V.—THE FOOD OF MARINE ANIMALS.

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All the known forms of animals may be divided into 155 orders; of these 52 live on land, 67 in fresh water, and 107 in salt water. The sea, therefore, is richer in animal forms than the fresh water and the land, and also produces more individuals than fresh water and land combined.

As the number of domestic animals on a farm depends on the extent and quality of the land belonging to it, in the same way the number of animals in the different domains of nature, both on land and in water, depends on the quantity of food.

As no animal is able to form the organic combinations of its body direct from water, air, and mineral substances, all animals of our earth depend on the quantity of organic matter produced by the vegetable kingdom; and the number of animals inhabiting the different seas, therefore, likewise depends on the quantity of organic nutritive matter which the water, either directly or indirectly, receives from the vegetable kingdom.

To prove this let us first of all cast a glance at our own seas, the Baltic and the North Sea.

Large meadows of green sea-weeds extend in the shallow waters near the coast, wherever the bottom does not consist of shifting sand, in which no plant can take root. Wherever the bottom is stony, brown algæ (*fucoids*) grow, and further away from the coast, at depths of 60 to 80 feet, the bottom is in many places covered with red algæ (*florids*). At a still greater depth there are few or no plants; but aquatic plants torn loose from the places where they grew are often brought up in dredges from a depth of several hundred yards. After the gases filling their tissues have escaped, such plants sink towards the bottom, fall to pieces, and finally form the principal component part of the mass of dark, soft mud forming the bottom of many bays of the Baltic and North Sea. When such mud, brought up in dredges, is put into a barrel,

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it does not appear to contain any animal life; but if it is put through a fine wire sieve, which cleans out all the mud, a large number of diminutive mollusks, worms, crustaceans, and other marine animals may be seen.

If we could dive down to the mud bottom without touching its surface, we would find it full of worms, shells, and other marine animals protruding from the mud, all busy absorbing with their mouths the particles of mud nearest to them; and we would also see flounders, codfish, eels, and other fish digging themselves into the soft mud for the purpose of devouring its inhabitants.

In the great depths of the Baltic, 90 to 95 fathoms, east of the island of Gottland, where the bottom consists of plastic clay containing but very few organic substances, I found very few worms during the summer of 1871. In the greatest depths of the Mediterranean southeast of Sicily (1,700 fathoms), where the bottom consists of yellowish clay, the British exploring expedition of 1870 found no traces of animal life.

In the southern part of the North Sea the muddy bottoms, at a depth of 20 to 25 fathoms, are literally alive with small crustaceans, worms, snails, mollusks, echinoderms, and polyps, and are therefore very rich in fish.

Enormous masses of dark mud, formed from vegetable matter which has sunk to the bottom, lie at the bottom of the deep fiords of Norway, and furnish excellent food for their numerous fish and other marine animals.

Besides the sea-weeds, which in all latitudes grow at a depth of 25 fathoms on level bottoms, the sea produces different kinds of floating algæ, which furnish food to marine animals.

During the summer a floating microscopic alga (*Melosira costata*) appears in the Bay of Kiel, and probably also in other parts of the Baltic, in such enormous masses that the water becomes turbid.

Clean plates of glass which I fastened to some poles in the Bay of Kiel one meter below the surface of the water were, after 8 to 14 days, completely covered with diatoms, among which infusoria were crawling about, the stomachs of which contained diatoms. Diatoms live in every sea, and when dead form the principal component part of the finer portions of the bottom.

Late in summer the Baltic near the mouths of the Oder, Vistula, and other rivers assumes a peculiar green color, from great masses of floating microscopic algæ, so-called "water blossoms." The commission for the scientific investigation of the German seas, which during this month has examined the Bay of Danzig, on the 10th of September found a herring-net which, east of Zoppoh, had been left at the bottom of the sea for one night, covered with a greenish slime, which principally consisted of such microscopic algæ.

In the Red Sea, the Atlantic, Indian, and Pacific Oceans, navigators and scientists have often observed floating microscopic algæ of a reddish color (*Trichodesmium erythræum*) covering the sea for miles and miles.

In the middle Atlantic Ocean large masses of algæ (*Sargassum bacciferum*) are floating about, which furnish food not only to the animals living on and among them, but also, after they have decayed and sunk to the bottom, to animals living in the depths of the sea.

Plants growing on land likewise furnish food for the animals of the sea. All rivers carry organic matter into the sea, which, with the fine mineral substances of the river water, sink to the bottom near the mouths of the rivers and form layers of rich mud.

In the Caribbean Sea, A. Agassiz found masses of leaves, pieces of bamboo, and sugar-cane at a depth of 900 fathoms, and at a distance of 16 to 24 kilometers from the shore, and wherever this was the case the deep-water fauna was particularly rich.

At the greatest depth of the ocean, below 900 fathoms, both the number of species of animals and individuals decrease, evidently because the quantity of food is smaller. Decaying plants and animals which either sink to the bottom perpendicularly or gradually glide down the incline of the coast, are either devoured by marine animals or dissolve entirely before they reach the deepest bottoms.

