more vessels are turning to longlining activity. Against this trend, there has been a reported increase in Indonesian catches since 1999, apparently as a result of increased demand for catch and possibly technological advances.

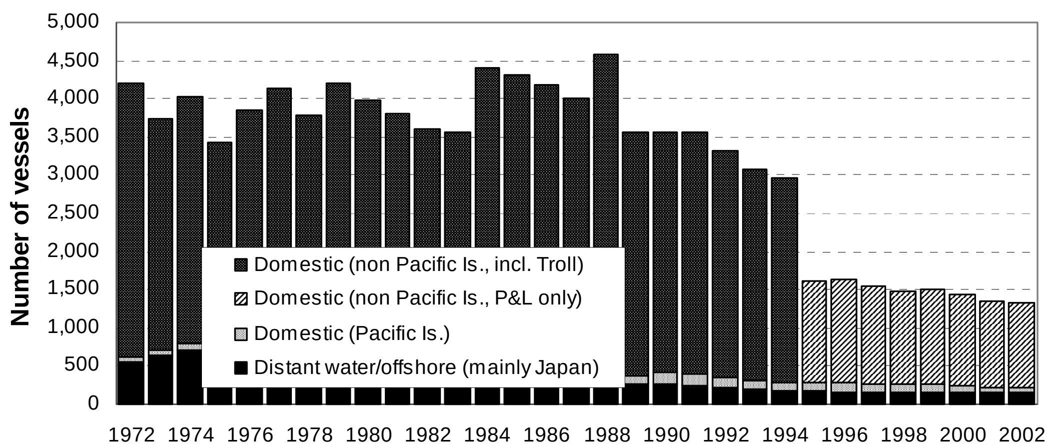

Figure 8. Pole-and-line vessels operating in the WCPO.

2.2.2 The Year 2002 Fishery (*provisional*)

Catch estimates and fleet sizes

The preliminary pole-and-line catch estimate for 2002 (330,968 mt–17% of total WCPO catch) is a slight increase on the 2001 level (324,676 mt), although the Japanese fleet catch estimate for 2002 has yet to be provided. As in previous years, skipjack accounts for the vast majority of the catch (85%); albacore taken by the Japanese coastal and offshore fleets in the temperate waters of the north Pacific (9%), yellowfin (5%) and a small component of bigeye (1%) make up the remainder of the catch. The Japanese distant-water and offshore fleets (130,497 mt in 2001) and the Indonesian fleet (182,545 mt in 2002) typically account for most of the WCPO pole-and-line catch. The Solomon Islands fleet (9,652 mt) continues to recover from low catch levels experienced in recent years (only 2,692 mt in 2000), but was still far from the level (of over 20,000 mt annually) experienced in most years of the 1990s.

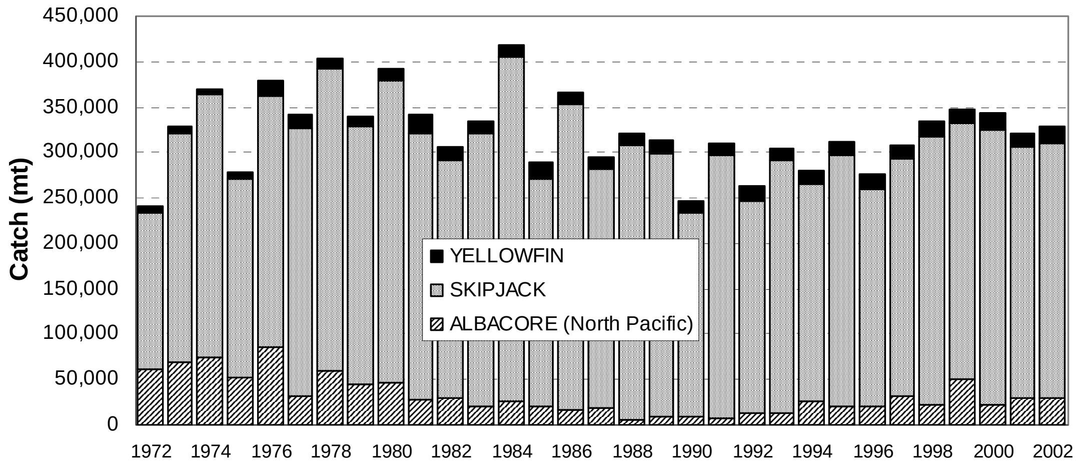

Figure 9. Pole-and-line catch in the WCPO.

Geographical distribution

Figure 10 shows the average distribution of pole-and-line effort for the period 1995–2001. Effort in tropical areas is usually year-round and includes the domestic fisheries in Indonesia and the Solomon Islands and the Japanese distant-water fishery. The pole-and-line effort in the vicinity of Japan by both offshore and distant-water fleets is seasonal (highest effort and catch in the 2nd and 3rd quarters). The effort in French Polynesian waters is essentially the bonitier fleet.

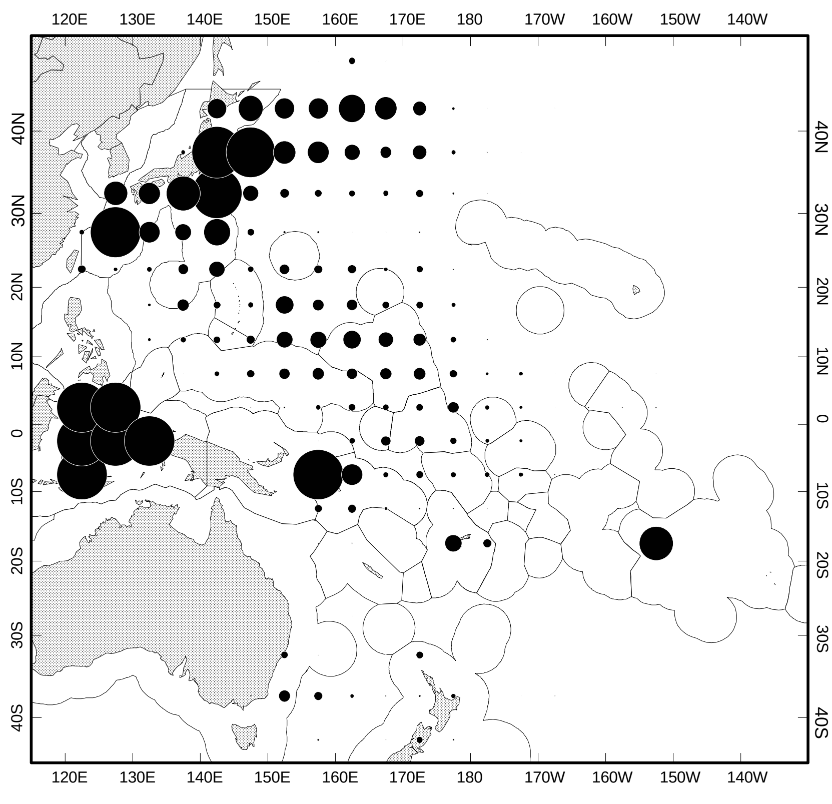

Figure 10. Average distribution of WCPO pole-and-line effort, 1995–2001.

2.3 Longline

2.3.1 Historical Overview

The longline fishery continues to account for around 10–12% of the total WCPO catch (Lawson, 2003), but rivals the much larger purse seine catch in landed value. It provides the longest time series of catch estimates for the WCPO, with estimates available since the early 1950s. The total number of vessels involved in the fishery has fluctuated between 4,000 and 5,000 for much of this period (Figure 11).

The fishery involves two main types of operation:

- Large (typically >250 GRT) **distant-water** freezer vessels, which undertake long voyages (months) and operate over large areas of the region (distant-water vessels). These vessels may target either tropical (yellowfin and bigeye tuna) or subtropical (albacore tuna) species. Some voluntary reduction in vessel numbers by one major fleet (Japan distant-water) has occurred in recent years.
- Smaller (typically <100 GRT) **offshore** vessels, usually **domestically based**, with ice or chilling capacity, and serving fresh or air-freight sashimi markets. These vessels operate mostly in tropical areas.

Additionally, small vessels in Indonesia and the Philippines (not included in Figure 11) target yellowfin and bigeye by handlining and small vertical longlines, usually around numerous arrays of anchored FADs in these waters. These fisheries have similar species composition as longliners operating in the same area.

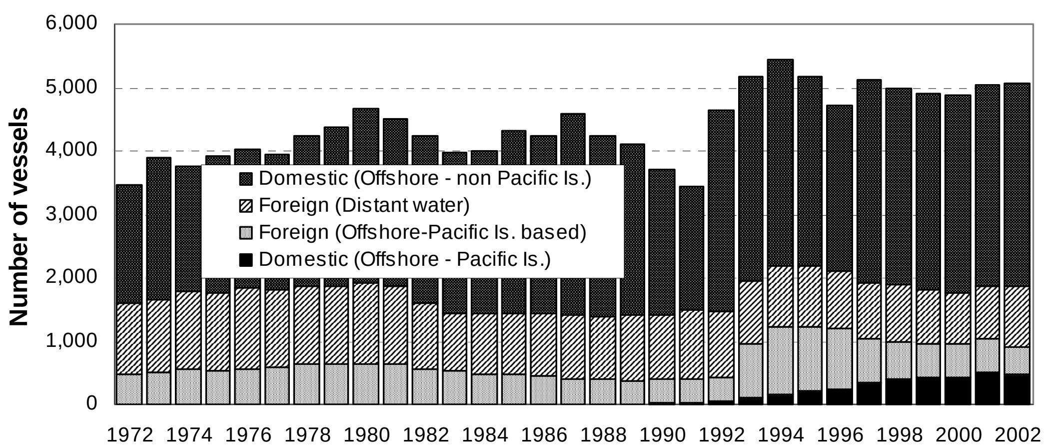

Figure 11. Longline vessels operating in the WCPO.

There have been significant changes in fleet operations and composition during the past two decades. For example, a feature of the 1980s was a change in targetting practices (fishing deeper to catch bigeye in cooler waters) in order to capitalise on a higher price for bigeye compared to yellowfin. The 1990s saw the gradual increase in the number of Pacific-Islands domestic vessels, such as those from Samoa, Fiji, French Polynesia, New Caledonia and Solomon Islands; these fleets operate in subtropical waters, with albacore the main species taken and now provide over 10% of the total WCPO catch. The entrance into the fishery and subsequent decline of the smaller "offshore" sashimi longliners of Taiwan and mainland-China, based in Micronesia, during the past decade is also noteworthy. There has also been a trend towards flexibility in species targeting in some fleets, notably those with ultra-low temperature freezing capacity.

The WCPO longline tuna catch steadily increased from the early years of the fishery (i.e. the early 1950s) to 1980 (215,253 mt), but declined in the five years after this to 147,803 mt in 1984 (Figure 12). Since 1984, catches steadily increased over the next 15 years until 2000, when catch levels were again similar to 1980. However, the composition of the catch in 1980 (ALB–20%;BET–

25%;YFT–55%), since the change in targeting, was very different to the composition of the catch taken in recent years (ALB–35%;BET–30%;YFT–35% in 2002).

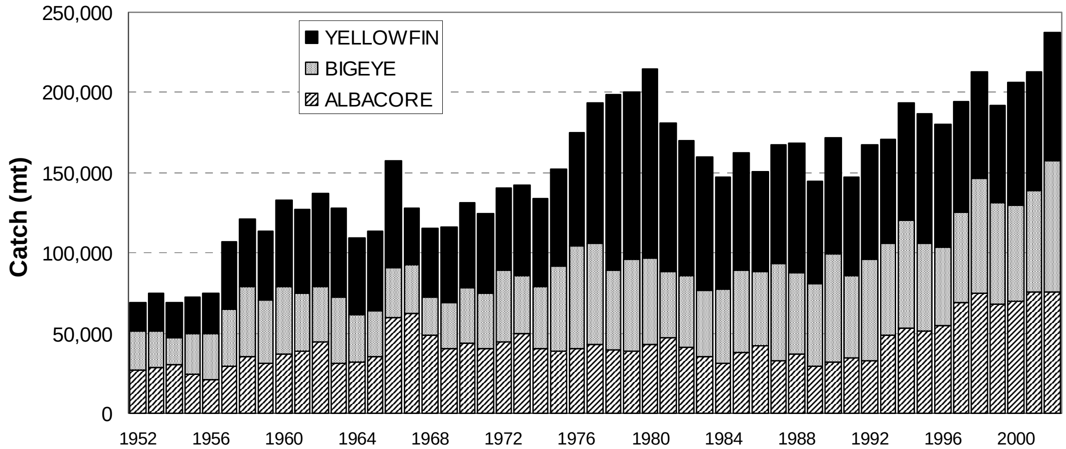

Figure 12. Longline catch in the WCPO.

2.3.2 The Year 2002 Fishery

Catch estimates and fleet sizes

The 2002 longline catch (241,917 mt) was the highest on record and nearly 24,000 mt more than the previous record catch in 2001 (218,487 mt). The WCPO bigeye (81,701 mt) and albacore (75,987 mt) catches were the highest on record, while the 2002 yellowfin catch (80,039 mt) was the highest catch in seven years and continued the significant recovery from the lowest catch (60,154 mt) recorded for nearly 30 years in 1999. The 2002 albacore catch in the south Pacific fishery (45,969 mt) was slightly higher than that the previous record catch level achieved in 2001, and again reflected the continued interest in developing Pacific Island domestic fisheries (American Samoa, Fiji, French Polynesia, Samoa and Tonga).

Domestic fleet sizes continue to increase at the expense of foreign-offshore and distant-water fleets (Figure 11), although the Taiwanese distant-water longline fleet has increased by 70% (to 133 vessels in 2002) over the past two years. This increase is primarily due to several vessels shifting activities to the Pacific Ocean from the Indian and Atlantic Oceans. Most of these vessels are "super-cold" longline vessels targeting bigeye and yellowfin tunas, and now contribute to a more diverse fleet that previously targeted albacore.

Geographical distribution

Figure 13 shows the distribution of effort by category of fleet for the period 1998–2001 (representing the most recently available data for all fleets, but reflecting the likely distributions for 2002).

Effort by the distant-water fleets is widespread, as sectors of these fleets target bigeye and yellowfin for the frozen sashimi market, and albacore in the more temperate waters for canning. Activities by the foreign-offshore fleets from Japan, mainland China and Taiwan are restricted to the tropical waters, where they target bigeye and yellowfin for the fresh sashimi market; these fleets tend to have limited overlap with the distant-water fleets. The substantial "offshore" effort in the west of the region is primarily by Indonesian and Taiwanese domestic fleets targeting yellowfin and bigeye (note that Figure 13 does not account for the coastal Japanese fleet and the Vietnamese longline fleet fishing in the south China Sea). The growth in domestic fleets in the South Pacific over recent years has been noted; the most significant examples are the increases in the Fijian and French Polynesian fleets.

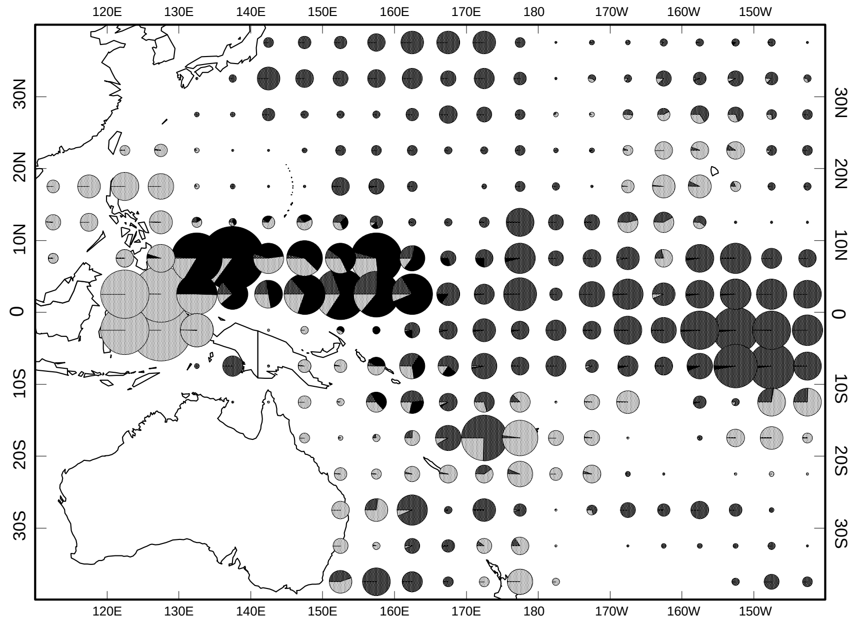

Figure 13. Distribution of longline effort for distant-water fleets (dark grey), foreign-offshore fleets (black) and domestic fleets (light grey) for the period 1998–2001.

Figure 14 shows species composition by area for 2001 (2002 data incomplete). The majority of the yellowfin catch is taken in tropical areas, especially in the western parts of the region, with smaller amounts in the often-seasonal subtropical fisheries. The majority of the bigeye catch is also taken from tropical areas, but in contrast to yellowfin, mainly in the eastern parts of the WCPO, adjacent to the traditional EPO bigeye fishing grounds. The albacore catch, in contrast, is taken in subtropical and temperate waters in both hemispheres.

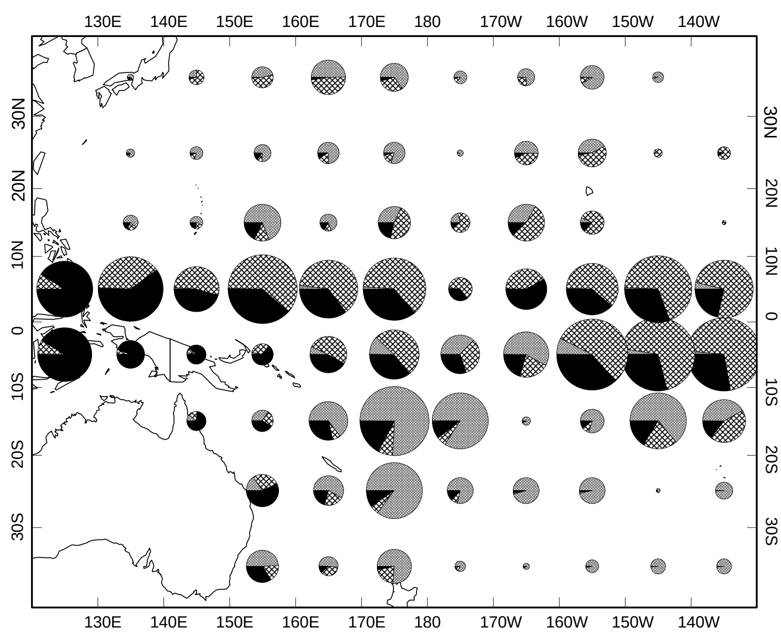

Figure 14. Distribution of longline catch, by species, during 2001
(black = yellowfin tuna; hatching = bigeye tuna; grey = albacore tuna).

2.4 Troll

2.4.1 Historical Overview

The South Pacific troll fishery is based in the coastal waters of New Zealand, and along the Sub-Tropical Convergence Zone (STCZ, east of NZ waters located near 40°S). The fleets of New Zealand and United States have historically accounted for the great majority of the catch, which in turn consists almost exclusively of albacore tuna.

The fishery expanded following the development of the STCZ fishery after 1986, with the largest annual catch (around 8,200 mt) taken in 1989 (Figure 15; Lawson 2003). Since then, annual catches have varied between 3,000 and 8,000 mt. The level of effort expended by the troll fleets each year tends to reflect the price commanded for the product (albacore for canning) to some extent, and by expectations concerning likely fishing success.

