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WORLD FISHERIES

WILBERT McLEOD CHAPMAN

The subject given me to discuss, World Fisheries, is delightfully broad and vague. The subject can be treated from numerous viewpoints. I intend to touch on several of these viewpoints in a cursory manner and then speculate a little on the future, some of the problems that it may bring, and some solutions that may be applied to those problems. All of the Statistics cited come from Yearbook of Fishery Statistics, FAO, Vol. 23, Fishery Commodities 1966 (1967) and Vol. 24. Catches and Landings 1967 (1968).

World catch of aquatic products is recorded by FAO in terms of round live weight of fish and shellfish in metric tons, with whales excluded, and this format is generally followed by writers and speculators on the subject. I will follow it too. It should not be forgotten, however, that whales of all sorts are still caught in substantial numbers. Of the large whales (blue, fin, sperm, etc.,) FAO records 51,593 taken in the 1966/67 season; of the smaller whales (minke, pilot, etc.), 7,951 in 1967, and of dolphin, porpoise, etc., about 7,000 tons. Thus, in terms of live weight, the total whale catch may still come to somewhere between 1.5 and 2.0 million metric tons, which amounts to about the same level as the total world yield of fish and shellfish in 1850 as estimated by Moiseev (1965). While the main product from whales is still edible and other oils, whale meat has been increasingly used since the end of World War II for direct human consumption and otherwise, especially in Japan.

The world fish catch approximately doubled to four million tons by 1900 and reached about 9.5 million tons in 1913 before the outbreak of World War I. This was the period of introduction of the steam engine to larger fishing craft and the development of the otter-trawl, particularly in the north-east Atlantic. In most of the world fishing remained on a subsistence basis.

There was material interruption in fish production, particularly adjacent to Europe, during World War I and recovery and growth were slow, being still about 10 million tons in 1932 (Meseck, 1968). Growth in production was then rather rapid until the outbreak of World War II, reaching about 21 million tons in 1938. This was the period noted for the expansion of use of internal combustion (and particularly diesel) engines in fishing vessels, the use of ice on a large scale at all levels in the fish trade from vessels at sea to the retail store, the beginning of freezing at sea, the large-scale manufacture of fish meal and its use in animal husbandry, substantial increases in the canning of fish in hermetically-sealed containers, and expansion in world trade of fishery products with increased ease of transportation not only at sea but internally in the developed countries of the northern hemisphere.

Again, there was an interruption of fish production during World War II, with it sinking to perhaps 15 million tons during the peak of hostilities (or lower, the statistical systems being disrupted also), rising back to 18 million tons in 1947 (Meseck, 1968) as nations rebuilt their fisheries as rapidly as they could, and then back to the 1938 level in 1950, when 21.1 million tons were landed.

There then began an unprecedented rise in world fish production. By 1960 world landings had very nearly doubled, to 40 million tons, in 1965 were at 53.5 million tons, and in 1967 had reached 60.5 million tons.

This was the period when a great many innovations came into the fish trade at all levels. These included widespread freezing of fish at sea; extensive use of the diesel engine in fishing vessels; the widespread use of synthetic fibers in webbing, ropes, etc.; the rapid extension of various acoustic devices for locating fish; the use of hydraulic power on vessels through winches, power blocks, line haulers, to markedly reduce physical labor inputs at sea. At the processing end machinery was introduced to fillet, skin, and dress fish mechanically at sea and ashore; automatic filling machines were adopted with much improved efficiency growing also in other parts of the canning line; sharp freezing processes, with improved machinery, became widespread; machinery for fishmeal manufacture became much improved and diversified, as did the whole fish-meal producing business, including economies of size. In transportation and merchandizing, shipment of frozen goods on a worldwide basis became commonplace, air transport of high-unit-cost delicacies began, bulk shipment of fish meal commenced, and the marketing of fish at the wholesale level gravitated to larger and firmer hands. Technological change is still moving swiftly through the fish trade, as it is through most of the rest of the economy, with resultant improvement in quality and diversity of product at lower relative cost.

PRODUCTION BY REGIONS

Fish and shellfish production has increased by different rates and magnitudes in different regions of the world. This will be traced only since 1957, which is the period most marked by change.

In Oceania production has gone from 110 to 200 thousand tons in the past ten years, but still amounts to only about 0.3 percent of the world production.

Production in Africa has increased from 2,130 to 3,739 thousand tons in this period but its share of total world production has decreased from 6.4 percent to 6.2 percent.

Production by U.S.S.R. is larger than for all Africa and has increased from 2,621 thousand tons in 1958 to 5,777 thousand tons in 1967. Russia's percentage of total world catch in the same period has increased from 7.9 percent to 9.5 percent.

Production in North America has stayed reasonably constant, being 3,990 thousand tons in 1958 and 4,300 thousand tons in 1967 (it had reached 4,490 thousand tons in 1962). North America's share of world catch has shrunk from 12 percent in 1958 to 7.1 percent in 1967.

The sharpest increase has been achieved by South America, where production in 1958 was 1,630 thousand tons and in 1967, 12,140 thousand tons. South America's share of world catch increased from 4.9 percent in 1958 to 20.1 percent in 1967. The increase came mostly in Peru and Chile.

European catches have increased steadily in the period from 7,750 thousand tons in 1958 to 11,820 thousand tons in 1967 when, for the second time, it fell behind South America. Europe's share of world catch has actually dropped from 23.4 percent in 1958 to 19.5 percent in 1967.

The great expansion in world production has been by Asia whose catches went from 14,940 thousand tons in 1958 to 22,580 thousand tons in 1967, but Asia's share of the world catch fell from 45.0 percent in 1958 to 37.7 percent in 1967. This was because of the great surge forward in South American production.

PRODUCTION BY SEPARATE NATIONS

The production of fish and shellfish by country is extremely skewed toward the high producers. In 1967 the biggest producer (Peru) took 17 percent of the world catch and the largest two (Peru and Japan) took 30 percent between them. The largest five fish producers (Peru, Japan, Mainland China, U.S.S.R., and Norway) took 54 percent of the world catch, the next five largest producers (U.S.A., South and South West Africa, Spain, India, and Canada) took 13 percent of the catch, and the third five largest producers (Indonesia, Denmark, Chile, U.K., Iceland) took 8 percent of the world catch. Thus about 11 percent of the countries of the world accounted for about 75 percent of the world production of fish and shellfish in 1967. The catches of these fifteen countries are set out in Table 1. The figures for Mainland China are FAO's best guess, not reported on by the nation since 1958, and then probably on an inflated basis. The catches cited by Indonesia do not have a secure statistical base. The other statistics are probably pretty accurate. They are, at least, all that are available.

TABLE 1

Landings of Fish and Shellfish by 15 Major Countries, 1967, Metric Tons, Round Weight

Peru	10,110,200
Japan	7,814,000
M. China	5,800,000 (1958)
U.S.S.R.	5,777,200
Norway	3,214,000
Subtotal	32,715,400
U.S.A.	2,384,100
S. and S.W. Africa	1,664,400
Spain	1,430,600
India	1,400,400
Canada	1,289,800
Subtotal	8,149,300
Indonesia	1,201,800 (1966)
Denmark	1,070,400
Chile	1,052,900
U.K.	1,026,100
Iceland	896,300
Subtotal	5,247,500

PRODUCTION BY SOCIAL AND ECONOMIC CLASS

Writers, and the United Nations apparatus, divide the countries of the world roughly into two categories, which are called developed or developing, industrialized or underdeveloped, rich or poor, or some such suitable pairing of terms. An examination of this dichotomy quickly establishes the fact that it is not the industrialized countries, which were the strong fishing countries of the pre-war period, that are developing their fish production most rapidly in the post-war period.

