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HARVESTING THE OCEANS

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Harvesting the Oceans

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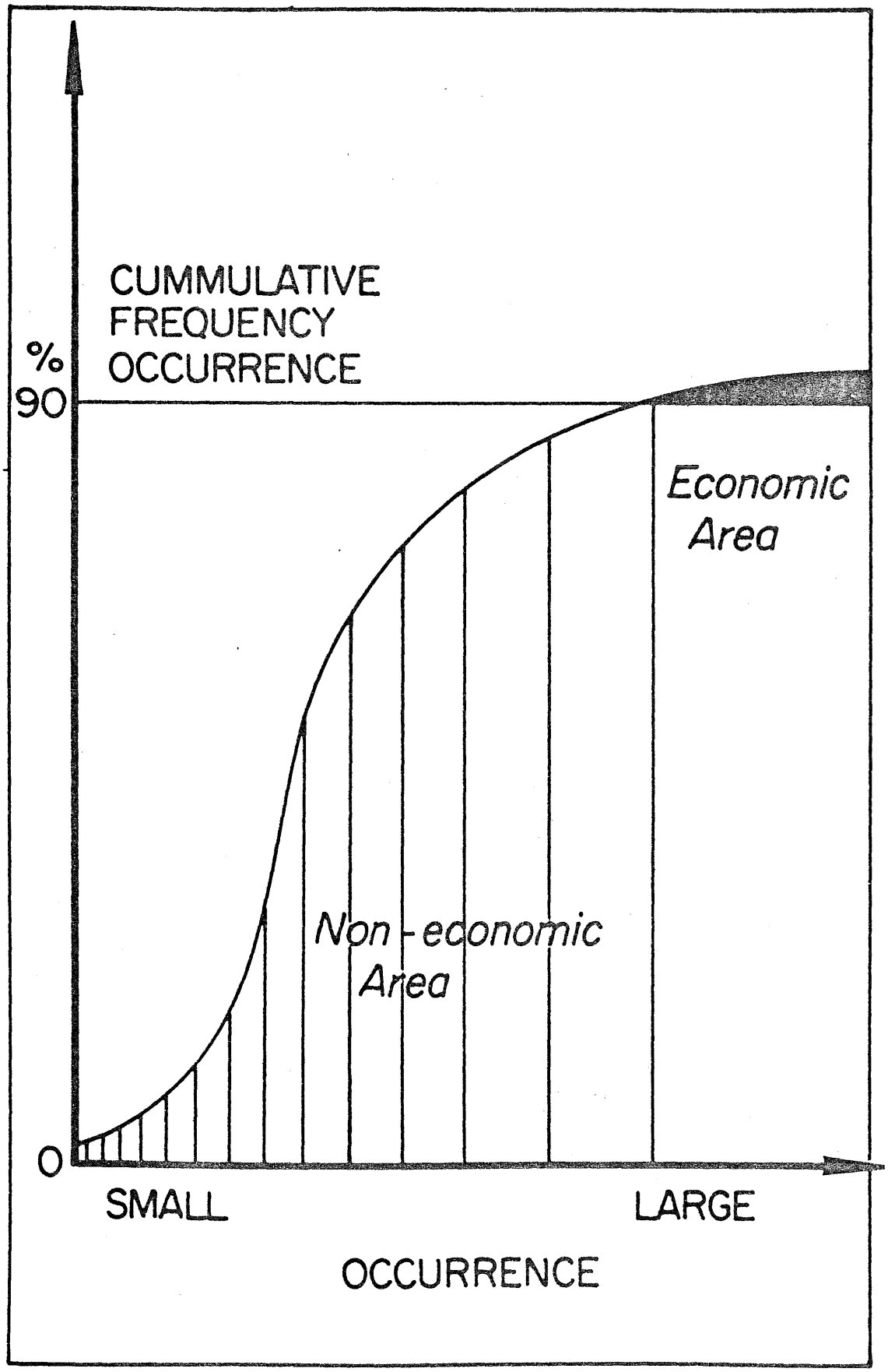
Tonight I shall talk about the wealth of the sea, the wealth of minerals in the nodules on the sea floor, and of the fish in the sea.

We are a nation of people who retain the promises of unexplored frontiers. The oceans are vast, and so must be their resources; they are our last earthbound frontier. We still echo the Forty-niners: "Thar's gold in them thar hills."

