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Author

A. Brooker Klugh

THE UTILIZATION OF THE ALGAE OF THE BAY OF FUNDY.

A. Brooker Klugh.

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The algae (seaweeds) of the Bay of Fundy are a potential resource which as yet has scarcely been tapped. The use which has, up to the present time, been made of the rich seaweed flora of this region is limited to the use of some of the larger algae (the Rock-weeds - i.e. the various species of Fucus and Ascophyllum nodosum) as fertilizer, usually along with "Mussel mud", for farm lands, and the collection and preparation of a comparatively small quantity of Dulse (Rhodymenia palmata) as food material. Since the Dulse industry is the only algal industry of any importance in Canada, and since this is confined to the Bay of Fundy, it seems advisable to give some data on this industry before passing on to the consideration of the possible development of some of the potential algal resources of this region.

Dulse, in the dried condition, is a confection, rather than a staple food, -- that is, it is something which is eaten in small quantities between meals, rather than furnishing a part of a regular meal. Furthermore, it is appreciated as a confection only by residents of the Maritime Provinces, and is not relished at all by the inhabitants of the inland portions of the Dominion. Whether the taste for Dulse could be developed as an acquired taste - in a manner similar to the taste of olives, which is also undoubtedly an acquired taste - among a wider clientele is a matter which only a long-continued trial and extensive advertising could determine and it is extremely doubtful if the cost of such a campaign could be norne by this relatively small and local industry.

From the table of statistics of the landings of Dulse given herewith it is obvious that the preparation of Dulse is practically confined to the island of Grand Manan, with a small, and somewhat sporadic, development of the Dulse industry in Annapolis County, Nova Scotia. On Grand Manan the industry is carried on almost entirely on the north side of the island. At Dark Harbour there were, in 1931, twenty-five Dulse pickers, at Indian Beach, eight, and at Whale Cove eight. At Indian Beach and Whale Cove there are settlements, but at Dark Harbour the pickers camp out while engaged in gathering Dulse. The plants can be gathered at any low tide, but really good picking can be done only at the very low tides each month. The prices paid the pickers range from seven to twelve cents per pound and an average picker can make from $30 to $40 a week. Such money can be earned only during the times of the very lowest tides. A good picker can gather about a hundred and fifty pounds during a single low tide.

In order to be of prime quality Dulse must be dried in a single day. Good drying days - that is days of clear sunshine and dry northerly winds - are not frequent on the Bay of Fundy, and are still less frequent on Grand Manan where fogs are extremely prevalent. If the conditions for drying are not favourable at the time of gathering the Dulse may be kept in bags in the sea for three days, but not for a longer period, as if kept longer than this in masses it becomes pale and mottled with greenish spots. Consequently much Dulse is greatly impaired in quality by the delay of suitable weather for drying. It would seem as if artificial heat - in the form of some type of kiln - might be employed for the drying of Dulse, but Captain Andy Nelson, who has had considerable experience in the Dulse industry, informs me that such trials of artificial heat as have been made have not yielded a product of good quality. This, it seems to me, may be due to the fact that the moisture from the drying dulse has not been carried off, and that currents of hot, dry, air, playing over the Dulse - the latter being laid out in thin layers - would probably yield a first-class product. It is a question, however, if the price obtained for the finished product would warrant the cost of the installation and operation of the machinery necessary for such a method of preparation.

The utilization of marine algae as food in Canada is, as we have seen, confined entirely to the limited use of a single species, Dulse. This is far from being the case in many other countries, and it may be of some value to point out the manner in which various species of algae - either the same species, or species closely allied to those of the Bay of Fundy - are used in these countries.

In Scotland and Ireland the red alga Porphyra laciniata is used along the coast. In the former country it is called "laver" and is served boiled with milk, while in the latter country it is termed "sloke" and is boiled, and served with butter, pepper and vinegar as a dressing for cold meat. Species of Porphyra are abundant on the coasts of Fundy.

In several European countries, and in the State of Massachusetts, Irish Moss, Chondrus crispus, is gathered and dried to be used in the making of jellies and blanc mange. The "moss" is either gathered by hand, or by means of rakes used from boats, and the season of gathering is from May to September. When brought ashore the plants are washed in salt water and spread on a sandy beach to dry and bleach, being raked up, washed, and spread out again, three or four times. After the last washing the fronds are left to dry for about two weeks, if the weather is favourable, and longer if it is not. Towards the end of the drying period it is important that the crop be protected from rain, as if it becomes wet in these later stages of drying it is ruined. Consequently, when bad weather seems to be setting in the fronds are raked into heaps and covered with canvas. Chondrus crispus and Gigartina mamillosa - a species which appears to be equally good as a source of jelly-like material - are common in many localities on the rocky coasts of the Bay of Fundy.

