STATUS OF ALBACORE TUNA IN THE PACIFIC OCEAN

CONTENTS

There are apparently two stocks of albacore, *Thunnus alalunga*, in the Pacific Ocean, one occurring in the northern hemisphere and the other in the southern hemisphere (Section 3.1.5). Accordingly, data for all parts of the Pacific Ocean are included in this report, but in many cases albacore of the North and South Pacific Oceans are discussed separately.

1. EXECUTIVE SUMMARY

There are apparently two stocks of albacore in the Pacific Ocean, one occurring in the northern hemisphere and the other in the southern hemisphere. Albacore are caught by longliners in most of the North and South Pacific, but not often between about 10°N and 5°S, by trollers in the eastern and central North Pacific and the central South Pacific, and by baitboats in the western North Pacific. Total landings of albacore from the North Pacific peaked in the early seventies at over 100 000 metric tons per year, and then declined. Landings recovered during the 1990s, and reached an all-time high of 127 800 metric tons in 1999. In the South Pacific, catches have ranged between about 25 000 and 55 000 metric tons during the 1980s and 1990s.

The adults are caught mostly in the Kuroshio Current, the North Pacific Transition Zone, and the California Current in the North Pacific and the Subtropical Convergence Zone in the South Pacific, but spawning occurs in tropical and subtropical waters.

There appear to be two subgroups of albacore in the North Pacific Ocean. The fish of the northern subgroup are found mostly north of 40°N when they are in the eastern Pacific Ocean. There is considerable exchange of fish of this subgroup between the troll fishery of the eastern Pacific Ocean and the baitboat and longline fisheries of the western Pacific Ocean. The fish of the southern subgroup occur mostly south of 40°N in the eastern Pacific, and relatively few of them are caught in the western Pacific. Fish that were tagged in offshore waters of the eastern Pacific and recaptured in the coastal fishery of the eastern Pacific exhibited different movements, depending on the latitude of release. Most of the recaptures of those released north of 35°N were made north of 40°N, and most of the recaptures of those released south of 35°N were made south of 40°N.

Much less is known about the movements of albacore in the South Pacific Ocean. The juveniles move southward from the tropics when they are about 35 cm long, and then eastward along the Subtropical Convergence Zone. When the fish approach maturity they return to the tropics, where they spawn. Recoveries of tagged fish released in areas east of 155°W were usually made at locations to the east and north of the release site, whereas those of fish released west of 155°W were usually made at locations to the west and north of the release site.

Production modeling indicates that the average maximum sustainable yield of albacore in the South Pacific is 30 000 to 35 000 metric tons. It should be noted, however, that in the South Pacific the catches have exceeded 30 000 metric tons in each of the last 15 years, and in 9 of these years the catches have exceeded 35 000 metric tons. Recent applications of production models to North Pacific albacore suggest that biological productivity has increased in that region. Maximum sustainable yield is estimated to have increased from about 90 000 metric tons per year in the period 1952-1988 to 150 000 metric tons per year from 1989-1998. The results of age-structured modeling in the North Pacific corroborate that finding of increased production, suggesting that recruitment and biomass have increased since the late 1980s. There does not seem to be any need to restrict the fisheries for albacore in either the North Pacific or the South Pacific.

2. DATA

2.1. Definitions of the fisheries

2.1.1. Longline fisheries

Longline vessels of Australia, the Cook Islands, Fiji, French Polynesia, Japan, New Caledonia, New Zealand, Papua New Guinea, the Peoples Republic of China, the Republic of Korea, the Solomon Islands, Taiwan, Tonga, the United States, Vanuatu, and Western Samoa fish for tunas, including albacore, and billfishes in the Pacific Ocean between about 50°N and 50°S (Kume, 1974; Yoshida, 1975; Bartoo and Foreman, 1994; Murray, 1994; Park *et al*., 1994; Caton *et al*., 1998; Ito *et al*., 1998; Childers and Miller, 2000).

2.1.2. Troll fisheries

Albacore are caught in the Pacific Ocean by trolling by vessels of Australia, Canada, French Polynesia, New Zealand, and the United States (Bartoo and Foreman, 1994; Murray, 1994; Childers and Miller, 2000).

2.1.3. Baitboat fisheries

Albacore are caught in the Pacific Ocean by baitboats of Japan and the United States (Shiohama, 1973; Kume, 1974; Bartoo and Foreman, 1994; Childers and Miller, 2000).

2.1.4. Gillnet fisheries

From the mid-1970s until the end of 1992 there was a high-seas fishery for tunas and billfishes carried out with large-meshed gillnets by vessels of Japan, the Republic of Korea, and Taiwan (Bartoo *et al*., 1993; Bartoo and Foreman, 1994; Murray, 1994). In addition, small amounts of albacore are caught in coastal waters of Chile with gill nets that are deployed to catch swordfish (Childers and Miller, 2000).

2.1.5. Purse-seine fisheries

Small amounts of albacore are caught in the North Pacific Ocean by Japanese purse-seine vessels (Childers and Miller, 2000).

2.1.6. Recreational fisheries

There is an important recreational fishery directed at albacore in California (Clemens and Craig, 1965; Laurs and Dotson, 1992; Childers and Miller, 2000). No information is available on recreational fisheries for albacore in other parts of the Pacific Ocean.

2.2. Catch and effort data

2.2.1. Commercial fisheries

Data on the commercial catches of albacore are shown in Tables 2.2.1a and 2.2.1b. (The data were taken from Childers and Miller (2000: Tables 1 and 2). Those tables have numerous footnotes concerning the completeness and accuracy of the data, so anyone who uses these data should examine the footnotes in that report.) The catches in the North Pacific have exceeded those of the South Pacific, and have varied more from year to year than those of the South Pacific. The catches by Japanese baitboats in the North Pacific were greatest from about 1965 through 1980. Large amounts of fish were caught by the gillnet fisheries of Japan, Korea, and Taiwan from about 1978 through 1992, but, as noted above, the high-seas gillnet fishery ceased after that.

Longline fishing takes place throughout most of the Pacific Ocean between about 50°N and 50°S, but albacore are caught mostly between about 25°N and 45°N and between about 5°S and 45°S (Figure 2.2.1). Information on the distributions of the catches of albacore by U.S. trollers is given by Childers and Miller (2000: Figures 1 and 3a). Substantial amounts of albacore are caught at the surface near the coasts of North America and northeastern Asia by trollers and baitboats, respectively, but important equivalent fisheries do not exist near the coasts of South America and Australia.

The countries involved in fishing for albacore in the North Pacific (Canada, Japan, Korea, Mexico, Taiwan, and the United States) maintain a central repository of data relating to Pacific albacore at the Southwest Fisheries Science Center, La Jolla, California.

2.2.2. Recreational fisheries

Data on the recreational catches of albacore by U.S. vessels are shown in Table 2.2.2. There are no data available on the recreational catches of albacore by vessels of other nations. Most of the recreational catches by U.S. vessels are taken off Southern California (Clemens and Craig, 1965: Figures 122-174).

2.3. Size composition data

2.3.1. Longline fisheries

Length-frequency data for albacore caught by longliners in the Pacific Ocean are given by Honma and Kamimura (1957: Figures 4, 5, and 9), Otsu and Hansen (1962: Figures 3 and 9-11), Otsu and Sumida (1968: Figures 15 and 16), Shiohama (1973: Figures 1 and 2), Yoneta and Saito (1973: Figure 2), Kume (1974: Figures 10 and 14), Yoshida (1975: Figures 12-13), Kleiber and Baker (1987: Figures 2 and 4-6), and Uosaki and Bayliff (1999: Figures 59-61).

