69.—CAN WE DO ANYTHING TO DECREASE, PRESERVE, OR INCREASE THE NUMBER OF OUR USEFUL MARINE ANIMALS?*

By KARL MÖBIUS.

The fishermen of the Prussian coast have for a long time complained of the decrease of the flounders (*Pleuronectes flesus*). It is also alleged that, on the Baltic coast of Schleswig-Holstein, the flat fish, especially the golden flounders (*Pleuronectes platessa*), are on the decrease. According to the statement of a Kiel eel-smoker, the net-fishery for summer eels (with yellow belly) is said not to produce as much as in former times. These complaints suggest the question whether man is really able to change the number of animals in the sea. On land man has exterminated wild animals and substituted useful ones; and by changing the character of the vegetation he has driven away from various localities many insects, birds, and small mammals. By raising different kinds of good food-fish he has also extended his dominion over the inhabitants of fresh water. Why should not man also be able to increase the useful marine animals? This question lies so near that I was not in the least astonished when, last year, the directors of our Fishery Association requested me to make it the subject of a paper to be read at the general meeting.

Although I am fully aware of the fact that we are far less acquainted with the various conditions of life of the useful marine animals than with those of the fresh-water fish and the land animals, and that consequently we are not yet prepared to make as well-founded rules for the preservation and increase of the useful marine animals as for the increase of fresh-water fish, I considered it my duty to comply with the request of our directors, with the view of making more generally known the great truth that the preservation and increase of marine animals is subject to the same general laws as that of the land animals and fresh-water fish; and of stimulating our fishermen to carry on their business in such a manner as not to decrease, to their own loss, the number of useful marine animals.

In every territory—both land and water—where animals are able to live, an average number of animals is developed per season, or per year, which is duly proportioned to the conditions of food and propagation within that territory. The entire inhabitable portion of our globe is therefore fully occupied by plants and animals. The truth of these assertions can easily be proved by examples from agriculture. Every farmer knows, from his own experience, how many grains of seed will

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be fully matured in his fields. He knows that the quantity of field and garden produce is increased by manure, which supplies the vegetables with the necessary food. He knows exactly how many heads of cattle his land can feed. It is very disagreeable to him that he has to wage a constant war against weeds, which threaten to diminish the room and food needed for his cultivated plants, and against hurtful animals which injure his domestic animals. It can also be shown by examples from the fresh-water fisheries that the quantity of fish raised is dependent on the quantity of food found within a certain territory.

The estate of Hagen in the Probstei [a district of Holstein] has a carp-pond, measuring upwards of 80 hectares, which is drained for each alternate period of three years, during which time oats and clover are cultivated in it. At the end of three years the water is again let into the pond, and 30,000 one-year old carp are placed in it, which after three years generally yield 20,000 kilograms of food-fish. In order to obtain still better results more than 30,000 young carp were once placed in the pond. After three years had elapsed the number of fish was greater than heretofore, but in all they did not weigh more than 20,000 kilograms. The quantity of carp-food, therefore, which this pond produced in three years had produced the maximum quantity of carp of which it was capable.

As the food of carp consists of tender vegetable matter, of insects, and other small aquatic animals, ponds with a heavy bottom developing rich vegetation and animal life are particularly suitable for carp-culture. In carp-ponds where fish are to be developed for the market in as short a time as possible, there should always be some pike. These fish of prey, by devouring the young of other less valuable fish and spawning carp, remove from the pond useless destroyers of good carp-food, and thus, by their voracity, further the development of the carp.

A carp-pond is, therefore, not merely a body of water inhabited by carp, but a community of different plants and animals, which in that water find all the conditions of their well-being, and each kind of which is represented by the greatest number of individuals which, under these conditions, can be developed, for in all kinds of animals the number of individuals in each period of propagation which reach full maturity is smaller than the total of seed or eggs produced.

Like the carp-pond, every coast-water of our Baltic and North Sea coasts is a community of living beings, which in various ways are mutually dependent upon each other, and which, combined, exhibit the maximum quantity of life which can be developed under the given circumstances or conditions. Among these conditions are: the temperature, saltness, and movements of the water, the depth and character of the bottom, the degree of fecundity of the various animals and plants, and the migrations of some kinds of animals.

That the combined effect of all these causes in the bays of our Baltic coasts produces in the course of each year the full number of animals

which they are capable of producing will appear doubtful to those who have seen in the Baltic, besides fish, crabs, and shell-fish, only worms, snails, starfish, and medusæ.

