28–30. Secretary, Dr. Edmund Otis Hovey, American Museum of Natural History, New York City.

Association of Economic Entomologists.—December 28 and 29. Secretary, A. F. Burgess, U. S. Department of Agriculture, Washington, D. C.

American Nature-Study Society.—January 1. Secretary, Dr. M. A. Bigelow, Columbia University, New York City.

Association of American Anatomists.—December 28–30. Secretary, Dr. G. Carl Huber, Ann Arbor, Mich.

The American Chemical Society.—During the entire week. Secretary, Professor Charles L. Parsons, New Hampshire College, Durham, N. H.

American Society of Vertebrate Paleontologists.—December 28–30, with the Geological Society of America. Secretary, Mr. E. S. Riggs, Field Museum of Natural History, Chicago, Ill.

American Society of Zoologists (Central Branch in joint meeting with, and under the auspices of, the Eastern Branch).—December 28–30. *Eastern Branch*—Secretary, Professor Lorande Loss Woodruff, Yale University, New Haven, Conn. *Central Branch*—Secretary, Professor Charles Zeleny, University of Illinois, Urbana, Ill.

The American Physical Society.—Secretary, Professor Ernest Merritt, Ithaca, N. Y.

The American Psychological Association.—December 29–31. Secretary, Professor A. H. Pierce, Smith College, Northampton, Mass.

The American Physiological Society.—December 28–30. Secretary, Dr. Reid Hunt, U. S. Public Health and Marine Hospital Service, Washington, D. C.

American Anthropological Association.—December 27–31. Secretary, Dr. George Grant MacCurdy, New Haven, Conn.

The Entomological Society of America.—December 30 and 31. Secretary, J. Chester Bradley, Ithaca, N. Y.

The American Folk-Lore Society.—Professor R. B. Dixon, Peabody Museum, Cambridge, Mass.

American Federation of Teachers of the Mathematical and the Natural Sciences.—December 27 and 28. Secretary, Dr. C. R. Mann, University of Chicago, Chicago, Ill.

American Society of Biological Chemists.—Secretary, Dr. William J. Gies, 437 West 59th St., New York City.

Sullivant Moss Society.—December 30. Secretary, Mrs. Annie Morrill Smith, 78 Orange St., Brooklyn, N. Y.

Botanical Society of America.—December 28–31. Secretary, Dr. Duncan Starr Johnson, Johns Hopkins University, Baltimore, Md.

Society of American Bacteriologists.—December 28–30. Secretary, Dr. Norman McL. Harris, University of Chicago, Chicago, Ill.

Association of Mathematical Teachers in New England.—December 28. Secretary, George W. Evans, Charlestown High School, Charlestown, Mass.

Eastern Association of Physics Teachers.—Meets in conjunction with American Federation of Teachers of the Mathematical and Natural Sciences.

Physics Teachers of Washington, D. C.—Meets in conjunction with American Federation of Teachers. Secretary, Dr. Howard L. Hodgkins, George Washington University, Washington, D. C.

American Phytopathological Society.—Secretary, C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

American Alpine Club.—December 30. Secretary, Dr. Henry G. Bryant, Room 806 Land Title Building, Philadelphia, Pa.

American Breeders' Association.—Meeting of Eugenics Committee. Secretary, Dr. Chas. B. Davenport, Cold Spring Harbor, N. Y.

OUR FOOD FROM THE WATERS[1]

At the last meeting of the British Association in Canada (Toronto, 1897) I was able to lay before Section D a preliminary account of the results of running sea-water through four silk tow-nets of different degrees of fineness continuously day and night during the voyage from Liverpool to Quebec. During the eight days' traverse of the North Atlantic, the nets were emptied and the contents examined morning and evening, so that each such gathering was approximately a twelve hours' catch, and each day and each night of the voyage was represented by four gatherings. This method of collecting samples of the surface fauna of the sea in any required quantity per day or hour from an ocean liner going at full speed was suggested to me by Sir John Murray of the *Challenger* expedition, and was first practised, I believe, by Murray himself in crossing the Atlantic. I

[1] Abstract of evening discourse, delivered before the British Association at Winnipeg on August 31, 1909.