If production statistics for ten of these industrialized countries of Europe and North America (U.S.A., U.K., Germany, France, Canada, Netherlands, Italy, Denmark, Belgium, and Sweden) are combined it will be seen that their total production in 1938 was 6,423.6 thousand tons; in 1958 7,367 thousand tons; and in 1967 8,106 thousand tons, giving in 1967 a 9 percent increase in the previous ten years, and a 24 percent increase over the preceding thirty years (Table 2).

On the other hand if one takes the catch of thirty countries of the developing world combined (Morocco, Senegal, Ghana, Sierra Leone, Tanzania, Uganda, Zambia, Liberia, Madagascar, Cuba, Mexico, Panama, Argentina, Chile, Colombia, Guyana, Peru, Venezuela, Ceylon, Taiwan, Hong Kong, India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Thailand, South Viet Nam, and Poland), it will be found that they were 5,915.7 thousand tons in 1958, and ten years later were 20,973.3 thousand tons, nearly a quadrupling. Since these statistics include those of Peru and Chile (both developing countries) where fish production has increased extraordinarily, it might be felt that this comparison was slanted. If the catches of those two countries are removed from both the 1958 and 1967 columns, the combined catches of the remaining countries is 4,928 thousand tons in 1958 and 9,810 thousand tons, or nearly a doubling in ten years, which is considerably better than the highly industrialized countries have done (Table 3).

TABLE 2

Landings of Fish and Shellfish in Selected Industrialized Countries, 1938, 1958 and 1967, Metric Tons, Round Weight

Country	1938	1958	1967
U.S.A.	2,360,100	2,703,400	2,384,100
United Kingdom	1,198,100	999,000	1,026,100
Germany	777,200	725,400	661,500
France	643,600	611,800	820,000
Canada	838,600	1,007,600	1,289,800
Netherlands	256,200	313,800	314,600
Italy	181,000	245,700	337,300
Denmark	97,100	598,000	1,070,400
Belgium	42,500	64,000	63,900
Sweden	129,200	238,000	338,300
Totals	6,423,600	7,367,000	8,106,000

TABLE 3

Landings of Fish and Shellfish in Selected Countries of the Developing World, 1958 and 1967, Metric Tons, Round Weight

Country	1958	1967
Morocco	172,700	258,000
Senegal	85,900	173,700
Ghana	30,900	110,100
Sierra Leone	17,700	33,600
Tanzania	55,000	118,400
Uganda	54,700	88,400
Zambia	26,900	38,500
Liberia	1,400	11,800
Madagascar	25,500	40,200
Cuba	21,900	63,000
Mexico	163,900	350,300
Panama	6,800	72,100
Argentina	84,200	240,900
Chile	225,800	1,052,900
Colombia	25,000	57,300
Guyana	3,500	13,900
Peru	961,200	10,110,200
Venezuela	78,300	107,200
Ceylon	40,700	115,600
Taiwan	229,700	458,100
Hong Kong	69,500	86,900
India	1,064,600	1,400,400
Indonesia	691,000	1,201,600(1966)
Korea	403,600	749,100
Malaysia	139,900	367,100
Pakistan	283,700	417,000
Philippines	447,300	769,200
Thailand	196,300	849,400
South Viet Nam	143,000	380,500
Poland	145,100	338,900
Total	5,915,700	20,973,300

PRODUCTION BY KINDS OF FISH

The relative proportion of fresh water and diadromous fishes; marine fishes; crustacean, molluscs, and other invertebrates; and other things such as seals, miscellaneous animals and plants, in the total world catch has remained remarkedly stable over the years, always dominated by marine fish. Marine fish have proportionately increased slightly over the years, being 71.9 percent of the catch in 1938, 72.7 percent in 1958, and 77.6 percent in 1967. The variation has been within that range. The proportion of fresh water and diadromous fish in the catch has declined slightly from 16.7 percent in 1938 and 1958 to 13.6 percent in 1967, with only one year (1948) being slightly outside that range with 13.2 percent. The category crustacea, molluscs, and other invertebrates formed 8.7 percent of the catch in 1938, then rose to 10.1 percent in 1948, from which it has slowly and steadily declined (8.9 percent in 1958 and 7.4 percent in 1967). The category "other" (seals, and miscellaneous animals and plants) was never large and has declined rather steadily from the high point of 2.7 percent of total world catch in 1938 to 1.4 percent in 1967.

It has been in the category marine fishes that the big expansion of production has taken place in the past ten years, going from 24.12 million tons in 1958 to 46.94 million tons in 1967.

Substantially all the crustacea, mollusca, and other invertebrates also come from salt water and their catches have increased from 3.26 million tons in 1958 to 4.48 million tons in 1967. Although the increase in the net physical yield of these has been modest, they are such high cost items that this increase has brought more than one billion dollars of extra income to shrimp and lobster fishermen around the world over that period. A substantial part of the fish in the fresh water and diadromous category (salmons, some trout, some smelts, alewives, some sturgeon), also are raised in the ocean, even though they come back to fresh water to spawn. This category has increased in yield from 5.56 million pounds in 1958 to 8.22 million pounds in 1967. Thus in 1967 the total production of marine animals and plants comprised at least 90 percent of the total fish and shell fish catch of the world, and the relative proportion was increasing with the years.

In the category of marine fishes the startling expansion has been in the group of herring-like fishes (herring, sardines, anchovy, and the like). Production went from 7,250 thousand tons in 1958 to 19,680 thousand tons in 1967. This was dominated by increased catch of one species of anchovy off western South America which went from 777 thousand tons in 1958 to 10,530 thousand tons in 1967. This in turn was dominated by the fabulous growth of the anchovy fishery in Peru whose yields increased from 737 thousand tons in 1958 to 9,825 thousand tons in 1967. This one-species-fishery so dominated the world fishery scene that when production from it dipped in 1965, total world fish production figures leveled off from their steady rise since the end of World War II and some writers (Mikhaylov, 1968) gained the impression that world fish production had begun to level out.

The herring-like fishes thus dominate world fish and shellfish catch, providing nearly ⅓ of it. The next largest category totally and in growth is FAO's category of unsorted and unidentified fishes, which rose from 5,280 thousand tons in 1958 to 8,290 thousand tons in 1967. Since a share of these are certainly herring-like fishes, these sorts of animals certainly provide more than ⅓ of the world catch of fish and shellfish. It is likely that this will be the case in the near future, as these sorts of fish, feeding as they do on the plants of the ocean or the animals one stage removed therefrom, are the most abundant fish in the world. This statement is made not only on the basis of theory but on the basis of observed large underutilized resources of them, such as the anchovy of

Southern California, the anchovy and sardine of the Gulf of Mexico, the sardinella of West Africa and Angola, the anchovy and sardinella of the Arabian Sea, the sardinella of Northwest Australia, etc.