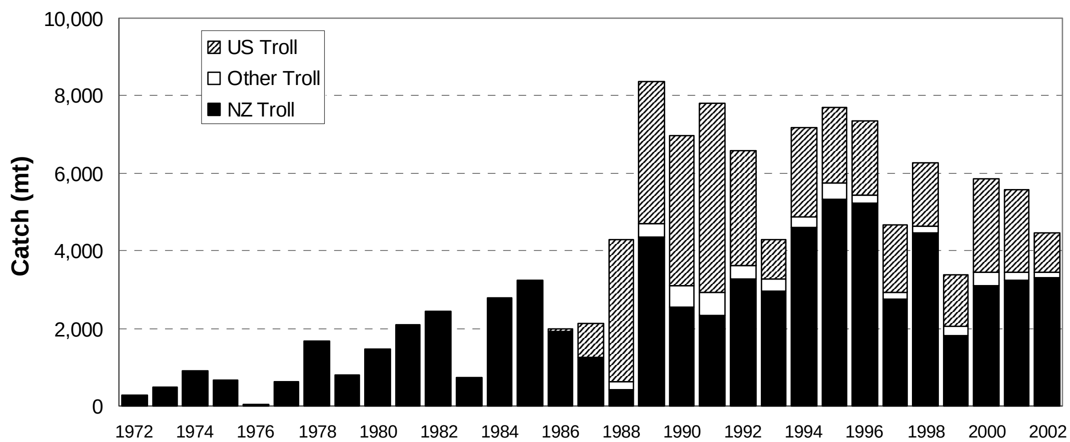

Figure 15. Troll catch of albacore tuna in the South Pacific Ocean.

2.4.2 The Year 2002 Fishery

The 2002 troll albacore catch (4,477 mt) was more than 1,000 mt less that the 2001 level. The fleets of New Zealand (3,311 mt) and USA (1,020 mt) accounted for over 95% of this catch, with minor contributions coming from vessels from Canada and Australia. Figure 16 shows the distribution of effort for troll fleets for 2002, which as in previous years constitutes effort off the coast of New Zealand and in the STCZ.

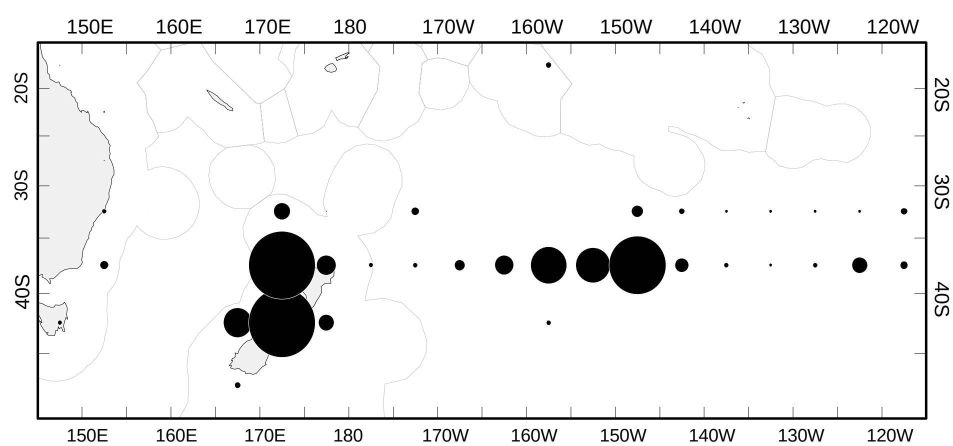

Figure 16. Distribution of South Pacific albacore tuna troll fishery effort during 2002.

3 Status of Tuna Stocks

In this section, we review the status of skipjack, yellowfin, bigeye and South Pacific albacore tuna stocks. The reference area used for skipjack, yellowfin and bigeye tuna is the WCPO as earlier defined. For albacore tuna, we continue the past practice of considering the entire Pacific Ocean south of the equator.

In each section, the catch history for that species is briefly summarised. Two types of fishery indicators of stock status are then reviewed — trends in catch per unit of effort and the size composition of catches. In some circumstances, measures based on these variables can provide useful, albeit approximate, indications of the impact of fishing on the stocks. Finally, the results of stock assessment analyses, focusing on the most recent MULTIFAN-CL analyses, are reviewed.

It should be stressed that these analyses are still evolving and may change over the next few years as additional data become available and new insights into the statistical properties of the models are obtained. Nevertheless, the results presented represent the best available information on the current status of WCPO tuna stocks.

3.1 Skipjack Tuna

3.1.1 Catch

Skipjack tuna is the dominant species in the western and central Pacific Ocean (WCPO) tuna catch accounting for nearly two-thirds of the target tuna species catch over the past decade (Lawson 2003). This species is taken primarily by purse seine and pole-and-line gear, with smaller catches by other artisanal gears in eastern Indonesia and Philippines.

Catches in the WCPO increased steadily since 1970, more than doubling during the 1980s, and continuing to increase in the subsequent years. Annual catches exceeded 1.2 million mt in three of the last five years (Figure 17). Pole-and-line fleets, primarily Japanese, initially dominated the fishery, with the catch peaking at 380,000 mt in 1984. The relative importance of this fishery, however, has declined over the years primarily due to economic constraints. The skipjack catch increased during the 1980s due to growth in the international purse seine fleet, combined with increased catches by domestic fleets from Philippines and Indonesia (which now make up 20–25% of the total skipjack catch in WCPO in recent years).

The 2002 skipjack catch of 1,320,692 mt was the highest on record and nearly 7,000 mt more than the previous record of 1998. A general absence of the restrictions placed on effort in the purse seine fishery in previous years, as a result of falling prices, no doubt contributed to this higher catch level.

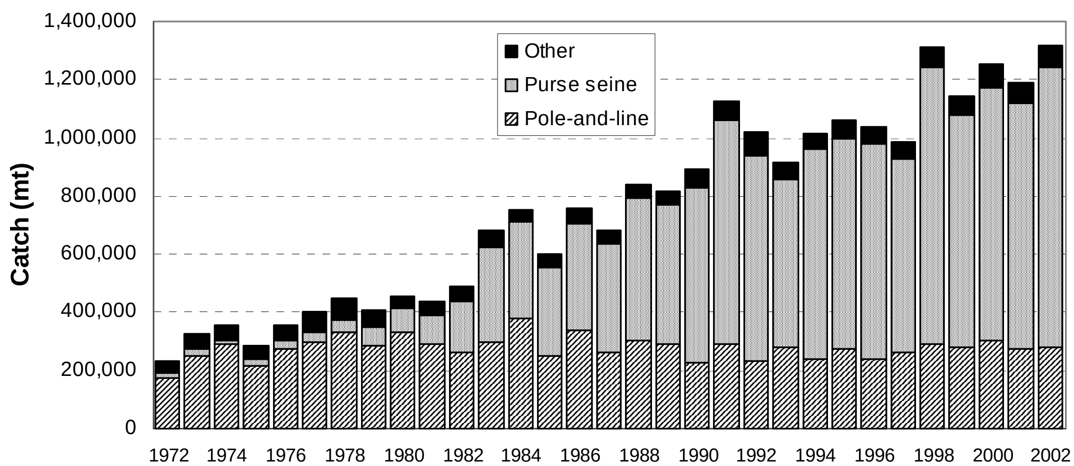

Figure 17. WCPO skipjack tuna catch, by gear.

The 2002 catch comprised the following:

- The **purse seine** gear accounted for a record 962,233 mt (73%), most of which was taken by the four main DWFN fleets (644,704 mt) and Philippines purse seine and ringnet fisheries, but with a significant contribution from the PNG fleet (89,948 mt);
- The provisional estimate for the **pole-and-line** gear 280,377 mt (21%). This catch primarily comprised catches by the Japanese fleet (the most recent estimate was 96,144 mt for 2001–the lowest catch in more than 30 years) and the Indonesian fleet (167,046 mt). There was also a noted recovery in the contribution (9,013 mt) by Solomon Islands fleet compared with the low catches in recent years;
- Other gears – ~70,000 mt (6%) representing mostly unclassified gears in Indonesia, Philippines and Japan.

The great majority of the skipjack catch is taken in equatorial areas, and a lesser amount in the seasonal home-water fishery of Japan (Figure 18). The domestic fisheries in Indonesia (pole-and-line) and the Philippines (e.g. ring-net and purse seine) account for the skipjack catch in the western equatorial portion of the WCPO. The distribution (and catch) of skipjack by purse-seine vessels in equatorial areas to the east of the Philippines oscillates from east to west in relation to ENSO events. For example, skipjack catches in 2002 were more eastwards than the average of the past decade and understood to be related to the El Nino event during this year.

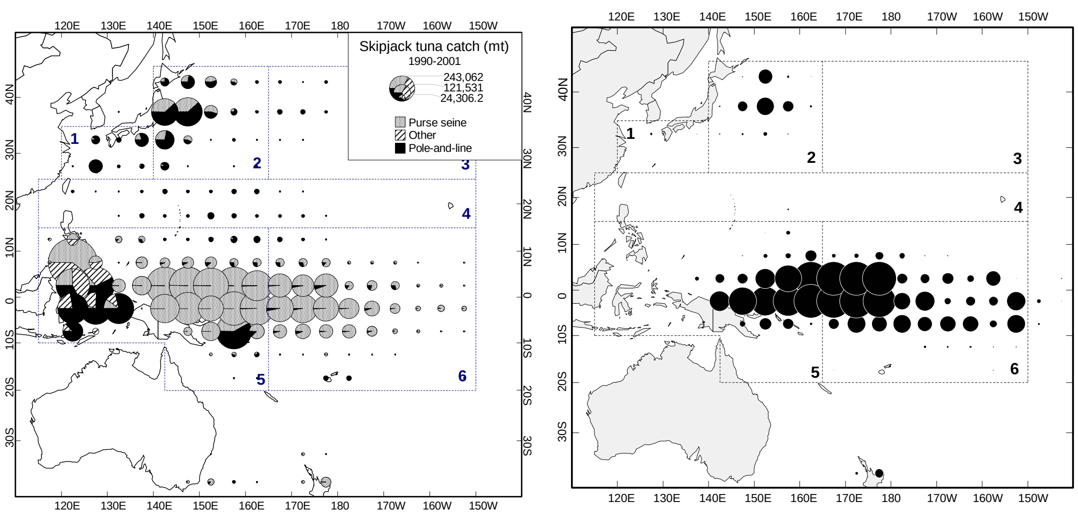

Figure 18. Distribution of skipjack tuna catch, 1990–2001 (left) and the 2002 purse seine skipjack catch (right). **The six-region spatial stratification used in stock assessment is shown.**

3.1.2 Catch Per Unit of Effort

Various skipjack tuna CPUE time series can be examined for evidence of abundance trends. Nominal CPUE series (i.e. simply catch divided by reported effort) for Japanese, USA, Korean and Taiwanese purse seiners by major set types are shown in Figure 19. These fleets are the major purse-seine fleets fishing in the WCPO.

Skipjack tuna CPUE was generally stable during the period 1988–1997 for all fleets and set types. The slight increase in skipjack CPUE for free-school sets over the past five years is possibly related to technological advances enabling better detection of free-swimming schools. For log and FAD sets, CPUE was generally higher over the period 1998–2002 than previous periods. These increases may be due to higher skipjack stock levels, an increase in the effectiveness of purse seine effort, or both.

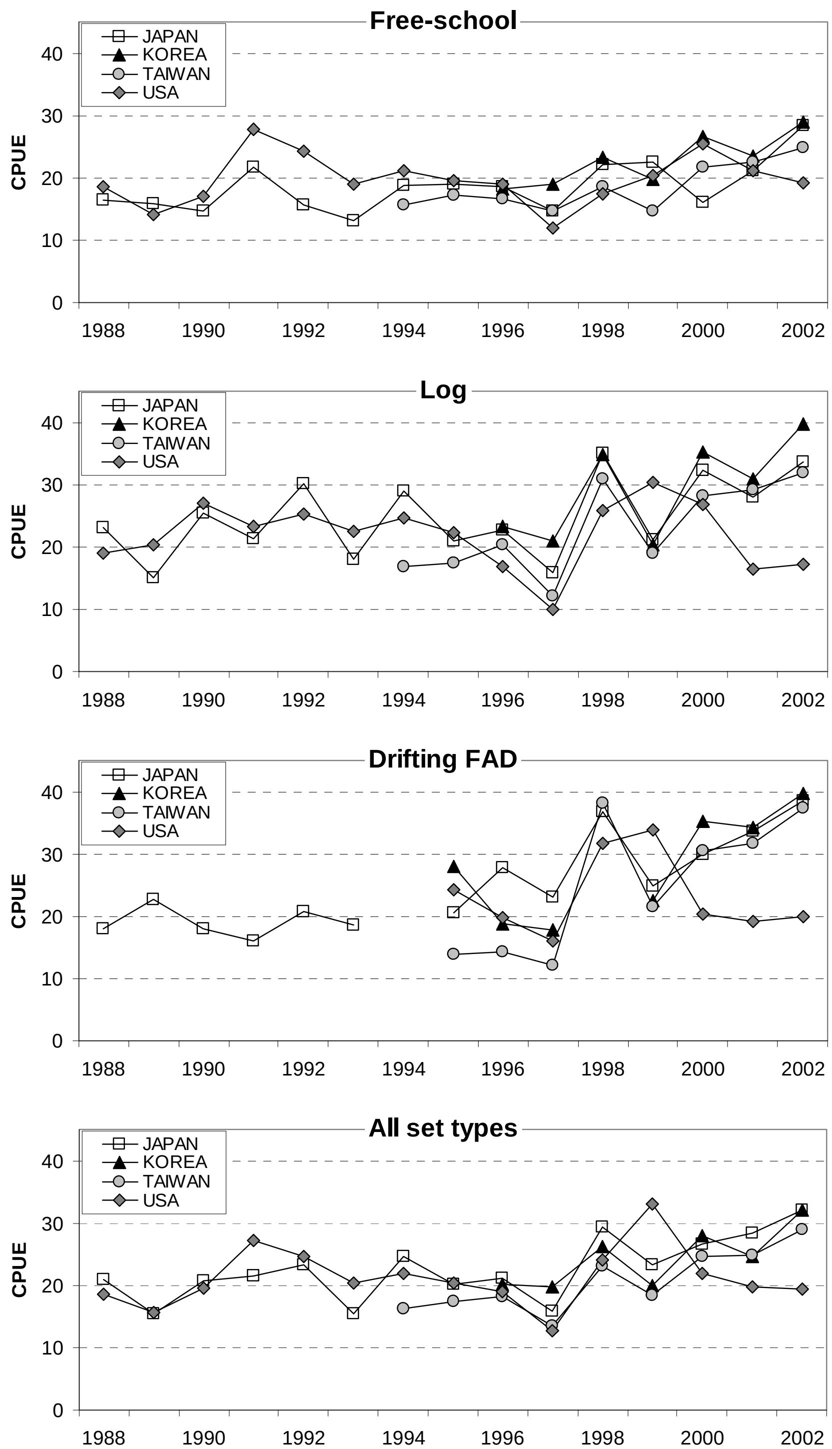

Figure 19. Skipjack tuna CPUE (mt per day) by major set type categories (free-school, log and drifting FAD sets) and all set types for Japanese, Korean, Taiwanese and USA purse seiners fishing in the WCPO. Effort and CPUE were partitioned by set type according to the proportions of total sets attributed to each set type.

The 2002 skipjack CPUE for all set types are consistent for the three Asian fleets (Japan, Korea and Taiwan) and continues the overall increasing trend since 1997. In contrast, the US fleet, which fished further to the east and south of the equator during 2002, generally experienced lower skipjack catch rates. Skipjack CPUE for drifting FAD sets undertaken by the US fleet during 2000–2002 was also clearly lower than the other fleets and perhaps related to differences in areas fished (mentioned above). The lower catch rates from FAD sets by the US fleet also accounts for the lower overall CPUE for the US fleet, given the high proportion of the drifting FAD sets compared to the three Asian fleets–see Figure 6). Fishing in the equatorial waters in the vicinity of the 160°E longitude produced very high rates in the latter months of 2002 and into the first months of 2003.

Nominal skipjack CPUE for the offshore Japanese pole-and-line fleet has remained relatively constant since 1991, while nominal CPUE for the distant-water fleet has declined steadily during the period (Figure 20). The skipjack CPUE for the offshore fleet, active in and around the Japanese home fishery, shows an oscillating pattern (between 4–6 mt/day) for most of the 1990s. In contrast, the distant-water fleet, primarily active in tropical waters, consistently accounted for a higher CPUE (between 6–8 mt/day). In contrast to the industrial purse-seine fleets, the Solomon Islands pole-and-line fleet has been operating in the region for many years using fairly consistent fishing practices and technology. Skipjack CPUE in the Solomon Islands domestic pole-and-line fishery tends to be stable but lower than the Japanese fleets. Nominal skipjack CPUE for the Japanese and Solomon Island fleets tend to follow similar patterns from year to year, suggesting that stock-wide effects are involved.

Some increases in CPUE by the Japanese fleet have coincided with substantial effort reduction and the departure of less competitive boats from the fishery, as well as the acquisition of improved technology, e.g. bird radar. Ogura and Shono (1999) considered several of these factors in estimating the standardised CPUE for the Japanese pole-and-line fleets (Figure 21). The importance in considering these factors is demonstrated when comparing nominal (Figure 20) and standardised (Figure 21) CPUE for the Japanese distant-water fleet where, for example, the trend in nominal CPUE over the past decade is downwards while there is no clear trend in standardised CPUE (low in 1993–97 and 2001; high in 1998–2000).

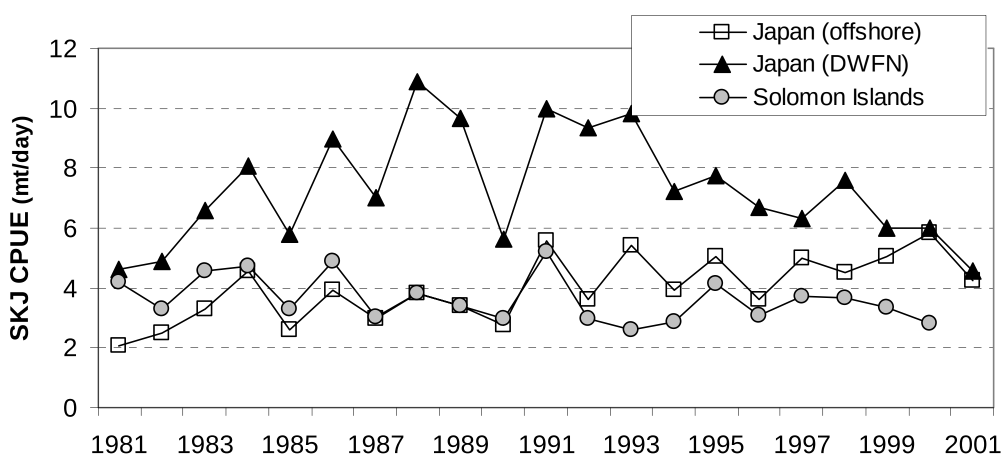

Figure 20. Nominal skipjack tuna CPUE (mt/day) for selected pole-and-line fleets.

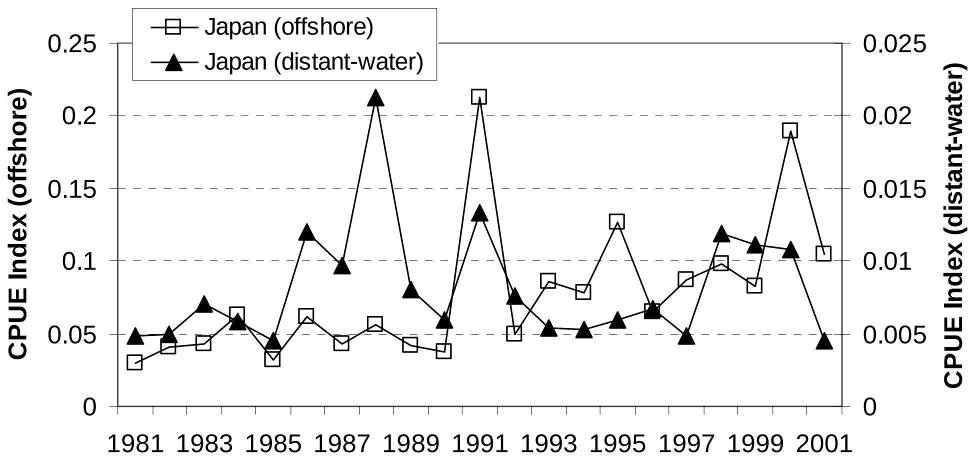

Figure 21. Standardised skipjack tuna CPUE (mt/day) for Japanese pole-and-line fleets.