If we wish to see the maximum use which can be made of marine algea as food we must turn to Japan, in which country algal products are staple articles of diet.

The algal products which are used in Japan are quite numerous, but of these none is more important than "Kombu", which name the Japanese apply to the various kinds of food made from the kelps. The kelps are large olive-brown algae, of which numerous species, occur in the Bay of Fundy, and which are, in this region, often very abundant on suitable rocky shores. The genera Laminaria and Alaria, which are the chief sources of "Kombu" in Japan, are the commonest genera on our coast. In Japan the kelps are collected by means of hooks of various kinds which are used from open boats.

The best description of the preparation of "Kombu" which I know of is that given by Hugh M. Smith, Deputy U.S. Fish Commissioner, in the Bulletin of the U.S. Bureau of Fisheries Vol. XXIV, from whose report I quote with some abbreviations, the following.

When the boats return to shore the kelp is carefully spread on the beaches in the vicinity of the villages and left there until thoroughly dried. The curing accomplished, the plants are taken indoors and prepared for shipment. Plants of the same size and quality are tied together into long bundles of rather uniform size and these bundles are sent by water to the kombu manufacturers.

The forms in which kombu is made ready for consumption number a dozen or more. Some of the preparations are not pleasing to the taste of the average foreigner, but others are highly palatable and ought to prove very acceptable to Americans and Europeans.

Shredded or Green-dyed Kombu. This is one of the most important preparations of kombu, being largely consumed at home and also extensively exported. The steps in the manufacture are as follows-

(1) The dried kelp is immersed in large, covered, iron kettles, containing a strong solution of a dye in fresh water. A wood fire is kept under the kettles, and the solution is maintained at a boiling temperature, the kelp being left therein for fifteen or twenty minutes and stirred from time to time.

(2) The dyed fronds are drained and then taken into the open air, where they are either spread on straw mats or suspended on poles to dry.

(3) When drying has proceeded to a point where the surface of the kelp is no longer wet, the fronds, taken one at a time and carefully spread, are rolled into wheel-shaped masses about a foot in diameter, in order to facilitate subsequent handling. The rolls are tied by ropes to keep them in shape, and then go to the women, who unroll the fronds one by one and arrange them flat in wooden frames, making a pile one and a half feet high, five or six inches across, and the full length of the fronds. Each pile is then tightly com-

pressed by four transverse cords, and cut into four equal lengths, each held by a cord.

(4) The cut pieces are then arranged by hand in a rectangular frame four to five feet square, its thickness corresponding to the length of the sections of seaweed. When the frame is filled by the evenly arranged pieces, which are sprinkled with water in order that they may pack more closely, the whole mass is compressed by means of ropes, wedges and levers. One of the side boards forming the frame is then removed, the frame is supported at a convenient height and tilted at a convenient angle, and the kelp is reduced to shreds by means of a hand plane, which cuts the fronds lengthwise along their edge.

(5) The shredded kelp is spread on mats or on board platforms in the open air and repeatedly turned to secure uniform drying. When the surface has become dry, but the interior still retains its moisture as shown by the pliability of the shreds, the shavings are stored under cover and are ready for packing and shipment.

Those species of kelp with the thickest and widest fronds are often dried with special care, so that they will lie flat and smooth. The various grades of kombu, as will be seen, simply represent successive steps in the preparation of the kelp, one frond yielding a sample of each variety of kombu.

(a) The entire frond is dipped in vinegar until thoroughly soaked, then drained and dried in the open air. The vinegar softens the frond and leaves it pliable, it also imparts a flavour and doubtless has a slight preserving effect.

(b) With a raw-edged knife shaped like a mince-meat chopper the epidermis is scraped from both sides of the frond. This outer skin is the cheapest grade of kombu.

(c) The scraping is continued with a raw-edged knife, and a fine white, stringy mass results, which is known as white pulpy kombu.

(d) A sharp-edged knife is used after the green coats are removed, and the scrapings then take the form of exceedingly thin and delicate filmy sheets of irregular sizes, which preparation is known as filmy kombu.

(e) The remaining central part of the frond, now very thin, is pressed into bundles with similar pieces, divided into equal lengths, and with a plane cut edgewise. These shavings resemble coarse hair and the preparation is called white-hair kombu.

