The U.S. Air Force has been able to resist pressures to declare that UFO's are under extraterrestrial control, but not pressures for the repetition of investigations. However, if the U.S. Patent Office can take a position on the feasibility of constructing perpetual motion machines, then the Air Force should be able to take a position on closing out its investigations of UFO's.

We have been reminded (*1*) that 21st-century science will look back on us. This is true. We, ourselves, look back on eras when many people believed in the existence of centaurs, mermaids, and fire-breathing dragons. I am afraid that 21st-century science will contemplate with wonder the fact that, in an age of science such as ours, the U.S. Air Force was required to sponsor repeated studies of UFO's.

I have no quarrel with anyone who wishes to believe that UFO's are under extraterrestrial control. As for me, I shall not believe that we have ever been visited by any extraterrestrial visitor—either from the moon, from a planet of our solar system, or from any other stellar system—until I am shown such a visitor.

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3. W. Markowitz, in *Air, Space, and Instruments*, S. Lees, Ed. (McGraw-Hill, New York 1963), pp. 201–06; the method is based on the fact that the observed time of minimum of an eclipsing binary depends upon the position of an observer in space relative to the sun.
4. Electrons given an energy of 1×10^9 ev in an electron synchrotron should have a speed of $62c$, according to Newtonian mechanics. However, from measurements of the synchrotron diameter and the frequency of the alternating field it is readily determined that the speed is nearly $1c$. The speed, according to relativity theory, is $0.999\,999\,87c$ ($c = 3 \times 10^8$ meters per second).
5. His last name was Gauss.
6. The energy required is 3.1×10^7 joules; combustion of 0.5 kilogram of gasoline produces energy of 2.4×10^7 joules (1 joule = 0.74 foot-pound or 9.5×10^{-4} BTU).
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Human Food from Ocean and Land

K. O. Emery and C. O'D. Iselin

During recent years many claims have been made about the importance of the ocean to man's future well-being. Some of these claims appear to us to be reasonable, whereas others have an Alice-in-Wonderland quality. As a basis for judgment in this matter, we have compiled a table that shows our estimate of the tonnage and dollar value of food derived from the ocean as compared with that derived from the land during 1964, the latest year for which statistics are reasonably complete. The difference in the former productivity of the ocean and the land is so great as to suggest that an enormous effort will be required before the production of the ocean can be comparable with that of the land.

A sort of genetic classification of food resources was used to compare the present stages of technology in the ocean and on the land. For plants, the primitive stage is that of gathering wild plants (on land—berries, nuts, mushrooms, herbs); the next stage is farming (whereby seed are planted and the plants are tended and then harvested). For animals, the primitive stage is that of hunting wild animals for food (on land—deer, rabbits, quail); the next stage is herding (whereby selected breeding, culling of young, and controlled slaughter are practiced along with the nondestructive taking of byproducts such as eggs, milk, and wool). This terminology, gathering and farming of plants, and hunting and herding of animals, is also applied to the ocean in a strict sense. For example, we consider that only algae or bacteria can be farmed, and that oysters, clams, and fish can be herded (not farmed) as an improvement over catching them in their wild state. Note that nonedible materials such as lumber, whale oil, shells, pearls, wool, hides, and fertilizer are not included in this study.

Data

The production figures (Table 1) are uneven in quality. Some figures, such as those for fishing, herding, and farming are reasonably well known and have been reproduced in many publications. Others, such as for gathering and hunting on land, must be based upon judgment guided by scanty measurements. The data for the United States are far better than those for the whole world, so they are presented separately. Tonnages are expressed in wet weight or live weight as usually reported, and dollar values are for the level of the fisherman, farmer, or hunter; values at the retailer level would be much higher.

Data for the gathering of seaweed were compiled by the Battelle Institute (*1*), but the quantity and value of wild plants gathered from land is so poorly

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Table 1. Tonnage and dollar value of human food produced from ocean and land during 1964. The United States population in 1964 was 0.19 billion; the population of the entire world was 3.22 billion. Figures in italics are less accurate than the others which are believed to be accurate within ± 25 percent.