The other group of fishes that has shown sharp increase in production over the past ten years are the cod-like fish (cods, hakes, haddocks, pollacks, etc.). Their production increased from 4,490 thousand tons in 1958 to 8,150 thousand tons in 1967 (nearly a doubling). There was an increase of half a million tons in cod catch during this period, but the big increases in this category were in hakes and Alaska pollack, which before this period were classed more or less as trash fish. The hake catch of the world increased from 323 thousand tons in 1958 to 1,483 thousand tons in 1967, more than a quadrupling. Most of this increase went to the frozen fish market, with much of it going into the frozen fish block market. The production of Alaskan pollack went from 345 thousand tons in 1958 to 1,735 thousand tons (an increase by a factor of five). Most of this went to the minced fish market of Japan, but a fair part of it also went into the frozen fish market of Russia. Much of it was caught off the United States.

There are probably 24,000 species of fish in the world other than those included in the three categories of herring-like, cod-like, and unsorted or unidentified species referred to above. Most of these occur in the ocean. The recorded production of all other fishes aside from these three categories was 7,100 thousand tons in 1958 and 9,820 thousand tons. The increase in all of these catches was, thus, about 2,720 thousand tons in this period of time, or about half the increase in catches of cod-like fishes, and about a quarter of the increase in catch of herring-like fishes.

The major increase in this "all-other" category was in mackerels, the catch of which went from 532 thousand tons to 2,027 thousand tons. Sharp increase of mackerel catch was noted in Japan, where it went from 268 thousand tons in 1958 to 687 thousand tons in 1967, and in South Africa, where it went from 20 thousand tons in 1958 to 139 thousand tons in 1967. The most startling increase in mackerel catches, however, was in Norway where it went from 15 thousand tons in 1958 to 867 thousand tons in 1967. This was almost an accidentally discovered fishery resulting from using acoustic locating devices and deeper and longer purse-seines for herring (made possible by the introduction of synthetic webbing and power block) which dipped into the deeper swimming mackerel schools. Most of the production went into fish meal.

While there was also some increase in the worldwide catch of sea perch, sea basses, etc., (2,250 thousand tons in 1958 and 3,140 thousand tons in 1967), the catches of other groups of fishes held level or declined during this decade. The group of flat fishes (flounders, plaice, halibut, turbot, etc.), actually declined somewhat. The main increases in the sea perch-bass category was in catches of sea perch from the Pacific (mostly Japanese and Russian catches in the Northeast Pacific which reached their peak in 1965), and from sand lances in Denmark (which went from 75 thousand tons in 1958 to 208 thousand tons in 1967).

One may roughly summarize the rapid growth of fisheries in the last decade, then, by saying that the major increases were in the production of herring-like fishes (mostly anchovy for fish meal raw material) and of the cod-like fishes (mostly hake and Alaskan pollack for the frozen fish trade). Other sharp increases were in production of sea-perch (for the frozen fish trade) which appears to have passed its peak, and in mackerel and sand lance (most of which went for fish meal).

While their total tonnage of production is submerged in the much greater tonnages of marine fish production, some additional mention should be made of what has been going on in the production of crustaceans and molluscs because (a) several of these are delicacies that bring very high income to the fishermen who land them and (b) some of them represent very large underutilized resources (squid and octopus, shrimp and prawn, and some sorts of crab), or are luxury products susceptible to mariculture (oysters, mussels, clams) because they can bear its cost.

Crustacean production, as a whole, increased from 850 thousand tons to 1,350 thousand tons in 1968. Among the sharp increases were king crab (rising from 64 thousand tons to 134), and shrimp (440 thousand tons to 690). Other increases were noted in other marine crabs and other marine crustacea. Market demand for crustacea is increasing sharply (frozen king crab meat sells for $8,000 per ton), known underutilized resources of considerable size exist, and it is inevitable that further increase will come quickly in this category. The application of new technology in handling frozen products, and in air transport of sea foods as well as in processing these products, is beginning to have effect.

The mollusc category is particularly interesting. It has increased from 2,070 to 3,080 thousand tons in this ten-year period. Squid represent one of the largest underutilized resources of the world ocean. The flesh is delicious but there is market resistance in much of the world because of the look of the animal, and old wives' tales. Nevertheless, production of squid increased from 466 to 750 thousand tons in this period. Octopus bear even worse connotations than squid, are equally delicious, and there are substantial underutilized resources of them known. Production increased from 70 to 80 thousand tons in this decade.

Mussels (166 to 275 thousand tons) and oysters (639 to 829 thousand tons) are particularly susceptible to mariculture and their increased use on a worldwide basis is steady, as noted by the above figures. This is not true in the United States where mussels are not much eaten and where most of the vast original oyster beds have been wantonly destroyed by unwise or lacking conservation measures.

CHANGING PATTERNS OF USE

There have been consistent changes in the worldwide pattern of use of fish and shellfish over the years that are interesting in the slowness, steadiness, and persistence of the trends. The FAO Yearbook of Fishery Statistics for fishery commodities, 1967 (Vol.

25), is not yet available and the following statistics are from Volume 23 (1966), but the trends have undoubtedly persisted through 1967.

The largest single use still is for fresh marketing, but the relative use for this purpose has dropped off steadily since 1938 when 52.9 percent of production was used in this form until 1966 when only 31.1 percent was used for this purpose. The downward trend has developed slowly, with 44.6 percent used fresh in 1958.

The old, traditional ways of preserving fish for later use (drying, smoking, salting, etc.), have also steadily fallen off in favor over the years. In 1938 27.1 percent of world production was used in this fashion, whereas in 1966 only 14.3 percent was so used. The trend of drop-off in this use has speeded up since 1958, when 22.0 percent of production was used in this fashion.

The overwhelmingly largest change in trend of usage over the years has been as raw material for fish meal. In 1938, 8.1 percent of world production was used in this fashion. The disruptions of World War II decreased this use somewhat, so that it was only 7.7 percent in 1948. Since then the increase has been steady (except for a slight dip in 1965 because of perturbations in Peru) and since 1958 it has been rather sharply upward. In 1958, 13.0 percent of total world fish and shellfish production was used for this purpose, and by 1966 a full 31.2 percent of production (only slightly less than for fresh marketing) was so used.

The other steadily increasing use for fish and shellfish has been in the frozen form. None was recorded as used in this manner in 1938 (although small volumes of higher-priced items such as steelhead trout, halibut, oysters, and a few others had been produced for such use in the United States for twenty years before that and some, such as frozen steelhead, had been in international trade between the west coast of the United States and France). By 1948, 5.1 percent of world production was noted as being used in this fashion. This use has grown steadily and slowly since then, with 12.3 percent of world production being used in this fashion in 1966.

Undoubtedly the slow, but steady, increase of use of fish and shellfish in the frozen form has been an attribute not only of the slowness of change in eating habits generally, but also the slow-spread change in provision of refrigeration facilities in the long line of production through the supply channel from the fishing vessel to the consumer's kitchen. The big growth of this use has been in the United States and Canada where, since the end of World War II, the spread of facilities for handling frozen food in the grocery trade and in the home has been broad, enabling the shipment and purchase of frozen fish quite easily throughout the continent. This custom is beginning to spread in England and throughout Europe (eastern as well as western). In South Europe, West Africa, and some other places, frozen fish is produced aboard ship increasingly and permitted to thaw during transportation to the point of retail sale. This does not produce a very good product, but the practice grows nevertheless. In West Africa there was scarcely a pound of frozen fish sold in 1960, and by 1967 volume had increased to over 200,000 tons.

The proportion of fish used for canning has held rather constant through this 30-year period. In 1938, 7.1 percent of production was used in this form, and the same was the case in 1948. The percentage used for this purpose since has risen somewhat, but has vacillated in a close range between 9.5 percent (in 1956 and 1957) and 8.4 percent in 1963. It was 8.8 percent in 1966.

