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(Revised)

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National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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REPORT

of the

WORKSHOP ON THE POPULATION DYNAMICS OF NORTH PACIFIC ALBACORE

Honolulu, Hawaii, U.S.A.

10-12 December 1975

May 1976

CONTENTS

1. Opening of the Workshop

1.1 The workshop was conducted at the National Marine Fisheries Service (NMFS) laboratory in Honolulu, Hawaii, on 10-12 December 1975, as part of an informal agreement established in 1974 between the Southwest Fisheries Center, NMFS and the Far Seas Fisheries Research Laboratory of the Japan Fisheries Agency to promote and accelerate joint investigations into the population dynamics of North Pacific albacore. Participants at the workshop included representatives of the Southwest Fisheries Center, the Far Seas Fisheries Research Laboratory, the California Department of Fish and Game, the Oregon Department of Fish and Wildlife, the Washington Department of Fisheries, and the Pacific Marine Fisheries Commission. A complete list of participants is given as Appendix A to this report.

1.2 Richard S. Shomura, Director of the Honolulu Laboratory, welcomed the participants, reviewed the terms of reference for the workshop, and set out the objectives, which were

a. To produce a rapid, preliminary assessment of the status of the North Pacific albacore stock in terms of standard equilibrium yield and yield per recruit criteria,

b. To identify weaknesses in the preliminary assessments, and,

c. To recommend a set of goals for the next phase of the cooperative research program.

1.3 Jerry A. Wetherall, head of the North Pacific albacore population dynamics task at the Honolulu Laboratory, acted as chairman of the workshop. He appointed Gary T. Sakagawa of the Southwest Fisheries Center, La Jolla and Robert A. Skillman of the Honolulu Laboratory as rapporteurs.

1.4 The workshop participants agreed that the tentative nature of the preliminary assessments should be explicitly emphasized, and that the results reported here should be treated circumspectly.

2. Adoption of Agenda and Distribution of Working Documents

2.1 The workshop agenda, as adopted by the participants, is given as Appendix B. A list of the working papers distributed to participants and reviewed during the workshop is presented in Appendix C.

3. Review of Basic Statistical Information

3.1 Statistics from the Japanese pole-and-line and longline fisheries and the United States bait and troll fisheries for North Pacific albacore were presented. Rather complete and comparable statistics on the magnitude and size composition of catches from the United States and Japanese fisheries are available at least since the late 1940's. Nominal effort statistics by month and 5° square of longitude and latitude are available in the longline fishery beginning with 1952, and nominal effort measures are also available for the United States and Japanese surface fisheries.

3.2 Table 1 summarizes catch statistics since 1961 and Table 2 presents standardized catch-per-unit-effort (CPUE) and effort as given by Shiohama and Morita (background document NPALB/75/2). Some length-frequency distributions for the Japanese pole-and-line fishery are shown in Figure 1, and Table 3 shows annual statistics on mean length for fish taken in the major Japanese and United States fisheries.

3.3 In addition to the substantial landings by the Japanese pole-and-line and longline fleets and the United States troll and bait vessels, minor quantities of North Pacific albacore are taken by other Japanese fisheries, by United States sport fishing boats and by vessels from Canada, South Korea, and Taiwan. These catches are judged to comprise less than 5% of the total landings, and were not included in analyses. However, Canadian landing statistics are presented in Table 1.

Table 1.--Catch statistics in metric tons for North Pacific albacore fisheries, 1961-75.

Year	Japan			United States	Canada[1]	Total
	Pole and line	Longline	Other gears[1]			
1961	18,636	15,999	--	14,891	4	49,530
1962	8,729	12,617	--	20,838	1	42,185
1963	26,420	11,445	--	27,574	5	65,444
1964	23,858	11,558	--	21,800	3	57,219
1965	41,491	11,214	121	16,878	15	69,719
1966	22,830	20,874	585	16,769	44	61,102
1967	30,481	24,374	520	21,927	161	77,463
1968	16,597	19,040	1,109	25,347	1,028	63,121
1969	31,912	15,169	1,480	21,822	1,365	71,748
1970	24,263	12,695	956	25,455	354	63,723
1971	52,957	9,083	1,262	24,267	1,587	89,156
1972	60,591	10,594	922	31,026	3,547	106,680
1973	69,640	13,855	1,922	18,506	--	103,923
1974	73,576	[2]17,000	--	24,494	--	[2]115,070
1975	[2]45,000	[2]17,000	--	[2]25,000	--	[2]87,000

[1]Dashes indicate no estimates available.

