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Marine Biology in British Columbia

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The problem of Marine Biology in British Columbia is a very extensive one, so much so that it is entirely impossible to give any adequate idea of its scope in a brief paper such as this. There are 7,000 miles of coast in this province, while if the inlets are included, together with the shores of the islands, there is an estimated tide-water line of 25,000 miles. Even the casual observer, who sees the crabs among the rocks and the shellfish in the sand, must associate the idea of such extent of coast line with that of a wonderful fullness of life.

Nor can the shore and shallow water claim a monopoly of all that is of interest. In the territorial waters alone, a depth of 200 fathoms or over is reached in many places. The possibility of bathymetrical variation is thus as great as that due to geographical distribution.

The province affords the richest hunting ground for rare and valuable game in the temperate regions of the world today, and the same is probably true, in an economical as well as in a biological sense, of the British Columbia waters. The Japan Current, the most beneficent of caterers, gathers the choicest morsels from the whole of the North Pacific to furnish the food supply for the inhabitants of these waters, hence the wealth, the prodigality, in variety and in quantity, shown already in the case of the food fishes, but just as true of a host of other forms.

With all this extent and with all this richness, what has been done towards taking advantage of the wealth? Very little. Not that those who have worked have not done their work well, but that there have been so few laborers for so vast a field. The pioneers have hewed out a little clearing and have gathered a harvest of knowledge. The richness of the region is becoming recognized, and already the forerunners of large forces are coming or are here.

Who were these pioneers and what is the value of the work they have done? In any field that is new geographically, if biology is to obtain a permanent foothold, the taxonomist must first be called upon to classify the commonest forms, so that the classes, orders, genera, species, most abundantly represented, may be made known, after which investigators in other branches of the science, knowing what material is

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available, may carry out research work in their own particular lines. But here a great difficulty comes in. So many systematic papers have been published for each class, and even in some cases for each order, of plants and animals, that only those who have made an intensive study of special classes, are at all likely to have literature complete enough to do satisfactory work in classification in that field. What a hopeless task, therefore, it is to undertake to get together the literature necessary for the classification of all marine life. In very few of the world's libraries is there any pretence of doing anything of the kind. Even in many of the largest scientific libraries on this continent there is not literature enough to make it possible to attack successfully even a single class. An investigator in a new field, with only his own library to consult, has little chance to give exhaustive treatment to the classification of a great variety of forms.

How is the difficulty overcome? Only in one practical way, which is by collecting specimens and sending them to authorities for identification. This is what some of the pioneers in B. C. biology did; and in so doing they became familiar with the names, general appearance and something of the life history of such a host of forms that it seems a marvel how their knowledge was obtained and retained. These men are of the type often spoken of as the "old time naturalist." Unfortunately there are too few of them at the present day. Some of them had to depend largely upon their own unaided efforts; but others were supported by such institutions as the Geological Survey and the Natural History Society. Chief among them may be mentioned Dawson, Richardson, Lord, Lyall, Taylor, Newcombe and Macoun. To all of these and to their assistants, the biologist of the present day owes much. All of them are too well known to require any other eulogy than the mention of their names.

In the last decade, the good work started by the pioneers mentioned has been continued under circumstances more favorable than those under which they labored. In 1901, the Minnesota Seaside Station was established at Port Renfrew, on the west coast of Vancouver Island, largely through the instrumentality of Miss Tilden, who, in years previous, had done much alga collecting in the Vancouver Island and Puget Sound regions. Much good work, especially in marine botany, was done at that station. But later Miss Tilden's interest was transferred to the algæ of the South Seas; and no regular work has been attempted since 1907. At about the same time as the Minnesota Station was established, Professor Kincaid of the University of Washington began exploring among the San Juan Islands. At first

this was done largely on his own responsibility; but later the interest of the university authorities was aroused to such an extent that a fine station was established on San Juan Island near Friday Harbor. The interest continued to grow. The co-operation of the biological departments of other universities and colleges has made the expansion very noticeable, until now the institution is largely attended during the summer months and much good work is being done. This is not a B. C. station; but it is so near the boundary that any information obtained from material from the San Juan waters is as useful to us in British Columbia as it is to the State of Washington, and no review of the work done in these waters would be complete without mention of Professor Kincaid, who is one of the most omnivorous collectors of the present day. Five years ago the Dominion Station was established at Departure Bay, near Nanaimo, largely on account of the representations made by the late Mr. Taylor, the first president of this Academy. Since its establishment it has been adding its quota to the biological knowledge of the region. The facilities for carrying on investigations are improving year by year; but more men are needed to make use of the facilities that are afforded. Finally the Provincial Department of Marine and Fisheries has inaugurated a policy of engaging men to carry on research along lines that are largely economic but none the less scientific. Gilbert and Thompson have started in already; and I am credibly informed that provision will be made for others to follow. Besides all of these, the various officers of the Marine and Fisheries Departments, federal and provincial, in connection with their regular duties, have added much to the knowledge of the life history, habits, etc., of many inhabitants of the sea. We know little about their work unless we consult the blue books; but it is of none the less value on that account. The more co-operation there is between men of this class and others engaged in biological work, the greater will be the benefit to both and to the province at large.