Indeed there is gold in the oceans. There are four parts of gold for every trillion parts of seawater. Unfortunately, it is uniformly distributed, and even with the most modern technological "pan" one could not in a lifetime get enough to pay the grocery bill.

This is an extreme example of the general problem in harvesting the ocean resources. We are dependent upon high concentrations to permit economic harvest. The technical way of saying this is to plot the frequency or probability of occurrence against the concentration (Figure 1). Thus, for example, a concentration represented by the rightmost vertical line may be necessary for economic harvest--say a ton of clams per acre of bottom, or 10 kilos/M^2 (2 lb/sq ft) of nodules. However, 90% of the bottom has less than this concentration. This problem of the density distribution applies to all of the marine resources.


CUMMULATIVE
FREQUENCY
OCCURRENCE
%
90
0
Economic
Area
Non - economic
Area
SMALL
LARGE
OCCURRENCE

In discussing minerals, if they are in economic concentrations represented by the small black area above the top line in Figure 1, the minerals are a reserve. If they are not, and are found in the striped area under the left part of the curve, we call them resources--meaning that if in the future we improve our technology or get desperate enough, the resources may become reserves. This is not the way we usually talk about fish potential, but, I shall try to be consistent.

Minerals

There have been discovered large reserves and even larger resources of what we commonly call manganese nodules on the deep ocean floor. In close-up, we can see that these nodules are about 1-1½ inches in diameter. They are formed by consolidation of metal ions circulating in hydrothermal fluids that escape from the deep earth through the ocean bottom. Two areas in the Pacific south of the Hawaiian Islands contain the best concentrations of the nodules and are the most probable initial areas of harvest.

Why is there such interest in these? The ores we now mine on land have twice the content of the metals as do the nodules. The nodules require more expensive processing because they contain metals deleterious to steel-making and are more expensive to get at. In addition, they are found in the ocean areas which are beyond the U.S. 200-mile economic zone, and their harvest poses social problems which form the major road-block in the U.N. Law of the Sea negotiations.

Part of the story lies in the source of some important metals--a problem of geographical distribution and U.S. self-sufficiency. Present

U.S. demand is dependent on foreign supply of some important metals (Figure 2). Current imports are: manganese (100%), chromium (90%), bauxite (aluminum ore, 90%), tin (80%), nickel (75%), zinc (60%). For many of these (chromium, cobalt, nickel, aluminum, copper, lead, tin) the U.S. land resources, even if completely utilizable, would not meet current U.S. demand. For some others, that is not the case (iron, manganese, zinc).

The deep-sea nodules contain quantities of manganese, copper, cobalt, and nickel which provide reserves more than sufficient for our current needs, and much of the current world needs. The reserves of nodules are estimated to be at least tens of billions of tons.

The energy requirements for processing are prohibitive even now for deposits below about 2% metal content. The reserves have concentrations above 2½% nickel and copper, and above 2% when cobalt is included.

Fish

All the resources of the ocean are being continually formed, but at greatly different rates. The nodules are forming at about 10-million tons per year--relatively low with respect to rate of use, and essentially a nonrenewable resource. In the living marine resources, the time for regeneration is less than a year for plankton--the small plants and animals that float in the open ocean and midwater--and yearly for fish. Of course, they are regenerated biologically. This rapid regeneration from a parent stock makes them a renewable resource. We have a major constraint in their use--not harming the reproductive potential of the spawning stocks. As long as we maintain this, the yield and enjoyment of them is continually possible without time limits.