[2]Preliminary estimates.

Table 2.--Standardized catch-per-unit-effort (CPUE) and effort statistics for North Pacific albacore fisheries, 1961-72.

Year	Standardized CPUE[1]			Standardized effort[2]			
	Japan		United States	Japan		United States	Total
	Pole and line	Longline		Pole and line	Longline		
1961	0.6832	1.6875	0.6105	27,278	9,303	24,391	60,972
1962	1.1211	1.0938	0.7368	7,786	11,532	28,282	47,600
1963	0.9767	1.0938	0.8947	27,050	10,464	30,819	68,333
1964	1.0652	1.5313	0.7368	22,398	7,548	29,587	59,533
1965	0.9720	1.2500	0.6947	42,686	8,971	24,295	75,952
1966	0.9224	2.3750	0.6421	24,751	8,789	26,116	59,656
1967	0.9457	2.9063	0.8526	32,231	8,387	25,718	66,336
1968	0.8292	1.9063	0.9684	20,016	9,988	26,174	56,178
1969	0.7686	1.7813	0.8632	41,520	8,516	25,280	75,316
1970	0.9519	1.1563	0.9579	25,489	10,979	26.574	63,042
1971	1.0776	0.8125	0.8737	49,143	11,179	27,775	88,097
1972	0.9705	1.0313	1.1789	62,433	10,272	26,318	99,023

[1]Nominal CPUE for each year divided by average CPUE over 1970-72.

[2]Catch (Table 1) divided by standardized CPUE.

Table 3.--Estimates of mean fork length (cm) of North Pacific albacore taken in United States and Japanese fisheries, 1952-73.

Year	Japanese pole-and-line	Japanese longline	United States
1952	74.7	81.6	68.5
1953	79.6	87.5	66.7
1954	82.5	84.5	65.6
1955	79.4	87.9	63.5
1956	74.4	85.4	68.0
1957	78.0	84.7	71.9
1958	79.0	87.0	70.0
1959	83.7	91.2	66.3
1960	79.0	89.5	70.2
1961	82.6	90.1	73.7
1962	89.3	88.0	65.2
1963	78.6	87.4	67.5
1964	76.2	86.8	70.2
1965	83.5	84.9	71.1
1966	82.6	86.1	69.9
1967	84.2	89.0	68.0
1968	82.6	87.0	68.0
1969	81.7	92.0	69.3
1970	74.4	87.9	69.0
1971	76.7	96.3	65.9
1972	83.2	92.7	71.5
1973	77.8	--	--

