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SUMMARY REPORT OF THE BILLFISH STOCK ASSESSMENT WORKSHOP

PACIFIC RESOURCES

Honolulu Laboratory, Southwest Fisheries Center
Honolulu, Hawaii
5-14 December 1977

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INTRODUCTION

The recent extension of national fishery jurisdiction throughout the world has resulted in an increased interest in developing fishery management agreements, guidelines, and policies. Basic to this development is information on the status of exploited fish stocks. For many species, particularly the pelagic species, the dimensions of the resource base are unknown, since basic research on population dynamics and the collection of adequate fishery statistics have not been accomplished. This is certainly the case for the several species of billfishes even though they are important targets of commercial and recreational fisheries (Table 1). At the International Billfish Symposium convened in 1972 at Kailua-Kona, Hawaii, a glaring shortcoming was the virtual absence of information on stock assessment or fishery dynamics (Shomura and Williams 1974, 1975a, 1975b).

Table 1.--Total Pacific billfish catch (metric tons) by species, 1952-75.

Year	Blue marlin	Striped marlin	Swordfish	Sailfish and spearfish	Black marlin	Total
1952	15,525	4,994	11,339	2,000	1,806	35,664
1953	17,250	3,789	11,689	3,300	3,188	39,216
1954	10,519	7,256	13,392	2,400	5,370	38,937
1955	24,190	7,075	16,485	3,300	5,379	56,429
1956	18,770	7,724	12,584	3,200	6,466	48,744
1957	23,500	7,150	16,243	2,800	6,376	56,069
1958	22,106	8,999	21,341	3,400	4,548	60,394
1959	20,275	8,986	19,663	3,700	3,081	55,705
1960	18,155	7,362	23,409	5,000	2,721	56,647
1961	26,581	10,084	24,286	4,800	3,170	68,921
1962	30,743	13,685	14,604	6,800	4,066	69,898
1963	31,344	16,944	14,133	7,900	3,180	73,501
1964	23,233	23,480	10,112	6,100	2,805	65,730
1965	18,585	24,017	12,949	12,800	4,039	72,390
1966	18,588	20,967	14,601	11,100	3,729	68,985
1967	17,233	22,050	15,649	11,800	2,836	69,568
1968	15,283	27,143	15,230	12,500	3,547	73,703
1969	17,427	21,706	18,934	12,800	2,546	73,413
1970	20,115	24,221	15,721	9,000	2,207	71,264
1971	13,342	24,264	11,037	8,100	2,674	59,417
1972	15,300	14,541	11,029	8,600	3,424	52,894
1973	17,285	15,407	13,791	8,700	3,720	58,903
1974	15,594	14,669	11,664	7,100	3,048	52,075
1975	12,546	16,279	13,376	5,500	2,796	50,497

In early 1977 the National Marine Fisheries Service's Southwest Fisheries Center developed plans jointly with the Western Pacific Regional Fishery Management Council (WPRFMC) to hold a Pacific Billfish Stock Assessment Workshop. The workshop was subsequently expanded to include the Atlantic stocks. Its objective was to produce a report containing a scientific assessment of the status of billfish stocks in the Pacific and Atlantic along with a summary of appropriate background information, supporting analyses, and recommendations. The workshop was held at the Honolulu Laboratory of the Southwest Fisheries Center in December 1977 and consisted of two parts, a Pacific section (5-9 December 1977), which reviewed the Pacific billfish stocks, and an Atlantic section (12-14 December 1977), which treated the Atlantic billfish stocks. The Pacific workshop covered the six species of Pacific billfishes: blue marlin, Makaira nigricans; black marlin, M. indica; striped marlin, Tetrapturus audax; shortbill spearfish, T. angustirostris; sailfish, Istiophorus platypterus; swordfish, Xiphias gladius.

Since by far the greater part of the exploitation of the Pacific billfish resources is carried on by foreign fishers, and consequently foreign governments possess most of the data relevant to their management, the success of the workshop required the joint participation of scientists from the major billfish fishing nations. Scientists from the Honolulu, La Jolla, and Miami Laboratories of the National Marine Fisheries Service, the California Department of Fish and Game, the Far Seas Fisheries Research Laboratory (Shimizu, Japan), National Taiwan University (Taipei, Taiwan), Fisheries Research & Development Agency (Pusan, Korea), and the International Commission for the Conservation of Atlantic Tunas were invited to participate in the workshop. The WPRFMC sponsored the participation of the foreign scientists. The Council has direct interest in the results of the workshop, since it is presently developing a management plan for the Pacific billfishes.