Imports Supplied Significant Percentages of Total U. S. Demand in 1973

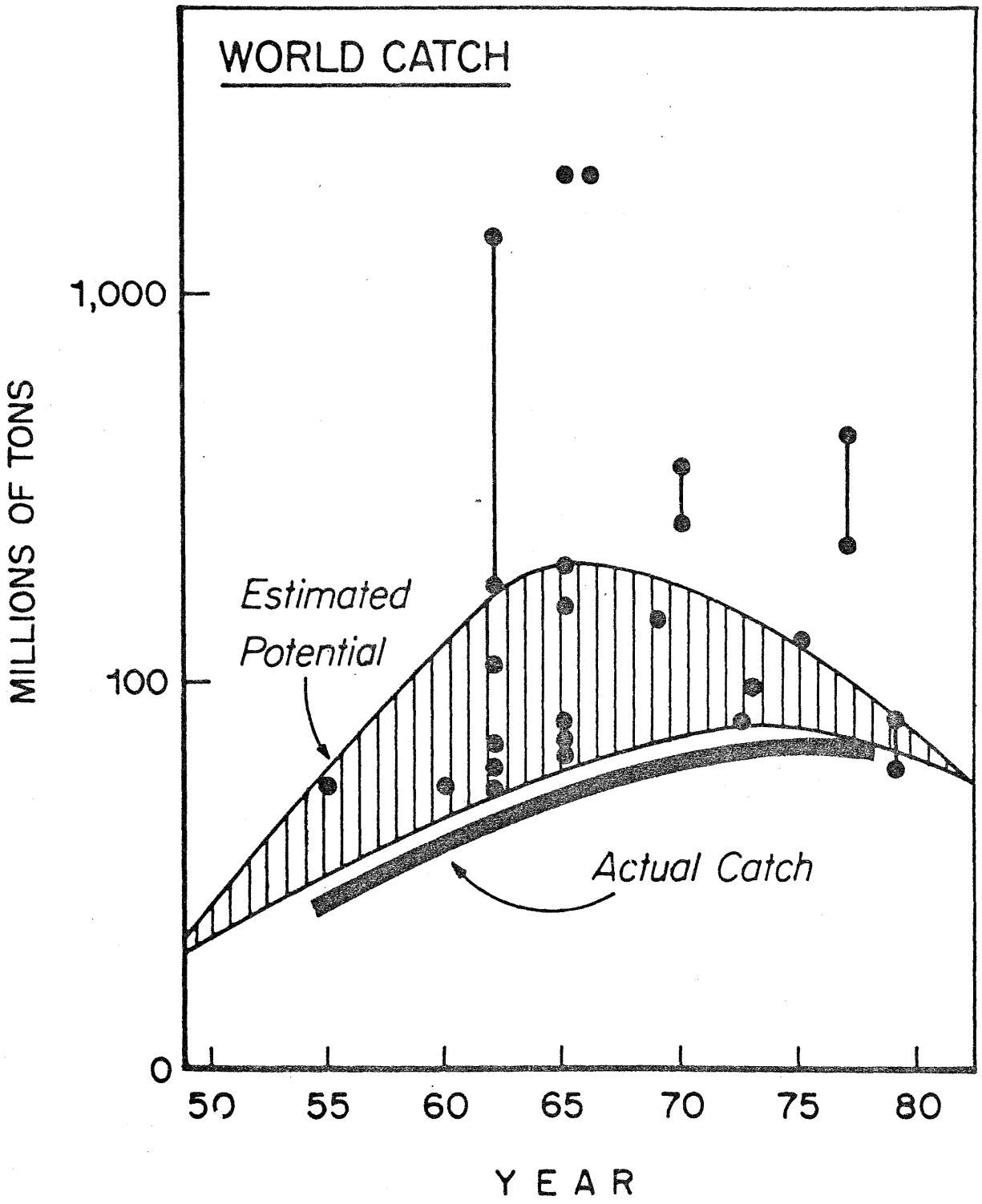
MINERAL		PERCENTAGE IMPORTED (100 75 50 25 0)	MAJOR FOREIGN SOURCES
PLATINUM METALS			UK · USSR · S. AFRICA
CHROMIUM			USSR · S. AFRICA · TURKEY · PHILL
COBALT	▲		AFRICA · EUROPE · CANADA
MANGANESE	▽▲		BRAZIL · AFRICA
ALUMINUM			CARIB. · CANADA · AUSTRALIA
TIN			ASIA · BOLIVIA
NICKEL	▲		CANADA · NORWAY
ZINC	▽		N. AMERICA · PERU · AUSTRALIA
IRON	▽		CANADA · VENEZUELA · EUROPE
LEAD			N. AMERICA · AUSTRALIA
COPPER	▲		CANADA · PERU · CHILE

▽ *U. S. land source suff.* ▲ *Marine source suff.* ||||||||||||| *% imported suff.*

The global catch increased steadily at about 15% per year after World War II, up until the 1960's (Figure 3). Since then the marine catch has leveled off, and was about 67-million metric tons in 1978. The estimates of potential by marine biologists and others have started at the actual catch and in the extreme cases have been stated as billions of tons. It just seems that the more we catch, the more we ought to be able to catch.