have since been able to make similar traverses of several of the great oceans, in addition to the North Atlantic, namely, twice across the equator and through the South Atlantic, between England and South Africa, and four times through the Mediterranean, the Red Sea and the Indian Ocean to Ceylon; and no doubt other naturalists have done much the same. The method is simple, effective and inexpensive; and the gatherings, if taken continuously, give a series of samples amounting to a section through the surface layer of the sea, a certain volume of water being pumped in continuously through the bottom of the ship, and strained through the fine silk nets, the mesh of which may be the two-hundredth of an inch across, before passing out into the sea again. In examining with a microscope such a series of gatherings across an ocean, two facts are brought prominently before the mind: (1) the constant presence of a certain amount of minute living things; (2) the very great variation in the quantity and in the nature of these organisms.

[Illustrations showing this were given.]

Such gatherings taken continuously from an ocean liner give, however, information only in regard to the surface fauna and flora of the sea, including many organisms of fundamental importance to man as the immediate or the ultimate food of fishes and whales and other useful animals.

[Examples were shown.]

It was therefore a great advance in planktology when Professor Victor Hensen (1887) introduced his vertical, quantitative nets which could be lowered down and drawn up through any required zones of the water. The highly original ideas and the ingenious methods of Hensen and his colleagues of the Kiel School of Planktology—whether all the conclusions which have been drawn from their results be accepted or not—have at the least inaugurated a new epoch in such oceanographic work; and have inspired a large number of disciples, critics and workers in most civilized countries, with the result that the distribution of minute organisms in the oceans and the fresh waters of the globe are now much more fully known than was the case twenty, or even ten, years ago. But perhaps the dominant feeling on the part of those engaged in this work is that, notwithstanding all this activity in research and the mass of published literature which it has given rise to, much still remains to be done, and that the planktologist is still face to face with some of the most important unsolved problems of biology.

It is only possible in an address such as this to select a few points for demonstration and for criticism—the latter not with any intention of disparaging the stimulating work that has been done, but rather with the view of emphasizing the difficulties, of deprecating premature conclusions and of advocating more minute and more constant observations.

The fundamental ideas of Hensen were that the plankton, or assemblage of more or less minute drifting organisms (both animals and plants) in the sea, is uniformly distributed over an area where the physical conditions are approximately the same, and that by taking a comparatively small number of samples it would be possible to calculate the quantity of plankton contained at the time of observation in a given sea area, and to trace the changes of this plankton both in space and in time. This was a sufficiently grand conception, and it has been of great service to science by stimulating many workers to further research. In order to obtain answers to the problems before him, Hensen devised nets of the finest silk of about 6,000 meshes in the square centimeter, to be hauled up from the bottom to the surface, and having their constants determined so that it is known what volume of water passes through the net under certain conditions, and yields a certain quantity of plankton.

[Examples of the nets and the methods of working shown.]

Now if this constancy of distribution postulated by Hensen could be relied upon over considerable areas of the sea, far-reaching conclusions, having important bearings upon fisheries questions, might be arrived at; and such have, in fact, been put forward by the Kiel planktologists and their followers—such as the calculation by Hensen and Apstein that the North Sea in the spring of 1895 contained at least 157 billions of the eggs and larvæ of certain edible fish; and from this figure and the average numbers of eggs produced by the fish, their further computation of the total number of the mature fish population which produced the eggs—a grand conclusion, but one based upon only 158 samples, taken in the proportion of one square meter sampled for each 3,465,968 square meters of sea. Or, again, Hensen's estimation, from 120 samples, of the number of certain kinds of fish eggs in a part of the West Baltic; from which, by comparing with the number[2] of such eggs that would normally be produced by the fish captured in that area, he arrived at the conclusion that the fisherman catches about one fourth of the total fish population —possibly a correct approximation, though differing considerably from estimates that have been made for the North Sea.

Such generalizations are most attractive, and if it can be established that they are based upon sufficiently reliable data, their practical utility to man in connection with sea-fishery legislation may be very great. But the comparatively small number of the samples, and the observed irregularity in the distribution of the plankton (containing, for example, the fish eggs) over wide areas, such as the North Sea, leave the impression that further observations are required before such conclusions can be accepted as established.

[2] It is probable that too high a figure was taken for this.