(f) Fronds from which the outer green skin has been more or less completely removed are often cut into small pieces of various shapes - strips, squares, oblongs, fans, etc. - which are then dried over a fire and made crisp, the long strips being frequently tied into peculiar loose knots. These pieces are placed on the market in this form and are then known as "dried-on-the-fire kombu"; or they may be coated with a hard white or pink icing and called "sweet-cake kombu".

(g) The dried pieces mentioned above are sometimes pulverized and put through a fine wire sieve, yielding a fine slightly greenish or grayish flour. These powdered preparations are called "finely-powdered kombu" and such powders are compressed into small cakes of various shapes and coated with sugar.

(h) A form of kombu known as "tea kombu" is prepared by taking fronds which have been subjected to the first scraping process, reducing them to shreds by planing, and, after drying, cutting the shreds into half-inch lengths comparable to the rolled leaves of green tea.

Another algal product which is of considerable importance in Japan is "Kanten", which is made from algae of the genus Gelidium, This product is very similar to that made from Chondrus crispus - a jelly-like matrix - but it is much more extensively used in Japan than the corresponding algal product is used in North America.

Marine algae have been used for the production of iodine at various times and in several countries - Scotland, Ireland, France, Japan - but the industry has proved neither very profitable nor permanent, so that, though the kelps which have been chiefly used in the production of iodine, are abundant in the Bay of Fundy an attempt to produce iodine in this region cannot be advocated.

From the above it can be seen that there are several ways in which the potential value of the algae of the Bay of Fundy might be developed.

In conclusion I wish to thank Captain Andy Nelson, Professor H. B. Hachey and Mr. John Stevenson for information concerning the Dulse industry.

[illegible]

Cwt. of "Green" Dulse. (Dried dulse weighs 1 7 of green).

B I O L O G I C A L B O A R D O F C A N A D A

No.	Locality	Date	1929	1928	1927	1926	1925	1924	1923	1922	1921	1920
1	Charlotte Co.											
2	International Boundary to St. George (net)						2660					
3	St. George to Back Bay											
4	Back Bay to Red Head				1120							
5	Red Head to Lepreau											
6	Grand Manan		7700	2450	1750	5186	1140	4480	8015	240	5040	
7	Campobello											
8	West Isles											
9		Total	7700	2450	2870	5186	3800	4480	8015	240	5040	
10												
11	Annapolis Co.											
12	Digby Co. to Annapolis											
13	Annapolis to Victoria Beach		48	45								
14	Victoria to Parket Cove			25	74	76	1120				1200	
15	Port Lorne to Kings Co.			6								
16		Total	48	76	74	76	1120				1200	
17												
18												
19												
20												
21												

In earlier statistics Dulse is included together with crabs cockles and other shellfish.

The Ecology of the Algae of the Miramichi Region, New Brunswick.

by

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The region covered by this report is from Redbank, at the head of the tide on the North-west branch of the Miramichi river to Escuminac point, Lat. 47°5' N., Long. 64°50'W.

The rock of the region is sandstone, and the shores and bottom are largely sand.

The Miramichi river and Inner Miramichi bay are very shallow, the deepest part of the river being 14.6 metres, and the deepest part of the bay 20.13 metres in the channel between Vin island and the mainland. The average depth of the inner bay is only 5 metres. Outer Miramichi bay is also shallow, the deepest part being only 10 metres.

Considered from the standpoint of its Algal flora the region is not rich in species, and there is a marked paucity of the larger Phaeophyceae (Brown Algae) and Rhodophyceae (Red Algae). The reason for the poor development of Phaeophyceae is undoubtedly due to unfavourable conditions of density and temperature, as I shall show later, and the scarcity of even stunted specimens of both Phaeophyceae and Rhodophyceae is due to the absence, over most of the area, of suitable places for attachment. As previously mentioned the bottom is predominantly sand, the occurrence of ledges of rock, or even of beds of shingle or boulders, being rare, and such a condition furnishes but few habitats for the larger marine Algae.

A marked characteristic of the region is the abundance, both of species and of individuals, of Enteromorpha. Further than this the region presents a large number of variations in the same species of Enteromorpha, these variations being, as I shall show later on, directly related to ecological conditions.

Not only is the Miramichi region very interesting ecologically, but in the course of my work I came across three new species of Cyanophyceae which I have described in Contributions to Canadian Biology, 1918-20.

Polymorphism.

During the course of my work on the algae of the Miramichi I discovered a well-marked case of ecological polymorphism.