The enormous number of small animals and plants which, at certain times, float about in the water, and the many worms, crustaceans, and shell-fish which densely throng every muddy bottom, can only be observed by applying the scientists' implements of investigation—purse-nets with fine meshes, floating-nets, drag-nets, sieves, and magnifying-glasses. Even the sharp eyes of the fishermen cannot see most of those small animals which form the principal food of herring, sprat, mackerel, and flounders.

It is evident that the fisheries became a disturbing element in the natural co-operation of all the members of the communities of living beings in our seas.

From May, 1879, till the end of February, 1880, the fishermen of Eckernförde, in Schleswig, caught upwards of 1,407,000 golden flounders (*Pleuronectes platessa*), according to reports made from Eckernförde to the Kiel Commission for the scientific investigation of the German seas.

We do not know whether this number of fish, if left undisturbed, would have increased still further, or how many eggs they might have laid, if they had not been caught. It is certain, however, that during those ten months the number of golden flounders has been diminished more by the Eckernförde fishermen than could have been done in the same time by seals and other enemies of these fish or by other causes. And what were the necessary consequences of this decrease?

(1.) For those flounders which had escaped the fishermen's nets, the removal of so many of their kind had certainly this advantage, that the survivors had more food at their disposal; and as, moreover, those fish which had escaped were, probably, mostly small fish, they would have a still better chance to have plenty to eat, and thus grow faster, than if the additional 1,400,000 flounders would have had to share the food with them. For, large as is the quantity of shell-fish and worms at the bottom of the sea, it has, after all, its limits; and it certainly will not increase, if the number and the demands of these voracious fish increase.

(2.) As the 1,400,000 flounders were caught before they had, once more, engaged in the work of propagation, their removal implied the removal of a considerable number of young flounders.

On the 26th and 27th February, 1883, I bought in the Kiel fish market five live female flounders, measuring 27 to 36 centimeters in length and weighing 200 to 450 grams. The ovaries of the largest one of these fish weighed 110 grams and only contained immature eggs. By counting the eggs of two small, but carefully weighed, portions of these ovaries, it was found that there were 2,558 to one gram; according to which there would be in the two ovaries 281,380 eggs. As with the other four the eggs were already flowing from the genital openings, and the ovaries contained large mature and small immature eggs, the

weighing, counting, and calculating did not give as reliable a result as was the case with the largest fish. For these four I got the following number of eggs: 48,000, 80,000, 108,000, and 116,000; and these figures are certainly below the actual number of eggs. All the five flounders together contained 633,380 eggs, which would make the average number of eggs per spawner 126,676.

As according to the observations of the fishermen there are always two to three female flounders to one male, it may be supposed that of the 1,400,000 caught in the Eckenförde waters during the years 1879 and 1880, at least 900,000 were spawners. Giving to each of these an average of only 120,000 eggs, the number of flounder eggs withdrawn from these waters would be 900,000 times 120,000 = 108,000 millions, or more than 100 milliards, whereby doubtless the number of young flounders in the summer of 1880 had been considerably decreased. For it would be a great mistake to suppose that the withdrawal of so large a number of eggs would do no harm, because the surviving flounders would lay a sufficiently large number of eggs.

Similar opinions relative to the oyster have induced the oyster fishers on the coast of France and England to entirely ruin their oyster beds. When they had learned that a grown oyster produces 1 to 2 millions young oysters, they thought that a few mother oysters would suffice to rapidly populate again an oyster bed where fishing had been going on. They, therefore, scraped the beds so long that the work ceased to be profitable. Of the young oysters which develop in the so-called "beard," between the mantle and the gill-plates of the mother oyster, only a comparatively small number reach suitable places on the bottom of the sea, where they can develop to oysters which are fit to be brought into the market. Many of them get into the sand and heavy mud, in which they are smothered, while others, which have found a suitable body to which to adhere, are eaten by star-fish and crabs before their shell is thick enough to ward off these enemies.

The eggs of the flounders are also exposed to many dangers before they develop into mature fish. When, coming from the ovaries, they reach the water, the spermatozoa of the milters must enter them, in order that they may develop. The female does not protect her eggs, but leaves them to their fate. It is likewise certain that many of the impregnated eggs are devoured by other animals before the young fish slip out; and even later many of the young fish become the prey of other fish and aquatic birds, at least as long as they float about near the surface and live in shallow waters near the coast.

Thus, even under the natural conditions of life, only a small portion of the numberless flounder eggs produced each spawning season ever reach sexual maturity. A large production of eggs in any species of animals is, therefore, by no means an indication that large numbers of these animals will be raised. A female intestinal worm (*Ascaris lumbricoides*) produces about 60 million eggs, and a female tape-worm

(*Taenia salium*) 40 millions. Most of these millions of eggs are destroyed because numerous and regularly recurring difficulties prevent their development. It is highly probable that this enormous production of eggs has been brought about by these very difficulties. Only the most fertile kinds bequeathed their qualities from one generation to the other in the struggle with the numerous destructive influences, because they furnished a larger number of combatants than the less fertile kinds, which therefore finally died out.