The category miscellaneous purposes (mostly waste products) has decreased steadily in consequence from a high level of 5.1 percent of production used for these purposes in 1938 to 1.7 percent in 1966, as greater portions of this went into reduction for animal feeding, the canning of pet foods, etc.

In terms of actual, rather than relative, use, the consumption of fish and shellfish in the fresh state increased from 14.8 to 18.0 million tons from 1958 to 1966, the amount used in the frozen form went from 2.8 to 7.0 million tons in this period, the amount used in the smoked, salted, dried, or cured form went from 7.3 to 8.1 million tons, the amount used for canning grew from 3.0 to 5.0 million tons, the amount used for making fish meal shot up from 4.3 to 17.7 million tons, and the amount used for miscellaneous purposes has been kept level in the FAO statistical system at 1 million tons during the entire period.

THE FUTURE MARKET

There is a great deal of talk heard these days about solving the protein malnutrition problems of the world, and public health, social, and economic problems attributable thereto, by Food from the Sea. Most of this is done by people who do not know the least thing about what they are talking about either from the standpoint of people, fish, or the ocean, or how to get these things working together. Most of the response is from similarly uninformed people who point out that only 1 percent of man's food comes from the water, fisheries development is not economically practical anyway, and that the limit of the ocean's ability to produce food is near at hand (Scott, 1968; Ceres, 1968).

One must keep in mind, when talking about food, that, in relation to the current food distribution systems, there is a surplus of proteins and carbohydrates. Protein and carbohydrates from vegetable sources and cereal grains are moving into international markets in such volume presently that such proteins are at 14-year lows on price, and prices of such staple carbohydrate sources as cereal grains and sugar are at 20 to 30-year lows. These commodities are frequently selling on the international market at well below the cost of production. Sugar presently can be had on some of the world markets at half the cost of production. France is presently negotiating the sale of its surplus wheat, stimulated by government subsidy, in Asia at well below the cost of production. More examples could be given (Dean, 1968).

The problem is distribution. Distribution of food is through three main channels—commercial marketing where a money market exists, governmental give-away programs, and subsistence economies where the consumer raises or catches what he eats or barters these products with his near neighbors.

A major part of the world's human population lives in a subsistence economy. No government or groups of governments, are sufficiently strong enough economically to give sufficient foods into these populations living on subsistence economies to meet their minimum needs over and above their own productivity. There has been no means devised yet to get food from the commercial marketing economy into subsistence economies which have nothing to exchange for the food.

The ocean is a poor place to look for the total food requirements of many people, but it is an excellent source of the most critical element—high quality animal protein. The reason is that, although the total primary production of plants in the sea is about the same as on the land, the plants of the sea are mostly microscopic plankton, with fast growth rates, short longevity, and low standing crops that are not amenable to economic harvesting or processing. They also are not amenable to cultivation in bulk terms competitive with land sources of carbohydrates. The major food harvest of the sea has been, is, and will be animals one or more steps above the plants in the ocean's food chain (Bogorov, 1965; Schaefer, 1965, 1968).

Schaefer (*loc. cit.*) has made computations describing the ability of the ocean to produce high-quality animal protein. They may be summarized thus. The waters of the world presently yield a harvest of about 60 million tons of fish and shellfish per year, and provide about 15 percent of the world's supply of animal protein. The average human per capita requirement for animal protein is about 15 gr. per day, or 5.5 kg. per year. This is contained in about 37 kg. (or 81 lbs.) of ordinary marine animals. Thus if there were no waste, and the protein were evenly distributed, the present world population of about 3.5 billion people could obtain all of their necessary animal protein from about 128 million tons of marine animals, or a little more than twice present production. There is general agreement among scientists that known ocean resources are capable of supporting sustainable yields of at least 200 million tons per year. This would provide the protein requirements, in terms stated above, of about 6 billion people. Schaefer calculates, further, that using the total probable potential yield of protein from the ocean at the second trophic level above plants, enough is available to supply the requirements of a 6 billion population by somewhere between 9 and 34 times.

Thus the problem is not availability of protein being produced by the ocean. The problem is tapping the ocean protein production for products that people will buy and eat at prices they can afford in the money (or commercial) section of the world's economy, or providing improved facilities in the sustenance economy for people to catch and use what they need. Work proceeds actively on all of these levels. Here we will deal only with the activity in the money economy sector, but not forgetting the important efforts made by UNDP, FAO, many bilateral governmental programs, and many programs of governments internally to improve the production of fish for immediate use in the sustenance economy.

FISH MEAL

As noted above, the prime growth in fish production since World War II has not been for filling direct human nutrition requirements at all, but has been for fish meal used in animal nutrition. The overwhelmingly largest part of this production has been used in poultry and pork production. The production of fish meal on a worldwide basis has come from about 579,000 tons in 1948 (Peterson, Giertsen, and Co., 1966) to 4,350,000 tons in 1967 (Groben, 1968).

This use is entirely contingent on competitive prices in the market. The three prime end variables are the rate of consumption of poultry, eggs, and pork. The second level of competition is between fish meal and other sources of equivalent protein nutritional value. An example is soya meal plus methionine which is equivalent in nutritional value to fish meal and is chosen as a feed ingredient in a particular geographic location primarily on the basis of price but also on convenience and other economic characteristics.

In the decade under examination (1958–1967), worldwide production of fish meal has come from 1,360 to 4,350 thousand tons (Groben, 1968). Assessing the above factors as well as he can, Groben believes a world fish meal production of 6.0–6.5 million tons is possible by 1975. This would be a drop in market growth and is perhaps conservative. This two million ton increase in fish meal demand equates with about 11 million tons of round weight extra fish catch over the next eight years. This equates roughly with the whole fish meal output of Peru and Chile. It cannot be had from that resource (anchovy) which is producing presently at about top sustainable level, or a little beyond.

Other resources will require to be opened to production, such as the sardinella of the Arabian Sea, the anchovy of southern California, the anchovy and sardine of the Gulf of Mexico, the sand lances of the North Atlantic, etc.

The use of fish for direct human consumption in all forms (fresh, frozen, canned, cured) increased from 28 to 38 million tons in the period 1958–1966, or at the rate of a little better than one million tons per year. There is no reason to expect that this rate of gain will be less in the next decade than it was in the last. One can perhaps expect modest or little gains in the period in the use of cured and fresh fish, with rather larger gains in use of canned fish, and the most gain in the use of frozen fish, if the pattern of the last decade (and actually the last three decades) persists.

CONVENIENCE FOODS

The trend to use fish in the frozen form began in the most affluent countries as an attribute of the spread of the mechanical means of preserving frozen foods through the distribution chain and into the home. It is continuing to grow in the more affluent countries and to spread geographically as affluence, and the machinery which goes with it, spreads. In the most affluent countries this form of use has spread ever more rapidly with the increased use of convenience foods that require little preparation before eating. This has led to the use of frozen fillets, and then to the frozen block of fillets which can be further processed into fish sticks, fish portions, fish sandwiches, etc. These may be retailed still frozen in either cooked, breaded, or uncooked form. Companion to this is the growth in use of frozen shrimp in various forms and frozen crab meat and molluscs. Similar patterns of use seem to be developing in the poorer countries as they become more affluent.