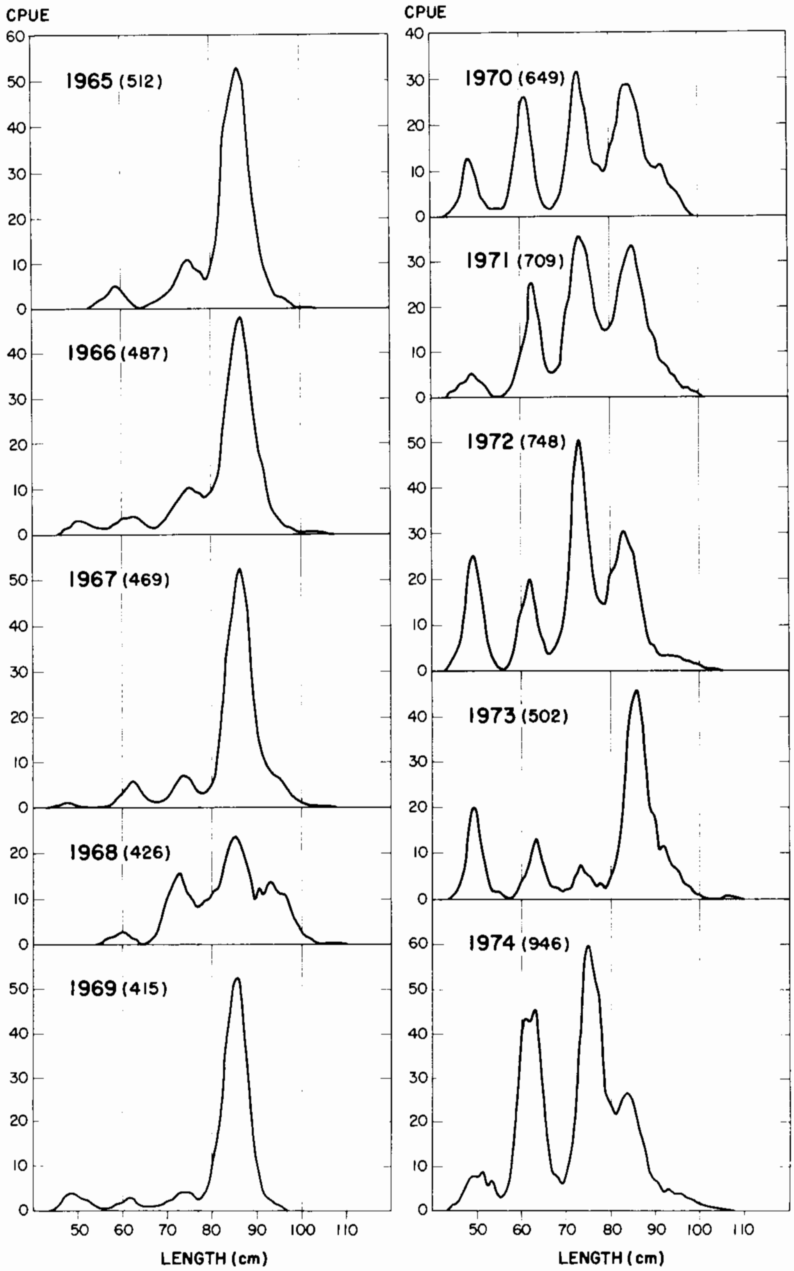

Figure 1.--Length-frequency distributions for North Pacific albacore taken in the Japanese pole-and-line fishery, 1965-74, in catch per fished day (CPUE). Annual mean CPUE also given.

4. Recent Trends in the Fisheries

4.1 Japan and the United States are the principal nations fishing for albacore in the North Pacific. In recent years about 100,000 metric tons (MT) have been landed annually. The Japanese pole-and-line fishery took about 64%, the Japanese longline fishery 15% and the American troll and bait fishery about 21% of the total catch landed in 1974.

4.2 The number of boats in the Japanese pole-and-line fleet fluctuated between 510 and 582 during 1965-73 (Table 4). Since 1971, there has been a marked decrease in the number of boats in the 20-50 and 100-200 gross tons (GT) classes and a marked increase in the number of boats in the 50-100 GT class and especially in vessels greater than 200 GT. Vessels greater than 200 GT have a greater operating range and better refrigeration and bait-holding capabilities than smaller vessels. The impetus for this increase in large boats has been the expansion of the southern water skipjack tuna fishery to meet the foreign and Japanese domestic demand for skipjack tuna.

Table 4.--Number of Japanese albacore pole-and-line vessels by size class.

Year	Total	Size of vessel (gross tons)			
		20-50	50-100	100-200	>200
1965	572	298	91	148	35
1966	571	299	71	167	34
1967	564	296	54	173	41
1968	561	276	60	170	55
1969	528	248	71	156	53
1970	512	220	91	140	61
1971	510	165	133	129	83
1972	554	131	162	116	145
1973	582	93	210	80	199

4.3 Effective fishing effort on North Pacific albacore by the Japanese longline fishery shows a downward trend during 1967-72 (Figure 2). This is primarily due to a shift of fishing effort onto North Pacific bigeye tuna in response to increased prices for this species which is sold for "sashimi" in the Japanese domestic market (NPALB/75/1). In coming years, however, it is likely the Japanese longline effort on albacore will level off or even increase. Albacore is gaining in popularity with the Japanese consumer primarily when canned in oil, but also partially dried, and as sashimi. If this continues, the fleet will probably refocus fishing effort onto albacore to meet the domestic demand.

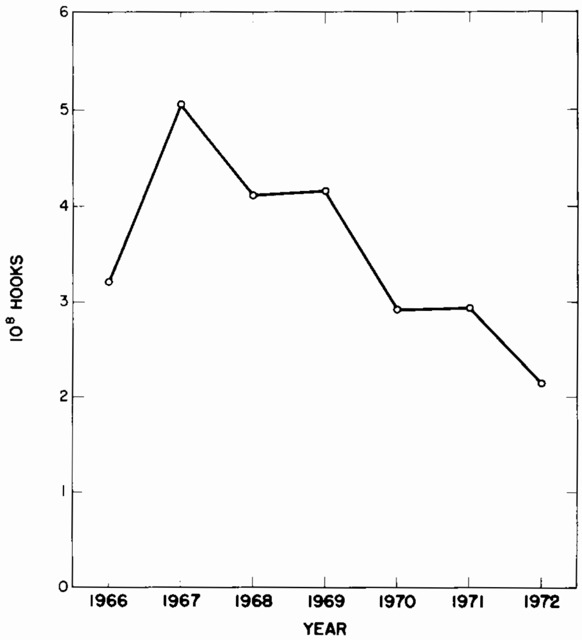

Figure 2.--Effective fishing effort in the Japanese longline fishery for North Pacific albacore, 1965-72.