2.3.2. Troll fisheries

Length-frequency data for albacore caught by trollers in the Pacific Ocean are given by Clemens and Craig (1965: Figures 10-16), Kume (1974: Figure 8), Kleiber and Baker (1987: Figures 2 and 4-6), Bartoo and Holts (1993: Figure 8), Bartoo *et al.* (1993: Figures 3-7), and Childers and Miller (2000: Figures 7 and 8).

2.3.3. Baitboat fisheries

Length-frequency data for albacore caught by baitboats in the Pacific Ocean are given by Kume (1974: Figure 9) and Kleiber and Baker (1987: Figures 2 and 4-6).

2.3.4. Gillnet fisheries

Length-frequency data for albacore caught by gillnetters in the Pacific Ocean are given by Bartoo and Holts (1993: Figures 2 and 7-11). The sizes of the fish caught are positively correlated with the mesh sizes of the nets.

2.3.5. Recreational fisheries

No comprehensive data on the sizes of albacore caught by recreational fishermen are available.

3. ASSUMPTIONS AND PARAMETERS

3.1. Biological and demographic information

3.1.1. Growth

Otsu (1960) analyzed 15 tag returns from 1 201 released, mainly from troll fisheries in the central and eastern North Pacific, and fitted the Gompertz equation to the data. Clemens (1961) performed a similar analysis for 73 albacore tagged off the coasts of California and Baja California. Laurs and Wetherall

(1981) estimated the growth rates of North Pacific albacore from 410 tag returns of a total of 13 605 fish that were tagged and released from 1971-1978. Labelle *et al*. (1993) estimated the growth of South Pacific albacore from analysis of counts of vertebral rings. The estimates of the parameters of the von Bertalanffy growth equation obtained by Laurs and Wetherall (1981) and Labelle *et al*. (1993) are shown in Tables 3.1.1a and 3.1.1b, respectively, and estimates of the lengths at age obtained from these equations are shown in Tables 3.1.1c and 3.1.1d.

Three weight-length equations for Pacific albacore are shown in Table 3.1.1e.

3.1.2. Reproduction

The reproduction of albacore in the Pacific Ocean has been studied by Partlo (1955), Ueyanagi (1957 and 1969), Otsu and Uchida (1959), Otsu and Hansen (1962), Yoneta and Saito (1973), Kume (1974), Shingu *et al*. (1974), Nishikawa *et al*. (1985), Ratty *et al.* (1990), and Ramón and Bailey (1996). Albacore larvae appear to be scarce east of 140°W, and most abundant west of 180° (Nishikawa *et al*., 1985), although this could be an artifact of sampling. Partlo (1955) found what he considered to be mature males and females in the "eastern Pacific," presumably caught off Canada and/or the United States. Otsu and Uchida (1959), however, said that albacore "supporting the American west coast summer fishery are non-spawning fish," and stated that spawning occurs only in tropical and subtropical waters. Ratty *et al.* (1990) found mature males, but not mature females, in the South Pacific Subtropical Convergence Zone, between about 35° to 40°S. They said that spawning occurs mostly in Southern Tropical Convergence waters, between about 10° and 20°S. Spawning occurs in the North Pacific mostly or entirely during the northern summer (Otsu and Uchida, 1959) and in the South Pacific mostly or entirely during the southern summer (Ramón and Bailey, 1996).

The minimum lengths at first maturity found by various workers are shown in Table 3.1.2.

Otsu and Sumida (1968) found the percentages of males among albacore caught by the longline fishery of American Samoa during 1954-1965 to be as follows: all fish, about 50 to 70 percent; fish over 90 cm in length, about 50 to 90 percent. About 62 percent of the fish caught by that fishery during 1962-1965 were males. Yoneta and Saito (1973) found the percentages of males to range from about 66 to 77 percent for "large" albacore caught in the western South Pacific during 1964-1969.

Ueyanagi (1957) estimated the range of the number of eggs per spawning in the northwestern Pacific to be about 0.8 to 2.6 million, and Otsu and Uchida (1959) obtained estimates of 0.9 to 1.8 million for fish from Hawaii.

3.1.3. Movement

Information on the movements of albacore in the North Pacific Ocean is given by Clemens (1961), Otsu and Uchida (1963), Rothschild and Yong (1970), Kume (1974), Kikawa *et al*. (1977), Laurs and Lynn (1977 and 1991), and Kimura *et al*. (1997). According to Laurs and Lynn (1977 and 1991), there appear to be two subgroups of albacore in the North Pacific Ocean (Section 3.1.5). The fish of the northern subgroup, when in the eastern Pacific Ocean, occur mostly north of 40°N. There is considerable exchange of fish of this subgroup between the troll fishery of the eastern Pacific and the baitboat and longline fisheries of the western Pacific. The fish of the southern subgroup occur mostly south of 40°N in the eastern Pacific, and relatively few of them are caught in the western Pacific. Fish that were tagged in offshore waters of the eastern Pacific and recaptured in the coastal fishery of the eastern Pacific exhibited different movements, depending on the latitude of release. Most of the recaptures of those released north of 35°N were made north of 40°N, and most of the recaptures of those released south of 35°N were made south of 40°N. Kimura *et al*. (1997) state that "the annual migration route for mature albacore is described as a closed ellipse with a centre at 20°N and 170°E, and is wider in El Niño years than in non-El Niño years associated with an appearance of a cold-water region in the central and south-western North Pacific. Immature albacore also have an anticlockwise migration route in winter which extends from 25°N to 35°N and from 130°E to 180°, when the Kuroshio has a relatively straight path. However, the migration does not persist when the Kuroshio takes a large meander path."

Much less is known about the movements of albacore in the South Pacific Ocean. According to Jones (1991) and Murray (1994), the juveniles move southward from the tropics when they are about 35 cm long, and then eastward along the Subtropical Convergence Zone. When the fish approach maturity they return to the tropics, where they spawn. According to Labelle (1993), recoveries of tagged fish released in areas east of 155°W were usually made at locations to the east and north of the release site, whereas those of fish released west of 155°W were usually made at locations to the west and north of the release site.

3.1.4. Natural mortality

Suda (1963 and 1966) estimated the natural mortality rate, *M*, for North Pacific albacore to be 0.2. Suda (1966) estimated *M* to be 0.2 for 6-year-olds and 0.4, 0.6, and 0.8 for fish at the end of their sixth, seventh, and eighth years of life, respectively. Bertignac *et al*. (1999), however, estimated the average *M* for North Pacific albacore after recruitment to the fishery to be about 0.6, assuming that about 90 percent of the tagged fish which are recaptured are reported. They performed a sensitivity analysis that showed that the estimate of *M* would be about 0.4 if only about 30 percent of the recaptures were reported and about 0.2 if only about 15 percent were reported.

Fournier *et al*. (1998: Figure 7) estimated *M* for South Pacific albacore to be about 0.2 for 1- to 5-year-old fish and to increase to about 0.35 for 9-year-old fish. The fact that there are more males than females among the older fish (Section 3.1.2) may indicate that *M* is greater for females than for males.

3.1.5. Stock structure

The albacore of the North Pacific Ocean and the South Pacific Ocean have usually been considered to be separate stocks (Nakamura, 1969; Kume, 1974; Bartoo and Foreman, 1994, Murray, 1994; Uosaki and Bayliff, 1999). Nakamura (1969) stated that "(1) there is no evidence that the albacore migrate across the Equator in any season, and (2) the population structures of the albacore in the two hemispheres are roughly symmetrical, [which] would indicate that it is reasonable to consider the two populations as discrete." Chow and Ushiama (1995) analyzed the mitochondrial DNA of albacore caught in the North and South Pacific, and concluded that there is gene flow between the two areas. However, even limited exchange of genetic material between two areas is sufficient to maintain genetic homogeneity.

