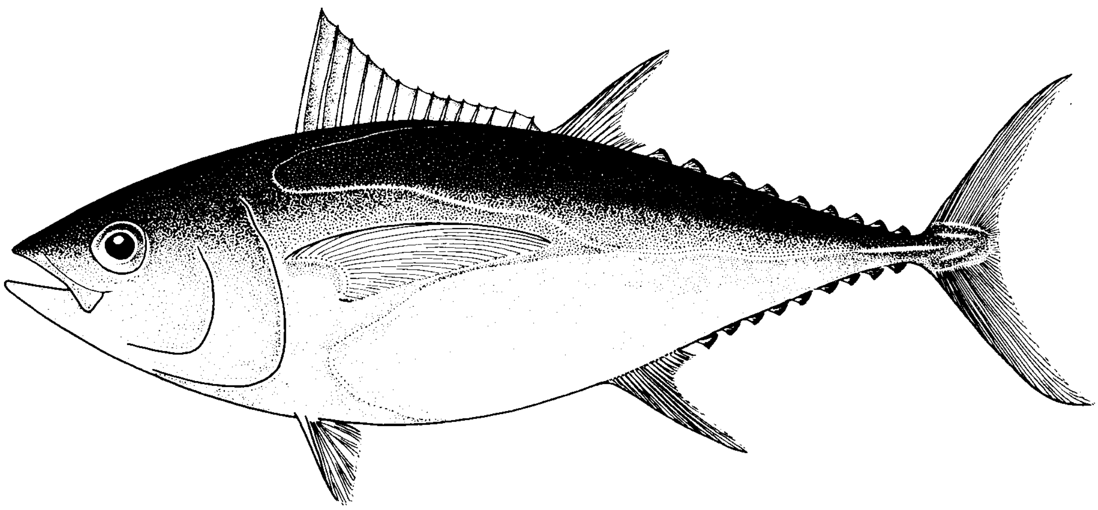
REPORT OF THE ELEVENTH MEETING OF THE STANDING COMMITTEE ON TUNA AND BILLFISH

28 May – 6 June 1998

Honolulu, Hawaii

United States of America



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WORKSHOP ON PRECAUTIONARY LIMIT REFERENCE POINTS

1. The Inter-sessional Technical Consultation on Issues Relating to Fisheries Management of the Multilateral High-Level Conference on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (MHLC) met in Honiara, Solomon Islands, in December 1997. Under the terms of reference for the Consultation, participants were asked to consider the application of the precautionary approach, in particular the establishment and potential application of precautionary reference points. Given their technical nature, the Consultation requested the Standing Committee on Tuna and Billfish (SCTB) to consider these matters.

2. To this end, the Workshop on Precautionary Limit Reference Points for Highly Migratory Fish Stocks in the Western and Central Pacific Ocean was held from 28 to 29 June 1998, in Honolulu, Hawaii, United States of America, as part of the Eleventh Meeting of the Standing Committee on Tuna and Billfish. The workshop addressed the use of precautionary reference points in tuna fisheries management, which is embodied in the agreement[1] which resulted from the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, which concluded in August 1995. The record of discussion of the Workshop on Precautionary Limit Reference Points is given in Appendix 1. The report of the Workshop on Precautionary Limit Reference Points to the Third Multilateral High-Level Conference on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean is given in Appendix 2.

SUMMARY OF DISCUSSIONS

1. PRELIMINARIES

3. The Eleventh Meeting of the Standing Committee on Tuna and Billfish (SCTB11) was held from 28 May to 6 June 1998, in Honolulu, Hawaii, at the invitation of the Western Pacific Regional Fisheries Management Council of the United States of America. SCTB11 was attended by participants from American Samoa, Australia, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Japan, Kiribati, Korea, Marshall Islands, New Caledonia, New Zealand, Northern Mariana Islands, Palau, Samoa, Solomon Islands, Taiwan, Tonga, United States of America and Vanuatu. Participants from the Food and Agriculture Organization of the United Nations (FAO), the Forum Fisheries Agency (FFA) and the Secretariat of the Pacific Community (SPC) also attended.

4. The agenda is presented in Appendix 3. The working papers presented at the meeting are listed in Appendix 4. The list of participants is presented in Appendix 5.

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1 Agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks. See Lévy, J.-P. & G.G. Schram. 1996. United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, Selected Documents. Kluwer Law International, The Hague. 840 pp.

1.1 Opening Address

5. The current Chairman of SCTB, the Honourable 'Akau'ola, thanked the Western Pacific Regional Fisheries Management Council for hosting SCTB11. He introduced Mr Jim Cook, Chairman of the Council, who welcomed all the participants to Honolulu. Ms Kitty Simonds, Executive Director of the Council, presented Mr Manu Boyd, Director, and Ms Vicky Holt Takamine, Head, of *Ilio ula o kalani*, who performed a traditional welcome chant for the participants. 'Akau'ola then gave an opening address, which is presented in Appendix 6.

1.2 Confirmation of Chairman and Appointment of Rapporteurs

6. 'Akau'ola was confirmed as Chairman of SCTB11.

7. Mr Tim Lawson was appointed chief rapporteur and rapporteur for agenda items 1–4 and 10–13. Dr Michel Bertignac, Dr John Hampton, Dr Antony Lewis, Mr Keith Bigelow and Mr Wade Whitelaw were appointed rapporteurs for agenda items 5–9 respectively. Assistance with rapporteuring was provided by 'Akau'ola, Dr Xavier Bard, Mr David Itano, Dr Pierre Kleiber, Dr Jacek Majkowski, Mr Naozumi Miyabe, Dr Chris O'Brien, Mr Tim Park, Dr Ian Poiner, Dr Gary Sakagawa, Mr Peter Sharples, Dr John Sibert, Mr Peter Ward and Mr Peter Williams.

1.3 Adoption of the Agenda

8. The agenda was adopted without modifications.

1.4 Adoption of the Report of the Tenth Meeting of the SCTB

9. The report of the Tenth Meeting of the SCTB, held in Nadi, Fiji, from 16 to 18 June 1997, was adopted. A report on recommendations and action items from SCTB10 is presented in Appendix 7.

1.5 Discussion of the Revised SCTB Structure and Working Arrangements

10. Dr Lewis, SCTB Coordinator, referred to Recommendation 1 of SCTB10 (see Appendix 7), which established revised terms of reference for SCTB. Recommendation 1 was endorsed by the Thirty-Seventh South Pacific Conference, held in Canberra, Australia, in October 1997. Six working groups have been established: the Statistics Working Group (SWG), the Albacore[2] Research Group (ARG), the Bigeye Research Group (BRG), the Skipjack Research Group (SRG), the Yellowfin Research Group (YRG), and the Billfish and Bycatch Research Group (BBRG). The Albacore Research Group is concerned with south Pacific albacore, and not with north Pacific albacore. Dr Lewis noted that during SCTB11, the Research Groups would review all available information, and possibly consider identifying reference points, as suggested during the Workshop on Precautionary Limit Reference Points.

11. The meeting was advised that the Coordinator of the Skipjack Research Group, Mr Joel Opnai, was unable to attend the meeting, and that Dr Lewis would therefore act as Coordinator of the SRG in his place.

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2 All scientific names are listed in Appendix 8.

2. OVERVIEW OF WESTERN AND CENTRAL PACIFIC OCEAN TUNA FISHERIES

2.1 Regional Overview

12. Dr Lewis provided a brief overview of the western and central Pacific Ocean (WCPO) tuna fisheries, describing each of the fisheries by gear and fleet, with emphasis on 1997 catches relative to those of recent years. In compiling statistics for this review (Tables 1–9), the Western Pacific Yellowfin Research (WPYR) area (Figure 1) was used.

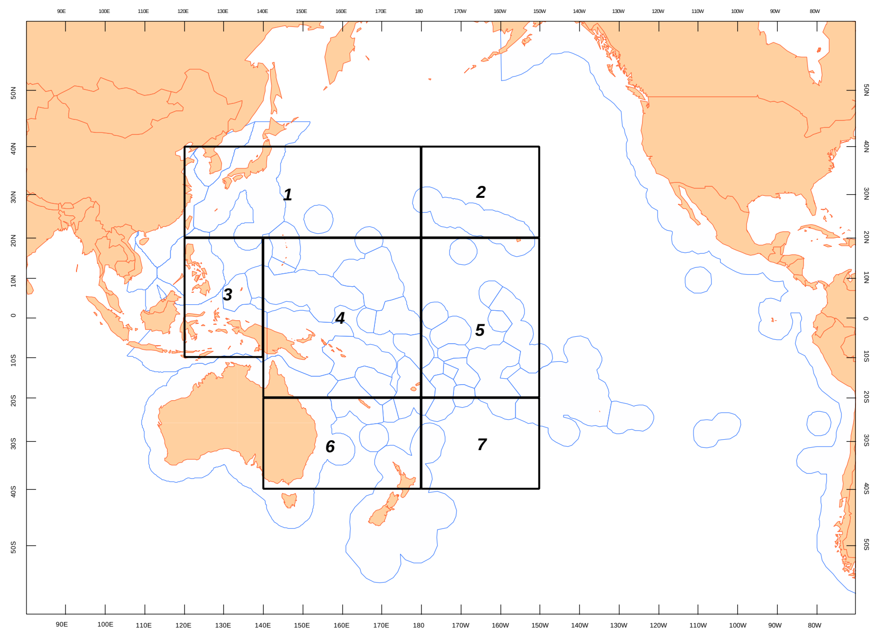

Figure 1. Western Pacific Yellowfin Research (WPYR) area and sub-areas

13. The total catch during 1997 was estimated to be 1,439,000 mt, which was a slight increase on the 1996 catch (Table 5, Figure 2). The purse-seine fishery accounted for an estimated 859,000 mt of the total catch, pole-and-line taking an estimated 239,000 mt, and the longline fishery, an estimated 187,000 mt (Table 6, Figure 3). The catch in the WCPO represents 73 percent of the total Pacific Ocean catch of 1,965,000 mt in 1997, and 46 percent of the world catch of 3,120,000 mt (Table 9).

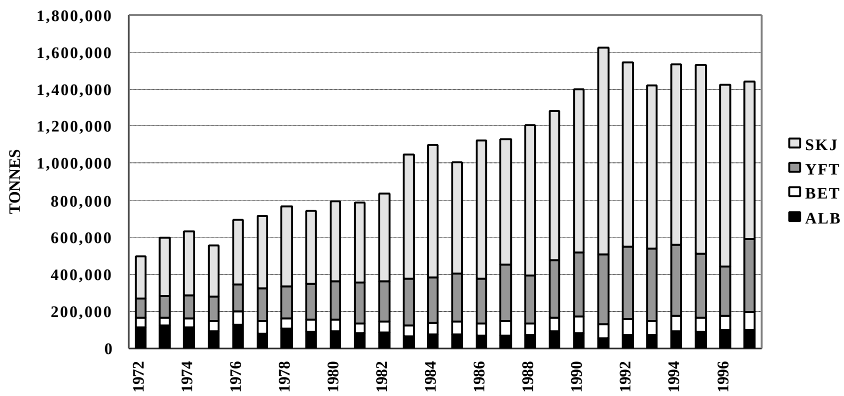

Figure 2. Catch (mt) of albacore, bigeye, skipjack and yellowfin in the central and western Pacific Ocean

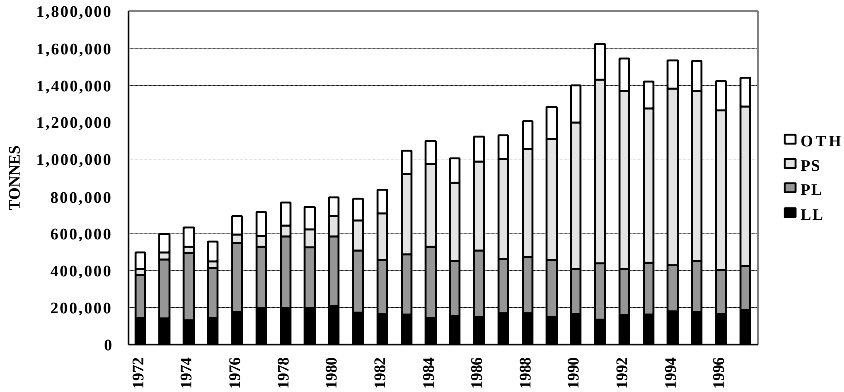

Figure 3. Catch (mt) of albacore, bigeye, skipjack and yellowfin in the central and western Pacific Ocean, by longline (LL), pole-and-line (PL), purse-seine (PS) and other (OTH) gear types

14. The species composition of the purse-seine catch was approximately 70 percent for skipjack, 27 percent for yellowfin and an estimated 3 percent for bigeye. The areas fished by purse-seine fleets during 1997 extended towards the eastern boundary of the WCPO, a situation typical of an El Niño period. This is in contrast to the 1995–1996 pattern, where most of the fishing activities were concentrated in the area of Papua New Guinea and the Federated States of Micronesia, typical of a La Niña period. It was noted that, despite the significant eastward extension of activities during 1997, there was limited overlap with eastern Pacific Ocean (EPO) purse-seine activities. Purse-seine catches by fishing nation were estimated to be 180,000 mt for Japan, 152,000 mt for Korea, 167,000 mt for Taiwan and 144,000 mt for the United States. The catch rate for skipjack in 1997 decreased from the 1996 level, but the yellowfin catch rate increased in 1997, from the historical low of 1996.

15. The pole-and-line catch of 239,000 mt during 1997 now accounts for only 17 percent of the catch in the WCPO, due to the gradual decline in pole-and-line effort over the past decade. Skipjack is the primary species, accounting for 93 percent of the catch, and three fleets account for nearly all of this catch. The Japanese offshore and distant-water fleets caught 102,000 mt, the Indonesian fleet caught 87,000 mt, and the Solomon Islands fleet caught 22,000 mt. Catch rates varied consistently among the three fleets.

16. The longline catch in the WCPO in 1997 of 187,000 mt accounts for 13 percent of the total catch in the WCPO. The longline catch increased by over 22,000 mt from the 1996 catch of 164,000 mt. The overall species composition of the 1997 catch was 37 percent for yellowfin, 31 percent for albacore and 30 percent for bigeye, but these values vary markedly by fleet and area. Most of the catch was taken by the large distant-water fleets of Japan, Korea and Taiwan, although it was noted that there was a continuation of the steady increase in the number of domestic vessels entering the fishery. Highlights of the 1997 period were the overall increase in yellowfin catches.

17. The south Pacific troll fishery caught an estimated 6,600 mt of albacore during 1997, a decline from the 1996 catch of 7,400 mt. The coastal waters off New Zealand and the Sub-Tropical Convergence Zone (STCZ) are the main areas fished, and fleets from New Zealand and the United States account for nearly all of this catch.

18. The remainder of the catch in the WCPO, 148,000 mt or nearly 10 percent, was caught by vessels of other or unclassified gear types active in Indonesia and the Philippines. It was noted that

various recreational and subsistence catches taken throughout the WCPO were excluded from the estimates presented above.

19. A brief mention of the WCPO catch by species was provided as an introduction to the work of the species research groups. Highlights for 1997 were the record catches of yellowfin and bigeye taken by all gears. It was also noted that only 10 percent of the total Pacific Ocean albacore catch for all gears were taken in the eastern Pacific (i.e. east of 150°W).

2.2 National Tuna Fishery Reports

American Samoa

20. Mr Dan Su'a presented Working Paper 28. The domestic longline fleet in American Samoa has seen rapid growth in recent years. Following test fishing in 1992, the fleet grew from four vessels in 1993 to 22 vessels in 1997. The vessels are 27 ft (8.2 m) alia catamarans, made of aluminum and usually powered by a 40 hp outboard. There is no electrical or hydraulic equipment, and the 10 mi longline is stored on a hand-cranked reel. The mainline and branchlines are made of monofilament, with steel snaps to attach the branchlines. The main source of bait is the sanma, and no lightsticks are used. There are usually three crew, and trips are a day long. The catch is stored in coolers with ice. The total catch during 1997 was 419 mt, including 285 mt of albacore, 38 mt of yellowfin, 19 mt of blue marlin, 17 mt of skipjack, 17 mt of mahi mahi, 8 mt of wahoo, 3 mt of bigeye, and 33 mt of other species. Two larger longliners, one 40 ft (12.2 m) and the other 90 ft (27.4 m), have entered the fishery, and it is anticipated that the number of larger vessels will increase.

Australia

21. Mr Ward presented Working Paper 29. Activity by Australian longliners increased substantially during 1997, with many operators introducing larger vessels and extending the range of their longline activities offshore. Landings of yellowfin in 1997 were at similar levels to recent years, whereas landings of swordfish and bigeye rose substantially.

22. Since late 1996, many Australian longliners have relocated from New South Wales to southern Queensland, where they use night sets, squid baits and lightsticks to target swordfish and bigeye. Bigeye catches rose to 869 mt in 1997, compared with past years where annual catches averaged 72 mt.

23. Swordfish catches by Australian longliners rose to 1,394 mt in 1997. Combined with Japanese catches of 261 mt, total swordfish catches in the Australian Fishing Zone surpassed the 800 mt 'trigger' established by the Australian Fisheries Management Authority (AFMA). The purpose of the 'trigger' was to alert AFMA that the fishery was expanding and that careful attention would now need to be paid to swordfish.

24. Other methods, such as pole-and-line, purse seine and trolling, are used by commercial operators in the northeastern Australian Fishing Zone (AFZ). Pole-and-line and purse seine are used to take skipjack off New South Wales. The skipjack catch exceeded 6,000 mt in 1992, then fell below 1,500 mt per year. The 1997 catch by both pole-and-line and purse seine totalled 4,689 mt. The 1998 season appears poor, with only 400 mt landed to date.

25. Seabird bycatch is being investigated under a draft threat abatement plan. The intention is to provide some observer coverage of the Australian longline fishery during 1998 and 1999 to

determine the nature and extent of sea bird bycatch. It is now mandatory for all longline vessels fishing south of 30°S to have 'tori' lines deployed while fishing.

26. It was noted that the total catch of striped marlin did not increase with the increase in fishing effort, as the effort was specifically directed at swordfish and bigeye, with a corresponding low bycatch of striped marlin. Analysis of the fishery and targeting practices is currently underway using vessel logbooks, which provide information on set times and setting practices, e.g. light stick deployment, hook numbers between buoys, etc.

27. Logbooks indicate that there has been a decrease in the catch of blue marlin and black marlin. This is due to the fact that it is now mandatory for these species to be released, dead or alive. As such, they tend not to be recorded on the vessel log sheets.

Cook Islands

28. Mr Joshua Mitchell presented Working Paper 30. During 1994–1997, the total catch by domestic longliners was estimated to be approximately 300 mt. Albacore, swordfish and marlins were the predominant species, followed by yellowfin, bigeye and mahi mahi. By the end of 1996, the two joint-venture vessels had left the fishery, leaving only one small longliner still operating. This vessel foundered on a reef early in 1997, effectively ending all commercial fishing activity in the Cook Islands for that year. Thus, just 30.3 mt in total were landed in 1997. Fifty percent of the catch was air freighted to the United States mainland, 24 percent to Hawaii, 18 percent sold on the local market, and most of the remainder exported to Japan. The reasons the joint ventures failed in 1996 were given as poor productivity, combined with a relatively high cost of operations and limitations in fishing range and flight schedules.

29. In 1997 a National Fisheries Assessment based on available data was prepared by SPC and provided to the Ministry of Marine Resources (MMR) by SPC Fisheries Research Scientist Mr Bigelow. This document has been heavily relied upon to address resource assessment in a recently formulated comprehensive policy paper released by MMR. Guidelines for future MMR actions established in the policy paper, to coordinate government and inform investors, will be incorporated into a corporate plan aimed at the future development of the offshore fisheries sector.

30. Developments in early 1998 include the renewed interest by distant-water longliners in fisheries access. The Taiwan Deepsea Tuna Boatowners and Exporters Association has expressed interest. Tropac, a Korean company based out of American Samoa, has negotiated access for four vessels which have been reporting good catches of albacore. Several other companies have shown interest and at the time of SCTB11, four more longliners were being licensed.

31. It was noted that attempts will be made to get observer coverage of the Korean vessels currently fishing. Also noted was that a French Polynesian longline vessel had visited Rarotonga and had applied for a licence to fish in Cook Island waters, but that a licence was yet to be issued.

Fiji

32. Mr Iliapi Tuwai presented Working Paper 32. The Fiji tuna fisheries are made up of domestic and foreign longline fleets and a domestic pole-and-line fleet.

33. The number of vessels active in the domestic longline fleet decreased from 42 in 1996 to 34 in 1997. However, the 1997 total catch of 4,156 mt was only slightly less than the 1996 catch of

4,475 mt. The catch of albacore increased from 1,447 mt to 1,750 mt. Catches by this fleet have yet to approach the provisional Total Allowable Catches (TACs) which were established in 1994.

34. The foreign longline fleet based out of Levuka numbered 18 vessels in 1997, and unloaded 3,000 mt of albacore, compared with 2,043 mt during 1996. This fleet is primarily made up of Taiwanese freezer vessels targeting albacore in the high-seas waters to the south of the Fiji EEZ.

35. There was a marked decline in the fishing activities by the pole-and-line fleet during 1997, with a catch of only 1,033 mt, compared to 3,288 mt in 1996. One of the main reasons for this decline was the low price offered by the PAFCO cannery in Levuka compared with other canneries in the region. This resulted in some vessels switching to other methods of fishing (i.e. longline) and other vessels ceasing operations. It was also noted that issues related to customary fishing rights also contributed to the decline in pole-and-line fleet activities.

36. The establishment of a new National Tuna Management Plan to stimulate development of the local tuna industry is planned. Several developments, such as the improvement of onshore infrastructure facilities and the design of vessels to better suit operations in Fiji waters, have already commenced.

37. It was noted that estimates of the foreign longline catch presented in the working paper were determined from landings data collected at Levuka, and that these data may include some purse-seine unloading – hence high values for skipjack in 1993 and 1994 – and may not account for the bigeye and yellowfin that were not unloaded at the cannery during 1996 and 1997.

38. It was also noted that the provisional TACs established with the assistance of SPC were, in effect, harvest targets estimated from historical catch trends, and that these represent an example of an ad hoc precautionary approach to management. Further information made available in recent years suggest that a review of these harvest targets could be attempted.

Federated States of Micronesia

39. Mr Park presented Working Paper 31. Catch data for 1997 are considered preliminary, as logsheets represent approximately two-thirds to three-quarters of the total catch for the year. All three of the major gear types (purse seine, longline and pole-and-line) operate in the Federated States of Micronesia (FSM) EEZ. In 1997, the total catch was 53,900 mt, which is significantly lower than the largest recorded catch of 251,587 mt in 1995.

40. Purse seine, longline and pole-and-line catches in 1997 were 47,188 mt, 5,952 mt and 760 mt respectively. There were 120 purse-seine vessels, 245 longline vessels and 14 pole-and-line vessels actively fishing in the EEZ. The reduction in catch in 1997 resulted from two factors: (i) a reduction in the number of fishing vessels and (ii) an El Niño period during which the major purse-seine fleets operated to the east of FSM.

41. Domestic longliners caught 225 mt in 1997. Domestic purse-seine catches are probably over 1,000 mt. Purse seiners are operated by two companies: the Caroline Fishing Company, which operated two vessels, and the Yap Fishing Company, which operated one vessel. The longline companies – Micronesian Longline Fishing, Pacific Seafoods, and the National Fisheries Corporation – are adding vessels to their fleets.

42. Chuuk harbour was the predominant FSM port utilised for purse-seine transhipments in 1997. In 1997, there were 131 purse-seine transhipments, totalling 55,619 mt. There was a reduction in the

number of longline transhipments in 1997, to 1,374, and a reduction in volume, to 3,360 mt. Most of the longline transhipment, i.e. 2,002 mt, took place at Pohnpei.

French Polynesia

43. Mr Stephen Yen presented Working Paper 33. Five fleets operate in French Polynesia: ‘bonitiers’, ‘poti marara’, domestic longliners, trollers, and foreign longliners. The bonitiers primarily use jiglines rigged with a barbless hook on a mother-of-pearl lure, and target skipjack. The poti marara, or coastal crafts, use several techniques, such as pole-and-line, trolling, deep handline, harpoon, and scoop nets. The trollers are domestic longliners which convert to trolling for the seasonal albacore fishery south of 40°S. The foreign longliners included Japanese and Korean vessels until 1992, but since then have included only Korean vessels. The number of bonitiers decreased from 75 in 1996 to 70 in 1997. The number of poti marara increased from 160 to 166, while the number of vessels that trolled decreased from four to one. The number of domestic longliners was stable, 59 in 1996 and 60 in 1997, while the number of foreign longliners decreased from 64 to 56.

44. Domestic vessels accounted for about 80 percent of the total catch in 1997, and the remainder was taken by foreign vessels. The total catch by domestic vessels increased from 5,143 mt in 1996 to 6,272 mt in 1997. The catch of skipjack decreased from 1,091 mt to 896 mt, due to the decrease in the number of bonitiers. Decreases in the yellowfin catches by poti marara were compensated by an increase in the longline and bonitier catches, such that the total catch of yellowfin was unchanged, 661 mt in both 1996 and 1997. The total catches of albacore and bigeye, which are taken primarily by longliners, increased from 1,636 mt to 2,697 mt and from 184 mt to 308 mt, respectively. The 65 percent increase in the albacore catch in 1997 was due to high catch rates and to targeting of albacore for export. Previously, almost all of the domestic catch was marketed locally, but with the local market reaching saturation, exports increased from 148 mt in 1996 to 1,302 mt in 1997. The main export markets were the United States for fresh albacore, and frozen albacore and yellowfin loins; American Samoa for frozen albacore; Western Samoa for frozen albacore; and France for frozen albacore and loins.

45. Catches by foreign longliners have usually been dominated by bigeye; however, in 1996 more yellowfin than bigeye were caught, 911 mt and 879 mt respectively. The situation returned to normal in 1997, with 428 mt of yellowfin caught, compared to 1,078 mt of bigeye. The total catch by foreign longliners decreased from 2,074 mt in 1996 to 1,737 mt in 1997.

46. An objective of producing 11,000 mt by the domestic fleets has been fixed. In the next few years, 24 longliners of 13 m and 10 longliners of 26 m should be introduced. With little growth expected in the local market, the increase of about 4,700 mt from the current domestic catch should be exported. The objective for total exports has been fixed at 6,000 to 7,000 mt by 2003/2004.

Japan

47. Mr Miyabe presented Working Paper 35. The most important event that has affected Japanese catch and effort has been the recent El Niño. This is demonstrated by increased fishing between the Gilbert Islands and the Line Islands, which coincided with the movement of warm water from the western tropical Pacific to the eastern tropical Pacific Ocean.

48. The general declining trend in longline vessel numbers has continued over recent years. This is mainly attributed to lack of trained crew and economic reasons. The distant-water purse-seine fishery has remained fairly constant.

49. The longline catch of bigeye, yellowfin, striped marlin and blue marlin have all declined during 1996, as has the effort. Albacore catches remained at a fairly high level with swordfish catches remaining fairly steady.

50. The 1996 pole-and-line skipjack catch decreased by 25,000 mt from the 1995 level.

51. During 1997, the purse-seine fishery experienced a record high bigeye catch, 13,000 mt, and an increase in the yellowfin catch, compared to the previous year, while the skipjack catch decreased. This change appears to be related to the El Niño event that resulted in a shift of the fishing grounds to the east of 170°E. This is the first time that this fleet has operated in this area. The shift of the fishing area occurred around March, which is in accordance with the movement of warm waters from the western Pacific to the eastern Pacific. During the first few months, operations were made on FAD-associated schools of medium-sized bigeye and yellowfin (60–80 cm), and considerably higher percentages of bigeye were recorded. Thereafter, fishing continued in the same area, but targeting shifted to free-swimming schools of large yellowfin and skipjack.

Kiribati

52. Mr Johnny Kirata presented a report on the current status of the domestic fishery in Kiribati. There has been little activity recently. The national fishing company, Te Mautari, has tied up its pole-and-line vessels and the company is chartering its vessels for non-fishing activities. There is one Kiribati-registered purse seiner, originally from Japan, which currently fishes under the FSM Arrangement. There are also about 200 artisanal vessels, ranging in size from 17 ft (5.2 m) to 21 ft (6.4 m); 83 of these are active full-time. These vessels do not require licences. Data are not collected from artisanal vessels on a regular basis, but survey estimates suggest they landed about 130 mt in 1997. The relatively low catch rate is blamed on a high level of foreign purse-seine activity in adjacent waters.

53. During 1997, transhipment activity took place in Tarawa from May to July and in Kiritimati in September and October.

54. It was noted that the Te Mautari fleet of pole-and-line vessels did not fish in 1997. It is believed that during an El Niño event, as experienced in 1997, the local bait species become dispersed so that they are not readily available to the pole-and-line fleet. During past El Niño events, the Te Mautari fleet has worked in Fiji and the Solomon Islands waters, but financial constraints prevented that from happening in 1997.

Korea

55. Mr Yeong-Chull Park presented Working Paper 37. There was a total of 175 vessels, including 148 longliners and 27 purse seiners, operating in the Pacific Ocean during 1997, which is an increase of 8 longliners and one purse seiner compared to 1996.

56. Total landings by the Korean longline fleet for 1997 were about 35,000 mt, which is an increase of about 20 percent from 1996. The species composition of the catch was 41.2 percent bigeye, 34.7 percent yellowfin, 5.0 percent albacore, and 19 percent other species, which include billfish. There was a significant increase in the catch of albacore during 1997 due mainly to good catches north of the Hawaiian Islands. The 1997 catch rates for bigeye, 0.77 fish per 100 hooks, and yellowfin, 0.82 fish per 100 hooks, were higher than the 1996 values, 0.56 and 0.67 respectively.

57. The estimated 1997 purse-seine catch of 159,500 mt was a 7.2 percent increase compared to 1996. The species composition of the catch, determined from logbook data, was 72.7 percent skipjack, 27.0 percent yellowfin and less than 1 percent of other species. Fishing effort during recent years has extended further eastwards than in previous years.

58. It was noted that the longline catch of other species, particularly billfish, is determined by applying the species composition obtained from logbook data to the landings value. There are logbooks yet to be received for 1997, and coverage is notably lower than in previous years. As such, the species composition of the 1997 catch should be considered provisional.

Marshall Islands

59. Mr Glen Joseph presented the report for the Marshall Islands. No domestic vessels operated during 1997; however, locally-based longliners from Taiwan and mainland China, and distant-water longliners, pole-and-line vessels and purse seiners from Japan, fished in the EEZ, together with purse seiners operating under the multilateral treaty with the United States.

60. During 1997, Dr Lewis and Mr Bigelow presented a National Fishery Assessment prepared by the OFP. Recent concerns expressed by the Marshalls Billfish Club, regarding interactions between sport fishing and longlining, were addressed. An analysis of the available data did not indicate that interactions have been significant.

New Caledonia

61. Mr Régis Etaix-Bonnin presented Working Paper 38. In 1997, seven domestic longliners were active, including one freezer vessel and six smaller vessels that targeted tuna, mainly for the sashimi market. The total catch in 1997 was 1,056 mt, of which 40 percent was yellowfin and 20 percent was bigeye. Two-thirds of all tuna was sent to the Japanese sashimi market.

62. In preparation for expansion of the New Caledonian fleet, recent studies have examined the comparative efficiency of freezer vessels and vessels using ice slurry, and the difference in catches between traditional and monofilament longlines. It appears that monofilament is more efficient at catching the high-quality tunas, such as yellowfin and bigeye, but it was observed that, contrary to expectations, the average weight of monofilament-caught bigeye is lower than that of bigeye caught on traditional lines. It is expected that the domestic longline fleet will expand to twelve or thirteen vessels during 1998.

63. With the increase in vessel numbers, attention is being focused on developing new markets. The local market is considered to be capable of absorbing between 400 and 500 mt, and these levels are already being achieved. In an effort to increase local consumption, efforts are being made to develop new products through processing of the catch and to find new markets for the low quality tuna.

New Zealand

64. Dr Talbot Murray presented Working Paper 39. Prior to the 1980s tuna catches were primarily by foreign-flagged vessels from Japan, Korea, Taiwan and the United States. New Zealand vessels developed the albacore troll and skipjack purse-seine fisheries in the mid-1970s. In recent years the New Zealand fleet has expanded to around 500 albacore troll vessels (some part time), 20–60

medium-sized longliners, 5 chartered Japanese longliners and 5–6 medium-sized purse seiners. Albacore and skipjack are the primary species in the New Zealand tuna fishery.