Of the criticisms that have appeared in Germany, in the United States and elsewhere, the two most fundamental are: (1) That the samples are inadequate; and (2) that there is no such constancy and regularity in distribution as Hensen and some others have supposed. It has been shown by Kofoid, by Lohmann and by others that there are imperfections in the methods which were not at first realized, and that under some circumstances anything from 50 to 98 per cent. of the more minute organisms of the plankton may escape capture by the finest silk quantitative nets. The mesh of the silk is one two-hundredths inch across, but many of the organisms are only one three-thousandths inch in diameter, and so can readily escape.

[Examples shown.]

Other methods have been devised to supplement the Hensen nets, such as the filtering of water pumped up through hose-pipes let down to known depths, and also the microscopic examination in the laboratory of the centrifuged contents of comparatively small samples of water obtained by means of closing water-bottles from various zones in the ocean. But even if deficiencies in the nets be thus made good by supplementary methods, and be allowed for in the calculations, there still remains the second and more fundamental source of error, namely, unequal distribution of the organisms in the water; and in regard to this a large amount of evidence has now been accumulated, since the time when Darwin, during the voyage of the *Beagle* on March 18, 1832, noticed off the coast of South

America vast tracts of water discolored by the minute floating Alga, *Trichodesmium erythræum,* which is said to have given its name to the Red Sea, and which Captain Cook's sailors in the previous century called "sea-sawdust." Many other naturalists since have seen the same phenomenon, caused both by this and by other organisms. It must be of common occurrence, and is wide-spread in the oceans, and it will be admitted that a quantitative net hauled vertically through such a *Trichodesmium* bank would give entirely different results from a haul taken, it might be, only a mile or two away, in water under, so far as can be determined, the same physical conditions, but free from *Trichodesmium.*

[Illustrations shown.]

Nine nations bordering the northwest seas of Europe, some seven or eight years ago, engaged in a joint scheme of biological and hydrographical investigation, mainly in the North Sea, with the declared object of throwing light upon fundamental facts bearing on the economic problems of the fisheries. One important part of their program was to test the quantity, distribution and variation of the plankton by means of periodic observations undertaken four times in the year (February, May, August and November) at certain fixed points in the sea. Many biologists considered that these periods were too few and the chosen stations too far apart to give reliable results. It is possible that even the original promoters of the scheme would now share that view, and the opinion has recently been published by the American planktologist, C. A. Kofoid—than whom no one is better entitled, from his own detailed and exact work, to express an authoritative verdict—that certain recent observations "can but reveal the futility of the plankton program of the international commission for the investigation of the sea. The quarterly examinations of this program will, doubtless, yield some facts of value, but they are truly inadequate to give any reliable view of the amount and course of plankton production in the sea."[3] That is the latest pronouncement on the subject, made by a neighbor of yours to the south, who has probably devoted more time and care to detailed plankton studies than any one else on this continent.

[Examples were shown of very diversified plankton hauls from neighboring localities on the same date, or from the same locality on adjacent days, to illustrate irregularity in distribution.]

It is evident from such results that before we can base far-reaching generalizations upon our plankton samples, a minute study of the distribution of life in both marine and fresh waters at very frequent intervals throughout the year should be undertaken. Kofoid has made such a minute study of the lakes and streams of Illinois, and similar intensive work is now being carried out at several localities in Europe.

Too little attention has been paid in the past to the distribution of many animals *in swarms,* some parts of the sea being crowded and neighboring parts being destitute of such forms, and this not merely round coasts and in the narrow seas, but also in the open ocean. For example, some species of Copepoda and other small crustacea occur notably in dense crowds, and are not universally distributed. This is true also of some of the Diatoms, and also of larger organisms. Many naturalists have remarked upon the banks of *Trichodesmium,* of Medusæ and Siphonophora, of Salpæ, of Pteropods, of peridinians and of other common constituents of the plankton. Cleve's classification into tricho-plankton (arctic), styli-plankton (temperate) and

[3] *Internationale Revue der Hydrobiologie und Hydrographie,* Vol. I., p. 846, December, 1908.

desmo-plankton (tropical) depends upon the existence of such vast swarms of particular organisms in masses of water coming into the North Atlantic from different sources.