Laurs and Lynn (1977 and 1991) stated that tagging data indicate that there are probably two "subgroups" of albacore in the North Pacific Ocean, and that the fish of the two subgroups have different "migratory patterns, modal sizes, growth rates, and spawning periods, although they do not appear to be genetically distinct." Off North America the boundary between the two subgroups is located at about 40°N. Labelle (1993) noted that tagging data for the South Pacific suggest "the existence of different migration patterns, as has been hypothesized for the North Pacific population."

3.2. Environmental influences

In the North Pacific Ocean surface-dwelling albacore inhabit the Kuroshio Current, the North Pacific Transition Zone (NPTZ), and the California Current. Information on the oceanography of these regions is given by Reid *et al*. (1958), Marr (1970), Stommel and Yoshida (1972), Sugawara (1972), Takenouti (1980), Laurs (1983), Reid (1988), Laurs and Lynn (1991), and Roden (1991). Albacore are most abundant at 200 to 260 m below the surface, but they have been caught at depths as great as 380 m with experimental vertical longlines. The greatest catches of albacore are made in areas with sea-surface temperatures (SSTs) of about 16° to 19°C, but acoustic tracking experiments have revealed that 3- to 5-year-old fish spend most of their time in or near the thermocline, where the temperatures can be as low as 10°C (Laurs and Lynn, 1991). Albacore, like the other tunas, have countercurrent heat exchangers that enable them to spend significant amounts of time in deeper, colder water. They are apparently restricted to waters with dissolved oxygen saturations greater than 60 percent (Graham and Laurs, 1982). Also, there is evidence that albacore tend to remain in waters with greater clarity than adjacent waters, possibly because they are better able to see their prey in clearer water (Laurs, 1983). Laurs *et al*. (1984) found aggregations of albacore in "pockets of warm, blue oceanic water intruding into the boundary between oceanic and cooler greenish coastal waters" off California.

In the South Pacific Ocean albacore inhabit the Subtropical Convergence Zone, which is analogous to the NPTZ (Labelle, 1993). Information on the oceanography of the South Pacific Ocean is given by Knox (1970). Fournier *et al*. (1998) noted that "the spawning seasons corresponding to low recruitments match well with the occurrence of El Niño episodes (negative values of the Southern Oscillation Index) in the Pacific Ocean," and *vice versa*.

4. STOCK ASSESSMENT

4.1. Indices of abundance

Indices of abundance of albacore in the North Pacific Ocean have been calculated by Laurs *et al*. (1976: troll fishery), Bartoo and Weber (1979: longline, troll, and baitboat fisheries), Kleiber and Perrin (1991: troll fishery), and Uosaki and Bayliff (1999: Figure 25, longline fishery east of 150°W). The longline data of Bartoo and Weber (1979: Figure 5) indicate that the abundance of albacore decreased from 1952 to 1963, and then remained at about the same level from 1963 to 1976. Their troll (their Figure 3) and baitboat (their Figure 4) data do not show clearcut upward or downward trends from 1961 to 1976. Kleiber and Perrin (1991) showed that the distribution of surface-dwelling albacore is patchy, and that during the period of their study, 1961-1988, the ability of the fishermen to locate high concentrations of fish had increased. The unadjusted data indicate that the abundance of albacore had neither increased nor declined during the 1961-1988 period, whereas the adjusted data indicate that the abundance of albacore had declined during that period (their Figure 2). Shono and Ogura (2000) calculated an index of abundance, using data from Japanese distant-water baitboats. They showed (their Figure 3) an index from 1972 to 1999, which declined in the 1980s, and then recovered in the 1990s, while varying considerably from year to year. A similar pattern was shown by most of the indices for individual age classes calculated by Uosaki (2000), using data from the Japanese longline fishery from 1975 to 1998.

Indices of abundance of albacore in the South Pacific Ocean have been calculated by Otsu and Sumida (1968: Figure 9), Skillman (1975: Figure 10), Yoshida (1975: Figures 2 and 5), Yeh and Wang (1996: Figures 5 and 6), Uosaki and Bayliff (1999: Figure 25, east of 150°W), and Wang (1999: Figure 4), all of whom used longline data. In every case the data show declines in the abundance of the fish.

4.2. Assessment models

Three general types of models, age-structured models, spawner-recruit models, and production models, all of which are described by Anonymous (2000: 51-65), are used to assess the condition of stocks of fish. All three types of models require that the analyses be done with a discrete stock of fish. As stated in Section 3.1.5, there appear to be two stocks of albacore in the Pacific Ocean, the North Pacific stock and the South Pacific stock.

4.2.1. North Pacific albacore

Assessment of the North Pacific stock of albacore has been conducted by Bartoo and Weber (1979), Bartoo and Shiohama (1984), Kleiber and Baker (1987), Kleiber and Perrin (1991), Bertignac *et al*. (1999), Takeuchi *et al*.. (1999), Ogura (2000), and Uosaki *et al.* (2000). Of these studies, the following used age-structured models: Bartoo and Weber (1979), Kleiber and Baker (1987), Bertignac *et al*. (1999)), Takeuchi *et al*.. (1999), and Uosaki *et al.* (2000).

Bartoo and Weber (1979) estimated that the yields per recruitment of North Pacific albacore during the 1955-1970 and 1971-1976 periods were approximately as follows: northeastern Pacific troll fishery, 2.6 and 1.6 kg; northwestern Pacific baitboat fishery, 3.0 and 4.3 kg; North Pacific longline fishery, 2.5 and

0.4 kg; three fisheries combined, 8.0 and 6.0 kg. They stated that decreases in effort and increases in age at first capture would benefit both the longline fishery and the fishery as a whole. They noted, however, that increases in effort would benefit the troll fishery of the northeastern Pacific. The results of Kleiber and Baker (1987) and Bertignac *et al*. (1999) indicate that the fishing mortality rate for North Pacific albacore is relatively low. Kleiber and Baker (1987) conducted a simulation study to estimate the interactions among the three fisheries, using Suda's (1966) estimate of $M = 0.2$. Their estimates of the effects of doubling and halving the fishing effort for each fishery are presented in Table 4.2.1. Doubling the effort for a fishery would increase the catch by that fishery by 85 to 98 percent and decrease those of the other two fisheries by 0.1 to 7.5 percent, and halving the effort for a fishery would decrease the catch by that fishery by 48 to 50 percent and increase those of the other two fisheries by 0.1 to 4.1 percent. Obviously, the interaction among the three fisheries is minimal, which means, of course, that the fishing mortality rates are low relative to the value of M used in their simulations. If they had used a higher value of M the effects of the various fisheries on the other fisheries would have been even less. Takeuchi *et al.* (1999) and Uosaki *et al.* (2000) used ADAPT, a tuned virtual population analysis (Conser, 1999), applying it to aggregated data for all the major fisheries for North Pacific albacore. Uosaki *et al.* (2000) used 0.3 as the natural mortality rate, M, in the base case. They compared various values of M and estimated the age of catches using different parameters for the von Bertalanffy equation. They found patterns that were consistent for a range of parameters (Figure 4.2.1). Recruitment appears to have declined until about 1988, and then increased considerably. Total biomass follows the same trends as recruitment, with less year-to-year variability, apparently lagging recruitment by one year. Estimates of the spawning stock biomass do not decline so markedly in the seventies and eighties, but they, too, increase markedly in the nineties. Estimates of exploitation rates show a trend toward lower values throughout the period studied, declining from 12 to 20 percent in 1975 and 1976 to 7 to 8 percent in the late 1990s. Bertignac *et al. (*1999), in a study that covered the 1972-1992 period, used tag return data to estimate exploitation rates. These estimates are lower than those that Uosaki *et al*. (2000) obtained with a cohort analysis model for every year for which they can be compared. Bertignac *et al. (*1999) hypothesized that tagged fish might become "hook-shy," and thus less available to trolling gear. They showed that if this were so, neglecting it would have led to a substantial underestimate of the true exploitation rate, at least until 1986.