Where would all the flounders find food and room, if *all* the eggs of the mature spawners were destined to become fish? It is only by the circumstance that the mature females lay so many eggs that the full amount of flounders allowed by the quantity of food obtained, and the life in common of all the members of their community, can be maintained. How can we demand that this amount, exposed to so many natural enemies, should not be decreased by our destroying milliards of eggs before they have been laid?

We can do this without diminishing the amount if we remove the natural causes by which eggs and young animals are destroyed. This is successfully done in artificial oyster-culture in Holland and France, where the oyster spawn is, in suitable places, made to adhere to bricks, and the young oysters are protected in boxes and artificial basins against enemies and other hurtful influences, and allowed to grow to maturity in places where there is plenty of food.

If we desire to obtain permanently from our coast waters more useful salt-water fish than can be developed under the natural conditions of life, we must protect their eggs and their young according to the same rules which are followed in the artificial culture of oysters and fresh-water fish. We might possibly construct basins for flounders in suitable places on the coast, where artificially-impregnated eggs, protected from enemies, would develop in much larger quantities than in the open sea. Suitable food for the young fish might be introduced by frequently renewing the water from the sea before the young fish are allowed to go into it.

If it is possible to start such flounder hatcheries, or similar ones, for stocking the waters on our Baltic coast with flounders, their construction, support, and superintendence would cost so much that before they can be constructed an attempt will have to be made to carry on the flounder fisheries in such a manner that they will permanently yield the maximum quantity of fish which they can yield under the existing natural conditions; and this they can only do permanently when no small fish are caught at all, and, during a certain protected season, no full-grown ones. The fishermen themselves must learn to know this, and for their own advantage act accordingly.

I believe that these explanations have made it sufficiently plain that the number of animals within a given territory is not dependent on accidents, but is determined by the co-operation, according to fixed

laws, of existing causes; and in treating of our relations to some other useful marine animals, not mentioned so far, I shall be able to be brief.

First, as to the herring: formerly it was thought that at certain periods the herring in their migrations from their home in the northern seas, also visited our coasts, and that all those which escaped fish of prey and the fishermen again returned to their home. Now, we know for certain, that every part of the Baltic which is distinguished from other parts of the Baltic by its temperature, its vegetation, and its fauna, has its own peculiar kind of herrings. Thus the herrings of the bays of Kiel and Eckernförde, as well as those which ascend the Schlei, belong to one and the same kind, which fact leads us to the conclusion that they are born and developed within the limits of this territory, and that, therefore, it is a matter of considerable importance what relations we hold to the conditions of life in this their home.

The herring which, during the winter months, find good food in the bays of Kiel and Eckernförde, migrate, when their sexual organs approach maturity, to shallow coast waters having less saltness than the Baltic, especially to the upper portions of the Schlei. As they spawn in these shallow brackish waters, and as the young herring are hatched there, it is highly important to let at least as many full-grown and sexually mature herrings get there as is necessary to keep the stock of herrings in our coast waters at its average height.

According to the reports made by the Schleswig fishermen to the Kiel commission for the investigation of the German seas, the herring fisheries in the inner portions of the Schlei have not declined during the period 1878–1882, although during that period more nets than formerly have been placed outside the mouth of the Schlei. Even the building of a railroad bridge across the Schlei has not disturbed the herring in their ascent. But if, by an increase of the number of stationary nets outside the mouth of the Schlei, and of the nets and herring-fences in the narrow parts of the Schlei, the herring fisheries in the entire coast territory of Schleswig-Holstein should be caused to permanently decline, the limits of the allowable fisheries would have been exceeded. Want of food cannot cause a decrease of the average number of herring or other useful marine animals in our coast-waters or in the sea, because the plants and small animals which form the principal articles of fish-food are every year produced anew, and therefore remain in the sea. If, therefore, the quantity of useful marine animals is diminished by the interference of man, we must find the cause of this in the destruction of too large a number of spawn-producing individuals.

In a territory of brackish water so limited and peculiar as the upper Schlei the introduction of a fish of prey may also cause a change in the quantity of fish. In 1875 a number of pike perch were placed in the Schlei; and in 1881 fish of this kind were caught weighing 3 to 4½ kilograms apiece. As this fish chiefly lives on small fish, any considerable increase of its number in the Schlei will not fail to exercise an influ-

ence on the quantity of the young herring which are hatched in that water. Whether the value of the fisheries in the whole of the Schlei would be decreased thereby, is a question which cannot be answered at present.