The subject of polymorphism has received a good deal of attention from algologists, and a considerable literature has arisen in regard to this matter, some of it of a very controversial nature. The idea of polymorphism in the algae was first put forward by C. A. Agardh in 1829, and Kützing ('41) Borzi ('83) and especially Hansgirg ('85) claimed that most of the Cyanophyceae and Chlorophyceae were polymorphic, and that the simpler forms of these groups were only developmental stages of higher forms. Hansgirg set forth his conclusions in the form of several "theses", the most important of which were as follows:-

Thesis 1. Most of the Cyanophyceae, if not all, are polymorphic Algae, which in different stages of growth, assume unicellular vegetative forms, and often retain these forms through many generations.

Thesis 2. Most, if not all, of the forms hitherto classed with Chroococcaceae, as the genera Chroococcus, Gloeocapsa, Aphanocapsa, Gloeotheco and others, have a connection with other more highly developed forms.

Thesis 7. Many of the Chlorophyceae are polymorphic Algae. Most of the filamentous forms such as Microspora, Conferva, Rhizoclonium, Ulothrix and Schizomeres stand in close relation to the higher forms of the families Chaetophoraceae, Siphonocladiaceae, Ulvaceae and others, which forms are produced by a widening of the single filaments and dividing longitudinally, thus gradually producing leaf-like forms. On the other hand by the separation of the parts and division of the cells in one, two, or three directions, most of the so-called unicellular Green Algae are produced, embracing forms of Protococcus, Dictyosphaerium, Apiocystis, Palmella, Pleurococcus, Gloeocystis, Characium and others."

Wolle in his "Fresh-water Algae of the United States", 1886, declares himself a strong adherent of the idea of polymorphism. In his preface he says "The subject-matter is in an unsettled state, passing through a period of transition. There is an Old School and a New School. The former accepts all forms as distinct species, the latter rejects a large portion of the forms, mostly unicellular, as only conditions of development", and his "Introduction" is largely a citation of the views of prominent algologists in favour of polymorphism.

There is not the slightest doubt but that the generalizations of Hansgirg, Kützing and Borzi were far too sweeping and that they were in many cases founded on insufficient evidence. It was the swing of the pendulum from the idea of the absolute constancy of species to that of wide polymorphism, and, as is usually the case, the truth lay between the two extremes.

Cienhowshi ('76) showed that certain species of Stigeoclonium were polymorphic and had a Palmella-stage.

Livingston (1900) confirmed Cienkowski's work on Stigeoclonium, and showed that in solutions of high osmotic concentration S. tenue took on the rounded Palmella-form, while in solutions of low concentration it became filamentous.

Kützing, Itzigsohn, Kirchner, Hansgirg, and other earlier students did not work with pure cultures, but relies entirely upon observations of collected material. The method of growing isolated species of algae or agar, and other culture media, was introduced by Klebs, and was carried on by several algologists, notably Beijerink of Germany and Chodat of Switzerland. Chodat in his "Etude Critique et Experimentale sur le Polymorphism des Algues", 1909 gives a resumé of the whole matter of polymorphism in this group and presents the results of his own experiments. That Chodat recognizes that the method of pure cultures cannot be entirely relied upon in interpreting what takes place under natural conditions is shown by his statement (op.cit. p33) "Dans cet exposé nous attributerons dans le mesure du possible une importance equilibree aux observations faites au moyen de cultures pures at a celles faites directment dans la nature lorsque l'observateur y aura pu suivre pas a pas l'evolution ontogénique d'une algue". Chodat found that some algae exhibited a high degree of variability, but he did not find such extensive polymorphism as that proclaimed by Hansgirg and Kützing. In his conclusion he sums up his results as follows:- Il y a certainment des Algues qui par leur extreme variabilité méritent le nom de polymorphe, si par ce nom on entend exprimer qu'une plante peute se présenter sous plusier aspects sans changer de nature" and "Nous ne croyons pas qu'il soit justifé de parler d'une maniere génerale d'une théorie du polymorphisme des Algues"

Rayss (1915) shows that Coelastrum proboscideum is highly polymorphic. Pure cultures, grown under diverse condition, exhibit typical coenobia, botryoidal colonies with rounded or pointed cells, and isolated cells of the form typical of Chlorella or Polyedrium. Analagous stages were found in plancton material. Experiments proved that coenobia predominate in media of low concentration and of relatively high temperature, while high concentration, low temperature and low oxygen content give isolated cells.

