Arq. Ciên. Mar, 15 (2): 127 — 131
Dezembro, 1975 — Fortaleza, Ceará, Brasil

PROSPECTS FOR THE WORLD MARINE FISHERY PRODUCTION

Melquíades Pinto Paiva
Antônio Adauto Fonteles-Filho
José Sávio Colares de Melo
Sinfrônio Sousa Silva

Laboratório de Ciências do Mar
Universidade Federal do Ceará
Fortaleza — Ceará — Brasil

The oceans are not the inexhaustible source of food they were once thought to be. On account of that, it is necessary to keep an watchful eye on their exploitation, so that proper management is applied towards obtaining the potential yield that can be haversted.

After the II World War, the world fishery production showed a threefold increase, from less than 20 million metric tons in 1948 to more than 60 million metric tons in 1970. This has been the result of the discovery of new fishery resources and the increasing number of mobile fleets and factory vessels and to the use of modern and efficient fishing methods and gears.

The possibilities for increased marine catches over the next years have been extensively investigated. The known estimates were commented on and discussed by Rounsefell (1971). The fulfillment of those forecasts is very important, in view of the dwindling food sources and the growing of the human population.

In this paper the authors shall be concerned with attempting to find out the year when the most likely of those estimates will be reached, and what will be the composition of the catches by oceans and their regions, as well as by groups of species.

MATERIAL AND METHODS

The basic data have been drawn from the FAO Yearbooks of Fishery Statistics, and they have been arranged in two ways: by oceans and their regions (figure 1), and by phillum or classes of marine animals and groups of species, only natural populations being taken into account.

The fishery production was computed for each region and each group of species, over the years 1964 — 1973.

There are three methods whereby prediction of future catches can be performed: 1 — extrapolation of present trends in world marine catch; 2 — extrapolation of resource estimates from a known sub-area to the whole area; 3 — estimation of primary production at each sucessive stage of the food chain and its dynamics.

We have herein used the first method by applying a linear regression model of the type $Y = a + bX$, where Y = annual catch in 10^3 metric tons and X = year, being 1964 = 1. The null hypothesis of no correlation between the variables has been tested at the probability level of $P < 0.05$.

The world marine fishery production during the considered years ranged between 45,601 x 10^3 metric tons in 1965 and 60,926 x 10^3 metric tons in 1970 (table I).

TABLE I

World marine fishery production during the years 1964 — 1973.

Years	10^3 metric tons
1964	46,200
1965	45,601
1966	49,385
1967	52,611
1968	55,875
1969	54,359
1970	60,926
1971	60,622
1972	55,835
1973	55,897

Source : FAO Yearbook of Fishery Statistics, 1964 — 1973.