The workshop agenda is shown as Appendix A. Appendix B lists the participants, and Appendix C gives the titles and authors of workshop documents.

Brief summaries of the Pacific billfish stock appraisals and recommendations for improvement of fishery statistics, research, and management are provided in the next few sections. These are followed by the several rapporteurs' reports (Appendix D), which provide detailed discussions of the stock assessments. Results of the Atlantic section will be provided in a separate report.

Data Limitations

A complete understanding of the effects of fishing on fish stock productivity and catch requires a knowledge of growth rates, mortality rates, reproductive rates, and other vital determinants of population dynamics. Unfortunately, in the case of Pacific billfishes such detailed information has not been acquired. Except for a very limited amount of data on size composition and some estimates of growth rates, the only kinds of information available for stock assessment purposes are statistics

on nominal fishing effort and catch. Under these data limitations the billfish stocks were assessed using catch per unit effort (CPUE) and effort trends, as well as the surplus production approach popularized by M. B. Schaefer in the 1950's and improved most recently by Fox (1975).

In using the production model we made two fundamental assumptions concerning the catch and effort data:

(1) the CPUE is proportional to average stock abundance, with the ratio of CPUE to abundance remaining constant over the period of analysis, and

(2) the total catch is known.

Violation of these assumptions was suspected for certain billfish stocks, and known to occur in others. In the latter cases no attempt was made to fit a production model or to estimate a maximum sustainable yield (MSY).

With respect to CPUE, the statistic used in all analyses was the catch per thousand hooks fished in the Japanese pelagic longline fishery, a fishery which generally concentrates on tunas and harvests billfishes only incidentally. Changes in the construction or deployment of the longline gear, shifts in fishing strategy or target species, and changes in availability of the fish to the gear are some of the factors which may alter the ratio of CPUE to average abundance. For example, in the North Pacific, a reduction in nighttime longlining activity targeted specifically on swordfish is almost certainly responsible for a sharp drop in the average swordfish CPUE in that area since the early 1960's. The assessment of the North Pacific swordfish stock is therefore complicated, because the effects of the change in fishing strategy on the ratio of CPUE to abundance are unknown. Similar problems may exist in the assessment of other species.

In the case of total catch, there are generally reliable figures in numbers of fish for the Japanese tuna longline fleet, which accounts for most of the overall harvest and dominates the catch statistics of most billfish species. An exception is the Japanese catch of sailfish and shortbill spearfish, which is reported as a combined total in the longline statistics. In addition, there are serious problems in estimating the total weight of billfishes taken in the inshore or coastal fisheries which use other kinds of gear, e.g., gill nets, and in determining the total catch of other major distant-water longline fleets, particularly the catch of Korean vessels. Where biased catch estimates are suspected, the magnitude of bias may vary from year to year, creating serious problems in interpretation of catch-effort relationships.

Aside from the major assumptions about the catch and effort data, there are several other important conditions which must be met if the production model analysis is to be valid. The most important of these is that the data refer to a single stock of the species under consideration. Stock units for the Pacific billfish populations were selected on the basis of limited evidence concerning larval distribution, seasonality and locations of spawning, catch rate distribution, and tag return

pattern. The validity of the stock boundaries assumed for this report remains to be established.

Other critical assumptions of the production model are discussed in detail by Fox (1975). When these are considered along with the ones discussed above, it is clear that the production model analysis and the resulting estimate of MSY can give at best only very rough approximation on the status of a fish stock and the effects of fishing effort on yield. The stock appraisals summarized below and discussed in greater detail in the rapporteurs' reports should be judged in this context.