A trend is now beginning in North America for the increased use of frozen seafoods as a component of frozen ready-prepared dinner meals and it seems likely that this newer use of such things as shrimp, crab, tuna, etc., in such convenient, ready-to-cook and serve form will continue to increase steadily in volume.

FISH PROTEIN CONCENTRATE

For a number of years there has been a dream in the mind of nutritionists and similarly interested people that the very abundant and underutilized smaller animals of the ocean could be processed into a defatted, dehydrated fish protein concentrate that would be stable as to flavor and odor in storage for long periods of time and be easy and cheap to store and transport. In essence this would be fish meal manufactured to human food hygiene standards, and with substantially all the fats removed, so that it would be substantially neutral as to odor, flavor, and light in color. It could be added to formulated foods such as breads, pastas, gruels, mushes, soft drinks, and other forms of staple consumption of carbohydrates so that the staple food would be nutritionally well-rounded and sufficient.

The dream is real. The product can be, and has been, produced by several means. A great deal of research is under way currently under various auspices in the United States, Canada, Russia, Sweden, South Africa, Chile, and elsewhere on the technology, and on the adaptation of laboratory means of production to commercial plant scale level. It is, however, still a dream. The only market presently available is for nutritional studies and government public health programs that involve the use of only a few thousand tons of FPC per year and in which the product is given away.

If the product gets developed to the level where an 80 percent protein fish protein concentrate that is water soluble and is odor and flavor free becomes commercially available at prices close to 25 cents per pound, then it is likely to come into commercial use in formulated foods as an expander, or substitute, for dried skim milk, soya concentrate fortified with methionine, and proteins from other vegetable sources such as oil seeds similarly fortified with appropriate synthetic amino-acids. It seems likely that such commercial use of FPC will begin in the United States and Canada within the next five years, and may assume noticeable proportions within the next decade.

This development is coming along at the same time that food habits in the United States are changing in the direction of increased use of formulated foods, which is a logical extension of the already very large market for convenience foods, that need little preparation before serving.

The resources available in the ocean for such FPC production are enormous. All of the things now used as raw material for fish meal would be suitable raw material for FPC, and it is likely that FPC manufacturing will be conducted together with fish meal production. Entirely aside from the small fishes such as anchovy and sardine available for such purposes, smaller crustacea such as red crab, krill, etc., would also make suitable raw material. The size of the known resources available for such production is indicated by the amount of krill thought to be available in the Antarctic alone. It is estimated conservatively that this one kind of animal in that region alone could support a sustainable fishery of 100 million tons a year.

THE SHAPE OF THE IMMEDIATE FUTURE

As noted above, despite all of the concern in the United States, whose domestic fishery has been stagnating in growth for thirty years, production of world fisheries has been increasing for twenty years at a much more rapid rate than the increase of the human population or than that of land agriculture. It continues to grow at about the same rate as it has for the past twenty years.

If the growth of production of fish and shellfish on a worldwide basis continues at an annual rate of 4 percent increase (which is a little slower than its growth rate since 1948), production will be about 86 million tons in 1976 and about 123 million tons in 1986. Both anticipated market demand and resource availability make this projection appear to be reasonable, and perhaps conservative.

The income to fishermen from the 60 million ton production of 1967 was a little better than $9 billion. Presuming stability of price (and there will be, of course, increase) fishermen's income would be about $13 billion in 1976 and somewhat more than $18 billion in 1986. It is interesting to compare this with the highly publicized value of petroleum production from the sea bed, which currently runs at about $4 billion per year, and will be some time in catching up with the value of fish and shellfish catches.

The highly publicized mineral resources of the sea bed produce less than $50 million of product per year.

Roughly speaking, fish products triple in value between the landing and retail prices. Thus, translating the above to retail levels, the retail value of fish products should be about $27 billion in 1967, $39 billion in 1976, and $54 billion in 1986. Thus the economic effect of fishery development is not nominal, and this is one of the prime reasons why both developing and industrialized countries (both worried about foreign exchange balance) put in so much effort in fishery development both by their own efforts and through multi-lateral means. This is likely to continue.

AQUACULTURE

In some quarters the subject of aquaculture has taken on the flavor of religious argument in recent years. The difficulty in dealing with the subject in brief compass is that both the true-believers and the iconoclasts have some truth on their side.

The one point that requires constant remembering is that animal protein from the ocean has no particular *nutritional* attributes better than those of animal protein produced from land animals. Both provide that balance of amino-acids which the human body requires in some measure to keep in good health. On straight out nutritional qualities anchovy protein is no more, or less, valuable than pig or cow protein. Also it is no more valuable in this sense than protein from vegetable sources (soy, oilseed press cake) fortified by appropriate synthetic amino-acids.

Accordingly, in the low-cost bulk animal protein market the product of aquaculture is unlikely to ever be of much importance. There is too much wild stock in the ocean which can be landed profitably at prices of 1 cent or less per pound. I do not know of any aquatic animal that can be raised by aquaculture in much volume at costs as low as 10 cents per pound.

Except for the provision of bulk, low-cost animal protein, however, aquaculture has more or less a place at all other levels of the protein market.

In the sustenance economy aquaculture has a place in the home farm pond. This has never yet been a matter of much importance outside the region of paddy-rice culture because such essentially wild culture without management is not very productive, and when management is applied the costs go up so that the production must compete in the money economy. Experiences by governments in West Africa, for instance, have not been very fruitful (Kimble, 1960). As an experienced FAO field expert told me in Nigeria one time, people who are not sophisticated enough to take care of cows and chickens cannot be expected to be proficient in the much more highly sophisticated business of raising fish in ponds.

In situations where the ponds are close to market and there is no processing, storage or transportation costs of consequence between the producer and the consumer, pond production of fish can be both profitable and locally important from the standpoint of protein nutrition. This is quite important in the area of paddy-rice culture through southeast Asia, and in the vicinity of the temple ponds of India.

A number of carps, among other fishes, are particularly amenable to fresh-water pond culture and in regions where there is a market for this sort of fish (through much of Asia, Central Europe, Israel) they form the basis for both a lucrative and highly productive pond culture. As this pond culture is made more sophisticated by proper management, fertilizing, feeding, breeding of stocks, use of several species in the same pond, etc., the productivity per unit area or pond becomes quite high, but costs also are such that the end product is not cheap. This sort of culture has been raised to particularly high levels of efficiency in Taiwan and in Russia (Ryther, Bardach, *et al.*, 1968).

Aquaculture, both fresh water and marine, has a particular role to play in the luxury and semi-luxury field of the money market economy. Mussels, oysters, salmon. trout, eel, cat fish, shrimp, yellowtail, pearls, and other such delicacies and desirables are raised in more or less volume for this high-value market in Japan, United States, and Europe, and in many instances the aquaculture is quite sophisticated. Considerable quantities of food are produced in this manner. For instance, Japan produces somewhat more than 30,000 tons of oyster meats per year through aquaculture, somewhat more than 30,000 tons of catfish are produced per year through pond culture in the United States, etc. In all cases the cost of production and end product is rather high.

For instance, the catfish farmer in the United States receives for his product something more than $600 per ton, about midway between the prices received for their products by tuna and shrimp fishermen.

In essence, aquaculture can not be expected to yield very much of the three to four million tons of additional fish and shellfish production the world will demand each year for the next generation, but in some situations its expansion can be quite useful from the nutritional viewpoint, and in several situations it can be quite lucrative from the profit standpoint in the money economy.