4.4 Catch by the U.S. fishery has fluctuated over the years but within a relatively narrow range (Table 1). The fleet consists of approximately 2,000 vessels that fish for albacore. Most of these boats fish for salmon, crab, and other fish species as well. Trollers make up about 95% of the U.S. albacore fleet, and land about 75% of the catch.

4.5 Recent exploratory fishing surveys have shown that the catch can be increased by starting the U.S. troll fishery early in offshore fishing areas. In fact exploratory fishing has been carried out as far west as the Kuroshio front area (north of lat. 30°N, long. 140°E-180°). If this practice is widely adopted by the fleet, then we can expect fishing pressure to increase in the near future.

4.6 U.S. albacore fishermen actively support and finance government-industry research programs with the objectives of increasing the efficiency of albacore fishing and developing scientific information for albacore conservation. Greater efficiency in searching out and following concentrations of albacore is assisted by preseason forecasts, intraseason monitoring of the fishery and the fishing environment, and the widespread use of modern shipboard communications equipment. In addition, some fishermen are adopting new labor-saving gear, such as automatic fishing poles. With these developments it is likely that the effectiveness of a day's fishing in the U.S. albacore fishery is increasing, and an overall increase in the effective fishing effort of U.S. vessels may be expected.

4.7 Besides these developments, there are other considerations that should be mentioned here because they have a bearing on the future of the North Pacific albacore fisheries. Paramount is the fact that many nations besides Japan and the United States have tuna fleets that are large, highly mobile, and capable of exerting considerable fishing pressure on a stock. Currently these other fleets, e.g., the longline and pole-and-line fleets of Taiwan and South Korea, are not participating in the North Pacific albacore fisheries to any significant degree. However, as the available world supply of tunas begins to level off, and fishing regimes under extended fishery jurisdiction become clearer, it is likely that greater participation by those fleets will occur, accompanied by a considerable increase in fishing pressure upon the stock.

5. Status of the Stocks

5.1 Production model analysis

5.1.1 The analysis discussed in this section is based on NPALB/75/2 and on computations made during the workshop. While analyses for the Japanese pole-and-line fishery, the Japanese longline fishery, and combined North Pacific albacore fisheries were presented, most discussion related to the latter case.

5.1.2 The generalized production model of Pella and Tomlinson was fitted to the catch data and fishing effort statistics derived from the CPUE statistics in Table 2. A computer program, PRODFIT, by W. W. Fox, Jr., Southwest Fisheries Center, La Jolla, was used.

5.1.3 Two procedures were followed in estimating fishing effort. First normalized annual CPUE statistics for each fishery were derived by computing an average CPUE over the period 1970-72 and dividing this into the nominal annual CPUE statistics. It was suggested that 1970-72 were not typical years in the fishery and that the use of an average CPUE over all the years would be preferable.

In addition, since the CPUE time series differed markedly among the three principal fishing areas of the Japanese pole-and-line fishery, it was felt that a better procedure would be to normalize the CPUE statistics for each area separately (Figure 3). Relative standardized fishing effort was estimated by dividing the annual catch for each fishery by the corresponding normalized CPUE (Table 1) and summing over fisheries.