SUMMARY OF STOCK APPRAISAL

Blue Marlin

A single Pacific-wide stock of blue marlin is assumed. Total harvest in 1975 was approximately 12,500 metric tons (MT), with about 80% taken by the longline fleet of Japan. CPUE has decreased steadily since the early 1950's, while total effective fishing effort has increased. Production model analysis gives an MSY estimate of about 22,000 MT, which is associated with an effective fishing effort equal to about 50% of the 1975 total effective effort. The Pacific blue marlin stock is judged to be overfished.

Black Marlin

Stock structure of black marlin is unknown, but the restricted coastal distribution of the species and the occurrence of isolated areas of high catch rates suggest the possibility of more than one stock in the Pacific. Furthermore, there is a strong likelihood that movement of black marlin between the western Pacific and the eastern Indian Ocean occurs. The total Pacific catch in recent years has been estimated at around 3,000 MT. Stock assessment is complicated by underestimation of total catches, particularly those made by the Republic of China fleet. For this reason no estimate of MSY is available; however, sharply declining catch rates during the 1950's and a more gradual reduction of apparent abundance since the early 1960's suggest that increased fishing effort would, at best, produce only a small increase in average catch. Until better estimates of total catch are obtained, the status of black marlin harvests cannot be reliably ascertained.

Striped Marlin

Striped marlin total catches increased steadily from nearly 5,000 MT in 1952 to 24,000 MT in 1965. From 1965 to the early 1970's, the catches remained in the 20,000 to 27,000 MT range. In 1972 striped marlin catches dropped to 14,500 MT and remained between 14,000 and 16,000 MT through 1975.

The stock structure of the Pacific striped marlin is unclear; however, evidence based on distribution of catch rates and other factors suggests the population could consist of either (1) separate north and south stocks or (2) a single unit stock for the entire Pacific Ocean.

Estimated MSY is 22,000 MT in the case of a single Pacific-wide stock. Current assessments indicate that the stock(s) of Pacific striped marlin is in good condition and not in need of restrictive management.

Swordfish

Most of the catch of swordfish from the Pacific Ocean is landed by the Japanese longline fleet and is caught in the northwestern Pacific. The total Pacific catch increased from 11,000 MT in 1952 to a record high of 24,000 MT in 1961. The catch then declined abruptly to about 15,000 MT in 1962 and has leveled off at an average of 14,000 MT since 1962.

The stock structure of the Pacific swordfish population is not clearly understood. Current opinion is that the population consists either of a single Pacific-wide stock or of three separate stocks: the latter with centers of concentration in the northwestern, southwestern, and eastern Pacific. The MSY calculated from the production model analysis assuming a single Pacific-wide stock is 20,000 MT, compared to the current catch level of about 14,000 MT. Since present fishing effort is about 20% below the effort required to take the MSY, the fishery does not appear to be overexploiting the stock, and the stock is in good condition.

No individual estimates of MSY are available in the case of three separate stocks.

Shortbill Spearfish

The major longline fisheries report the catches of shortbill spearfish together with catches of sailfish. Very little of the combined catch, however, consists of shortbill spearfish. Since the shortbill spearfish commands the lowest price among the billfish caught by longline gear, catches of this species are not consistently reported. The amount of shortbill spearfish reported is probably an underestimate of the actual catch.

The stock structure of shortbill spearfish is not known; however, the catch rates are relatively high around lat. 20°N and 20°S and low at the equator, thus suggesting a possible North Pacific stock and a South Pacific stock.

Estimates of MSY for the stock(s) of shortbill spearfish are not available due to the unreliable catch statistics. Assumed catch rates of this species from longline data suggest that the stocks are currently at a relatively high level of abundance and the species is probably underutilized.

Sailfish

Although the catches of shortbill spearfish and sailfish are reported combined, the bulk of the catch consists of sailfish. The estimated sailfish-spearfish catch increased gradually from 2,000 MT in 1952 to 6,100 MT in 1964. It then increased markedly to a record high level of 12,800 MT in the 1965-69 period. From 1970 through 1975 the catch declined to about 5,500 MT.

Based on distribution of catch rates, the sailfish in the Pacific is assumed to consist of two stocks--an eastern Pacific stock and a western Pacific stock. In the western Pacific the catch rates of sailfish has shown a decline since 1959. The 1975 catch rate of two fish per 10,000 hooks is the lowest average rate recorded for the western Pacific fishery. The CPUE for the eastern Pacific fishery increased sharply between 1960 and 1965 to about 200 fish per 10,000 hooks, fluctuating downward to about 110 fish per 10,000 hooks in 1975.