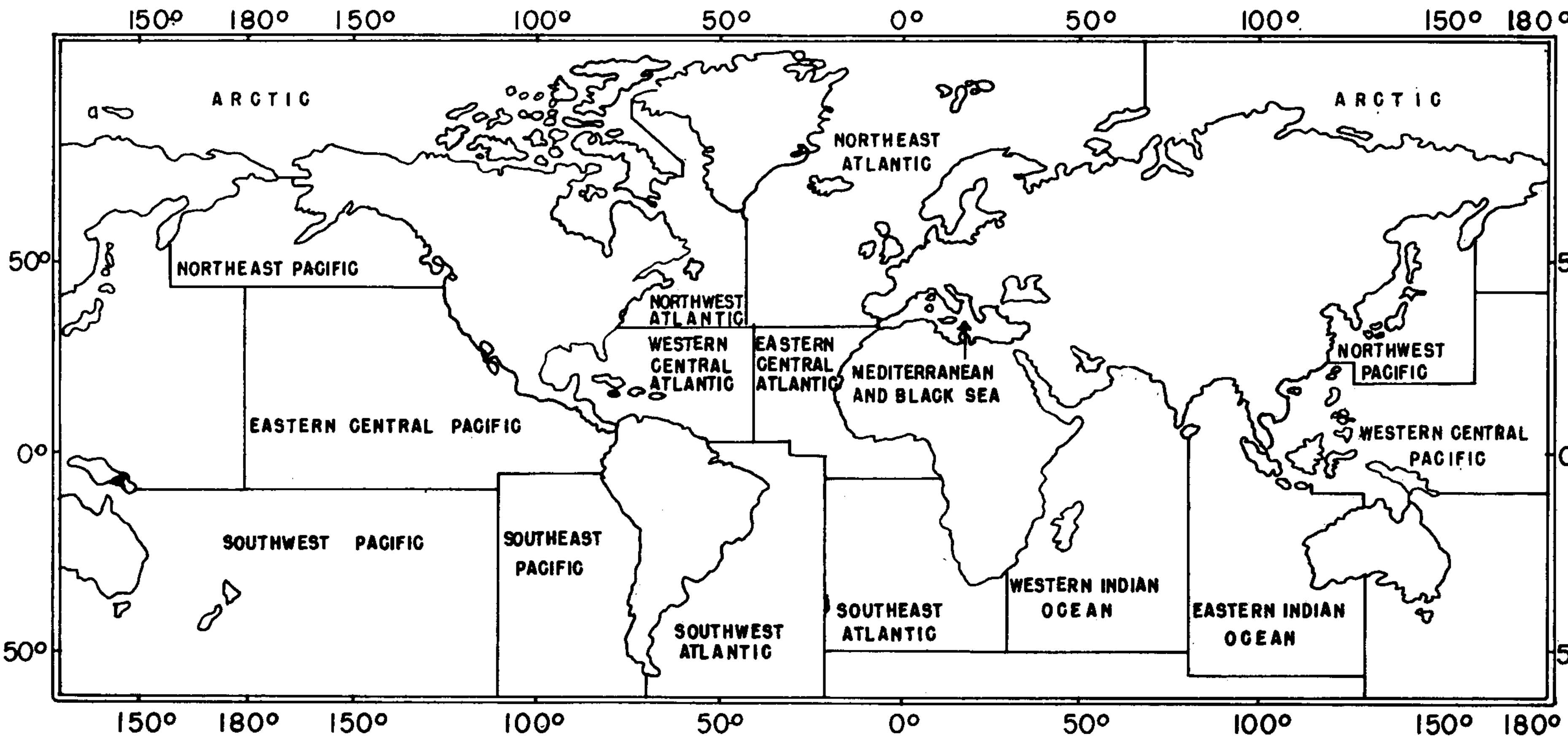

Figure 1 — The oceans and their regions. (Adapted from Gulland, 1970).

A survey of the known estimates is given in table II. Gulland's estimate of 104,200 x 10^3 metric tons has been chosen as the most likely, because it is the result of estimates by areas, and within areas, by resources. The year corresponding to that catch was then fed back into the equations, whereby estimates by regions and groups of species could be obtained.

TABLE II

Some estimates of the potential world marine fishery production.

Authors	10^3 metric tons
Thompson (1951)	22,000 (1)
FAO (1953)	34,000 (1)
Meseck (1962)	100,000 (2)
Graham & Edwards (1962)	171,000 (2)
Pike & Spilhaus (1962)	254,000 (2)
Schaefer (1965)	290,000 (2)
Cushing (1969)	60,000 (1)
Ryther (1969)	145,000 (2)
Gulland (1970)	104,200 (2)
Rounsefell (1971)	94,000 (2)

Observations : (1) — estimate already surpassed by the world marine fishery production; (2) — estimate not yet surpassed by the world marine fishery production.

RESULTS AND DISCUSSION

The time series within which we have worked covers only ten years, and this somehow reduces the reliability of the results. Nevertheless, there does exist a statistically significant upward trend in world marine fishery production, slightly broken towards the end of the period, as shown by the equation obtained by regression, fitted to the values of annual production given in table I. This is the equation :

$$Y = 45{,}780 + 1{,}446\ X\ (\ r = 0.820^*\ ).$$

According to this equation, Gulland's estimate will be materialized in year 2003, that is, 30 years thence. This means that the world marine fish production will increase at an annual rate of 2.1% over that period.

In terms of oceans there was found to be a significant correlation between fishery production and time in the Atlantic and Indian, but not in the Pacific, due to a sharp fall in its yield in 1972 and 1973, consequent of the decline of Peruvian anchovy catch (table III).

As to the regions, several significant correlations were obtained: Atlantic — in the northwest, eastern central and in the Mediterranean and Black Sea; Indian — in the western region; Pacific — in the northeast, northwest, southwest, eastern central and western central (table III).

TABLE III

Regression equations of the marine fishery production on time by oceans and their regions, where Y = annual catch in 10^3 metric tons and X = year (1964 = 1). Based on data from 1964 to 1973.