It is possible that in some parts of the ocean, far from land, the plankton may be distributed with the uniformity supposed by Hensen. It is important to recognize that at least three classes of locality exist in the sea in relation to distribution of plankton:

1. There are estuaries and coastal waters where there are usually strong tidal and other local currents, with rapid changes of conditions, and where the plankton is largely influenced by its proximity to land.

2. There are considerable sea areas, such as the center of the North Sea and the center of the Irish Sea, where the plankton is removed from coastal conditions, but is influenced by various factors which cause great irregularity in its distribution. These are the localities[4] of the greatest economic importance to man, and to which attention should especially be directed.

3. There are large oceanic areas in which there may be uniformity of conditions, but it ought to be recognized that such regions are not those in which the plankton is of most importance to men. The great fisheries of the world, such as those of the North Sea, the cod fishery in Norway and those on the Newfoundland Banks, are not in mid-ocean, but are in areas round the continents, where the plankton is irregular in its distribution.

As an example of a locality of the second type, showing seasonal, horizontal and vertical differences in the distribution of the plankton, we may take the center of the Irish Sea, off the south end of the Isle of Man. Here, as in other localities which have been investigated, the phyto-plankton is found to increase greatly about the time of the vernal equinox, so as to cause a maximum, largely composed of diatoms, at a period ranging from the end of March to some time in May—this year to May 28, in the Irish Sea. Towards the end of this period the eggs of most of the edible fishes are hatching as larvæ.

[Statistics and diagrams showing this maximum for the last three years were exhibited.]

This diatom maximum is followed by an increase in the Copepoda (minute crustacea), which lasts for a considerable time during the early summer; and as the fish larvæ and the Copepoda increase there is a rapid falling off in diatoms. Less marked maxima of both diatoms and Copepoda may occur again about the time of the autumnal equinox. These two groups—the diatoms and the Copepoda—are the most important economic constituents in the plankton. A few examples showing their importance to man may be given: Man eats the oyster and the American clam, and these shell-fish feed upon diatoms. Man feeds upon the cod, which in its turn may feed on the whiting, and that on the sprat, and the sprat on Copepoda, while the Copepoda feed upon peridinians and diatoms; or the cod may feed upon crabs, which in turn eat "worms," and these feed upon smaller forms which are nourished by the diatoms. Or, again, man eats the mackerel, which may feed upon young herring, and these upon Copepoda, and the Copepoda again upon diatoms. All such chains of food matters from the sea seem to bring one through the Copepoda to the diatoms, which may be regarded as the ultimate "producers" of food in the ocean. Thus our living food from the waters of the globe may be said to be the diatoms and

[4] See Dakin, *Trans. Biol. Soc. Liverpool*, XXII., p. 544.

other microscopic organisms as much as the fishes.

Two years ago, at the Leicester meeting of the British Association, I showed that if an intensive study of a small area be made, hauls being taken not once a quarter or once a month, but at the rate of ten or twelve a day, abundant evidence will be obtained as to: (1) variations in the distribution of the organisms, and (2) irregularities in the action of the nets. [Examples shown.] Great care is necessary in order to ensure that hauls intended for comparison are really comparable. Two years' additional work since in the same locality, off the south end of the Isle of Man, has only confirmed these results, viz., that the plankton is liable to be very unequally distributed over the depths, the localities and the dates. One net may encounter a swarm of organisms which a neighboring net escapes, and a sample taken on one day may be very different in quantity from a sample taken under the same conditions next day. If an observer were to take quarterly, or even monthly, samples of the plankton, he might obtain very different results, according to the date of his visit. For example, on three successive weeks about the end of September he might find evidence for as many different far-reaching views as to the composition of the plankton in that part of the Irish Sea. Consequently, hauls taken many miles apart and repeated only at intervals of months can scarcely give any sure foundation for calculations as to the population of wide sea areas. It seems, from our present knowledge, that uniform hydrographic conditions do not determine a uniform distribution of plankton.

[Some statistics of hauls shown.]

These conclusions need not lead us to be discouraged as to the ultimate success of scientific methods in solving world-wide plankton and fisheries problems, but they suggest that it might be wise to secure by detailed local work a firm foundation upon which to build, and to ascertain more accurately the representative value of our samples before we base conclusions upon them.