Estimation of MSY for sailfish was not attempted because there is yet no reliable method of separating the combined catch by species. The patterns in catch rates and associated nominal fishing effort, however, suggest that the sailfish stock(s) are not in a bad shape.

SUMMARY OF RECOMMENDATIONS

Statistics

The statistics needed to accurately assess the conditions of a fish stock and to evaluate the effects of fishing include estimates of total catch, catch and effort, and data on the size-, sex-, and age-composition of the catch. Except for catch and effort statistics from some segments of the longline fishery, required data are virtually nonexistent for billfishes. Even with the available catch and effort data a number of shortcomings were noted at the workshop. These were (1) incomplete catch and effort records for certain commercial fisheries, e.g., the Korean longline fishery; (2) the virtual absence of recreational billfish catch and effort data, e.g., the Australian and United States recreational fishery; (3) combining of sailfish and shortbill spearfish catches in the basic logbooks maintained by the Japanese longline fleet; and (4) reporting of catch in different units, e.g., round weight, dressed weight, or number.

The workshop recommended that all nations with billfish fisheries be urged to establish new sampling programs and procedures to insure the collection of adequate statistics including (1) total catch by species, gear, type of fishing operation, and ocean region; (2) total nominal effort by gear, type of fisiing operation, and ocean region; (3) CPUE by effort, small area-time strata, gear, and type of fishing operations; and (4) size and sex composition of the catches by species and by small area-time strata.

Research

Appraisals of fish stock conditions rely on availability of basic biological information and adequate statistics describing the fisheries over several years. For billfishes, such basic information and data are not adequate for comprehensive stock appraisals. The present assessment of billfish stock is based on catch and effort data from the Japanese longline fishery and estimates of Pacific-wide catches. The lack of adequate data permitted only tentative assessments of the various billfish stocks. These assessments were based on assumed stock structures, and computed measures of effective fishing effort, a statistic which is

assumed to be proportional to fishing mortality rates. These assumptions are difficult to test and verify because they require collections of extensive and detailed data, or long and expensive experimentation. It is possible, however, to use computer simulation models to examine the sensitivity of stock assessment conclusions and management advice to changes in assumptions, e.g., doubling the effective fishing effort. The cost of this kind of analysis is expected to be modest and should provide valuable guidance for research planning.

The workshop recommended that countries be urged to support modeling and computer simulation analyses as a high priority research task.

Another high priority research task identified at the workshop was the need to define the stock structure of the various species of billfishes. Proper assessment and management of the billfish resources will require some understanding of stock structure. While tagging programs provide some of the necessary information, the low catch rates of commercial and recreational fisheries suggest that other techniques are probably more suitable, e.g., immunogenetic methods.

The workshop also recognized the need for the application of other analyses to the billfish stocks, e.g., yield-per-recruit analysis. Since these approaches require age and growth information the workshop recommended that research be undertaken to determine the age of billfish and to establish age-size relations.

The workshop noted that assessments of the billfish resources could be improved by conducting a further detailed study of the longline fishery and a more complete treatment of other fisheries for billfishes, including the Japanese gill net fishery. For the longline fishery it was noted that changes in fishing method and strategy, such as the recent increased effort by deep-fishing longline gear and the reduction in the longline fishery for swordfish, could have a marked influence in the computation of effective fishing effort. The workshop recommended that countries having access to extensive historical data undertake studies to define these changes and their relation to effective fishing effort.

Management

Sophisticated management advice for the Pacific billfish fisheries is difficult to formulate at this time because of (1) the lack of adequate data needed to fully understand the fish stocks and fisheries and (2) the absence of effective international arrangements for conservation of highly migratory species. Production model analyses of available data, however, provide a basis for tentative management advice.

The available data on the Pacific blue marlin stock suggest that this species is overfished. Whether the overfished condition is due to recruitment overfishing or yield-per-recruit overfishing is not known. If the condition is caused by recruitment overfishing, the situation is probably very serious and appropriate action should be taken to provide for additional escapement as a means of increasing the spawning stock. If, on the

other hand, the condition is caused by yield-per-recruit overfishing, the situation is not as serious, but restrictions on effort and/or minimum size at capture would be required to improve the average yield.