65. Since 1991, the number of Japanese vessels fishing in the New Zealand EEZ has declined, due to low abundance of southern bluefin, area and vessel number restrictions, the cost of licences, and observers. During this same period, the domestic longline fleet expanded from fewer than 10 to about 50 vessels. These vessels mainly use monofilament mainline and are widely distributed with some vessels now fishing outside the EEZ.

66. New Zealand tuna fisheries are most active during the summer months, with catches of all but yellowfin and skipjack possible all year around. Albacore are mainly caught from December to April, bigeye from November to June, skipjack from December to May, and yellowfin from October to April. Swordfish are caught all year. It is prohibited to land any other type of billfish. The 1997 catches were as follows: albacore, 3,626 mt; bigeye, 142 mt; skipjack, 5,780 mt; yellowfin, 143 mt; and swordfish, 282 mt.

Northern Mariana Islands

67. Mr Richard Seaman presented the report. Tuna fisheries in the Commonwealth of the Northern Mariana Islands (CNMI) are restricted to a small-scale fleet of domestic trollers. This fleet rarely ventures more than 20 nm off the coast. The species composition of the catch includes yellowfin, skipjack, mahi mahi and wahoo. The fleet is made up of small vessels, less than 27 ft (8.2 m) in length. In 1996, there were 101 full-time troll vessels and 62 part-time troll vessels comprising the fleet. This fleet takes small catches compared to the large commercial fleets operating in the region. There is no foreign fleet activity in the CNMI zone at present.

68. It was noted that CNMI is a member of the Western Pacific Regional Fisheries Management Council, and future developments related to the tuna fishery include building a longline port facility and the establishment of a Fisheries Act to better cater for the development of the CNMI tuna fishery.

Palau

69. Ms Evelyn Oiterong presented the report for Palau. She noted that the Palau Maritime Authority, which in the past had been responsible for tuna fisheries, was incorporated into the Bureau of Natural Resources and Development in February 1998. Although a working paper was not presented, certain tuna fishery statistics were discussed, and these are presented in the two tables below.

70. The total number of foreign longliners based in Palau decreased from 185 vessels in 1996 to 141 vessels in 1997, following a change in government policy to allow only 150 permits. The number of Taiwanese vessels increased from 81 to 121, while the number of Chinese vessels decreased from 104 to 20. The numbers of vessels managed by each of the shore-based companies during 1994–1997 are presented in the following table:

COMPANY	FLEET	1994	1995	1996	1997
KFC	CHINESE	0	0	4	12
	TAIWANESE	45	87	54	68
	SUB-TOTAL	45	87	58	80
PMIC	CHINESE	56	66	41	8
	TAIWANESE	98	8	0	50
	SUB-TOTAL	154	74	41	58
PITI	CHINESE	66	3	59	0
	TAIWANESE	0	0	27	3
	SUB-TOTAL	66	3	86	3
TOTAL	CHINESE	122	69	104	20
	TAIWANESE	143	95	81	121
	TOTAL	265	164	185	141

71. With the Marine Protection Act of 1994, all exports of marine products by the locally-based companies must be declared, and coverage by export data is currently greater than 90 percent. Exports of bigeye, yellowfin and billfish during 1996 were 524 mt, 325 mt and 37 mt respectively, for a total of 886 mt, which was worth approximately US$ 1.6 million. Exports declined in volume during 1997 to 812 mt, including 541 mt of bigeye, 249 mt of yellowfin and 22 mt of billfish, while the value increased to approximately US$ 2.0 million.

72. The following table presents catches (mt) within the Palau EEZ reported by Japanese longliners and purse seiners:

		1992	1993	1994	1995	1996
LONGLINE	YELLOWFIN	335	105	31	43	58
	BIGEYE	380	112	49	75	94
	ALBACORE	1	1	0	1	0
	BLUE MARLIN	12	6	1	8	3
	OTHER MARLIN	6	4	1	2	3
	OTHERS	0	0	0	0	0
	TOTAL	734	228	82	129	158
PURSE SEINE	SKIPJACK	1,531	327	3,585	3,626	8,269
	YELLOWFIN	3,266	93	1,028	1,213	850
	OTHERS	3	0	3	5	46
	TOTAL	4,800	420	4,616	4,844	9,165

Samoa

73. Mr Antonio Mulipola presented Working Paper 40. The domestic longline fleet has undergone significant expansion in the last four years. Presently, there are over 200 alias in the fleet. The fleet occurs in three categories: 29–32 ft (8.4–9.8 m), 32–46 ft (9.8–14.0 m), and greater than 50 ft (15.2 m). The 166 smaller alias comprise most of the fleet, but in the future there may be a greater proportion of larger vessels that can travel farther offshore.

74. The alias typically deploy horizontal longlines which are 5–9 mis (9–14 km) in length and carry 350–500 hooks. Preliminary catch and effort data indicate that an average of about six fish (approximately 15 kg mean weight) is caught per 100 hooks. Fish export data for 1997 indicate a

total catch of 1,772 mt, but these estimates are probably under-reported by 40–50 percent. Port sampling data provided a better estimate of the annual longline catch. The annual catch determined from port sampling data was 2,200 and 4,000 mt in 1996 and 1997 respectively. During the past three years, alia catch rates have ranged from 20 to 60 kg per 100 hooks. During 1998, catch rates have declined to their lowest levels. The low catch rates may have resulted from the El Niño event.

75. Albacore and yellowfin dominate longline catches. In the past three years, albacore has comprised 62–91 percent of the catch. Given the close proximately of the canneries in American Samoa, 80 percent of the total exports by weight went to Pago Pago. Approximately 15 percent of the total exports are air-freighted to markets in the United States, including Hawaii.

76. The longline fleet in Samoa is currently a commercial success that is largely due to entrepreneurs in the private sector; however, there are several problems inherent in the fishery. While the fishery exploits tunas that are highly migratory, the density of alias in some areas is high, and catch competition and gear conflicts may occur between the vessels. In order to reduce competition between vessels, the government requires that all vessels over 50 ft (15.2 m) must fish beyond 50 mi (80 km) offshore. Between April and December 1997, there were more than 20 deaths from lost vessels. These tragedies result from several factors such as: (i) lack of skills in naval architecture and boat building; (ii) lack of safety and survival skills; (iii) exploitation of much farther fishing areas; and (iv) engine failures and insufficient fuel. The government is currently taking measures to correct these factors. In addition, the government is improving infrastructure and product quality.

Solomon Islands

77. Mr Eddie Oreihaka presented Working Paper 41. The tuna fishery is one of the major foreign exchange earners and the largest employer in the country. The commercial tuna fishery is currently being managed based on a quota system that allocates a TAC of 120,000 mt for the surface fishery and 8,500 mt for the longline fishery. Domestic fleets have dominated the fishery, with foreign fleets consistently catching less than 10 percent of the catch.

78. The total catch in 1997 for the domestic fleet was 50,248 mt, which was less than half of the TAC and which accounted for 95 percent of the total catch. The catch by single purse seiners, 17,963 mt, dropped dramatically from the 1996 catch of 33,649 mt, even though the NFD fleet, which accounted for 65 percent of the single purse-seine catch in 1997, reported an increase. The overall decline may be due to reporting problems. During 1998, these problems have been addressed, and the reported catch up to March 1998 already stands at 20,962 mt, more than for all of 1997.

79. Of the total catch in 1997, 31,863 mt were skipjack, 9,913 mt were yellowfin, and 1,317 mt were bigeye. It was noted that there is no bigeye catch reported by the surface fisheries; however, this is due to the misidentification of bigeye as yellowfin on data collection forms.

80. The major buyers of Solomon Islands domestically-caught tuna are Japan, for frozen and fresh tuna, and the United Kingdom, for canned tuna. Japan also buys smoked tuna processed by the joint-venture Solomon Taiyo company.

81. A total of 92 transhipments were made in Honiara during 1997, including 83 by purse seiners and 9 by longliners. The transhipment activity mostly took place towards the end of the year and has continued at a high level into 1998.

82. The most recent development of significance in Solomon Islands fisheries is the repealing of the Fisheries Act of 1972. The new act allows for long-term conservation and sustainable utilisation

of fisheries resources. Solomon Islands has also revamped its observer programme by employing 18 additional observers on a contract basis. The observers have been trained by staff of SPC and the Forum Fisheries Agency. Since the start of 1998, 37 observer trips have been undertaken. A new vessel licensing procedure has been introduced to ensure that future foreign vessels, and companies attempting to get involved in tuna fishing in the Solomon Islands, are reputable. Each proposal must score 25 points before the Foreign Investment Board can approve its application and the Fisheries Division can issue a licence.

83. It was noted that some longline vessels are currently licensed to target sharks in Solomon Islands waters. According to recent observer data, these vessels operate much as tuna longliners; however, they fish shallower and tend to use the tuna that is caught as bait for the shark hooks. It was noted that the 5.2 mt of bluefin that was landed in 1997 was mostly large northern bluefin.

Taiwan

84. Dr Shui-Kai (Eric) Chang presented Working Paper 42. The Taiwanese longline fleet can be separated into a distant-water component that targets albacore in the more temperate waters of the WCPO, and the smaller vessels of the offshore fleet that tend to target bigeye and yellowfin for the sashimi market.

85. The total catch for the distant-water longline fleet in the WCPO during 1997 was estimated to be about 18,000 mt, most of which was albacore. The catch by the offshore longline fishery was estimated to have been 16,296 mt of yellowfin and 9,368 mt of bigeye, for a total for the two species of 25,664 mt.

86. The Taiwanese purse-seine fleet took an estimated 167,188 mt during 1997, including 115,934 mt of skipjack, 48,792 mt of yellowfin and 2,311 mt of bigeye. Fishing activities for this fleet during 1997 extended well to the east, with high catch rates experienced in the waters of Kiribati. The species composition of the 1997 catch was markedly different from 1996, with a significant increase in the amount of yellowfin taken.

87. The estimates of the catch for the distant-water longline fleet are obtained by raising the available logbook data using landings collected at the vessel-trip level. Some difficulties have been experienced with the estimates for the offshore fleet, and further information will be sought in order to provide more reasonable estimates for this fleet in the future. Logbook coverage of the purse-seine fleet is complete and therefore does not need to be raised.

Tonga

88. ’Akau’ola presented the report on Tongan fisheries. He described the Fisheries Sector Study, funded by FAO and the Australian Agency for International Development (AusAID), which involved eight consultants. The draft report concerns policy issues and related issues. It was concluded that the coastal fisheries sector has been heavily impacted, and that development should concentrate on pelagic fisheries. Fuel is currently taxed at a rate of 63 percent, and it is recommended that the tax be eliminated. It is also recommended that the availability of capital loans be increased. Port facilities will be reviewed, and it is anticipated that air freight capabilities will also be examined.

89. A 40 m Japan-built longliner was recently delivered to the Ministry of Fisheries. This vessel will be used for research and training, and it is hoped that sales of the catch will fund the vessel’s activities. Two new longliners will be acquired by Sea Star, a government-owned company, later in

1998. The possibility of introducing alias into Tonga is being considered, and Samoa and American Samoa will be visited in this regard.

United States of America

90. Mr Al Coan presented Working Paper 43. The U.S. distant-water purse-seine fleet and several small-scale fisheries operate in the central and western Pacific. Small-scale fisheries consist of longline, pole-and-line and troll, and usually occur within EEZs of the United States.

91. The U.S. purse-seine fleet operates between 10°N and 10°S latitude and 130°E and 150°W longitude. Thirty-five vessels caught 144,424 mt in 1997. Typically, skipjack tuna account for 70 – 80 percent of the catch, but comprised only 59 percent in 1997. Skipjack catches declined for the third consecutive year, partly due to a reduction in fleet size, but also due to a change from fishing predominately free-swimming schools to fishing predominately on schools associated with drifting objects (e.g. FADs). In 1997, over 90 percent of the purse-seine catch was landed or transhipped to canneries in American Samoa. Of the landed catch, 82 percent was processed in American Samoa, whereas the remainder was sent to other canneries in the Pacific region or Europe. Species composition and lengths are routinely sampled when vessels unload in American Samoa. From 1993 to 1997, the average sizes of yellowfin, skipjack and bigeye did not change significantly. As in the past, larger fish occurred in free-swimming schools, while smaller fish were caught in schools associated with drifting objects.

92. Three separate U.S. longline fleets operate in the WCPO. In 1997, the largest was the Hawaii-based fleet of 105 vessels. This fleet targets swordfish and bigeye and accounts for 90 percent of the U.S. longline catch in the WCPO. Yellowfin and bigeye catches for this fleet were 3,300 and 4,500 mt in 1996 and 1997 respectively. Tuna catches are anticipated to increase for this fleet as more vessels switch to targeting tunas instead of swordfish. The remaining two longline fleets operate in American Samoa and Micronesia. The American Samoa-based fleet increased to 22 vessels in 1997 and caught 285 mt of mainly south Pacific albacore. Four vessels, based in Micronesia, caught 102 mt in 1997.

93. U.S. trollers operate in various areas of the WCPO. On the high seas, a fleet of distant-water trollers targets south Pacific albacore. In the U.S. EEZs of Hawaii, American Samoa, Guam and the Northern Marianas, small-scale commercial and artisanal fleets operate and catch mainly skipjack and yellowfin tuna. During the 1996/97 season, 28 U.S. distant water trollers participated in the South Pacific albacore fishery. The albacore catch was 1,400 mt, a decrease from 2,100 mt caught in the 1995/96 season. This decrease was largely due to fewer vessels participating in the 1996/97 season. The small-scale and artisanal vessels landed an aggregated 2,113 mt in 1996, of which 71 percent was yellowfin and skipjack.

94. A small-scale pole-and-line fleet is based in Hawaii and fishes exclusively in the Hawaiian EEZ. The catch is sold directly to the domestic market. Both demand of this market and the availability of adequate bait are constraints affecting landings of this fleet. Catches in 1996 and 1997 were 781 mt for each year, of mostly skipjack.

95. Bycatch and discards are monitored in the purse-seine fleets and the Hawaii-based longline fleet through an observer programme. Bycatch statistics can also be recorded in the vessel’s catch and effort logbook, but the estimates are incomplete.

Vanuatu

96. Mr Robert Jimmy presented Working Paper 45. Historically, Vanuatu tuna resources were exploited at a low level by Taiwanese, Korean and Japanese longliners. During 1996 and early 1997, 34 vessels were licensed to operate in the EEZ. Only 19 were recorded for 1997/98. These foreign vessels are mainly longliners, although two purse seiners were licensed in 1996 as local vessels.

97. Seven domestic vessels were licensed to operate within the 6–12 mi territorial waters for 1996 and early 1997. Six game fishing licenses were also granted. The main species, in descending order, are yellowfin, albacore, other species and striped marlin. Taiwanese longliners mainly caught albacore.

98. Foreign vessels licensed in Vanuatu's EEZ mainly land their catch in Pago Pago, American Samoa, and Suva, Fiji. Game-fishing clubs in Vanuatu, in collaboration with the Department of Fisheries and ORSTOM, used to supply catch data. This agreement ended and no data are now available.

2.3 Economic Condition of the Fishery

99. Ms Anna Willock presented Working Paper 2. Approximately 147 distant-water purse-seine vessels were active in 1997. The fleet operating in the WCPO consisted of 34 U.S., 42 Taiwanese, 35 Japanese, 26 Korean and 10 Filipino vessels. The purse-seine catch increased for both the Japanese and Korean fleet, while the Taiwanese catch was stable. The U.S. catch declined, due to vessels fishing for a short time or leaving the fishery. Seventy to eighty percent of the distant-water purse-seine catch was taken in EEZs of Pacific island countries. The catch increased in the locally-based purse-seine fleet. This increase was largely due to fleets based in the Solomon Islands and the basing of eight purse-seine vessels in Papua New Guinea. Though there has been an increase in the locally-based fleet in Papua New Guinea, local fleets are considered unlikely to increase within the region.

100. The processing sector gained an additional cannery in Madang, Papua New Guinea, during the last half of 1997. There are now three canneries operating in the region, the others being in Fiji and the Solomon Islands. Another cannery is being considered in Papua New Guinea. The PAFCO cannery in Fiji has scaled down and has largely converted to loining activities. The Marshall Islands will soon commence construction of a loining plant, while Papua New Guinea is considering one. Cannery prices remained high during 1997, due largely to a shortage of raw materials, reaching a peak of US$ 1,250 per mt in August 1997. Thailand is still the world's largest processor of canned tuna, though the downturn in Asian economies and the shortage of fish has reportedly forced some small to medium size canneries in Asia to suspend or scale down their operations. The United States has the largest canned tuna market, but demand has stagnated in recent years.

101. Development in the domestic longline fishery was largely confined to the fresh tuna market. The number of local vessels increased in Papua New Guinea, but decreased in the Federated States of Micronesia. Vessel activity also decreased in Fiji to 34 active vessels, but the annual catch fell less than 10 percent. The alia fishery in Samoa expanded significantly to over 200 vessels, which ship most of the catch to canneries in neighbouring American Samoa.

102. Conditions in the Japanese sashimi market remained sluggish in 1997, particularly in the frozen sashimi sector. In 1997, imports of fresh and frozen bigeye and yellowfin declined about 29,000 mt to 230,000 mt. The net decline in total imports continues a trend evident since 1993. Japan imports

of fresh or chilled bigeye and yellowfin from Pacific island countries totalled 16,291 mt, compared to total imports of 55,900 mt. Imports from Pacific island countries declined 3,000 mt, possibly due to the departure of many Taiwanese and Chinese small longline vessels. Despite poor economic conditions in Japan, import prices for fresh bigeye and yellowfin remained strong.

103. The United States is considered an emerging market for sashimi and a viable alternative to Japan. The U.S. market is currently attractive because it has a favourable exchange rate in contrast to Japan. In addition, the market is less demanding than Japan with respect to product characteristics.

104. Taiwanese vessels catch over 50 percent of the albacore longline catch in the WCPO, and often land the fish in American Samoa. Albacore landed in San Diego have a reported price of US$ 2,200 per mt.

105. The Japanese pole-and-line fleet followed the usual annual cycle in distribution and target species. Total catches of albacore and skipjack improved slightly. The average price also increased to 246 yen per kilo, which was 4 yen per kilo higher than the previous year. Solomon Islands has the only domestic pole-and-line fleet still operating in the region, with catches remaining stable in 1997.

2.4 Fishery Management Developments

106. Dr Lewis briefly described new fishery management developments, and how they may impact the SCTB.

- Multilateral High-Level Conference: since the last SCTB, there have been two inter-sessional technical consultations on Management Issues and on Monitoring, Control and Surveillance, and most recently the Workshop on Precautionary Limit Reference Points. The Third MHLC will be held in Tokyo at the end of June 1998. A draft text of a Convention will be tabled for consideration. The goal still appears to be to conclude the process by June 2000.

- Regional arrangements involving FFA member countries or subsets thereof, such as the Palau Arrangement (for the regulation of purse-seine effort), the FSM Arrangement (to facilitate access), and the Niue Agreement (concerning surveillance), were mentioned.

- National and in-zone management arrangements appear to be developing more as obligations under the United Nations Implementing Agreement become clear.

- The Interim Scientific Committee on North Pacific Tuna and Tuna-like Species has not met since May 1996. The next meeting is tentatively scheduled for January 1999 in Hawaii.

- The Annual Meeting of the Inter-American Tropical Tuna Commission will take place in San Diego in the week following SCTB11, and among other things, will consider possible management interventions in the purse-seine fishery in order to regulate the catch of bigeye.

- There is an increasing focus on non-target, associated and dependent (NTAD) species. The FAO Expert Consultation on Management of Fishing Capacity, Shark Fisheries and Incidental Catch of Seabirds in Longline Fisheries will be held in Rome in October 1998.

- Other organisations active in or adjacent to the SCTB area of interest include the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the North Pacific Albacore Workshop, and the Southeast Asian Fisheries Development Center (SEAFDEC).

3. REPORTS BY ORGANISATIONS

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

107. The CSIRO Division of Marine Research was established in 1997 with the merging of the CSIRO Divisions of Fisheries and Oceanography. The new Division has five research programmes, including the Tropical and Pelagic Ecosystems Program.

108. The Tropical and Pelagic Ecosystems Program is a group of about 60 scientists which aims to understand the ecology and dynamics of Australia's tropical and pelagic marine resources, and to use this knowledge to assist government and industry to manage these resources for ecological and economic sustainability. It utilises the diverse resources of CSIRO, collaborating agencies and industry to develop new techniques and novel approaches to the problems of managing Australia's tropical and pelagic marine resources.

109. Emphasis is placed on the assessment and management of the impacts on the marine environment of resource exploitation and economic development by integrating physical, ecological and biological research and mathematics, statistics and modelling research, to develop and support scientific advice to managers of tropical and marine and pelagic ecosystems.

110. There are four research groups in the programme: Tropical Ecosystems, Pelagic Ecosystems, Tropical Continental Shelfs and Marine Statistics. The Pelagic Ecosystems research group aims to develop quantitative and predictive understanding of the ecological, environmental and biological processes determining the temporal and spatial variation in the abundance of large pelagic fish resources. The long-term scientific goals are to develop integrated biophysical models of the pelagic ecosystem based on data describing the physical and biological habitats and the physiology, ecology, and spatial and temporal dynamics of the key species, and to use these models to develop robust management strategies for sustainable use of the harvested tuna and billfish resources and the ecosystem.

111. The current research priorities of the group are southern bluefin; tropical tunas and billfish; and ecosystem effects of fishing, including effects on endangered species. Research of direct relevance to SCTB is as follows:

- The origin of recruits to the Australian east coast yellowfin fishery and delineation of the structure of yellowfin stocks in the Western Pacific using studies of otolith microchemistry and microsatellite genetics. Contact: John.Gunn@marine.csiro.au

- The SeaWIFS project to assess the value of ocean colour information in the tuna fisheries off the east coast of Australia. The project aims to develop near real-time predictive methods to predict the distribution of tuna to improve both fishing operations and fishery management. Contact: Vince.Lyne@marine.csiro.au

- Preliminary assessment of the yellowfin tuna resources in the eastern Australian EEZ. The details of this project were reported under Agenda Item 6, Yellowfin Research Group (see paragraph 209). Contact: Robert.Campbell@marine.csiro.au

- Evaluation of performance indicators in the Australian east coast tuna fishery. A progress report from this project was reported to the Workshop on Precautionary Limit Reference Points. This project aims to evaluate management strategies for the Australian east coast tuna fishery using an operational model of the fishery that simulates various population dynamics hypotheses. Contact: Tony.Smith@marine.csiro.au

- Guide to the Indo-Pacific Billfish. This manual will help commercial and recreational fishers identify the various billfish species in the water or after landing and dressing. It also includes a description of a genetic 'finger-printing' test developed to help in the positive identification of fish before and after dressing. Contact: Peter.Grewe@marine.csiro.au

- In response to incidental catches of seabirds during oceanic longline fishing operations being declared a key threatening process under the *Australian Endangered Species Act 1992*, we are developing the design and implementation of a fisheries observer programme to monitor seabird bycatch rates in the Australian domestic longline fisheries. Contact: Dennis.Heinemann@marine.csiro.au

Food and Agriculture Organization of the United Nations

112. Dr Majkowski reported on the progress of the following FAO activities of potential interest to the meeting:

- the organisation of the Expert Consultation on Implications of the Precautionary Approach to Tuna Biological and Technological Research, which may be hosted by FAO's Regional Office for Asia and the Pacific, in Bangkok, in the second half of 1999;

- the finalisation of a CD-ROM with a global atlas of tuna and billfish catches;

- the preparation of overview global maps of average catches of tuna and billfish, which will be available on the home page of the FAO Fisheries Department;

- the work on a digitised synopsis of tunas and billfishes on a global scale, for inclusion in FAO's general atlas;

- a global review of bycatches of fisheries targeting tunas and billfishes;

- the organisation of the Expert Consultation on Indian Ocean Tunas and a meeting of the Scientific Committee of the Indian Ocean Tuna Commission, both to be held in the Seychelles in October–November 1998; and

- preparation for the Expert Consultation on Management of Fishing Capacity, Shark Fisheries and Incidental Catch of Seabirds in Longline Fisheries, to be held in Rome in October 1998.

113. Regarding the Expert Consultation on Implications of the Precautionary Approach, an informal meeting of the Steering Committee of the Consultation was held during SCTB11. Regarding the atlas on CD-ROM, a preliminary version has been sent to sources of the data. After comments are received, the final version of the atlas will be distributed in the second half of 1998. Dr Majkowski thanked the sources of the data for their cooperation.

Pelagic Fisheries Research Program

114. The Pelagic Fisheries Research Program (PFRP) is situated in the Joint Institute of Marine and Atmospheric Research (JIMAR) and the University of Hawaii. JIMAR is one of several joint institutes established by NOAA at universities across the United States to foster collaboration between government and academic researchers. The PFRP sponsors research on all aspects of pelagic fisheries systems in the Pacific. Since 1993, the PFRP has sponsored more than 35 different research projects on economics, biology, genetics, stock assessment and oceanography. The principle geographic focus of this research is the area administered by the Western Pacific Regional Fishery Management Council, but since the pelagic species are wide ranging, many PFRP projects are of wider interest. Some projects of regional interest include a study of yellowfin reproductive biology; development of an age-structured, spatially resolved model for yellowfin stock assessment; a genetic analysis of bigeye stock structure; yellowfin and bigeye tagging in Hawaii; and analyses of skipjack movement patterns. Details of all PFRP projects can be found at the PFRP web site (www.soest.hawaii.edu/PFRP/). The PFRP selects projects through a competitive proposal process; a request for proposals will be issued later this year.

4. STATISTICS WORKING GROUP

115. Under this agenda item, Mr Lawson, Coordinator of the Statistics Working Group, presented Working Paper 3 on issues of concern to the SWG, and proposed procedures for addressing the coordination of data collection, data compilation and the dissemination of data. After presenting each section of the paper, the meeting discussed the proposed procedures and came to a consensus.

116. In introducing his paper, he noted two recent initiatives concerned with principles and procedures for data collection, compilation and dissemination: (1) the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, which concluded in August 1995, and (2) the Technical Consultation on the Collection and Exchange of Fisheries Data, Tuna Research and Stock Assessment, held in July 1996. Both initiatives had resulted in certain guidelines for data collection, compilation and dissemination, and these were summarised in Working Paper 3.

4.1 Issues Concerning the Coordination of Data Collection

117. The issues with respect to the coordination of fisheries data collection by the SWG concern the types of data with which the SWG should be concerned, and the manner in which the SWG should coordinate data collection. The data for which the collection could be coordinated by the SWG include logsheet catch and effort data, landings data, port sampling data, and observer data.

118. It was proposed that the coordination of data collection by the SWG could be accomplished through (1) periodic reviews of all data collection forms in use, in order to ensure that they include a minimum standard of data; (2) periodic reviews of the level of coverage by logsheet and landings data for each of the fleets, in order to ensure that a minimum level of coverage is being achieved; (3) periodic reviews of the level of accuracy and reliability of the logsheet data, in order to ensure that the logsheet data have been subject to a minimum level of verification; and (4) the establishment of a regional sampling design for port sampling and observer programmes.

119. It was also proposed that the Tuna Fishery Data Collection Forms Committee, established by SPC and FFA, be adopted by the SCTB in order to review data collection forms, including the

regional data collection forms developed by the Forms Committee and used by many domestic and distant-water fleets.

120. The suggestion of adopting the Forms Committee to review data collection forms was the main issue discussed by the meeting after the presentation of this item. While some felt that the SWG should be concerned with minimum standards of data, and not the forms themselves, most felt that it would be useful to review data collection forms. While it was recognised that it would be difficult for the SWG to review data collection forms during its regular sessions, it was felt that data collection forms could still be reviewed during the annual meeting of the SCTB, perhaps by a group meeting outside the main SCTB sessions or perhaps by a group meeting for one day prior to the beginning of the SCTB meeting. It was therefore felt that there was no need to adopt the Forms Committee.

121. The need for the SWG to review and maintain the regional forms developed by the Forms Committee was questioned. It was noted that Pacific island countries need assistance with the development of data collection forms for their domestic fleets, and that the regional forms were also used by the Chinese, Korean, Taiwanese and U.S. fleets. It was noted that if the regional forms were reviewed by the SWG, then those Pacific island countries and distant-water fishing nations would have an opportunity to have greater input in their development. It was therefore proposed that the regional forms be reviewed at the next meeting of the SCTB on a trial basis, in order to see if the review could be adequately accomplished during the meeting.

122. The translation of the regional forms into the local languages of Pacific island countries was suggested as a necessary component of the forms development process, and it was agreed that the OFP would collaborate with the appropriate countries to develop translated forms.

123. It was noted that in addition to the data items on the form, one of the most important points to consider in form development is the linkage between the various types of data collected. For example, this would involve ensuring that data collected from an observer trip can be linked to both the logsheet data and landings data for that trip.

124. It was also noted that the format of data collection forms, i.e. the layout of the data fields on the form, particularly for observer forms on which a great deal of information is collected, was important.

125. Two other points raised during the discussion were the problems related to species identification in data collection, and the need to incorporate a description of collection methods used for each fishery into each database, as this would enable researchers to deal with inconsistencies within data sets in future analyses.

126. During his presentation, Mr Lawson presented Working Paper 4, which contains tables of coverage of total catches by logsheet, landings, port sampling and observer data held by the OFP. Each table covers a single fleet, with one row for each year that the fleet has operated, and columns for the total catch; the catches covered by logsheet, landings, port sampling and observer data; and coverage rates for each type of data. It was agreed that the tables were useful for easily identifying which data are held for each fleet and the level of coverage. It was noted that in addition to total catches, different units could be used to establish coverage rates.

127. With regard to regional sampling designs for port sampling and observer programmes, it was noted that the sampling design would depend on the research objectives of the Research Groups. It

was also noted that the design of observer programmes would be complicated by the fact that several types of data were collected, each for different research purposes.

128. In summary, the meeting indicated that the SWG would coordinate data collection by establishing minimum standards for data collection forms, and to review data collection forms, for logsheet, landings, port sampling and observer data, at annual meetings of the SCTB. It was agreed that fishing nations would develop coverage tables for their fleets and update them prior to each annual meeting of the SCTB. During the coming year, the SWG Coordinator will liaise with the SCTB participants, with a view to achieving progress with these activities by the next meeting of the SCTB. He will also consider the development of regional sampling designs for port sampling and observer programmes, and will report on this issue to the next meeting of the SCTB.

4.2 Issues Concerning the Coordination of Data Compilation

129. In the presentation, it was noted that the issues with respect to the coordination of fisheries data compilation concern the types of data that should be compiled and the level of resolution at which the data should be compiled. The types of data for which the compilation could be coordinated by the SWG include estimates of annual catches, catch and effort data, and length data. Other types of data, such as data on bycatches and discards, and tagging data, could also be considered. The coordination of the compilation of data by the SWG could be accomplished through (1) specifying the data items that should be compiled for each type of data and (2) reviewing the data that have been compiled on an annual basis, for each type of data.

Compilation of annual catch statistics

130. The annual catch statistics to be compiled should satisfy the needs of each of the Research Groups, and also the statistical needs of SCTB as a whole, for annual catch estimates. To this end, the annual catch statistics compiled by the SWG could include (1) catch statistics by species, covering an area and sub-areas to be defined by each of the Research Groups, and (2) catch statistics by species covering a broad area of interest to SCTB for statistical purposes, to be defined by the SWG. With regard to (2), a statistical area was proposed, consisting of the WPYR area with the northern and southern boundaries modified to extend to 50°N and 50°S, in order to better cover the range of the species, and with part of the western boundary modified to coincide with the boundary of the area covered by the Indian Ocean Tuna Commission (Figure 4). The eastern boundary, at 150°W, which corresponds to the western boundary of the area for which statistics are compiled by the Inter-American Tropical Tuna Commission, was not modified.