Research and development projects in aquaculture should be closely reviewed from the standpoint of cost-effectiveness with other means of producing the same desired results.

NOURISHING THE POOR

Unfortunately the great bulk of humanity that suffers from protein malnutrition lies outside the money economy and they are very hard to get at because they have nothing to trade for the abundant protein available in the money economy and on the international market. It is not readily apparent how the very abundant protein resources of the sea can be got to these great masses of people any more easily than the available surpluses of vegetable proteins that still depress the international protein markets, or than through solving the general problem of getting them into the money market.

A particularly sharp (but no unique) example is provided by Peru. Its fish production has risen from 84 thousand tons in 1948 to 10,110 thousand tons in 1967. Its domestic consumption of fish has risen from about 20 to 155 thousand tons per year in the same period of time, which is not a bad rate of growth. Yet the very large population of Peruvians living in the high Andes suffers generally from protein malnutrition and probably is not as well off nutritionally as it was in the days of the Inca empire. This population is largely outside the money economy and cannot buy the cheapest product of the coastal fisheries, which are the cheapest and most voluminous of any country in the world. The product of these enormous fisheries is made into fish meal and sold in Europe, North America, Japan, and elsewhere in the world primarily for chicken feed.

Another example is provided by Upper Volta where protein malnutrition is rampant. Its government wants a fishery pre-development survey and assistance from FAO and UNDP in fishery development. There is only one substantial river in Upper Volta, and it has no sea coast. From the standpoint of other equally pressing demands on such funds as they have available for fishery development, this is not a very cost-effective place for FAO and UNDP to allocate much such funds, although the need is admittedly great. Upper Volta sits astride one of the ancient but still well-used trade routes along which flows the dried freshwater fish from the upper Niger delta to the coast, and the fish from the prolific coastal fisheries going into the interior. Plenty of fish is available in Upper Volta; the people who need it nutritionally do not have the money to buy it.

Great hopes have been held out that fish protein concentrate will bring relief to these protein malnutrition problems among these numerous very poor people outside the money economy. It is difficult to see how this can be realized on practical levels. In very large parts of the world where this situation exists the odor and flavor of rancid fish is not only not objected to, but is an added attraction to spice up the tasteless rice, or cassava, or other bland carbohydrate dishes. In such instances it would be considerably cheaper and more practical to provide dried anchovy or sardine without going through the rather expensive manufacturing process of making bland FPC. But the people who need the protein have nothing to trade for either.

Although most of the increased fish production from the world ocean has been consumed by the industrialized nations there has been a great deal of increased availability of fish protein also to the very poor. The increased fish consumption in Peru is a case in point. This could not have occurred in the absence of a large export fishery which supported by its earnings the fishery development required for this purpose. The whole of Table 2 also illustrates this point.

FAO and a number of bilateral fishery assistance schemes are often criticized because time and money is spent on providing synthetic webbing, outboard motors for canoes, experts in pond-culture, uneconomically small cold-stores and iceplants, and similar not very cost-effective activities for increasing fish production. It is true that the same amount of money and effort spent elsewhere and otherwise would produce more fish and shellfish, but these activities at the village level in mostly sustenance economies brings local relief to protein malnutrition problems that is of more than casual consequence. It also frequently starts the village into the money economy, and brings it within range of more practical assistance.

All of this is not very satisfying to those who wish to solve the very serious problem of protein malnutrition among pre-school children and lactating mothers outside the money economy quickly. Aside from the slow process of bringing them into the money economy no very satisfactory scheme has been found except provision of needed food by government largesse, and this is not anywhere nearly adequate to need. Fish protein concentrate can be useful in such give-away programs but they are not sufficient to solve the problem in near time.

DEVELOPING FISHERIES

In the United States it is not generally realized how much government money goes into developing fisheries. This has begun to be effective in recent years as the Special Fund of the United Nations Development Program through its executing agency, the Food and Agriculture Organization of the United Nations, and has increasingly improved its methodology and support. At present there are about 25 of these longish term fishery development projects in train through which the recipient nation provides matching funds. Perhaps as much as $20 million per year is now being administered in this form by FAO Department of Fisheries. Some assistance to this activity is now being experienced through capital loans from the International Bank for Reconstruction and Development. This has already been effective in building the long-range fisheries of Taiwan and Korea.

On another scale entirely, many industrialized, or semi-industrialized countries spend large sums in building up their sea fisheries as state enterprises (in socialist countries) or in subsidizing private enterprise in fishing in non-socialist countries. Russia has purportedly invested $4 billion in building up its worldwide fish production from the war's end up to 1965, and allocated about $3.2 billion to this purpose under the current five-year plan. Poland, East Germany, Rumania, and Bulgaria have also made considerable steps along this line. In the western world Norway, England, Italy, Spain, and Canada have subsidized fish production considerably. Various bilateral programs have been more or less effective, such as the Indo-Norwegian project, the Colombo plan projects in Ceylon, the German project in Thailand, the Russian projects in Somalia, Yemen, Cuba, Egypt, and Senegal, the French and EEC projects in Ivory Coast and Congo Brazzaville, United States projects in West Pakistan and India, etc.

Government money is still increasingly flowing into fishery development projects on a worldwide basis and this can be expected to continue to increase for a rather long while to come. An essential reason for this is that the resources of the sea not only produce rather cheap animal protein that is badly needed and desired on a broad world-wide basis, but these resources of the high seas under international law are the common property of all nations and freely available to all only for the cost of harvesting. By increasing its harvest of them the individual nation can improve the nutritional base of its people without the use of foreign exchange (except for fishing gear and vessels it cannot make itself), or earn foreign exchange with which to buy other things it wants or needs.

MANAGING FISHERIES

This common property nature of the high seas ocean resources not only gives rise to peculiar economic considerations in fishery development, but leads to a vast and increasing array of resource management problems as among the sovereign nations who are owners of the resources. Resources of the high seas are the private property of an individual only when reduced to his possession. The private fisherman operates on the high seas not under rights that pertain to him under international law, but under rights that pertain to the sovereign whose flag his vessel wears. The use of the high seas falls under international law. Individuals are frequently the objects of international law, but only sovereign nations are its subjects.

All users of the common pastures of the high seas want to maximize their possibility of using it, few wish to provide the funds or restraint required to manage the use of these resources wisely. What is owned by everybody is not very well taken care of by anybody.

These factors have given rise to numerous conflicts among nations over time, and still do. There are three main proposals currently under debate in the international community to handle these increasing problems:

a. Turn the whole problem over to the United Nations. Nobody yet has figured just how to do this on a practical basis, or to demonstrate that the United Nations might be able to handle it better than the problem is handled now.

b. Split up ownership of the high-seas resources among the nations, keeping in mind that agriculture never prospered very well until the common pastures were put under private ownership. A major problem is that many major resources are highly mobile. This solution might well stir more conflicts than it settles.

c. Perfect the present system of international and intergovernmental fisheries commissions through which the immediately concerned nations attempt to apply conservation regulations in high seas fisheries. This subject is too complicated to review here, and has been recently treated by Chapman (1967, 1968).

It may be stated, however, that increased fishing effort on the high seas exacerbates these fishery management questions. The rise in production of fish and shellfish from 20 to 60 million tons per year has more than tripled these problems and their consequences. A rise in production to 86 million tons in 1976 and to 123 million tons in 1986 will exacerbate all of these problems sharply and seriously, bringing more major resources under need of conservation management and bringing increased conflicts because of lack of knowledge as to what to do and lack of desire to do it anyway.