G.S.West, (1916) asserts that "The amount of polymorphism in the group (Cyanophyceae) is really very small", and that the idea that the Chroococcaceae were only developmental stages in the life-histories of higher forms were "only assumptions based on crudities of observation", and further that "to a skilled observer with a thorough taxonomic knowledge of the group, there is rarely much difficulty in discriminating between the developmental stages of the higher types and the unicellular or colonial plants of a lower type". Concerning polymorphism in the Chlorophyceae West (loc.cit.p.145) says that "most of these statements" (i.e. in favour of polymorphism)" are assumptions which are not supported in any way by modern scientific evidence, and they have been in large measure due to misjudgment and lack of precise methods of investigation. The evidence rested in nearly every case on the occurrence together in one habitat, perhaps even in one matrix, of many different algae in various stages of growth. There is a great similarity between certain stages of widely separated species, and since they may be commingled in one stratum or mass, very exact methods are required to unravel the separate lifehistories", and "The methods of pure culture simply clinched the arguments for the stability of algal species".

From the above quotations it is clear that West is inclined to relegate polymorphism to a very unimportant position in algological considerations, yet he gives considerable list, viz, "The Protoderma-state of <u>Protococcus</u>, the Dactylococcus-state of <u>Scenedesmus obliquus</u>, the Palmella-state of <u>Chlamydomonas</u> and of certain species of <u>Ulothrix</u> and <u>Stichococcus</u>, the Hormidium- and Schizogonium-states of <u>Prasiola</u> and the Gongrosira-states of <u>Cladophora</u>" as being "among the few definite examples" of polymorphism.

We have seen that Chodat recognized the necessity of observations of algae under natural conditions as a check upon the results obtained by pure cultures. West (loc.cit.p.146) says "If the cultures are carried out under conditions which are nearly natural, very valuable results often accrue, but cultures in sugar solutions and on gelatin or agar require the most careful interpretation. Some Green Algae are much more plastic than others, but even the least susceptible members of the Protococcales are generally profoundly modified when grown under such abnormal conditions."

At various points in the Miramichi region where the salinity of the water was low, that is where the total salts per mille varied from zero to 8.35 with the ebb and flow of the tide, I found a filamentous green alga, shown in Fig. 4, which resembled a species of the family Ulotricaceae, but which did not agree with any described species of this family. After examining thousands of specimens from different habitats I was able to trace its connection with <u>Enteromorpha crinita</u>, a tubular, much-branched alga which is very abundant in this region. It proved in fact to be a developmental form of this species, but further than this I found that in water of low salinity this stage was as far as <u>E.</u>

crinita proceeded in the course of its development. This monosiphonous form is evidently self-perpetuating. Further data on this ecological polymorphism in *Enteromorpha crinita* will be found in a paper by the writer ('22) and under *E. crinita* in the list which follows.

Comparison of the Algae of the Miramichi and the Bay of Fundy.

Having a fairly intimate knowledge of the distribution of the Algae of the Passamaquoddy region, bay of Fundy, and of the Algae of the Miramichi, and since data on the densities and temperatures of the water of both regions are now, through the work of the Biological Board of Canada, available, I thought that a comparison of the Algae of the two regions, and of their environment, might reveal something of interest ecologically.

An out-standing feature of the algal flora of the Passamaquoddy region is the abundance and the luxuriant growth of the larger Phaeophyceae - the Laminariaceae and Fucaceae, while in the Miramichi region the species of these families are few and the individuals are depauperate. With the type of bottom - sand and silt - which occurs over most of the Miramichi region an abundance of these Phaeophyceae is not to be expected, but unless there is some other factor, or factors, which inhibit their full growth, there is no reason why they should not reach full development in such places as provide a suitable bottom. Such a bottom - rock-ledges and boulders - is found in the Miramichi region off Escuminac and at Pt. au Car, yet the Phaeophyceae growing at these places are extremely small.

The main factors affecting marine Algae are light, density and temperature of water currents and character of substratum. The latter factor we have discussed. Light will not be a decisive factor except in water of some depth and where tidal fluctuations are small. Currents opperate in two ways, mechanically by force of flow and in the case of tidal currents by bringing about a change of density with the flood and ebb in habitats situated in the estuaries of rivers. The mechanical effect is important in the case of plankton forms, and in the case of delicate forms, but the ordinary rate of current, nor indeed even the high speed of such a current as flows through Letite passage out of Passamaquoddy bay, (approximately 10 kilometres per hour at its strongest), has no effect on the large Phaeophyceae. Moreover the conditions of light and current are much the same in the habitats we are discussing in the two regions.