Oceans and regions	Regression equations	Correlation coefficients (r)
Atlantic	Y = 18,478 + 720 X	0.959 *
— northeast	Y = 9,075 + 203 X	0.077 n.s.
— northwest	Y = 3,735 + 87 X	0.724 *
— southeast	Y = 588 + 29 X	0.379 n.s.
— southwest	Y = 2,130 + 93 X	0.063 n.s.
— eastern central	Y = 1,989 + 28 X	0.976 *
— western central	Y = 1,364 + 10 X	0.273 n.s.
— Mediterranean and Black Sea	Y = 960 + 14 X	0.669 *
Indian	Y = 1,779 + 87 X	0.934 *
— eastern	Y = 709 + 7 X	0.508 n.s.
— western	Y = 1,135 + 69 X	0.997 *
Pacific	Y = 25,503 + 642 X	0.565 n.s.
— northeast	Y = 1,293 + 126 X	0.774 *
— northwest	Y = 10,208 + 445 X	0.719 *
— southeast	Y = 12,015 − 432 X	- 0.402 n.s.
— southwest	Y = 95 + 19 X	0.905 *
— eastern central	Y = 524 + 54 X	0.960 *
— western central	Y = 2,091 + 299 X	0.972 *

Source: FAO Yearbook of Fishery Statistics, 1964 — 1973.

It may be seen that whilst most regions in the Pacific presented significant correlation, the total itself did not, which shows the effect of one region, namely the southeast, on the overall production.

For groups of species, the regression equations displayed a more uniform feature, in that the production of fishes, crustaceans and molluscs were significantly correlated with time. No correlation existed for the river eels, among the diadromous fishes; for the sardine and sardine-like fishes, among the marine fishes ; for the oysters, scallops and pectens, and squids and octopusses, among the molluscs (table IV).

A comparison between the average productions in the considered years and the estimates predicted by regression equations and by Gulland (1970), emphasized by relative indexes of growth in relation to the average production of each ocean or region, taken as 100, is provided in table V. It may be seen there to be a reasonable agreement between the two sets of estimates, except for some wide differences, as in the western Indian Ocean, and in the eastern and western central Pacific Ocean.

Considering the data shown in table VI, the diadromous fishes will experience the largest increase, most of it represented by the

TABLE IV

Regression equations of the marine fishery production on time by groups of species, where Y = annual catch in 10^3 metric tons and X = year (1964 = 1) . Based on data from 1964 to 1973 .

Groups of species	Regression equations	Correlation coefficients (r)
Diadromous fishes	Y = 903 + 260 X	0.970 *
— sturgeons	Y = 19 + 0.4 X	0.775 *
— river eels	Y = 42 + 0.2 X	0.151 n.s.
— salmons, trouts and smelts	Y = 314 + 227 X	0.971 *
— shads and milkfishes	Y = 551 + 23 X	0.748 *
Marine fishes	Y=40,749 + 1,033 X	0.721 *
— flounders, halibuts and soles	Y = 969 + 40 X	0.848 *
— cod and cod-like	Y = 5,662 + 654 X	0.985 *
— redfishes, basses and congers	Y = 2,917 + 100 X	0.897 *
— mullets and mullet-like	Y = 1,668 + 134 X	0.830 *
— sardines and sardine-like	Y = 16,207 + 92 X	0.102 n.s.
— tunas and tuna-like	Y = 1,379 + 33 X	0.917 *
— mackerels	Y = 1,326 + 231 X	0.929 *
— sharks and rays	Y = 389 + 16 X	0.966 *
Crustaceans	Y = 1,084 + 64 X	0.990 *
— crabs	Y = 314 + 7 X	0.708 *
— lobsters	Y = 131 + 4 X	0.941 *
— shrimps and prawns	Y = 608 + 47 X	0.989 *
Molluscs	Y = 2,721 + 77 X	0.828 *
— abalones, winkles and conchs	Y = 37 + 2 X	0.943 *
— oysters	Y = 817 – 7 X	- 0.405 n.s.
— mussels	Y = 218 + 20 X	0.943 *
— scallops and pectens	Y = 155 + 1 X	0.190 n.s.
—clams and cockles	Y = 519 + 14 X	0.695 *
— squids and octopusses	Y = 768 + 32 X	0.616 n.s.
Other marine animals	Y = 343 + 26 X	0.431 n.s.

Source: FAO Yearbook of Fishery Statistics, 1964 — 1973 .

group of salmons, trouts and smelts; among the marine fishes, the mackerels, the cod and cod-like species, and the mullets and mullet-like species stand out in that respect ; among the crustaceans, the group of the shrimps and prawns, as well as the mussels among the molluscs, will have the highest relative increase in production.