Activity	Tonnage (millions/year)				Dollars (billions/year)			
	United States		World		United States		World	
	Ocean	Land	Ocean	Land	Ocean	Land	Ocean	Land
			Plants					
Gathering	0.01	*2*	0.02	*100*	0.02	*0.1*	0.04	*5*
Farming	0.0	230	0.01	2000	0.0	17	*0.01*	100
			Animals					
Hunting	1.6	*1.3*	29	*27*	0.3	*0.6*	4.4	*11*
Herding	*.01*	85	*0.6*	520	*.01*	22	*.2*	120
			Minerals					
Mining					0.7	20	3.6	73

known that only rough estimates by the writers can be given. Production of plants by the more advanced stage of farming is better established. Essentially no farming of the ocean takes place in the United States; almost all of it is in Japan, where algae used largely for flavoring is grown on racks in broad bays near shore. Data for the Japanese production is from the Battelle Institute (*1*) supplemented by information obtained by Emery during a recent visit to Japan.

Rather complete data on farm production in the United States and for the entire world was compiled by the U.S. Department of Agriculture (*2*). The dollar value for the United States farm income (Table 1) is also readily available from the USDA and from current commodity prices, but that for the entire world had to be computed on the basis of a price per ton somewhat lower than that for the United States.

Data for the hunting of animals in the ocean are fairly good, having been compiled by the Food and Agriculture Organization of the United Nations (*3*) and interpreted by Chapman (*4*). A total of 51.6 million tons of fish, mollusks, crustaceans, and small mammals were taken commercially in 1964. After removal of 16.4 million tons not used directly for human consumption and 6.6 million tons of freshwater fish, the remainder is 28.6 million tons, of which only 1.5 million tons were caught by the United States fishermen. To both the world and the United States totals for commercial fishing must be added a small quantity representing products of saltwater sport fishing and other noncommercial fishing. The totals are about 1.6 and 29 million tons, respectively. The tonnages given in Table 1 are also expressed in dollars on the basis of an average price to the fisherman of $200 per ton in the United States and $150 per ton in the rest of the world. Note that these prices are for only the high-grade fish that are used directly for human consumption.

Information about the quantity of animal food obtained by hunting on land is as inadequate as that for plant food which is gathered on land. The Bureau of Sport Fishing and Wildlife (*5*) compiled the number of deer, elk, and other big game that were legally shot during 1964 in the United States. These numbers were converted to tons (152,000) on the basis of average weights of each kind of game, and doubled to allow for the take by poaching. This tonnage was trebled to include small game such as rabbits and ducks, figures for which are not available from the bureau. This last estimate is reasonable if the average bag of the 10 million small-game hunters was 10 pounds for each of their 128 million "recreation days" (*6*). The total bag is then about 1 million tons, to which 0.3 million tons must be added for freshwater fish (*4*). The total value was computed on the basis of $500 per ton for mammals and $200 for fish—commercial prices for pork and desirable marine fish. Had the tonnage been evaluated on the basis of the $4 billion spent by sportsmen (*6*), the cost per ton would have been $3000; obviously, the sportsmen buy fresh air and exercise rather than meat. For the entire world, the take of freshwater fish amounted to 6.6 million tons in 1964 (*3, 4*), and the mammals that were hunted on land were guessed at 20 million tons (no data are known to the writers). The values were computed as for the United States.

Figures for the herding of animals are reasonably good. Only a minor quantity of oysters and clams are cultivated in the United States, but a serious attempt is being made in Japan, where not only oysters and clams, but also squid, shrimp, crabs, and yellowtail fish (*Seriola*) are being cultivated —all, so far, at costs in excess of those for the hunting of the wild animals. According to a compilation (*7*), the tonnage for Japanese "aquaculture" is about 0.5 million for 1964; that for the rest of the world may be another 20 percent (Table 1). Production by herding of animals on land also is well summarized by the USDA (*2, 8*). About three-quarters of this total is milk, cheese, and eggs; only one-quarter is meat. The dollar value is from the USDA's tabulation of farm income from livestock. The world's total for herding was tabulated by the USDA (*2*), but the dollar value was computed by the writers on a somewhat lower unit basis than for the United States.

For comparison with food resources, the value of minerals from the ocean and land are included in Table 1 from a previous compilation by Emery (*9*). Of these mineral resources, petroleum and natural gas are by far the greatest. In terms of energy, the 1.6 billion barrels of petroleum produced from the ocean floor during 1964 corresponded to 2.5×10^{15} kilogram calorie, and the total oil, gas, and coal that was produced on land and sea floor throughout the entire world during 1964 (*9*) was equivalent to about 47×10^{15} kilogram calorie. In contrast, the 2360 kilogram calorie average daily food intake of the world's human population (*2*) totals about 0.008×10^{15} kilogram calories, but about half of this energy is required merely to maintain bodily functions, leaving only about 0.004×10^{15} kilogram calories of human energy to compete with the more than 10,000 times greater annual supply of energy from fossil fuels.