Bartoo and Shiohama (1984) carried out a production model analysis, with estimates of the sensitivity of the results to measurement errors in the data. They used catch and standardized catch-per-unit-of-effort (CPUE) data for the North Pacific longline, northeastern Pacific troll, and northwestern Pacific baitboat fisheries for 1961-1981 to calculate standardized effort data for that period. The average maximum sustainable yield (AMSY) for the North Pacific was estimated to be about 89 000 metric tons, with possible errors of plus or minus 20 percent, which would result in a range of about 71 000 to 108 000 metric tons. The optimum effort was estimated to be about 134 000 units, with a range of 107 000 to 162 000 units. The estimates of AMSY are insensitive to errors in the estimates of effort, but sensitive to errors in the estimates of catch. The estimates of optimum effort are insensitive to errors in catch, but sensitive to errors in the estimates of effort. The optimum effort was nearly reached in 1976, when the catch was 121 106 metric tons, and in 1978, when the catch was 90 300 metric tons. It should be noted that the fit of the catch and effort data to the dome-shaped curve (their Figure 1) was poor. Kleiber and Perrin (1991) showed that during the 1961-1988 period the ability of the troll fishermen to locate high concentrations of fish had been increasing, which would create a bias in Bartoo and Shiohama's (1984) estimates of fishing effort. Ogura (2000) noted that after decades of relative stability, CPUE had increased substantially in the 1990s. He divided the data and fitted the same model to the periods 1952-1988 and 1989-1998 separately, estimating different parameters for each period. The estimated maximum sustainable yield for the two periods differs considerably: it is about 90 000 metric tons per year in the earlier period, increasing to about 150 000 metric tons per year recently.

4.2.2. South Pacific albacore

Assessment of the South Pacific stock of albacore has been conducted by Skillman (1975), Yeh and Wang (1996), Fournier *et al*. (1998), and Wang (1999).

Fournier *et al*. (1998) used catch and effort data and length composition data in an age-structured model, MULTIFAN-CL, which estimates selectivity and catchability coefficients, growth parameters and age composition of the catch, natural and fishing mortality rates, movement parameters, and population biomass and recruitment. They showed that the relative biomass of albacore reached a maximum during the 1970s, and subsequently declined. They did not make any statements regarding whether the stock was over- or underfished.

Skillman (1975), Yeh and Wang (1996), and Wang (1999) all used catch and CPUE data for the longline fishery and production models to assess the status of the stock of albacore in the South Pacific Ocean. Skillman estimated AMSY to be about 33 000 to 35 000 metric tons. Yeh and Wang (1996) used the method of Honma (1974) and a general linear model to standardize catch and effort data for the Japanese, Korean, and Taiwanese fisheries, and then used these data to estimate the parameters of the symmetrical production model. The data from the Honma and general linear models produced estimates of 31 320 and 31 620 metric tons, respectively, for the AMSY. Wang (1999), using the method of Schnute (1977), estimated the AMSY to be 30 806 metric tons. It should be noted that the fits of the catch and effort data to the various dome-shaped curves were poor (Skillman, 1975: Figure 11; Yeh and Wang, 1996: Figure 8).

4.3. Comparison to external data sources

Fournier *et al*. (1998) stated that, "although further questions concerning the albacore analysis need exploration, the consistency of the model results with various exogenous data sets is encouraging. These include the consistency of MULTIFAN-CL length-at-age estimates with those previously derived from vertebral ring counts [Labelle *et al*., 1993], the consistency of age-dependent natural mortality rate estimates with changes in albacore sex ratio with size and with the onset of female reproductive maturity [Ramón and Bailey, 1996], and the apparent relationship between variation in estimated recruitment and variation in the Southern Oscillation Index."

4.4. Sensitivity to assumptions

Bartoo and Shiohama's (1984) production model analysis, summarized in Section 4.2.1, included estimates of the sensitivity of the results to measurement errors in the data. Analyses to determine the sensitivity of estimates of the natural mortality rates to assumptions regarding tag-reporting rates were carried out by Bertignac *et al*. (1999). These are summarized in Section 3.1.4. Takeuchi *et al.* (1999) and Uosaki *et al.* (2000) investigated the sensitivity of their model to various parameters, such as natural mortality and those of the von Bertalanffy growth equation, as summarized in Section 4.2.1. The results of some runs, based on different estimated size-at-age functions and a different assumption concerning the fishing mortality in the last age-classes, are given in Figure 4.2.1.

5. STOCK STATUS

Albacore are apparently not overfished in either the North Pacific or the South Pacific.

6. FUTURE DIRECTIONS

6.1. Specification of management objectives

At the 17th meeting of the North Pacific Albacore Workshop, Taiwan, on December 6-13, 2000, it was decided that length-frequency data that are deposited in the central repository should include the sample size. Those attending also resolved to develop both biomass and age-structured models further. Production modeling would be developed in the manner proposed by Conser (1998), in which natural mortality is incorporated explicitly into the equations. This would allow such a biomass model to be compared directly with the results of an age-structured model, using the same value for *M*. Age-structured models would be developed by applying a model similar to the A-SCALA model of Maunder and Watters (submitted). A-SCALA is a form of cohort analysis that recognizes that many relationships, such as the efficiency of fleets and the size at age of fish, may vary through time and space. These relationships are estimated at the same time as fishing mortalities, selectivities, *etc*. It is hoped that A-SCALA will provide a framework for incorporating disparate data that cannot be formally incorporated into other methods.