THE APPLICATION OF SCIENCE AND TECHNOLOGY TO THE PRODUCTION OF FOOD FROM THE SEA

Great progress has been made in the last 100 years, and particularly in the past decade, in accumulating knowledge and understanding of the natural processes of the ocean, the atmosphere, and the biological resources of the ocean—together with the dynamic relationships among these factors. Scientific publications and committee reports on these subjects now come in the mail faster than they can be read.

Nevertheless, the need for such knowledge and understanding accrues more rapidly than the latter develops in both fishery conservation and development.

In fishery conservation a few simple parameters are required for each population of fish to make possible rational management of the use of the resource. It is necessary to know something of the general biology of the species, the rate of recruitment, the rate of growth, the rate of mortality, and the part of the latter resulting from fishing effort.

The difficulty is that variation in environmental factors, both biological and physical affect the rate of recruitment, sometimes the rate of growth, and frequently the rate of mortality in substantial manners. In almost no instance is the relationship of variations in these environmental factors and these vital statistics of the population known well enough to account for effects, much less predict them.

In particular we have only the slightest ideas of the paths, and effects, of transfer of energy through the multitude of pathways and recycling in the web of life in the ocean. We do not understand in any cases in detail what happens to the other populations when we heavily fish one kind of animal out of a complex group, which we normally do. Thus the task of managing the use of living resources of the sea is largely a game of educated guessing, with the guessers not being very well educated.

In fishery development we do not yet have very good ways of measuring the size of a population of animals aside from indirect measurements resulting from applying a fishery to it. Methods derived from various acoustic devices, and inferring population strength from relative abundance of young in the plankton are useful, but rather crude.

Changes in strength and transport of major ocean currents are known to affect materially the strength and transport of upwelling that brings nutrients to the surface layers of the ocean and supports the waxing and waning of ocean life. Changes in strength of lower atmosphere wind currents are known to affect in a major way the strength of upper ocean currents. Nothing of this is known with enough precision to predict any part of it for more than a few days ahead of time, or to understand effects either on currents or resource fluctuations. No system of global measurements is in being to gather the information needed to construct theory from which interpretations and predictions can be made. Accordingly such theory does not exist able to yield useful interpretations or predictions.

Because of this ignorance, generally referred to by the name ecology, use of the living resources of the sea is still in the hunting stage of neolithic times. In a very few cases it has emerged to the range management stage, and only in inconsequential areas has it come to the point where crude agricultural management is possible or desirable.

FISH AND STRATEGY

Quite aside from the effect of national fish production on the foreign exchange balance, the contribution of such production to the national food budget, and the national economy (none of which appear to be of much concern to United States policy makers), there are two other strategic elements of national posture in which fisheries play a sufficient role to be mentioned briefly:

a. Controversies over jurisdiction over fisheries lying in the adjacent high seas prevented agreement on the breadth of the territorial sea at the Law of the Sea Conferences in 1958 and 1960. These controversies are unlikely to be settled peacefully without a material expansion in ocean research to elucidate their root causes.

b. Who controls the sea may control the world. In conditions like those presently existing where Naval power cannot be used except in an extremity, who uses the sea most may come the closest to controlling it. The United States has permitted the decay of its use of the sea by civilian industry (merchant marine and fisheries) steadily since World War II with consequent decay to its posture.

THE CONDITION OF UNITED STATES FISHERIES

The condition of United States fisheries can be briefly summed up:

The total annual supply of fish and shellfish available for use in the United States was just 3 million metric tons in 1950 and in 1967 is just short of 7. Thus the use of fish and shellfish for all purposes in the United States has increased sharply since the war both absolutely and per capita. The per capita use in the United States (about 70 lbs. per year) is now among the highest in the world (Fisheries of the United States, 1967).

The supply of fish and shellfish to the United States market has come increasingly from imports. In 1950 they provided 25.1 percent, and in 1967, 71.1 percent. The United States has become the largest and most lucrative market for fish and shellfish in the world. In 1928 these imports were valued at $39 million, in 1950 at $198 million, and in 1967 at $727 million.

The most recent estimate by U.S. Bureau of Commercial Fisheries experts of the resources of fish and shellfish available in our near coastal waters indicates supplies adequate to produce about 20 million tons per year on a sustainable basis (Pruter, 1968).

The United States flag fishing fleet has averaged producing about 2.5 million tons per year for the last thirty years; the U.S. market continues to grow, and presently uses well more than twice the product of the U.S. fleet; resources available are sufficient to support yields about eight times those presently taken and about three times what is consumed per year. Foreign fishermen, mostly from Europe and Asia, actually take almost as much off the United States coast per year as do those of the United States.

There appears to be scope for the much vaunted United States business know-how and skills in applying science and technology to production problems in improving the yield of United States flag fishing vessels.

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DISCUSSION: Dr. Wilbert McLeod Chapman— WORLD FISHERIES

Discussant: Dr. Alan R. Longhurst

Longhurst: I think we have about 15 minutes to discuss this contribution, and I have just one or two points to make.

Wib said that he very strongly believes in the continued increase of world landings at something like the present world rate over the next few decades, and I wonder whether I ought to ask him to rehash this a bit in the light of the fact that a very high percentage of our present landings comes from a very small number of species and the landings by species are skewed in a manner similar to the distribution of landings among countries.

I brought some figures here that show that in 1965 nearly 60 percent of the world's landings of fish came from 12 species-groups, if you group the mackerels and jack mackerels separately. These 12 species-groups run: Peruvian anchovy, Atlantic cod, Atlantic herring, South African sardine, mackerels as one group, jack mackerels as one group, the Alaska pollack, haddock, red-fish as a group, menhadens as a group, North Pacific herring and European pilchard. Of these species, I know of 5 which are in serious trouble, and I would like to ask Wib what his opinion is, in general terms, about maintaining the catches which we have now, while projecting our future increases in landings.

Chapman: My feeling is that there will be opened up the use of new resources. As an example, what has been going on in the last 5 years is a great expansion and use of hake on a world-wide basis. There is still some room for hake expansion, especially in the Chilean area. I frequently refer to the sardinella of the Arabian Sea area, which is a big resource, but there are a lot of other herring-like fishes available there too—really about 50 species—but the sardinella is the prominent one. The anchovy of the Pacific Ocean is a fair sized resource. There is still considerable room for development in sardinella of West Africa and northern part of Angola, and anchovy in that region too, I believe. And this is what I think is going to happen, is that the market pressure, the market demand for fish, is going to continue to be along about the same trend as we have—it requires opening up new resources and also the maintenance of the resources that we have now at the level of nearly maximum sustainable production. I think we are losing out on cod in the Atlantic. Menhaden has already gone over the hill; the California sardine did. As to the Peruvian anchovy, we may have enough grasp of this to hang on to it. The two problems must go hand in hand, opening up new fisheries to fill the demand and maintaining what we've got.

Isaacs: What about elasmobranchs?

Chapman: They don't amount to much in total, John. They form about 2 percent of production and they don't increase much. Not very abundant anywhere.

Isaacs: They're also some of the competitors of ours; this may be their most important aspect.

Chapman: Quite. We haven't really done anything about weeding out competitors. We don't even know what competition is. We think of competitors mainly from a standpoint of nuisance. The dog fish along this coast is really a nuisance, but nobody thinks of it as a competitor except a few scientists.