I do not doubt that in limited, circumscribed areas of water, in the case of organisms that reproduce with great rapidity, the plankton becomes more uniformly distributed, and a comparatively small number of samples may then be fairly representative of the whole. That is probably more or less the case with fresh-water lakes; and I have noticed it in Port Erin Bay in the case of diatoms. In spring, and again in autumn, when suitable weather occurs, as it did two years ago at the end of September, the diatoms may increase enormously, and in such circumstances they seem to be very evenly spread over all parts and to pervade the water to some depth; but that is emphatically *not* the case with the Copepoda and other constituents of the plankton, and it was not the case even with the diatoms during the succeeding year.

I have published elsewhere an observation that showed very definite limitation of a large shoal of crab *Zoëas*, so that none were present in one net while in another adjacent haul they multiplied several times the bulk of the catch and introduced a new animal in enormous numbers. [Diagrams shown.] Had two expeditions taken samples that evening at what might well be considered as the same station, but a few hundred yards apart, they might have arrived at very different conclusions as to the constitution of the plankton in that part of the ocean.

It is possible to obtain a great deal of interesting information in regard to the "hylokinesis" of the sea without attempting a numerical accuracy which is not yet attainable. The details of measurement of catches and of computations of organisms become useless, and the exact figures are non-significant, if the hauls from which they are derived are not really comparable with one another and the samples obtained are not adequately representative of nature. If the stations are so far apart and the dates are so distant that the samples represent little more than themselves, if the observations are liable to be affected by any incidental factor which does not apply to the entire area, then the results may be so erroneous as to be useless, or worse than useless, since they may lead to deceptive conclusions. It is obvious that we must make an intensive study of small areas before we draw conclusions in regard to relatively large regions, such as the North Sea or the Atlantic Ocean. Our plankton methods are not yet accurate enough to permit of conclusions being drawn as to the number of any species in the sea.

The factors causing the seasonal and other variations in the plankton already pointed out may be grouped under three heads, as follows: (1) The sequence of the stages in the normal life history of the different organisms; (2) irregularities introduced by the interactions of the different organisms; (3) more or less periodic abnormalities in either time or abundance caused by the physical changes in the sea, which may be grouped together as "weather."

[Illustrated by diagrams.]

These are all obvious factors in the problem, and the constitution of the plankton from time to time throughout the year must be due to their interaction. The difficulty is to disengage them from one another, so as to determine the action of each separately.

Amongst the physical conditions coming under the third heading, the temperature of the sea is usually given a very prominent place. There is only time to allude here to one aspect of this matter.

It is often said that tropical and subtropical seas are relatively poor in plankton, while the colder polar regions are rich. In fishing plankton continuously across the Atlantic it is easy from the collections alone to tell when the ship passes from the warmer Gulf Stream area into the colder Labrador current. This is the reverse of what we find on land, where luxuriant vegetation and abundance of animal life are characteristic of the tropics in contrast to the bare and comparatively lifeless condition of the arctic regions. Brandt has made the ingenious suggestion that the explanation of this phenomenon is that the higher temperature in tropical seas favors the action of denitrifying bacteria, which therefore flourish to such an extent in tropical waters as to seriously diminish the supply of nitrogen food and so limit the production of plankton. Loeb,[5] on the other hand, has recently revived the view of Murray, that the low temperature in arctic waters so reduces the rate of all metabolic processes, and increases the length of life, that we have in the more abundant plankton of the colder waters several generations living on side by side, whereas in the tropics with more rapid metabolism they would have died and disappeared. The temperature of the sea-water, however, appears to have little or no effect in determining the great vernal maximum of phyto-plankton.

Considering the facts of photosynthesis, there is much to be said in favor of the view that the development and possibly also the larger movements of the plankton

[5] "Darwin and Modern Science" (Cambridge, 1909), p. 247.

are influenced by the amount of sunlight, quite apart from any temperature effect.