Flat, sandy bottoms, on which the constant motion of the waves allows nothing to rest, be it alive or dead, are almost void of animal life.

Firm coral reefs, on the other hand, towards which wind and breakers carry vegetable and animal life from the open sea, both by day and night, are among the most densely inhabited portions of the sea, especially on their outer edges, because these receive the greatest quantity of nutritive matter (Murray).

As the growth of young marine animals, just as much as that of land and fresh-water animals, depends on the quantity of food, large numbers of young fish and other marine animals, which were hatched within a limited space, must spread over a larger extent of water, if many of them are not to perish from want of food. To find this food, they swim in large schools from one place to another, and continuing in the direction in which they find the most food, they gradually get to migrating, without the slightest idea or purpose of finding a more pleasant place of sojourn. Thus the schools of herrings enter the bays of the Baltic, following those portions of the sea which are richest in copepods. The herrings are followed by the codfish, which feed on the former, and near the coasts of Norway large numbers of whales follow the herring and devour many thousands (O. Sars).

The migrations of marine animals are therefore caused by the periodical appearance of food within certain parts of the sea, just as the migrations of the South African antelope, the North American buffalo, and the Siberian reindeer are produced by the same causes.

Food-fish, by seeking their food in different parts of the sea, thus furnish us with wholesome food from numberless small marine animals, which without them would be of no use to us.

The periodical increase and decrease of nutritive matter in the different parts of the sea depend on the degree of warmth and light which, during the changing seasons, they receive from the sun.

Food and temperature exercise a powerful influence on the development of the eggs of marine animals.

The eggs of many invertebrate marine animals develop simultaneously with the eggs of fish which come in large shoals; the young fish therefore find numerous microscopic embryos in the same water in which they were hatched. By inhaling this water when breathing they at the same time get the food which is most suitable for them. The water flowing through their gills is in a certain sense their mother's milk. If the water does not contain the food which is absolutely required by the young fish they perish as soon as the nutritive yolk of the egg has been consumed, for on water alone no marine animal can live.

Though it is therefore an easy matter to develop young salt and fresh water animals from healthy eggs in small vessels, because the eggs contain all the substance which is necessary for such development, it is very difficult to raise the young fry in aquaria, because these but rarely contain the necessary food.

There is no doubt that many young fish and other marine animals do not attain to maturity simply because the water where they were born does not contain a sufficient quantity of suitable food.

The average quantity of sunlight and warmth, repeating itself from year to year, develops a certain quantity of nutritive matter for the animal life of the sea, and the total mass of mature animals of one part of the sea is as large during every period of development as the quantity of food in that part allows, for during every breeding-period all the animals living together in one region produce a much larger number of eggs than the number of mature animals developed from them. The germinating faculty of all species of animals is greater than their maturing faculty.

One of the most obvious reasons why the maturing faculty of animals decreases is the destruction of eggs, embryos, and young fry by other species or by larger individuals of the same species. Thus, the *Coregonus lavaretus* eats the eggs of its own species; large codfish devour small codfish, and eels fill their stomachs with the spawn of different fish.

In certain localities man exercises a considerable influence on the maturing faculty of marine animals. In Greenland the whale (*Balæna mysticetus*) is at present a very rare animal, because Dutch, Hamburg, British, American, and other whalers have caught old and young whales for centuries.

In nearly all the fishing villages on the coasts of the Baltic and the North Sea the fishermen complain that the former wealth of fish is disappearing. It is unfortunately impossible to ascertain from comparative statistics in how far these complaints are justified; but there is scarcely a doubt that in most of our coast waters more fish are caught within

one year than in former times. The number of consumers of salt-water fish in our inland provinces has, since the introduction of railroads, increased so much that the quicker and larger sales of fish have induced the fishermen to bring more small fish to market than formerly; thereby they of course reduce the productiveness of the food-fish in their waters. They follow the same course as large fish of prey, and do their share in reducing the maturing faculty of valuable fish. The invertebrates found in such waters then serve as food for other worthless fish, or at best they only serve to develop a larger number of young immature food-fish, whose total weight has much less value than the same weight of fully grown fish, which moreover could do something in the way of propagating the species before they were caught. If fishermen, therefore, wish to permanently reap an average reward of their labor, the fish which spawn in coast waters should not be caught at all ages, but should be protected especially during the period of their youth and during the spawning season.

In no part of the sea has fish-food decreased, as has been the case in many fresh waters of highly cultivated countries, causing a decrease of fresh-water fish. In many countries our modern civilization has destroyed the *natural communities* (Cenobitisms) of plants and animals, and substituted those plants and animals which were most profitable to man. But the natural communities of the sea human agencies can only change to a certain degree in the coast waters. In the open sea the natural communities of plants and animals will continue to live and sustain each other as long as the waves of the eternal ocean continue to roll.

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