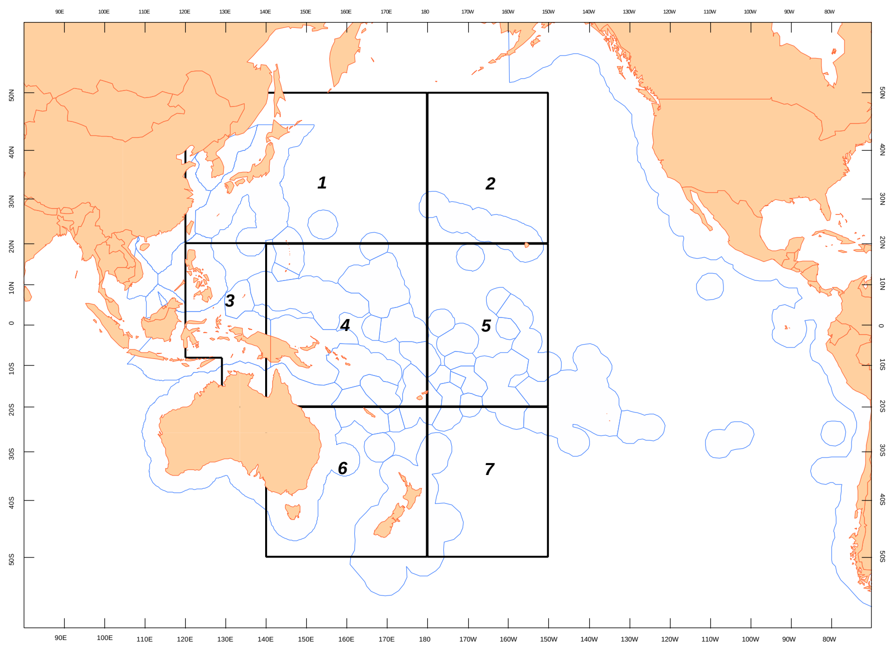

Figure 4. Proposed SCTB statistical area

131. The discussion following the presentation centred on the areas to be used in compiling annual catch statistics. While it was recognised that there was a need for annual catch statistics to be compiled for purely statistical purposes, it was noted that for the Research Groups, the areas should correspond to the range of the stock. The adoption of a statistical area to encompass 50°N to 50°S was considered useful, particularly for albacore, bigeye and skipjack. However, it was suggested that, for the southern hemisphere, the eastern boundary of the area be extended from 150°W further to the east, to better cover the range of albacore, bigeye and yellowfin stocks. It was also noted that extension of the eastern boundary to include all of French Polynesia might be appropriate. It was agreed that the meeting would return to the issue of statistical area under Agenda Item 10, after the Research Groups had had the opportunity to consider the matter.

<u>Compilation of catch and effort data</u>

132. In the presentation, it was noted that the Technical Consultation affirmed its support for the compilation of catch and effort data at a degree of detail and at a level of resolution to be agreed upon to enable effective stock assessment. During the Technical Consultation, the case was made for compiling catch and effort data at the finest degree of resolution, i.e. logsheet data. The advantages of compiling logsheet data, rather than data grouped by time-area, are as follows:

- Certain analyses, such as the standardisation of catch rates and the development of indices of abundance based on catch rates, require information concerning environmental conditions, vessel and gear characteristics, and the species composition of the set, each of which in most cases is only available from logsheet data.

- Certain analyses, such as spatially disaggregated analyses of tagging data, require catch and effort data grouped at a high level of resolution, often smaller than 1° latitude by 1° longitude, and several grouping schemes are usually tested in the course of the analysis. For such analyses, the compilation of logsheet data is preferred, since logsheet data will allow catch and effort data to be grouped in any size of time-area strata. Logsheet data are also essential for verification and editing of tagging data, and for estimating reporting rates.

- Certain analyses, such as length-based age-structured models, work best with standardised effort data, which, in turn, require logsheet data.

133. It was also noted that the OFP, which will process the data compiled by the SWG, has demonstrated the technical capacity to process large amounts of logsheet data, and the ability to maintain confidentiality of logsheet data. The logsheet data held by the OFP cover a high percentage of the total catch in the SPC Statistical Area, 78 percent of the total catch during 1995. The percentages by gear type are 52 for longline, 79 for pole-and-line and 83 for purse seine. The proportion that is not covered corresponds primarily to fishing on the high seas.

134. The discussion focussed on the need to compile logsheet data, rather than catch and effort data grouped by time-area. Certain participants agreed that there was a need for logsheet data for research purposes, but that their government's current policy would not allow for logsheet data to be provided to SCTB. They did, however, note that logsheet data could be made available for specific research projects conducted in collaboration with scientists from their country, if there was a strong justification for the use of logsheet data.

135. It was noted that government policy restricting the provision of logsheet data was established to preserve the confidentiality of the individual data. However, it was again noted that the OFP, which would compile data on behalf of SCTB, had an excellent record with regard to maintaining the confidentiality of the logsheet data that it held. It was further noted that a coding system for individual vessels could easily be introduced to prevent the identification of vessels.

136. Several other participants stressed the usefulness of logsheet data, as opposed to data grouped by time-area, giving their own research as examples. The point was made that the analyses based on logsheet data are often more credible than those relying on data grouped by time-area, and that industry, which could in the future be impacted by management measures based on stock assessment, would therefore stand to benefit through the provision of their logsheet data to the SCTB.

137. Recognising that it was unrealistic to expect those fishing nations that cannot at present provide logsheet data to change their policy in the short term, it was agreed that the compilation of logsheet data from those fishing nations would be limited to specific research projects. Nevertheless, the participants expressed hope that the compilation of logsheet data from those fishing nations would, in the future, occur on a regular basis.

138. In summary, the meeting indicated that catch and effort data should be compiled at a minimum level of resolution of 5° latitude by 5° longitude by month, and that, where possible, catch and effort data would be compiled at a finer level of resolution, such as 1° latitude by 1° longitude by month or as logsheet data (i.e. by set for longline and purse-seine, and by day fished for pole-and-line and troll).

Compilation of length data

139. In the presentation, it was noted that the Technical Consultation also supported the compilation of length-frequency data. The length-frequency data to be compiled by the SWG on a regular basis should cover albacore, bigeye, skipjack and yellowfin, and they should be grouped by gear type. Length-frequency data for billfish and other bycatch species could be compiled as the need arises.

140. It was also noted that the resolution at which the length-frequency data can be provided will depend on the information which is available to allocate a sample to a particular time-area strata. In some cases the sample can be allocated to the time and location at which the fish were caught, i.e. to the date and time, and the nearest minute of latitude and longitude. In other cases, the time and location at which the fish were caught cannot be identified and only the general time period and area can be assigned to the sample. For this reason, the SWG may not wish to specify the resolution at which length-frequency data should be compiled. Instead, the SWG could take a more flexible approach, wherein length data would be compiled at a level of resolution appropriate to the particular set of data.

141. In the discussion, it was suggested that the Research Groups could determine the requirements for length data.

142. Dr Ziro Suzuki noted that length data for Japanese fleets were available stratified by 10° latitude by 20° longitude for early years, while for later years the data were available at a finer resolution.

143. It was noted that it will be important to synchronise the stratification of the length data with the catch and effort data.

144. In summary, the meeting indicated that length data grouped by time-area strata would be compiled on a regular basis for albacore, bigeye, skipjack and yellowfin, and that the level of resolution should be the finest level appropriate for the particular set of data.

145. The SWG Coordinator will liaise with SCTB participants during the coming year concerning the compilation of annual catch estimates, catch and effort data grouped by time-area strata, and length data grouped by time-area strata.

4.3 Issues Concerning the Coordination of Data Dissemination

146. In the presentation, it was noted that the issues with respect to the coordination of fisheries data dissemination concern the types of data that should be disseminated and the policies for data dissemination. The data for which the dissemination could be coordinated by the SWG include annual catch statistics, catch and effort data, length-frequency data, and possibly other types of data. Coordination of the dissemination of data by the SWG could be accomplished by (1) establishing policies for the dissemination of data and (2) reviewing the instances of the dissemination of data on an annual basis.

<u>Dissemination of annual catch statistics</u>

147. It was noted that annual catch statistics compiled by the SWG for the Research Groups, and for an area of interest to the SCTB for statistical purposes, should be considered as being in the public domain. Dissemination of annual catch estimates could be accomplished through publication in the reports of SCTB meetings, or possibly as a separate document which would accompany the reports of SCTB meetings, or possibly in the Tuna Fishery Yearbook, a statistical bulletin prepared by the OFP. The annual catch statistics could also be made available on an Internet site, either the SPC site or a new site developed for the SCTB. Annual statistics should also be made available on a request basis, in either hardcopy or various computer formats.

148. If the SWG compiles statistics for an area of interest to the SCTB, then it may be appropriate to revise the Tuna Fishery Yearbook to cover the SCTB area, rather than the SPC Statistical Area. Such a revision would result in the modification of statistics only for the four distant-water longline and pole-and-line fleets, and thus should be easily accomplished. If the statistics in the SWG tables for the coastal fisheries of Japan and certain unclassified fleets are included in a revised Yearbook, then the Yearbook could be published in place of the SWG tables for the SCTB area. The advantages of using the Yearbook are that (1) in addition to the SWG tables for the SCTB area, the Yearbook also contains estimates of annual fishing effort and catch rates, and maps of fishing effort and histograms of annual catches, for each fleet; and (2) duplication of work would be avoided.

Dissemination of catch and effort data

149. It was noted that catch data for commercially important tuna species of the Pacific Ocean, covering 1967–1993 and grouped by year and quarter, and 5° quadrangle, for each gear type and all fishing nations combined, were recently published by FAO on a diskette included with Carocci & Majkowski (1996)[3]. Hence, catch and effort data at this level of resolution should be considered as being in the public domain. The SWG could make data at this level of resolution, or perhaps slightly finer, i.e. by year and month rather than by year and quarter, available on the Internet.

150. Dissemination of catch and effort data at a higher level of resolution, whether in regard to the stratification by time, area or fishing nation, should be subject to certain conditions in order to ensure confidentiality and the proper use of the data. In order to provide a starting point for discussion, the conditions concerning the release of catch and effort data that has been applied by the OFP for many years were presented.

151. It was noted that the OFP does not distribute catch and effort data to all sources of the data on a regular basis. Past experience has shown that such an exercise is time-consuming and not particularly useful, since many recipients never actually use or even examine the data. Releasing catch and effort data in response to individual requests has been found to be the most efficient practice.

152. Incidences of the release of data by the OFP during 1997 were listed in Appendix 3 of Working Paper 3. There were ten releases of catch and effort data and one release of length-frequency data.

153. Several variations to the OFP policy for disseminating catch and effort data were suggested. There was agreement that catch and effort data for surface fisheries could be released by 1° longitude by 1° latitude by month, and that catch and effort data could be released to certain individuals or agencies for long-term usage, rather than just for specific research projects, upon receipt of authorisation from the source of the data. Further, the provision of a report of the research project could be made a preference, rather than a condition for the release of data. It was suggested that the condition concerning the individual requesting the data, and their being known to staff of the OFP, either be eliminated or reworded to stress that the data are released only to individuals who can be trusted to use the data responsibly.

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3 Carocci, F. & J. Majkowski. 1996. Pacific Tunas and Billfishes: Atlas of Commercial Catches. Food and Agriculture Organization of the United Nations, Rome, Italy. 75 pp.

154. Dr Chang stated that Taiwan will provide purse-seine data, stratified by 1° by 1° by month, which could be disseminated by the SCTB.

155. Mr Coan stated that U.S. troll data for the south Pacific fishery can only be provided, and hence disseminated, grouped by 5° by 5° by month, due to an agreement between the National Marine Fisheries Service and industry regarding the use of the data.

156. In summary, the meeting indicated that the policy for disseminating catch and effort data should be as follows:

- Catch and effort data grouped by 5° longitude by 5° latitude by month for longline and 1° longitude by 1° latitude by month for surface fisheries, for all fishing nations combined, are considered to be in the public domain.

- Catch and effort data grouped by 5° longitude by 5° latitude by month for longline and 1° longitude by 1° latitude by month for surface fisheries, stratified by fishing nation, are available for release at the discretion of the Coordinator of the SCTB Statistics Working Group, for those sources of data which have so authorised the SWG Coordinator. For those sources of data that have not authorised the SWG Coordinator to release data at his discretion, authorisation for the release of data must be obtained from the sources of the data.

- Catch and effort data grouped at a finer level of time-area stratification may be released with authorisation from the sources of the data.

- Catch and effort data are released for research purposes only, and to individuals who can be trusted to use the data responsibly. The person requesting the data is required to provide a description of the research project. The data are released only for use in the specified research project and the data must be destroyed upon completion of the research project. However, catch and effort data may be released for long-term usage for research purposes, such that the data need not be destroyed, with authorisation from the sources of the data.

- The person requesting the data will be asked to provide a report of the results of the research project to the SWG Coordinator, for subsequent forwarding to the sources of the data.

Dissemination of length data

157. Mr Lawson noted that requests for length-frequency data occur much less frequently than requests for annual catch statistics or catch and effort data. The current OFP policy with respect to releases of length-frequency data is similar to that for catch and effort data. He suggested that the SWG may wish to adopt a policy for the dissemination of length-frequency data that is similar to that for the dissemination of catch and effort data, and the meeting agreed with this suggestion.

4.4 SWG Tables of Annual Catch Estimates

158. Annual catch statistics for south Pacific albacore have previously been compiled in the South Pacific Albacore Research (SPAR) database, which has been maintained by the OFP. The compilation of tables of annual catch statistics for bigeye, skipjack and yellowfin, and the number of vessels active, has previously been coordinated by the Western Pacific Yellowfin Research (WPYR) Group. The tables cover the entire WPYR area and, for yellowfin, WPYR sub-areas. The WPYR tables of annual statistics were maintained by the United States National Marine Fisheries Service

until February 1998, when the task was passed by the Chairman of the WPYR Group to the OFP. The SPAR and WPYR tables were included and updated in Working Paper 5. The tables, which previously covered 1970 onwards, were extended to cover 1950–1969. Tables of annual catch estimates by species and gear type for the eastern Pacific Ocean, and by species for the Atlantic Ocean and the Indian Ocean, were also included.

159. During the discussion, the method used to adjust estimates of purse-seine catches of bigeye and yellowfin for the inclusion of bigeye in estimates of yellowfin, for the period not covered by sampling data, i.e. prior to 1989, was questioned. It was noted that fishing techniques on associated and unassociated schools remained much the same from the late 1970s until recently, and that the proportion of bigeye in associated schools did not vary considerably, ranging from about 10 to 16 percent, according to sampling data for 1989–1995. It was therefore considered that the average proportion of bigeye by set type determined from sampling during this period could be applied to previous years.

160. On the other hand, whereas the U.S. data had been used to adjust estimates of bigeye catches by other fleets, the relationship between the proportion of bigeye by school type, and fleet or fishing area, had not been examined. It was noted that the OFP holds observer data that could be used to study the relationship.

161. The U.S. purse-seine fleet changed its technique during 1996, by using deeper nets and targeting bigeye. As a result, the sampling data for U.S. vessels for 1996 indicate that the proportion of bigeye in associated schools increased to 41 percent. The extent to which other fleets modified their technique is unknown; therefore, it was not considered appropriate to use the U.S. sampling data to adjust catches by other purse-seine fleets for 1996 and 1997. Therefore, average values of the proportion of bigeye determined from sampling data for 1989–1995 were used in the tables to estimate bigeye catches by the other fleets in 1996 and 1997.

162. In regard to the extension of the tables back to 1950, it was noted that Pacific-wide annual estimates for Japanese fleets are available for years prior to 1970, but there would be some work involved in estimating annual estimates for sub-areas.

163. The question arose whether processed or whole weights have been estimated for longline. It was noted that the tables are intended to cover whole weights. Mr Lawson will attempt to determine the extent, if any, to which processed weights have been included in the tables during the coming year.

164. It was suggested that vessel statistics are useful indicators of changes in the fishery, and that the tables for the number of vessels should therefore be expanded to include the breakdown of the numbers of vessels by area and by vessel size or carrying capacity.

5. SKIPJACK RESEARCH GROUP

165. Prior to commencing the work of the SRG, Dr Lewis, in his role as overall Coordinator of SCTB, again reviewed the revised Terms of Reference 2–5 of SCTB, which read as follows:

2. *Review research on the biology, ecology, environment and fisheries for tunas and associated species in the western and central Pacific Ocean;*

3. *Identify research needs and provide a means of coordination, including the fostering of collaborative research, to most efficiently and effectively meet those needs;*

4. *Review information pertaining to the status of stocks of tunas and associated species in the western and central Pacific Ocean, and to produce statements on stock status where appropriate;*

5. *Provide opinion on various scientific issues related to data, research and stock assessment of western and central Pacific Ocean tuna fisheries.*

166. He noted that SCTB was asked to form a Statistics Working Group and five Research Groups (albacore, bigeye, skipjack, yellowfin, and subsequently, billfish and bycatch) and that a generic agenda had been established for the five Research Groups. The general objectives of the Research Groups might be to review available research information, consider the possibility of producing species stock assessments (if not immediately, then at an achievable time in the future), and to identify, plan and prioritise research that would allow stock assessment needs to be met. He noted that during the Workshop on Precautionary Limit Reference Points, it was suggested that the Research Groups might begin to consider whether limit reference points might be developed for each species and how these might be developed.

5.1 Regional Fishery Developments

Overview

167. Dr Lewis, acting as Coordinator of the SRG, introduced this session with an overview of skipjack catches summarised from Working Paper 5. The total catch of skipjack in the WCPO was 851,000 mt in 1997, a decline of 130,000 mt from the previous year (Table 3). Skipjack made up more than 70 percent of the purse-seine catch and more than 95 percent of the pole and line catch. Catch rates in the purse-seine fleet have fluctuated interannually with no long-term trend apparent, except in the U.S. fleet, which has seen a declining trend in the past several years. Pole-and-line catch rates have also fluctuated, but an increasing trend is evident for the Japanese fleet, due perhaps to increasing use of improved gear technology and the retirement of older vessels.

168. There was some discussion about the interannual variations seen in the catch rates. Because of their short life span and rapid growth, the skipjack stock would seem to be more prone to interannual fluctuations than the longer-lived tunas. The fact that the fluctuations are approximately in phase throughout the region, leads to speculation that the fluctuations are either driven in part by large-scale environmental phenomena or reflect stock-wide variations in abundance. Fluctuations appear to be more pronounced near the north and south edges of the skipjack range as evidenced by the seasonal catches in the Japanese and New Zealand domestic fisheries. Fluctuations at the edges could be amplified by changes in the extent of north-south migration and by increased environmental variability in subtropical and temperate waters.

Data

169. Mr Lawson summarised OFP data holdings relevant to assessing skipjack. Catch data for the various fleets are well covered since 1993. Taiwan and Korea purse-seine catches are not well covered prior to that time due to under-reporting on logsheets submitted under bilateral access agreements. Length frequency data are available for some fleets only. Much of the skipjack length-frequency data held by OFP are the results of two SPC tagging programmes, the Skipjack Survey

and Assessment Programme, 1977–1980, and the Regional Tuna Tagging Project, 1989–1992. These programmes also produced two highly relevant sets of tagging data. It was noted that catch and effort data, other than annual catch statistics, for the domestic fisheries of Indonesia and the Philippines were lacking.

170. It was noted that standardising effort of purse seiners catching primarily skipjack is problematic. The best, and in some cases, only source of operational information is from scientific observers. Observer coverage of the U.S. purse-seine fleet is approximately 20 percent, whereas coverage of other purse-seine fleets is less than five percent.

Catch trends

171. Dr Sakagawa presented Working Paper 10, which takes a simplistic approach in adjusting nominal purse-seine CPUE for assumed bias in the estimate. Nominal CPUE is routinely computed from purse-seine data and the trend is universally flat for recent years. This trend is believed to be biased upward because improvements in purse-seine fishing gear, equipment and technique have occurred. Data on the improvements have not been systematically collected for correcting this bias. Data on set type have been collected and it can serve as a proxy of change in fishing technique.

172. Set type data for the U.S. fleet were analysed and they indicate significant differences between CPUEs of drifting object sets and free-swimming school sets. The daily catch rate of drifting object sets is about double that of sets on free-swimming schools. Also, virtually all drifting object sets occur early in the morning before sunrise, whereas free-swimming school sets occur throughout the day, with peaks at sunrise and in the late evening. Average catch per set is about the same for the two types of sets, 40–45 mt per set. For the U.S. fleet, about 80 percent of the sets were on free-swimming schools during 1989–1994, declining steadily to 45 percent in 1997. In contrast, for the Japanese fleet, the percentage of sets on free-swimming schools during 1989–1997 was stable at about 45 percent.

173. The simplistic approach adjusted the nominal CPUE for changes in set type (nominal catch per effort of all tunas multiplied by the proportion of sets on free-swimming schools). The results show a significantly declining trend in adjusted CPUE since 1994 for U.S. purse-seine data and a gradual downward trend for Japanese purse-seine data. If this decline is related to stock abundance, then skipjack tuna would be the indicator stock because it makes up more than 70 percent of the catch.

174. During the discussion, it was noted that if the proportion of sets on free-swimming schools decreased to zero, e.g. with 100 percent of sets on drifting objects, then the adjusted CPUE would be zero, although tuna were still being caught in drifting object sets. The adjustment procedure is, therefore, unreliable. The use of GLM was mentioned as a way to correct this adjustment flaw, although past attempts have not been satisfactory. In the end, the participants felt that more attention need to be paid to collecting data on the fishing process and particularly for estimating effective fishing effort.

175. In Working Paper 6, presented by Mr Miyabe, it was noted that the annual nominal CPUE for skipjack by the Japanese purse-seine fleet has fluctuated considerably since 1983, between 11 to 19 mt per set, but with no consistent trend. The 1997 catch rates were the lowest for several years. Analyses of distance between fishing operations and number of searching days suggested a possible decrease in density of tuna schools during the 1990s, provided that the distance between operations reflects the distance between schools.

176. In Working Paper 8, Dr Park noted that skipjack catch rates by Korean purse seiners have also fluctuated considerably between 1985 and 1995, with catch rates of around 25 mt per set during 1994–1995. Total catches from log sets have been consistently higher than those from free-swimming schools since the inception of the fishery. The percentage of skipjack in log schools has been greater than 70 percent in all years, whereas the percentage in free-swimming schools has been lower than 60 percent in some years. The total catch from log schools has exceeded that from free-swimming schools since 1989, and may be increasing.

Small fish

177. Dr Lewis noted that representatives of the U.S. tuna industry have in the past suggested that the capture of small skipjack may have a negative impact on the resource, but that analyses by the OFP and others, using yield per recruit approaches, have shown that this was unlikely to be the case, given the characteristics of the species, e.g. very high natural mortality, rapid growth, etc. Any problems are likely to be more of an economic rather than biological nature, e.g. the lower price paid for small fish possibly driving down the average price of fish. Further work on this subject may be carried out, but only if funding and additional economic and marketing information became available.

5.2 Biological and Ecological Research, and El Niño Southern Oscillation (ENSO) Update

178. During this session, past research was reviewed. No working papers or other new information were presented.

Stock structure

179. The hypothesis of little mixing between skipjack stocks in the WCPO and those in the EPO is still valid, mainly based on the lack of significant tagged skipjack movement between those zones.

Reproduction

180. Spawning occurs over a large area in the Pacific, larger in the west than in the east. No link between spawning biomass and recruitment has been observed to date. It was mentioned that Mr Kurt Schaefer of the Inter-American Tropical Tuna Commission (IATTC) is currently conducting a histological study on reproductive biology of eastern Pacific skipjack, and spawning in that area may prove to be more widespread than previously believed.

Age and growth

181. Skipjack growth is highly variable both in space and time. Younger fish show rapid growth, reaching 2 kg or 45 cm after one year. Older fish have a growth rate from 5 to 10 cm per year. It was noted that certain types of stock assessment approaches may require better estimates of growth, and the OFP was considering additional work in this area.

Larval and juvenile studies

182. Some studies of larval and juvenile skipjack are currently being conducted at the Tohoku Laboratory in Japan. The first phase of the work, consisting of mid-water trawl sampling, has been largely completed and has produced considerable data, not only on larval and juvenile skipjack, but also on oceanic anchovy, an important prey species for adult skipjack. The next phase of the study

will be a quantitative analysis, with an attempt to link study results to indicators of recruited skipjack abundance in the commercial fishery.

Movement and mixing rates

183. Much information on the movement of skipjack, based on the results of tagging, is available. Movement is considered to be due to both diffusion and advection, with advection being largely driven by environmental conditions. However, long-distance movements of tagged skipjack are more the exception than the rule. Dr Sibert mentioned that a manuscript on the analysis of Skipjack Survey and Assessment Programme data has been completed and submitted for publication. An analysis of data from the Regional Tuna Tagging Project and tagging data provided by Japan is underway.

184. It was noted that a paper[4] has recently been published by Dr Patrick Lehodey and co-workers showing that skipjack tend to move eastward during El Niño events and westward during intervening La Niña years, and that areas of higher catch rates, which tend to occur at a convergence zone at the edge of the warm pool, shift in the same way.

ENSO update

185. Dr Tom Schroeder described the Pacific ENSO Application Center (PEAC), which works to interpret results of El Niño prediction models and disseminate the information to the public in easy-to-understand form. The models make use of the TAO array of oceanographic and meteorological buoys located in a band across the tropical Pacific. Dr Schroeder showed evidence that the current El Niño is now rapidly abating.

186. There was discussion as to whether the apparent increase in frequency of El Niño events in recent years is an indication of an environmental 'regime shift'.

El Niño effects on productivity and catchability

187. In addition to the effects of El Niño mentioned above, there may be additional effects either on overall abundance or on availability. It was suggested that there is some indication, though no statistical confirmation, that the effects on skipjack are reflected in an opposite manner compared to the effects on yellowfin.

5.3 Stock Assessment

Mortality rates

188. Mortality rates for skipjack have been estimated from tagging data. An analysis incorporating size category resulted in a U-shaped relationship between M and size, with the minimum value of M occurring at medium sizes.

Simulation model of population dynamics

189. Dr Bertignac presented an updated version of a simulation model of tuna populations in the Pacific, which uses a habitat index. The main characteristic of this model is that it incorporates a

4 Lehodey, P., M. Bertignac, J. Hampton, A. Lewis & J. Picaut. 1997. El Niño Southern Oscillation and tuna in the western Pacific. Nature **389**:715–718.

spatial dimension to account for variation in the spatial distribution of fish and fishing effort over time. A movement model has thus been developed. It is based on a diffusion-advection equation in which the advection term is a function of the gradient in the habitat index. As a preliminary step, the habitat index was defined as a function of sea-surface temperature and simulated tuna forage. Results obtained from the model are promising, with predicted CPUEs being reasonably consistent with observed data. However, the model does not currently allow investigation of interannual variability, which is particularly important for the purse-seine fishery in the western Pacific. The spatial distribution of CPUE is strongly influenced by El Niño and La Niña conditions. It seems that the most productive skipjack catch area for this fishery is located in the vicinity of the convergence zone at the eastern edge of the warm pool. The simulation of potential forage for skipjack on a real time basis confirms the hypothesis that this area of convergence is characterised by an enrichment of forage on which skipjack might be feeding. Further development of the population model will include the use of time-series of actual environmental data, the incorporation of other environmental parameters in the movement model, density dependence to limit the local concentration of fish, and the fitting of the model to tagging and/or catch and effort data. It was mentioned in the following discussion that this model could also be used as part of an operational model for evaluating management strategies.

Stock status

190. Dr Hampton briefly discussed the previous assessment of skipjack stocks based on tagging data. Tagging data allow the estimation of mortality rates and the calculation of the corresponding exploitation rate for the fishery. It was found that for skipjack, the level of exploitation is low to moderate, assuming the level of skipjack productivity is not lower now than it was at the time of tagging. The analysis of tagging data provides a snapshot of the fishery, and the need to conduct such tagging experiments at regular time intervals was suggested, perhaps every ten years. This would mean that another large-scale tagging experiment should be conducted in the near future.

Reference points

191. There was little consensus regarding the degree of urgency for declaring limit or target reference points for skipjack, and for setting up a scheme for monitoring the state of the fishery in relation to such reference points. There was some confusion between the separate tasks of setting reference points and monitoring the fishery in relation to them. There seemed to be some consensus that even though it is not at present known what an appropriate reference point should be for WCPO skipjack stocks, the state of the fishery is nevertheless safely below any reference point that could reasonably be imagined. As for monitoring, it was again suggested that regular tagging, perhaps every decade, would be the most reliable source of relevant information, with monitoring of CPUE in a carefully chosen index fleet or fleets in the intervening periods to check for possible changes in skipjack productivity. It was recommended that distant-water and locally-based pole-and-line fleets be evaluated for suitability as index fleets.

5.4 Research Coordination and Planning

192. The following research needs were identified:

- examination of detailed information on fishing operations collected from observer data, with a view to using this information for standardising effort and CPUE;
- further studies on age and growth and on stock-recruitment relationships;

- investigation of environmental effects on skipjack availability and production;
- development of 'operational models' for management strategy evaluation;
- elaboration of the steps necessary to set reasonable reference points and monitor the state of the fishery in relation to such reference points; and
- research on schooling and aggregating behaviour of skipjack and other tunas.

6. YELLOWFIN RESEARCH GROUP

193. The YRG Coordinator, Dr Sakagawa, led the session of the Yellowfin Research Group.

6.1 Regional Fishery Developments

Overview

194. At 394,000 mt, the 1997 catch of yellowfin was the largest on record for the western and central Pacific (Table 4). The fisheries taking yellowfin in the western and central Pacific are more complex than those for skipjack. In addition to purse seine, which accounts for 60 percent of the yellowfin catch, longline (18–20 percent) and pole-and-line (3 percent) take yellowfin. The yellowfin taken by pole-and-line are almost all juveniles (less than 80 cm). Longliners take mostly large adults (greater than 100 cm), whereas purse seiners take a wide range of sizes, from juveniles through to adults and, occasionally, large adults.

195. In contrast to skipjack and albacore, most of the yellowfin catch comes from equatorial waters of the western and central Pacific. Yellowfin remain the largest component of the catch retained by longline. Generally, however, increased targeting of bigeye has resulted in a decline in longline catches of yellowfin since the 1970s. Against that trend, the yellowfin catch for 1997 was higher than recent annual catches. In 1996 and 1997, Japanese and Taiwanese longliners reported an increase in nominal catch rates for yellowfin.

196. Purse-seine catches of yellowfin also increased in 1997. Yellowfin represents 20–25 percent of the total purse-seine catch. However, the species attracts higher prices at canneries than skipjack and is often targeted by purse seiners. The geographical extent of purse seining is linked with ENSO patterns and their associated effects on sea surface temperatures and ocean productivity. In El Niño years, purse seining extends eastwards to 150°W, where purse seiners target free-swimming schools of large yellowfin. Size composition of purse-seine catches also shows high variation between years and between areas, with 1997 featuring increased amounts of yellowfin in associated sets.

Purse-seine CPUE

197. Dr Park presented Working Paper 7, which presented observer data from trips on Korean purse seiners, and Working Paper 8, which presented changes in the Korean purse-seine fleet and its fishing methods. The dimensions of Korean purse-seine nets have not changed significantly, although mesh size has increased from 5 in (12.7 cm) to 8–10 in (20.3–25.4 cm) and pursing speed has increased. Before 1991, Korean logbook data did not distinguish between school and associated purse-seine sets. Interviews with vessel captains revealed that during this period purse seiners mostly set on logs; they rarely used FADs, but occasionally deployed payao-like structures. Log sets

declined to represent 28 percent of the Korean purse-seine catch by 1989, then fluctuated between 20 percent and 50 percent of the annual catch. The proportion of purse seiners using helicopters increased, from 20–25 percent in the mid 1980s to 70–90 percent of purse seiners during the 1990s. Helicopters are sometimes used cooperatively between several purse seiners in the Korean and other fleets.

198. Mr Itano presented Working Paper 48, which reviewed changes in the efficiency and fishing power of purse seiners in the western and central Pacific. A desire to improve the success rate of sets on free-swimming schools has largely driven technological improvements in the U.S. purse-seine fleet. Developments affecting purse-seine catch rates and total catches include:

- electronic equipment, such as global positioning systems and satellite imagery, that reduce searching time and time locating FADs;
- greater utilisation of drifting FADs in fishing strategies;
- larger, deeper and lighter nets;
- more powerful winches that provide faster pursing and hauling speeds;
- faster sacking-up procedures and brailing equipment;
- increased storage capacity with improved refrigeration systems; and
- reduction in port unloading time through onboard sorting and transhipment.

199. The economic condition of the fishery influences the adoption of technology, with owners more likely to upgrade or add new equipment when commercial performance was good. Many of those innovations are considered trade secrets, and are therefore difficult to document and to measure.

200. The YRG commended the documentation of purse-seine changes presented in Working Paper 48, and encouraged further work in this area. Stock assessments using catch and effort data will require the quantification of those changes in fishing power and their affects on catch rates. Empirical studies were required which involved calibration of the performance of old technology with new technology. Such studies, if they utilised commercial fishing vessels, would require access to fine-scale, set-by-set data.