Longhurst: I am not sure I share your optimism, that we could maintain the base we've got, although it's a very good idea to hold this very optimistic outlook and to think that while moving on to a new species we will continue to build our total catch. Really our record doesn't seem to be awfully good in maintaining exploited species on a long-term basis, particularly in international or interstate fisheries.

Chapman: I agree.

Longhurst: This seems to be a very central problem, and very, very intractable.

Chapman: I agree because mostly you are dealing with humans and they are hard to get along with.

Carry: Speak a little louder so the *guests* in the back can hear?

Chapman: I said humans are hard to get along with, and you highlighted my statement. It is hard enough to understand fish but to understand humans is beyond comprehension.

Longhurst: If I might put one more question to the speaker before we open it up for general discussion—

You speak about a technological revolution in fisheries starting in the early 50's with new sorts of gear and vessels, and so on. Has anybody measured, on a global basis, the increase in fishing effort that all this implies. I have the feeling, just reading the trade literature, that we are increasing our effort and technological pressure on stocks much faster than we are increasing our landings, both on a global basis and on single fisheries.

Chapman: The only fellow in the world that I know, that has been dabbling with this problem, is Paul Adams, with the OECO in Paris, and he has now gotten pretty good statistics coming in from all European vessels and what they are producing and so forth. I don't think anybody else is paying any attention to this at all.

Longhurst: I think it is a very serious thing too.

Chapman: I do too.

Bullis: Commenting on your point about the resources base, I think this rapid growth over the last 20 years hasn't been concentrated on established species. In my region (Gulf of Mexico) 70 percent of the shrimp production is based on species that weren't harvested 20 years ago; 50 percent of the menhaden are species that weren't harvested 20 years ago; the same with 50 percent of the snapper production. This is contributing very heavily to the expanding world production and I think the big question is one of how much farther can we go into this unutilized species group category?

Chapman: Another good example is provided by the Gulf of Alaska. All of the added productions that have come from there in the last 10 years have been of species that weren't used before. Now we are getting into the pandalid shrimps and they're going to be a good sized resource. There are technological as well as marketing improvements that have made this development possible. The use of minced fish (surumi) in Japan is what made the increase in pollack fishing practical. This makes a good fish-product raw material and so there has been a big expansion. I am not saying I'm optimistic or pessimistic, but how I think things are going to go. Really I am predicting on the basis of how it has gone in the last 20 years and the thing that is surprising to me is how steady these trends have been when you look over a 30-year period.

Preston: The point is, I suppose, there isn't an infinite number of new resources. Considering conservative estimates of these and the difficulties in managing the ones you have, you may top off somewhere around 250 million tons per year.

Chapman: I have been going along with this 200–250 million tons production level but I don't believe it at all because of what Harvey just said. By the time we get to producing 100 million tons per year out of the ocean instead of 50 million tons, you are going to be looking at the whole mass of living matter in the ocean with a different set of market demands. You may be thinking of *krill,* for instance, of which perhaps 100 million tons a year are available—keeping in mind that mysids now form the raw material for a large direct human consumption business as fish sauce in Thailand and Japan.

What we think of in the United States is tuna and shrimp and halibut and cod and salmon, but there are a lot of different animals in the ocean that you can get hold of pretty cheap that make fairly good eating and the market keeps changing steadily. We should dip into these other resources.

McGowan: It bothers me a little bit that one of these so-called new resources, that you mentioned, California anchovy, is not a new resource at all in an energetic sense. It is a replacement for an old resource, the California sardine, that had been fished out. I very much suspect that if you want to maintain the present levels of fishing on all the species that we are using now, plus spread to new ones, that somehow, the calories and materials formerly utilized by the crops we are taking out are going to be shunted somewhere else and it is very likely to go through species that are absolutely useless to us—salps, for instance; they turn much of their carbon intake into cellulose.

Bullis: Isn't it as likely though, that it could go to something that would be a little bit better?

McGowan: Who knows? Nobody on God's green earth can tell you that. At the present time there is no reason, that I know of, to believe that the trophic resources that formerly went into "useful" populations will be switched to other species of equal usefulness to man. This is a very important question in ecology and much more work needs to be done on it.

Chapman: Well, what we are trying to get at a bit in this exercise of the IDOE, is to push the research into that field we keep talking about but not doing much about. That is ecology. Actually I would prefer to phrase it "the transfer of energy through the web of life."

We do nothing about this presently and these questions you bring up are the very real ones and I think are pressing very hard on our whole foundation of knowledge presently.

McGowan: I think we have overextended it, as a matter of fact.

Isaacs: Just taking that bare bones of your statistics there, with the 2 percent increase on fisheries a year, this is then falling behind the rate of population increase. Of course, that doesn't say that it isn't contributing in a particular way to those people that need the food.

Chapman: I think the quickest way you can get anchovy into Europeans anyway, is to run it through chickens.

Isaacs: This always sounds inefficient at first—wouldn't you like to comment on this?

Chapman: Well the transfer of essential amino acid by chickens is approximately 1 to 1, keeping in mind, however, that you are using up grain in the process. But from the amino acid standpoint you don't lose anything running it through chickens—also catfish—which are a hair better.

Isaacs: One thing that was brought up was the matter of subsidy in other countries—you might comment on some comparable subsidies between farmers and fishermen and their relative productivity.

Chapman: The only thing I can say is that the farmers, everywhere in the developed world, are pretty heavily subsidized. Fishermen, by and large, don't have as large a subsidy as farmers do and this is becoming more and more of a problem and particularly in the developing world. The Europeans are increasingly subsidizing their fishermen. The three most recent very sharp examples of this in western Europe are Spain, Italy, and Greece where very substantial subsidies are being granted. From the economic standpoint, straight out, what it is being done for is to save foreign exchange.

Longhurst: Also recently in Great Britain, when distant-water trawl fisheries began getting into real trouble, the immediate answer was an increase in Government subsidies.

Farris: If I understood what you said, the expanded world fisheries aren't going to do a doggone thing for the poor people, but the rich people are going to have a better diet nutritionally, more conveniently packaged out of this whole ball of wax.

Chapman: That is approximately what I said. That is the way it has been running.

The interesting thing that I failed to say was anything about the Peruvian example. The consumption of fish domestically in Peru has increased from some 20 thousand tons per year to 155 thousand tons per year over a 10-year period and it is going up quite steadily. This is a sharp increase. This would not be possible in Peru if it were not for the export fisheries which bring enough money into the business to permit the bonito and other food fisheries to be expanded, and produce food for local consumption. This is so in a number of these developing countries where they are hitting heavily on fisheries for export in order to earn foreign exchange. What this is doing is building up the whole structure of their fishing industry because of the capital coming back into it, producing fish cheaper for home consumption than would otherwise be the case. Ceylon is a good example, Thailand is a good example, Malaysia is a good example. But there is no way to stimulate fisheries to really help poor folks only, with heavy subsidization. Poor folks are pretty nearly beyond help.

Isaacs: I think there are some very important points to the problems here and an immense amount of discussion is possible on almost any single one. We certainly have never paid much attention to the effects of a fishery of a species on its competitors or predators, or even on behavioristic groups within the population. With the U.S. tendency for highly selective fisheries, such interaction may be even more immediately important than in the less selective cases. In the long run these latter, of course, may give rise to even more profound reactions—an ocean of only salps and medusae is repulsive.

We have introduced a great number of such open subjects in this symposium. Perhaps we can discuss some of them further this afternoon.

I suggest right now we have a coffee break.