This leaves us two factors - density and temperature - to consider. Copeland's stations Nos 20, 41, 42, 50, 51, 53, and 54, around Deer island in the bay of Fundy are situated at places where there is a very luxuriant growth of Laminariaceae. At these stations the temperatures for July and August at a depth of 10 metres range from 9.75°C to 11.5°C., while the densities at these stations range from 23.5 to 24.9. At "Prince" Station No. 77 in Outer Miramichi bay the temperatures for July and August at a depth of 10 metres range from 8.13°C. to 15.79°C., and the densities range from 20.30 to 23.92. The conditions of temperature and density of Station No. 77 will prevail off Escuminac, the location of depauperate forms of Laminaria.

From the date just presented we can draw the conclusion that it is either the difference in temperature between 11.5 and 15.79°, or the difference in density between 23.92 and 24.9 which is the criterion in deciding the development attained by the Laminariaceae. That it is not the difference in temperature is shown by the fact that at Copeland's stations Nos. 6,7,8, and 9 the temperatures range only from 9° to 10°C, and at these stations the development of Laminariaceae is poor. The densities at Copeland's stations 6,7,8, and 9 range from 21.4 to 23.5, o or almost precisely those of Outer Miramichi bay.

From this comparison I think we are warranted in drawing the conclusion that the minimum density which will permit the full development of Laminariaceae - such species as Laminaria digitata, L. longicruris, L. saccharina, Alaria esculenta, Agarum turneri, and Sacchorhiza dermatoidea - is 23.5.

That there is a difference in the requirements for perfect metabolism among the different species of Laminariaceae is undoubtedly true. In fact evidence at hand shows that Laminaria saccharina does not require water of as great a density as the other species mentioned above; it goes farther up the estuary of the St. Croix than the other species and it is the only species which reaches even a fair size in Miramichi bay.

With regard to the other group of large Phaeophyceae - the Fucaceae - we find an extremely luxuriant development of Fucus vesiculosus and Ascophyllum nodosum in the bay of Fundy at temperatures ranging from 9°C to 11.5°C, and at densities ranging from 21.40 to 24.9. We find a fair development of these same species in the estuary of the St. Croix at 9° to 10.5°C, and at densities ranging from 17.0 to 23.5.

In outer Miramichi bay there is a fair development of Fucus vesiculosus at temperatures ranging from 8.13°C to 15.79°C, and at densities ranging from 20.30 to 23.92, while in Inner Miramichi bay this species exists, but in an extremely depauperate form, at temperatures ranging from 14.05°C to 15.94°C, and at densities ranging from 15.93 to 17.89. The development of Ascophyllum cannot be compared as I did not find it in the

Miramichi Region.

From these data we can conclude that Fucus vesiculosus requires a temperature lower than 12°C and a density greater than 17.00 for its full development.

Naturally many species of the bay of Fundy, such as Halosaccion ramentaceum, Dictysiphon hippuroides, Sacchoriza fuscum blytti, which require water with a density greater than 23.5 do not occur in the Miramichi region.

Distribution of the Algae of the Miramichi Region by Stations.

In presenting the following data on the distribution of the Algae of the Miramichi I group the different locations at which Algae were collected under the "Prince" Station nearest to them, and give the range in temperature and salinity for June, July and August for that station. The data for salinity are given in the form of grammes of total salts per litre, otherwise expressed as grammes per mille, or S‰. I abbreviate temperature to T. and salinity to S. The positions of the stations can be seen on the accompanying map.

Station 77.

T. at 10 m., 2.38 - 13.05.
S. at surface, 16.15 - 27.74.
S. at 10 m., 27.65 - 29.92.

Dredged at 10 m.

(Laminaria saccharina.
(Gelidium crinale.
(Ptilota serrata.

Off Escuminac in 8 m.

(Delesseria sinuosa.
(Rhodymenia palmata.
(Chondrus crispus.
(Callithamnion pylaisaei.

Off Escuminac in 5 m.

(Polysiphonia urceolata.
(Delesseria sinuosa.
(Chondrus crispus.
(Rhodymenia palmata.

Off Escuminac in 2.5 m.

Lithothamnion polymorphum.

On shingle beach at Escuminac.

(Fucus furcatus.
(Fucus evanescens.
(Scytosiphon lomentarius
(Rhodymenia palmata.
(Chondrus crispus.
(Corallina officinalis.
(Enteromorpha compressa.

Off Fox Island.