Bullen[6] showed the correlation in 1903–7 between the mackerel catches in May and the amount of copepod plankton in the same sea. The food of these Copepoda has been shown by Dakin to be largely phyto-plankton; and Allen has lately[7] correlated the average mackerel catch per boat in May with the hours of sunshine in the previous quarter of the year [curves shown], thus establishing the following connection between the food of man and the weather: Mackerel—Copepoda—diatoms—sunshine. One more example of the influence of light may be given. Kofoid has shown that the plankton of the Illinois River has certain twenty-nine day pulses, which are apparently related to the lunar phases, the plankton maxima lagging about six days behind the times of full moon. The light from the sun is said to be 618,000 times as bright as that from the full moon; but the amount of solar energy derived from the moon is sufficient, we are told, to appreciably affect photosynthesis in the phyto-plankton. The effectiveness of the moon in this photosynthesis is said to be to that of the sun as two to nine, and if that is so, Kofoid is probably justified in his contention that at the time of full moon the additional light available has a marked effect upon the development of the phyto-plankton.

As on land, so in the sea, all animals ultimately depend upon plants for their food. The plants are the producers and the animals the consumers in nature, and the pastures of the sea, as Sir John Murray pointed out long ago, are no less real and no less necessary than those of the land. Most of the fish which man uses as food spawn in the sea at such a time that the young fry are hatched when the spring diatoms abound, and the phyto-plankton is followed in summer by the zoo-plankton (such as Copepoda), upon which the rather larger but still immature food fishes subsist. Consequently the cause of the great vernal maximum of diatoms is one of the most practical of world problems, and many investigators have dealt with it in recent years. Murray first suggested that the meadows of the sea, like the meadows of the land, start to grow in spring simply as a result of the longer days and the notable increase in sunlight. Brandt has put forward the view that the quantity of phyto-plankton in a given layer of surface water is in direct relation to the quantity of nutritive matters dissolved in that layer. Thus the actual quantity present of the substance—carbon, nitrogen, silica, or whatever it may be—that is first used up determines the quantity of the phyto-plankton. Nathansohn in a recent paper[8] contends that what Brandt supposes never really happens; that the phyto-plankton never uses up any food constituent, and that it develops just such a rate of reproduction as will compensate for the destruction to which it is subjected. This destruction he holds is due to two causes: currents carrying the diatoms to unfavorable zones or localities, and the animals of the plankton which feed on them. The quantity of phyto-plankton present in a sea will then depend upon the balancing of the two antagonistic processes—the reproduction of the diatoms and their destruction. We still require to know their rate of reproduction and the amount of the destruction. It has been calculated that one of these minute forms, less than the head of a pin, dividing into two at its normal rate of five times in the day, would at the end of a month form a mass of living mat-

[6] *M. B. A. Journ.*, VIII., 269.

[7] *Ibid.*, VII., 394.

[8] *Monaco Bulletin*, No. 140.

ter a million times as big as the sun. The destruction that keeps such a rate of reproduction in check must be equally astonishing. It is claimed that the *Valdivia* results, and observations made since show that the most abundant plankton is where the surface water is mixed with deeper layers by rising currents. Nathansohn, while finding that the hour of the day has no effect on his results, considers that the development of the phyto-plankton corresponds closely with evidence of vertical circulation. Like some other workers, he emphasizes the necessity of continuous intensive work in one locality; such work might well be carried on both at some point on your great lakes and also on your Atlantic coast. The *Challenger* and other great exploring expeditions forty years ago opened up problems of oceanography, but such work from vessels passing rapidly from place to place could not solve our present problems—the future lies with the naturalists at biological stations working continuously in the same locality the year round.

The problems are most complex, and may vary in different localities—for example, there seem to be two kinds of diatom maxima found by Nathansohn in the Mediterranean, one of *Chætoceros* due to the afflux of water from the coast, and one of *Rhizosolenia calcaravis,* due to a vertical circulation bringing up deeper layers of water. As a local example of the importance of the diatoms in the plankton to man, let me remind you that they form the main food of your very estimable American clam. The figures I now show, and some of the examples I am taking, are from the excellent work done on your own coasts in connection with fisheries and plankton by Professor Edward Prince and Professor Ramsay Wright and their fellow workers at the Canadian biological station, on your eastern seaboard.