201. In view of the substantial increases in fishing power, the Yellowfin Research Group noted concern over the decrease in skipjack CPUE for the U.S. purse-seine fleet. There is a clear need to develop a measure of effective effort in the fishery. This could include data specifically collected for that purpose by observers.

202. Observer reports also suggest that very large purse-seine sets (greater than 200 mt) may be more common than previously believed. Fishing masters occasionally record very large sets over several days in their logbooks to protect against reduced prices paid by canneries, which occurs when they suspect fish quality is poor due to the longer handling time for very large sets.

203. Purse seiners rarely use XBTs to measure thermocline depth. The depth of the thermocline was not now considered a factor limiting the success of purse-seine sets because nets were sufficiently deep and winches sufficiently powerful to fish the deepest thermoclines encountered. Current velocities, measured by Doppler current meters, were a more important consideration for purse-seine operations.

204. Dr Chi-Lu Sun presented Working Paper 13, which presented the results of a GLM analysis of yellowfin CPUE in Taiwanese longline and purse-seine fisheries for yellowfin. The trend of nominal and standardised CPUE both show sharp increases during 1992 and 1993, followed by sharp declines in 1995 and 1996. The Yellowfin Research Group noted problems for interpreting the analyses stemming from under-reporting by Taiwanese purse seiners on logsheets prior to 1992. A previous comparison of logsheet data with landings suggested that Taiwanese purse seiners reported in logbooks only about 25 percent of the catch levels that actually occurred. Reporting on logsheets improved in late 1992, and improved further following the ban on transhipment at sea, which occurred in June 1993. Consequently, improved reporting is partly responsible for the increasing trend in the CPUE index for 1992–1993 shown in Working Paper 13. However, it was noted that standardised CPUE for large yellowfin caught by Japanese purse seiners also increased during 1992, but not in 1993.

205. Mr Miyabe presented Working Paper 6, which highlighted fishery indicators for Japanese purse seine. Overall, Japanese purse-seine activity has declined, from about 7,500 operations in 1984 to less than 5,000 in 1997. Nominal catch per set for both associated and free-swimming schools show increasing trends, from 1983 to the mid 1990s, perhaps reflecting increasing fishing power. The distance between sets on free-swimming schools does not show a trend, whereas the distance between log sets increased steadily from 1983 to 1997. The trend in set distance is difficult to interpret. It might, for example, reflect changes in the abundance of tuna, the abundance of floating objects, or competition among purse seiners for logs.

206. The third and fourth quarters of 1997 featured an eastward extension in activities, with Japanese purse seiners targeting free-swimming schools of yellowfin. Yellowfin sizes ranged from about 30 cm to 130 cm in 1997 compared with a much tighter range, 30 to 70 cm, in 1996.

207. Dr Norm Bartoo presented Working Paper 14, which updated a previous GAM analysis of yellowfin CPUE in the U.S. purse-seine fishery. The analysis indicates that, not surprisingly, the proportion of yellowfin in the catch is highly correlated with the index of yellowfin CPUE. This is not particularly useful because the proportion of yellowfin is closely related to yellowfin CPUE, the variable that the model is trying to standardise. The other variables considered (SOI, set type, yellowfin size category, month and area) explain little of the variation in the yellowfin CPUE data. The analysis highlights the need for alternative, operational data for the development of an abundance index based on CPUE.

Longline CPUE

208. Time series of standardised yellowfin CPUE for Taiwanese offshore and distant-water longline show downward trends since 1971 (Working Paper 13). The two fleets represent quite different operations, with distant-water longliners targeting albacore in the sub-tropical and temperate south Pacific, whereas offshore longliners target bigeye and yellowfin in equatorial waters. Catch rates for offshore longliners increased as the fleet expanded and harvested concentrations of bigeye and yellowfin. There has been a sharp decline in vessel numbers in recent years.

209. Dr Robert Campbell presented Working Paper 11, which examined long-term trends in yellowfin abundance in the southwest Pacific based on Japanese longline data. Off eastern Australia, standardised CPUE displays large interannual variation, with catch rates after 1985 generally being higher than for the period 1971–1984. Years of high catch rates followed by years of sequential decline in catch rates were seen in the time series. A similar analysis of Japanese catch rates in the

equatorial regions found that the standardised CPUE has generally been lower since 1986 than during the previous decade. The analyses suggested that changes in CPUE were not correlated between the two regions, with the declines in CPUE in the tropical region not being apparent in the eastern Australian region. This suggests that mixing between the regions is not as high as would be expected if these two regions were part of a single, homogeneous stock. Changes in the spatial distributions of catch rates may be a result of the large increase in purse-seining during the 1980s. Further analyses also found no consistent long-term changes in the size of fish caught by Japanese longliners in the southwest Pacific, though there was some indication of a decrease in average size in the equatorial regions during the early 1990s and an increase in average size in the more southern temperate regions.

Separating bigeye and yellowfin in purse-seine catches

210. Bigeye are not usually distinguished from yellowfin in purse-seine logsheet reports. Consequently, bigeye-yellowfin ratios derived from species composition sampling are used to adjust logsheet estimates of yellowfin and bigeye. The Yellowfin Research Group noted concern over the application of bigeye-yellowfin ratios derived from port sampling of U.S. purse-seine landings. In the absence of port sampling data for other fleets, annual catch estimates in Working Paper 5 were determined by applying annual ratios of the proportion of bigeye, by set type, derived from 1989–1995 U.S. port sampling, to catches by other fleets. The U.S. data showed that the proportion of bigeye in the bigeye-yellowfin catch from sets associated with drifting objects ranged from 10 to 16 percent during 1989–1995. However, the area of operation and size composition of catches varied considerably between the U.S. and other fleets. A small number of participants felt that the adjustment procedure was inappropriate; however, others accepted the procedure on the basis that the alternative, i.e. using the logsheet data without any adjustments, would have resulted in less accurate estimates of annual catches of bigeye and yellowfin.

211. It was noted that the proportion of bigeye in the bigeye-yellowfin catch from associated sets by U.S. purse seiners increased from the 1989–1995 average of 13 percent to 41 percent in 1996, due to a change in targeting and to the use of deeper nets. Since the extent to which the other fleets made similar changes is unknown, the U.S. port sampling data for 1996–1997 were not used to adjust bigeye and yellowfin catches for other fleets for 1996–1997 in Working Paper 5. Instead, the average proportion during 1989–1995 of bigeye in the catch of bigeye-yellowfin, by set type, was used. The need to establish the extent to which the other fleets have modified their technique for setting on schools associated with drifting objects was identified.

212. Working Paper 5 presents both raw and adjusted catches for purse seine. For future compilations, the Statistics Working Group Coordinator agreed to include further documentation on the procedures used to estimate bigeye and yellowfin.

213. Bigeye-yellowfin ratios vary with set type and fish size, and possibly also with area and vessel nationality. Analyses of the U.S. port sampling data are required to assess the spatial variability in bigeye-yellowfin ratios. The inclusion of Japanese port sampling data in such analyses may provide information on differences between fleets. Set-specific information obtained from port sampling is less reliable for Taiwanese and Korean purse seiners because of onboard sorting and grading. However, the OFP holds observer data for these fleets. Operational characteristics, such as net depth and the use of sonar, may also affect the species composition of purse-seine catches. If information were available on such operational characteristics, they might provide a more accurate basis for estimating the bigeye-yellowfin composition.

214. The YRG encouraged participants to salvage any historical data that may exist on bigeye-yellowfin ratios. Regardless, the YRG stressed the need for all fleets to commence (or continue) port sampling programmes to provide an accurate breakdown of the bigeye and yellowfin composition in purse-seine catches. Of particular concern is the situation in the Philippines and eastern Indonesia, which account for about 28 percent of the yellowfin catch and about 12 percent of the bigeye catch in the WCPO.

Specification of the area used to compile annual catch statistics for yellowfin

215. The YRG considered a proposal to expand the geographical area of data coverage to cover catches of skipjack in the north (to 50°N), albacore in the south (to 50°S), and to match the IOTC boundary in the west and the IATTC boundary in the east (150°W). It was noted that purse seiners were active north-east of the Marquesas Islands, to the east of 150°W. The meeting agreed that plots of catch distributions should be reviewed before making a decision on the area of coverage. The matter was discussed further under Agenda Item 10.

6.2 Biological and Ecological Research

Stock structure

216. Dr Campbell presented Working Paper 46, which described an attempt to determine stock relationships of western Pacific yellowfin from otolith microchemistry analysis. Yellowfin otolith samples from Fiji, the Solomon Islands, the Philippines, Indonesia, the Coral Sea and the New South Wales region of eastern Australia were examined using Wave Dispersive Electron Microprobe Analysis. This technique examines the chemical microconstituents of the inner portion of an otolith to determine the chemical signature of the environment in which the fish lived during the first few months of life, theoretically equivalent to the region of origin. Samples were collected during the 1994/5 and 1996/7 periods.

217. Results indicate that the region(s) from which yellowfin tuna recruit to the fishery off southern Queensland and New South Wales may vary from year to year. In some years, recruitment may principally be confined to fish from the Coral Sea region, while in other years the recruitment base may be more widespread, with yellowfin also recruiting from the Solomon Island region or other areas with a similar water chemistry. Genetic differences among the six sites in the WCPO were significant, though these differences are not consistent across years. This indicates that either the gene flow between different regions of the WCPO changes from year to year or that the populations in this region effectively exist as a single gene pool or breeding unit.

Age and growth

218. Mr Bigelow presented Working Paper 12, which describes work on the age and growth of western Pacific yellowfin. These parameters were estimated through the analysis of otolith increment deposition and tagging/recapture data from the SPC Regional Tuna Tagging Project. Initial validation work from three OTC-marked and SEM-examined yellowfin otoliths supported the hypothesis of daily deposition of growth increments in western Pacific yellowfin, in agreement with previous studies from other regions. Initial results from both the otolith analysis and tagging data indicate a period of slower growth at around 50 cm fork length. However, the growth curve resulting from the otolith analysis suggested a higher growth rate compared to the results of the tagging analysis and previous studies of the age and growth of yellowfin from other regions and oceans. In general, the growth curve proposed by the otolith analysis suggested a rapid growth rate

to age three followed by a levelling off of growth and lower asymptotic size compared to other studies, with proposed lengths at age one and two of 65 and 115 cm respectively.

219. A potential problem of the otolith analysis was discussed. Increments laid down during the first few days of life may be sub-daily or daily in nature. These marks were assumed to be sub-daily in the analysis, which would artificially shift the growth curve to the left if indeed they are found to be daily increments.

220. The paper suggests a possible explanation for the slower growth rate evident in both otolith and tagging data near 50 cm fork length. The swim bladder in yellowfin does not become functional until a fork length of approximately 50 cm, after which the structure provides buoyancy and reduces the energy required to maintain static equilibrium. It was suggested that the higher energy demands on a fish without a functional swim bladder from the onset of maturation may create a negative effect on somatic growth that would diminish as the swim bladder developed.

Larval and juvenile studies

221. Mr Miyabe reported on the work being conducted by Dr Miki Ogura of the Tohoku National Research Institute in Japan on the early life stages of skipjack (see paragraph 182). Their work utilises a large mid-water trawl to sample late larval and early juvenile tunas that are difficult to obtain with smaller nets or other sampling methodologies. It was noted that work was in progress, and that the sampling vessel and principal investigator were currently at sea. It is anticipated that preliminary or final results from these surveys would be reported to the 1999 meeting of SCTB.

Migration and distribution

222. Discussion of yellowfin migration and distribution was deferred to the Bigeye Research Group, where both yellowfin and bigeye tagging work was discussed.

6.3 Stock Assessment

223. Dr Hampton presented Working Paper 15, which described an application of a length-based age-structured model (MULTIFAN-CL) to the integrated analysis of western and central Pacific yellowfin catch, effort, size and tagging data. The results obtained so far are preliminary and should not be interpreted for stock assessment purposes. Several aspects of the analysis to date are promising. In particular, there appears to be a coherent growth signal in the length data if four cohorts per year are assumed. Under this assumption, von Bertalanffy growth parameters converged to reasonable values. Estimates of exploitation rates are consistent with estimates from tagging data, and the estimated recruitment pattern is consistent with some standardised abundance indices.

224. Further development of the analysis will include incorporation of environmental information, use of effective longline effort rather than nominal effort, extension of the time window of the analysis back to 1962, and further model development to facilitate comparison of current and projected stock conditions with a range of reference points.

225. In discussion, several participants applauded the progress in model development, noting that this appeared to be a potentially powerful tool for yellowfin stock assessment. Comments were made on various aspects of the analysis, including the unreasonable geographical distribution of biomass, a possible bias in the estimated age structure for area 1, the possible mechanisms for trends in catchability, and the estimated pattern of age-dependent natural mortality rates.

6.4 Research Coordination and Planning

226. The YRG noted that available fisheries data have been analysed and have, so far, not produced a reliable index of the condition of the yellowfin stock. The YRG concluded that new approaches need to be tried, including the collection of additional information on gear and fishing procedural changes, studies to develop reliable estimates of effective fishing effort, and fishery independent methods for indexing stock abundance. New approaches and assignments were incorporated into a work plan for yellowfin stock assessment research for 1998/99.

Monitoring fisheries

227. The following research topics, and potential investigators, were identified by the YRG Coordinator:

(a) Compile data on purse-seine equipment and operations, e.g. dimension of net, use of sonar, use of helicopter, type of pursing and brailing equipment, etc., for estimating effective fishing effort (see Working Paper 48). (A. Coan, C.L. Sun, N. Miyabe, Y.C. Park, P. Sharples, D. Itano)

(b) Collect data on longline equipment and operations, e.g., type of line and hook, set time, type of bait, etc., for estimating effective fishing effort. (I. Tuwai, C.L. Sun, N. Miyabe, Y.C. Park, S. Yen, R. Ito)

(c) Analyse available single set data for information on purse-seine vessel efficiency and operations (see Working Paper 6). (N. Miyabe, Y.C. Park, G. Sakagawa, C.L. Sun, D. Itano)

(d) Analyse available observer data for information on the evolution of purse-seine efficiency (see Working Paper 48). (P. Sharples, D. Itano)

(e) Analyse changes in purse-seine catches and CPUE. (A. Coan, N. Miyabe, Y.C. Park, C.L Sun, T. Murray)

(f) Analyse changes in longline catches and CPUE. (R. Campbell, P. Kleiber, N. Miyabe, Y.C. Park, C.L. Sun, S. Yen)

(g) Analyse changes in pole-and-line catches and CPUE. (M. Ogura, E. Oreihaka)

Biological and ecological research

228. The following research topics and potential investigators were identified by the YRG Coordinator:

(a) Report on results of age and growth study. (P. Lehodey)

(b) Report on results of juvenile tuna survey. (M. Ogura)

(c) Report on results of a stock structure study (DNA and otolith). (J. Gunn)

Stock assessment research

229. The following research topics and potential investigators were identified by the YRG Coordinator:

(a) Report on application of the MULTIFAN-CL model. (J. Hampton)

(b) Report on results of a fisheries interaction study. (M. Bertignac)

(c) Report on production model analysis. (C.L. Sun)

(d) Report of ad hoc committee on methods and procedures for monitoring stock biomass. (Z. Suzuki)

230. Research topics which were directed to the Statistics Working Group concerned the adjustment of estimates of bigeye and yellowfin catches by purse-seine to account for the misidentification of bigeye as yellowfin, and the area to be used for compiling annual catch statistics. These topics were further discussed under Agenda Item 10.

Report of a working group on improvement of yellowfin CPUE in the western and central Pacific

231. During the meeting of the Yellowfin Research Group, the YRG Coordinator requested that a small working group meet to discuss options and alternatives for improvement of yellowfin CPUE. Seven scientists including the YRG Coordinator participated in the informal discussion. The following is a brief summary of the discussion.

232. The discussion started with the longline fishery. The group noted a problem with longline CPUE being interpreted as a change in the yellowfin population. The general feeling from the group was that the longline CPUE for yellowfin appeared to be somewhat dubious as an indicator of yellowfin abundance. However, it was also noted that the longline CPUE may be able to convey a signal from yellowfin population if various factors are incorporated in the process of adjustment of nominal CPUE. Examples of important factors which affect nominal longline CPUE would be thermocline depth; depth of hooks measured by time-depth recorders; hooking time; starting and ending time of a set; and gear structure (i.e. number of hooks per basket, length of float line, length of branch line, etc.) and line materials (monofilament, conventional materials, etc.).

233. Then the group dealt with the purse-seine fishery. The group identified the increasing difficulty of obtaining meaningful CPUE from the purse-seine fishery, especially problems caused by changes in operating modes, such as the extensive use of log and FADs in recent years. There are several important factors to be assessed in future CPUE studies of the purse-seine fishery: searching time (observer data and VMS data may help to define searching time); time spent in a single set; gear structure (depth and length of net, mesh size, etc.); use of helicopter, bird radar, sonar, radio beacon put on logs or FADs, etc.; distance between schools; catch per set and number of schools sighted; and the number of FADs deployed.

234. All the factors considered should cover time periods long enough so that they are successfully incorporated in the CPUE analysis. Discrimination of school modes, such as log-associated, free-swimming, etc., is essential in any analysis.

7. BIGEYE RESEARCH GROUP

235. The BRG Coordinator, Mr Miyabe, led the session of the Bigeye Research Group.

7.1 Regional Fishery Developments

Overview

236. The BRG Coordinator gave an overview of the fisheries. About 60 percent of the total bigeye catch in the WCPO were made by longline gear in 1997 (Table 2). Longline catches increased by 9,000 mt, from 47,000 mt in 1996 to 56,000 mt in 1997. The purse-seine catch, which was determined by adjusting for the misidentification of bigeye as yellowfin in logsheet and landings data, was the highest on record in 1997. The purse-seine catch increased from 18,000 mt in 1996 to 28,000 mt in 1997. In the eastern tropical Pacific (ETP), the purse-seine catch rose considerably in 1993 to 29,000 mt, and increased further to 51,000 mt in 1996. The purse-seine catch in the ETP remained stable at 51,000 mt in 1997. The longline catch in the ETP has declined consistently from 83,000 mt in 1990 to 34,000 mt in 1996. The overall catch in the Pacific reached 181,000 MT in 1997, which is close to the record 1987 catch of 184,000 mt. It was noted that, for the first time, the surface catch was larger than the longline catch.

237. The longline fishery takes medium to large fish (100–170 cm), while the surface fishery catches small fish (40–80 cm). There is no significant increasing or declining trend in nominal CPUE from the various longline fisheries, except the Japanese fishery in the ETP, which indicates a small, but steadily declining trend.

238. The number of U.S. purse seiners declined by five in 1997. The number of active longline vessels in Fiji also declined. In Samoa, on the other hand, the small-scale longline fleet, which consists of alia catamarans, has increased considerably.

239. Mr Itano gave a talk on the Hawaiian offshore handline fishery that fishes bigeye and yellowfin schools found in association with the Cross Seamount and four NOAA weather monitoring buoys, all of which are located in the outer areas of the Hawaii EEZ. Simple, single hook handline and troll gears are used, employing a combination of *ika shibi* fishing gear (night time fishing), *palu ahi* fishing (daytime handlining) and other slow trolling and jigging techniques. About 20 boats (27–68 feet, 8.2–20.7 m) are currently operating. Catch rates can be high, and the fishery supplies significant quantities of medium grade sashimi or grilling grade tuna to local markets. The catch is composed of approximately 75 percent bigeye and 25 percent yellowfin by weight, with the majority of the catch being juvenile fish of 4–32 kg. However, the extent of the total catch and the amount of bigeye in the catch have been significantly under-reported due to non-reporting or the incorrect reporting of bigeye as yellowfin on catch report forms. As this fishery targets juvenile tunas, while local longline, troll and charter groups target mature fish, a number of management, user group and interaction issues have arisen. These management concerns led to a PFRP-funded tagging project, the Hawaii Seamount Tagging Project, which was designed to investigate interaction issues centred on the Cross Seamount fishery. Preliminary results indicate that bigeye maintain an association with the seamount for a significantly longer period than yellowfin, thus exposing the juvenile bigeye to longer periods of vulnerability.

240. Mr Itano then presented a report on the Hawaii Tuna Tagging Project, which followed on from the Seamount Tagging Project with additional funding from the PFRP. This project started in March 1998, and will involve the tagging of yellowfin and bigeye throughout the Hawaii EEZ over a two-year period, using a variety of local commercial vessels. Already, over 3,300 tuna have been tagged and released. The main objectives are to investigate movement, interaction, exploitation rates, stock structure, mixing rates, etc.

Catch estimates for the purse-seine fishery

241. Most of the purse-seine catch of this species is not separated from yellowfin when reported on logsheets or in landings. Species composition data from port sampling are available for the U.S. fleet since 1988 and for the Japanese fleet since 1995, but other fleets are not covered extensively. At SCTB10, the bigeye catch for other fleets, and U.S. and Japanese catches for the years for which sampling data were not available, were estimated by applying the available sampling data for the U.S. fleet. Table 8 of Working Paper 5 presents an update of those statistics. The BRG noted that certain questions in this regard had been discussed during the Yellowfin Research Group session.

7.2 Biological and Ecological Research

Ecology

242. Dr Bard presented Working Paper 9, which described results from a research programme on the swimming behaviour of bigeye in the French Polynesia EEZ from 1995 to 1998. Bigeye were tracked in the water column using sonic tags to depths of 550 m. It appeared that they moved to deeper habitats during daylight, as they tracked and fed on nyctemeral prey. Occasionally, they would ascend to the mixed layer, presumably to warm up. Night was spent in surface waters. Comments from other members of the working group indicated that this daily migration of bigeye has been observed in other parts of the Pacific. Spatial variation in the distribution of bigeye in the EEZ was noted, with high availability in the northern part related to the abundant forage associated with the equatorial upwelling.

243. Mr Miyabe described Japanese sonic tagging experiments with adult fish in the eastern tropical Pacific, which showed similar daily migration, and close association with the deep scattering layer. The practical aspects of capturing bigeye in good condition for sonic tagging were also discussed, as were lunar effects on catches. Increased catches around the full moon at night in surface layers were noted in most areas, and it was suggested that this lunar effect even extended to daytime longline catches.

244. A simulation model developed in French Polynesia, which describes well the observed behaviour of bigeye in response to environmental factors and the availability of forage, was demonstrated for the group. Recent physiological work that had elucidated the special features of bigeye hemoglobin, enabling the species to maintain high activity at low dissolved oxygen levels, was described.

Age and growth

245. Dr Hampton presented Working Paper 18, which described tagging work and preliminary analyses of otoliths undertaken by the OFP to estimate age and growth of bigeye. Since 1991, around 300 tags have been returned. Reading of daily rings on otoliths from small bigeye (less than 110 cm) has been straightforward, and estimated growth rates are consistent with those estimated from the tagging data. In contrast, daily rings on otoliths from larger bigeye (greater than 110 cm) are less well defined and the ages of these fish may be prone to underestimation. In general, the preliminary growth estimates from this work are consistent with those estimated in other studies.

246. Dr Sun presented Working Paper 21, concerning preliminary estimates of bigeye growth derived by reading sections from the first dorsal spine. The BRG agreed that this approach was a potentially useful and cost effective way of obtaining an age-length key; however, as ring deposition

can be influenced by a variety of factors, validation of the method, especially for older bigeye, is vital, as was indicated in the working paper.

Natural mortality

247. Dr Hampton presented Working Paper 19, which described preliminary estimates of natural mortality of bigeye derived from the SPC Regional Tuna Tagging Project undertaken between 1989 and 1992. Tagging was undertaken in three locations – the Philippines (very small fish), the Coral Sea (medium-sized fish), and the western equatorial Pacific (small fish). M was estimated across a range of reporting rates, using only those recaptures caught in their general release areas. There is strong evidence that M is size-related, possibly an order of magnitude higher in very small bigeye captured in the Philippines fishery. It was noted that behavioural features of bigeye, such as migration and deep swimming, which may result in reduced catchability, could be inflating the estimates of M to some extent. On the basis of the Coral Sea tagging results, the annual M for medium-sized bigeye in the WCPO is likely to be less than 0.5.

7.3 Stock Assessment

Abundance indices

248. Several abundance indices were presented, all involving longline fisheries. Nominal CPUEs were standardised by different methods to attempt to reflect the real abundance of the bigeye stock. Dr Sun presented Working Paper 20, which addressed abundance west of 150°W using statistics from the Taiwanese longline fishery. Standardised CPUEs, using a GLM approach, showed a slight but consistent decline over the period 1967–1996. Mr Miyabe presented Working Paper 16, which considered the abundance of bigeye year classes 3 to 6 for years 1965 to 1996 for the whole Pacific, applying a GLM approach to the Japanese longline fishery data. The standardised indices of abundance for all year classes showed a similar trend, i.e. a decline from the beginning of the fishery and, after some fluctuation during the 1980s, a continuing decrease during recent years.

249. Mr Bigelow presented Working Paper 17, which introduced a rather different method of CPUE standardisation, using a habitat index based on water temperature and dissolved oxygen levels. Alternative hypotheses associating bigeye behaviour, temperature at various depths, and oxygen tolerance, were applied to CPUE data from all major longline fleets for the period 1962–1995, for all daylight sets. Oceanographic data were extracted from the NOAA database, and the whole Pacific was considered in the analyses. Abundance indices obtained by this method varied according to the hypothesis used. The most constraining hypothesis produced a continuous and marked decline over the whole time series, and also saw a marked spatial constriction in the density of adult fish. The more relaxed hypothesis showed only a slight decline in abundance over the time series, for each area considered. Discussion indicated that this useful and innovative approach would benefit from closer examination of the assumptions made, and also from archival tagging, to more precisely estimate bigeye environmental responses. It was noted that in the WCPO, where increased targeting had definitely occurred in recent decades although nominal longline CPUE had not declined, a decline in fish density would be logical.

250. As a general conclusion regarding abundance indices for longline fisheries, a general decline is observed over several decades, but the severity of the decline varies considerably according to the hypothesis and standardisation method used.

Virtual Population Analysis

251. Working Paper 16 used a tuned Virtual Population Analysis (VPA) applied to a catch-at-age table for the Japanese longline fishery covering the whole Pacific. The indices of abundance were for age classes 3 to 6, and a large increase in the catch of fish of age 0+, 1+ and 2+ was noted in recent years. Size data were available for some fleets only and were extrapolated to other fleets. The results show vectors of fishing mortality fluctuating for years 1965 to 1995, but with a slightly increasing trend during the last decade. F at age 6 is almost the highest by age class. Estimated recruitment appeared to fluctuate without any consistent trend. It must, however, be stressed that these results are highly sensitive to the estimates of natural mortality used. The estimates for recent years are imprecise, which is typical of VPAs.

7.4 Research Coordination and Planning

252. In summing up future research needs, the BRG Coordinator noted that the catch of bigeye continued to be poorly estimated for some fisheries; that better estimates of the purse-seine catch by species was a high priority task; that some work at producing better estimates of age and growth and mortality rates was ongoing; as was research on the ecology of the species; and that much more work was needed on abundance indices and the application of age-structured assessment models, the latter being badly constrained at present by inadequate estimates of natural mortality. It was agreed that considerable uncertainty surrounds the present situation with respect to the Pacific bigeye stock, and the group agreed on the following statement regarding this situation:

> *The 11th SCTB noted with concern the large and continuing increase in the catch of small-medium sized bigeye in both the eastern Pacific and the western and central Pacific, and the steady decline in longline catches in some areas. However, because of the varying interpretation of observed CPUE trends and the present inability of stock assessments to produce unequivocal results due to poor estimates of some key parameters,* ***the Group considered that the present conditions of the Pacific bigeye stock was uncertain.***
>
> *It recommended that directed research efforts to reduce this uncertainty be urgently undertaken, and noted in particular the need for better estimates of the bigeye tuna catch by surface fleets, mixing rates and movements of fish across the range of the stock, and estimates of biological parameters such as size-specific natural mortality rates.*

253. In response to these concerns, a research prospectus calling for coordinated international research to reduce some of the identified scientific uncertainties was tabled by the Pelagic Fisheries Research Programme of JIMAR, University of Hawaii. This prospectus, with emphasis on suitably designed tagging experiments, both conventional and archival, was well supported by the BRG, with numerous indications of cooperation and acknowledgement that the initiative could serve as an important catalyst. It was recognised that obtaining necessary funding could be challenging, and that good Pacific-wide coordination would be necessary. All aspects of the research may not need to be contemporaneous, provided that good coordination was maintained.

254. The following statement was then agreed by the BRG concerning the research plan:

> *The Group strongly supported a research prospectus tabled by the PFRP for coordinated international research to address scientific uncertainties regarding Pacific bigeye populations; recommended that a detailed research proposal be developed by a*

working group involving interested individuals as soon as possible; and proposed that the initiative be immediately brought to the attention of relevant authorities to determine the level of interest and range of resources which may be available to support this work. The research proposal should contain a detailed plan for collaborative Pacific-wide research, and likely funding requirements.

8. ALBACORE RESEARCH GROUP

255. The ARG Coordinator, Mr Su'a, led the session of the Albacore Research Group.

8.1 Regional Fishery Developments

256. The recent trends in catch, size composition and CPUE were reviewed by Mr Bigelow. The total catch in 1997 was estimated at 37,000 mt (Table 1). The longline catch, 30,000 mt in 1997, is dominated by Taiwanese distant-water longliners, while the surface catch, 7,000 mt in 1997, is dominated by the New Zealand troll fleet. Longline and troll catches are widely distributed throughout the EEZs of Pacific island states, with appreciable catches in subtropical and temperate areas of the high seas. For Taiwanese longliners, CPUE is highest in temperate latitudes and declines in subtropical and tropical waters.

257. Mr Lawson reviewed the data held by the OFP, and indicated that annual catch estimates, catch and effort data, and size composition data were available from all participants in the fishery. The OFP has facilitated port sampling in Fiji, New Caledonia, New Zealand, Samoa and Tonga, and port sampling in American Samoa is planned in conjunction with the National Marine Fisheries Service, with funding from Taiwan. In addition, French Polynesia conducts port sampling and compiles logsheet data, and Mr Yen indicated that these data would be made available to the OFP.

258. Mr Miyabe presented Working Paper 36, which reviewed catch trends in Japanese fisheries. With the exception of the Japanese driftnet fishery, which operated in 1982–1989, the only Japanese fisheries for albacore are a small pole-and-line fishery operating in the Tasman Sea and the longline fishery. Albacore represents bycatch in both fisheries. He noted that albacore catches appeared to have increased over the last few years, but also that retention practices for albacore for small to medium-sized boats, operating in the western south Pacific, had changed since the 1980s, as new boats have been added which carry deep freezers. Furthermore, catches of target species have declined and the market for albacore has improved.

259. Dr Murray presented Working Paper 39, which reviewed the New Zealand troll fishery. The increased use of remote sensing forecasts appears to have helped fishers to better target albacore, especially early in the season (i.e. December–January) off the west coast of the North Island. Annual catches are now about 5,000 mt.

260. Dr Norm Bartoo presented Working Paper 43, which reviewed the U.S. troll fishery, which operates in high seas areas along the Subtropical Convergence Zone. This fishery landed about 2,200 mt of albacore from 25 boats in the 1996/97 season, but only about 1,400 mt from 24 boats in 1997/98. CPUE was low early in the season; contributing factors may have been El Niño and low prices. Low prices in Pago Pago, not only for troll-caught albacore (about US$ 1,800 per short ton), but also for longline-caught albacore, had resulted in most fish being landed in Fiji or being taken back to the United States.

261. Mr Yen presented Working Paper 34, which reviewed the albacore catches in French Polynesia. The albacore catch from domestic longliners increased between 1995 and 1997, with CPUE in 1997 and 1998 double that of 1995. CPUE in the EEZ appears to be highest between 12°S and 15°S. The average size of albacore increased slightly in 1997.

262. Dr Hiroshi presented Working Paper 22, which concerns revised standardised longline CPUE. This work was requested at the Sixth South Pacific Albacore Research Workshop, held in Rarotonga, Cook Islands, from 6 to 8 March 1996. This analysis, which developed separate GLM models for the SPAR area and for sub-areas (tropical, western tropical, and temperate), indicated that the index of relative abundance was not sensitive to the inclusion of CPUE for the eastern tropical Pacific. The models suggested that the trend in relative abundance was flat, but highly variable, for the temperate area. Relative abundance in tropical areas was similarly flat prior to about 1992, but had doubled since then. The paper noted that the increase in relative abundance in tropical areas was inconsistent with CPUE for troll fisheries, and may be due to spatial coverage of the data or to large-scale oceanic environmental factors. Noting that albacore had not been targeted by the Japanese longline fisheries since the 1960s, and also noting reports of changes in retention practices for this species by small to medium-sized boats, concern was raised to as to whether these data could be used to develop an index of relative abundance.