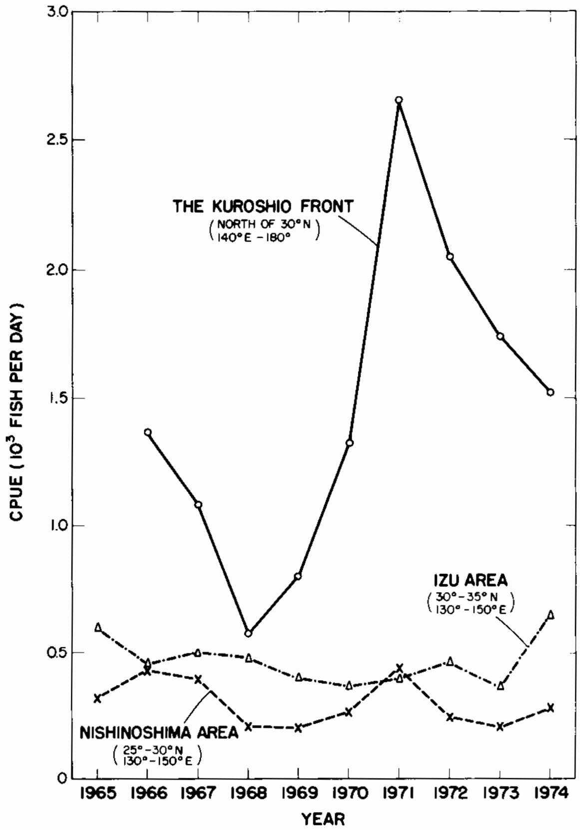

Figure 3.--Annual average catch rates (number of fish per fishing day) in the Japanese pole-and-line fishery for North Pacific albacore, 1965-74, by major fishing grounds.

5.1.4 This procedure resulted in a CPUE/effort relationship showing no decline in apparent stock density with increased fishing effort, so no production model was fitted to the data. Another standardization procedure and a division of the Japanese pole-and-line fishery into its three components might give different results.

5.1.5 Second, overall fishing effort was standardized to units of effort in the Japanese pole-and-line fishery, since this fishery accounts for a majority of the harvest and operates on fish as young as those taken in the United States fishery and as old as those comprising the bulk of the longline catch. Overall fishing effort was obtained by dividing aggregate catch (Table 1) by the observed CPUE of the pole-and-line fishery (Table 2). CPUE seems inversely related to effort. The size composition of the Japanese pole-and-line catch changed markedly following the expansion of the fishery into the Kuroshio front area, where smaller fish predominate. The effect of such changes on assessments using the production model has not been determined.

5.1.6 The generalized production model was fitted to the data with the parameter "m" fixed at 0.0 (asymptotic curve), 1.001 (Gompertz curve), 2.0 (logistic curve), and also with "m" variable. The equilibrium approximation method was used, with the albacore assumed to contribute significantly to the catch for 3 or 4 years. This preliminary analysis provided no guidance on choosing among the different shapes of the production curve, since residual mean squares were the same. All solutions indicated a maximum sustainable average yield (MSAY) of 100,000-115,000 MT. These are regarded as rough, preliminary estimates. Further detailed study including evaluation of alternative standardization procedures and assumptions, as indicated above, is required.

5.2 Yield per recruit assessment

5.2.1 A cohort analysis of year-class catch histories was conducted to estimate age-specific fishing mortality rates (NPALB/75/3). Estimates of F were obtained on a quarterly basis over an 8-year period of exploitable life (age 2.5 years through age 10.5 years), and under different assumptions on natural mortality rate (M, both constant and age-specific) and fishing mortality rate during the last age interval (F_o from age 10.25 to 10.50 years). The catch histories were constructed from pooled catch and size composition statistics from the United States fishery and the Japanese pole-and-line and longline fisheries. Statistics for the years 1952-72 were used, so complete 32-quarter catch histories were produced for the 1949-62 year classes. The same sets of assumptions on M and F_o were applied to each catch sequence.

5.2.2 Age-specific F vectors for fishing years 1959-65 were averaged to establish base conditions for a yield per recruit assessment; estimates of F for more recent years were derived from shorter catch sequences and were considered less reliable.

5.2.3 A choice of the most reasonable assumptions on F_o was made by comparing estimates of F generated under each alternative set of assumptions with independent estimates of F obtained through an analysis of age-specific catch rates in the longline fishery, and by a consideration of tag recovery rates in recent experiments by NMFS and the American Fishermen's Research Foundation. Of the sets of assumptions examined, the most reasonable were considered to be $F_o = 0.01$ with $M = 0.2$ at all ages, and $F_o = 0.10$ with $M = 0.2$ from ages 2.5 years through 5.5 years, and then increasing progressively for older albacore.

5.2.4 An assessment of yield per recruit was made using the two chosen F vectors. The two vectors gave almost identical results. They produced an estimated base period (1959-65) yield per recruit of 4.4 kg and indicated that the stock was underfished, in a yield per recruit sense, in the mid-1960's. Table 5 shows the estimated responses of the yield per recruit to various fishery-specific increases in fishing mortality and changes in assumed length at first capture. A doubling of fishing mortality rates in all fisheries over the base period levels would have been expected to produce a 35% increase in yield per recruit over base conditions, and a slightly greater average yield per recruit if minimum size were also increased. Similar results would be obtained with a threefold increase in fishing mortality rates in the United States fishery and the Japanese pole-and-line fishery and no change in the longline mortality rates. The analysis indicated that further increases in average fishing mortality would produce only slightly greater yield per recruit, unless average size at capture was increased.