3.1.3 Size of Fish Caught

As fisheries become heavily exploited, the size distribution of fish caught often changes (usually with a decline in the proportion of large fish). It is therefore useful to monitor the size composition of the catch as another potential indicator of the impact of fishing. Other factors, however, such as variable recruitment and changes in fishing methods, may also impact the catch size composition.

Decadal trends in catch-at-size for the Indonesian/Philippines domestic fisheries and the pole-and-line and purse-seine fleets are shown in Figure 22. The pole-and-line fishery accounted for nearly all of the catch up to the 1980s, but since this time the purse seine gear and the Indonesian and Philippines fisheries have been more dominant. Purse-seine unassociated sets usually take slightly larger skipjack than the pole-and-line and purse-seine associated sets (i.e. log and FAD). In contrast, the Philippines and Indonesian domestic fisheries take much smaller fish and account for most of the WCPO skipjack catch in 20–40 cm size range. The dominant mode in the overall skipjack catch generally falls in the range 50–60 cm range, corresponding to 1–2 year-old fish.

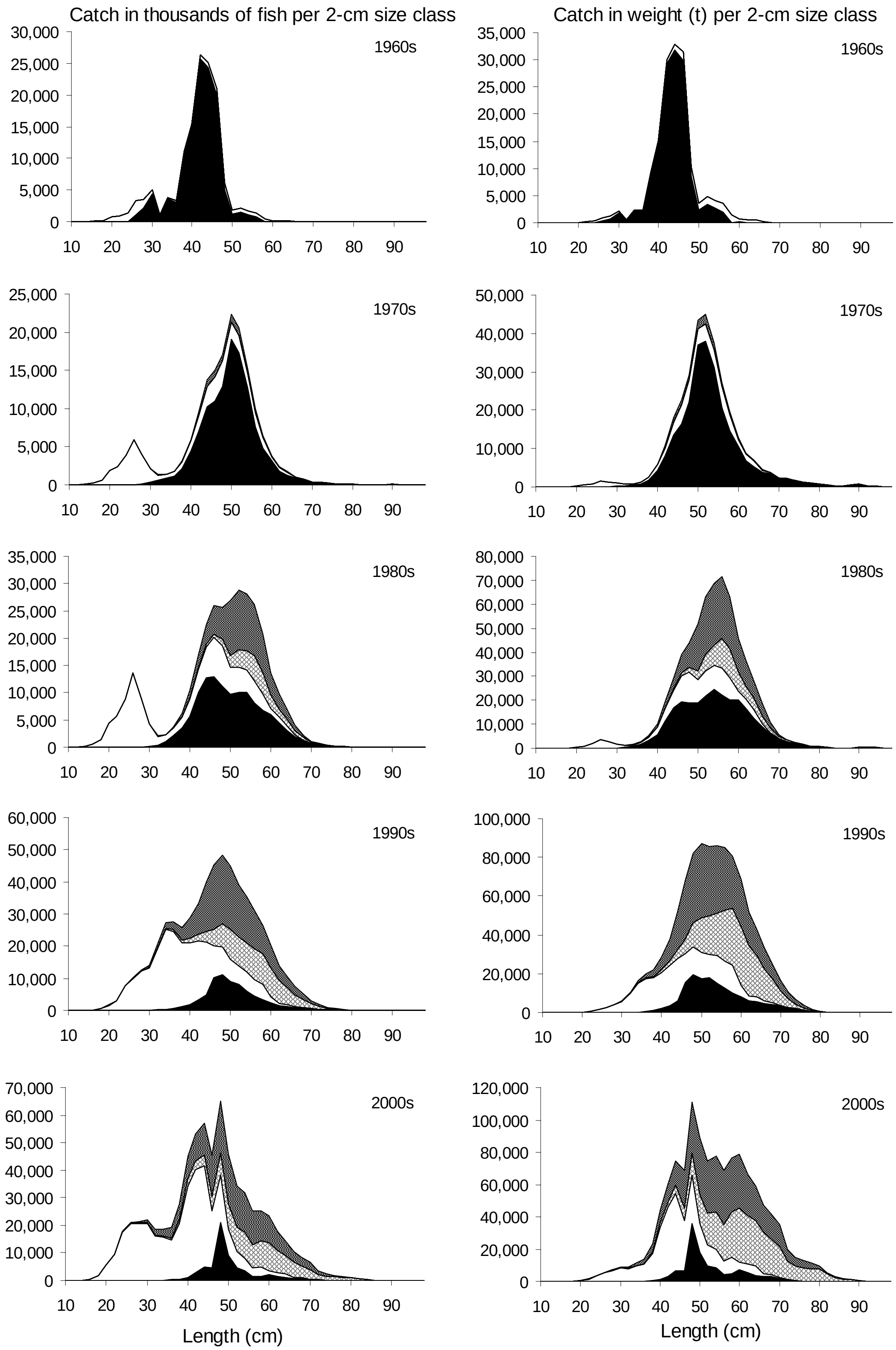

Figure 22. Average annual catches of skipjack tuna in the WCPO by size and gear type during decadal periods. **(black–Pole-and-line; white–Phil-Indo fisheries; grey–purse seine associated; hatching–purse seine unassociated)**

3.1.4 Stock Assessment

An integrated, length-based, age- and spatially-structured model known as MULTIFAN-CL (Fournier et al. 1998; Hampton and Fournier 2001) is now routinely applied to tuna stock assessment in the WCPO. For skipjack tuna, a six-region stratification of the WCPO (see Figure 18) similar to that employed by Ogura and Shono (1999) is used.

The data analysed in the most recent assessment cover the period 1972–2002 using a quarterly time stratification. Catch, effort and size data for 24 fisheries (12 pole-and-line, Philippine and Indonesian domestic, 7 purse-seine and 3 research longline fisheries) were used in the analysis, with the purse-seine fisheries classified by set type (log, FAD and unassociated sets) in each region. Tagging data from SPC tagging experiments in the tropical WCPO and from Japanese experiments in the subtropical WCPO (221,093 releases, 17,295 returns) were incorporated into the analysis. The skipjack tuna population is assumed to comprise 16 quarterly age classes (the last being a cumulative age class), which are exploited by the 24 fisheries with estimated age-specific selection patterns and time-varying catchability.

Complete details of the data, model structure and results are given in Langley et al. (2003) (see http://www.spc.int/OceanFish/Html/SCTB/SCTB16/skj1.pdf); only the subset of results of direct importance to stock assessment is given here.

Annual fishing mortality rates are highest for adult skipjack tuna (< 45 cm) and have increased continually over time for both age groups since the beginning of the analysis until about 1997 (Figure 23). Since 1997, there has been a reduction in fishing mortality that is coincident with the increase in stock biomass. Juvenile skipjack tuna are very lightly exploited. Overall fishing mortality rates remain considerably less than the corresponding natural mortality rates (which are around 2.0 per year).

Recruitment estimates show considerable low- and high-frequency variation (Figure 24). Recruitment appears to be higher following El Niño episodes (e.g. during 1990–91 and 1997–98), which is consistent with hypotheses currently advanced regarding the impact of ENSO events on tropical tuna productivity (Lehodey 2000). There was an upward shift in recruitment in the mid-1980s, which may be related to decadal-scale changes in biological productivity.

Population biomass trends are driven by the recruitment variability as expected in a short-lived species such as skipjack tuna (Figure 25). Large peaks are observed in 1987–89 and 1999–2001, following the large recruitments in those years or immediately before. Recent levels of total skipjack tuna biomass are above their long-term average levels.

The impact of the fishery on the stock is summarised in Figure 26, which compares the estimated biomass trajectory with the trajectory that would have resulted (based on the model parameters) in the absence of fishing, assuming that the fishery has had no effect on recruitment. The highest levels of impact occurred in the 1990s, when the fishery was estimated to have reduced its biomass by 20–25% from the level it would otherwise have attained.

Conclusion

The available fishery indicators suggest that, while skipjack tuna stock biomass in the WCPO shows considerable inter-annual variation, overall trends in stock biomass are either stable or increasing. The application of the MULTIFAN-CL assessment model gave results generally consistent with the fishery indicators and previous tag-based assessments. While fishing mortality has increased significantly over time, the overall estimates of recent fishing mortality-at-age remain considerably less than the corresponding estimates of natural mortality-at-age. The percentage reduction in stock biomass attributable to the fishery has been 20–25% in recent years. Current levels of stock biomass are high and recent catch levels are easily sustainable under current stock productivity conditions.

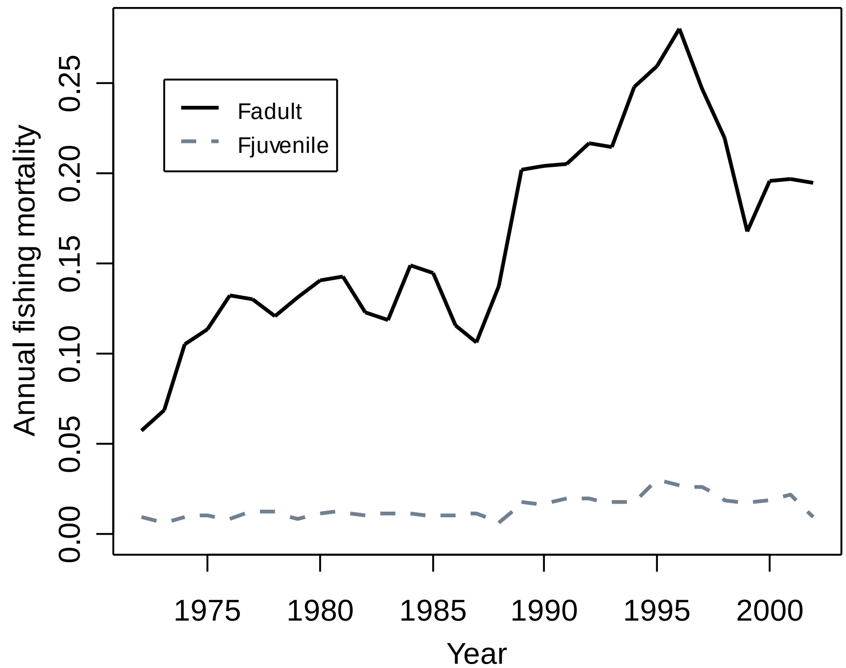

Figure 23. Estimated annual fishing mortality rates for juvenile (< 45 cm) and adult skipjack tuna.

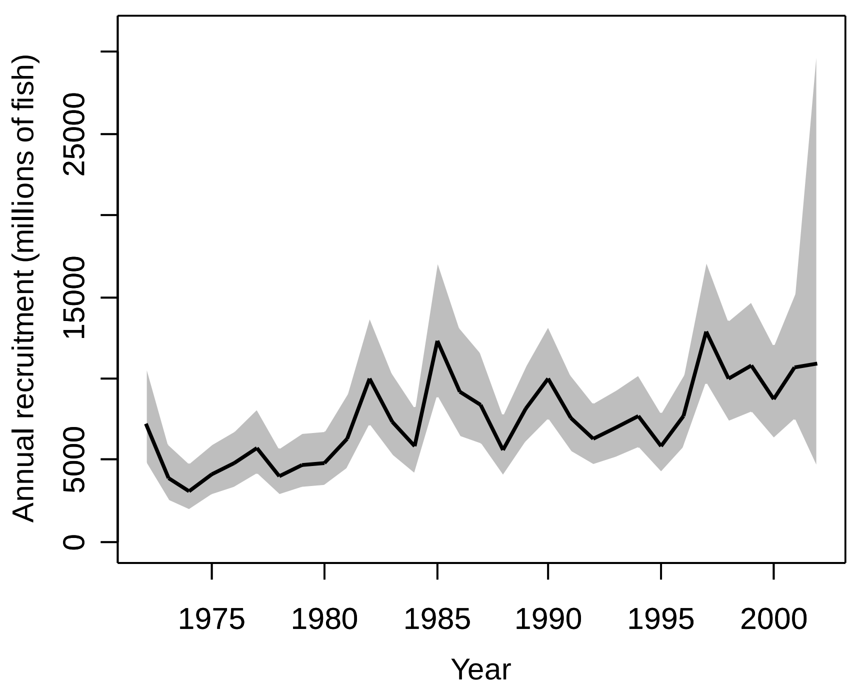

Figure 24. Estimated annual recruitment (millions) of skipjack tuna for the WCPO. The shaded area represents the approximate 95% confidence interval.

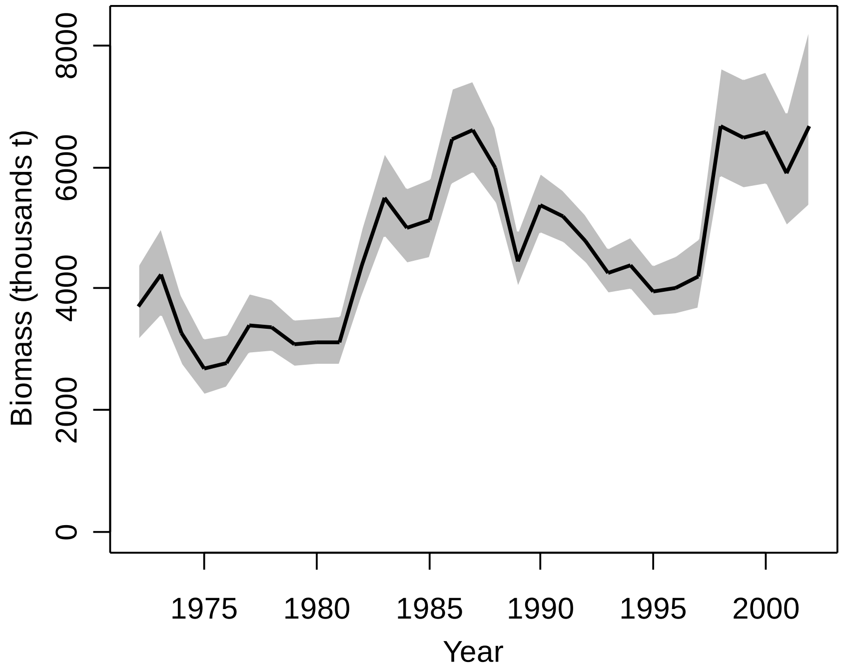

Figure 25. Estimated total skipjack tuna biomass (thousands of tonnes). **The shaded area represents the approximate 95% confidence interval.**

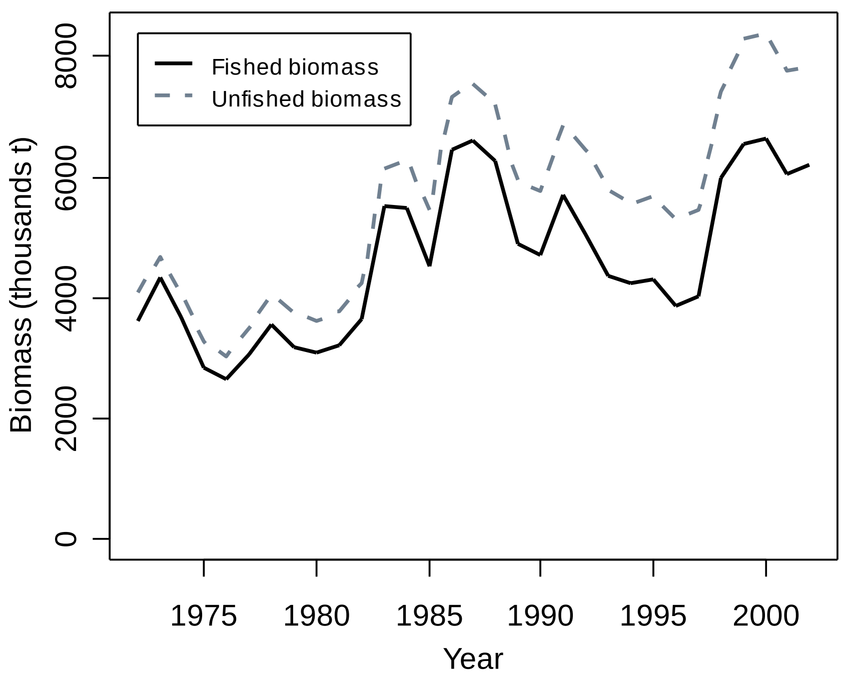

Figure 26. Comparison of the estimated skipjack tuna biomass trajectories (lower heavy lines) with biomass trajectories that would have occurred in the absence of fishing (dashed lines). **Biomass is presented in thousands of metric tonnes.**

3.2 Yellowfin Tuna

3.2.1 Catch

Yellowfin tuna, an important component of tuna fisheries throughout the WCPO, are harvested with a diverse variety of gear types, from small-scale, artisanal fisheries in Pacific Island and Southeast Asian waters to large, distant-water longliners and purse seiners that operate widely in equatorial and tropical waters. Purse seiners catch a wide size range of yellowfin tuna, whereas the longline fishery takes mostly adult fish. Yellowfin tuna usually represent approximately 20–25% of the overall purse-seine catch, but may contribute higher percentages of the catch in individual sets as unassociated schools of large yellowfin tuna are often directly targeted by purse seiners.

Since 1990, the estimated yellowfin tuna catch in the WCPO has varied between 320,000–500,000 mt with annual catches exceeding 4000,000 mt each year since 1997 (Figure 27). The 2002 yellowfin catch for all gears in the WCPO was 446,122 mt, which is more than 50,000 mt less that the record catch in 1998 (501,438 mt). The 2002 Pacific-wide yellowfin catch (all gears) of 873,786 mt was about 30,000 mt less than the record catch of 2001 (904,580 mt).

In the WCPO, purse seine typically harvests most of the yellowfin catch, which for 2002 was 176,175 mt (or 39% of the total yellowfin catch). This catch level was the lowest since 1996 and considered unusual for an El Nino period. In contrast, the eastern Pacific (EPO) purse seine catch of yellowfin (417,472 mt) for 2002 was an all-time record and continued on from the good catches experienced during 2001.

The WCPO longline catch in recent years (53,000–80,000 mt) is well below catches in the late 1970s and early 1980s (90,000–120,000 mt), presumably related to changes in targeting practices by some of the large fleets and the gradual reduction in the number of distant-water vessels. The 1999 yellowfin longline catch of 60,154 mt was the lowest for 25 years, but catches have been progressively higher in subsequent years. The 2002 catch was 80,039 mt, or 18% of the catch for all gears.

The pole-and-line fisheries took 17,815 mt (4% of the total yellowfin catch) during 2002, and the 'other' category accounted for 172,093 mt, which was a similar level to that taken in the WCPO purse seine fishery (that is, approximately 39% of the total catch for all gears). Catches in the ‘other’ category in Figure 27 are largely composed of yellowfin tuna from the Philippines and eastern Indonesia. These catches come from a variety of gear types (e.g. ringnet, bagnet, gillnet, handline and seine net) and have increased steadily over the past decade, particularly in the past three years in Indonesia.