8.2 Biological and Ecological Research

263. There were no papers submitted on biological or ecological research on albacore. The ARG Coordinator reviewed the current knowledge on albacore stock structure and life-history characteristics.

264. The stock structure of albacore is perhaps the best known of the four main tuna species. Conventional tagging has been conducted in both the north and south Pacific. In the northern Pacific, albacore demonstrate trans-Pacific migrations. In the south Pacific, the majority of albacore tagged have been juveniles. These juveniles have a demonstrated northward movement as they grow older. While there are abundant long-distance migrations in both hemispheres, there has been no movement across the equator. For this reason, and because CPUE is very low from 10°S to 10°N, separate north and south Pacific stocks have been hypothesised for management purposes.

265. A comprehensive study on south Pacific albacore age and growth was published in 1993 by Dr Marc Labelle and co-workers[5]. They used three independent methods, length-frequencies, tag-recapture and vertebral analysis, to estimate length-at-age. This study indicated that albacore are long-lived and slow growing compared to the tropical tunas. Longevity may be up to ten years. Due to a limited spawning season, albacore have well recognised annual length-frequency modes, unlike the tropical tunas.

266. A collaborative study on south Pacific reproductive biology conducted by the NMFS La Jolla Laboratory and SPC was published in 1996[6]. Albacore were sampled from Tonga and New

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5 Labelle, M., J. Hampton, K. Bailey, T. Murray, D.A. Fournier & J.R. Sibert. 1993. Determination of age and growth of South Pacific albacore (*Thunnus alalunga*) using three methodologies. Fishery Bulletin **91**: 649–663.

6 Ramon, D. & K. Bailey. 1996. Spawning seasonality of albacore, *Thunnus alalunga*, in the South Pacific Ocean. Fishery Bulletin **96**: 725–733.

Caledonia and histological examination found that albacore spawn in the summer within the south Pacific. Similarly, north Pacific albacore were found to spawn in the north Pacific summer. From extensive larval surveys conducted by Japan, albacore larvae are generally found in tropical and sub-tropical latitudes.

8.3 Stock Assessment

267. Dr Chien-Hsiung Wang presented two analyses (Working Papers 23 and 24) on the assessment of the south Pacific albacore stock. A production model estimated the carrying capacity, intrinsic growth rate and catchability of the stock. Indices of the area and perimeter of SST isotherms were analysed in relation to fluctuations in the albacore stock. Preliminary results indicated that preferred SST (15–22°C) could not be used to adequately explain stock fluctuation, but distributions of SST greater than 28°C were better correlated with stock dynamics. Dr Wang also proposed that the fluctuation of the south Pacific albacore stock may be mainly affected by severe El Niño events and the period of driftnet exploitation.

268. There was a general discussion on some aspects of the model output. The model suggested that the stock was overfished, which is contrary to the age-based assessment (Working Paper 25); that annual production was greater than the standing biomass, which would be abnormal for such a long-lived fish; and that the population has been remarkably stable for the last 20 years though the estimated fishing mortality is high. The participants agreed that these peculiar aspects of the model should be investigated further.

269. The time-series of Taiwanese longline statistics is currently being revised. Future iterations of the model should include the revised statistics, since the Taiwan longline fleet is the dominant fleet used in the albacore assessment.

270. Dr Hampton presented Working Paper 25, which gives an overview of 'MULTIFAN-CL', a length-based, age-structured model for stock assessment, with application to south Pacific albacore during 1962–1993. The major findings of the paper were:

- catchability coefficients for most fisheries showed significant trends and seasonal variation;
- estimated natural mortality rates increased at around the size at first spawning;
- albacore exploitation rates for both juvenile and adult fish are relatively low, but with some increasing trends towards the end of the time series;
- albacore biomass in each of the three geographic regions showed an increasing trend up to the late 1970s and a decreasing trend thereafter;
- average recruitment appears to have been higher over the first half of the time series, and lower and more variable during the second half, possibly as a result of decadal-scale environmental variation; and
- estimated recruitment variation over the second half of the time series is consistent with a negative impact of El Niño conditions on albacore recruitment.

271. Following revision and updating of the Taiwanese longline data, the analysis will be updated to incorporate tagging data as auxiliary information, and several other new features of the MULTIFAN-CL model.

272. There was general agreement that the fit of the model was good, though some aspects of data quality still require further attention.

273. The model results for recruitment have thus far been correlated with a broad-scale climatic indicator, the SOI, rather than with specific oceanographic or environmental parameters, such as sea surface temperature. The current approach was felt to be a reasonable means of investigating recruitment variability in relation to broad-scale climatic variation. The model, at present, does not discriminate between changes in gear efficiency (i.e. the effectiveness of the gear given that albacore are present in the vicinity of the gear) or availability (the degree to which albacore are in the vicinity of the gear). In the model, both of these processes are aggregated into 'catchability'. The model cannot, at present, be used for projections; however, this would be easy to do, given a reasonable hypothesis regarding future recruitment.

274. It was noted that the model is regionally based, and could not be easily applied to very small geographical areas, such as the Samoan EEZ. This would require an additional layer of complexity in the model and more tagging data for the estimation of movement parameters.

8.4 Research Coordination and Planning

275. The following research needs were identified:

- efforts should continue to improve the data quality of the Taiwan longline fleet;
- better measures of effective effort should be developed; and
- the MULTIFAN-CL model should be adapted for the use of precautionary reference points.

9. BILLFISH AND BYCATCH RESEARCH GROUP

276. The BBRG Coordinator, Mr Ward, led the session of the Billfish and Bycatch Research Group.

9.1 Introduction

277. The BBRG Coordinator highlighted the task faced by the BBRG in providing scientific advice on billfish and bycatch. Over one hundred species are taken by the western and central Pacific tuna fishery, including commercial swordfish and striped marlin, sharks and various fish species. Catches of marine wildlife, such as seabirds and turtles, are reported to be rare in most areas, but those reports need to be verified. Many species, such as mahi mahi and wahoo, are important sources of food and income to Pacific island communities. Several Pacific island nations are also interested in developing their own commercial gamefishing industries. Billfish and bycatch have the potential to drive management, given the generally healthy status of most commercial tuna stocks (skipjack, yellowfin and albacore). The task of the BBRG is to harness disparate national and regional resources to address a wide range of species and issues, in a data-poor environment.

278. Similar groups in other regions spend time defining terminology, such as 'bycatch', 'target' and 'non-target', 'incidental species' and 'discards'. The BBRG Coordinator proposed that BBRG should not spend time on defining such terms; the BBRG is essentially concerned with all those species and issues not covered by the SCTB's other research groups. The BBRG covers billfish, and

non-target, associated and dependent (NTAD) species. However, discards of commercial species are not within the BBRG's scope. He considered that the inaugural meeting of the BBRG was essentially a planning meeting, with the BBRG having the responsibility to develop a cooperative programme that will provide scientific advice needed to assess the effects of fishing on those species and the wider marine environment at the regional level. An important function of the BBRG will be the exchange of information and the peer review of research results. This is an area that the BBRG should promote because of the diverse nature of the species and issues.

9.2 Issues Concerning the BBRG

279. Dr Campbell presented Working Paper 26, a review of billfish bycatch in commercial tuna longline fisheries along the eastern Australian coast, highlighting concern by recreational fishers over the potential for commercial fisheries to impact recreational fisheries. He also reviewed tagging of black marlin, as well as other research and management measures directed at resolving the recreational concerns. It was pointed out that while considerable tagging had been conducted regularly since 1967, the experimental design had not been directed at the main problem, essentially an allocation issue between fisheries, and also tag recovery rates have been low (less than one percent). The result was that progressive management actions had been taken to resolve the concerns of the recreational fishery, primarily time and area closures. The latest measures by government include legislation to prohibit commercial landings of blue marlin and black marlin, the main species of recreational interest.

280. Mr Whitelaw presented Working Paper 50, concerning information on bird bycatch from longliners operating in the Australian Fishing Zone, on behalf of CSIRO. Bird bycatch, particularly of endangered species, was of sufficient concern that tuna longlining had been identified, under domestic legislation, as a 'key threatening process'. As a result, Australia had developed a Threat Abatement Plan that prescribes a suite of actions, including enhanced monitoring and research, as well as a time frame within which the adverse impacts of longlining on seabird populations can be reduced to acceptable levels. The first step of this plan is to devise suitable observer coverage that will determine the size and scope of the problem.

281. Mr Paul Dalzell raised issues concerning Hawaii's 50 mi exclusion zone, which was implemented to reduce the perceived interaction between recreational gamefish and commercial tuna and swordfish longliners. He noted that blue marlin are an important component of the commercial landings in Hawaii, and that the approach taken by Australia would be impractical in Hawaii. The area closures had largely resolved the perceived conflict for a number of years, and only now were some individuals calling for a review and possible extension of closed areas. He also noted that for most albatross populations there was little concern over the small bycatch in longline fisheries in Hawaii. However, even small catches of short tailed albatross, which have a small population size and are highly endangered, were of concern. These species were subject to population studies and other research.

282. In the discussion, it was evident that, to date, there was growing concern over billfish and bycatch in tuna longline fisheries, but that these were often specific to individual countries. In many cases, it seemed that the issue was not related to the sustainability of the particular bycatch species, although arguments were frequently framed in this context. Especially for billfish bycatch, the issue was frequently an issue of access to the resource by different fishing sectors and maximising benefits. The BBRG also noted that there was a need to determine what were the bycatch issues and how broadly distributed they were. To this end, the OFP offered some preliminary comments based on previous analyses that suggested that the problem may not be large for industrial fisheries in the

central and western Pacific. A number of issues were raised concerning how the BBRG could best approach identification of the major issues to be addressed in the central and western Pacific Ocean.

9.3 Review of Monitoring, Research and Assessment

283. Mr Bigelow presented Working Paper 27, concerning estimates of longline billfish catches in the western and central Pacific Ocean. Total annual catches since 1980 of four main billfish species – blue marlin, black marlin, striped marlin and swordfish – were compiled from commercial logsheet data. The two other istiophorids – shortbill spearfish and sailfish – occur in the WCPO, but are not routinely recorded on logsheets. Several potential biases in the catch estimates were described, such as discarding and non- or under-reporting, inaccuracies in statistical extrapolation, and species misidentification.

284. Future work on improving billfish estimates should include increasing observer coverage; improving estimates for fisheries in the Philippines and Indonesia; addressing reporting problems with sailfish and spearfish catches; and obtaining further information on the sports fishery catch of billfishes.

285. As an introduction to his presentation on shark bycatch in western and central Pacific Ocean longline fisheries, Mr Williams mentioned that several international meetings had been convened in response to concern regarding the lack of information on shark catches in fisheries throughout the world. Sharks, in contrast to the tuna species, typically exhibit low fecundity and productivity, slow growth and late sexual maturity, which suggest they would be vulnerable to exploitation. The FAO Technical Working Group Meeting on the Conservation and Management of Sharks was recently convened in Tokyo, Japan, 23–27 April 1998, to establish guidelines and a plan of action for subsequent presentation to FAO member governments.

286. Previous OFP reviews of shark bycatch in WCPO tuna fisheries highlighted the general lack of information. Data that have been collected on logsheets to date are problematic, since the shark bycatch has been grouped into one category for all shark species, and, even though provision for recording shark bycatch by species now exists, there remain problems with species identification. There are also the problems of non- and under-reporting because there has been no enforcement of obligations to report bycatch, and it would be difficult to verify any shark bycatch reported on logsheets. Observer data provide the most reliable means of obtaining shark bycatch data, although the overall coverage of the longline fisheries is estimated to be currently less than one percent.

287. Even though observer coverage is currently low, some indications of shark bycatch are available. Observer data suggest that blue shark, silky shark and oceanic whitetip shark are the most common shark species encountered in the tropical longline fisheries of the WCPO. Several examples of the type of information obtained from observer data were then presented, including the broad areas where these species had been observed in the longline catch; the market interest for each of these species, as inferred by the fate of the bycatch when landed; life status on landing (e.g. alive, barely alive, dead, etc.); and the size distribution of the observed catch, by species.

288. Observer data are used to study the factors thought to affect the bycatch of shark. It was proposed that these might be area fished; temporal determinants (interannual, seasonal and daily variability); depth of fishing; and bait used. Preliminary analyses of the observer data suggests that there is some relationship between CPUE for some species and two factors, the depth of fishing and soak time (i.e. day versus night soak time).

289. The BBRG agreed that increasing observer coverage will be essential for improving the monitoring and assessments of shark species.

290. It was noted that there was a recent tendency for more direct targeting of sharks by Taiwanese and Chinese longliners, with extra hooks, baited with bycatch, being placed directly on the longline buoys.

291. In Australia, the removal of fins from sharks ('finning') on foreign vessels was banned unless the carcass was kept as well. This was a result of a television news item that showed sharks being thrown back in the water after being finned. The BBRG noted that finning live sharks is dangerous, and that sharks are almost always killed before being finned.

292. Dr Michael Laurs provided the workshop with an overview of the Hawaiian longline fishery and the bycatch of sharks. The Hawaii longline fleet has developed from less than 50 vessels in the late 1980s to around 140 larger vessels with a catch value of around US$ 40 million. This fishery, which mainly targets swordfish and bigeye, also catches other tunas, pelagic fishes and sharks. The fishery is now limited to 167 vessels (only 105 of which are active), with closed areas around the Hawaii islands to avoid gear conflicts. There is a mandatory logbook and observer programme in place. The observer coverage is presently around five percent, and it is felt that the logbooks provide reliable estimates of the shark bycatch. There is an increasing proportion of sharks that are being processed, usually finned. Of those not processed or finned, around 80 percent are released alive.

293. Blue sharks are the main shark bycatch species, accounting for about 95 percent of the shark bycatch. Blue sharks are processed for their fins, while a number of other shark species, mainly threshers and makos, are processed for their fins and flesh. Since 1993, there has been a gradual decrease in the number of sharks caught, and this is attributed to changing targeting practices, including using fewer lightsticks. Sharks are caught in highest numbers by vessels targeting swordfish, though this has decreased, while the number of sharks caught by fishermen targeting tuna has increased.

294. The annual bycatch of sharks by the domestic Hawaiian longline fishery, using around 12–15 million hooks, is approximately 2,000 mt. The annual catch of sharks by longline in the whole Pacific, according to Dr Laurs, is about 148,000 mt and effort is about 710 million hooks.

295. An issue that may arise in Hawaii concerns the under-utilisation of carcasses of finned sharks. This may have future ramifications for the industry. While blue shark flesh (the main shark caught in Hawaii) has no market in the United States, markets are developing in other countries.

9.4 Approaches to Assessing the Status of Billfish and Bycatch Species

296. Dr Kleiber described a Classification and Regression Tree (CART) analysis of turtle bycatch in Hawaii to investigate the effects of various predictive factors on levels of bycatch using logbook and observer data. An advantage of CART analyses is that they accommodate highly skewed data, which typically occurs with bycatch data because encounters with many bycatch species (such as turtles) are rare. The regression trees stratified the turtle bycatch data and determined important predictive variables through an iterative process. Uncertainty was estimated using bootstrapping procedures. An example of incorporating results from CART analyses into management risk scenarios with respect to allowable take were also presented.

297. Mr Lawson presented estimates of annual catches of bycatch species in the SPC Statistical Area, by major fleet, based on observer data compiled by the OFP. For purse seiners, the observer data covered 72 trips from August 1994 to November 1996, and for longliners, they covered 85 trips from June 1992 to February 1997. Catch estimates were derived by multiplying an estimate of the catch rate by an estimate of total effort. Information on the variability of the catch rates was used to derive standard errors of the catch estimates, together with an indication of the amount of sampling that would be required to obtain more reliable estimates. There was insufficient observer data to obtain reliable estimates of catch rates on an annual basis; observer data had therefore been used to estimate average catch rates over the whole period.

298. The catch of non-target species by purse seiners, for the four major fleets combined, was estimated to account for less than one percent of the total catch; bycatches from associated sets represented 0.9 percent, while those from unassociated sets represented 0.5 percent. The most important bycatch species or species groups were sharks and rainbow runner, followed by frigate tuna, oceanic triggerfish, mackerel, black marlin, mahi mahi, and blue marlin. In general, the reliability of the catch estimates was low, due to a high level of variability in the catch per set and small sample sizes.

299. In contrast to the low level of bycatch estimated for purse seiners, the catch of non-target species by longliners, for seven major fleets combined, was estimated to account for 42 percent of the total catch. The most important bycatch species were blue marlin, swordfish, striped marlin, wahoo, sailfish, black marlin, escolars, silky shark, thresher shark, and oceanic whitetip shark. Sharks as a group accounted for 23 percent of the total catch. The reliability of the catch estimates was higher than for the estimates of purse-seine bycatches, due to the lower level of variability in catch rates for longliners. The implication is that a greater level of sampling is required to obtain reliable estimates of purse-seine bycatches than would be the case for longline.

300. In the discussion, the BBRG noted that the highly skewed distribution of catch rates for bycatch species, such that there were a large number of zero values and only a small number of positive values, posed a problem for estimating the central tendency of catch rates. A solution to the problem may lie in the use of mixture models, such as the negative binomial with added zeros.

9.5 Summary of Work Plan and Action Items

301. The BBRG noted that there was a need to better understand how to address the UN Implementing Agreement with respect to bycatch species, and particularly to determine how the obligation to assess fishery impacts could be conducted. This latter issue is important since many of the standard approaches to fish stock assessment assume that the catch rate is related to abundance, a situation which may not be true for bycatch species. Assessment is also problematic for rarely caught species because of the difficulty in obtaining reliable estimates of the catch. At present, however, the most pressing need was for more information on specific billfish and bycatch issues, so that they could be prioritised. The BBRG considered that the best way to advance this work was for each participant to add a section on billfish and bycatch to their national fishery report for the next meeting. This section should contain the following specific information:

- description of the fishery and gear type;
- the species caught as bycatch, including non-fish species;
- the reason for concern;

- the evidence in support of concerns;
- any management actions taken;
- the data, research and information available to address concerns; and
- the data and research required to address the issue.

302. At the next meeting, the BBRG intends to draw together this information and identify common issues.

10. REVIEW OF DIRECTIVES TO THE STATISTICS WORKING GROUP

303. The Chairman opened the Agenda Item by noting that the principle directive for the Statistics Working Group concerned the area that should be used to compile annual catch statistics for the Research Groups and for the broad area of interest to SCTB. Under Agenda Item 4.2, the area presented in Figure 4 (page 23) had been proposed to represent the broad area of interest to SCTB. However, it was noted by the Yellowfin Research Group and the Bigeye Research Group that this area may not sufficiently cover the range of the yellowfin and bigeye stocks. A significant portion of the South Pacific albacore stock and fishery also extends to the east of 150°W. It was also noted that the eastern boundary cut through French Polynesia, and that purse seiners based in the EPO had fished near the Marquesas, just outside the eastern boundary. On the other hand, it was pointed out that the estimates of annual catches presented in Working Paper 5 were presented separately for the WCPO and for the EPO, together with totals for the whole Pacific Ocean, and therefore that catches to the east of the proposed area were covered in the tables.

304. It was suggested that an additional sub-area be proposed for the south Pacific from 150°W to a boundary further to the east, to be determined, or that the whole EPO be divided into sub-areas. The meeting requested Mr Lawson and Dr Hampton to review data on the distribution of catches, in collaboration with the coordinators of the Research Groups, and propose a solution at the next meeting of the SCTB.

305. The SWG Coordinator summarised the other directives to the Statistics Working Group as follows:

- Regarding the coordination of data collection, Mr Lawson was requested to prepare a discussion paper concerning a sampling design for regional port sampling and observer programmes, for the next meeting of SCTB.

- Regarding the tables of annual catch statistics presented in Working Paper 5, the OFP was requested to study the relationship between the proportion of bigeye in the catch of bigeye and yellowfin, by purse-seine set type, and fleet and area, using observer data held by the OFP. The Coordinator of the Yellowfin Research Group proposed that Mr Coan and Mr Miyabe examine port sampling data in this regard. Mr Lawson was also requested to include more information concerning the adjustment of estimates of purse-seine catches of bigeye and yellowfin with the tables in Working Paper 5.

- The Statistics Working Group was directed to determine the extent to which longline catch statistics in Working Paper 5 represented processed weights, rather than whole weights.

- The Statistics Working Group was directed to include information on the number of vessels, by gear type, by area, and by vessel size or carrying capacity, in the tables presented in Working Paper 5.

11. CLEARING OF THE WORKSHOP ON PRECAUTIONARY LIMIT REFERENCE POINTS REPORT

306. The report of the Workshop on Precautionary Limit Reference Points to MHLC3 was cleared with several modifications (Appendix 7). An Executive Summary was subsequently prepared by Dr Hampton and circulated to participants (Appendix 7). A statement on bigeye will be appended to the report to MHLC3 (see paragraphs 252 and 254), with a preamble explaining that while the statement was not part of the terms of reference of the Workshop on Precautionary Limit Reference Points, it was considered of importance to SCTB that MHLC3 be informed of concerns that arose during the meeting of the Bigeye Research Group.

12. OTHER BUSINESS

307. The outgoing Chairman of the SCTB, ’Akau’ola, proposed Dr Suzuki as the next Chairman. In so doing, ’Akau’ola wished to give a clear signal of unity and of equal participation of distant-water fishing nations within SCTB. All participants supported Dr Suzuki as the incoming Chairman. In accepting the chairmanship, Dr Suzuki noted that his election was a reflection of the wider scope of SCTB under its new terms of reference.

308. It was proposed that a small group meet to draft a charter for SCTB, including procedures for the election of the SCTB Chairman and the Coordinators of the Statistics Working Group and the Research Groups. In the meantime, the meeting agreed that present Coordinators of the Statistics Working Group and the Research Groups stay in place, with responsibility for appointing new Coordinators, if the need arises, remaining with the SCTB Chairman.

309. Mr Yen offered on behalf of the government of French Polynesia to hold the next meeting of SCTB in French Polynesia, and the offer was well received. The meeting was tentatively scheduled for the first week of June 1999.

13. CLOSE

310. In closing the meeting, ’Akau’ola thanked Dr Lewis and the OFP for their work in organising the meeting. He also thanked Ms Simonds and the Council for their outstanding hospitality and support. Mr Bernard Thoulag thanked ’Akau’ola for the excellent job that he did as Chairman of SCTB10 and SCTB11, noting that his leadership occurred during an important time for the management of tuna resources in the region. The meeting was then closed with a vigorous round of applause.

Table 1. Total catches of albacore in the Pacific Ocean. Symbols: '…' = missing data; '–' = no effort, hence no catch; '0' = effort, but no catch; estimates in parentheses have been carried over from previous years

YEAR	SOUTH PACIFIC					NORTH PACIFIC					TOTAL
	LONGLINE	POLE-AND-LINE	TROLL	OTHER	SUB-TOTAL	LONGLINE	POLE-AND-LINE	TROLL	OTHER	SUB-TOTAL	
1950	-	...	-	-	-	...	...	...	...	...	...
1951	-	...	-	-	-	...	...	...	...	...	...
1952	154	...	-	-	154	26,735	41,786	23,914	1,764	94,199	94,353
1953	803	...	-	-	803	27,800	32,921	15,745	341	76,807	77,610
1954	9,578	...	-	-	9,578	20,971	28,069	12,246	208	61,494	71,072
1955	8,625	...	-	-	8,625	16,286	24,236	13,264	721	54,507	63,132
1956	7,281	...	-	-	7,281	14,347	42,810	18,768	539	76,464	83,745
1957	8,757	...	-	-	8,757	21,057	49,500	21,173	538	92,268	101,025
1958	18,636	...	-	-	18,636	18,439	22,175	14,929	180	55,723	74,359
1959	17,841	...	-	-	17,841	15,807	14,252	21,202	72	51,333	69,174
1960	22,248	45	-	-	22,293	17,373	25,156	20,105	637	63,271	85,564
1961	23,742	0	-	-	23,742	17,442	21,473	12,059	1,636	52,610	76,352
1962	35,219	0	-	-	35,219	15,771	9,814	19,753	1,933	47,271	82,490
1963	31,095	16	-	-	31,111	13,471	28,852	25,145	1,445	68,913	100,024
1964	22,930	0	-	-	22,930	15,488	27,269	18,391	1,275	62,423	85,353
1965	25,838	0	-	-	25,838	13,965	41,908	16,557	866	73,296	99,134
1966	39,113	0	-	-	39,113	25,329	24,430	15,377	1,293	66,429	105,542
1967	40,318	0	5	-	40,323	29,516	34,594	17,975	1,328	83,413	123,736
1968	29,051	0	14	-	29,065	24,670	21,503	21,462	2,337	69,972	99,037
1969	24,360	0	...	-	24,360	18,654	35,103	20,192	2,371	76,320	100,680
1970	31,380	100	50	-	31,530	16,897	28,792	21,422	1,942	69,053	100,583
1971	33,825	100	...	-	33,925	12,805	55,269	22,272	2,455	92,801	126,726
1972	34,140	100	268	-	34,508	15,748	64,512	27,521	1,669	109,450	143,958
1973	37,747	100	484	-	38,331	16,201	72,047	17,053	2,023	107,324	145,655
1974	30,919	100	898	-	31,917	13,632	78,353	21,509	1,448	114,942	146,859
1975	26,404	100	646	-	27,150	14,050	55,400	19,043	1,263	89,756	116,906
1976	24,324	100	25	-	24,449	18,029	88,036	16,183	3,240	125,488	149,937
1977	34,995	100	621	-	35,716	17,439	33,431	10,022	2,309	63,201	98,917
1978	35,214	100	1,686	-	37,000	13,627	60,827	16,636	8,121	99,211	136,211
1979	28,693	100	814	-	29,607	14,695	44,965	7,302	4,245	71,207	100,814
1980	30,688	119	1,468	-	32,275	15,658	47,125	7,768	4,753	75,304	107,579
1981	31,937	8	2,085	5	34,035	18,843	28,174	12,837	11,964	71,818	105,853
1982	28,416	1	2,434	6	30,857	17,813	30,040	6,713	14,633	69,199	100,056
1983	25,035	2	744	39	25,820	16,083	21,705	9,584	7,904	55,276	81,096
1984	20,546	0	2,773	1,589	24,908	15,720	27,045	9,354	18,631	70,750	95,658
1985	27,330	0	3,253	1,937	32,520	14,720	22,212	6,471	15,047	58,450	90,970
1986	32,601	0	2,000	1,946	36,547	13,186	16,528	4,738	11,087	45,539	82,086
1987	27,264	0	1,978	930	30,172	14,973	19,249	2,870	11,672	48,764	78,936
1988	32,085	0	3,583	5,423	41,091	14,360	6,814	4,367	19,427	44,968	86,059
1989	22,822	0	8,319	22,130	53,271	14,069	8,683	2,000	20,258	45,010	98,281
1990	23,868	0	6,368	7,541	37,777	16,403	8,647	2,905	26,336	54,291	92,068
1991	24,814	0	8,102	1,517	34,433	11,048	7,103	1,984	11,109	31,244	65,677
1992	29,268	49	6,846	20	36,183	19,824	13,888	4,935	16,914	55,561	91,744
1993	29,783	5	4,390	20	34,198	31,593	12,809	6,748	4,400	55,550	89,748
1994	31,087	2	5,674	20	36,783	31,740	26,391	11,814	3,944	73,889	110,672
1995	24,375	0	8,016	25	32,416	33,384	20,981	9,615	3,634	67,614	100,030
1996	27,248	0	7,412	25	34,685	34,500	23,383	16,102	2,146	76,131	110,816
1997	30,330	0	6,583	25	36,938	(34,500)	(23,383)	12,421	(2,146)	72,450	109,388

Table 2. Total catches of bigeye in the Pacific Ocean. Symbols: '…' = missing data; '–' = no effort, hence no catch; estimates in parentheses have been carried over from previous years

YEAR	WPYR AREA					EPO						TOTAL
	LONGLINE	POLE-AND-LINE	PURSE SEINE	OTHER	SUB-TOTAL	LONGLINE	POLE-AND-LINE	PURSE SEINE	TROLL	OTHER	SUB-TOTAL	
1950	...	...	...	...	...	...	...	...	...	...	...	...
1951	...	...	...	...	...	...	...	...	...	...	...	...
1952	...	...	...	...	...	...	...	...	...	...	...	...
1953	...	...	...	...	...	...	...	...	...	...	...	...
1954	...	...	...	...	...	...	...	...	...	...	...	...
1955	...	...	...	...	...	...	...	...	...	...	...	...
1956	...	...	...	...	...	...	...	...	...	...	...	...
1957	...	...	...	...	...	...	...	...	...	...	...	...
1958	...	...	...	...	...	...	...	...	...	...	...	...
1959	...	...	...	...	...	...	...	...	...	...	...	...
1960	...	...	...	...	...	...	...	...	...	...	...	...
1961	...	...	...	...	...	...	57	156	-	-	...	...
1962	...	...	...	...	...	44,200	168	160	-	-	44,528	...
1963	...	...	...	...	...	65,300	75	-	-	-	65,375	...
1964	...	...	...	...	...	45,400	68	-	-	-	45,468	...
1965	...	...	...	...	...	28,600	117	-	-	-	28,717	...
1966	...	...	...	...	...	34,100	157	109	-	-	34,366	...
1967	...	...	...	...	...	35,035	748	916	-	-	36,699	...
1968	...	...	...	...	...	34,216	63	2,496	-	-	36,775	...
1969	...	...	...	...	...	50,938	-	576	-	-	51,514	...
1970	33,661	...	649	2,820	37,130	32,498	-	1,332	-	-	33,830	70,960
1971	34,252	...	850	3,060	38,162	29,687	58	2,494	-	14	32,253	70,415
1972	45,190	1,761	865	3,498	51,314	35,798	66	2,172	-	-	38,036	89,350
1973	35,105	1,250	1,074	4,218	41,647	52,383	131	1,848	-	-	54,362	96,009
1974	38,301	1,038	1,330	4,720	45,389	36,273	-	890	-	-	37,163	82,552
1975	49,911	1,317	1,328	4,943	57,499	42,548	28	3,695	-	-	46,271	103,770
1976	63,713	3,423	1,309	4,138	72,583	50,966	45	10,136	1	4	61,152	133,735
1977	60,869	3,325	1,587	5,637	71,418	71,039	2	7,053	-	-	78,094	149,512
1978	45,331	3,324	1,146	4,243	54,044	70,622	-	11,714	-	-	82,336	136,380
1979	55,071	2,397	2,019	4,674	64,161	56,049	-	7,531	-	1	63,581	127,742
1980	52,731	2,243	2,165	4,149	61,288	58,042	-	15,318	-	103	73,463	134,751
1981	41,237	2,595	4,330	4,929	53,091	48,438	-	10,090	-	1	58,529	111,620
1982	44,735	4,105	5,111	4,742	58,693	43,920	23	4,079	-	-	48,022	106,715
1983	41,133	4,045	9,398	5,024	59,600	77,705	21	3,144	-	95	80,965	140,565
1984	45,867	3,446	8,557	5,189	63,059	66,568	1	5,919	-	16	72,504	135,563
1985	50,956	4,326	7,273	6,125	68,680	70,731	17	4,497	-	18	75,263	143,943
1986	46,783	2,865	7,599	6,481	63,728	107,451	-	1,939	-	-	109,390	173,118
1987	60,630	3,128	11,550	5,566	80,874	102,408	-	771	-	5	103,184	184,058
1988	50,148	1,914	7,265	6,452	65,779	60,634	2	1,051	-	-	61,687	127,466
1989	51,123	4,272	12,775	7,146	75,316	64,642	-	1,470	-	-	66,112	141,428
1990	63,671	3,863	12,186	8,894	88,614	82,621	-	4,701	-	11	87,333	175,947
1991	49,573	1,907	12,914	10,288	74,682	79,430	25	3,702	-	13	83,170	157,852
1992	59,820	1,640	19,505	7,356	88,321	64,764	-	5,488	-	9	70,261	158,582
1993	50,962	2,339	14,307	7,391	74,999	64,374	-	8,043	-	26	72,443	147,442
1994	61,068	2,784	11,171	8,723	83,746	53,323	-	28,683	692	-	82,698	166,444
1995	50,702	3,500	13,975	8,215	76,392	41,056	-	36,155	1,154	-	78,365	154,757
1996	46,627	3,434	18,060	8,451	76,572	34,361	-	50,764	-	625	85,750	162,322
1997	55,669	3,434	28,491	(8,451)	96,045	(34,361)	-	50,811	-	-	85,172	181,217