The difference in the estimates is partly due to including different parts of the resource--traditionally caught fish, those fish not caught but which we think are abundant, and plankton. This is often not made clear, and leads to some confusion. The recent leveling of the rate of catch has dampened some but not all of the optimism. My opinion is that maintaining the current yield is about the best we can expect from the traditional fishery. By traditional, I don't mean just sardines and codfish. Most of you may not have eaten squid, nor capelin, perhaps not even have seen them, but they are very much a part of today's world's fisheries. In fact, capelin--an oceanic smelt, a near relative of the California grunion--provides nearly 50% of Norway's catch. The U.S. finfish catch is 50% menhaden. You do not see it on the table very much, but you use it as fertilizer or eat it in the form of chickens. There are not many unfished stocks left in the oceans.

As I said, it appears that the world's total catch of marine fish and shellfish will increase very little in the long run. Indeed, good management will be required to maintain the present levels. The traditional fisheries use what we have earlier termed reserves. Are there any resources--the nontraditional species?

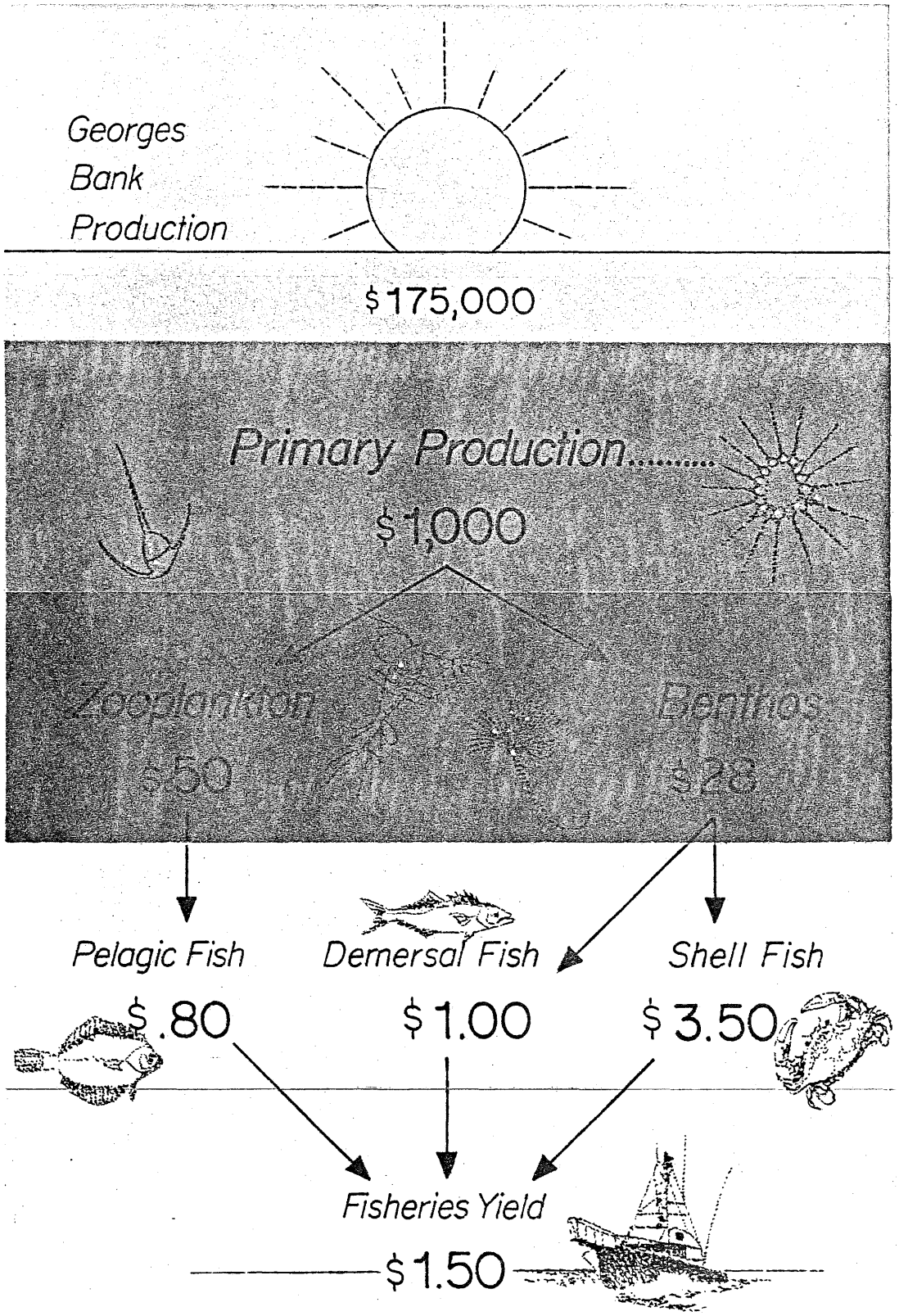

WORLD CATCH
1,000
100
0
MILLIONS OF TONS
Estimated
Potential
Actual Catch
50
55
60
65
70
75
80
YEAR