Conclusions

The figures in Table 1 yield some interesting results. The total annual value of food and mineral resources taken from the ocean is $8.3 billion, in contrast to $309 billion from the land. Using the land value as the yardstick, if the annual value of produce from the ocean were in ratio to the area relationship of ocean and land, the ocean potential would be $750 billion; the actual recovery for 1964 was only 1.1 percent of that potential. This very low percentage is the basis for either great optimism for the future development of the ocean (on the basis of unrealized potential), or great pessimism (on the basis of high costs compared with further development of land resources, or present exploitation to near the limit of productivity).

Closer inspection of Table 1 indicates that the development of the marine food resources is in a more primitive stage than the development of the resources on land. For example, far more food is recovered from the ocean by primitive techniques of gathering and hunting than by farming and herding. The situation is greatly reversed on land with most recovery by farming and herding. Progress toward the more advanced stages of food recovery in the ocean is inhibited by political factors (failure of governments to agree on ownership of the ocean and its often mobile food resources), by economic factors (high capital costs of harvesting equipment as compared with costs ashore, and high labor costs under union control), esthetic and tradition factors (tastes, customs, and religious prejudices regarding food—witness the difficulty in securing acceptance by the Food and Drug Administration of fish protein concentrate, the reluctance of Americans to eat squid, and of Orthodox Jews to eat shrimp), and industrial factors (conservative design of fishing boats and equipment, and the preference of American fishermen for small independent boats rather than the large ocean factory ships used by the Soviets and Japanese).

Although the world fishery has been increasing quite rapidly in recent years and the trend is likely to continue as more efficient fishing methods come into wider use, the total yield continues to be very small as compared with that from the land. The apparent reasons for this situation have been thoroughly discussed by others (*10*); nevertheless, considerable controversy exists about whether the ocean can support much more efficient and intensive hunting (*11*). Has overkill been reached for oysters, lobsters, abalone, sardines, tuna, and whales just as it was reached earlier on land for elephants, buffalos, and passenger pigeons? If hunting has reached its practical limit, then the only way of increasing the food resources of the ocean is by cultivation—of plants by farming and of animals by herding. The high value per ton of animals has led to some initial efforts in herding, particularly in Japan. Probably these efforts will continue and even increase although the cost of catching food for the captive animals and for confining them presently exceeds the cost of catching the desired animals in their wild state.

Since farming is far closer to the energy source on the complex and inefficient food pyramid than is herding, one should expect greater rewards from farming than from herding. However, farming of the ocean (for plants) has as its major obstacle the difficulty of harvesting. Most of the bulk of plants that live in the ocean are microscopic in size and they are distributed in three dimensions. The cost (energy) of harvesting them exceeds the value (energy) that is recovered by eating (or burning) the crop. Near shore in clear water larger attached algae can be grown, but most of them are not particularly tasty and few are used directly as food. We do not know of a single experimental project in the United States that is designed to farm the ocean! Many projects investigate laboratory aspects of photosynthesis, plant physiology, and biochemistry, but none appear to be making direct tests of planting and harvesting in the ocean. One answer is that "we must understand the processes before they can be utilized," but we may ask in return "how well did early man understand photosynthesis and biochemistry when he improved and adapted to farming the primitive corn and other wild plants that he had encountered in his gathering stage of economy?"

These major conclusions from the study are quite self-evident, but for readers who have not looked into the literature of marine science the following remarks may be helpful:

1) Photosynthetic production in the ocean is comparable to that on the land, although great regional variations in productivity exist in both environments. Since the area of the ocean is nearly three times that of the land, the potential harvest is proportionally large, even without equivalent agricultural practices.

2) The old concept of the freedom of the seas, which developed because the ocean was considered nearly worthless except for cheap transportation and defense, is diametrically opposed to wise utilization of the seas.

3) Fishermen prefer to sell fresh fish because the price is much higher than for the so-called "trash" fish, which are being increasingly processed into fish meal as an additive for chicken and cattle food. Fish flour, a more refined product that is fit for human consumption, is just coming onto the market; it is an efficient source of cheap protein for the human diet.

4) Fishermen are likely to remain hunters rather than herders or farmers unless responsibility is clearly defined for management of the biological resources available in the saltwater envelope that covers so much of the world. For some resources national agencies can be adequate, but for others some international agency is needed.

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