The same principles and series of facts could be illustrated from the inland waters. Your great lakes periodically show plankton maxima, which must be of vast importance in nourishing animals and eventually the fishes used by man. Your geologists have shown that Manitoba was in post-glacial times occupied by the vast Lake Agassiz, with an estimated area of 110,000 square miles; and while the sediments of the extinct lake form your celebrated wheat-fields, supplying food to the nations, the shrunken remains of the water still yield, it is said, the greatest fresh-water fisheries in the world. See to it that nothing is done to further reduce this valuable source of food! Quoting from your neighbors to the south, we find that the Illinois fisheries yield at the rate of a pound a day throughout the year of cheap and desirable food to about 80,000 people—equivalent to one meal of fish a day for a quarter of a million people.

Your excellent "whitefish" alone has yielded, I see, in recent years over 5,000,000 pounds in a year; and all scientific men who have considered fishery questions will note with approval that all your fishing operations are now carried on under regulations of the Dominion government, and that fish hatcheries have been established on several of your great lakes, which will, along with the necessary restrictions, form, it may be hoped, an effective safeguard against depletion. Much still remains to be done, however, in the way of detailed investigation and scientific exploitation. The German institutes for pond-culture show what can be done by scientific methods to increase the supply of food-fishes from fresh waters. It has been shown in European seas that the mass of living food matters produced from the uncultivated water may equal that yielded by cultivated land. When aquiculture is as scientific as agriculture your regulated and cultivated waters, both inland and marine, may prove to be more productive even than the great wheat lands of Manitoba.

Inland waters may be put to many uses: sometimes they are utilized as sewage outlets for great cities, sometimes they are converted into commercial highways, or they may become restricted because of the reclamation of fertile bottom-lands. All these may be good and necessary developments, or any one of them may be obviously best under the circumstances; but, in promoting any such schemes, due regard should always be paid to the importance and promise of natural waters as a perpetual source of cheap and healthful food for the people of the country.

W. A. HERDMAN

REFORM IN SYDNEY UNIVERSITY

CONSIDERABLE agitation has been going on for several years in New South Wales for a reform in the constitution and policy of the University of Sydney, and this unrest has at last taken the definite shape of a bill before the legislature of the state. The University of Sydney, founded in the early fifties, can boast of as antiquated a system of government as if it had been in operation for five hundred years. It is governed by a senate, a body corporate consisting of sixteen members who are elected and have a life tenure of office. It pursues a conservative and exclusive policy, making no allowances for the difference between British and Australian conditions. Where there are many colleges, as in America, there is little to be apprehended from the oligarchical government of a few; but where there is but one, as in New South Wales, with a practical monopoly of higher education, the absence of any democratic or social adaptation is severely felt. Sydney University does not employ Australian professors and does not teach Australian subjects beyond necessity. The minor lecturers are Australians who have won the highest honors at home and abroad, but they are not allowed to aspire to the title and office of a professor. A British committee that had been requested to make nominations for a vacant chair recently nominated an Australian, whose name was rejected by the senate in favor of the man named by the committee as its second choice. The second nominee declined in order to show his disapproval of the proceeding, and a third choice became necessary. Again, Australian literature and history offer an attractive harvest, but they are not taught by the University of Sydney; Australian economics fares no better, and the local Australian spirit is not understood.

The amending bill is extremely moderate in its provisions for reform, and by no means satisfies the radical or national party, which in Australia is for practical purposes the labor party. It provides that the government's annual appropriation towards the revenues of Sydney University shall be increased from £10,000 to £20,000; that chairs of agriculture and veterinary science shall be established, the latter chair having been already filled by arrangement between the government and the university; that the fees of students shall be reduced; that the tenure of office of members of the senate shall be limited to eight years, four to retire at the first election and four more every second year until the whole constitution of the body is changed; and finally that the electors shall vote by letter, and that every graduate of the institution over the age of twenty-one years shall be entitled to vote.

It is probable that the present amending bill is but a step in the direction of state absorption of the university. Whatever may be best elsewhere, this is what is needed in Australia. At the same time, it is not to be forgotten that Sydney University has always maintained a high standard of scholarship and efficiency within its aims; that the average salary of its professors is over a thousand pounds a year, representing a higher rate of payment than that of the best of American universities; that in 1907 it had 1,165 matriculated students; that its staff consisted in that year of 15 professors and 68 lecturers, of whom