The stocks of Pacific striped marlin and swordfish appear to be exploited at levels close to estimated MSY. Nevertheless, the stocks appear to be in good condition and from a biological viewpoint the fisheries are not in need of restrictive management. However, these species should be monitored closely for signs of overfishing.

The status of the stocks of black marlin, sailfish, and shortbill spearfish is less certain. It is conceivable that a detailed reassessment of historical data may provide the basis for separating the combined sailfish-shortbill spearfish catch data, thus permitting appropriate production model analyses to be undertaken. Similarly, improved estimates of total catch may lead to better assessment of the black marlin resources. In the meantime no restrictive management is deemed necessary from a biological viewpoint.

With respect to management institutions, the widespread distribution and migratory tendencies of the billfishes suggest that effective management can only be achieved by a broad-based management program, covering the entire range of the stocks. To date, a management mechanism of this nature does not exist in the Pacific.

The workshop recommended that countries harvesting billfishes in the Pacific support continuing efforts to assess the stocks and assist in formulating management options which will lead to optimal utilization of the billfish resources.

LITERATURE CITED

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1975. Fitting the generalized stock production model by least-squares and equilibrium approximation. Fish. Bull., U.S. 73:23-37.

SHOMURA, R. S., and F. WILLIAMS (editors).
1974. Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972, Part 2. Review and Contributed Papers. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675, 335 p.

1975a. Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972, Part 1. Report of the Symposium. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675, 33 p.

1975b. Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972, Part 3. Species Synopses. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-675, 159 p.

Appendix A

AGENDA

Session I - Pacific Billfish Resources (5-9 December 1977)

1. Opening remarks (R. S. Shomura, chairman)
2. Adoption of agenda
3. Overview of United States, Japan, South Korea, and Republic of China fisheries
4. Review and discussion of data base
5. Review and discussion of billfish life history statistics and parameters
6. Stock assessments
   a. Blue marlin, Makaira nigricans
   b. Striped marlin, Tetrapturus audax
   c. Sailfish, Istiophorus platypterus, and shortbill spearfish, Tetrapturus angustirostris
   d. Swordfish, Xiphias gladius
   e. Black marlin, Makaira indica
7. Review and reanalysis of data as needed
8. Final discussion of assessments and recommendations to be included in summary report
9. Write-up of summary report
10. Review and approval of summary report
11. Closing remarks (R. S. Shomura)

SESSION II - Atlantic Billfish Resources (12-14 December 1977)

1. Adoption of agenda

2. Overview of United States, Japan, South Korea, and Republic of

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Appendix C

WORKING PAPERS

Session I - Pacific Billfish Resources

BSAW/WP1 Wetherall, Jerry A., and Marian Y. Y. Yong.
An assessment of Pacific billfish stocks based on the generalized production model.

BSAW/WP2 Ueyanagi, Shoji.
A review of the Japanese commercial fisheries for billfishes.

BSAW/WP3 Honma, Misao, Tamotsu Yonemori, and Shoji Ueyanagi.
Drift gill-net (ōme ami) fishery in Japanese waters and its possible influence on the stock of the North Pacific striped marlin.

BSAW/WP4 Suzuki, Ziro, and Misao Honma.
Stock assessment of billfishes in the Pacific.

BSAW/WP5 Yuen, Heeny S. H.
Overview of fisheries for billfishes in Hawaii.

BSAW/WP6 Bartoo, Norman W.
A brief review of billfish life history and population dynamics parameters.

BSAW/WP7 Squire, James L., Jr.
Review paper on billfish sportfishing catch rates, weight/length/sex data, and tagging effort and recoveries.

BSAW/WP8 Bell, Robert R.
The California swordfish fishery.

BSAW/WP9 Sakagawa, Gary T.
The Pacific swordfish resource.

BSAW/WP10 Yang, Rong-Tszong.
Billfish fishery in Taiwan.

Appendix D

RAPPORTEURS' REPORTS

[To be provided at a later date.]