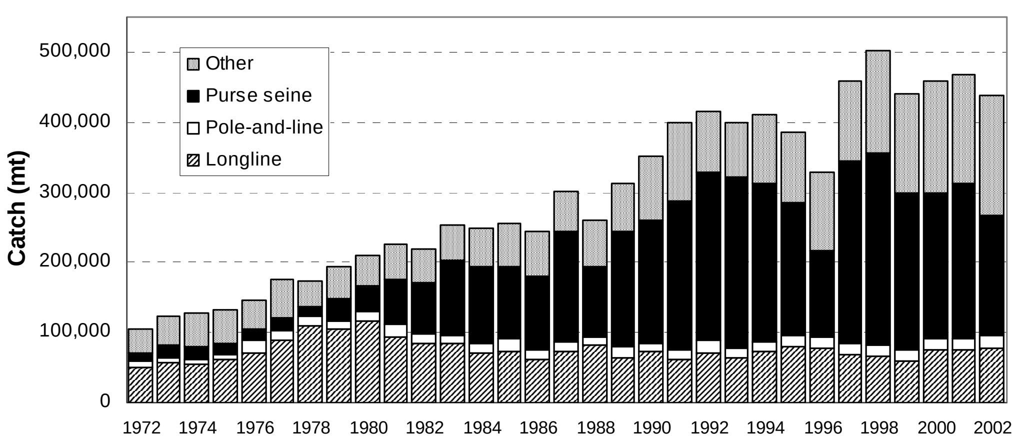

Figure 27. WCPO yellowfin tuna catch, by gear.

Figure 28 shows the average spatial distribution of yellowfin catch by gear type for the period 1990–2001, and the spatial distribution of the 2002 catch for the purse seine gear only (catch data by area for the other gears are not complete for 2002). As with skipjack, the great majority of the catch is taken in equatorial areas by large purse seine vessels, and a variety of gears in the Indonesian and Philippine fisheries. The distribution of yellowfin catch at the eastern equatorial boundary of the WCPO during 2002 was noticeably higher than the average distribution over the past decade, and no doubt related to the record catch experienced in the EPO for that year.

The east–west distribution of yellowfin catch is strongly influenced by ENSO events, with larger catches taken east of 160°E during El Niño episodes. Figure 29 highlights the inter-annual variation in the distribution of purse-seine yellowfin catch by set type in recent years. During recent El Nino years, most of the yellowfin catch to the east of 160°E was taken from unassociated schools, with logs sets accounting for most of the remainder. In contrast, during recent La Nina years, drifting FADs were widely used east of 160°E and took a significant proportion of the total purse seine catch of yellowfin. Anchored FADs are an important component of the PNG domestic purse seine fishery taking mainly juvenile skipjack and yellowfin. Note the relatively poorer catches of yellowfin between 160°E–180° during 2002 compared to the previous years, despite substantial effort in this area during 2002 (Figure 7).

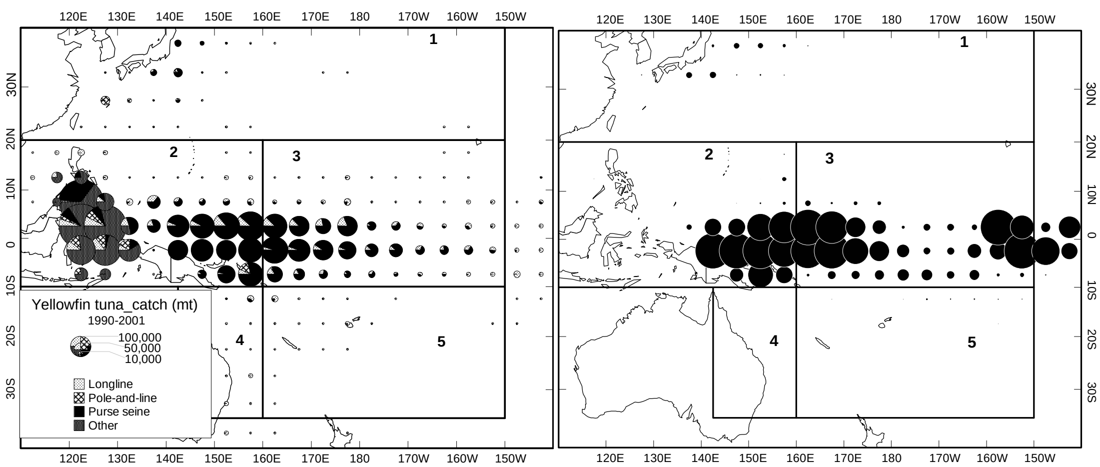

Figure 28. Distribution of yellowfin tuna catch, 1990–2001 (left) and the 2002 purse seine yellowfin catch (right). **The five-region spatial stratification used in stock assessment is shown.**

3.2.2 Catch Per Unit of Effort

Yellowfin purse seine CPUE is characterized by strong inter-annual variability and differences amongst the fleets (Figure 30). School-set CPUE is strongly related to ENSO variation in the WCPO, with CPUE generally higher during El Niño episodes. This is believed to be related to increased catchability of yellowfin tuna due to a shallower surface mixed layer during these periods. ENSO variability is also believed to impact the size of yellowfin and other tuna stocks through impacts on recruitment. In line with this hypothesis, the purse seine fishery generally experienced a decline in yellowfin CPUE during recent La Niña periods (1995-96 and 1999–2000) from the highs experienced during previous El Niño years (1994–1995 and 1997–98).

During 2001, the yellowfin CPUE increased in line with the weakening of La Niña. However, yellowfin CPUE for all set types declined in 2002 compared to 2001, for all but the US fleet. The US purse seine fleet effort for 2002 was concentrated more eastwards than the other purse seine fleets (Williams, 2003) into an area where oceanographic conditions may have improved the availability of yellowfin to the gear. The 2002 effort by the other purse seine fleets does not appear to have extended as far east as in the previous El Nino event (1997–1998) and could therefore explain the poor yellowfin catch rates for these fleets during 2002.

The distant-water longline fishery, which has operated since the early 1950s, provides another means of monitoring changes in yellowfin tuna abundance. As longliners target larger fish, the CPUE time series should be more indicative of adult yellowfin tuna abundance. However, as with purse-seine CPUE, the interpretation of longline CPUE is confounded by various factors, such as the changes in fishing depth that occurred as longliners progressively switched from primarily yellowfin tuna targeting in the 1960s and early 1970s, to bigeye tuna targeting from the late 1970s on. Such changes in fishing practices will have changed the effectiveness of longline effort with respect to yellowfin tuna, and such changes need to be accounted for if the CPUE time series are to be interpreted as indices of relative abundance.

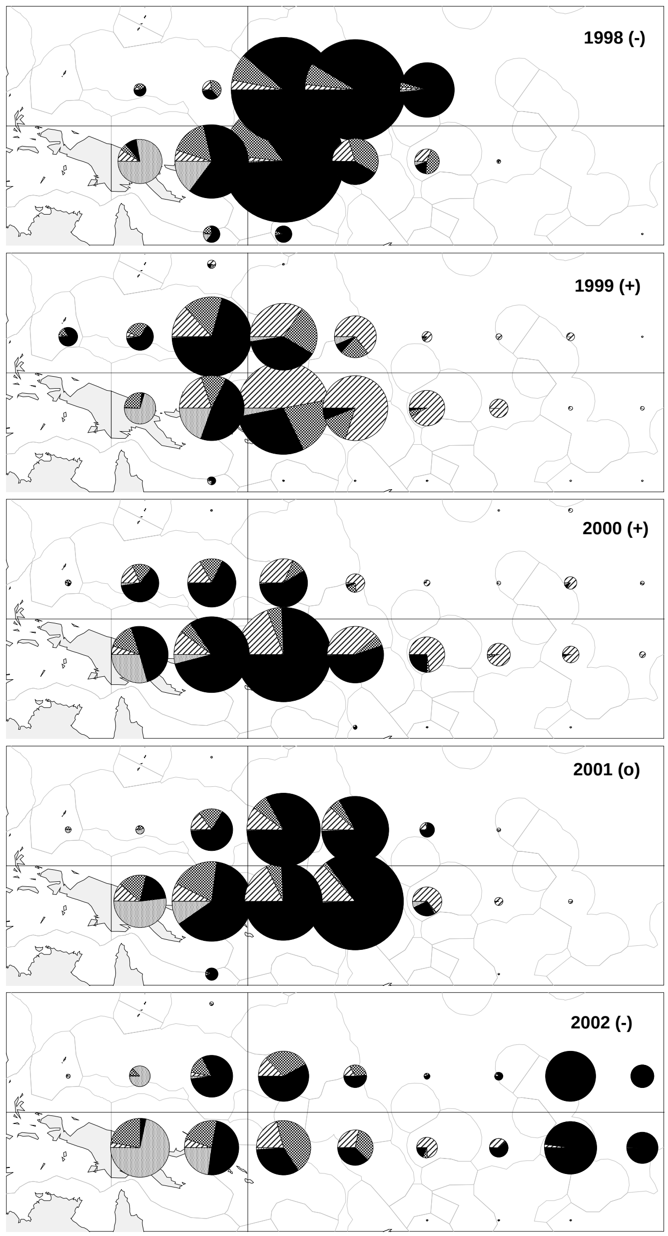

Figure 29. Distribution of purse-seine yellowfin catch by set type, 1998–2002 (Solid–Unassociated; Dark Grey–Log; Striped–Drifting FAD; Light Grey–Anchored FADs). ENSO periods are denoted by "+": La Niña; "-": El Niño; "--": strong El Niño; "0": transitional period.

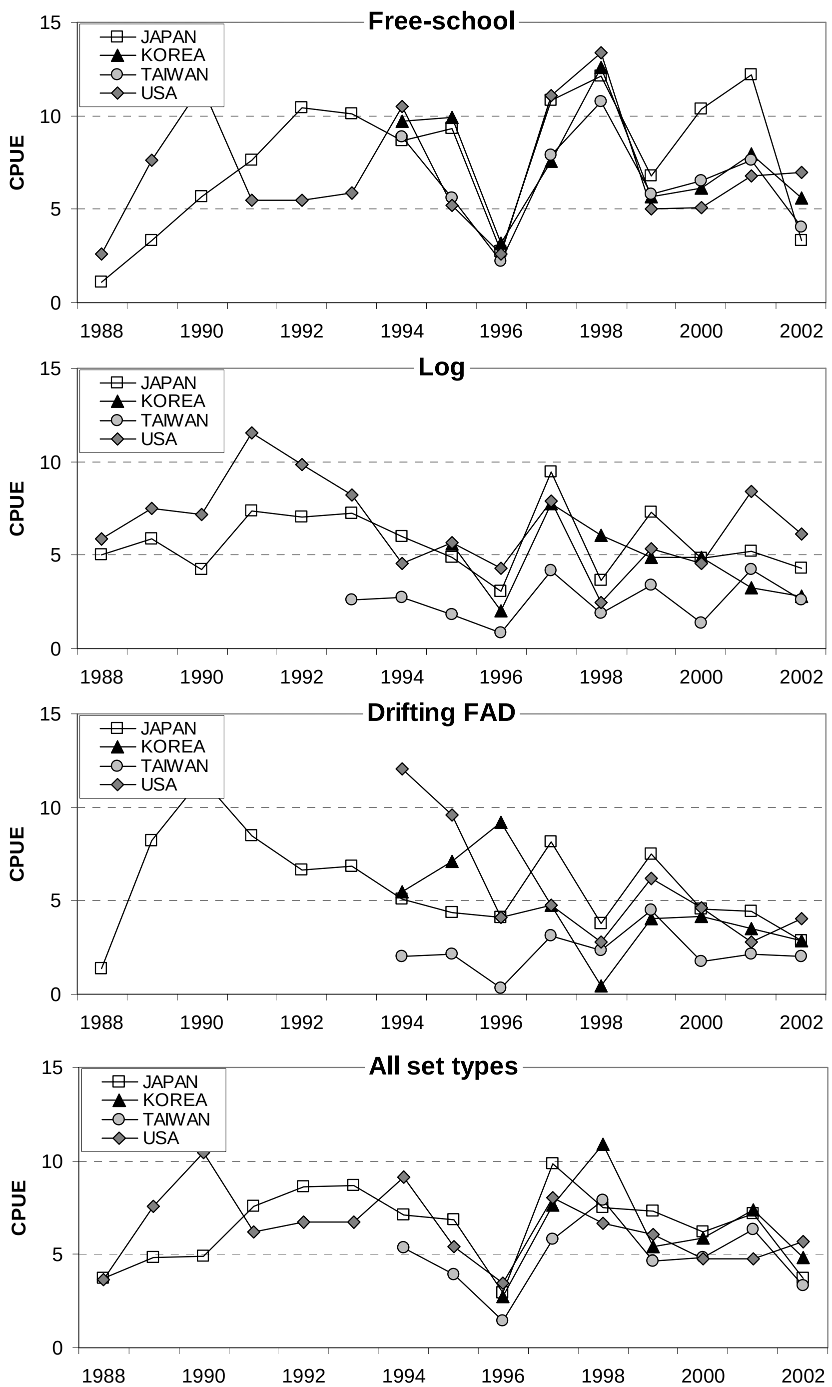

Figure 30. Yellowfin tuna CPUE (mt per day) by major set type categories (free-school, log and drifting FAD sets) and for all sets combined for Japanese, Korean, Taiwanese and USA purse seiners fishing in the WCPO. **Effort and CPUE were partitioned by set type according to the proportions of total sets attributed to each set type.**

Time series of nominal CPUE and standardised CPUE (catch per unit of 'effective' effort) for the five regions used in yellowfin stock assessment (Hampton and Kleiber, 2003) are shown for all longline fleets in Figure 31. "Effective" or standardised effort is determined and used to account for factors that are understood to affect the availability of yellowfin to the longline gear. For example, habitat-based studies account for the effects of changes in targeting as well as the variation in environmental parameters that define yellowfin tuna habitat. The following standardised effort series have been used to produce the three standardised CPUE time series shown in Figure 31: (1) a general linear model (GLM – Langley, 2003b); (2) a deterministic habitat-based standardisation (HBS - Bigelow et al. 2003); and (3) an unconstrained statistical habitat-based standardisation (statHBS - Bigelow et al., 2003).

The trends in standardised GLM CPUE follow the trends in nominal CPUE throughout, although the GLM CPUE is generally lower in the years prior to the change in targeting practice from yellowfin to bigeye (i.e. pre–1980), and generally higher than the nominal CPUE in the years since, when effective effort was directed away from yellowfin. The nominal and GLM-standardised CPUEs have been generally stable in most regions over the past twenty years, except Region 2 and to a lesser extent Region 3 (the areas accounting for most of the catch), which exhibit a steady decline in both measures over this period. In contrast to nominal and GLM standardised CPUEs, the trends in the habitat-based standardised CPUEs are generally flatter over the entire time series for all regions (for example, while there is a declining trend in the habitat-based standardised CPUEs in Region 2 over the past two decades, it is not as pronounced as in the nominal and GLM CPUEs). The habitat-based standardised CPUEs increased in the late 1970s compared to the previous decade. This change corresponds to the period when effort was directed away from yellowfin, and in several regions, this new higher level has been sustained since.

In Region 4 and Region 5, catch rates declined sharply during the development of the fishery in the 1950s. This occurred as the fishery expanded spatially and the decline in catch rates is not considered to be representative of the abundance of yellowfin in the overall region during this period.

3.2.3 Size of Fish Caught

Average annual yellowfin tuna catch-at-size for the Indonesian/Philippines domestic fisheries and the longline and purse-seine fisheries are shown in Figure 32. The domestic surface fisheries of the Philippines and Indonesia take large quantities of small yellowfin in the range 20–50 cm. Purse seine sets on floating objects (i.e. associated schools) generally take smaller fish than sets on unassociated or free-swimming schools, which are often 'pure' schools of large, adult yellowfin. Yellowfin taken in unassociated purse-seine sets are of a similar size range to fish taken in the longline fishery and the handline fishery in the Philippines (both gears target adults in the range 80–160 cm). The purse-seine catch of adult yellowfin tuna, on average, has been higher than the longline catch over the past 10–15 years.

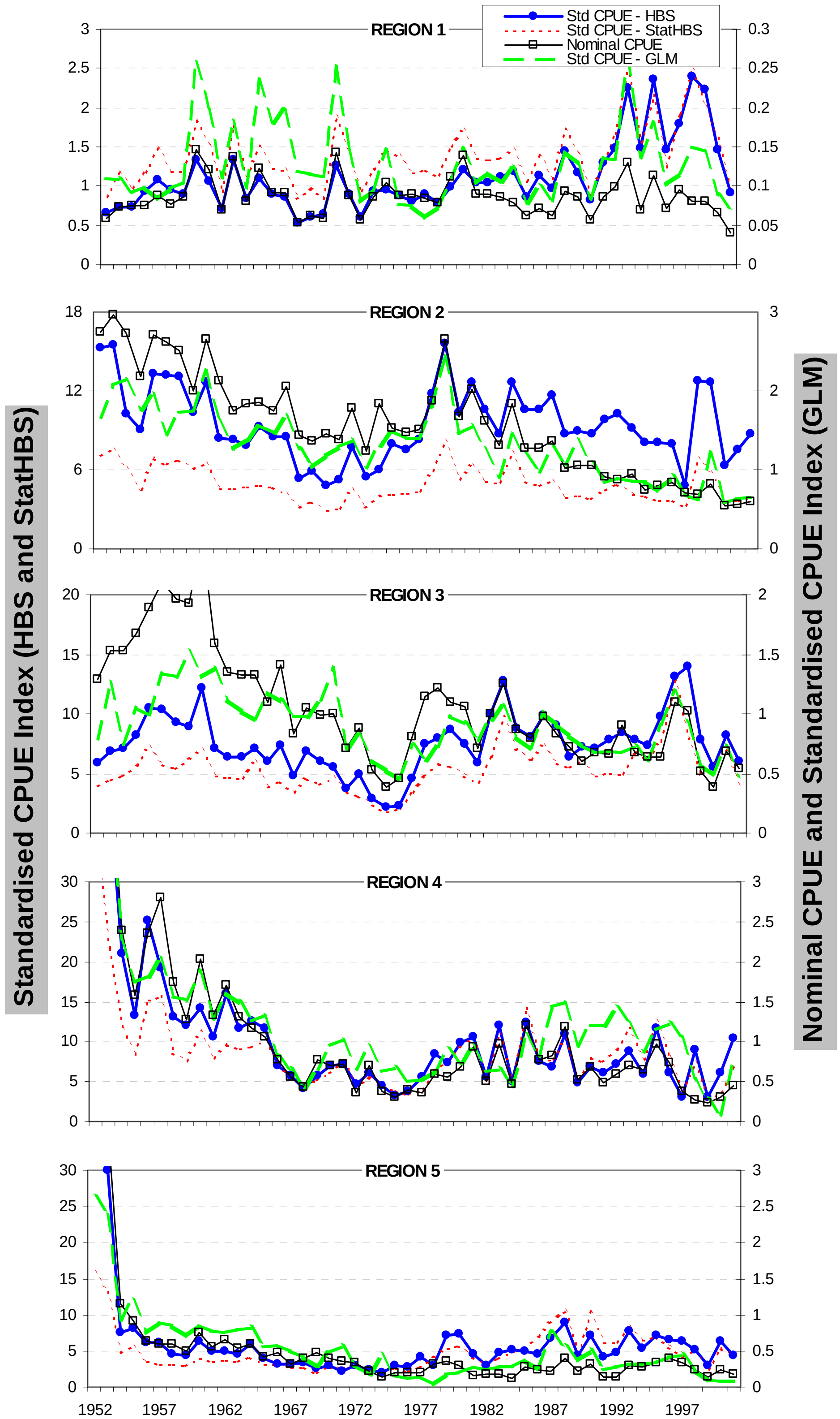

Figure 31. Nominal and standardised yellowfin tuna CPUEs for all longline fleets combined stratified by yellowfin stock assessment region. **The three different standardised CPUE methodologies presented here are described in Hampton and Kleiber (2003).**