While due credit must be given to those who have spent so much time in becoming acquainted with general conditions, it must not be forgotten that much of their knowledge could not well have been correlated without the assistance of the specialists in taxonomy, who gave of their time and their energy to classify material sent them, with little to remunerate them but the love for their work. These should certainly have mention in a review of this nature. A complete bibliography covering the whole field would give the best idea of what work has been done; but that cannot be given in the present paper. It is possible only to mention in a general way something of what has been accomplished. While some biologists, like Whiteaves, for example,

have done systematic work in several classes, the work of each individual has been usually confined to one class, or at most, to one sub-kingdom. Consequently it seems best to consider the sub-kingdoms individually to cover the ground in the shortest time.

I shall begin with the investigators in marine botany. In this the most important work has been done in connection with the Minnesota Station, by MacMillan, Tilden and assistants. Within the last five years Macoun has collected much. Some of this he classified himself, but much of it he sent to Collins for diagnosis. Almost all this work has been done on the algæ. As far as I am aware, no work has been published on the Protophyta.

In the animal kingdom, the same may be said of the Protozoa as of the Protophyta, although a description of some local species is likely to be found in Cushman's "North Pacific Foraminifera." Many of the Protozoa occur in the plankton, which has received some incidental treatment, but no serious consideration. Other species may be found attached to Metazoan species or to seaweed, and hence may have been observed often enough, but only with a passing interest.

The Porifera or sponges are well represented. On these Lambe has done a great deal of work and has published several papers. The collection made by Macoun and assistants for the Geological Survey is at present with von Lendenfeld, who is preparing a report containing a reference to these species.

The Cœlenterate sub-kingdom is very extensive, and has been worked up by classes. In the early days, Hincks and Allman reported on hydroid material collected by Dawson and Richardson. Later Clark, Hartlaub, Nutting, and Calkins published papers on hydroids from these and contiguous waters. I have done some work on these myself, and hope to have a more complete report ready in the near future. Little has been done on the Medusæ, though some B. C. species find mention in papers by Agassiz, Bigelow and Mayer. McMurrich is working on a collection from Departure Bay at present. He has reported on the Actinians also. Apparently the Alcyonarians are not numerous. A description of most of the species is found in the papers by Nutting and Torrey, though they have not been described from these waters especially. The Ctenophores are pretty well covered in papers by Torrey and Bigelow.

In the large Annelid group there has been little done, although there seems to be a great abundance and variety of material. Potts and

Pixell collected at the Departure Bay station in 1911; but I have seen no published report of the results obtained.

Parker's heterogeneous sub-kingdom, the Molluscoidea, has been much neglected. The Bryozoa are very plentiful, but no satisfactory report on them has been prepared. Hincks reported upon some material collected by Dawson in the neighborhood of Queen Charlotte Islands, and Robertson has made mention of some B. C. species in her Pacific Coast papers; but the great mass of them remain untouched. The Brachiopods have received incidental treatment by some of the conchologists, but that is all. Some species of the erratic Phoronid group have been studied by Pixell.

Like the Cœlenterata, the sub-kingdom Echinodermata is very extensive, and is abundantly represented in this region. The Asteroidea or starfish have received a great deal of attention from Verrill, who has an extensive report nearly ready at the present time. Fisher has done and is doing much work in the group, and earlier Whiteaves made some reports. Clark's large work on the "Ophiurians of the North Pacific" includes most of the B. C. species of brittle stars. I know of no papers bearing directly on the B. C. echinoids, which include the sea urchins, cake and heart urchins, although several species are abundant. The same is true of the holothurians or sea-cucumbers; but some of Fisher's papers may include some of the species. The few species of crinoids or sea-lilies are probably all described by Clark.