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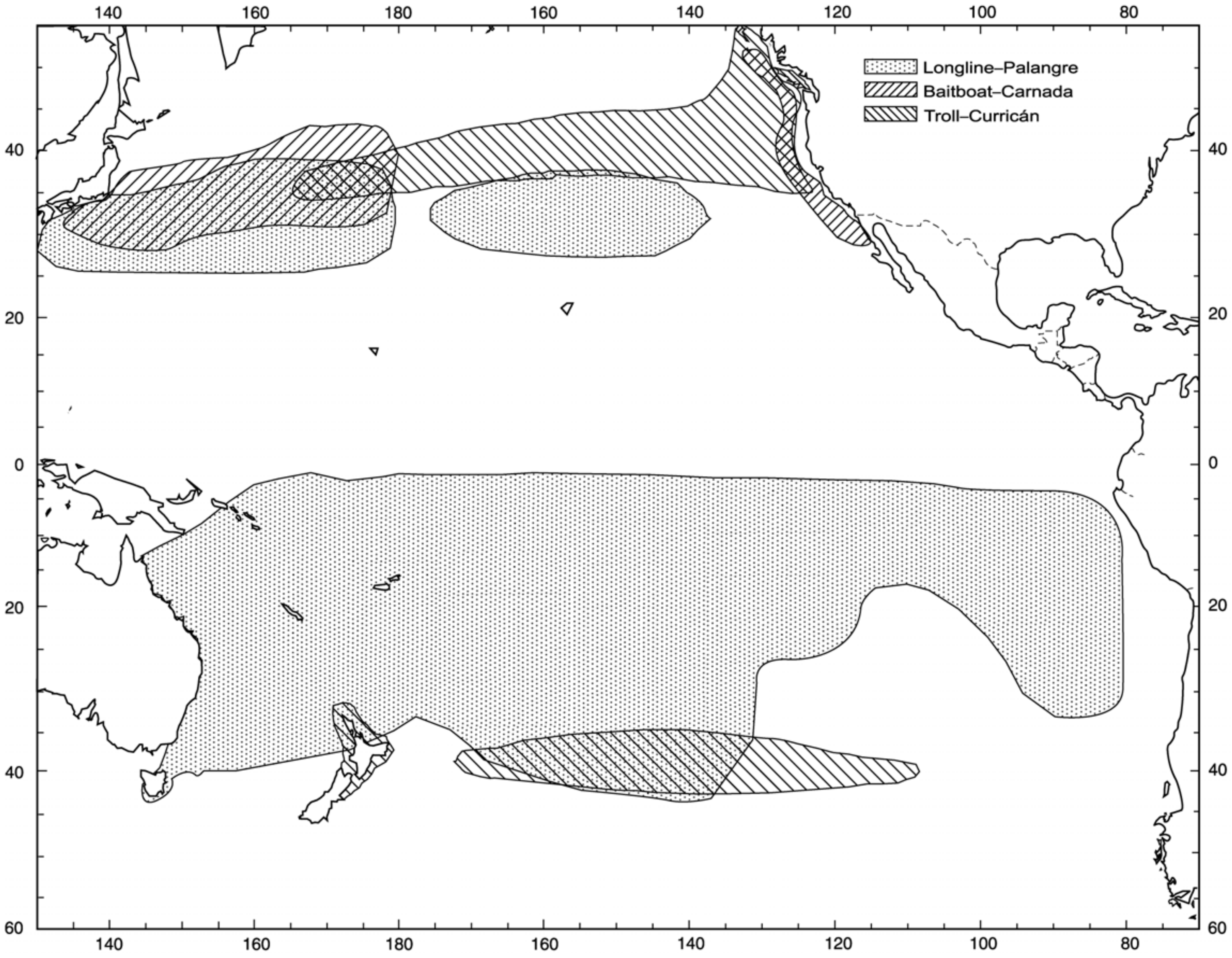

FIGURE 2.2.1. Schematic representation of fisheries for albacore, adapted from Fournier *et al*. (1998) and Bertignac *et al*. (1999).
FIGURA 2.2.1. Representación esquemática de las pesquerías de albacora, adaptada de Fournier *et al*. (1998) y Bertignac *et al*. (1999).

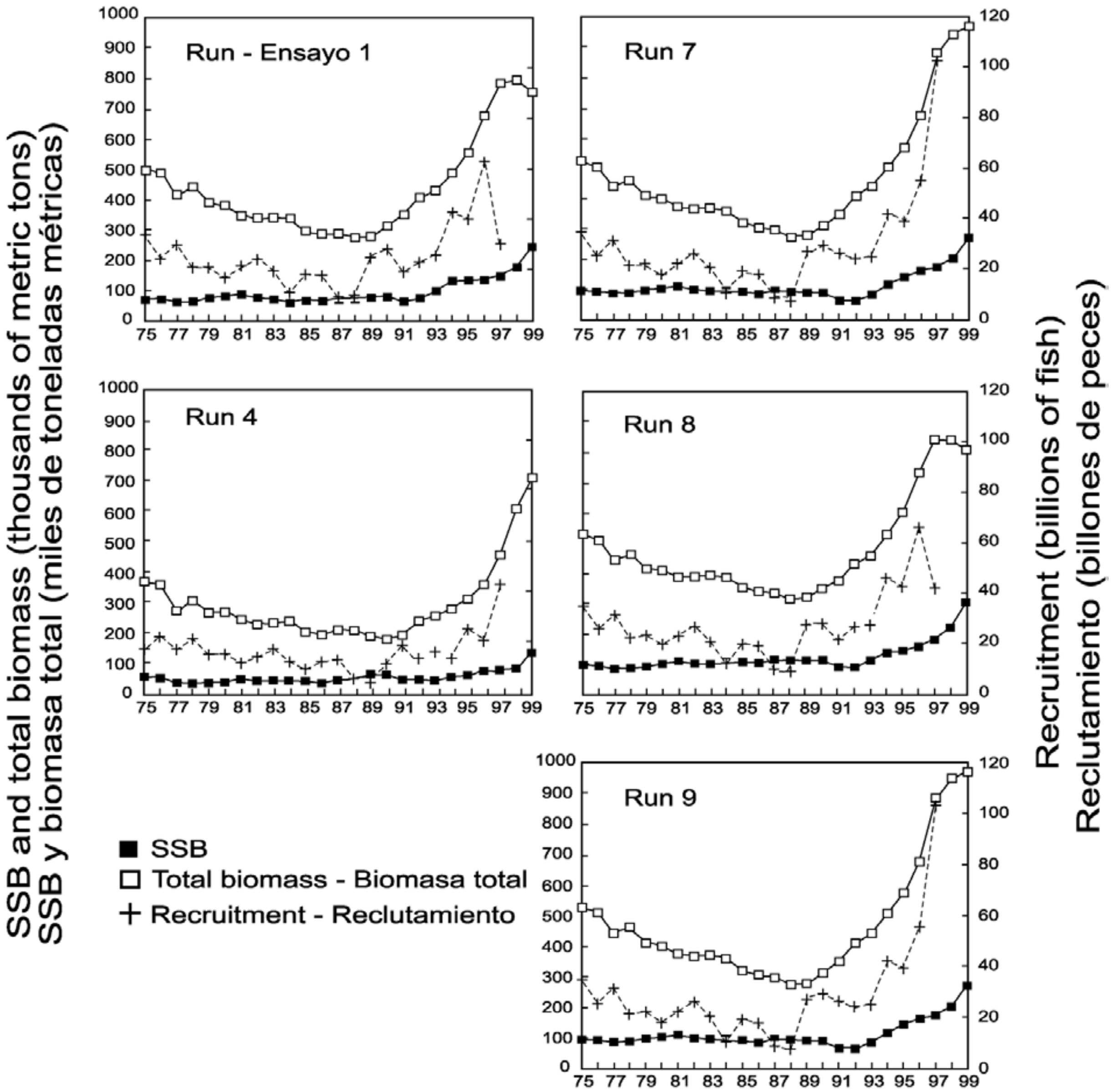

FIGURE 4.2.1. Estimates of spawning-stock biomass (SSB), total biomass (age-1 and older), and number of recruits (age-1) estimated with an age-structured model, using different estimates of length at age and different assumptions concerning the fishing mortality in the last two age classes (after Uosaki *et al*. (2000: Figure 1)).

FIGURA 4.2.1. Estimaciones de la biomasa del stock reproductor (SSB), biomasa total (edad 1 y mayores), y número de reclutas (edad 1) estimadas con un modelo con estructura de edades, usando distintas estimaciones de talla a edad y distintos supuestos sobre la mortalidad por pesca en las dos últimas clases de edad (de Uosaki *et al*. (2000: Figura 1)).

TABLE 2.2.1a. Catches of albacore in the North Pacific Ocean, in metric tons, by gear type and flag of vessel (after Childers and Miller, 2000: Table 1). The values in bold face are preliminary. The country codes are listed at the bottom of the table.