Those indexes indicate that in future some regions and some groups of species will stand out as more productive than others, although this does not exclude the possibility for production of the ones already under heavy exploitation to be further enhanced. Naturally the predictions based on extrapolation 30 years ahead should be regarded with caution.

TABLE V

Predicted values of world marine fishery production in year 2003 , by oceans and their regions, based on extrapolation and other methods, with their respective indexes of growth in relation to the average production in years 1964 — 1973 taken as 100 .

Oceans and regions	10^3 metric tons		Indexes of growth	
	from regression equations	from Gulland (1970)	from regression equations	from Gulland (1970)
Atlantic	47,280	43,700	211	195
— northeast	...	13,500	...	132
— northwest	7,215	6,500	171	154
— southeast	...	4,300	...	548
— southwest	...	7,400	...	280
— eastern central	3,109	3,500	145	163
— western central	...	5,800	...	408
— Mediterranean and Black Sea	1,520	2,700	156	257
Indian	5,259	14,300	233	633
— eastern	...	5,400	...	726
— western	3,895	8,900	257	587
Pacific	...	46,200	...	159
— northeast	6,333	5,000	318	252
— northwest	28,008	16,700	221	132
— southeast	...	12,600	...	131
— southwest	855	600	423	297
— eastern central	2,684	6,100	328	745
— western central	14,051	5,200	376	139

TABLE VI

Predicted values of world marine fishery production in year 2003 , by groups of species, based on extrapolation, with their respective indexes of growth in relation to the average production in years 1964 — 1973 taken as 100 .

Groups of species	10^3 metric tons	Indexes of growth
Diadromous fishes	11,303	550
— sturgeons	35	167
— river eels	...	...
— salmons, trouts and smelts	9,394	694
— shads and milkfishes	1,471	238
Marine fishes	82,069	188
— flounders, halibuts and soles	2,569	217
— cod and cod-like	31,822	379
— redfishes, basses and congers	6,917	212
— mullets and mullet-like	7,028	304
— sardine and sardine-like	...	...
— tunas and tuna-like	2,699	182
— mackerels	10,566	469
— sharks and rays	1,029	226
Crustaceans	3,644	270
— crabs	594	180
— lobsters	291	197
— shrimps and prawns	2,488	308
Molluscs	5,801	191
— abalones, winkles and conchs	117	254
— oysters	...	...
— mussels	1,018	327
— scallops and pectens	...	...
— clams and cockles	1,079	198
— squid and octopusses	...	...
Other marine animals	...	...

CITED BIBLIOGRAPHY

Cushing, D. H. — 1969 — Upwelling and fish production. *FAO Fish. Tech. Pap.*, Roma, (84) : 1 - 40, 20 figs.

FAO — 1953 — Improving the fisheries contribution to world food supplies. *FAO Fish. Bull.*, Roma, *6* (5) : 159 - 191.

Graham, H. W. & R. L. Edwards — 1962 — The world biomass of marine fishes. In : Heen, E. & R. Kreuzer (ed.) — *Fish in Nutrition*, pp. 3 - 8. Fishing News (Books) Ltd., XXIII + 447 pp., illus., London.

Gulland, J. A. (ed.) — 1970 — The fish resources of the ocean. *FAO Fish. Tech. Pap.*, Roma (97) : 1 - 425, illus.

Meseck, G. — 1962 — Importance of fisheries and utilization in the food economy. In : Heen, E. & R. Kreuzer (ed.) — *Fish in Nutrition*, pp. 23 - 27. Fishing News (Books) Ltd., XXIII + 447 pp., illus., London.

Pike, S. T. & A. Spilhaus — 1962 — Marine resources. A report to the Committee on Natural Resources of the National Academy of Sciences. National Research Council Publ. 100-E : 1 - 8.

Rounsefell, G. A. — 1971 — Potential food from the sea. *J. Mar. Scien.*, Bayou la Batre, *1* (3) : 1 - 85, 8 figs.

Ryther, J. H. — 1969 — Photosynthesis and fish production in the sea. *Science*, Washington, *166* (3901) : 72 - 76.

Schaefer ,M. B. — 1965 — The potential harvest of the sea. *Trans. Amer. Fish. Soc.*, Lawrence, *94* (2) : 123 - 128, 1 fig.

Thompson, H. — 1951 — Latent fishery resources and means for their development. *Proc. U. N. Conf. Cons. Util. Resour.*, New York, 7 : 28 - 38.