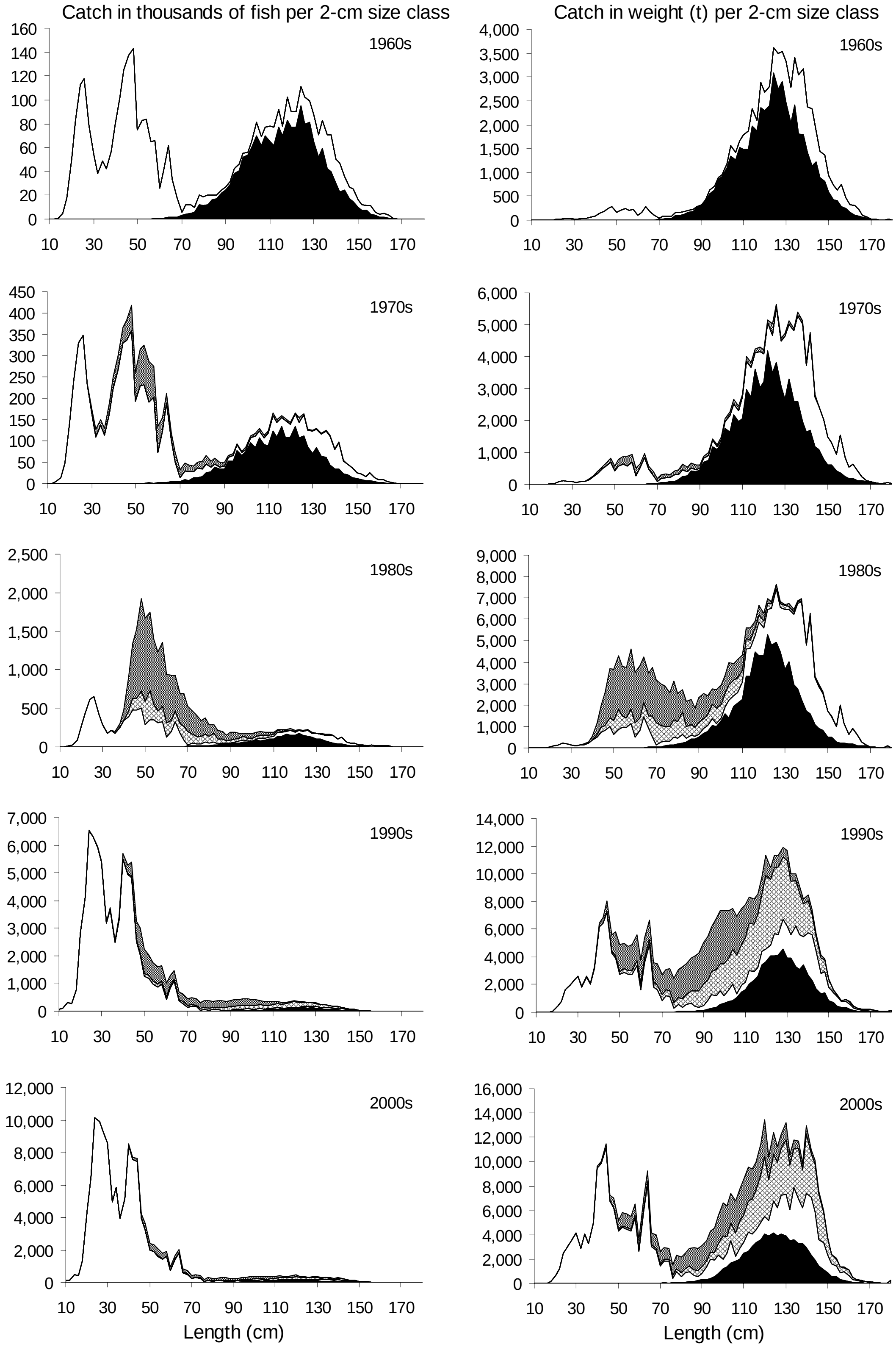

Figure 32. Average annual catches of yellowfin tuna in the WCPO by size and gear type during decadal periods. **(black–Longline; white–Phil-Indo fisheries; grey–purse seine associated; hatching–purse seine unassociated)**

3.2.4 Stock Assessment

The most recent application of the MULTIFAN-CL model to yellowfin tuna in the WCPO was based on five regions (see Figure 28). The time period covered by the analysis is 1950–2002 stratified by quarter. The model structure adopted included: quarterly recruitment, 28 quarterly age classes, independent mean lengths for the first 8 age classes with von Bertalanffy growth constraining the mean lengths for the remaining age classes, structural time-series variation in catchability for all non-longline fisheries, age-specific natural mortality and age-specific movement among the model regions.

Catch, effort and size data (both length and weight frequency), stratified by quarter, for 17 fisheries (8 longline, 2 Philippine domestic, 1 Indonesian domestic, and 6 purse-seine fisheries classified by log, FAD and school sets) were used in the analysis. For the longline fisheries, several estimates of effective (or standardised) effort were available (Bigelow 2003; Langley 2003) and separate analyses were undertaken for each longline effort series. Tagging data from the RTTP were also incorporated into the analysis. A more detailed description of the data, the model structure employed for the analysis and the complete set of results is given in Hampton and Kleiber (2003) (http://www.spc.int/OceanFish/Html/SCTB/SCTB16/yft1.pdf).

The stock assessment results presented in this report are from the analysis using the standardised GLM CPUE time-series. The details of this assessment may differ from the other analyses depending on the respective longline effort series included, however, the overall conclusions of the separate assessments are comparable.

Annual average fishing mortality rates for juvenile (< 100 cm) and adult yellowfin tuna for the WCPO as a whole are shown in Figure 33. Fishing mortality rates for both juvenile and adult yellowfin tuna increased steadily from 1970 to 1990, although adult fishing mortality rates were consistently higher than for juveniles. Since the early 1990s, fishing mortality rates for both juvenile and adult tuna have continued to increase at an accelerated rate. Nevertheless, fishing mortality rates for both juvenile and adult yellowfin tuna are still less than the corresponding average natural mortality rates for both groups.

Recruitment estimates for the entire WCPO region indicate considerable variation about the level of average recruitment. For the standardised GLM CPUE assessment, there were no significant temporal trends in the level of recruitment over the model period (Figure 34).

Total **biomass** has declined relatively steadily over the model period, with the largest decline in biomass occurring in the equatorial regions (Figure 35). The total WCPO biomass has declined to approximately 60% of the level of unexploited biomass. This decline is consistent with the increasing level of fishing mortality over the history of the fishery.

The impact of fishing on the total biomass has increased over time, as catches and fishing mortality have increased, and is estimated to be in the vicinity of 35% in recent years (Figure 36). The impact is differentially high in the tropical regions (around 50%) compared to the subtropical regions.

Conclusion

The assessment reaffirms the result of the previous assessment that the yellowfin stock in the WCPO is presently not being overfished (ie. $F_{CURRENT} < F_{MSY}$) and that it is not in an overfished state ($B_{CURRENT} > B_{MSY}$). However, the stock is likely to be nearing full exploitation and any future increases in fishing mortality would not result in any long-term increase in yield and may move the yellowfin stock to an overfished state. The assessment indicates that the equatorial regions are likely to be fully exploited, while the temperate regions are likely to be under-exploited. While these spatial patterns of exploitation remain uncertain, if true, this may indicate the need for region-specific management. Furthermore, the attribution of depletion to various fisheries or groups of fisheries indicates that the Indonesian fishery has the greatest impact, particularly in its home region. The purse seine fishery also has high impact, particularly in the equatorial regions (Figure 37).

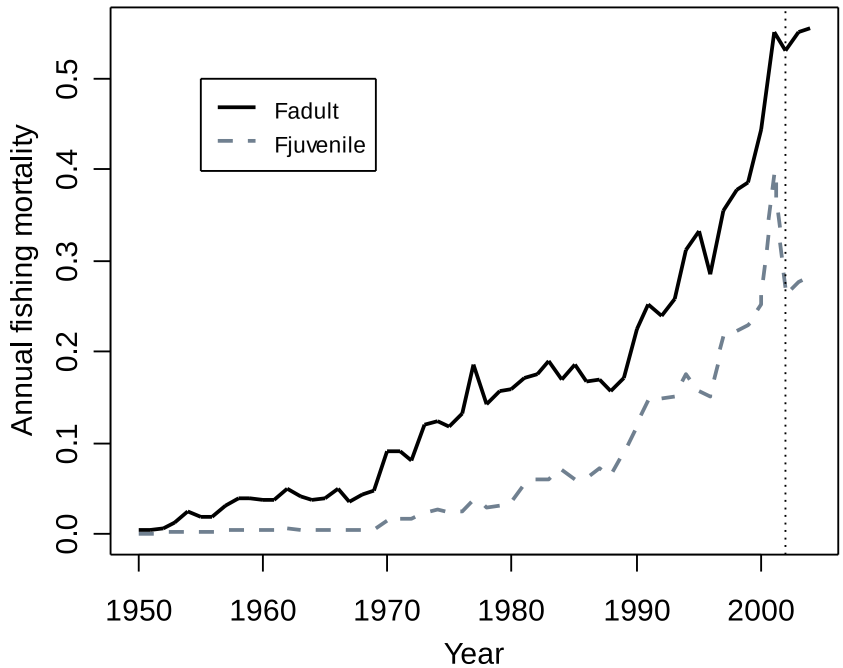

Figure 33. Estimated average annual fishing mortality rates for juvenile (< 100 cm) and adult yellowfin tuna.

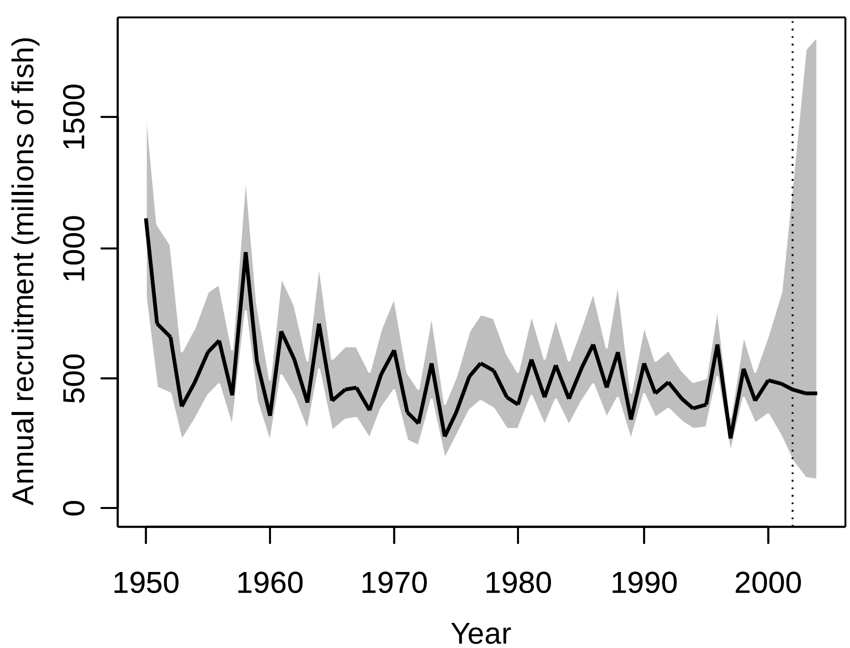

Figure 34. Estimated annual yellowfin tuna recruitment (millions) for the WCPO. **The shaded area indicates the approximate 95% confidence intervals.**

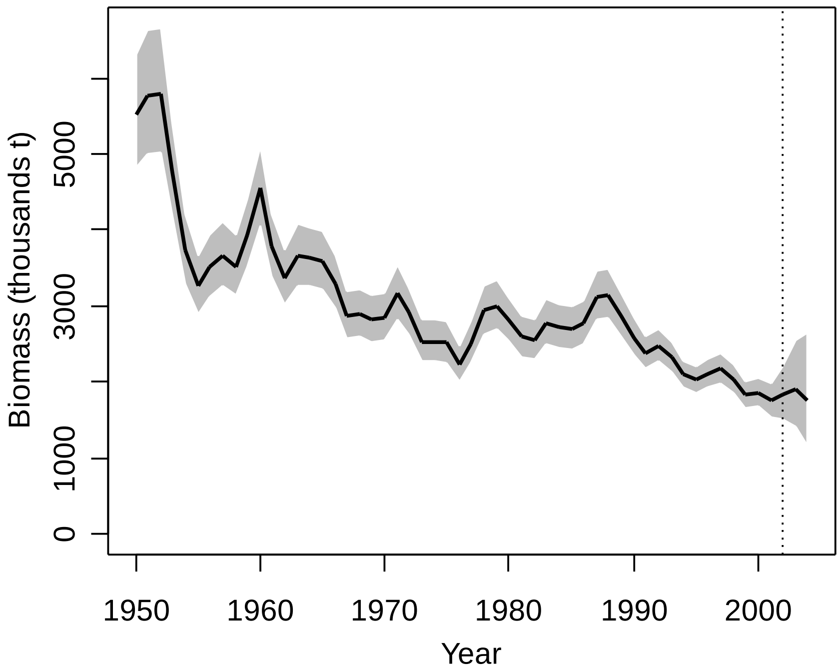

Figure 35. Estimated annual average total yellowfin biomass (thousand t) for the base-case analysis (GLM longline effort). **The shaded areas indicate the approximate 95% confidence intervals.**

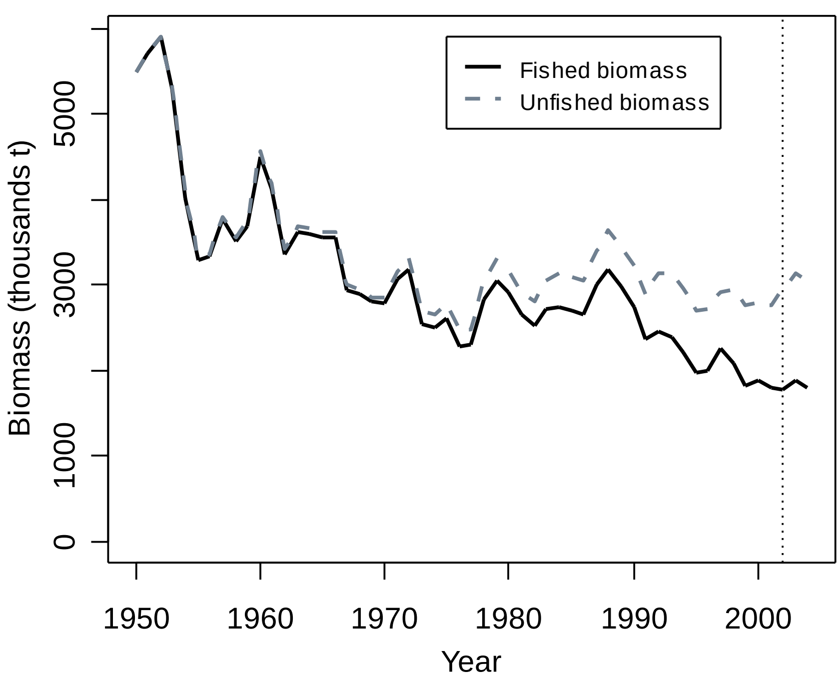

Figure 36. The estimated impact of fishing on yellowfin tuna biomass. **The lower biomass trajectory (darkest line) represents the model estimates of total biomass. The upper trajectory is the estimated biomass that would have occurred in the absence of fishing assuming that recruitment was unaffected by fishing.**

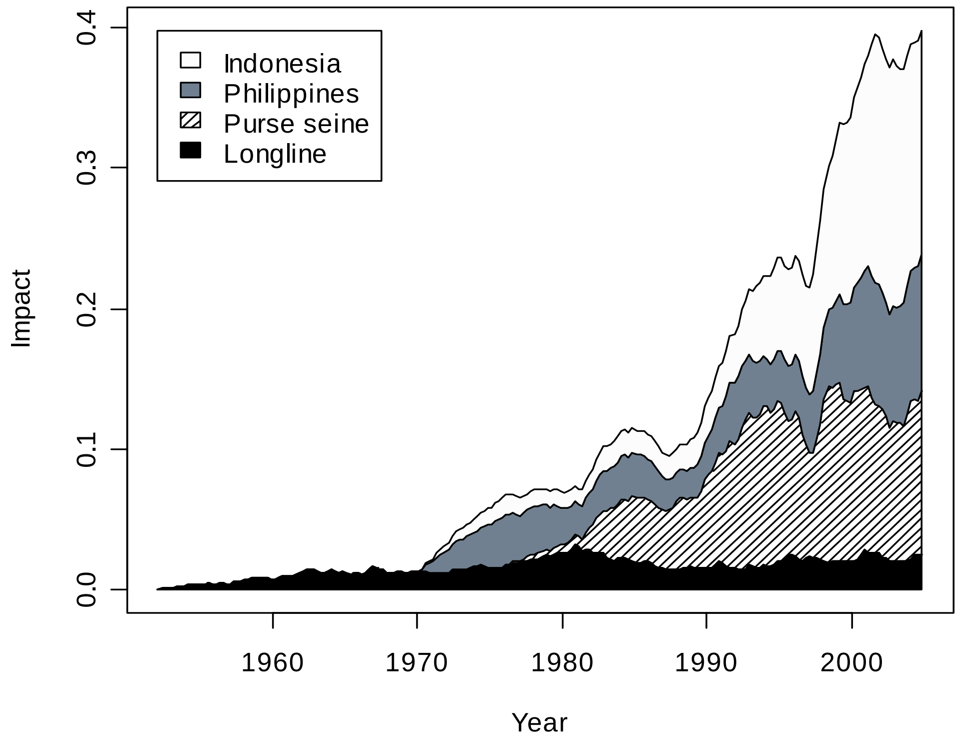

Figure 37. The estimated impact of each fishery on the yellowfin tuna biomass in the WCPO. Impact is expressed as the proportional reduction in biomass attributed to fishing.

3.3 Bigeye Tuna

3.3.1 Catch

Bigeye tuna are an important component of tuna fisheries throughout the Pacific Ocean. Bigeye are taken by purse seine and pole-and-line (surface) gears, mostly as juveniles, and by longline gear, as valuable adult fish. They are a principal target species of both the large distant-water longliners from Japan, Korea and more recently Taiwan, and of the smaller fresh sashimi longliners based in several Pacific Island countries. Prices paid for both frozen and fresh product on the Japanese sashimi market are the highest of all the tropical tunas. Bigeye tuna are the economic cornerstone of the tropical longline fishery in the western and central Pacific Ocean, the catch of which in the WCPO has an estimated landed value of approximately US$ one billion annually.

Since 1980, the Pacific-wide total catch of bigeye (all gears) has varied between 115,000 and 220,000 mt (Figure 38), with Japanese longline vessels generally contributing over 80% of the catch until the early 1990s. The total WCPO bigeye catch (124,107 mt) for 2002 was the highest ever recorded, although the Pacific-wide bigeye catch (189,719 mt) for 2002 was down on recent years, primarily due to significant decreases in the EPO catches.

Longline catch in the EPO, the area east of 150°W and historically the primary bigeye longline fishing area, varied in the range 50,000-102,000 mt throughout the 1980s and early 1990s, but has fallen to below 50,000 mt in recent years, with an historical low in 1999 (29,493 mt). The WCPO longline catch has ranged between 40,000-70,000 mt for the past thirty years (Figure 38), and in more recent years, has exceeded the catches taken in the EPO. The WCPO longline catch for 2002 (81,701 mt) was the highest ever for this fishery and more than 9,000 mt higher than the previous record in 1999 (72,050 mt).