TABLA 2.2.1a. Capturas de albacora en el Océano Pacífico oriental norte, en toneladas métricas, por arte de pesca y pabellón de buque (de Childers y Miller, 2000, Tabla 1). Los valores en negritas son preliminares. Al pie de la tabla se explican los códigos de paises.

	Longline—Palangre					Baitboat—Carnada			Troll—Curricán		
	JPN	KOR	TWN	USA	Total	JPN	USA	Total	CAN	USA	Total
1952	26,687			46	26,733	41,787		41,787	71	23,843	23,914
1953	27,777			23	27,800	32,921		32,921	5	15,740	15,745
1954	20,958			13	20,971	28,069		28,069		12,246	12,246
1955	16,277			9	16,286	24,236		24,236		13,264	13,264
1956	14,341			6	14,347	42,810		42,810	17	18,751	18,768
1957	21,053			4	21,057	49,500		49,500	8	21,165	21,173
1958	18,432			7	18,439	22,175		22,175	74	14,855	14,929
1959	15,802			5	15,807	14,252		14,252	212	20,990	21,202
1960	17,369			4	17,373	25,156		25,156	5	20,100	20,105
1961	17,437			5	17,442	18,639	2,837	21,476	4	12,055	12,059
1962	15,764			7	15,771	8,729	1,085	9,814	1	19,752	19,753
1963	13,464			7	13,471	26,420	2,432	28,852	5	25,140	25,145
1964	15,458		26	4	15,488	23,858	3,411	27,269	3	18,388	18,391
1965	13,701		261	3	13,965	41,491	417	41,908	15	16,542	16,557
1966	25,050		271	8	25,329	22,830	1,600	24,430	44	15,333	15,377
1967	28,869		635	12	29,516	30,481	4,113	34,594	161	17,814	17,975
1968	23,961		698	11	24,670	16,597	4,906	21,503	1,028	20,434	21,462
1969	18,006		634	14	18,654	31,912	2,996	34,908	1,365	18,827	20,192
1970	15,372		1,516	9	16,897	24,263	4,416	28,679	390	21,032	21,422
1971	11,035		1,759	11	12,805	52,957	2,071	55,028	1,746	20,526	22,272
1972	12,649		3,091	8	15,748	60,591	3,750	64,341	3,921	23,600	27,521
1973	16,059		128	14	16,201	68,808	2,236	71,044	1,400	15,653	17,053
1974	13,053		570	9	13,632	73,576	4,777	78,353	1,331	20,178	21,509
1975	10,060	2,463	1,494	33	14,050	52,157	3,243	55,400	111	18,932	19,043
1976	15,896	859	1,251	23	18,029	85,336	2,700	88,036	278	15,905	16,183
1977	15,737	792	873	37	17,439	31,934	1,497	33,431	53	9,969	10,022
1978	13,061	228	284	54	13,627	59,877	950	60,827	23	16,613	16,636
1979	14,249	259	187		14,695	44,662	303	44,965	521	6,781	7,302
1980	14,743	597	318		15,658	46,743	382	47,125	212	7,556	7,768
1981	18,020	459	339	25	18,843	27,426	748	28,174	200	12,637	12,837
1982	16,762	387	559	94	17,802	29,615	425	30,040	104	6,609	6,713
1983	15,103	454	520	6	16,083	21,098	607	21,705	225	9,359	9,584
1984	15,111	136	471	2	15,720	26,015	1,030	27,045	50	9,304	9,354
1985	14,320	291	109	0	14,720	20,714	1,498	22,212	56	6,415	6,471
1986	12,945	241			13,186	16,096	432	16,528	30	4,708	4,738
1987	14,642	182		149	14,973	19,091	158	19,249	104	2,766	2,870
1988	13,904	109	38	309	14,360	6,216	598	6,814	155	4,212	4,367
1989	13,194	81	544	250	14,069	8,629	54	8,683	140	1,860	2,000
1990	15,928	20	287	168	16,403	8,532	115	8,647	302	2,603	2,905
1991	17,043	3	353	313	17,712	7,103	0	7,103	139	1,845	1,984
1992	19,149	43	300	332	19,824	13,888	0	13,888	363	4,572	4,935
1993	29,616	43	494	440	30,593	12,809		12,809	494	6,254	6,748
1994	29,612	43	586	546	30,787	26,391	0	26,391	836	10,978	11,814
1995	29,080	43	2,504	880	32,507	20,981	0	20,981	1,698	8,200	9,898
1996	32,492	**43**	3,594	1,184	**37,313**	20,272	0	20,272	602	16,346	16,948
1997	40,711	**43**	4,199	1,642	**46,595**	32,250	0	32,250	1,045	14,151	15,196
1998	**40,711**	**43**	4,797	1,131	**46,682**	**28,512**	6	**28,518**	3,034	14,025	17,059
1999	**40,711**	**43**	**4,797**	**1,526**	**47,077**	**28,512**	51	**28,563**	**3,034**	**11,169**	**14,203**

TABLE 2.2.1a. (continued)
TABLA 2.2.1a. (continuación)

	Gillnet—Red agallera					Purse seine—Cerco				Sport	Other—Otro				Total
	JPN	KOR	TWN	USA	Total	CAN	JPN	USA	Total	USA	JPN	MEX	USA	Total	
1952					0		154		154	1,373	237			237	94,198
1953					0		38		38	171	132			132	76,807
1954					0		23		23	147	38			38	61,494
1955					0		8		8	577	136			136	54,507
1956					0					482	57			57	76,464
1957					0		83		83	304	151			151	92,268
1958					0		8		8	48	124			124	55,723
1959					0					0	67		5	72	51,333
1960					0	136			136	557	76		4	80	63,407
1961					0		7		7	1,355	268	0	6	274	52,613
1962					0		53		53	1,681	191	0	8	199	47,271
1963					0		59		59	1,161	218	0	7	225	68,913
1964					0		128		128	824	319	0	4	323	62,423
1965					0		11		11	731	121	0	3	124	73,296
1966					0		111		111	588	585	0	9	594	66,429
1967					0		89		89	707	520	0	12	532	83,413
1968					0		267		267	951	1,109		10	1,119	69,972
1969					0		521		521	358	935		12	947	75,580
1970					0		317		317	822	456	0	9	465	68,602
1971					0		902		902	1,175	308	0	11	319	92,501
1972	1				1		277		277	637	623	100	8	731	109,256
1973	39				39		1,353		1,353	84	495	0	14	509	106,283
1974	224				224		161		161	94	879	1	9	889	114,862
1975	166				166		159		159	640	228	1	43	272	89,730
1976	1,070				1070		1,109		1,109	713	272	36	27	335	125,475
1977	688				688		669		669	537	355	0	36	391	63,177
1978	4,029				4029		1,115		1,115	810	2,078	1	69	2,148	99,192
1979	2,856				2856		125		125	74	1,126	1	31	1,158	71,175
1980	2,986	6			2992		329		329	168	1,179	31	24	1,234	75,274
1981	10,348	16			10364		252		252	195	663	8	60	731	71,396
1982	12,511	113			12624		561		561	257	440	7	84	531	68,528
1983	6,852	233			7085		350		350	87	118	33	213	364	55,258
1984	8,988	516			9504		3,380	3,728	7,108	1,427	511	113	138	762	70,920
1985	11,204	576		2	11782		1,533		1,533	1,176	305	49	83	437	58,331
1986	7,813	726		3	8542		1,542		1,542	196	626	3	106	735	45,467
1987	6,698	817	2,514	5	10034		1,205		1,205	74	155	7	136	298	48,703
1988	9,074	1,016	7,389	15	17494		1,208		1,208	64	134	15	318	467	44,774
1989	7,437	1,023	8,350	4	16814		2,521		2,521	160	393	2	272	667	44,914
1990	6,064	1,016	16,701	29	23810		1,995	71	2,066	24	249	2	181	432	54,287
1991	3,401	852	3,398	17	7668		2,652		2,652	6	392	2	384	778	37,903
1992	2,721	271	7,866	0	10858		4,104	0	4,104	2	1,527	10	408	1,945	55,555
1993	287			0	287		2,889	0	2,889	25	867	11	331	1,209	54,560
1994	263			38	301		2,026		2,026	106	799	6	712	1,517	72,942
1995	282			40	322		1,177		1,177	102	937	5	1,096	2,038	67,025
1996	116			38	154		581	11	592	51	932	21	0	953	**76,284**
1997	359			38	397		1,068	2	1,070	744	1,708	53	0	1,761	**98,013**
1998	**359**			79	**438**		879	33	912	1,153	1,708		1	1,709	**96,471**
1999	**359**			**108**	**467**		**879**	**47**	**926**	**1,874**	**1,708**		**56**	**1,764**	**94,874**