Table 5.--Percentage changes in average yield per recruit expected under various alterations in fishery-specific fishing mortality rates and assumed minimum size at capture, relative to conditions in mid-1960's base period.

Minimum length at capture (cm)	Fishery-specific F-multipliers (U.S., pole and line, longline)			
	(1.0, 1.0, 1.0)	(1.5, 1.5, 1.5)	(2.0, 2.0, 2.0)	(3.0, 3.0, 1.0)
59	Base yield per recruit, 4.4 kg	+22%	+35%	+36%
71	-4%	+21%	+38%	+40%

5.3 Stock and recruitment

5.3.1 Spawning biomass.--Estimates of spawning biomass from the cohort analysis, assuming F_o constant over years, suggested that the biomass of albacore older than 6 years decreased in the early 1950's, was relatively constant from the mid-1950's until 1966 and then increased markedly, at least through 1968 (more recent estimates were less reliable). This pattern in estimates of spawning biomass is remarkably consistent with trends in average catch rates of mature albacore in the Hawaiian longline fishery and with the annual pattern of catch rates by Japanese longliners in the subequatorial spawning area.

5.3.2 Recruitment.--Estimates of recruitment from the cohort analysis of 2.5-year-old albacore suggest a fivefold variation in strength of year classes, with peak recruitments every 4 or 5 years.

5.3.3 Stock-recruit relations.--Plots of estimated recruitment against spawning biomass show a wide scatter. Ricker stock-recruit models fit better to data points generated under assumptions of age-specific natural mortality than under constant M.

5.4 Sustainable yields

5.4.1 Surfaces of sustainable average yield were estimated (NPALB/75/4) by coupling the yield per recruit model with two alternative stock-recruit relations: (1) The Ricker model associated with the chosen conditions on M and F_o, and (2) a linear-segmental model giving constant recruitment at all but very low levels of spawning biomass, and at these low levels a sharply reduced recruitment.

5.4.2 The maximum sustainable average yield was estimated to be about 100,000 MT under the Ricker model and approximately 115,000 MT under the linear-segmental stock-recruitment relation. Under the latter model, the maximum yield is achieved at a greater average fishing mortality rate and a lower average age at capture than under the Ricker option.

5.4.3. Estimated sustainable average yields under different fishery-specific fishing mortality multipliers are given in Table 6. Under the assumed base period conditions (1959-65) the average yield was about 70,000 MT. With a threefold increase in fishing mortality in the United States and pole-and-line fisheries, and a 50% reduction in the longline fishing mortality rate, an average yield of about 90,000 MT could be sustained as long as recruitment was not reduced. With reduced recruitment, under the Ricker model, yields would not be sustainable. The analysis indicated clearly that a maximum yield policy, unconstrained by economic and political considerations, would involve a concentration of effort on older age groups.

Table 6.--Estimated sustainable yields expected under two alternative stock-recruit models (Ricker and linear-segmental) and various assumed changes in fishery-specific fishing mortality rates.

Spawner-recruit model	Fishery-specific F-multipliers U.S.	Pole and line	Longline	Average age at capture (yr)	Average fishing mortality rate	Sustainable average yield 10^3 MT per year
Ricker	1	1	1	4.8	0.20	70
Lin-seg	1	1	1	4.8	0.20	71
Ricker	2	2	0.5	4.3	0.32	77
Lin-seg	2	2	0.5	4.3	0.32	82
Ricker	3	3	0.5	Yields not sustainable		
Lin-seg	3	3	0.5	4.0	0.49	90
Ricker	0	0	6	5.4	0.30	96
Lin-seg	0	0	10	4.9	0.45	109

5.4.4 In recent years the North Pacific albacore harvest has increased from the 70,000 MT level to approximately 100,000 or 110,000 MT. Because of lags in the response of the stock to changes in mortality rates, such transitional yields are perhaps greater than the sustainable average yields to be expected under assumed increased levels of fishing mortality. Simulation studies showed that a 50% increase in fishing mortality rates (in all fisheries) over base period conditions would have produced an increase in yield from the 70,000 MT level to 100,000 MT in the first year. However, under both stock-recruit options simulated annual yields then declined to an equilibrium level of 85,000 MT. When fishing mortality rates were increased further to a level twice as great as during the base period, the simulated yield increased in the first year to about 110,000 MT and then settled gradually to a steady level of 92,000 MT under constant recruitment. Under the Ricker stock-recruitment relation, the simulated yield was increased in the first year to a similar high level but then underwent a steady reduction with no equilibrium achieved.