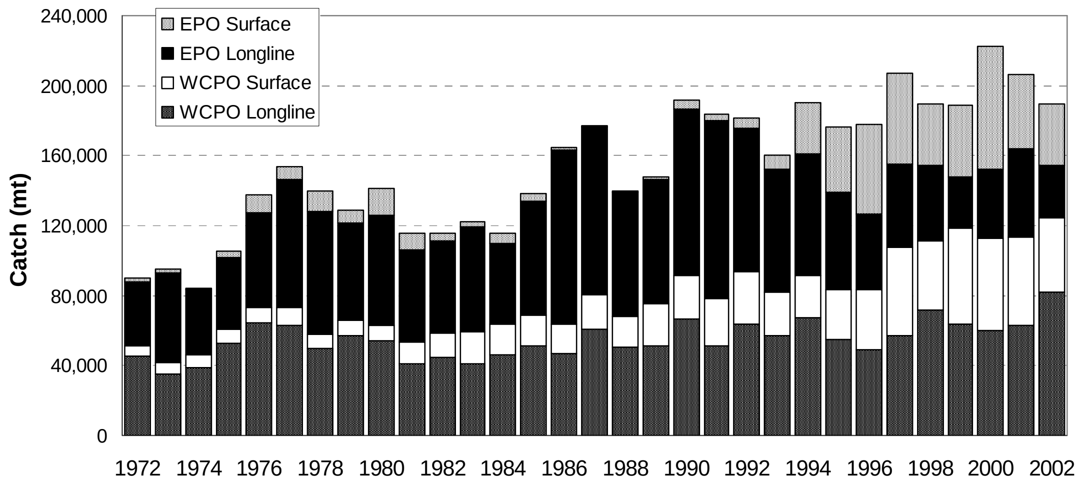

Figure 38. Bigeye tuna catch in the Pacific Ocean.

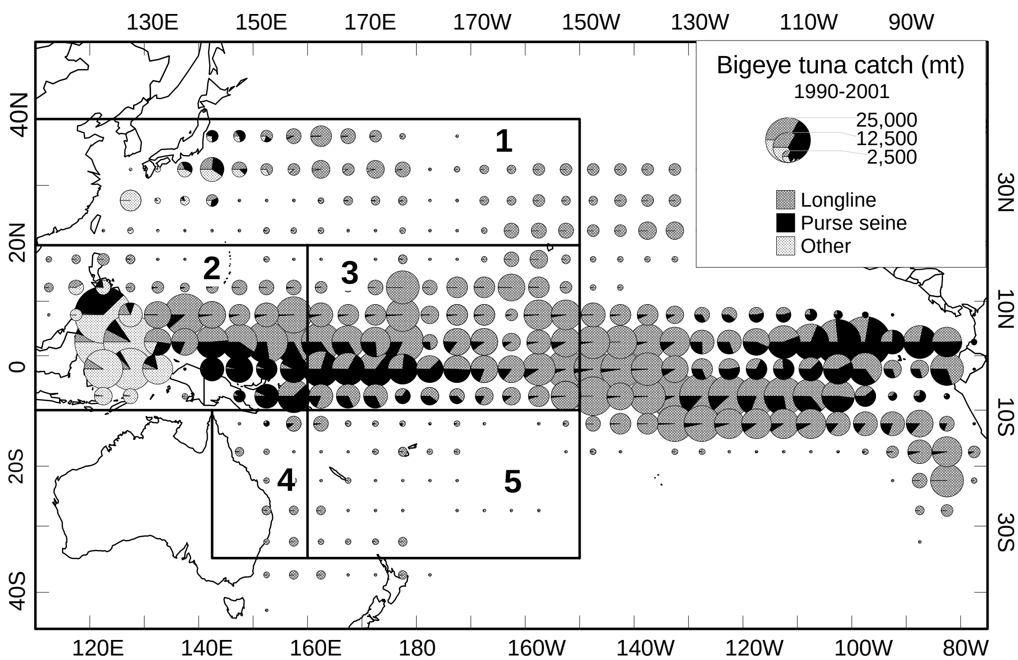

Figure 39. Distribution of bigeye tuna catch, 1990–2001. **The five-region spatial stratification used in stock assessment for the WCPO is shown.**

Since about 1994, there has been a rapid increase in purse-seine catches of juvenile bigeye, first in the EPO and then in the WCPO from 1996. Purse-seine catches in the EPO increased from levels of less than 10,000 mt per year prior to 1994, to approximately 30,000 mt in 1994, then to around 50,000 mt in both 1996 and 1997 (Lawson, 2003). There was a decline in catches during 1998 (around 35,000 mt), but there have again been increases in recent years to a record level in 2000 (70,153 mt). The recent increases in the EPO catch resulted from fishing in largely new or previously lightly fished areas, with different fishing methods, that is, the use of drifting FADs to aggregate tuna and deeper purse-seine nets to catch those tuna, mostly bigeye, located deeper in the water column.

In the WCPO, purse-seine catches of bigeye are estimated to have been less than 20,000 tonnes per year up to 1996 (Lawson, 2003). By 1997, this catch had increased to approximately 30,000 mt through the adoption of similar fishing techniques to those used in the EPO. The estimated 1999 WCPO purse seine catch reached a record level of 38,367 mt, mainly as a result of increased fishing on drifting FADs. Since 1999, bigeye catches have progressively reduced in line with the gradual reduction in fishing on drifting FADs by most fleets. The WCPO purse seine bigeye catch for 2002 was estimated to be 21,696 mt, the lowest catch in five years and directly related to reduced drifting FAD use.

Figure 39 shows the spatial distribution of bigeye catch in the Pacific for the period 1990–2001 (2002 longline data for all fleets are not yet available). The majority of the WCPO catch is taken in equatorial areas, both by purse seine and longline, but with significant longline catch in some sub-tropical areas (east of Japan, east coast of Australia). In the equatorial areas, much of the longline catch is taken in the central Pacific, continuous with the important traditional bigeye longline area in the eastern Pacific, but just south of the Equator.

3.3.2 Catch Per Unit of Effort

The longline fishery provides the most potentially useful information on bigeye tuna relative abundance in the Pacific. In the years prior to 1980, yellowfin was the preferred target species in the WCPO longline fishery, in contrast to years after 1980, when bigeye targeting became progressively more important; such changes need to be accounted for if the CPUE time series are to be interpreted as indices of relative abundance.

Time series of nominal CPUE and standardised CPUE (catch per unit of ‘effective’ effort) for the five regions used in bigeye stock assessment (Hampton et al, 2003) are shown for all longline fleets in Figure 40. "Effective" or standardised effort is determined and used to account for factors that are understood to affect the availability of bigeye to the longline gear. For example, habitat-based studies account for the effects of changes in targeting as well as the variation in environmental parameters that define the bigeye tuna habitat. The following standardised effort series have been used to produce the three standardised CPUE time series shown in Figure 40: (1) a general linear model (GLM – Langley, 2003b); (2) a deterministic habitat-based standardisation (HBS - Bigelow et al., 2003); and (3) an unconstrained statistical habitat-based standardisation (statHBS - Bigelow et al., 2003).

In Region 2, an area which shares most of the WCPO bigeye catch with Region 3, the trend in nominal CPUE has been downwards since about 1990. The trends in Region 2 for the standardised CPUEs also show a decline in the first half of the 1990s, but appear to be more optimistic in recent years than the nominal CPUE. All CPUE measures in Region 3 exhibit a general downward trend for the early years of the time series, but appear to have been relatively stable since the early 1980s, with instances of significant oscillations in CPUE for some years.

3.3.3 Size of Fish Caught

Average annual catch-at-size of bigeye tuna in the WCPO is shown in Figure 41. The longline fishery has clearly accounted for most of the catch of large bigeye in the WCPO. This is in contrast to large yellowfin tuna, which (in addition to the longline gear) are also taken in significant amounts from unassociated (free-swimming) schools in the purse seine fishery and in the Philippines handline fishery. Large bigeye are very rarely taken in the WCPO purse seine fishery and only a relatively small amount come from the handline fishery in the Philippines. Bigeye sampled in the longline fishery are predominantly adult fish with a mean size of ~130 cm FL (range 80–160 cm FL).

The domestic surface fisheries of the Philippines and Indonesia take small bigeye in the range 20–60 cm. Associated sets account for nearly all the bigeye catch in the WCPO purse seine fishery with considerable variation in the sizes from year to year. As with yellowfin (Figure 32), catches of medium-sized (60–100 cm) bigeye in the longline and purse seine fisheries are sometimes very low, indicating a period in their life history when this species is less vulnerable to these gears.

Since the 1980s, there has been a reduction in the proportion of very large (greater than 170 cm FL) bigeye in the longline catch. This is consistent with an increase in the exploitation rate of the adult component of the population (see Section 3.3.4).

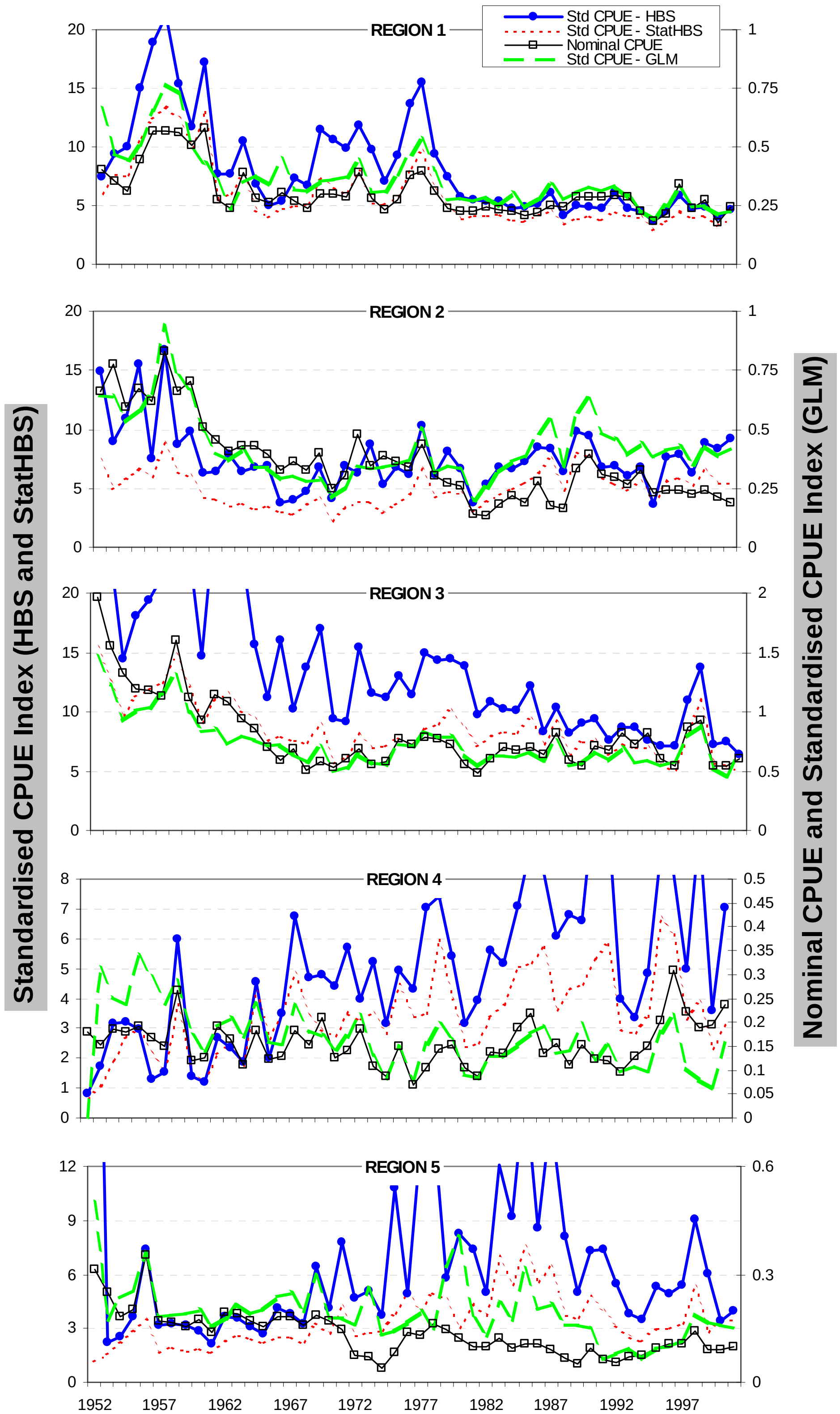

Figure 40. Nominal and standardised bigeye tuna CPUEs for all longline fleets combined stratified by bigeye stock assessment region. **The three different standardised CPUE methodologies presented here are described in Hampton and Kleiber (2003).**

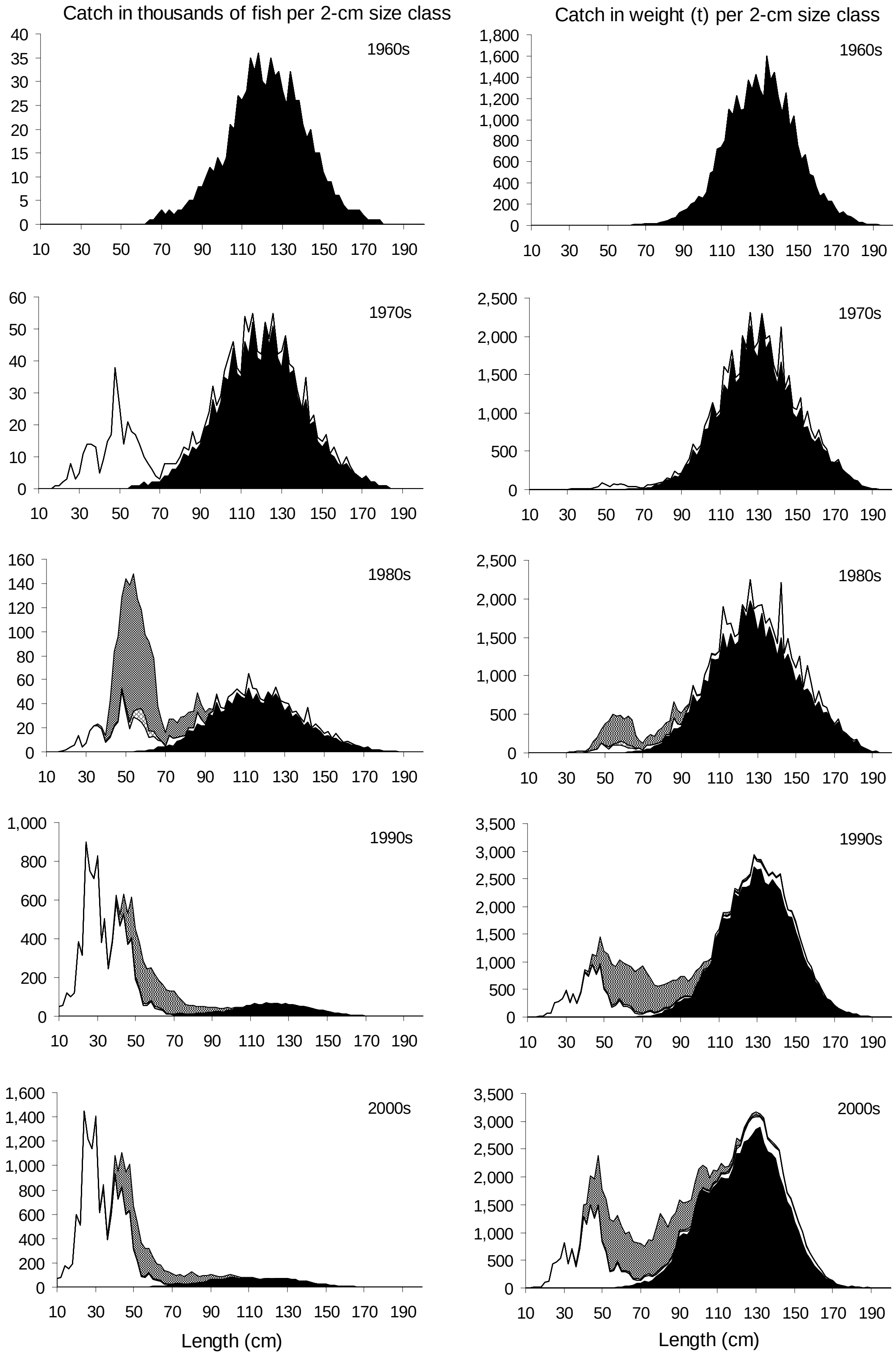

Figure 41. Average annual catches of bigeye tuna in the WCPO by size and gear type during decadal periods. **(black–Longline; white–Phil-Indo fisheries; grey–purse seine associated; hatching–purse seine unassociated, catches negligible)**

3.3.4 Stock Assessment

Previous reports have presented the results of a MULTIFAN-CL analysis of bigeye tuna on a Pacific-wide basis. This work is ongoing and will be reported separately in due course. The analysis described here is restricted to the WCPO (i.e. west of 150°W) assuming that movement between the WCPO and the EPO is minimal. Catch, effort (standardized and unstandardized) and size composition data covering the period 1950–2002 using a quarterly time stratification have been assembled. The spatial coverage of the model is the WCPO, within which a five-region spatial stratification (see Figure 39) has been adopted. Catch, effort and size data for 17 fisheries (8 longline, 2 Philippine domestic, 1 Indonesian domestic and 6 western Pacific purse-seine fisheries) were used in the analysis. Several different model options were investigated using the different standardized effort series from the longline fisheries.

The limited amount of tagging data available from SPC's Regional Tuna Tagging Project was incorporated into the analysis. The model structure adopted thus far includes: quarterly recruitment, 40 quarterly age classes, independent mean lengths for the first 8 age classes with von Bertalanffy growth constraining the mean lengths for the remaining age classes, structural time-series variation in catchability for non-longline fisheries, age-specific natural mortality and age-specific movement among the model regions. A detailed description of the data, model structure and results is available in Hampton et al. (2003) (http://www.spc.int/OceanFish/Html/SCTB/SCTB16/bet1.pdf).

The stock assessment results presented in this report are from the analysis using the standardised GLM CPUE time-series. The details of this assessment may differ from the other analyses depending on the respective longline effort series, however, the overall conclusions of the separate assessments are comparable.

Annual average **fishing mortality rates** for juvenile (< 100 cm) and adult bigeye tuna for the WCPO as a whole are shown in Figure 42. Fishing mortality for adults increased steadily over the time series before flattening out after 1995. In contrast, juvenile fishing mortality increased rapidly particularly since the early 1990s. A major factor in this increase has been the increase in assumed catches in Indonesia, which are based on yellowfin tuna catches reported by the Indonesian national authorities and an assumption (in the absence of sampling data) that these catches contain a fixed proportion of bigeye tuna. Increased purse seine catches, mainly using FAD sets, have also contributed to increased juvenile fishing mortality. The recent fishing mortality rates for adult bigeye are equivalent or greater than the corresponding natural mortality rates for adult fish.

Recruitment estimates (Figure 43) indicate some fluctuation but with a strong increasing trend since the early 1980s and reached the highest level in 1999, which is about 2.5–3 times higher than in 1980. This pattern may be an artefact related to the development of the surface fishery and/or the lack of early size data. This issue requires further investigation. The model also predicts above average recruitment in the mid 1950s to account for the high CPUE observed in regions 1–3 during the early period. There is high uncertainty for recruitment estimates from the 1950s and early 1960s due to a lack of size composition data from this period.

The time series of estimated **biomass** is shown in Figure 44. Total estimated biomass of bigeye tuna declined by about 30% during the 1950s and 1960s and remained relatively stable in the subsequent years. This trend is evident in all areas, except region 5. In regions 2 and 3, where the stock was heavily exploited during the beginning of the fishery, the stock biomass increased during the 1970s and 1980s before entering a sharp decline in the 1990s.

The impact of fishing on the total biomass has increased over time as catches and fishing mortality have increased (Figure 45) and currently fishing, particularly by longline (Figure 46), is having a large impact on the biomass level. The impact of fishing is highest in the equatorial area (regions 2 and 3). However, despite the high fishery impact (increasing fishing mortality), the model predicts total biomass has remained relatively stable due to the steady increase in annual recruitment over the last two decades.