The sprat, salmon, sea-trout, eel, sturgeon, and lamprey resemble the herring in this, that at different periods of their life they change their location. Just as the Baltic herring, in spring, seek the brackish coast-waters, for the purpose of spawning, thus the salmon, sea-trout, and lampreys ascend the rivers to the neighborhood of their sources for the purpose of depositing their eggs, and, reversing this, the mature eels migrate from fresh waters into the sea in order to spawn there.

The young herring, salmon, sturgeon, and lamprey live on organic matter which is developed in the localities where they are hatched, and after having reached a certain age they go into salt water. Young eels find their first suitable food in the sea, and afterwards develop in fresh water, whilst the salmon, sea-trout, sturgeon, and lampreys transform numberless marine animals into delicious fish-flesh.

The feeding territory of the migratory fish is larger than that of the stationary fish. The migratory fish are, therefore, more of flesh-forming fish than the stationary fish. Their marine pastures and spawning-places located in the sea cannot be changed by man; but it is within our power to change their pastures and spawning-places in fresh and brackish water, or to prevent them from reaching these places. In former times the Windeby Noor, an inlet near Eckernförde, was a good spawning-place for our herrings; but by the construction of a dike they have been deprived of it. We should be careful not to deprive the fish on our coast of any more spawning-places, if we desire that their number shall remain at its average height. For the young eels and sea-trout and the mature salmon, ways should be constructed near mill-dams so they may be able to ascend the streams. The descending salmon, sea-trout, and eels should be protected against turbines and other hurtful contrivances, if we desire that, both in fresh and salt water, all that matter which may serve as fish-food shall be transformed into food for man.

Of the shell-fish found in our coast-waters, only oysters and common mussels (*Mytilus edulis*) are eaten in Germany, whilst in France and England the heart-mussel [cockle], and in North America the sand-mussel (*Mya arenaria*) [soft clam] also form articles of food.

For the proper management of our Schleswig oyster-beds we have, by scientific and technical investigations, and by a rational system of renting, gained a safe basis, and they will soon again produce their former quantities of oysters.

With us the number of marketable oysters cannot, by artificial oyster-culture, be raised to such a height as on some parts of the French and Dutch coasts, because we have to contend with vast quantities of ice and heavy floods; but by scattering oyster-shells in parts of the

North Sea near our coasts, where a firm bottom is found, the area of colonies of young oysters will gradually be enlarged.

The attempt to plant oysters on the east coast of Schleswig is still in progress. Of the American oysters which had been planted a great many were still alive in September, 1882, when I had occasion to examine the oyster-beds; but no young oysters produced by them could be found. For continuing this experiment I have recommended to obtain American oysters from the outermost limits of the territory where they live; *i. e.*, from beds where they have been accustomed to the lowest degree of saltness and the coldest temperature which they are able to stand, because the water of the Baltic is less salty and, on the whole, colder than that of the North Sea.

Within the entire German coast territory of the Western Baltic, from the Little Belt to the west coast of the island of Rügen, the common mussel ought to be used as an article of food a great deal more than has been done hitherto. Only in the bays of Kiel and Apenrade mussel culture has been carried on for some time, by driving trees and piles of beech-wood in suitable places into the firm bottom at such a depth below the surface that they remain free of ice. After three or four years the mussels are harvested. Aided by the commission for the scientific investigation of the German seas fishermen have driven piles for mussel-culture in the bays of Kjelstrup and Gjenner; and in the Flensburg Fiord an enterprising fish-dealer has succeeded in changing tolerably large mussels, which originally had a muddy flavor, in some months, into a good, marketable article of food, by placing them in inclosed pens within the water. It is to be hoped that these attempts will be imitated by many fishermen. When large quantities of mussels, of an improved kind, are raised in our bays, a profitable market for them will not be wanting, especially as the mussel is gradually becoming a favorite article of food in the interior of the country.

My object in these remarks has principally been to point out the important fact that the quantity of useful marine animals within a certain given territory is dependent on the co-operation of many different causes, the principal one being the quantity of food found within that territory and the quantity of spawn produced every year. The changes of the temperature of the atmosphere and the sea-water, which are frequent with us, will certainly not remain without influence on the entire vegetable and animal life of our coast-waters, and will either increase or diminish the quantity of food of the marine animals as well as their fecundity. Years of great or limited fecundity are always followed by years of an average increase. Only on these last-mentioned years the fishermen should base their calculations and they will be absolutely safe. They may safely regulate the quantity of implements needed on these calculations, unless they desire more of nature than she can give them according to her immovable laws.