CAN: Canada—Canadá; JPN: Japan—Japón; KOR: Republic of Korea—República de Corea; MEX: Mexico—México; TWN: Taiwan; USA: United States—Estados Unidos

TABLE 2.2.1b. Catches of albacore in the South Pacific Ocean, in metric tons, by gear type and flag of vessel (after Childers and Miller, 2000: Table 2). The values in bold face are preliminary. The country codes are listed at the bottom of the table. BB: baitboat.

TABLA 2.2.1b. Capturas de albacora en el Océano Pacífico oriental sur, en toneladas métricas, por arte de pesca y pabellón de buque (de Childers y Miller, 2000, Tabla 1). Los valores en negritas son preliminares. Al pie de la tabla se explican los códigos de paises. BB: barco de carnada.

	Longline—Palangre														
	AUS	FJI	JPN	KOR	NCL	NZL	PYF	SLB	TON	TWN	USA	VUT	WSM	Other	Total
1952			154												154
1953			803												803
1954			9,578												9,578
1955			8,625												8,625
1956			7,281												7,281
1957			8,757												8,757
1958			18,490	146											18,636
1959			17,385	456											17,841
1960			21,638	610											22,248
1961			23,412	330											23,742
1962			34,620	599											35,219
1963			29,120	1,367						608					31,095
1964			19,390	2,911						629					22,930
1965			17,793	6,405						1,640					25,838
1966			21,627	10,817						6,669					39,113
1967			15,104	13,717						11,497					40,318
1968			6,659	10,138						12,254					29,051
1969			4,894	9,963						9,503					24,360
1970			5,297	11,599						14,484					31,380
1971			3,472	14,482						15,871					33,825
1972			3,027	14,439						16,674					34,140
1973			2,550	17,452				4		17,741					37,747
1974			1,868	12,194						16,857					30,919
1975			1,333	9,015						16,056					26,404
1976			2,054	9,058				6		13,206					24,324
1977			2,328	11,229				9		21,429					34,995
1978			2,845	11,658				9		20,702					35,214
1979			2,274	11,411				21		14,987					28,693
1980			2,216	10,449				25		17,998					30,688
1981			4,203	13,342				2		14,390					31,937
1982			4,899	10,769				8	106	12,634	0				28,416
1983			5,723	7,069	12			19	143	12,069	5				25,040
1984			3,804	5,321	112			19	135	11,155	9				20,555
1985	0		3,868	13,544	131			12	174	9,601	11				27,341
1986	0		4,426	15,877	179				206	11,913	0				32,601
1987	129		4,490	6,821	563				252	15,009	0				27,264
1988	107		7,469	6,563	584				242	17,120	1			0	32,086
1989	93	3	5,828	5,151	566	19			195	10,867	0			0	22,722
1990	51	68	6,573	3,947	1,053	249	20		152	11,619	0			4	23,736
1991	213	208	4,468	1,866	909	325	100		171	16,508	1			0	24,769
1992	192	243	3,814	2,271	692	706	195		199	20,956	0			0	29,268
1993	226	463	8,381	1,083	755	221	714		231	17,701	0		228	1	30,004
1994	351	586	7,151		840	474	913		343	19,731	34		641	29	31,093
1995	401	665	6,326	8	332	427	772	161	379	12,775	52	112	1,883	43	24,336
1996	408	1,024	3,879	215	414	480	1,463	1,154	494	11,909	99	287	2,470	49	24,345
1997	302	1,197	4,625	845	267	323	2,595	608	**494**	15,662	271	17	4,387	101	**31,694**
1998	480	1,207	4,625	2,680	860	323	3,189	370	**494**	15,101	326	17	6,508	36	**36,216**
1999	**480**	**1,207**	**4,625**	**2,680**	**860**	**323**	**3,189**	**370**	**494**	**15,101**	**326**	**17**	**6,508**	**36**	**36,216**

TABLE 2.2.1b. (continued)
TABLA 2.2.1b. (continuación)

	Troll—Curricán						Gillnet—Red agallera					BB	Total
	AUS	NZL	PYF	USA	Other	Total	CHL	JPN	KOR	TWN	Total	JPN	
1952													154
1953													803
1954													9,578
1955													8,625
1956													7,281
1957													8,757
1958													18,636
1959													17,841
1960												45	22,293
1961													23,742
1962													35,219
1963												16	31,111
1964													22,930
1965													25,838
1966													39,113
1967		5				5							40,323
1968		14				14							29,065
1969													24,360
1970	100	50				150							31,530
1971	100					100							33,925
1972	100	268				368							34,508
1973	100	484				584							38,331
1974	100	898				998							31,917
1975	100	646				746							27,150
1976	100	25				125							24,449
1977	100	621				721							35,716
1978	100	1,686				1,786							37,000
1979	100	814				914							29,607
1980	100	1,468				1,568						19	32,275
1981	5	2,085				2,090						8	34,035
1982	6	2,434				2,440						1	30,857
1983	7	744				751		32			32	2	25,825
1984	8	2,773				2,781		1,581			1,581		24,917
1985	9	3,253				3,262		1,928			1,928		32,531
1986	10	1,911		92		2,013		1,936			1,936		36,550
1987	11	1,227		751		1,989		919			919		30,172
1988	12	330		3,558	90	3,990		4,271		1,000	5,271		41,347
1989	13	5,161	102	3,280	162	8,718		13,263	172	8,520	21,955		53,395
1990	15	2,143	299	3,922		6,379		5,667		1,859	7,526		37,641
1991	20	2,236	326	5,540	4	8,126				1,394	1,394		34,289
1992	70	3,708	72	3,055	54	6,959						49	36,275
1993	55	3,282	45	1,036		4,418						5	34,427
1994	70	5,094		530	128	5,822						2	36,918
1995	25	5,760	184	2,092	121	8,182	15				15		32,533
1996	25	5,157	69	2,186	215	7,652	21				21		32,018
1997	25	3,303	24	1,403	356	5,111	0				0		36,805
1998	35	3,303		1,764	294	5,396	0				0		41,613
1999	35	3,303	0	1,200	129	4,667	0				0		40,883

AUS: Australia; CHL: Chile; FJI: Fiji; JPN: Japan--Japón; KOR: Republic of Korea--República de Corea; NCL: New Caledonia--Nueva Caledonia; NZL: New Zealand--Nueva Zelanda; PYF: French Polynesia--Polinesia Francesa; SLB, Solomon Islands--Islas Salomón; TON: Tonga; TWN: Taiwan; USA: United States--Estados Unidos; VUT: Vanuatu; WSM: Western Samoa--Samoa Occidental.