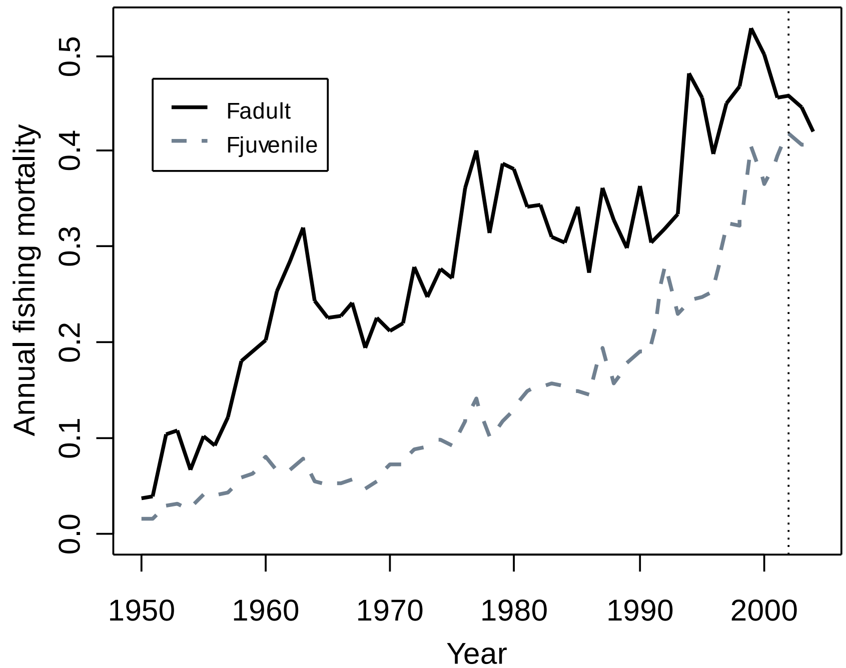

Figure 42. Estimated average annual fishing mortality rates for juvenile (< 100 cm) and adult bigeye tuna.

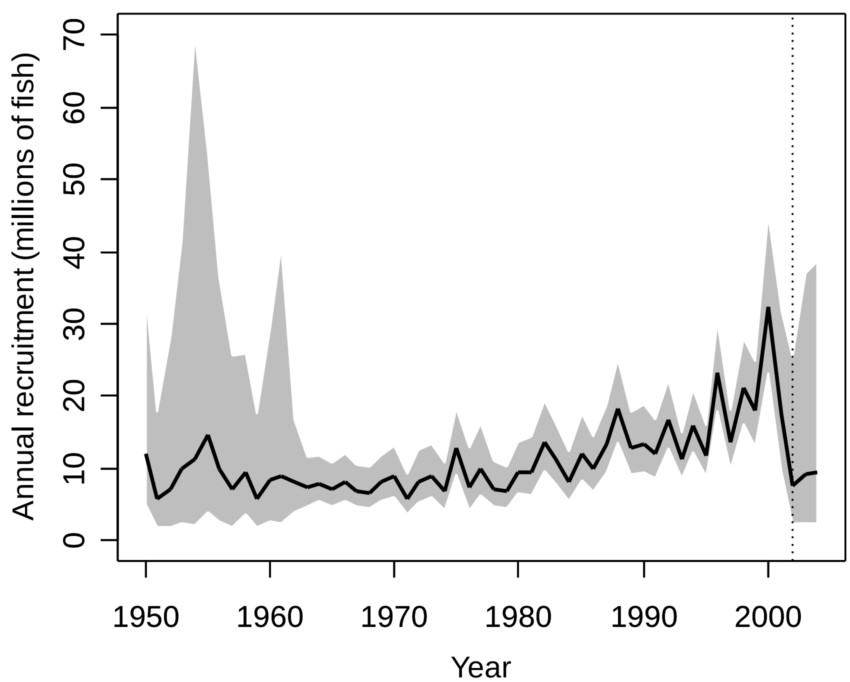

Figure 43. Estimated annual bigeye tuna recruitment (millions) for the WCPO.
The shaded area indicates the approximate 95% confidence intervals.

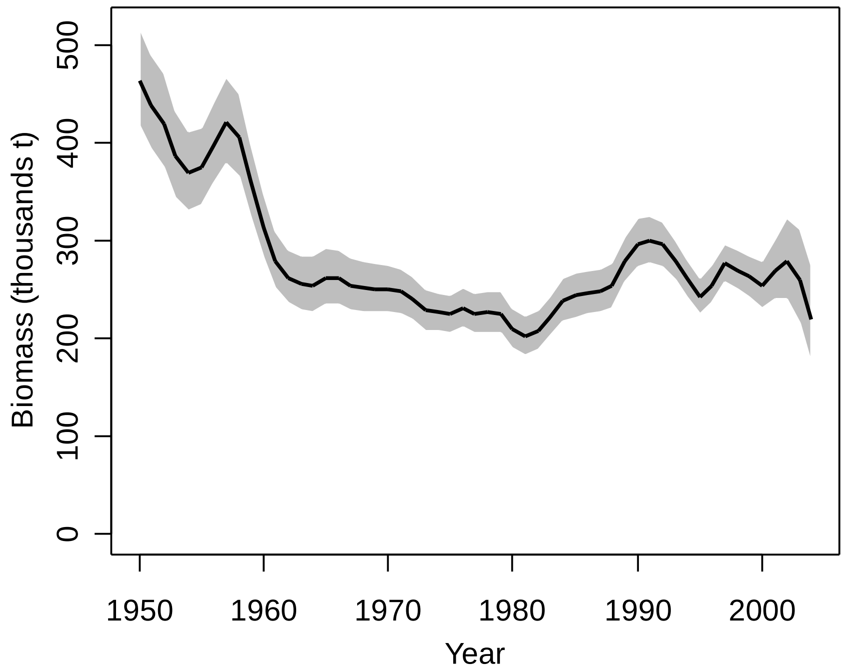

Figure 44. Estimated annual average total bigeye tuna biomass (thousand t) for the WCPO for the base-case analysis (GLM longline effort). **The shaded areas indicate the approximate 95% confidence intervals.**

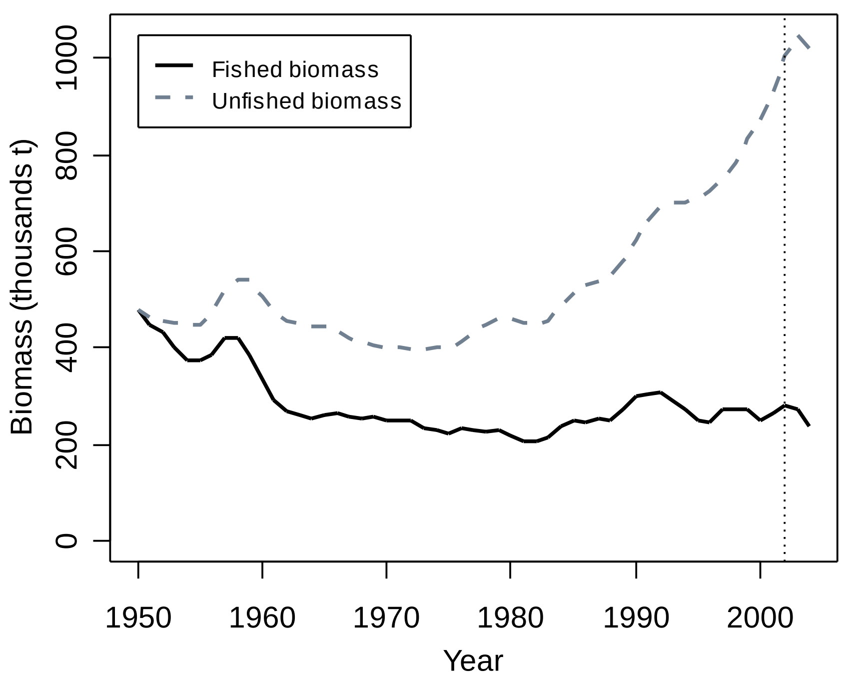

Figure 45. The estimated impact of fishing on bigeye tuna biomass in the WCPO. **The lower biomass trajectory (darkest line) represent the model estimates of total biomass in each area. The upper trajectory is the estimated biomass that would have occurred in the absence of fishing assuming that recruitment was unaffected by fishing.**

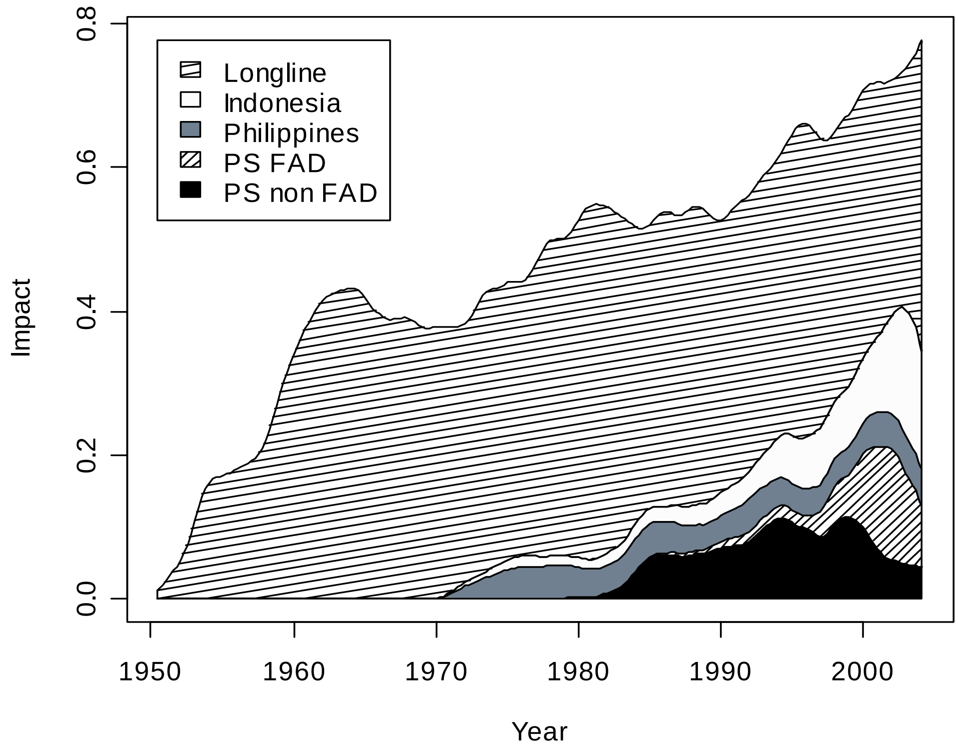

Figure 46. The estimated impact of each fishery on the bigeye tuna biomass in the WCPO. Impact is expressed as the proportional reduction in biomass attributed to fishing.

Conclusion

The current bigeye assessment indicates the stock is not in an overfished state ($B_{CURRENT} > B_{MSY}$) although overfishing is occurring ($F_{CURRENT} > F_{MSY}$) and the current level of exploitation appears not to be sustainable in the long term, unless the high recent recruitment is maintained in the future.

The current assessment differs considerably from the previous assessment, largely due to differences in the methodology used to standardize the longline effort data. The stock status of the bigeye fishery is sensitive to these inputs and, consequently, the validity of alternative approaches needs to be investigated to determine the true status of the bigeye stock. On this basis, the SCTB concluded that, caution should be exercised in applying the current results for management purposes. Further work is being undertaken to improve the assessment, however, in the interim the SCTB recommended that there be no further increase in the fishing mortality rate of bigeye tuna.

3.4 South Pacific Albacore Tuna

3.4.1 Catch

South Pacific albacore are exploited by a variety of longline fleets, by an international troll fleet operating seasonally in the region of the subtropical convergence zone (STCZ) and by a domestic troll fleet in New Zealand coastal waters.

Historically, south Pacific albacore catches have generally fallen in the range 25,000–40,000 mt, although a significant peak was attained in 1989 (52,576 mt), when driftnet fishing was in existence (Figure 47; ‘Other” is essentially the driftnet catch). In more recent years, annual catches have steadily increased since the mid-1990s. The highest catch in the post-driftnet period (51,698 mt) was attained during 2001, mainly as a result of the significant catch from the longline fishery. The 2002 south Pacific albacore catch of 50,858 mt was the second highest in the post-driftnet period.

Throughout the 1990s, the longline catch in the south Pacific has been in the range of 24,000–40,000 mt, while the troll catch, for a season spanning November – April, has been in the range 3,000–8,000 mt (Figure 47). The Taiwanese distant-water longline fleet has been the dominant fleet in this fishery for more than two decades, but there have been recent changes in the species and areas targeted by this fleet (more vessels are now targeting bigeye in the eastern equatorial waters of the WCPO), which has resulted in a reduced contribution to the overall albacore catch in recent years (Figure 48). In contrast, the annual longline albacore catches in several Pacific Island countries continued to increase (Figure 48). Fiji (8,026 mt–2002), Samoa (4,820 mt–2001), French Polynesia (4,557 mt–2002) and American Samoa (5,944 mt–2002) reported individual record catches of albacore in the last two years. The catch by Pacific-island countries in 2002 represented nearly 60% of the total south Pacific albacore longline catch (45,969 mt), which was the highest level ever for this fishery.

The distant-water longline catch is widely distributed in the south Pacific (Figure 49), but with catches concentrated in the western part of the region. Troll catches are distributed in New Zealand's coastal waters, mainly off the South Island, and along the SCTZ**.** Less than 15% of the overall south Pacific albacore catch is usually taken east of 150°W.

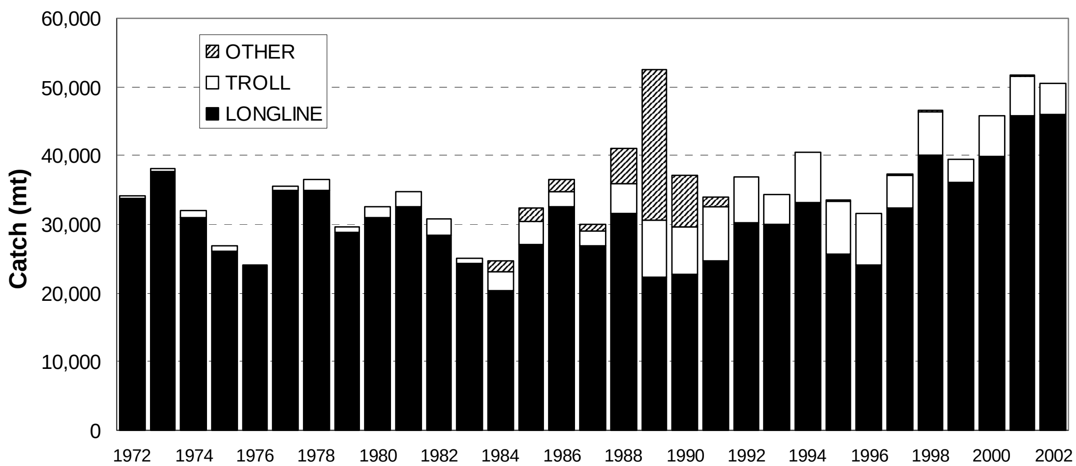

Figure 47. South Pacific albacore tuna catch, by gear. **(‘Other’ is primarily catch by the driftnet fishery.)**

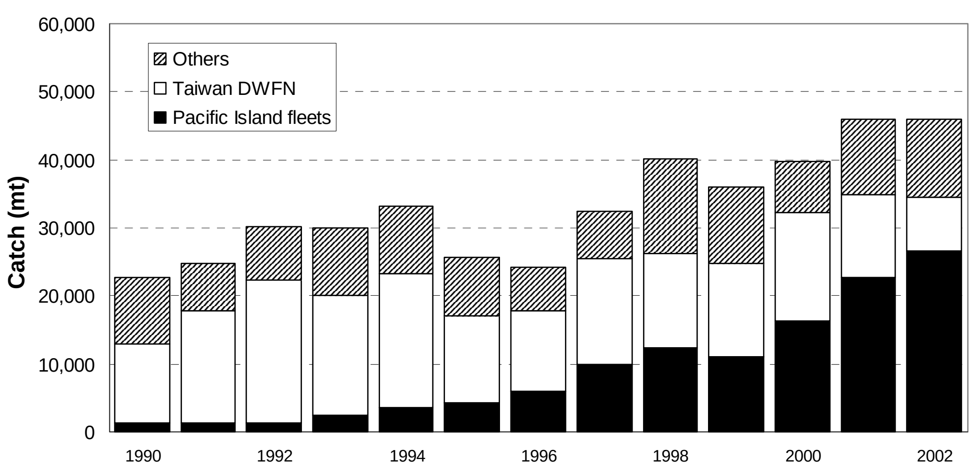

Figure 48. South Pacific albacore longline catch (mt) by fleet category

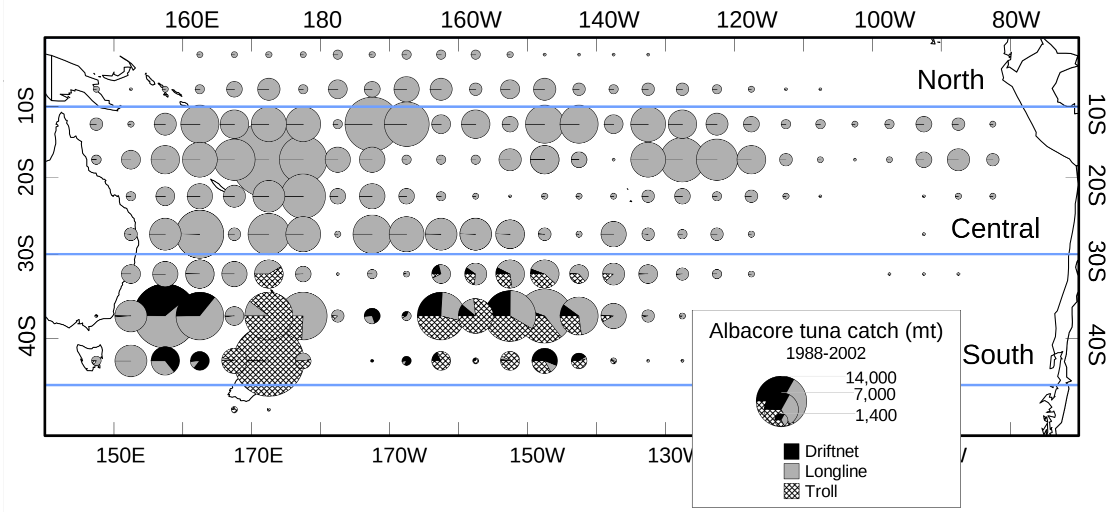

Figure 49. Distribution of South Pacific albacore tuna catch, 1988–2002. The three-region spatial stratification used in stock assessment is shown.

3.4.2 Catch Per Unit of Effort

The key fishery indicators for South Pacific albacore tuna are longline and troll fishery CPUE. For the longline fishery, data from the Taiwanese distant-water fleet are generally used as this fleet has consistently targeted albacore tuna over a long period of time. Longline CPUE (numbers of fish per hundred hooks) is typically highest in the higher latitudes (STCZ and 30–50°S), moderate in the tropics and subtropics (10–30°S) and low near the equator (0–10°S). Time series of CPUE for these latitudinal bands are plotted in Figure 50. Taiwanese longline CPUE declined from the late 1960s to the late 1980s in all areas, but has increased somewhat in the 1990s after a low point in 1990. Since 1999, nominal CPUE has been relatively stable in the central area, and progressively increasing in the southern area. The drop in CPUE in the northern area during recent years is probably related to the significant increase in effort targeting bigeye (and yellowfin) in the waters north and east of French Polynesia. Standardised CPUE indices were calculated for the Taiwanese longline fleet (Langley 2003a). For each of the main fishery areas, the standardised indices were very similar to the nominal CPUE.

Recent trends in the catch rate of albacore from the Pacific Islands domestic longline fisheries were summarised in Langley (2003c). The analysis noted recent declines in the catch rate of albacore in a number of fisheries, although the extent of the decline varied.