In the Arthropoda only the Crustacea are marine. Some orders of these have been well looked after; but others have been entirely neglected, the latter including chiefly the smaller forms usually found in the plankton. Smith and Bate have done some general work on the class. Taylor prepared a paper on the Malacostraca for the Marine and Fisheries Report, but it has not appeared in print yet. Rathbun has reported on the Decapods; and the papers by Pilsbury on the Cirripedia or barnacles, and by Richardson on the Isopods, include many B. C. forms.

The Mollusca has attracted more investigators than any other invertebrate group, probably because the region offers so good a field, and because the attractiveness of shells in the gross is more apparent than it is in most of the other groups. The orders in which the shell is not pronounced or is entirely absent, have not received the same attention as the others. The nudibranchs have scarcely been touched, although MacFarland's papers probably cover many of the species. The cephalopods or cuttle-fish have been described by Berry. Among the

conchologists may be included Carpenter, Baird, Lord, Whiteaves, Smith, Taylor, Newcombe, Hanham, Dall and Bartsch.

Coming now to the Chordata, species of *Balanoglossus* have been reported, but I have not seen any of them described. Huntsman has worked up the ascidians, and Macoun has diagnosed the birds. The marine mammals, with the exception of the whales that have been exploited commercially, have received little attention. Naturally, as the fish are of such economic value, much attention has been paid to them; but yet no systematic survey has been made. Most of the species that have been procured have been taken accidentally, or at best, incidentally, in connection with the fisheries for commercial food fish. Among those who have contributed to the ichthyology of B. C. are: Lord, Bean, Jordan, Gilbert, Gill, Evermann, Snyder, McMurrich and Taylor. Taylor's paper has not yet been published. Many of the Fisheries Reports give valuable information on this group, in connection with life history, distribution and economic value.

This list, incomplete though it is, will indicate the widespread interest that has been set up and maintained on the basis of the work done by a few naturalists who prosecuted their labors with such zeal when encouragement and appreciation were sadly lacking. Although the possibilities for investigation are without limit, a beginning has been made, and many problems appear right to hand, waiting to afford results to any and all who will attack them with real desire for accomplishment. Some of these that most readily suggest themselves may be mentioned, not necessarily in the order of their importance.

A general biological survey is very much needed. Heretofore, owing largely to lack of facilities, observations have been made here and there, at points isolated from one another, without any system or co-operation. If all the forces now at work would come to some agreement in that regard, much might be done in a general way in a short time. If a survey were made it would be possible to find out what special localities would be best suited for carrying on particular investigations, so that the time now lost in wandering around looking for material, might be put to a better use. The distribution of all the common forms would be made known, and many forms of value, hitherto untouched, would be discovered. This would entail more taxonomic work in adding species to the lists in the classes already studied, and in making out lists in classes hitherto neglected. The survey, as far as it has been carried at present, has been largely in connection with littoral forms and those that can be obtained in 30 fathoms or less. The plankton, in its way, offers just as rich a field. That the most of the

species are microscopic does not detract from their importance. The protozoa, protophyta, eggs, larvæ and such small crustaceans as the Copepoda, Ostracoda and Cladocera, are of interest in their morphological relations, and also because they form the food material, directly or indirectly, for the great mass of marine life. Quantitative and distributional research on the plankton should hence be of great value. Of the larger forms, your attention has been called to the classes that have been most neglected. The lists of Bryozoa, Nudibranchs, Annelids, etc., should be made as complete as in the classes that have received the greatest attention; while many others should receive important additions. Even among the fish, the chances are that there are many species, some of them common enough, that are not known. Tide pool and shallow water forms, except in a few localities, have scarcely been touched; and the bottom forms have not received due attention. When the distribution of the common species is known, it will be an easy matter to get material for investigators in other branches of the science: the physiologist, the biochemist, the experimental zoologist and botanist, the morphologist, the comparative anatomist, the embryologist and the ecologist will all find something to do. Enough is known already to start all of them going; but with a complete survey they would have a chance to do much better work.