To answer this question we need to look at the entire ecosystem (Figure 4). We attempt to describe the productivity of the whole system in common terms. The numbers I present have a dollar sign on them to illustrate more dramatically the point. I am really describing kilocalories of energy per unit area of ocean surface. The data are from one of the most productive areas of the world's oceans--Georges Bank, off New England.

If we start with $175,000 worth of sunlight, the present customary fisheries will yield about $1.50. This may seem rather small, but the original energy from the sun is expended to produce $1,000 worth of green algae--phytoplankton--in what we call primary production. The mostly small animals that eat the phytoplankton--but note that many whales also eat plankton--form the secondary stage of productivity, and result in about $78 worth of standing energy. Most of our $1.50 worth of catch comes from a standing (or perhaps I should say swimming) stock of $4.30 derived from the zooplankton and bottom dwellers called benthos.

If we can efficiently harvest and utilize the animals in the secondary stage--the zooplankton--then we can use directly some of the energy used up in conversion to make fish, and convert this resource to a reserve category. The magnitude is great--perhaps upwards of 10 to 50 times traditional yields.

One such resource that has attracted attention is the krill of antarctica. These are small, 1-3-inch, shrimp-like animals that at times swarm in large, dense concentrations. Several countries--Japan, U.S.S.R., Poland, West and East Germany--have sent expeditions to determine the fishery potential. Thus far, economic operations have not been developed.


Georges
Bank
Production
$175,000
Primary Production.....
$1,000
Zooplankton
$50
Benthos
$28
Pelagic Fish
$.80
Demersal Fish
$1.00
Shell Fish
$3.50
Fisheries Yield
$1.50

The fishing can only take place during the austral summer--4-5 months. The vessels must be the very largest of those that now exist; their operating costs are high. There are technical problems in processing and utilizing them for food which have not yet been solved. Recently they have discovered high levels of chlorides in the flesh, which poses problems of human health.