(Ulva lactuca rigida.
(Polyides rotundus.

On beach at Pt. Escuminac.

(Enteromorpha linza.
(Chordaria flagelliformis.
(Chondrus crispus.
(Scytosiphon lomentarius.

On beach at Portage Island.

Enteromorpha crinita.

Station 77.

T at 7 m., 3.66 - 15.94
S at surface, 6.20 - 22.18.
S at 7 m., 21.70 - 24.63.

On bottom in 7 m.

(Laminaria agardhii. (1 specimen, small)
(Ahnfeldtia plicata.
(Gelidium crinale.
(Ptilota serrata.
(Ceramium rubrum.
(Phyllophora membranifolia.

Off Burnt Church.

(Laminaria saccharina.
(Rhodymenia palmata.

On beach in Vin Harbour.

(Enteromorpha micrococca.
(Fucus vesiculosus. (Small).

On rock-ledge on shore at Pt. au Car.

(Fucus vesiculosus, (Common but small)
(Fucus furcatus. (Small).
(Polysiphonia nigrescens.
(Ectocarpus confervoides.
(Hildenbrantia rosea. On stones.
(Enteromorpha crinita
(Enteromorpha intestinalis.

Dredged in 2 m. off Pt. au Car.

Chondrus crispus.
Polysiphonia nigrescens.
Ulva lactuca rigida. (Two very small specimens, one 1 cm. long, the other 2.2 cm. long.)

Station 81.

T at 12 m., 3.94 - 17.31.
S at surface, 1.41 - 19.33.
S at 12 m., 16.04 - 22.77.

Dredged in 12 m.

Ectocarpus confervoides siliculosus.

On sunken log at Sta. 81

(Enteromorpha crinita.
(Ectocarpus littoralis.
(Scytosiphon lomentarius. (Small).
(Stigonema subsalsa.

Beach, sand and shingle, at Loggieville.

(Enteromorpha crinita. (typical)
(E. compressa.
(E. intestinalis.
(Scytosiphon lomentarius. (Small.)

Station 82.

T at 11m., 14.46 - 19.14
S at surface, 0.07 - 14.76
S at 11 m., 7.16 - 20.93.

On stones at low-tide mark.

Enteromorpha crinita. (With long monosiphonous branches).

On ledge of rock at high-tide mark.

(Enteromorpha micrococca.
(Enteromorpha crinita. (Monosiphonous.)

On timbers of wharf at ½ tide mark.

(Lyngbya aestuarii.
(Enteromorpha micrococca.
(E. crinita. (Monosiphonous).
(Oligoclonium inaequale.

Below Chatham. Dredged in 3-5 m.

(Enteromorpha crinita. (Typical).
(E. compressa.
(Gelidium crinale. (Small).
(Chondrus crispus. (Small).

Below Chatham. Shore.

(Enteromorpha crinita. (Long monosiphonous branches).
(E. compressa)
(Lyngbya aestuarii.
(Fucus vesiculosus. (Very small, fronds only 4.5 cm. long).

Station 94.

T at 12 m., 15.20 - 19.98.
S at surface, 0.04 - 3.37.
S at 12 m., 0.07 - 17.45.

Dredged in 10 m.

(Enteromorpha crinita (Long monosiphonous tips).
(Polysiphonia urceolata
(Spirogyra sp. (Not in fruit so undeterminable).
(Tolypothrix brevicellaris.

Dredged off Newcastle in 10 m.

Entermorpha crinita.

Station 95.

T at 7 m., 14.31 - 18.54.

S at surface, fresh water - 2.36.
S at 7 m., fresh water - 11.26.

In 5.7 m.

(Enteromorpha micrococca.
(Batrachospermum moniliforme.

Station 96.

T at 6 m., 11.56 - 20.06
S at surface, fresh water - 0.42.
S at 6 m., fresh water - 8.35.

In tow-net at 6 m.

(Enteromorpha crinita. (Monosiphonous form).
(Tolypothrix brevicellaris.
(Microcystis ichthyoblabe.
(Oscillatoria tenuis.
(Lyngbya aestuarii.
(Aphanothece prasina.
(Scenedesmus bijuga.
(Pediastrum boryanum.
(P. tetras.
(Chaetophora elegans.

In tow-net at surface off Middle-ground.

(Tolypothrix brevicellaris.
(Tetraspora lubrica.
(Stigeoclonium lubricum.
(Rivularia compacta.

On shore at 102-tide mark.

Cladophora keutzingiana.

Station 97.