In the working out of heredity problems, the cœlenterates and the echinoderms have received a great deal of attention. I believe I am correct in saying that nowhere along the shores of this continent at least, can be found greater numbers or a better variety of these two classes than can be found in these waters. The sea-urchin has been a favorite for experiments in fertilization. We have in abundance two species suited for such work, the smaller green urchin, *Strongylocentrotus drobachiensis*, and the large purple one, *S. franciscanus*. Experiments concerning the effect of controlled stimuli have been tried extensively on the starfish. There is scarcely anything more common along the coast than the starfish; and if one species does not prove satisfactory, there is a large enough variety to choose from. The anemone has been used for similar experiments. It would be impossible to find *Metridium* more plentiful than it is on some of the rocks in the Gulf. A species of *Anthopleura* and several others beside are more or less abundant. Co-ordination experiments have been tried on medusæ. *Gonionemus murbachi* has been the great favorite for these at Wood's Hole. *Gonionemus vertens*, which may or may not be the same species, is much more abundant in the Gulf of Georgia than the Atlantic species is at Wood's Hole. Many other genera are well represented. Regeneration experiments have been tried on hydroids; and they have been used

in heredity problems. We may even say that Weissmannism is founded largely on the results obtained from the study of that group. We have them in plenty. I might quote one case in corroboration. In one haul of a two-foot hand dredge, down less than five minutes, in Northumberland Strait, I obtained 36 species, a number more than one-third as great as that which represents all those obtained within a day's trip of Wood's Hole in 30 years. (I mention Wood's Hole because in all probability there has been more work done there than at all the other stations on the continent combined.) Enough has been said to indicate that the experimental zoologist need not remain idle, and on the same basis there are plenty of possibilities for the physiologist and biochemist.

The morphologist and the embryologist will find plenty of scope in working on life history. When it comes down to the facts of the matter, the life history of comparatively few of the myriads of species, here or elsewhere, is known. This is particularly true of marine forms. In the case of those that live continually in the deeper water, it is a very difficult matter to find out much about them; but even the littoral and shallow water forms are very little known. One reason for this is, that owing to the exigencies of climate, it is hard to keep track of even the most conspicuous forms throughout the year. This is the very reason why scarcely any locality in the temperate zones affords so satisfactory an opportunity to study life history as our own. There is nothing to hinder the work being carried on throughout the year; and the species are so numerous that there is no danger of ever running out of a supply, because every species, no matter how much it is like its nearest of kin, has some special feature in its life history that, when known, will help to unravel the great skein of relationship in which every biologist has a deep interest.

The study of life history has a great economic value in some cases. It has been and is very necessary in the case of food fishes. Much work has been done on the various species of salmon, in connection with the hatcheries for the early stages, and by McMurrich and Gilbert for the adults; but much still remains to be done before even an approximately complete knowledge is obtained of the whole life cycle. Other fish have scarcely been studied at all. Even from a dollars and cents point of view, it will surely pay to undertake such work. When last year, with fish value of over thirteen and a half millions, British Columbia easily led the provinces of the Dominion, is it not worth while to find out something as to the life history and habits of at least the principal species that go to produce such a value? Millions of herring are caught

in a single night; but nothing is known of the why and the wherefore of their migrations. If there is any danger of overfishing, should it not be known? If there is no such danger, the best methods of fishing and curing should be introduced. Halibut is brought into market, but little is known concerning it except that it can be caught on certain banks at certain times. This lack of knowledge is even more decided in connection with other flat fish. Now that trawling has a good chance of becoming a large factor in the fishing industry, with the British Columbia Fisheries Company already operating successfully off Skidegate, and the Canada Fish and Storage Company of Prince Rupert with two boats ready to start and more on the way from Grimsby, an excellent chance is now afforded for research in that interesting group. A careful search might reveal further that there are many species of good food fish readily available which at present are receiving no attention whatever.

While speaking of economic value, other cases may well be considered; because the fishes have not a monopoly of commercial value. Everywhere, reaches, tide-flats and beds of sand and gravel, make suitable abiding places for innumerable shellfish. Even at present their commercial value must be taken into account. But that value is as nothing compared with what it might be. Dr. Stafford, after working on the oyster for some time, came to the conclusion that not only could the large eastern oyster thrive in the waters of Vancouver Island, but that it could reproduce in these waters. Many attempts have been made farther south to get them to reproduce, but I believe in no case have the experiments met with success. Oyster farming such as is done in Japan, in some parts of Europe, and even in some parts of the Eastern United States and Canada, is a very profitable venture. There seems no reason why it should not be so here; but further experiments must be made before success as a commercial venture is assured. But the oyster is not the only valuable shellfish. Various clams and scallops are very desirable as food, while cockles, mussels, limpets and other similar forms are considered great delicacies in various parts of the world. The provincial department is going into this matter; it has shellfish jurisdiction now, and has set Mr. Thompson at the problem of distribution and extent of the beds of the edible forms. He has sent in a preliminary report on his work of last summer, and will continue the work next summer. Experiments as to edibility, food value and life history of many of these shellfish would add much to the value of the work now in progress.