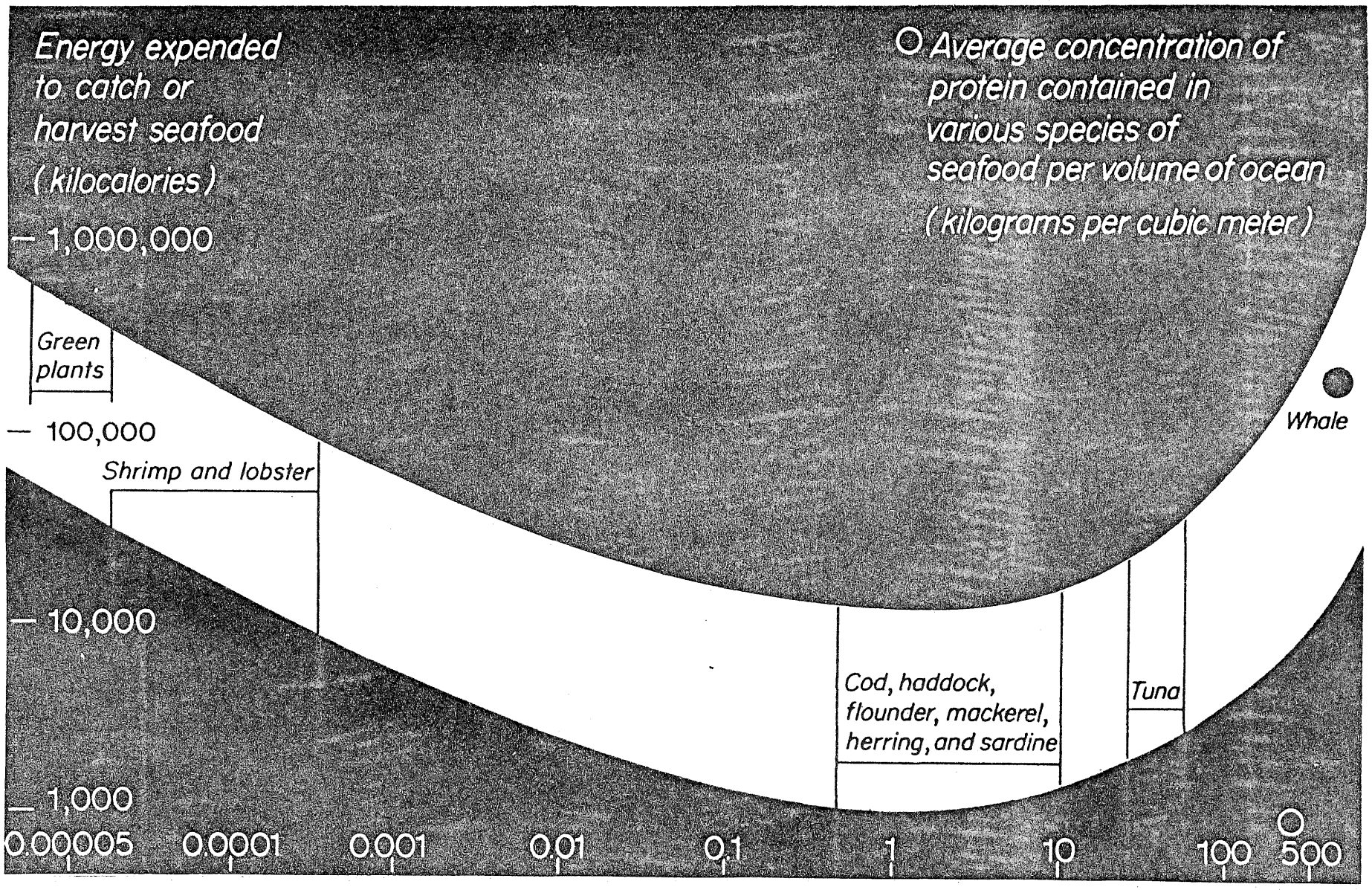
Whales, birds, seals, and fish depend on the krill for food, and man must share the krill with these animals even in the event harvest becomes feasible.

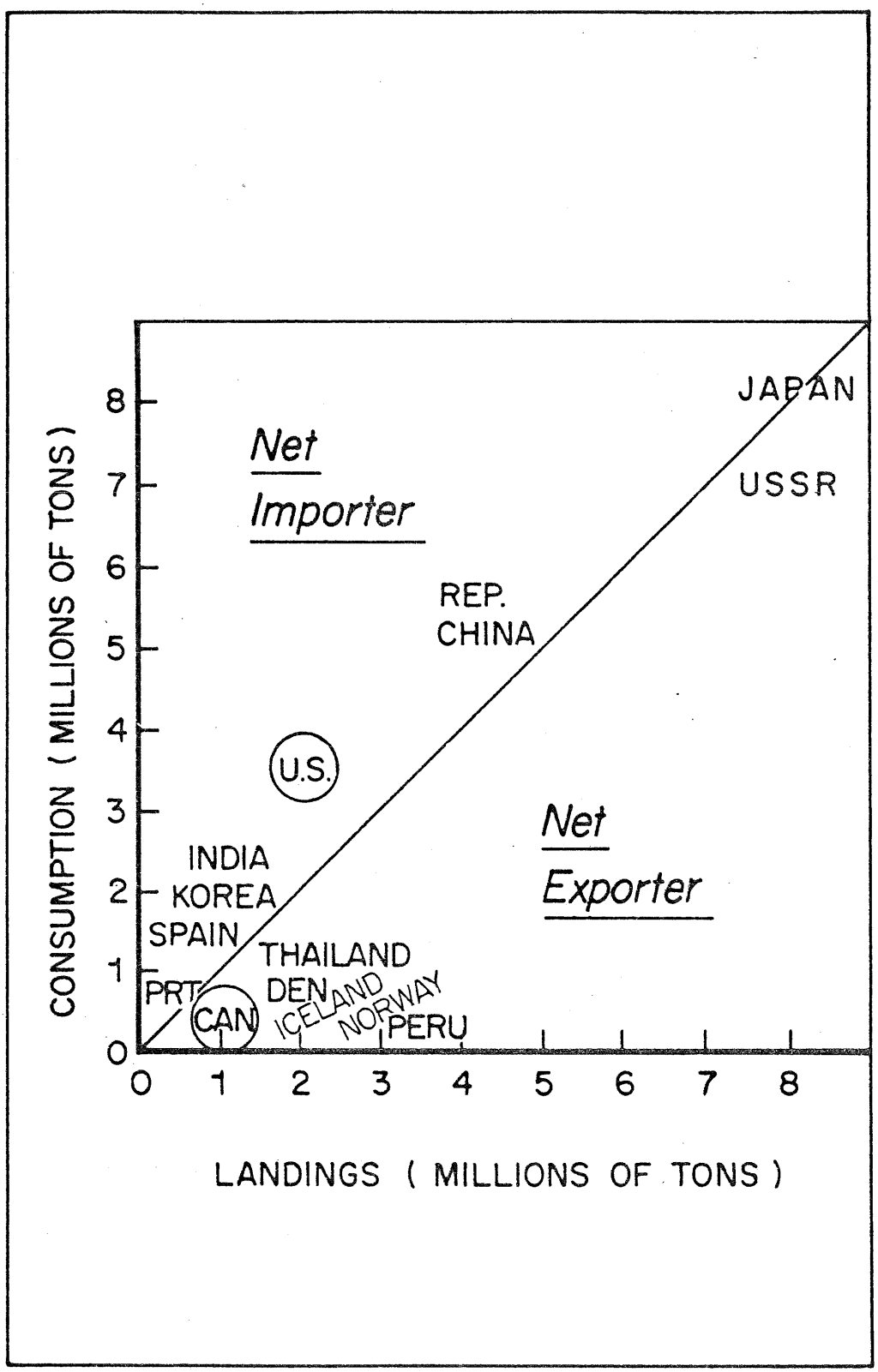
Krill are not yet in the reserve category.