T at 3 m., 11.93 - 18.89.
S at surface, fresh water.
S at 3 m., fresh water.

On shore at bridge at Redbank.

(Spirogyra catenaeformis.
(Nephrocytium agardhianum.
(Merismopedium glaucum.
(Rhaphidium falcatum.
(Lyngbya aestuarii.
(Chlamydomonas communis.
(Scenedesmus bijuga.

An examination of the general distribution of the Algae of the Miramichi given above shows that at surface salinities of from 29.74 to 3.37, and at deeper salinities of from 29.92 to 17.45 only marine Algae occur. When we ascend the river till we meet a surface salinity of from 0.04 to 3.37 and a deeper salinity of from 0.07 to 17.45 we find the fresh-water Algae appearing in company with some marine species. When we ascend to the point where the salinity at the surface is from 0 to 0.42 and the deeper salinity from 0.835 we find an abundance of species of fresh-water Algae and the only salt-water or brackish-water forms which occur are the monosiphonous form of Enteromorpha crinita, and Lyngbya aestuarii. In regard to the latter species it is interesting to notice that it occurs in perfectly fresh water above Station No. 97. It is usually regarded as a brackish water species, though Collins records it from fresh water in Massachusetts and Buchanan records it as growing "in a pond amid Bladderwort", which undoubtedly means in fresh water, in Iowa. This species does not occur on the Miramichi in water with a greater salinity than 15.00 per mille.

Discussion of the Ecology of Certain Species.

Fucus vesiculosus. This species reaches a fair development at temperatures ranging from 2.38 to 13.05, and densities ranging from 27 to 29.92, is poorly developed at a maximum temperature of 15.94 and a minimum salinity of 21.71, and only grows a diminutive frond 4.5 cm. long at a maximum temperature of 19.98 and a minimum salinity of 0.07.

Chondrus crispus. This Red Alga grows from the saltest water to Station 82 where the temperature ranges from 14.46 to 19.14 and the salinity from 7.16 to 20.93 at 11 metres.

Ulva lactuca rigida. This Green Alga evidently has its limiting salinity at about 21 grammes total salts per mille. In order to reach full development it appears to require a salinity of more than 23.5.

Enteromorpha crinita. This is the most abundant and most generally distributed species of the region. At salinities of from 27.00 to 16.04 it has short tubular branches with very short monosiphonous tips. At salinities of from 16.04 to 7.16 it has very long monosiphonous tips to the branches, and at salinities below this it occurs only in the monosiphonous form, in which condition it resembles, as previously mentioned, a species of the family Ulotrichaceae.

It is interesting to notice that at Station 82, where the salinity at the surface is from 0.07 to 14.76, and at 11 metres from 7.16 to 20.93, all the forms of Enteromorpha crinita occur, the tubular form at a depth of 5 metres, the form with long monosiphonous branches on the shores at low-tide mark, and the monosiphonous form on wharf timbers at half-tide mark and on a ledge of rock at high-tide mark. Thus the vertical distribution of these forms of Enteromorpha crinita at this station correspond to the vertical gradient of salinity.

On the accompanying map the distribution of the different forms of Enteromorpha crinita is indicated.

In conclusion I wish to thank Dr. Huntsman, Curator of the Atlantic Biological Station, for his kindness in furthering my work in every possible way, even to the extent of having collections of Algae from stations which I considered as particularly important ecologically forwarded to me after I had left the Miramichi.

Algae from the Miramichi Expedition. 1918.

Stomach contents of several specimens of Pseudopleuronectes americanus. Sta. 100. Enteromorpha crinita. Enteromorpha intestinalis.

Stomach contents of Liopsetta putnami. Sta 100. Enteromorpha intestinalis. Pieces of Zostera.

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A Note on the Terrestrial Biota of the Miramichi Region, New Brunswick.

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In view of the fact that the marine biota of the Miramichi region is characteristic of southern rather than of northern waters it is of interest to briefly survey the terrestrial biota of the region.

The region lies in the Canadian Zone, which is the third zone, counting from the south, which occurs in Canada. The characteristic trees are the White and red spruces and the paper birch. Among the characteristic animals are the moose, white-throated sparrow, slate-coloured junco, purple finch, pine siskin, Canadian chickadee, and hermit thrush, and particularly the numbers of warblers which breed only in the north, such as the Myrtle, Magnolia, Tennessee, Bay-breasted, Parula, and Cape May.

The terrestrial biota is thus Canadian with a tendency towards the Hudsonian rather than towards a more southerly fauna, or in other words, decidedly northern.