Table 3. Total catches of skipjack in the Pacific Ocean. Symbols: '…' = missing data; '–' = no effort, hence no catch

YEAR	WPYR AREA					EPO						TOTAL
	LONGLINE	POLE-AND-LINE	PURSE SEINE	OTHER	SUB-TOTAL	LONGLINE	POLE-AND-LINE	PURSE SEINE	TROLL	OTHER	SUB-TOTAL	
1950	...	...	...	...	...	-	49,534	5,741	-	1,299	56,574	...
1951	...	...	...	...	...	-	45,617	5,790	-	1,109	52,516	...
1952	...	...	...	...	...	-	32,724	4,806	-	905	38,435	...
1953	...	...	...	...	...	-	50,812	5,171	-	-	55,983	...
1954	...	...	...	...	...	-	61,221	8,519	-	1	69,741	...
1955	...	...	...	...	...	1	51,558	6,503	...	...	58,062	...
1956	...	...	...	...	...	...	64,971	3,204	...	...	68,175	...
1957	...	...	...	...	...	10	54,414	873	...	...	55,297	...
1958	...	...	...	...	...	23	67,594	5,481	...	...	73,098	...
1959	...	...	...	...	...	24	69,495	9,477	...	...	78,996	...
1960	...	...	...	...	...	21	34,900	11,820	...	...	46,741	...
1961	...	...	...	...	...	36	27,497	40,614	-	348	68,495	...
1962	...	...	...	...	...	34	16,153	52,572	-	-	68,759	...
1963	...	...	...	...	...	139	16,549	76,829	13	2,166	95,696	...
1964	...	...	...	...	...	76	9,783	46,006	-	3,469	59,334	...
1965	...	...	...	...	...	188	19,137	58,246	25	786	78,382	...
1966	...	...	...	...	...	178	13,666	45,119	1	1,696	60,660	...
1967	...	...	...	...	...	84	17,871	97,962	-	4,822	120,739	...
1968	...	...	...	...	...	157	7,008	54,362	1	9,738	71,266	...
1969	...	...	...	...	...	165	6,591	40,879	2	11,596	59,233	...
1970	1,464	...	7,995	32,184	...	110	6,998	42,101	11	6,910	56,130	...
1971	1,290	...	14,691	29,190	...	102	11,102	87,131	84	6,404	104,823	...
1972	1,417	163,529	19,508	41,915	226,369	176	6,081	26,434	22	872	33,585	259,954
1973	1,607	240,980	20,573	50,409	313,569	141	8,789	34,737	12	416	44,095	357,664
1974	2,005	280,662	15,673	49,687	348,027	63	7,150	71,255	2	396	78,866	426,893
1975	1,825	208,742	16,266	50,190	277,023	68	13,366	110,083	-	419	123,936	400,959
1976	1,964	268,173	28,070	51,262	349,469	84	10,846	114,715	27	573	126,245	475,714
1977	3,049	282,537	39,655	66,513	391,754	77	7,218	77,228	32	1,859	86,414	478,168
1978	3,264	312,915	42,156	73,651	431,986	77	5,603	162,915	39	1,253	169,887	601,873
1979	2,286	268,627	64,621	60,479	396,013	26	5,931	124,673	1	1,419	132,050	528,063
1980	629	311,387	74,803	42,915	429,734	19	5,040	123,687	10	1,934	130,690	560,424
1981	857	288,379	94,047	48,323	431,606	30	5,780	112,948	-	876	119,634	551,240
1982	1,120	244,398	174,529	53,120	473,167	30	3,676	94,681	20	379	98,786	571,953
1983	2,223	285,846	323,257	56,909	668,235	23	4,112	53,150	11	869	58,165	726,400
1984	885	340,887	326,544	44,350	712,666	24	2,770	56,948	7	826	60,575	773,241
1985	1,080	249,959	309,326	43,631	603,996	33	918	48,375	-	167	49,493	653,489
1986	1,421	327,049	369,493	49,159	747,122	42	1,939	61,486	-	127	63,594	810,716
1987	2,314	255,716	371,161	47,936	677,127	23	2,230	59,941	-	174	62,368	739,495
1988	1,903	281,834	479,658	49,265	812,660	20	4,278	80,445	5	638	85,386	898,046
1989	2,500	281,050	472,386	48,592	804,528	19	2,892	88,468	3	1,011	92,393	896,921
1990	1,287	213,295	604,837	60,848	880,267	26	835	69,927	-	1,857	72,645	952,912
1991	1,498	282,156	767,686	65,542	1,116,882	18	1,670	59,707	-	1,882	63,277	1,180,159
1992	1,038	216,084	703,094	76,146	996,362	14	1,860	81,026	-	1,078	83,978	1,080,340
1993	786	251,174	576,067	55,778	883,805	32	3,633	81,500	-	2,224	87,389	971,194
1994	1,897	205,816	717,673	49,025	974,410	137	3,110	71,449	-	761	75,457	1,049,867
1995	1,592	239,158	720,928	55,431	1,017,109	57	5,237	130,974	-	1,981	138,249	1,155,358
1996	1,504	201,820	730,963	49,330	983,617	70	2,560	108,574	-	873	112,077	1,095,694
1997	1,479	200,633	600,003	48,739	850,854	-	2,842	154,784	-	-	157,626	1,008,480

Table 4. Total catches of yellowfin in the Pacific Ocean. Symbols: '…' = missing data; '–' = no effort, hence no catch

YEAR	WPYR AREA					EPO						TOTAL
	LONGLINE	POLE-AND-LINE	PURSE SEINE	OTHER	SUB-TOTAL	LONGLINE	POLE-AND-LINE	PURSE SEINE	TROLL	OTHER	SUB-TOTAL	
1950	...	...	...	...	...	-	65,921	15,856	-	879	82,656	...
1951	...	...	...	...	...	-	65,499	6,598	-	727	72,823	...
1952	...	...	...	...	...	-	66,108	13,735	-	1,067	80,910	...
1953	...	...	...	...	...	-	43,920	16,121	-	-	60,041	...
1954	...	...	...	...	...	-	46,541	7,625	-	-	54,166	...
1955	...	...	...	...	...	665	50,811	13,086	...	...	64,562	...
1956	...	...	...	...	...	1,578	58,828	21,470	...	...	81,876	...
1957	...	...	...	...	...	9,365	58,402	15,544	...	...	83,311	...
1958	...	...	...	...	...	7,803	46,776	20,560	...	...	75,139	...
1959	...	...	...	...	...	4,497	30,053	28,126	...	...	62,676	...
1960	...	...	...	...	...	7,629	26,199	79,976	...	...	113,804	...
1961	...	...	...	...	...	16,640	16,762	84,897	-	984	119,283	...
1962	...	...	...	...	...	14,118	11,855	59,597	-	-	85,570	...
1963	...	...	...	...	...	22,941	7,678	53,624	-	726	84,969	...
1964	...	...	...	...	...	20,002	4,327	83,547	-	776	108,652	...
1965	...	...	...	...	...	18,315	7,417	71,160	-	321	97,213	...
1966	...	...	...	...	...	10,906	5,852	74,228	-	531	91,517	...
1967	...	...	...	...	...	11,065	5,214	73,188	-	1,557	91,024	...
1968	...	...	...	...	...	16,188	4,698	93,942	-	3,376	118,204	...
1969	...	...	...	...	...	17,837	7,560	119,322	12	1,964	146,695	...
1970	51,951	...	6,886	29,473	88,310	13,859	4,688	145,867	33	5,038	169,485	257,795
1971	48,679	...	9,788	31,567	90,034	7,790	5,469	114,416	343	2,611	130,629	220,663
1972	50,754	7,455	11,008	35,939	105,156	15,944	6,149	169,467	422	1,090	193,072	298,228
1973	55,697	7,447	15,330	41,964	120,438	12,570	4,355	200,204	19	675	217,823	338,261
1974	52,885	6,581	18,799	47,373	125,638	9,793	8,659	200,451	6	1,248	220,157	345,795
1975	59,026	7,796	15,208	49,253	131,283	13,205	6,114	195,442	5	581	215,347	346,630
1976	70,345	17,141	16,315	41,863	145,664	15,698	3,688	232,266	5	368	252,025	397,689
1977	87,004	15,246	18,448	55,853	176,551	12,279	2,093	196,427	21	276	211,096	387,647
1978	107,961	12,762	13,863	39,189	173,775	10,507	4,172	175,747	123	492	191,041	364,816
1979	103,847	11,460	31,352	47,238	193,897	10,209	5,191	184,236	13	234	199,883	393,780
1980	116,690	13,127	35,235	43,148	208,200	12,952	1,649	156,878	15	883	172,377	380,577
1981	92,481	19,318	62,483	49,979	224,261	8,346	1,595	179,371	5	842	190,159	414,420
1982	83,510	13,837	73,530	47,115	217,992	9,664	1,605	123,272	16	190	134,747	352,739
1983	83,740	12,985	106,082	49,827	252,634	10,208	4,271	88,779	18	1,188	104,464	357,098
1984	70,026	13,382	109,511	52,824	245,743	10,365	3,090	141,635	8	328	155,426	401,169
1985	73,710	18,232	105,381	60,259	257,582	12,481	1,081	215,610	-	301	229,473	487,055
1986	62,271	13,065	104,625	64,425	244,386	22,292	2,519	265,473	-	282	290,566	534,952
1987	73,939	14,818	156,363	57,883	303,003	19,213	5,110	266,800	-	336	291,459	594,462
1988	81,020	13,546	99,270	64,962	258,797	13,354	3,743	283,318	25	948	301,388	560,185
1989	63,995	14,514	164,212	68,911	311,632	17,072	4,189	284,621	2	563	306,447	618,079
1990	68,717	14,184	175,070	89,253	347,224	30,669	2,664	268,871	-	1,751	303,955	651,179
1991	55,811	12,868	208,788	100,603	378,070	26,135	2,909	234,974	-	1,069	265,087	643,157
1992	65,425	15,732	240,530	67,118	388,805	16,333	3,885	232,811	-	3,153	256,182	644,987
1993	61,022	14,365	243,044	71,194	389,625	19,031	5,089	223,519	-	3,463	251,102	640,727
1994	64,169	14,536	223,582	84,188	386,475	22,919	3,755	213,177	-	1,455	241,306	627,781
1995	68,398	14,195	184,458	79,842	346,893	15,331	1,284	220,486	-	2,047	239,148	586,041
1996	61,647	12,223	111,114	80,053	265,037	11,502	3,757	245,578	-	257	261,094	526,131
1997	72,177	11,726	230,498	80,022	394,423	(11,502)	4,314	256,004	-	-	271,820	666,243

Table 5. Total catches of albacore, bigeye, skipjack and yellowfin in the WPYR area. Symbols: '…' = missing data

YEAR	ALBACORE		BIGEYE		SKIPJACK		YELLOWFIN		TOTAL
	MT	%	MT	%	MT	%	MT	%	
1950	...		...		...		...		...
1951	...		...		...		...		...
1952	68,983		...		...		...		...
1953	61,050		...		...		...		...
1954	49,101		...		...		...		...
1955	40,666		...		...		...		...
1956	57,231		...		...		...		...
1957	70,799		...		...		...		...
1958	40,820		...		...		...		...
1959	30,338		...		...		...		...
1960	42,655		...		...		...		...
1961	36,357		...		...		...		...
1962	52,162		...		...		...		...
1963	59,373		...		...		...		...
1964	56,838		...		...		...		...
1965	77,726		...		...		...		...
1966	84,312		...		...		...		...
1967	93,459		...		...		...		...
1968	68,102		...		...		...		...
1969	76,456		...		...		...		...
1970	69,526		37,130		...		88,310		...
1971	97,687		38,162		...		90,034		...
1972	111,525	23	51,314	10	226,369	46	105,156	21	494,364
1973	121,456	20	41,647	7	313,569	53	120,438	20	597,110
1974	114,836	18	45,389	7	348,027	55	125,638	20	633,890
1975	89,518	16	57,499	10	277,023	50	131,283	24	555,323
1976	126,945	18	72,583	10	349,469	50	145,664	21	694,661
1977	76,905	11	71,418	10	391,754	55	176,551	25	716,628
1978	106,841	14	54,044	7	431,986	56	173,775	23	766,646
1979	88,723	12	64,161	9	396,013	53	193,897	26	742,794
1980	94,300	12	61,288	8	429,734	54	208,200	26	793,522
1981	79,197	10	53,091	7	431,606	55	224,261	28	788,155
1982	84,876	10	58,693	7	473,167	57	217,992	26	834,728
1983	65,061	6	59,600	6	668,235	64	252,634	24	1,045,530
1984	74,379	7	63,059	6	712,666	65	245,743	22	1,095,847
1985	74,637	7	68,680	7	603,996	60	257,582	26	1,004,895
1986	68,585	6	63,728	6	747,122	66	244,386	22	1,123,821
1987	66,812	6	80,874	7	677,127	60	303,003	27	1,127,815
1988	69,515	6	65,779	5	812,660	67	258,797	21	1,206,751
1989	90,395	7	75,316	6	804,528	63	311,632	24	1,281,871
1990	81,468	6	88,614	6	880,267	63	347,224	25	1,397,572
1991	55,288	3	74,682	5	1,116,882	69	378,070	23	1,624,923
1992	69,965	5	88,321	6	996,362	65	388,805	25	1,543,453
1993	72,452	5	74,999	5	883,805	62	389,625	27	1,420,881
1994	90,637	6	83,746	5	974,410	63	386,475	25	1,535,268
1995	88,608	6	76,392	5	1,017,109	67	346,893	23	1,529,002
1996	98,152	7	76,572	5	983,617	69	265,037	19	1,423,378
1997	97,682	7	96,045	7	850,854	59	394,423	27	1,439,004

Table 6. Total catches of albacore, bigeye, skipjack and yellowfin in the WPYR area, by gear type. Symbols: '…' = missing data

YEAR	LONGLINE		POLE-AND-LINE		PURSE SEINE		OTHER		TOTAL
	MT	%	MT	%	MT	%	MT	%	
1950	...		...		...		...		...
1951	...		...		...		...		...
1952	...		...		...		...		...
1953	...		...		...		...		...
1954	...		...		...		...		...
1955	...		...		...		...		...
1956	...		...		...		...		...
1957	...		...		...		...		...
1958	...		...		...		...		...
1959	...		...		...		...		...
1960	...		...		...		...		...
1961	...		...		...		...		...
1962	...		...		...		...		...
1963	...		...		...		...		...
1964	...		...		...		...		...
1965	...		...		...		...		...
1966	...		...		...		...		...
1967	...		...		...		...		...
1968	...		...		...		...		...
1969	...		...		...		...		...
1970	130,575		...		15,530		66,028		...
1971	125,595		...		25,329		66,832		...
1972	142,811	29	233,607	47	31,381	6	86,565	18	494,364
1973	140,145	23	319,588	54	36,977	6	100,400	17	597,110
1974	130,777	21	361,957	57	35,802	6	105,354	17	633,890
1975	145,932	26	270,112	49	32,802	6	106,477	19	555,323
1976	174,728	25	374,173	54	45,694	7	100,066	14	694,661
1977	193,383	27	333,142	46	59,690	8	130,413	18	716,628
1978	194,469	25	388,978	51	57,165	7	126,034	16	766,646
1979	197,442	27	327,549	44	97,992	13	119,811	16	742,794
1980	208,696	26	374,001	47	112,203	14	98,622	12	793,522
1981	170,702	22	338,474	43	160,860	20	118,119	15	788,155
1982	163,620	20	292,381	35	253,170	30	125,557	15	834,728
1983	159,519	15	324,583	31	438,737	42	122,691	12	1,045,530
1984	144,014	13	384,760	35	444,612	41	122,461	11	1,095,847
1985	156,778	16	294,729	29	421,980	42	131,408	13	1,004,895
1986	147,040	13	359,507	32	481,717	43	135,557	12	1,123,821
1987	169,463	15	292,911	26	539,074	48	126,368	11	1,127,815
1988	168,450	14	304,108	25	586,193	49	148,001	12	1,206,751
1989	149,009	12	308,519	24	649,373	51	174,970	14	1,281,871
1990	167,082	12	239,989	17	792,093	57	198,409	14	1,397,572
1991	134,975	8	304,034	19	989,388	61	196,525	12	1,624,923
1992	159,308	10	247,393	16	963,129	62	173,623	11	1,543,453
1993	161,352	11	280,692	20	833,418	59	145,419	10	1,420,881
1994	179,535	12	249,529	16	952,426	62	153,779	10	1,535,268
1995	172,697	11	277,834	18	919,361	60	159,110	10	1,529,002
1996	164,208	12	240,860	17	860,137	60	158,173	11	1,423,378
1997	186,568	13	239,176	17	858,992	60	154,268	11	1,439,004

Table 7. Total catches of albacore, bigeye, skipjack and yellowfin in the eastern Pacific Ocean. Symbols: '…' = missing data

YEAR	ALBACORE		BIGEYE		SKIPJACK		YELLOWFIN		TOTAL
	MT	%	MT	%	MT	%	MT	%	
1950	...		...		56,574	41	82,656	59	139,230
1951	...		...		52,516	42	72,823	58	125,339
1952	25,216	17	...		38,435	27	80,910	56	144,561
1953	15,757	12	...		55,983	42	60,041	46	131,781
1954	12,393	9	...		69,741	51	54,166	40	136,300
1955	13,841	10	...		58,062	43	64,562	47	136,465
1956	19,233	11	...		68,175	40	81,876	48	169,284
1957	21,469	13	...		55,297	35	83,311	52	160,077
1958	14,903	9	...		73,098	45	75,139	46	163,140
1959	20,995	13	...		78,996	49	62,676	39	162,667
1960	20,661	11	...		46,741	26	113,804	63	181,206
1961	16,253	8	...		68,495	34	119,283	58	204,031
1962	30,328	13	44,528	19	68,759	30	85,570	37	229,185
1963	40,651	14	65,375	23	95,696	33	84,969	30	286,691
1964	28,515	12	45,468	19	59,334	25	108,652	45	241,969
1965	21,408	9	28,717	13	78,382	35	97,213	43	225,720
1966	21,230	10	34,366	17	60,660	29	91,517	44	207,773
1967	30,277	11	36,699	13	120,739	43	91,024	33	278,739
1968	30,935	12	36,775	14	71,266	28	118,204	46	257,180
1969	24,224	9	51,514	18	59,233	21	146,695	52	281,666
1970	31,057	11	33,830	12	56,130	19	169,485	58	290,502
1971	29,039	10	32,253	11	104,823	35	130,629	44	296,744
1972	32,433	11	38,036	13	33,585	11	193,072	65	297,126
1973	24,199	7	54,362	16	44,095	13	217,823	64	340,479
1974	32,023	9	37,163	10	78,866	21	220,157	60	368,209
1975	27,388	7	46,271	11	123,936	30	215,347	52	412,942
1976	22,992	5	61,152	13	126,245	27	252,025	55	462,414
1977	22,012	6	78,094	20	86,414	22	211,096	53	397,616
1978	29,370	6	82,336	17	169,887	36	191,041	40	472,634
1979	12,091	3	63,581	16	132,050	32	199,883	49	407,605
1980	13,279	3	73,463	19	130,690	34	172,377	44	389,809
1981	26,656	7	58,529	15	119,634	30	190,159	48	394,978
1982	15,180	5	48,022	16	98,786	33	134,747	45	296,735
1983	16,035	6	80,965	31	58,165	22	104,464	40	259,629
1984	21,279	7	72,504	23	60,575	20	155,426	50	309,784
1985	16,333	4	75,263	20	49,493	13	229,473	62	370,562
1986	13,501	3	109,390	23	63,594	13	290,566	61	477,051
1987	11,956	3	103,184	22	62,368	13	291,459	62	468,967
1988	15,275	3	61,687	13	85,386	18	301,388	65	463,736
1989	7,360	2	66,112	14	92,393	20	306,447	65	472,312
1990	9,301	2	87,333	18	72,645	15	303,955	64	473,234
1991	9,547	2	83,170	20	63,277	15	265,087	63	421,081
1992	20,585	5	70,261	16	83,978	19	256,182	59	431,006
1993	17,259	4	72,443	17	87,389	20	251,102	59	428,193
1994	19,890	5	82,698	20	75,457	18	241,306	58	419,351
1995	11,420	2	78,365	17	138,249	30	239,148	51	467,182
1996	12,561	3	85,750	18	112,077	24	261,094	55	471,482
1997	11,334	2	85,172	16	157,626	30	271,820	52	525,952

Table 8. Total catches of albacore, bigeye, skipjack and yellowfin in the Pacific Ocean. Symbols: '…' = missing data

YEAR	ALBACORE		BIGEYE		SKIPJACK		YELLOWFIN		TOTAL
	MT	%	MT	%	MT	%	MT	%	
1950	...		...		...		...		...
1951	...		...		...		...		...
1952	94,199		...		...		...		...
1953	76,807		...		...		...		...
1954	61,494		...		...		...		...
1955	54,507		...		...		...		...
1956	76,464		...		...		...		...
1957	92,268		...		...		...		...
1958	55,723		...		...		...		...
1959	51,333		...		...		...		...
1960	63,316		...		...		...		...
1961	52,610		...		...		...		...
1962	82,490		...		...		...		...
1963	100,024		...		...		...		...
1964	85,353		...		...		...		...
1965	99,134		...		...		...		...
1966	105,542		...		...		...		...
1967	123,736		...		...		...		...
1968	99,037		...		...		...		...
1969	100,680		...		...		...		...
1970	100,583		70,960		...		257,795		...
1971	126,726		70,415		...		220,663		...
1972	143,958	18	89,350	11	259,954	33	298,228	38	791,490
1973	145,655	16	96,009	10	357,664	38	338,261	36	937,589
1974	146,859	15	82,552	8	426,893	43	345,795	35	1,002,099
1975	116,906	12	103,770	11	400,959	41	346,630	36	968,265
1976	149,937	13	133,735	12	475,714	41	397,689	34	1,157,075
1977	98,917	9	149,512	13	478,168	43	387,647	35	1,114,244
1978	136,211	11	136,380	11	601,873	49	364,816	29	1,239,280
1979	100,814	9	127,742	11	528,063	46	393,780	34	1,150,399
1980	107,579	9	134,751	11	560,424	47	380,577	32	1,183,331
1981	105,853	9	111,620	9	551,240	47	414,420	35	1,183,133
1982	100,056	9	106,715	9	571,953	51	352,739	31	1,131,463
1983	81,096	6	140,565	11	726,400	56	357,098	27	1,305,159
1984	95,658	7	135,563	10	773,241	55	401,169	29	1,405,631
1985	90,970	7	143,943	10	653,489	48	487,055	35	1,375,457
1986	82,086	5	173,118	11	810,716	51	534,952	33	1,600,872
1987	78,768	5	184,058	12	739,495	46	594,462	37	1,596,782
1988	84,790	5	127,466	8	898,046	54	560,185	34	1,670,487
1989	97,755	6	141,428	8	896,921	51	618,079	35	1,754,183
1990	90,769	5	175,947	9	952,912	51	651,179	35	1,870,806
1991	64,835	3	157,852	8	1,180,159	58	643,157	31	2,046,004
1992	90,550	5	158,582	8	1,080,340	55	644,987	33	1,974,459
1993	89,711	5	147,442	8	971,194	53	640,727	35	1,849,074
1994	110,527	6	166,444	9	1,049,867	54	627,781	32	1,954,619
1995	100,028	5	154,757	8	1,155,358	58	586,041	29	1,996,184
1996	110,713	6	162,322	9	1,095,694	58	526,131	28	1,894,860
1997	109,016	6	181,217	9	1,008,480	51	666,243	34	1,964,956

Table 9. Catches of albacore, bigeye, skipjack and yellowfin by ocean area. Symbols: '…' = missing data; estimates in parentheses have been carried over from previous years

YEAR	WPYR		EPO		ATLANTIC		INDIAN		TOTAL
	MT	%	MT	%	MT	%	MT	%	
1950	...		139,230		42,335		14,300		...
1951	...		125,339		37,617		15,400		...
1952	...		144,561		39,012		23,297		...
1953	...		131,781		38,735		26,252		...
1954	...		136,300		48,408		37,792		...
1955	...		136,465		43,120		52,683		...
1956	...		169,284		52,942		69,016		...
1957	...		160,077		77,396		56,263		...
1958	...		163,140		100,474		50,976		...
1959	...		162,667		122,384		55,266		...
1960	...		181,206		145,384		67,764		...
1961	...		204,031		135,231		73,568		...
1962	...		229,185		169,697		89,737		...
1963	...		286,691		188,374		72,382		...
1964	...		241,969		201,987		75,522		...
1965	...		225,720		222,254		85,665		...
1966	...		207,773		181,817		101,838		...
1967	...		278,739		184,929		129,552		...
1968	...		257,180		228,018		167,846		...
1969	...		281,666		236,693		147,218		...
1970	...		290,502		237,191		115,987		...
1971	...		296,744		290,960		117,636		...
1972	494,364	41	297,126	25	301,937	25	112,940	9	1,206,367
1973	597,110	44	340,479	25	306,180	23	115,282	8	1,359,051
1974	633,890	42	368,209	24	360,996	24	149,773	10	1,512,868
1975	555,323	40	412,942	30	301,679	22	128,686	9	1,398,630
1976	694,661	43	462,414	29	316,953	20	125,598	8	1,599,626
1977	716,628	44	397,616	24	372,569	23	143,970	9	1,630,783
1978	766,646	44	472,634	27	368,658	21	153,281	9	1,761,219
1979	742,794	46	407,605	25	338,014	21	135,496	8	1,623,909
1980	793,522	47	389,809	23	368,224	22	134,999	8	1,686,554
1981	788,155	45	394,978	23	413,241	24	140,498	8	1,736,872
1982	834,728	47	296,735	17	465,834	26	176,559	10	1,773,856
1983	1,045,530	54	259,629	13	423,898	22	195,882	10	1,924,939
1984	1,095,847	54	309,784	15	366,981	18	260,826	13	2,033,438
1985	1,004,895	48	370,562	18	419,412	20	301,030	14	2,095,899
1986	1,123,821	48	477,051	20	404,099	17	345,341	15	2,350,312
1987	1,127,815	48	468,967	20	384,235	16	385,465	16	2,366,482
1988	1,206,751	47	463,736	18	396,037	15	499,428	19	2,565,952
1989	1,281,871	48	472,312	18	404,828	15	517,031	19	2,676,042
1990	1,397,572	49	473,234	16	460,629	16	549,104	19	2,880,539
1991	1,624,923	53	421,081	14	497,441	16	532,226	17	3,075,671
1992	1,543,453	51	431,006	14	450,291	15	624,470	20	3,049,220
1993	1,420,881	46	428,193	14	505,436	16	738,164	24	3,092,674
1994	1,535,268	49	419,351	13	500,193	16	694,325	22	3,149,137
1995	1,529,002	48	467,182	15	454,197	14	707,405	22	3,157,786
1996	1,423,378	47	471,482	15	448,043	15	(707,405)	23	3,050,308
1997	1,439,004	46	525,952	17	(448,043)	14	(707,405)	23	3,120,404

APPENDIX 1. RECORD OF DISCUSSION OF THE WORKSHOP ON PRECAUTIONARY LIMIT REFERENCE POINTS

INTRODUCTORY COMMENTS

The Honourable ’Akau’ola, Secretary of Fisheries, Tonga, and current Chairman of the Standing Committee on Tuna and Billfish, opened the meeting. In his introductory comments, he outlined the background to the workshop, convened in association with SCTB11 and at the direction of the MHLC Inter-sessional Technical Consultation on Issues relating to Fisheries Management. He described its terms of reference, i.e. to consider the technical issues associated with the application of the precautionary approach and reference point-based management, and noted that a report of the workshop deliberations was to be presented to MHLC3 in Tokyo, 22–26 June 1998, after clearance by the group. The workshop was structured as a series of seven linked sessions, each moderated by an invited expert.

SESSION 1: Overview of the Precautionary Approach and its Application to Fisheries Science and Management (Moderator: Dr Robin Allen)

Dr Allen provided the workshop with an overview of the precautionary approach and its possible application to the management of tuna fisheries. The approach has its origins in the 1992 UN Conference on Environment and Development, Principle 15, and has since been incorporated in two international instruments: the Agreement for the Implementation of the Provisions of UNCLOS Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNIA) and the FAO Code of Conduct for Responsible Fishing.

The UNIA is intended to be part of international law, has been ratified (as at 17 April 1998) or acceded to by 18 states (six of them Pacific island nations). While it generally applies to areas outside national jurisdiction, the articles concerning the precautionary approach also apply within areas of national jurisdiction. Its application is restricted specifically to highly migratory and straddling fish stocks.

The Code of Conduct, negotiated at the same time as the UNIA, is a voluntary consensus agreement among FAO members, but with wide application.

In both instruments, there are general principles or obligations for conservation and management, and in both, the precautionary approach is not a management goal, but provides guidance in achieving such goals. Article 6 and Annex II of the UNIA, and Articles 6 and 7 of the Code of Conduct are most relevant in this regard, Annex II in particular providing guidelines for the establishment and use of precautionary reference points. Limit reference points are intended to constrain harvesting within safe biological limits, and target reference points (TRPs) provide management targets. Annex II concludes that the fishing mortality rate that generates maximum yield (MSY) should be regarded as a minimum standard for limit reference points (LRPs). The use of reference points enables the establishment of management goals rather than avoiding overfishing or exceeding MSY, but does not require new ideas or techniques. Where available data are limited, management measures are still required, and provisional reference points (PRPs) may be established, by analogy if necessary.

The precautionary approach, in summary, embodies six main elements:

- caution (to be applied widely, to protect resources and preserve the environment); more caution required when uncertainty; absence of adequate information no reason for failing to take measures);
- information and analysis (obtain and share best available information; need to deal with risk and uncertainty);
- reference points (use of limit and target reference points for conservation and management objectives respectively; develop plans as LRPs are approached or TRPs exceeded);
- non-target species, associated or dependent species and their environment (assess impacts of fishing; ensure conservation of species and protection of habitat);
- new or exploratory fisheries (early adoption of cautious measures or PRPs, remaining in effect until fishery impacts assessed; gradual development; set provisional reference points); and
- natural phenomena (adopt conservation and management measures to ensure fishing does not exacerbate the situation).

The precautionary approach signals a political intent to adopt a cautious approach that will balance the use of resources with protection of the environment. It does not require new scientific tools or techniques, but scientists will need to provide information to those making resource management decisions in a way that facilitates that process.

Application of the precautionary approach to the management of tunas, based on previous experience with the response of stocks to fishing, suggests that management will be related to the tuna stocks themselves. The following issue will influence the application of the precautionary approach. Recruitment for most tuna species has not generally been reduced as a result of reduced parental stock size, and, accordingly, LRPs might be based on a stock size (or equivalent level of fishing mortality). Environmental changes may affect abundance and/or availability of tunas and the precautionary approach will be different depending on whether abundance or availability is affected. Tuna stock assessment models typically have uncertainty associated with estimates and risks associated with management measures that will need to be assessed for managers. Levels of bycatch (NTAD species), while generally low, may be of concern in some cases and, in most cases, impacts of fishing on them are poorly understood.

Following the presentation, discussion on the main elements of the precautionary approach and its application initially centred on the apparent conflict between imposing precautionary measures, or provisional reference points (PRPs), at low levels of effort and the need to acquire adequate information on the response of the stock to increasing levels of exploitation. The possibility of increasing effort gradually and examining feedback was considered desirable, retaining the right to revise PRPs if negative feedback was received. The view was expressed that few tuna fisheries are, in reality, in new or exploratory phases. In the case of limit reference points (LRPs), however, it was important that once established, they not be exceeded.

In considering when to apply the precautionary approach, one view was that a decision matrix could be useful to take account of differing amounts of information available for different stocks. The guiding principles were generally that the approach should be applied widely, that more caution should be applied when there was more uncertainty (or relatively few data), and that the overall context of sustainable development should always be kept in mind.

That scientific advice, or LRPs, might itself incline towards or include precautionary elements was strongly discouraged, the unanimous view being that the best possible scientific advice be provided without bias, and that the management decisions themselves include precautionary factors and define acceptable levels of risk and uncertainty. An example was provided (Hawaiian lobster) where such a level of risk was prescribed by managers, and reference point parameters developed in accordance with these guidelines.