The troll fishery CPUE for the New Zealand domestic fleet tended to increase during the 1980s, but has been relatively stable during the 1990s (Figure 51). CPUE for the USA and New Zealand fleets operating in the STCZ is generally higher, but more variable, probably indicating a greater impact of environmental variation on the ability of this fleet to locate and catch albacore tuna. There has been some convergence in the CPUE of these fleets in recent years, regardless of the areas fished.

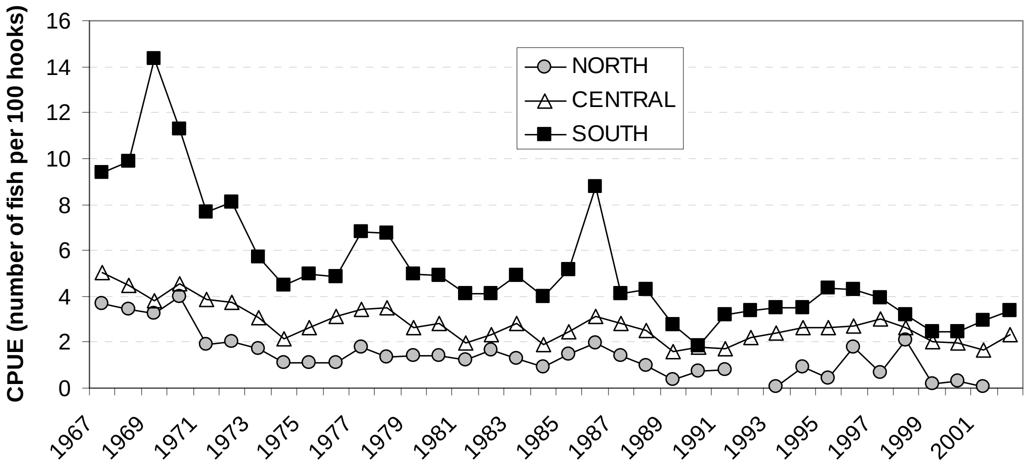

Figure 50. Nominal South Pacific albacore tuna CPUE for Taiwanese longliners (2002 data are provisional). South = 30–50°S, central = 10–30°S, north = 0–10°S.

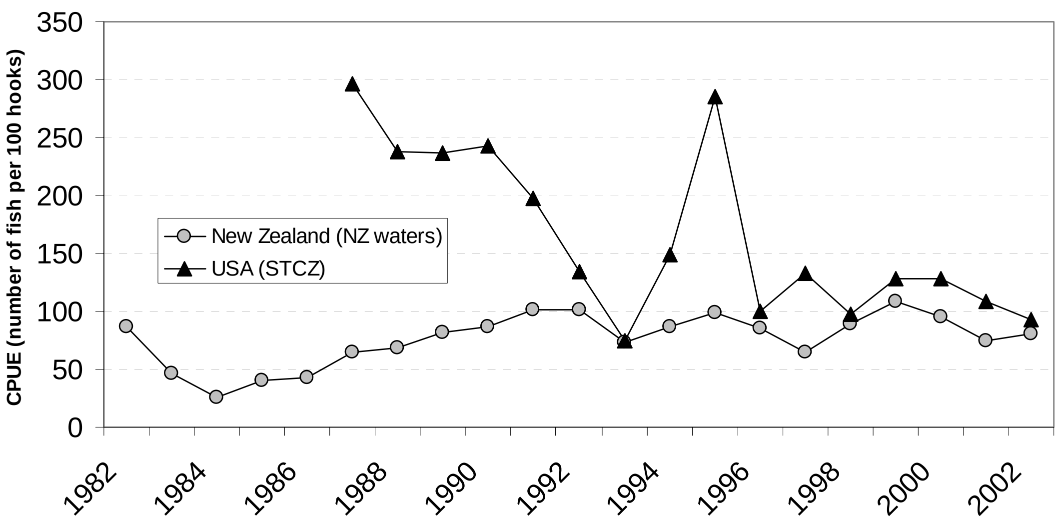

Figure 51. South Pacific albacore tuna CPUE for the New Zealand domestic troll fleet and the USA troll fleet operating east of 180° along the STCZ.

3.4.3 Size of Fish Caught

Average annual catch-at-size of albacore tuna is shown in Figure 52. There are no noteworthy changes in the size distributions for the longline fishery over time; this fishery tends to catch adult fish with a distinct mode around 95cm fork length. The troll fishery and the surface driftnet fishery (when it was operating) account for smaller albacore in the size range 50–80 cm; the similar size range of fish taken in these fisheries reflects the overlap in the area fished (Figure 49).

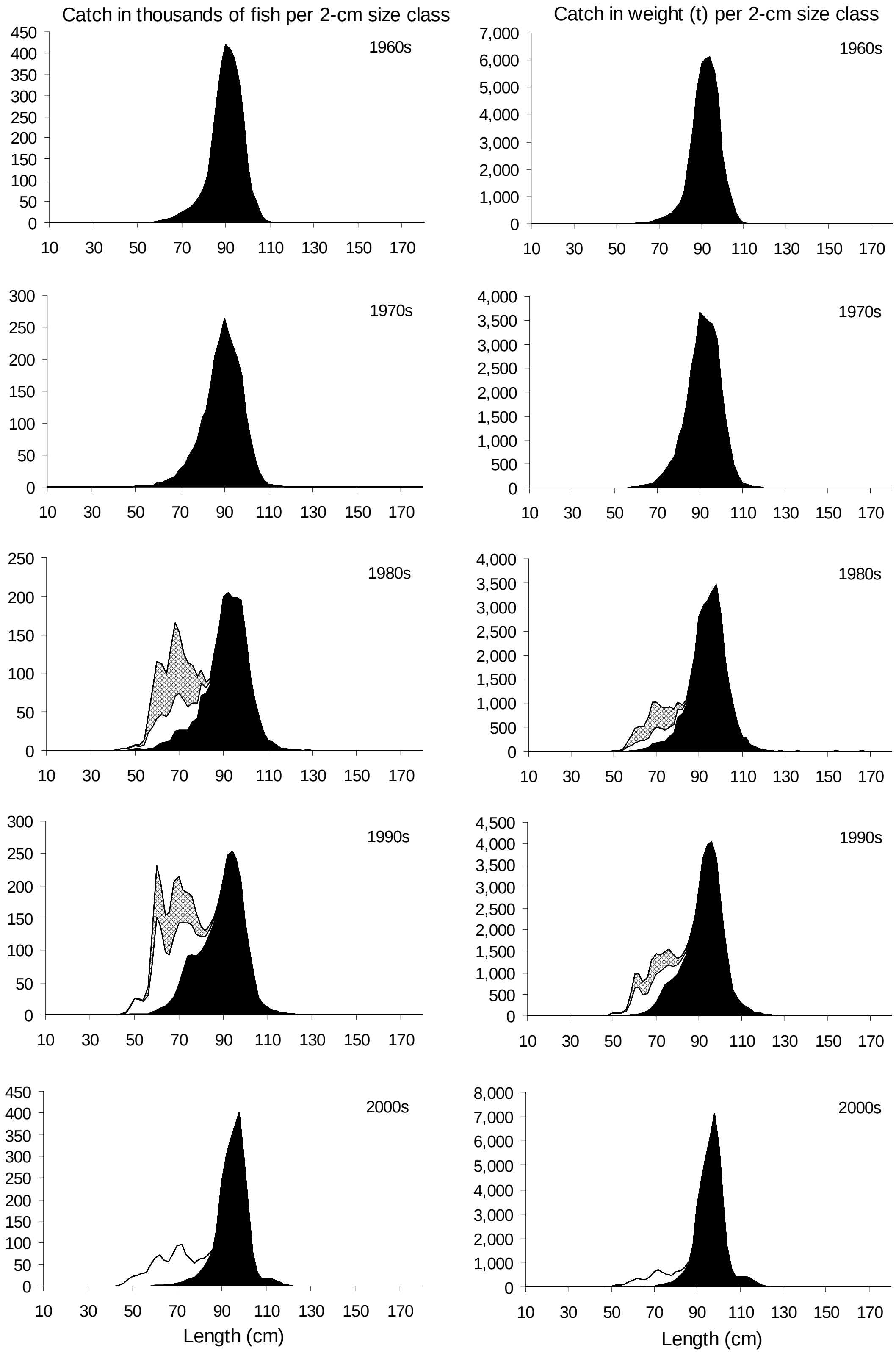

Figure 52. Average annual catches of albacore in the south Pacific by size and gear type during decadal periods. **(black–Longline; white–Troll; hatching–surface driftnet)**

3.4.4 Stock Assessment

The MULTIFAN-CL analysis considered fishery data from 1952 to 2002 using a quarterly time stratification. A simple spatial structure was adopted, consisting of three latitudinal bands: 0–10°S; 10–30°S; and 30–50°S, spanning the entire south Pacific. Distant-water longline fisheries for Japan, Korea and Taiwan were defined for each of these regions, as well as 'other domestic' longline fisheries in the central region. The surface fisheries, the New Zealand coastal troll fishery, the central South Pacific troll fishery and the driftnet fishery all occur in the southernmost region, giving a total of 13 region-specific fisheries. The model was fitted to catch, effort and length–frequency data for each fishery. The small amount of tagging data for South Pacific albacore were also incorporated into the model. A more detailed description of the data, the model structure employed for the analysis, and the complete set of results is available in Labelle & Hampton (2003) (http://www.spc.int/OceanFish/Html/SCTB/SCTB16/alb1.pdf).

Average annual **fishing mortality rates** for juvenile (< 85 cm) and adult albacore tuna are shown in Figure 53. Fishing mortality for juvenile fish (primarily taken by surface fisheries) was very low throughout the history of the fishery, increasing slightly in the late-1980s corresponding to the development of surface fisheries, particularly the driftnet fishery. For adult albacore tuna (primarily exploited by longliners), average fishing mortality increased in the early-1990s and has continued to increase as a result of developments in Pacific Island longline fleets. Recent mortality rates for adults have been at a historically high level (greater than 0.2), although these high exploitation rates are attributable to unrealistically high (> 0.5) fishing mortality rates estimated for the oldest age classes. Estimates of recent exploitation rates for the oldest age classes are not considered reliable. Overall, fishing mortality rates for age classes comprising most of the population (ages 1–8) remain low in comparison with estimates of natural mortality (0.3–0.5 per year over most of the exploited age classes).

The estimated **recruitment** time series (Figure 54) shows considerable variability, more so during the second half of the time series. Lehodey (2000) has hypothesised a negative effect of El Niño conditions on albacore recruitment, which may explain the relatively low recruitment around 1985, 1990, in the mid-1990s, and 2000 (approximately two years following El Niño events). Likewise, the relatively high recruitment for 2001–2003 may be attributable to the protracted La Niña conditions in the late-1990s and 2000.

Estimated trends in relative total and adult **biomass** are shown in Figure 55. Biomass was relatively stable during the 1960s and early 1970s, increased in the late 1970s, declined in the early 1980s, and has declined slowly over the subsequent period.

The estimated **impact of the fishery** on the South Pacific albacore population has been small, consistent with the low estimated fishing mortality rates for the main age classes (Figure 56). The percentage reduction in biomass due to fishing is currently estimated to be in the vicinity of 3%. However, due to the selectivity of the longline fishery towards the older age classes, the level of impact on this component of the stock is likely to be considerably greater (20–30% in recent years).

Conclusion

Fishery indicators and the MULTIFAN-CL analysis both suggest that the South Pacific albacore tuna stock declined moderately since the early 1980s. This decline in stock biomass was mainly recruitment driven, as was the slight recovery in the mid-1990s. One hypothesis concerning the relationship between recruitment and oceanographic conditions predicts that recruitment may have been low in 1999–2000 but may increase over the next few years due to recent La Niña conditions. The impact of the fishery on the stock is estimated to be small, and higher levels of catch could likely be sustained.

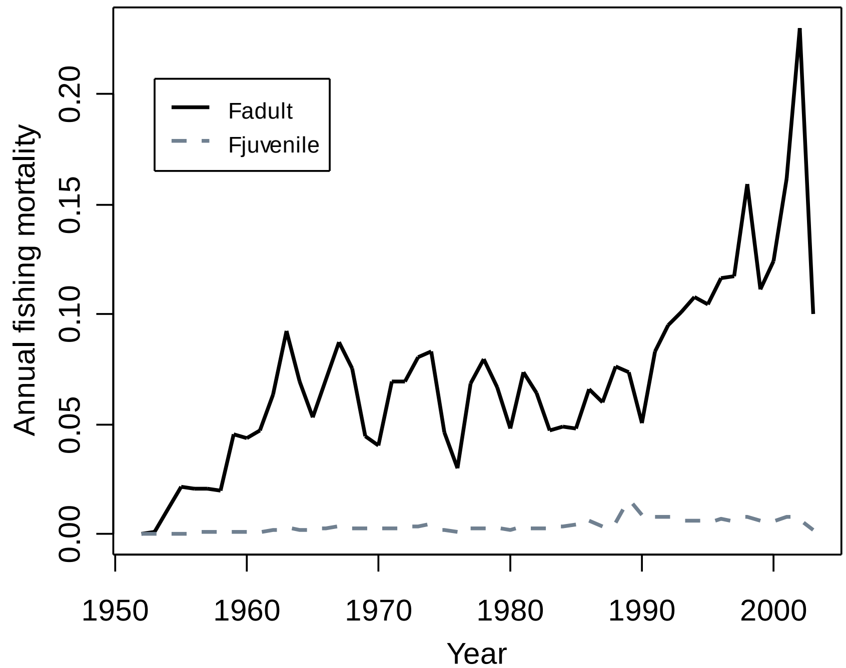

Figure 53. Estimated average annual fishing mortality rates for juvenile (< 85 cm) and adult South Pacific albacore tuna.

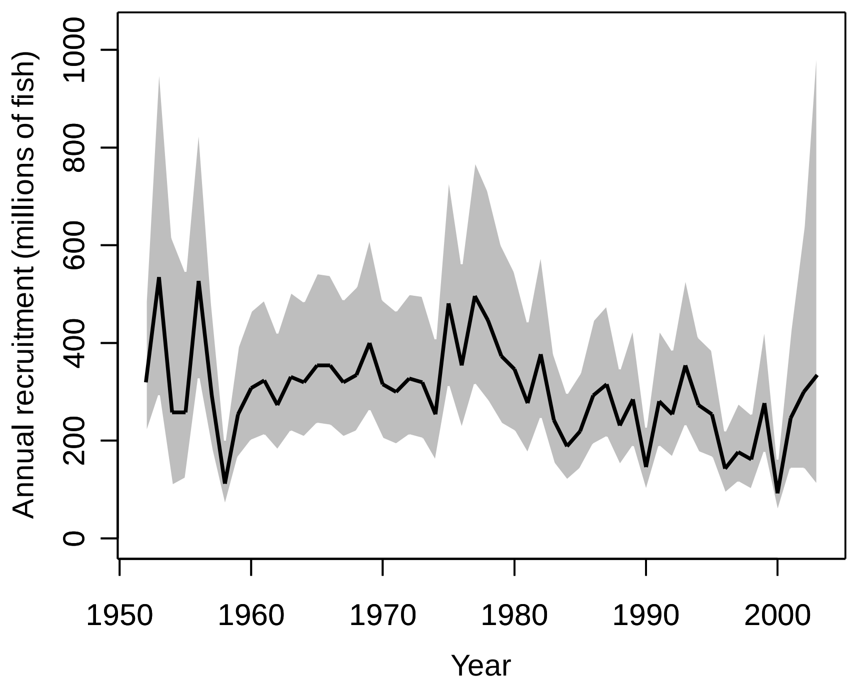

Figure 54. Estimated annual South Pacific albacore tuna recruitment with 95% confidence intervals.

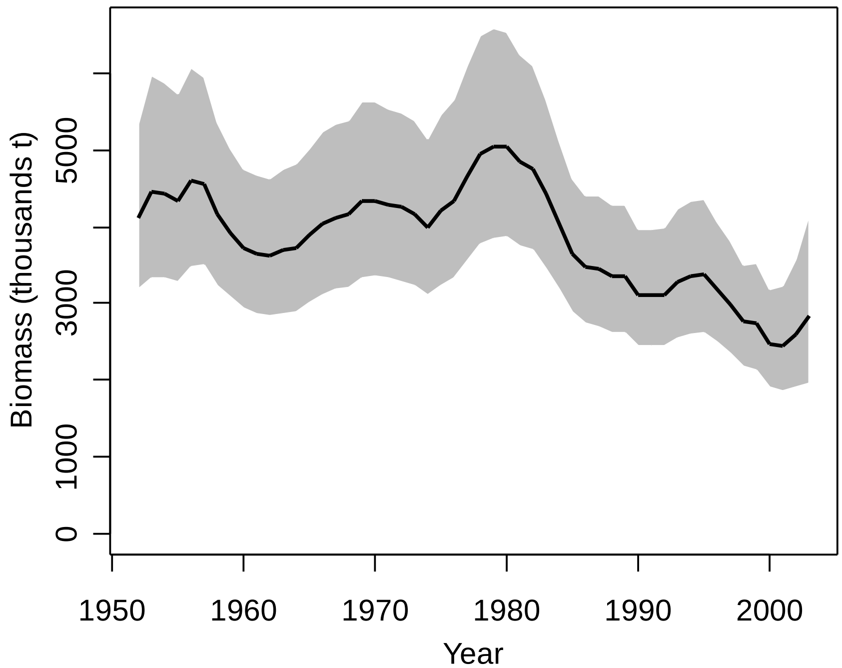

Figure 55. Estimated annual total South Pacific albacore tuna biomass (thousand t). **The shaded areas indicate the approximate 95% confidence intervals.**

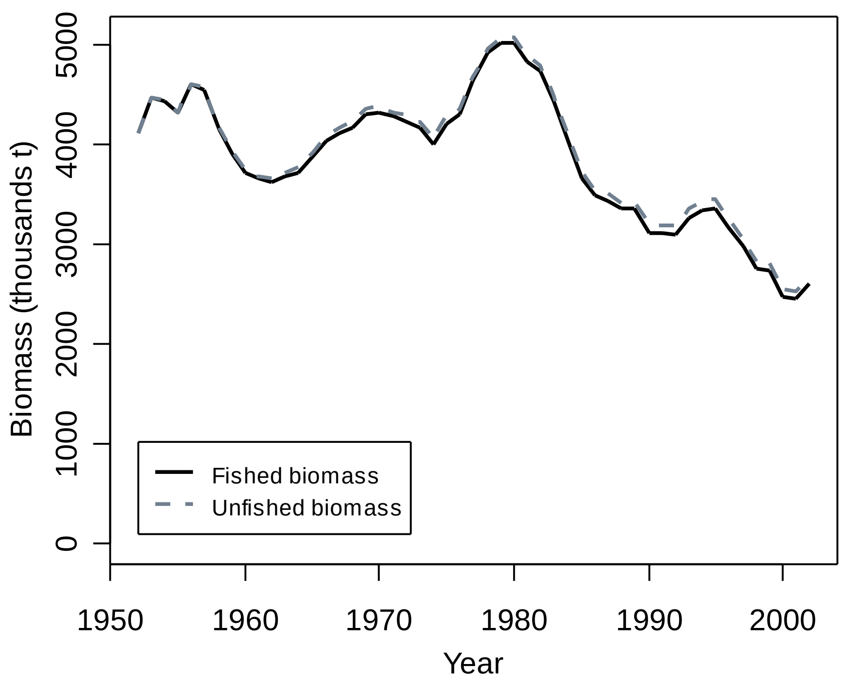

Figure 56. The estimated impact of fishing on South Pacific albacore tuna biomass. **The lower biomass trajectory (lighter line) represents the model estimates of total biomass. The upper trajectory is the estimated biomass that would have occurred in the absence of fishing assuming that recruitment was unaffected by fishing.**

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