TABLE 3.1.1a. Growth parameters of North Pacific albacore estimated by Laurs and Wetherall (1981: Table 3). Method BGC4 involved the use of a computer program by that name. The sequential method, for which L_∞ is set at 125 cm, is described by Laurs and Wetherall (1981). Group A: all fish recaptured inshore south of 40°N except those released inshore north of 40°N; Group B: all fish recaptured inshore north of 40°N except those released inshore south of 40°N; Group C: all fish recaptured west of 180°.

TABLA 3.1.1a. Parámetros de crecimiento de albacora del Pacífico norte estimados por Laurs y Wetherall (1981: Tabla 3), y parámetros de mortalidad natural estimados par este informe con el método de Pauly (1980). En el método BGC4 se usó un programa de computadora del mismo nombre. El método secuencial, para el cual se fija L_∞ en 125 cm, es descrito por Laurs y Wetherall (1981). Grupo A: todos los peces recapturados cerca de la costa al sur de 40°N excepto aquéllos liberados cerca de la costa al norte de 40°N; Grupo B: todos los peces recapturados cerca de la costa al norte de 40°N excepto aquéllos liberados cerca de la costa al sur de 40°N; Grupo C: todos los peces recapturados al oeste de 180°.

	Method	Recapture group	Sample size	L_∞ (cm)	*K* (annual)
	Método	Grupo de recaptura	Tamaño muestra	L_∞ (cm)	*K* (anual)
1	BGC4	A	221	94.5	0.505
2		B	75	107.5	0.272
3		C	114	98.5	0.345
4		B + C	189	102.1	0.310
5		A + B + C	410	100.9	0.342
6	Sequential-Secuencial	A	221	125.0	0.231
7		B	75	125.0	0.193
8		C	114	125.0	0.184
9		B + C	189	125.0	0.185
10		A + B + C	410	125.0	0.199

TABLE 3.1.1b. Growth parameters of South Pacific albacore estimated by Labelle *et al.* (1993: Table 3).

TABLA 3.1.1b. Parámetros de crecimiento de albacora del Pacífico sur estimados por Labelle *et al.* (1993: Tabla 3).

	Sex	Sample size	Ages	L_∞(cm)	*K* (annual)	t_0
	Sexo	Tamaño muestra	Edad	L_∞(cm)	*K* (anual)	t_0
1	male macho	70	2-10	122.0	0.168	-0.907
2	female hembra	58	2-9	169.3	0.077	-2.573
3	both ambos	484	2-11	121.0	0.134	-1.922

TABLE 3.1.1c. Estimated lengths, in centimeters, at age of North Pacific albacore, calculated from the data in Table 3.1.1a.
TABLA 3.1.1c. Talla estimada (cm) a edad para albacora del Pacífico norte, calculadas a partir de los datos en la Tabla 3.1.1a.

	Age in year—Edad en años									
	1	2	3	4	5	6	7	8	9	10
1	37	60	74	82	87	90	92	93	93	94
2	26	45	60	71	80	86	91	95	98	100
3	29	49	64	74	81	86	90	92	94	95
4	27	47	62	73	80	86	90	94	96	98
5	29	50	65	75	83	88	92	94	96	98
6	26	46	62	75	86	94	100	105	109	113
7	22	40	55	67	77	86	93	98	103	107
8	21	38	53	65	75	84	91	96	101	105
9	21	39	53	65	75	84	91	97	101	105
10	37	60	74	82	87	90	92	93	93	94

TABLE 3.1.1d. Estimated lengths, in centimeters, at age of South Pacific albacore, calculated from the data in Table 3.1.1b.
TABLA 3.1.1d. Tallas estimadas (cm) a edad para albacora del Pacífico norte, calculadas a partir de los datos en la Tabla 3.1.1b.

	Age in years—Edad en años									
	1	2	3	4	5	6	7	8	9	10
1	33	47	59	69	77	84	90	95	99	103
2	41	50	59	67	75	82	88	94	100	105
3	39	49	58	66	73	79	84	89	93	97

TABLE 3.1.1e. Equations for converting lengths, in centimeters, to weights, in kilograms, for albacore.
TABLA 3.1.1e. Ecuaciones para convertir tallas, en cm, a pesos, en kg, para albacora.

Area	Sample size	Length range (cm)	Equations	Reference
Zona	Tamaño muestra	Rango de talla (cm)	Ecuaciones	Referencia
Eastern Pacific—Pacífico oriental	1,073	38-100	$w = (2.1875 \text{ x } 10^{-5})l^{2.99}$	Clemens, 1961
Hawaii and northern Pacific—Hawaii y Pacífico norte	200	50-128	$w = (2.5955 \text{ x } 10^{-5})l^{2.9495}$	Nakamura and Uchiyama, 1966
American Samoa (landed)— Samoa Americana (descargado)	887	78-108	$w = (8.8405 \text{ x } 10^{-5})l^{2.6822}$	Nakamura and Uchiyama, 1966

TABLE 3.1.2. Minimum lengths at first maturity of albacore found by various workers.
TABLA 3.1.2. Tallas mínimas de primera madurez encontradas por varios investigadores.

Area	Sex	Length at first maturity (cm)	Reference
Area	Sexo	Talla de primera madurez (cm)	Referencia
Northeastern Pacific— Pacífico noreste	male female	70 69	Partlo, 1955
Northwestern Pacific— Pacífico noroeste	male female	97 90	Ueyanagi, 1957: Figure 6
Hawaii	female	90	Otsu and Uchida, 1959: Figure 11
South Pacific— Pacífico sur	male female	90 84	Otsu and Hansen, 1962: Figure 7
	male	71	Ratty *et al*., 1990: Figure 9
	female	82	Ramón and Bailey, 1996: 730

TABLE 4.2.1. Interactions among the troll, baitboat, and longline fisheries for North Pacific albacore when the fishing effort for one fishery is doubled or halved and those for the other two fisheries are not changed (after Kleiber and Baker, 1987: Table 3).
TABLA 4.2.1. Interacciones entre las pesquerías con curricán, carnada, y palangre de albacora del Pacífico norte al multiplicar o dividir por dos el esfuerzo de pesca de una pesquería y no cambiar el esfuerzo de las otras dos (de Kleiber y Baker, 1987: Tabla 3).

Effort	Multiplier of effort	Changes in weights (thousands of tons) and percentages							
		Troll		Baitboat		Longline		All gears	
		Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent
Esfuerzo	Multiplicador de esfuerzo	Cambios en peso (miles de toneladas) y porcentajes							
		Curricán		Carnada		Palangre		Todas artes	
		Peso	%	Peso	%	Peso	%	Peso	%
Troll— Curricán	2.0	+17.09	+93.3	-0.69	-1.3	-0.24	-2.5	+16.16	+18.4
	0.5	-9.00	-49.1	+0.37	+0.7	+0.12	+1.3	-8.51	-9.4
Baitboat— Carnada	2.0	-0.27	-1.5	+46.88	+85.1	-0.71	-7.5	+45.90	+50.8
	0.5	+0.14	+0.8	-26.43	-47.8	+0.39	+4.1	-25.90	-28.7
Longline— Palangre	2.0	-0.02	-0.1	-0.21	-0.4	+9.32	+98.4	+9.09	+10.1
	0.5	+0.01	+0.1	+0.11	+0.2	-4.72	-49.8	-4.60	-5.1