What has been said as to the study of shellfish may as truly be said of crustaceans. Many crabs are caught in some localities; but the

marketing of them can scarcely be called an industry here, though there seems no reason why it should not be. If one visits the fish markets of New York or Boston, he gets an idea of what a prominent place the various crabs occupy as food material in the East. Why should it not be the same in Vancouver or Victoria? The shrimp industry is of great importance in the State of Washington. It is possible that a thorough search would reveal just as good shrimp ground in the B. C. waters as in the waters but very little farther south. The species caught for market are certainly found farther north in the Gulf. Are they there in large quantities? As far as appearances go, the conditions seem favorable for the growth of lobsters along many parts of the coast. A feeble attempt was made to introduce them some years ago, but as there were no special arrangements for their care, no one knows whether any of them lived or not. Such experiments as these require strict and continued attention for years before a satisfactory conclusion can be reached.

Another problem that affects the fisherman from a different standpoint may be mentioned. The dogfish is a great nuisance to nets and lines. The dogfish of the Pacific is much like the dogfish of the Atlantic. The biochemist has made it possible to get value out of the Atlantic dogfish: he should be able to get similar value out of the Pacific species. At several points in the Maritime Provinces to the east, reduction works yield profit from oil and fertilizer. There is room for some such in the Maritime Province of the west.

While we have the biochemist, there is another problem, a large one, that we wish him to attack. Owing to the amount of fresh water that is poured into the sea by rivers, great and small, there is much variation in the salinity of the water at various points, all the way from the high percentage of the regular ocean water to the brackish or even fresh water at the outlets of the rivers. In the case of large rivers, the influence of the fresh water may extend a long way. The water of the Fraser crosses the Gulf, on the surface at least, to Gabriola, Valdez and Galiano Islands. How does this variation in salinity affect the forms that come in contact with it? Are there species peculiar to each degree of variation? Are there variations in the same species? Or can any difference be noticed? There may not be much difference in the freely swimming forms, but experience indicates that there may be much difference in sessile or slowly moving forms. Nowhere can greater variety in salinity be found than here, hence nowhere can the problem be studied to greater advantage. It has its economic value also; for a slight difference in flavor in an edible species may make

the difference between commercial failure and success. The problem is not confined to animals. It has an even greater bearing on marine plants, as a greater percentage of these are sessile forms.

Hitherto I have said little directly about plants, but the most of what I have said applies to the flora as well as the fauna. Animal life is dependent on plant life, directly or indirectly, for food material; hence it is just as necessary to obtain a knowledge of the nature, extent, and distribution of plants as of animals. In both cases the relation of each species to its environment and to other species forms a large and important problem in itself.

From an economic standpoint there are two problems at least, that loom up large in connection with marine plants. In some parts of the world, an important industry has been established in obtaining iodine and its compounds from seaweed. The seaweed is in abundance everywhere here. It might be worth while experimenting as to the possibility of obtaining these substances in quantity enough to be of economic value. Experiments have been conducted, with how much success I am not prepared to say, on the Pacific Coast of the United States, with the idea of obtaining potash from kelp. If that can be done profitably, there are large enough beds of *Nereocystis* growing on the reefs every year to provide any amount of raw material.

It is quite true that financial assistance is needed to supply the facilities to cope with these larger economic problems. They need government backing. In these days when every progressive government the world over is becoming more sympathetic towards scientific endeavor, more cognizant of the results of scientific investigations, the federal and provincial governments are sure to give due consideration to any feasible plan to advance such work. It is only reasonable that they should ask for men who will get results before they will give much encouragement. A call that has often been issued must be taken up once more, a call for men, men full of scientific spirit, willing to attack with patience and zeal the manifold problems of so rich a field. Apparently we must depend on university trained men, and there are not enough with interest in such work, available. In Britain, as in many of the older countries, the professional man and the artisan often take up the study of some science as a hobby, and do some very valuable work. In Canada and in the United States, "gross materialism" seems to crush out all desire for any hobby that has not to do with the making or spending of money.

It is the duty as well as the privilege of this Academy, by every means at its command, to foster a desire to have this work done with the greatest possible despatch. Every member, besides being fully informed of the needs of his own particular branch of science, should take a sympathetic interest in all the other branches. Doubtless he does so. In considering marine biology, this discussion may help to give further insight into the possibilities for profitable research. If your interest is aroused, show it by placing the situation fairly before others who by their personal efforts or by their influence, can give valuable assistance, and by giving encouragement to those who are already engaged in the work.