In response to an expressed view that the focus of the workshop on LRPs might be too restrictive, it was clarified that the MHLC process was not yet ready to consider target or management reference point issues, but that these can be kept in mind and can be brought to the attention of MHLC where appropriate. It was further noted that management decisions, such as setting TRPs, need to consider not just scientific advice, but other types of advice as well; the scientific advice needed to be well framed and more transparent to facilitate this process and not be ignored. Part of this process was framing uncertainty (and risk) for managers, which might relate to uncertainty in the available data or uncertainty as to which reference points might be appropriate. In dealing with uncertainty or perceived threats, there was a tendency to impose more restrictions while ignoring the need for more data or research.

While noting that no new tools or techniques were required for the precautionary approach, there was some change in emphasis on areas such as risk, uncertainty, NTAD species and the environment. More research and information would generally be required in such areas.

SESSION 2: Review of Precautionary Reference Points (Moderator: Dr Jacek Majkowski)

Dr Majkowski tendered an apology for the unexpected absence of Dr John Caddy, the original moderator, and presented the keynote paper, entitled "A short review of precautionary reference points, and some proposals for their use in data-poor situations," on his behalf.

The presentation outlined the recent development and use of reference points in fisheries management, and how they are being used to contribute to the precautionary approach. The paper describes several examples where considerable progress had been made in the north Atlantic area, with specific mention of the work done by the North Atlantic Fisheries Organization (NAFO) and the International Council for the Exploration of the Sea (ICES). However, it was noted that the existence of time series of age-structured data available for this work is unlikely to be a situation applicable to many tuna stocks. As such, a number of options to be further explored were described.

The paper classifies LRPs according to their applicability in data-poor situations. Yield per recruit analyses typically use F_{max} as the LRP and $F_{0.1}$ as the corresponding TRP, both being subject to change as a result of changes in age distribution, recruitment and selectivity. Reference points from spawning stock biomass per recruit analyses include $F_{rep,}$ F_{high} and F_{low} and may also be subject to variability due to changes in age distribution, recruitment and selectivity. The LRP obtained from production modelling has been F_{MSY}; nowadays, this value is more likely to be set at lower levels, such as $F_{0.1}$ or two-thirds the value of F_{MSY}. Also relevant to the production modelling approach is consideration of the economic equilibrium, F_{MEY}. Reference points based on survey data were understood to be unsuitable for tuna fisheries, while reference points based on past yields from a fishery can provide some rough indication of future potential, as long as independent biological conditions support the continuity of the fishery at historical levels. Several examples of the past yields approach that could be used to establish quotas were highlighted and include the Maximum Constant Yield, Current Annual Yield, Maximum Average Yield and the 'Magnusson-Stefansson feedback gain rule'.

Two possibilities of how to use established LRPs were proposed. The 'targeted' approach holds that the fishery is managed to try to hit the TRP, with the proviso that precautionary considerations, statistical analyses and modelling aim to minimise overshoots. The 'non-targeted' approach holds that the fishery operates at the economically optimal level of effort with no TRP, with the proviso that on triggering one or more LRPs, the fishing effort is reduced significantly the next season.

In regards to the problems and approaches for tuna fisheries, it was noted that economic considerations would have to be included, as well as the simple biological criteria, at the outset. In the event that the relevant data are available, certain indices could be used to monitor the fishery from an economic standpoint. It was also noted that reference points could also be established from appropriate size and age data.

Two areas that require attention in the establishment of reference points are consideration of the multi-species nature of the fishery and spatial information related to the fishery (e.g. highly migratory species).

Several issues were raised during the ensuing discussion. The issue of the use of MSY in the establishment of reference points was raised. It was believed that MSY would be problematic in data-poor situations; for example, if MSY is not exceeded, then it is not possible to determine where it lies. There was concern that MSY was 'model dependent' with the possibility of different values of MSY being obtained from different models. Also, it was noted that it appears that stock size and recruitment may have no relation in the WCPO tuna fisheries, whereas the notion of MSY relies on there being a relation between stock and recruitment, a factor catered for in age-structured models, for example.

The discussion also centred on the concern that 'F' type reference points are not amenable to a single value in the tuna fisheries situation, since there is high variability both temporally and spatially. It was suggested that separate LRPs could be established at the regional and national level, dependent on one's perspective on managing the stocks. Establishment of LRPs in this way would have to be coordinated in some manner and deal with any interaction issues that may arise.

In establishing LRPs, it was noted that gaining industry input and cooperation was fundamental.

It was noted that the UNIA does not yet place any obligation for the establishment of reference points.

SESSION 3: Setting Limit Reference Points and Definitions of Overfishing (Moderator: Dr Pamela Mace)

Dr Mace made her presentation citing the U.S. experience, where there has been a long and intensive history relevant to the development of overfishing definitions and biological reference points, as well as recent experience interpreting the precautionary approach.

Since 1989, fisheries management plans have been required to specify an objective and measurable definition of over-fishing for each stock or stock complex.

Between 1989 and 1996, considerable work was put into determining reference points indexing recruitment overfishing, particularly reference points based on percentage spawning biomass per recruit. Recruitment over-fishing occurs when fishing mortality is so high that a stock cannot replenish.

Management plans now have to incorporate recent changes to the 1996 Magnuson-Stevens Act (with respect to over-fishing criteria) where 'optimum yield' is prescribed as such on the basis of the maximum sustainable yield from the fishery as reduced by any relevant economic, social, or ecological factor. 'Overfishing' is a rate of fishing mortality that jeopardises the capacity of a fishery to produce the maximum sustainable yield on a continuing basis.

Important points from the 1995 UNIA were emphasised, being:

- Two types of precautionary reference points should be used: conservation, or limit, reference points and management, or target reference points.
- Fishery management strategies shall ensure that the risk of exceeding limit reference points is very low, and target reference points should not be exceeded on average.
- The fishing mortality rate that generates MSY shall be regarded as a minimum standard for limit reference points.

Potentially, this UNIA will not be binding for national fisheries management plans. However, the United States and other nations, as well as international organisations such as ICES and NAFO, have embraced the concepts presented in that agreement.

The United States now has guidelines to define 'over-fishing', which are called 'status determination criteria'. These require that each fisheries management plan must specify, to the extent possible, objective and measurable status determination criteria which must include both (1) a maximum fishing mortality threshold or reasonable proxy thereof, whereby $F > F_{limit}$ for one year or more constitutes overfishing, and (2) a minimum stock size threshold, or reasonably proxy thereof: whichever is the greater of half B_{MSY} or the minimum stock size at which rebuilding to B_{MSY} would be expected to occur within ten years if the stock were exploited at the maximum fishing mortality threshold. $B < B_{limit}$ means that the stock is considered to be overfished.

The simplest interpretation is when the MSY control rule is a constant F and the fishing stock is productive and resilient and can rebuild quickly. Then F greater than F_{MSY} constitutes overfishing and B less than half B_{MSY} means that the stock is considered to be overfished.

Dr Mace then provided a number of examples, derived from the International Commission for the Conservation of Atlantic Tunas (ICCAT) data of stocks, which according to the above criteria are, or have been, over-fished, including the western Atlantic bluefin tuna, which is in an over-fished condition with possible over-fishing still occurring. The north Atlantic swordfish is approaching an over-fished condition and is continuing to suffer severe over-fishing, while the Atlantic blue and white marlins are in severely over-fished condition and are continuing to be severely over-fished.

MSY control rules were presented including a Default Limit Control Rule, which specifies F_{MSY} as the upper limit on fishing mortality for a healthy stock, with reduced fishing mortality at low biomass, and a Default Target Control Rule, where the target is 75 percent of the F_{MSY} limit. The United States is now assessing the consequences of such a Target Control Rule.

It was discussed, especially in regard to data deficient fisheries, how MSY is difficult to calculate, so consequently a number of 'proxies' have been suggested to use in its stead. These include F_{max}, $F_{0.1}$, F=M, F_{med}, $F_{20\%}$, $F_{30\%}$, $F_{35\%}$, $F_{40\%}$, 30–60 % B_0, R_{mean} x $SPR_{30\%}$ and CPUE as a relative index.

ICES and NAFO are also in the process of developing reference points using fishing mortality and biomass. There are many common threads, but it was stressed that despite the long history of development of reference points, overexploitation of fisheries has not been prevented in many fisheries. It was stressed that fisheries scientists and managers must focus not only on biological reference points, but look wider to developing access control systems, evaluating alternative management systems and institutions, improving quality and reliability of input data improving monitoring and enforcement, designing 'environmentally friendly' fishing gear, and other facets of the precautionary approach.

The meeting went on to discuss the importance of precautionary management and not precautionary science. It was stressed that scientists should present good science for the managers to then make precautionary management plans. It was also stressed that this process should be transparent and include industry and other resource users.

The point was made that in order to determine stock status relative to reference points, it is essential to have a credible stock assessment that estimates overall fishing mortality.

The problem of different fisheries harvesting different components (age and area) of the stock were discussed, as was the concept of whether overfishing should be assessed 'globally' or 'locally'. The consensus was global, though it was pointed out that 'local' nations and/or fisheries could be adversely affected due to this.

There was also some discussion on the validity of using MSY to determine reference points. It was pointed out that it is up to the people involved in fisheries of the central and western Pacific to make their own interpretation of the appropriate acts and legislation.

SESSION 4: Use Of Sustainability Indicators In Evaluation Of Harvest Strategies (Moderator: Dr Tony Smith)

Scientists need to provide information in order to facilitate management decisions, and Dr Smith addressed the workshop on incorporating sustainability indicators into evaluating management harvest plans.

The broad aim of Management Strategy Evaluation (MSE) is to identify 'robust' harvest strategies that achieve fishery management objectives. These objectives usually include a combination of resource utilisation and resource conservation. Objectives may be potentially conflicting and different harvest strategies may achieve one objective and not another. The responsibilities of scientists are to compare alternative harvest strategies and examine trade-offs in performance of each strategy across the range of management objectives.

Components of the MSE include: (1) clearly defined management objectives, (2) performance measures related to those objectives, (3) a set of management strategies or options under consideration, (4) a method to predict the performance for each strategy, and (5) communication of the results to decision makers.

An MSE models the whole management cycle. An imaginary example of how an MSE could be conducted was presented. An essential element in the approach is to conduct simulation tests over a range of possible harvest strategies. An output of the MSE is a decision table, which provides a basis for decisions and examining trade-offs between multiple objectives.

Performance indices and measures are used to quantify management objectives. Performance indices are used in monitoring fishery trends, reporting whether management objectives are being met and as elements in decision rules. Performance measures are used to compare the performance of harvest strategies. These measures should be easily understood, show adequate contrast between management options, and be related to objectives.

Uncertainty is an inherent element in the MSE process. Types of uncertainty include process (e.g. future recruitment variability), observational, model, estimation, implementation (total allowable catch vs landings, landings vs catch) and institutional (changing objectives and stakeholders).

The last element of the MSE is communicating results to decision makers. In communicating results, it is essential to identify who are the decision makers, to distribute the basic decision table, provide choices of performance indicators and to communicate uncertainty. Though results can be communicated to decision makers, sometimes the entire system can fail as management does not respond to science or fishermen do not respond to management decisions.

An Operational Model (OM) can be utilised to predict performance of the process. An OM was compared and contrasted to a Stock Assessment Model (SAM). General features of the two models include: (1) OMs usually include a wider range of alternative hypotheses; (2) SAMs can be used to parameterise OMs; (3) OMs are used to calculate performance measures, whereas SAMs calculate performance indices; (4) OMs are used to test the performance of a SAM; and (5) OMs need not be explicitly fitted to data and need less information.

During the following discussion, it was mentioned that an operational model could be developed even in a new fishery. Though uncertainty can be very wide, it was suggested that parameters could be chosen with reasonable bounding, and basic life-history information could be included. Dr Campbell then outlined an OM approach for the developing domestic longline fishery in Australia. In the future, an OM could be built for this fishery which will generate management decision rules. It was also noted that an OM approach has applicability in situations where there is some information about the fishery. The OM could be used to infer some robustness in the methods and possibly develop some simpler types of reference points. The performance of reference points, and performance indices based on them, should be tested within an MSE framework.

SESSION 5: The Impact of Environmental Variability on Highly Migratory Fish Stocks: How to Accommodate in Reference Point Management Systems? (Moderator: Dr Jeff Polovina)

Dr Polovina started his presentation with several examples of physical-biological links in pelagic fisheries. Some estimates of south Pacific albacore recruitment obtained from an integrated catch-at-age model seem to be well correlated with variations in interannual environmental conditions related to El Niño-La Niña events. Similarly, north Pacific albacore catches are higher during higher sea surface temperature regimes. Zonal shift in fishing grounds and catches of U.S. purse seiners in the western and central inter-tropical Pacific are also well correlated with El Niño-La Niña events. Variation in CPUEs of longline-caught swordfish in Hawaii has also been studied in relation to some environmental parameters, and a strong relationship with sea surface height (SSH) has been demonstrated. High levels of SSH seem to correspond with low CPUEs, while higher values of CPUE are observed at low SSH levels. SSH is a good indicator of the heat content of seawater. When the sea temperature is low, the sea surface is depressed and the thermocline rises closer to the surface, leading to an increase in catchability. This is another example of the need for caution when using unadjusted CPUEs as abundance indices.

The second part of the presentation focussed on some ways of incorporating environmental variability in a precautionary approach to harvesting strategies. Work conducted on Pacific sardines was first presented. Three SST regimes were defined. For each regime, the stock recruitment relationship was found to be very different, resulting in large variations in both biomass levels and MSY. It is thus impossible in such situations to have only one harvest policy. Another study dealt with demersal stocks such as haddock or cod. The population was assumed to go through decadal variation in carrying capacity, reflecting variations in environmental conditions. Three simulations of catch variations were conducted based on several hypotheses: fixed exploitation rate, no information on the evolution of the system, prefect knowledge of the system. It was found that catches were not significantly different in the three simulations, suggesting that in such a case, knowledge of the environmental conditions and their evolution is not fundamental, as long as the biomass level is known.

A description of the environment and its evolution in the inter-tropical Pacific was then presented. It shows that a shift from a cool to a warm temperature regime, and a strong to a weak upwelling regime, occurred in the mid-seventies. This seems to have had an impact on yellowfin recruitment in the eastern Pacific, with higher recruitment being estimated during the higher temperature regime.

In conclusion, when large variations in stock productivity are observed, it is not possible to define only one harvest policy; one for each regime of productivity is necessary. Harvest strategies must be related to variable productivity, environmental effects and a knowledge of the variation in biomass.

During the discussion, it was noted that a good estimate of biomass is only necessary in the TAC-based management context, which is not the case when the fishing effort, or more precisely the fishing mortality, is used as a tool for management. It was also suggested to use the operational model approach (as presented during Session 4) to test the impact of various environmental conditions on the evolution of the fishery system and the evaluation of harvest strategies. The risk of using too many environmental data series leading to meaningless correlations was also highlighted. It was suggested that using a more mechanistic approach, rather than correlation analyses, was a way of avoiding such a problem. Finally, not only the value of biomass, but also its spatial distribution, needs to be accounted for, together with the way fishermen interact with this spatial distribution.

SESSION 6: Current Status Of Stock Assessment For The Target Tuna Species Of The Western And Central Pacific – Options For The Application Of Precautionary Reference Points (Moderator: Dr John Hampton)

Dr Hampton briefly reviewed the tuna fisheries of the WCPO, highlighting the catch by species for the main fishing gears, and the distribution of their effort. He then reviewed the quality of fishery data, biological information and stock assessment methods currently available for the four target tuna species as a series of summary matrices. In general, the least fishery data are available for bigeye, few data are available on non-retained catch, and other more species-specific gaps exist. General data problems include catch and effort data for the fisheries of Indonesia and the Philippines, appropriate measures of effort, estimates of bigeye catches and data integration. Gaps in available biological data are greatest for bigeye, and characteristics of recruitment and mortality for most species are uncertain.

The various stock assessment approaches that have been applied to WCPO tunas – abundance indices, production models, tagging data, VPA, statistical catch-at-age models and integrated models – were then reviewed, and examples provided of their application. Abundance indices could be much improved by the inclusion of environmental factors, as with a recent example for bigeye longline catch rates. The tagging data for skipjack and yellowfin tuna, which have been used in attrition models to produce estimates of F and M, could also be used to produce tag-based reference points as a specified level of exploitation, but this has the disadvantage of referring to the tagging period only. Extrapolation to other time periods would be dependent on various assumptions. Age-structured models, as developed for south Pacific albacore, can be used to estimate many parameters of interest, and could be used in risk analysis, by including process error and the statistical uncertainty in estimates. Statistical age-structured models could enable stock assessment relative to biomass, provide F-based reference points with estimates of uncertainty, and be adapted to harvest strategy assessment using risk analysis. These will certainly be applicable to albacore, and possibly yellowfin and bigeye.

Concerning the application of provisional reference points, scenarios were outlined for this in data-rich and data-challenged situations. With the latter the more normal situation, CPUE and size monitoring, monitoring the spatial distribution of the stock or fishery, application of operational models, and periodic tagging were felt to be potentially useful approaches to tuna stocks in the WCPO.

In the ensuing discussion, the utility of other approaches was considered. Spawning stock biomass per recruit had been found useful in the U.S. situation and was amenable to investigation by simulation, as was relative adult or parental biomass, with levels of 30 percent or so suggested as being suitable for tunas. The possible use of fishery-independent approaches, such as remotely-sensed stock size estimates and pelagic ecosystem models was raised. The scale of the WCPO itself was felt to limit many fishery-independent approaches at present, whereas the lack of information on trophic and other links within pelagic ecosystems would constrain the use of ecosystem models. These may well need to be considered with respect to NTAD species.

The case of mixed species fisheries, e.g. tuna purse-seine fisheries taking skipjack, yellowfin and bigeye, was raised. Selectivity needed to be considered, but if catches of a particular species of concern could not be avoided or limited, then controls might be needed and catches of other species may be impacted.

The need to consider bycatch, or NTAD species, in tuna fisheries was identified, noting that the UNIA required that the impact of fishing on NTAD species be assessed. In the Hawaiian longline fishery, a type of 'trigger level', not exactly a biological reference point, had been applied for turtle bycatch. Billfish stocks were recognised as needing attention, given various possible fishery interactions. Sharks, a significant tuna longline bycatch, provided an example of the difficulty of assessing fishery impacts on NTAD species, as even the level of catch was not known with any certainty.

In providing scientific advice to managers, the need to indicate levels of uncertainty in stock assessments – using risk analysis, decision tables, trigger indicators, etc. – was recognised, as was the need to interact with and better inform managers, not just scientists, on the application of the precautionary approach.

SESSION 7: The Application of Precautionary Reference Points in 'Data-Poor' Situations (Moderator: Dr John Sibert)

Dr Sibert commenced this session with the statement that, in his opinion, in order to achieve goals with the precautionary approach, one needs to be more creative. He then provided a classification of the information required to implement precautionary reference points:

- sufficient understanding of the resource and the fishery to determine appropriate indicators of the condition of the resource;
- sufficient understanding of the resource and the fishery to determine an effective regulatory response;
- sufficient understanding of the resource and the fishery to determine an appropriate threshold value of an indicator that will trigger the regulatory response;
- data on the resource and the fishery that is timely and informative about the indicator;
- statistical procedures used to estimate the value of the indicator from available data to indicate whether the threshold value has been exceeded; and
- the means to implement the regulatory response, that is: monitoring, control and surveillance; economic resilience; and political resilience.

He posed the question whether the satisfactory implementation of reference points, given the above criteria, would have prevented some of the fishery problems that have occurred throughout the world, e.g. the collapse of the north Atlantic cod fishery.

A matrix showing the level of 'data poverty' for each species group was presented (see below). Data categories were scored from 1 (poor data) to 3 (good data). The total score for all data categories provided an indication of whether sufficient data were available to conduct appropriate stock assessment analyses for that species. Significantly, only three tuna species were identified with a score of more than 10, a score which was used to indicate that sufficient information existed in order to consider appropriate stock assessment analyses.

Species or Species Group		Biological Data	Fishery Statistics	Tagging	Assessment Model	Regulatory Response	Total Score
Tunas	Skipjack	3	3	3	1	0	**10**
	Yellowfin	3	3	3	3	2	**14**
	Albacore	3	3	3	3	0	**12**
	Bigeye	2	2	1	2	0	7
	Bluefin	2	2	1	1	0	6
Swordfish		1	2	1	0	0	4
Marlins		1	2	1	0	0	4
Sharks	Blue	2	2	0	0	0	4
	Others	1	1	0	0	0	2
Others	Mahi mahi	3	1	0	0	0	4
	Wahoo	1	1	0	0	0	2
	Opah	0	1	0	0	0	1
	Turtles	3	1	3	2	0	9
	Albatrosses	3	1	3	2	0	9

Further, stock assessment models of greater complexity, and therefore requiring a greater amount of time and effort, usually achieved better results, according to an NRC[7] document. To date, sufficient funds have not been allocated to enable the level of work on this scale for most of the species groups mentioned.

A breakdown of the modalities of fisheries management were then presented:

- Numeric: for example, reference points, production models, VPA, business as usual, risky;
- Parametric: biological, customary, community-based decentralisation; note that these are not appropriate for highly migratory species; and
- Non-parametric: insensitive to assumptions regarding the dynamics, fail-safe, inherently precautionary; examples of this modality are closed areas and seasonal closures.

In summarising the session, Dr Sibert believed that it was not possible to come up with appropriate reference points in data-poor situations and that the provision of adequate funding was necessary to remedy this situation in the future. As such, the following recommendations were offered:

1. Secure a minimum ten-fold increase in funding.
2. Establish a permanent (ongoing) tagging programme for tuna and billfish.
3. Consider the establishment of a closed area in the high seas.
4. Task the Research Groups of the SCTB to look into the establishment of reference points for the four species of tunas.

In the ensuing discussion, there were supporting comments made for recommendations (1), (2) and (4). Specifically, it was suggested that the MHLC process should task the Research Groups of the SCTB to consider Limit Reference Points, work that is understood will take several years. In regards to funding, there was mention that some form of prioritisation for apportioning the funding to species groups (e.g. target species versus bycatch and ecosystem research) would have to be

6 National Research Council. 1998. Improving Fish Stock Assessment. National Academy Press, Washington D.C.

established. The benefits of new technology (e.g. pop-up archival tags) in tagging programmes were also highlighted.

Recommendation (3), regarding the closure of the high seas area to all fisheries, generated much discussion. The choice of the high seas was understood to be a better alternative to the problems involved in closing an EEZ to fishing, as it would be easier to administer. In effect, the introduction of closed areas is a proxy for effort limitation and ecosystem protection. However, it was generally believed that the highly migratory nature and other aspects of the species would make it inappropriate to establish a closed area in the high seas. For example, there would be increased costs in surveillance of the closed area and of research.

It was noted that the UNIA allows for reasonable decisions and judgement, i.e. common sense, in data-poor situations, and does not necessarily imply that a fishery should be cut back due to a lack of information. Research priorities are determined by management objectives; therefore, more linkage between these areas should be stressed.

SESSION 8: Summing Up And General Discussion (Moderator: ’Akau’ola)

The Chairman introduced a series of points for discussion, to draw together issues raised during the workshop, as a basis for the report to be presented to MHLC3. These, with associated discussion, are summarised as follows:

1. *Is Annex II of the United Nations Implementing Agreement, Guidelines for the Application of Precautionary Reference Points in Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, an appropriate starting point? If so, how best would this be applied to the western and central Pacific Ocean, and are there special requirements for highly migratory species in this region?*

The UNIA, with Annex II, will enter into force (six Pacific Island Nations have already ratified the UNIA) and will serve as the accepted guideline for the application of precautionary reference points. While there may be some reservations about the use of F_{MSY}, which generates MSY as the minimum standard for limit reference points, and MSY as a stock indicator for management generally, this approach can probably be accommodated for the highly migratory fish stocks of the WCPO. One view was expressed that there may, however, be other means of achieving the goals of the precautionary approach other than by the use of reference points, and these should be explored further.

It was noted that recruitment for most tunas had not generally been reduced as a result of parental stock reductions, and that limit reference points might be based on measures of stock size or equivalent levels of fishing mortality. Recruitment may, however, be subject to environmental influences, and reference points may therefore need environmental links or components.

2. *The choice of appropriate limit reference points.*

It was difficult to conclude unequivocally what type of limit reference point(s) would be best suited to tunas, and simulations could usefully be undertaken to address this. Assessment work should proceed and reference points gradually be identified which are relevant and available. It was also suggested that the SCTB Research Groups might relate their work plans to reference point needs, which will be data-dependent and stock-specific; that a check list of information currently available could usefully be compiled; and that the Research Groups begin to develop various types of reference points using this information.

3. Should science be precautionary?

It had been earlier affirmed that the best possible science should be provided without bias. Any suggestion that scientific advice in the form of LRPs be inclined towards or include precautionary elements should be strongly discouraged. Management decisions, on the other hand, should include precautionary factors and should also define acceptable levels of risk and uncertainty.

4. Global versus local issues in the conservation and management of highly migratory species.

In responding to concerns as to how local conservation or management issues (e.g. local depletion) might be dealt with by the global or regional precautionary approach and reference points, the view was expressed that while spatial aspects may need to be considered, and these may indeed be quite complex, the MHLC would most likely deal with stock-wide or regional scales. Provided replenishment can be assumed, and provided that action taken on a localised basis did not undermine conservation measures for the stock, issues such as local depletion are more of a national concern.

5. Delivery of science within the precautionary approach framework.

It was agreed that this should incorporate the best possible science, that estimates of uncertainty should be associated with advice provided, and that scientific advice should be well framed and transparent. It was also stressed that interaction with managers in framing advice is important, and that management objectives need also to be well defined. Where resources are limited, as is usually the case, priorities will need to be established.

6. Management response to uncertainty.

This usually involves imposition of more restrictions on fishing activity, but would more usefully also involve the direction of more resources to increased data collection and research, in order to reduce the levels of uncertainty. Although the required response to uncertainty under the precautionary approach was clear, the meeting agreed that efforts to reduce uncertainty through increased research should be encouraged wherever possible.

It was also noted that particularly with the target tuna stocks of the WCPO, environmental variability was a large component of any uncertainty regarding the impact of fishing on stocks, and should not be overlooked.

7. Commitment to provide scientific advice on non-target, associated and dependent species.

The workshop reaffirmed the importance of this commitment, and noted that with the large number of species involved and the complexity and poor understanding of the ecosystems concerned, priorities may need to be defined and guidelines established to set these priorities.

8. Science/industry/manager linkages.

The importance of involving industry and managers in all aspects of the application of the precautionary approach was noted, as was the importance of developing some sense of ownership of the outcomes, and the need to keep management fully informed.

Other issues raised during the general discussion included the need to evaluate what other management organisations have already done in terms of incorporating the precautionary approach in fisheries management, and to decide whether tunas really are a special case. It was noted that the precautionary approach involves more than just the application of limit reference points, and that all means of achieving the objectives of the approach need to be kept in mind.

The procedures for the preparation of the Chairman's report to MHLC3 were discussed. It was agreed that a draft outline would be produced by the rapporteurs, then further developed in a small group. The report would need to be tabled towards the end of SCTB11, and cleared by SCTB11 participants for presentation by the Chairman to MHLC3.

LIST OF WORKING PAPERS FOR THE WORKSHOP ON PRECAUTIONARY LIMIT REFERENCE POINTS

WP 1 Allen, R. The precautionary approach and tuna fisheries. Inter-American Tropical Tuna Commission, La Jolla, California, United States of America. 9 pp.

WP 2 Caddy, J.F. A short review of precautionary reference points, and some proposals for their use in data-poor situations (draft version). Food and Agriculture Organization of the United Nations, Rome, Italy. 45 pp.

APPENDIX 2. REPORT OF THE WORKSHOP ON PRECAUTIONARY LIMIT REFERENCE POINTS TO MHLC3

EXECUTIVE SUMMARY

The Inter-sessional Technical Consultation on Issues Relating to Fisheries Management (Honiara, December 1997) requested the Eleventh Meeting of the Standing Committee on Tuna and Billfish (Honolulu, June 1998) to comment on a number of issues related to the application of the precautionary approach and the use of limit reference points in the management of fisheries for highly migratory fish stocks of the western and central Pacific Ocean. A specially convened workshop, led by a number of international experts, was held in conjunction with SCTB11 to address these issues. The specific conclusions of the workshop were:

The development of an overall precautionary management framework for tuna fisheries of the western and central Pacific requires the collaboration of scientists, fisheries managers and industry.

The delivery of scientific advice using limit reference points is only one component of a precautionary management framework. The implementation and monitoring of harvest or other fishery control measures are also essential components of the overall framework.

The avoidance of recruitment overfishing (reduction of the adult biomass to the point where there is a significant risk of recruitment collapse) should be the major objective of fisheries management.

At least two limit reference points are required to express this objective: a percentage of the maximum observed spawning biomass beyond which the stock must not be allowed to fall, and a level of fishing mortality which should not be exceeded in any year.

Stock assessments, which should be based on the best possible science, should provide estimates of uncertainty regarding the stock status and the impact of fishing on the stock, and be presented in such a way that enables transparent management decision making.

Where formal stock assessments cannot be undertaken because of lack of data, a suite of fishery indicators, based on statistics such as catch per unit effort, average size of fish caught and the spatial range of the fishery, may be used as provisional reference points. The utility and robustness of such indicators should first be assessed using simulation models.

While there will likely be a requirement to provide scientific advice on non-target, associated and dependent species, there is presently insufficient data on which to base assessments in most cases. Additional data collection, fishery monitoring and research will be required.

The current levels of funding support for data collection, research and stock assessment of tuna fisheries of the western and central Pacific are insufficient (less than one percent of the value of the catch). Funding support will need to be increased substantially to allow management of this valuable fishery to be guided by good science.

INTRODUCTION

The Inter-sessional Technical Consultation on Issues Relating to Fisheries Management of the Multilateral High-Level Conference on the Conservation and Management of Highly Migratory Fish

Stocks in the Western and Central Pacific (MHLC) met in Honiara, Solomon Islands in December 1997. Under the terms of reference for the Consultation, participants were asked to consider the application of the precautionary approach, in particular the establishment and potential application of precautionary reference points. Given the technical nature of the issues involved, the Eleventh Meeting of the Standing Committee on Tuna and Billfish (SCTB) was requested to:

a) Review options for precautionary limit reference points and, to the extent possible, evaluate their utility when applied to highly migratory fish stocks, in particular the target tuna stocks of the western and central Pacific.

b) Review existing definitions for overfishing of highly migratory fish stocks and how these definitions might apply to the target tuna stocks of the region.

c) Identify appropriate methods for setting and applying provisional reference points in 'data-poor' situations, such as would be the case with newly developing fisheries for highly migratory fish stocks in the western and central Pacific.

d) Provide advice on the application of precautionary limit reference points, noting that application could vary according to the level of acceptable risks and uncertainty, and that data requirements differ depending on the level of acceptable risks and uncertainty.

In order to consider these matters, a two-day workshop was convened in Honolulu, Hawaii, from 28 to 29 May 1998, immediately prior to SCTB11. The workshop consisted of seven sessions, each moderated by an expert, as follows:

1. Overview of the precautionary approach and its application to fisheries science and management – Dr Robin Allen, Inter-American Tropical Tuna Commission, La Jolla, United States of America.

2. Review of precautionary reference points – Dr Jacek Majkowski, Food and Agricultural Organization of the United Nations, Rome, Italy.

3. Setting limit reference points and definitions of overfishing – Dr Pamela Mace, National Marine Fisheries Service, Woods Hole, United States of America.

4. Stock assessment using precautionary reference points – Dr Tony Smith, Commonwealth Scientific and Industrial Research Organization, Hobart, Australia.

5. The impact of environmental variability on highly migratory fish stocks: how to accommodate in reference point management systems? – Dr Jeffrey Polovina, National Marine Fisheries Service, Honolulu, United States of America.

6. Current status of stock assessment for the target tuna species of the western and central Pacific – options for the application of precautionary reference points. – Dr John Hampton, Secretariat of the Pacific Community, Noumea, New Caledonia.

7. Application of precautionary reference points in 'data-poor' situations. – Dr John Sibert, University of Hawaii, Honolulu, United States of America.

The following report of the workshop, agreed to by consensus among the participants, is provided for information to the Third MHLC, meeting in Tokyo, Japan, from 22 to 26 June 1998.

THE PRECAUTIONARY APPROACH

The meeting reviewed the development of the precautionary approach noting that there now exists a new global standard to ensure the sustainable development and use of highly migratory fish stocks. The meeting acknowledged the need to base the application of the precautionary approach on Article 6 and Annex II of the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNIA). While the workshop focused on the delivery of scientific advice using reference points, it is important to note that reference points are only one component of a precautionary management framework. Other elements of the management framework, such as the implementation and monitoring of harvest or other fishery control measures when reference points are approached or exceeded, should be in place as well.