The relationship between energy realized and energy expended for harvest is becoming a serious worldwide problem (Figure 5). For most plankton and some other animals (whales), it simply takes too much energy to catch them for what one gets in return. In order to harvest the plankton, efficiencies of up to 100 times that of present fisheries will be required. Now that's a technological challenge.

Some of the countries are leading producers and some leading consumers, not necessarily the same (Figure 6). The leading fishing countries by far are the U.S.S.R. and Japan, each at about 10-million metric tons a year. These are followed at the 3-4-million metric ton mark by China, Peru, and the U.S. The top ten is finished off by Norway, India, Korea, Denmark, and Thailand, at from 1-3-million metric tons a year.

Japan and Iceland lead per capita consumption at about 70 kilograms (154 pounds) per year per person. People in Portugal, Norway, Malaysia, Spain, and Denmark also eat quite a lot of fish per year at 30-50 kilograms. By comparison, the U.S. and Canada use about 16 kilograms per


Energy expended to catch or harvest seafood (kilocalories)
Average concentration of protein contained in various species of seafood per volume of ocean (kilograms per cubic meter)
1,000,000
100,000
10,000
1,000
Green plants
Shrimp and lobster
Cod, haddock, flounder, mackerel, herring, and sardine
Tuna
Whale
0.00005
0.0001
0.001
0.01
0.1
1
10
100
500


CONSUMPTION (MILLIONS OF TONS)
LANDINGS (MILLIONS OF TONS)
0
1
2
3
4
5
6
7
8
Net Importer
Net Exporter
JAPAN
USSR
REP. CHINA
U.S.
INDIA
KOREA
SPAIN
PRT
CAN
THAILAND
DEN
ICELAND
NORWAY
PERU

person per year, including what we use for feeding chickens, etc., but actually eat directly about half that. However, when we look at total country consumption, Japan and the U.S.S.R. are the leaders, eating about as much as they catch. China, U.S., India, Korea, and Spain are also high total users. Some are net exporters--they catch more than they eat--and others are net importers. Canada is a net exporter; the U.S. is a net importer. The U.S., in fact, uses a rather high proportion of other countries' catch.

I would like to end on a more optimistic note. The U.S. is more fortunate than almost any other country is, in the amount of fishery reserve within its 200-mile economic coastal zone. We could, with proper management and conservation, provide from coastal fisheries 50% of our nation's basic protein needs, perhaps even more. We are getting less than 10% now. This is high-quality protein that requires little or no processing, and is a continuing supply. It costs less to produce protein from fisheries than any other present alternative, including broilers.

Bad management, pollution, and failure to develop more energy-efficient methods may not allow us to achieve this goal, but we should plan on trying. I think we need to!