5.5 Summary of yield per recruit and stock-recruitment assessments

5.5.1 The analyses indicated that during the mid-1960's the North Pacific albacore stock was underfished in a yield per recruit sense and in terms of total equilibrium yield. Maximum sustainable average yields are judged roughly to be between 100,000 and

125,000 MT. These would be achieved with an average age at capture between 5.5 years and 6.0 years, and an average fishing mortality rate between 0.25 and 0.40, depending on the assumed stock-recruitment relationship. During the mid-1960's base period, the average age at capture was about 4.8 years and the average fishing mortality rate about 0.2. Achievement of the maximum sustainable yield would require a concentration of fishing mortality on older age groups, a situation presently infeasible.

5.5.2 The equilibrium yield levels associated with recent increases in fishing effort in the surface fisheries are not yet known. Whether recent levels of harvest can be sustained under the prevailing average age at capture and the present effort depends critically on the relationship between stock and recruitment.

5.5.3 The assessments stemming from the cohort analysis and yield per recruit investigation are based on several assumptions needing close scrutiny. In particular, it is recommended that the cohort analysis be repeated using alternative procedures for constructing catch histories, including examination of different growth models. It is suggested further that a detailed evaluation of recent tagging results be undertaken to strengthen understanding of age-specific fishing mortality rates. In addition the assumption of constancy in the fishing mortality rate on 10-year olds during the fourth quarter of each year should be critically evaluated.

5.5.4 More definitive assessment of North Pacific albacore will require a better understanding of fluctuations in recruitment and changes in the reproductive capacity of the stock. It is recommended that indices of recruitment be developed and that such indices be checked for consistency by comparison with subsequent catch rates in the longline fishery. It is further recommended that stock-fecundity indices be developed, taking into account possible age-specific differences in relative fecundity and in sex ratio.

6. Summary of Recommendations for Future Work

Several recommendations were discussed by the participants and are summarized here for easy reference.

6.1 Data from the U.S. fishery.--Improved procedures are currently being used by California, Oregon, and Washington in collecting and compiling catch, catch and effort, and length-frequency statistics from the U.S. fishery. These data are vital for determining the status of the North Pacific albacore stock and for formulating timely management advice. This will be especially critical in the coming years when fishing effort may increase at an accelerated rate and the stock may become more heavily exploited. It is essential, therefore, that collection, compilation, and dissemination of the U.S. fishery data on a timely basis be continued. The participants recommended that catch, catch per unit effort, and length-frequency data continue to be collected and compiled by the States and the data be made available to concerned scientists on a timely basis. The participants also recommended that the detailed procedures for collection, compilation, and dissemination of the data be discussed among the parties concerned with Dr. R. M. Laurs acting as coordinator.

6.2 Data from the Japanese fisheries.--Complete data on catch and nominal effort from the longline and pole-and-line fisheries are published annually by the Japanese. The length-frequency statistics for both fisheries are published at regular intervals. However, neither the longline data nor the pole-and-line data are yet available on a timely basis (at least 2 years old when published). The participants recommended that emphasis be placed on obtaining at least catch data from the Japanese fisheries on a more timely basis.

6.3 Data from other fisheries.--Complete statistics, especially on the catch, from all fisheries that exploit the North Pacific albacore stock are important in analyses of the status of the stocks. Currently, only a few thousand tons of North Pacific albacore are caught by nations other than Japan and the United States. The exclusion of this catch from current analyses does not significantly affect the results. But this will not be the case if this catch increases in the future, and this can be determined only if the catch is monitored. The participants, therefore, recommended that data on the catch from other nations, i.e., Canada, Taiwan, and Korea, that fish for albacore in the North Pacific Ocean be obtained.

6.4 Further production model analysis.--The production model analysis is a widely used technique in tuna stock assessment. It has the virtue of requiring relatively little data while yielding a general understanding of the status of the fishery. The participants recommended that further work be done on the application of the production model to the North Pacific albacore fishery. Refinements such as the treatment of CPUE of the three Japanese pole-and-line fishery areas separately in the effort normalization procedure and the use of total catch from all fisheries should be introduced. For the long term, however, detailed analyses of CPUE from the different fisheries as measures of relative abundance are required, and the participants recommended that such analyses be initiated.

6.5 Further cohort analysis.--The cohort analysis is a useful tool for understanding the dynamics of the albacore population of the North Pacific Ocean, but is demanding in data and assumptions. Sensitivity analysis, or analysis of the behavior of the model outputs to changes in assumptions, has not been done and the participants recommended that such analyses be completed. The use of different growth rates and a refined method of estimating appropriate F vectors employing tagging data should be studied.