It was noted that the application of the precautionary approach need not require the adoption of new technologies or methods of analysis (although some adaptations and refinements may be necessary). What are required are realistic assessments of the status of stocks and their fisheries, including the uncertainties in the assessments and the risks associated with the uncertainties. There is also a need to ensure that these assessments are supported by adequate research programmes, data collection and monitoring of target and non-target species. To ensure that the precautionary approach is applied in the conservation and management of highly migratory fish stocks of the western and central Pacific, there will be a need to agree on procedures for dealing with uncertainty and risk. There will also be a need to develop stock-specific reference points against which stock status can be measured. These aspects of the precautionary approach will likely require further work to refine models of stock dynamics and to develop ad hoc methods for determining stock status in relation to provisional reference points where information is insufficient for modelling.

DELIVERY OF SCIENTIFIC ADVICE IN A PRECAUTIONARY MANAGEMENT FRAMEWORK

Precaution must be exercised in meeting the fundamental management objective of resource conservation and sustainable exploitation. The provision of scientific advice using reference points would be an essential part of an overall precautionary management framework designed to meet this objective. The development of this framework will require the collaboration of scientists, managers and industry if it is to be effective.

Several steps are required in order to generate and implement scientific advice in a precautionary management framework.

a) The first step is to define what we mean by biological ‘overfishing’. The most immediate concern is whether or not the stock is currently in an *overfished state*. Generally, an overfished state is said to exist if the adult biomass is at a level low enough to represent a significant risk of recruitment collapse. This is known as recruitment overfishing, and its avoidance is central to precautionary management. If it occurs, stock rebuilding strategies must be implemented. A second concern relates to the current level of exploitation of the stock. If the stock is not in an overfished state, overfishing might still occur because the current level of exploitation is not sustainable – an overfished state would be reached in the future if fishing at this level continued.

b) The second step is to translate the definitions of *overfished state* and *unsustainable exploitation* into limit reference points that can be monitored by stock assessment. The definition of an overfished state should involve a relative measure of adult biomass or spawning potential. A level of 20 percent of the maximum spawning biomass, or maximum spawning biomass per recruit, is used to define an overfished state for some fisheries. The definition of unsustainable exploitation should be in terms of the rate of fishing mortality (*F*) or a related measure. The UNIA stipulates the level of *F* resulting in MSY (F_{MSY}) as a minimum standard.

c) The third step is to conduct regular stock assessments in order to estimate the current levels of the stock and exploitation in relation to both of the above reference points. Stock assessments may also be required to evaluate alternative harvesting strategies being considered by management. Stock assessments should:

- represent the best possible science. In particular, assessments *should not* be conservatively biased or 'err on the side of caution' in estimating stock size and fishing mortality. They should represent the best scientific interpretation of the available data and other information on the biology and fisheries.

- include estimates (or descriptions) of the uncertainty associated with the stock assessment. Where possible, simple quantitative estimates of uncertainty should be given. Risk analysis, which involves estimating the probability that biomass or *F*-based limit reference points are exceeded, is becoming an accepted means of expressing the uncertainty in stock assessments. Where it is not possible for technical reasons to incorporate specific sources of uncertainty into stock assessment, these should be identified and their possible relevance to management decisions explained.

- contribute to transparent management decision making and offer a means of evaluating the performance of the overall management system in relation to management objectives.

d) The final step is to develop management controls, such as catch and/or effort limitation, that are consistent with the particular harvest strategy adopted. This will require scientific advice, but will also need to consider other issues such as the socio-economic impact on industry and others, monitoring and surveillance, and cost effectiveness.

SCIENTIFIC ADVICE FOR THE MANAGEMENT OF THE TARGET TUNA SPECIES OF THE WESTERN AND CENTRAL PACIFIC

The target species of the western and central Pacific tuna fisheries are skipjack, yellowfin, bigeye and south Pacific albacore. Collectively, the catch of these species has been in the vicinity of 1.5 million tonnes per year during the 1990s. In common with most fisheries, some aspects of the biology of the species remain problematic and various problems exist in the documentation of the fisheries, notably the lack of detailed statistics for the domestic fisheries of the Philippines and Indonesia. However, considerable biological and fisheries data have been accumulated by various countries over the past 30 years, and, if integrated in a form suitable for stock assessment, would form a sound basis for the provision of scientific advice to a future management organisation or arrangement.

DEFINITIONS OF REFERENCE POINTS FOR TARGET TUNA SPECIES

There is no clear indication that any of the target tuna species are currently in an overfished state, i.e. that their spawning biomass has been depleted by fishing to the extent that the risk of recruitment collapse is significant. Available information would suggest that tropical tunas are very resilient to recruitment overfishing. Indeed there is no evidence that recruitment overfishing has occurred in any fisheries for these species worldwide. Considering the available stock-recruitment information for other species, 20–30 percent of pre-exploitation spawning biomass may be a reasonable default biomass-based limit reference point (although it was noted that further work will be needed to identify the most appropriate levels for tunas). In the case of tunas, however, the pre-exploitation spawning biomass may not be easily estimated. There is evidence that the size of tuna stocks is strongly influenced by environmental conditions, and may have varied greatly over time even in the absence of fishing. Under these circumstances, it may be prudent to define a biomass-based reference point as a percentage of the *maximum observed* spawning biomass. Regardless of the actual percentage initially chosen, there should be some facility for revision, if this is justified by new scientific information.

As noted earlier, the UNIA stipulates F_{MSY} as a minimum standard for limit reference points. Conceptually, there is no reason why F_{MSY} could not be applied as a limit reference point for sustainable exploitation of WCPO tuna stocks. We note, however, that estimates of F_{MSY} will depend on the stock-recruitment relationship assumed in the stock assessment model. For tunas, shifts in recruitment resulting from decadal-scale variation in ocean climate may occur, and such ‘regime shifts’ would need to be considered in the estimation of F_{MSY}. Also, most tuna stocks are characterised by different levels of F at different times of their life history. Typically, tuna stocks are exploited as juveniles by surface fisheries, such as purse seine, and as adults by longline. The levels of F generated by these different gear types may be very different. F also shows strong spatial variation within the geographical range of the stocks. Such age-dependent and spatial characteristics of exploitation would need to be considered in the determination of F_{MSY}.

Other F-based limit reference points might also be used, and the choice will largely be influenced by the available data and stock assessment method that is applied. For example, the level(s) of F that would, under assumed recruitment conditions, result in the adult biomass eventually approaching the biomass-based limit reference point, could be used as a sustainability indicator. More conservative levels of F might be used as target reference points to allow the fishery to operate at a point separated by a reasonable safety zone from the limit reference point. The degree of conservatism would depend on the level of uncertainty in the stock assessment and on other management objectives that might be specified. Computer simulation using operational models[8] could be used to determine appropriate levels of such reference points and to examine their robustness to different hypotheses of stock dynamics.

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8 Operational models are simulation models that incorporate a range of hypotheses regarding the spatial and temporal dynamics of the stock, the effect of the environment, and possibly other impacts.

STOCK ASSESSMENT OF TARGET TUNA SPECIES

Given the development of integrated databases and continued research on the target tuna species, it is likely that stock assessments incorporating appropriate limit and target reference points could be developed for these species over the next few years. In some cases, such as yellowfin and albacore, sophisticated stock assessment models are under development. These models could be structured to provide estimates of adult biomass and fishing mortality for comparison with chosen limit and/or target reference points. Importantly, estimates of uncertainties could be provided and scientific advice structured in a risk analysis form. Alternative harvesting strategies could be evaluated in a similar fashion, by calculating the risk of limit and/or target reference points being exceeded. Such methods are data intensive, but provide managers with the best possible information on which to base their decisions.

It may not be possible to apply such sophisticated methods to some species, such as skipjack and bigeye, in the short term. However, it might be possible to develop a suite of fishery indicators based on easily collected statistics such as catch per unit effort, average size of fish caught, spatial range of the fishery, and others. The actual critical values and robustness of the indicators chosen as provisional reference points would need to be assessed by simulation models. While such indicators may be a useful interim measure, it would be ill-advisable to rely on them for an extended period of time. They are not a long-term substitute for adequate stock assessment models.

CONSIDERATION OF NON-TARGET, ASSOCIATED AND DEPENDENT SPECIES

As part of the precautionary approach, the UNIA elaborates a specific requirement to assess the impacts of fishing on non-target, associated and dependent species (NTADs). Given the paucity of fisheries and biological data for many of these species, this requirement will likely require enhancements to existing data collection, fisheries monitoring and research programmes. In some cases, new programmes to provide information on NTADs will need to be developed. The meeting noted that there was a pressing need to determine what information was being collected, what was the likely nature of scientific advice that would be required, and especially to identify the NTADs which are being caught incidentally by tuna fisheries in the western and central Pacific.

The meeting noted that where possible, existing programmes should be enhanced to provide the information required to assess the impact of tuna fishing on NTADs. In those cases where information was lacking, new monitoring and research programmes would likely be required. In developing fisheries indicators for assessing NTADs, it was noted that scientists should review approaches developed elsewhere, especially in ICES and NAFO, where recent consideration of this issue has been progressing. It was also suggested that the operational model approach might be helpful to determine which fishery indicators might be most suitable for determining the impacts of fishing on NTADs.

SUPPORT FOR FISHERIES SCIENCE

The workshop noted with concern that current levels of funding support for data collection, research and stock assessment of tuna fisheries of the western and central Pacific are insufficient. The value of the total catch is currently of the order of US$ 1.7 billion annually. Probably less than one percent of this value is currently spent on tuna fisheries science in the region. Funding support will need to be increased substantially to allow management of this valuable fishery to be guided by good science. Scientists, managers and industry should cooperate in identifying and prioritising research and data needs.

The precautionary approach to fisheries management is to a large extent about appropriate management responses to uncertainty about the impact of fishing on the stocks. One response to this uncertainty is to reduce catch or fishing effort in order to reduce the risk that a limit or target reference point is exceeded. A second, longer-term response to uncertainty is to reduce it by investment in carefully targeted data collection and research.

It is recognised that funding requirements for fisheries science will need to be specified in the context of the overall needs of the fisheries management organisation or arrangement. If required, the SCTB could provide further input on this matter at an appropriate time.

APPENDIX 3. AGENDA

1. Preliminaries

    1.1 Opening Address
    1.2 Confirmation of Chairman and Appointment of Rapporteurs
    1.3 Adoption of the Agenda
    1.4 Adoption of the Report of the Tenth Meeting of the SCTB
    1.5 Discussion of the Revised SCTB Structure and Working Arrangements

2. Overview of Western and Central Pacific Ocean Tuna Fisheries

    2.1 Regional Overview
    2.2 National Tuna Fishery Reports
    2.3 Economic Condition of the Fishery
    2.4 Fishery Management Developments

3. Reports by Organisations

4. Statistics Working Group

    4.1 Issues Concerning the Coordination of Data Collection
    4.2 Issues Concerning the Coordination of Data Compilation
    4.3 Issues Concerning the Coordination of Data Dissemination
    4.4 SWG Tables of Annual Catch Estimates

5. Skipjack Research Group

    5.1 Regional Fishery Developments
    5.2 Biological and Ecological Research, and ENSO Update
    5.3 Stock Assessment
    5.4 Research Coordination and Planning

6. Yellowfin Research Group

    6.1 Regional Fishery Developments
    6.2 Biological and Ecological Research
    6.3 Stock Assessment
    6.4 Research Coordination and Planning

7. Bigeye Research Group

    7.1 Regional Fishery Developments
    7.2 Biological and Ecological Research
    7.3 Stock Assessment
    7.4 Research Coordination and Planning

8. Albacore Research Group

    8.1 Regional Fishery Developments
    8.2 Biological and Ecological Research
    8.3 Stock Assessment

8.4 Research Coordination and Planning

9. Billfish and Bycatch Research Group

9.1 Introduction
9.2 Issues Concerning the BBRG
9.3 Review of Monitoring, Research and Assessment
9.4 Approaches to Assessing the Status of Billfish and Bycatch
9.5 Summary of Work Plan and Action Items

10. Review of Directives to the Statistics Working Group

11. Clearing of the Workshop on Precautionary Limit Reference Points Report

12. Other Business

13. Close

APPENDIX 4. LIST OF WORKING PAPERS

Preliminaries

WP 1 Anonymous. Report of the Tenth Meeting of the Standing Committee on Tuna and Billfish, 16–18 June 1998, Nadi, Fiji. Oceanic Fisheries Programme, South Pacific Commission, Noumea, New Caledonia. 50 pp.

Overview of Western and Central Pacific Ocean Tuna Fisheries

WP 2 Anonymous. Economic overview of the tuna fishery. Forum Fisheries Agency, Honiara, Solomon Islands. 6 pp.

Statistics Working Group

WP 3 Lawson, T. Issues concerning the Statistics Working Group of the Standing Committee on Tuna and Billfish. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 20 pp.

WP 4 Anonymous. Coverage of western and central Pacific tuna fisheries by data held by the SPC Oceanic Fisheries Programme. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 21 pp.

WP 5 Anonymous. Estimates of annual catches of target species in the western and central Pacific Ocean. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 67 pp.

Research Groups

General

WP 6 Matsumoto, T., H. Okamoto, N. Miyabe & K. Ikehara. Fishery indicators from the Japanese tuna fisheries in the western Pacific. National Research Institute of Far Seas Fisheries, Shimizu, Japan. 12 pp.

WP 7 Park, Y.C. On-board scientific trip for Korean tuna fishery. National Research and Development Institute, Pusan, Korea. 6 pp.

WP 8 Park, Y.C., D.Y. Moon & S.J. Hwang. Review of changes for the Korean tuna purse seine fleet and fishing methods. National Research and Development Institute, Pusan, Korea. 7 pp.

WP 9 Bard, F.X., S. Yen & A. Stein. ECOTAP, a research program on biology, ecology and habitat of deep swimming tuna (*Thunnus obesus*, *T. albacares*, *T. alalunga*) in the Polynesian EEZ. Service des Ressources Marines, Papeete, French Polynesia. 10 pp.

WP 10 Sakagawa, G. & A.L. Coan, Jr. An observation on CPUE for U.S. and Japanese purse seiners fishing in the central-western Pacific. National Marine Fisheries Service, La Jolla, California, United States of America. 8 pp.

Yellowfin

WP 11 Campbell, R. Long term trends in yellowfin tuna abundance in the south-west Pacific. Division of Marine Research, Commonwealth Scientific and Industrial Research Organisation, Hobart, Australia. 27 pp.

WP 12 Lehodey, P. & B. Leroy. Age and growth of yellowfin tuna (*Thunnus albacares*) from the western central Pacific Ocean as indicated by daily growth increments and tagging data (draft 05/25/98). Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 15 pp.

WP 13 Sun, C.L. & S.Z. Yeh. Standardized CPUE of central and western Pacific yellowfin tuna from Taiwanese tuna fisheries. Institute of Oceanography, National Taiwan University, Taipei, Taiwan. 10 pp.

WP 14 Bartoo, N. & A.L. Coan, Jr. Standardization of yellowfin tuna CPUE for U.S. purse seiners fishing in the central-western Pacific. National Marine Fisheries Service, La Jolla, California, United States of America. 13 pp.

WP 15 Hampton, J. & D. Fournier. Preliminary analysis of yellowfin catch, effort, size and tagging data using an integrated age-structured model. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 16 pp.

Bigeye

WP 16 Miyabe, N. & Y. Takeuchi. Exploring VPA analysis on Pacific bigeye tuna. National Research Institute of Far Seas Fisheries, Shimizu, Japan. 16 pp.

WP 17 Hampton, J., K. Bigelow & M. Labelle. Effect of longline fishing depth, water temperature and dissolved oxygen on bigeye tuna (*Thunnus obesus*) abundance indices. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 18 pp.

WP 18 Hampton, J. & B. Leroy. Notes on preliminary estimates of bigeye growth from presumed daily increments on otoliths and tagging data. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 3 pp.

WP 19 Hampton, J. Note on preliminary estimates of bigeye tuna natural mortality rates from tagging data. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 6 pp.

WP 20 Sun, C.L. & S.Z. Yeh. Standardized CPUE of central and western Pacific bigeye tuna from Taiwanese tuna fisheries. Institute of Oceanography, National Taiwan University, Taipei, Taiwan. 8 pp.

WP 21 Sun, C.L., C.L. Huang & S.Z. Yeh. Preliminary results of age and growth study of bigeye tuna in the western Pacific. Institute of Oceanography, National Taiwan University, Taipei, Taiwan. 8 pp.

Albacore

WP 22 Uosaki, K. Standardization of CPUE for albacore caught by Japanese longline fishery in the SPAR area. National Research Institute of Far Seas Fisheries, Shimizu, Japan. 7 pp.

WP 23 Wang, C.H. Fluctuation of the south Pacific albacore stocks (*Thunnus alalunga*) relative to sea surface temperature. Institute of Oceanography, National Taiwan University, Taipei, Taiwan. 26 pp.

WP 24 Wang, C.H. A new method applying in assessing south Pacific albacore stocks (*Thunnus alalunga*). Institute of Oceanography, National Taiwan University, Taipei, Taiwan. 19 pp.

WP 25 Fournier, D.A., J. Hampton & J.R. Sibert. MULTIFAN CL: a length-based age-structured model for fisheries stock assessment, with application to south Pacific albacore (*Thunnus alalunga*). Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 43 pp.

Billfish and Bycatch

WP 26 Campbell, R. Billfish fisheries off eastern Australia and related research. Division of Marine Research, Commonwealth Scientific and Industrial Research Organisation, Hobart, Australia. 13 pp.

WP 27 Williams, P. & K.A. Bigelow. Estimates of longline billfish catch in the western and central Pacific Ocean. Oceanic Fisheries Programme, Secretariat of the Pacific Community, Noumea, New Caledonia. 14 pp.

National Tuna Fishery Reports

WP 28 Anonymous. American Samoa country report. Department of Marine and Wildlife Resources, Pago, Pago, American Samoa. 4 pp.

WP 29 Ward, P. Tuna and billfish fisheries of the north-eastern Australian Fishing Zone. Bureau of Resource Sciences, Canberra, Australia. 15 pp.

WP 30 Anonymous. Country report: Cook Islands. Ministry of Marine Resources, Rarotonga, Cook Islands. 4 pp.

WP 31 Anonymous. Federated States of Micronesia: national tuna fishery report. Micronesian Maritime Authority, Pohnpei, Federated States of Micronesia. 6 pp.

WP 32 Tuwai, I.L. Tuna and billfish fisheries of Fiji's fishing zone. Fisheries Division, Raiwaqa, Fiji. 10 pp.

WP 33 Anonymous. Tuna fisheries in French Polynesia: national fisheries report. Service des Ressources Marines, Papeete, French Polynesia. 7 pp.

WP 34 Stein, A. Recent trends in French Polynesian tuna fisheries. Service des Ressources Marines, Papeete, French Polynesia. 9 pp.

WP 35 Okamoto, H., N. Miabe, M. Ogura & Y. Nishikawa. Japanese tuna fisheries in the western Pacific Ocean, and the fishing activities in 1997. National Research Institute of Far Seas Fisheries, Shimizu, Japan. 14 pp.

WP 36 Uosaki, K. Recent status of the Japanese albacore fisheries in the SPAR area. National Research Institute of Far Seas Fisheries, Shimizu, Japan. 6 pp.

WP 37 Park, Y.C. Korean tuna fisheries in the western Pacific Ocean. National Research and Development Institute, Pusan, Korea. 9 pp.

WP 38 Anonymous. New Caledonia tuna fishery. Service territorial de la marine marchande et des pêches maritimes, Noumea, New Caledonia. 2 pp.

WP 39 Anonymous. National tuna fishery report – New Zealand. National Institute of Water and Atmospheric Research Ltd., Wellington, New Zealand. 5 pp.

WP 40 Mulipola, A.P. Report on Samoa's longline fishery. Fisheries Division, Apia, Samoa. 9 pp.

WP 41 Oreihaka, E. Domestic tuna fisheries of the Solomon Islands. Fisheries Division, Honiara, Solomon Islands. 12 pp.

WP 42 Chang, S.K. & H.J. Lu. Taiwan tuna fisheries in the western – central Pacific Ocean, 1997. Overseas Fisheries Development Council, Taipei, Taiwan. 9 pp.

WP 43 Coan, A.L., Jr., R. Ito & B. Kikkawa. U.S. fisheries for tropical tunas and billfish of the central-western Pacific and south Pacific albacore, 1993–1997. National Marine Fisheries Service, La Jolla, California, United States of America. 21 pp.

WP 44 Itano, D. Hawaii offshore handline fishery: a seamount fishery for juvenile bigeye tuna. Pelagic Fisheries Research Program, Joint Institute of Marine and Atmospheric Research, University of Hawaii at Manoa, Honolulu, Hawaii, United States of America. 13 pp.

WP 45 Jimmy, R.A. Country report: status of tuna fishery in Vanuatu. Department of Fisheries, Port Vila, Vanuatu. 9 pp.

Addendum

WP 46 Gunn, J. & P. Grewe. The origin of recruits to the east coast yellowfin tuna fishery and delineation of the structure of yellowfin stocks in the western Pacific. Division of Marine Research, Commonwealth Scientific and Industrial Research Organisation, Hobart, Australia. 19 pp.

WP 47 Itano, D. & K.N. Holland. Hawaii Tuna Tagging Project. Pelagic Fisheries Research Program, Joint Institute of Marine and Atmospheric Research, University of Hawaii at Manoa, Honolulu, Hawaii, United States of America. 2 pp.

WP 48 Itano, D. Notes on the improvement of fishing power and efficiency in the western tropical Pacific tuna purse seine fishery. Pelagic Fisheries Research Program, Joint Institute of Marine and Atmospheric Research, University of Hawaii at Manoa, Honolulu, Hawaii, United States of America. 8 pp.

WP 49 Anonymous. Bigeye tuna: five-year research plan, a prospectus for coordinated international research. Pelagic Fisheries Research Program, Joint Institute of Marine and Atmospheric Research, University of Hawaii at Manoa, Honolulu, Hawaii, United States of America. 13 pp.

WP 50 Poiner, I., T. Polachek & D. Heinemann. Bycatch and the development of a threat abatement plan in Australia. Division of Marine Research, Commonwealth Scientific and Industrial Research Organisation, Hobart, Australia. 19 pp.

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APPENDIX 6. OPENING ADDRESS BY 'AKAU'OLA, SECRETARY, MINISTRY OF FISHERIES OF TONGA

Distinguished colleagues, ladies and gentlemen, after that warm welcome which speaks to us from the past of these beautiful islands in a language that is alive and well, I should not try to gild the lily, but rather to pass on all our thanks to Manu and Vicky of *Ilio ula o kalani* for the dignity and grace of their welcome.

Therefore I'll proceed to open this the Eleventh Meeting of the Standing Committee on Tuna and Billfish – a continuous unbroken line since 1988 thanks mainly due to your continued support, usually, I might add, at your own expense. In view of our time constraints, I will make this welcome appropriately short. I must note, however, that this SCTB is different in several important ways.

After decisions taken at SCTB10 last June in Nadi, and subsequently approved by the Thirty-Seventh South Pacific Conference, the SCTB function of peer review of the work of the SPC Oceanic Fisheries Programme has been delegated to SPC in line with current policy.

The terms of reference and participation guidelines of SCTB have been revised, to emphasise the role of SCTB in facilitating tuna research cooperation and encouraging full and effective participation by all interested parties.

To streamline the existing system of regional scientific cooperation in tuna fisheries and to enable a more comprehensive treatment of stocks impacted by those fisheries, SCTB has been mandated to form a statistics working group and various species research groups to coordinate and promote collaborative research leading to stock assessments.

We meet today for the first time under these new arrangements for SCTB, and I look forward to this with some anticipation, particularly after the stimulating and related discussions of the past few days [during the Workshop on Precautionary Limit Reference Points].

We are also able to be here due in no small measure to the generous funding support of our hosts, the Western Pacific Regional Fisheries Management Council, a truly magnificent gesture of regional commitment. Without this, much fewer of us Pacific islanders would be here. One of the recommendations of SCTB was indeed "to attempt to locate sources of funding to support the participation of Pacific island countries". For this, Kitty [Simonds, Executive Director of the Council], I thank you warmly on behalf of ourselves and SCTB.

I need hardly add that we meet at an interesting time relative to the MHLC process, which charged us with the responsibility of providing advice to them on technical issues associated with the application of the precautionary approach to our regional situation. MHLC3 meets again in two weeks in Tokyo, when it will be a pleasure as your outgoing Chairman to present the report of the two-day workshop that preceded SCTB11. In so doing, I hope to be able to take more than a report. If it were possible, I would like to convey to MHLC the spirit in which you scientists warmed to the task. It would be a challenge for the meeting to match the sense of unity and purpose that was experienced. Applied to the overall process, it augurs well for the better management of the major tuna species of the region.

It is my great pleasure to open the Eleventh Meeting of the Standing Committee on Tuna and Billfish.

APPENDIX 7. REVIEW OF SCTB 10 RECOMMENDATIONS AND ACTION ITEMS

RECOMMENDATION 1

Recognising the need to modify the terms of reference of SCTB in order to provide a more efficient and effective forum for scientific debate and a vehicle for research/data coordination and collaboration in which all participants will be equal partners, the Tenth Meeting of SCTB recommends:

- *That "review of the OFP work programme" be removed from the SCTB terms of reference and the SPC provide an alternative means of critical, peer review of the OFP in line with its current policy;*

- *The Terms of Reference of the SCTB be amended as follows:*

    1. *Coordinate fisheries data collection, compilation and dissemination according to agreed principles and procedures;*

    2. *Review research on the biology, ecology, environment and fisheries for tunas and associated species in the western and central Pacific Ocean;*

    3. *Identify research needs and provide a means of coordination, including the fostering of collaborative research, to most efficiently and effectively meet those needs;*

    4. *Review information pertaining to the status of stocks of tunas and associated species in the western and central Pacific Ocean, and to produce statements on stock status where appropriate;*

    5. *Provide opinion on various scientific issues related to data, research and stock assessment of western and central Pacific Ocean tuna fisheries.*

- *In the interests of openness and transparency, participation in SCTB should not be restricted, but would specifically encourage the participation of scientists from countries having an interest in the tuna fisheries of the region. The following statement on participation is therefore proposed:*

    Participation in the Standing Committee on Tuna and Billfish is open to scientists and others with an interest in the tuna fisheries of the western and central Pacific Ocean. The participation of scientists from coastal states and territories of the region, scientists from countries whose vessels fish in the region, and scientists from international tuna fisheries management organisations, is particularly encouraged.

- *That, in order to streamline the existing system of regional scientific cooperation in tuna fisheries and enable a more comprehensive treatment of the stocks impacted by those fisheries, the SCTB forms a statistics working group and various species research groups to coordinate and promote collaborative research leading to stock assessments.*

    6. *The statistics working group will compile, evaluate and disseminate fisheries data, particularly in the form required by species research groups*

7. *The species research groups will coordinate and promote collaborative research leading to stock assessment. At this stage four species working groups are to be formed: skipjack, yellowfin (taking over the role of the WPYR Group), bigeye and albacore (taking over the role of the SPAR Group).*

Recommendation 1 was endorsed by the Thirty-Seventh South Pacific Conference, held in Canberra, Australia, in October 1997. The Statistics Working Group and Research Groups for albacore, bigeye, skipjack, yellowfin, and billfish and bycatch have been established.

ACTION ITEM 1

That the OFP seek endorsement of the revised terms of reference and structure of SCTB from the SPC Executive and the SPC Conference / Committee of Representatives of Governments and Administrations.

Recommendation 1 was considered and endorsed by the Thirty-Seventh Conference of the South Pacific Commission, held in Canberra, Australia, in October 1997, and the Statistics Working Group and four species research groups (albacore, bigeye, skipjack and yellowfin) were formed. A fifth research group was subsequently formed for billfish and bycatch species.

ACTION ITEM 2

In view of the increase in domestic fishery activities throughout the region, it was suggested that the OFP review the coverage of catch logsheet data collected from domestic fleets. This review should be conducted in collaboration with member countries having domestic fleets.

The coverage of logsheet data, together with landings data, port sampling data and observer data, by data held by the OFP, was documented (Working Paper 4) and presented to SCTB11 (see paragraph 126).

ACTION ITEM 3

The OFP consider placing its scientific observers, on a medium-term basis, in key ports where national observer programmes are experiencing difficulties in achieving observer placements. Solomon Islands was identified as a priority for such an exercise. Palau and Marshall Islands were also mentioned as countries that would benefit.

OFP scientific observers were outposted to Honiara, Solomon Islands, to assist the national port sampling and observer programmes, beginning in August 1997.

APPENDIX 8. SCIENTIFIC NAMES OF SPECIES

ENGLISH NAME	SCIENTIFIC NAME
Tuna and tuna-like species	
Albacore	*Thunnus alalunga*
Bigeye	*Thunnus obesus*
Frigate tuna	*Auxis thazard*
Skipjack	*Katsuwonus pelamis*
Wahoo	*Acanthocybium solandri*
Yellowfin	*Thunnus albacares*
Billfish	
Black marlin	*Makaira indica*
Blue marlin	*Makaira mazara*
Sailfish	*Istiophorus platypterus*
Shortbill spearfish	*Tetrapturus angustirostris*
Striped marlin	*Tetrapturus audax*
Swordfish	*Xiphias gladius*
Sharks	
Blue shark	*Prionace glauca*
Mako shark	*Isurus oxyrinchus*
Oceanic whitetip shark	*Carcharhinus longimanus*
Silky shark	*Carcharhinus falciformis*
Thresher shark	Alopias vulpinus
Other species	
Escolar	*Lepidocybium flavobrunneum*
Mahi mahi	*Coryphaena hippurus*
Oceanic triggerfish	*Canthidermis maculatus*
Rainbow runner	*Elagatis bipinnulata*

APPENDIX 9. ACRONYMS AND ABBREVIATIONS

AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
ARG	Albacore Research Group
AUSAID	Australian Agency for International Development
BBRG	Billfish and Bycatch Research Group
BRG	Bigeye Research Group
CART	Classification and Regression Tree
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
cm	centimetre
CNMI	Commonwealth of the Northern Mariana Islands
CPUE	catch per unit of effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ECOTAP	Etude de Comportement des Thonidés par l'Acoustique et la Pêche
EEZ	exclusive economic zone
ENSO	El Niño Southern Oscillation
EPO	eastern Pacific Ocean
ETP	eastern tropical Pacific
F	the instantaneous rate of fishing mortality
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FFA	South Pacific Forum Fisheries Agency
FSM	Federated States of Micronesia
GAM	general additive model
GLM	general linear model
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
in	inch
IOTC	Indian Ocean Tuna Commission
JIMAR	Joint Institute of Marine and Atmospheric Research
KFC	Kuniyoshi Fishing Company
kg	kilogram
LRP	limit reference point
M	the instantaneous rate of natural mortality
MHLC	Multilateral High-Level Consultation on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean
mi	mile
MMR	Ministry of Marine Resources
MSE	Management Strategy Evaluation
mt	metric tonnes
NAFO	North Atlantic Fisheries Organization
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NTAD	non-target, associated and dependant (species)
OFP	Oceanic Fisheries Programme
OM	Operational Model
ORSTOM	Institut Français de Recherche Scientifique pour le Development en Coopération
OTC	oxytetracycline
PEAC	Pacific ENSO Application Center
PFRP	Pelagic Fisheries Research Program
PITI	Palau Internation Traders Incorporated
PMIC	Palau Marine Industrial Corporation
PRP	provisional reference point
RP	reference point
SAM	Stock Assessment Model
SCTB	Standing Committee on Tuna and Billfish
SEAFDEC	Southeast Asian Fisheries Development Center
SEM	scanning electron microscope
SOI	southern oscillation index
SPAR	South Pacific Albacore Research (Group)
SPC	Secretariat of the Pacific Community (formerly the South Pacific Commission)
SRG	Skipjack Research Group
SSH	sea surface height
SST	sea surface temperature
SWG	Statistics Working Group
TAC	total allowable catch

TAO	Tropical Atmosphere Ocean (Project)
TRP	target reference point
UNIA	Agreement for the Implementation of the Provisions of UNCLOS Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
UNCLOS	United Nations Convention on the Law of the Sea
WCPO	western and central Pacific Ocean
WPYR	Western Pacific Yellowfin Research (Group)
VMS	vessel monitoring system
VPA	Virtual Population Analysis
XBT	expandable bathythermograph
YRG	Yellowfin Research Group