6.6 Indexing recruitment and stock fecundity.--The cohort analysis suggests that for the 1949-62 year classes variation in recruitment was as high as fourfold or fivefold, and had a major impact on fluctuations in the total yield. The participants therefore felt that recruitment variation or more specifically the stock-recruitment relationship for North Pacific albacore should receive more research emphasis. It was recommended that as an initial effort the spawning biomass estimates in NPALB/75/3 should be refined with fecundity indices and sex ratio information. The participants also felt that more refined measures of nominal CPUE by age groups from particularly the Kuroshio front fishing area should be collected because the changes in the catch rates of the young fish caught in that area might be useful as indices of recruitment strength and future yields.

6.7 Impact of environmental factors.--Environmental factors influence albacore behavior, availability, and abundance which in turn determine fishing success. The participants felt that the effects of environmental factors on measures of apparent abundance should be studied.

6.8 Socio-economic considerations in interpretation of data.--Socio-economic factors such as strikes or price disputes may materially affect fisheries data and should be considered wherever possible in interpretation of historic as well as current statistics.

6.9 Problems in measuring effective fishing effort.--It was pointed out that the North Pacific albacore fisheries are all multispecies fisheries. Nominal fishing effort for the United States troll fishery is easily separated into effort directed to albacore, and procedures are available for adjusting nominal effort of the Japanese longline fishery for effort directed to albacore only. For the Japanese pole-and-line fishery that exploits both skipjack tuna and albacore, nominal effort is probably underestimating effective effort, primarily because only days with successful catches are tabulated. The participants recommended that further work be done to better estimate effective effort as directed to albacore.

7. Future Activities

It was suggested that the Southwest Fisheries Center and the Far Seas Fisheries Research Laboratory develop specific objectives and a timetable for further joint research, drawing chiefly on the recommendations outlined in this report. It was further suggested that results of the next phase of investigation be reviewed in about 1 year, preferably in Japan. At this second workshop, invitation of participants from other countries exploiting the North Pacific albacore stock should be considered.

Appendix A

LIST OF PARTICIPANTS

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Richard Lincoln
Mark Pedersen

Others

John Harville, Pacific Marine Fisheries Commission
Alex Rawung, Marine Fisheries Research Institute, Jakarta, Indonesia
Minato Yasui, Tokai University, Shimizu, Japan

Appendix B

AGENDA

A. Preliminaries

1. Welcome by Richard S. Shomura, Director, Honolulu Laboratory

2. Appointment of workshop chairman and rapporteurs

3. Discussion and adoption of agenda

B. Recent status of Japanese North Pacific albacore fisheries and trends in albacore consumption

Mr. Toshio Shiohama
Far Seas Fisheries Research Laboratory, Shimizu

C. Assessments of the North Pacific albacore stock

1. General review of stock assessment approaches, objectives, and assumptions

Dr. Jerry A. Wetherall
National Marine Fisheries Service, Honolulu

2. Preliminary assessment of the North Pacific albacore stock by the analysis of catch and effort statistics

Mr. Toshio Shiohama
Far Seas Fisheries Research Laboratory

3. Cohort analysis of the albacore stock and assessment of yield per recruit

Dr. Jerry A. Wetherall
National Marine Fisheries Service

4. Summary and synthesis of stock assessments

D. Critical problems in stock assessment and specific recommendations for further cooperative research by the National Marine Fisheries Service and the Far Seas Fisheries Research Laboratory

E. Discussion of areas for further cooperation between National Marine Fisheries Service and state fishery agencies

F. Drafting of workshop report

G. Adoption of report and closing of workshop

Appendix C

LIST OF BACKGROUND DOCUMENTS

NPALB/75/1	Shiohama, T. 1975. Recent status of the Japanese North Pacific albacore fishery and changing trends in albacore consumption. (Translated from the Japanese by Tamio Otsu, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, Honolulu, Hawaii.)
NPALB/75/2	Shiohama, T., and Shou Morita. 1975. Assessment of North Pacific albacore stock (preliminary).
NPALB/75/3	Wetherall, J. A., and M. Y. Y. Yong. 1975. A cohort analysis of the North Pacific albacore stock and an assessment of yield per recruit in the American and Japanese fisheries.
NPALB/75/4	Wetherall, J. A., and M. Y. Y. Yong. 1975. A cohort analysis of the North Pacific albacore stock and an assessment of yield per recruit in the American and Japanese fisheries. Appendix on sustainable yields.