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Observations on the Seasonal Disappearance of Certain Marine Algae in the Tide Pools near the Biological Station, St. Andrew's, New Brunswick.

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Along the Canadian Atlantic Coast the most conspicuous marine algae are such perennials as Fucus, Ascophyllum, etc., But there are also many annuals which appear and disappear regularly as the seasons come and go. These are different from land plants in that they are not confined to any one or two seasons, but provide a continuous succession of species from January to December. Each species, however, appears, reaches its maximum growth, and disappears at about the same time each year. With the great total length of our irregular coast and the rich growth of algae along the waterline, the amount of decaying or dead organic matter thus added to the water of the ocean may be very great. On the other hand if these plants are merely broken off in a firm healthy condition, and washed up on the shore to dry on the rocks, their contribution to the organic matter in the water may be very small. It is thus of importance to know just how such removal takes place and the condition of the tissues of the plant at the time of removal.

Interesting examples of these seasonal changes in the marine flora, came to my attention during the summer of 1925, while I was collecting in the vicinity of the Biological Station

at St. Andrew's, New Brunswick. In the tide pools there, certain species of *Enteromorpha*, *Phyllitis*, *Scytosiphon* and *Halosaccion* were found in abundance and growing luxuriantly during the first part of June; but by the end of July it was difficult to locate any of them. As this time of maximum growth and decay coincided with the time one usually spends at the Biological Station, these forms were chosen as suitable material for a study of the conditions accompanying the seasonal disappearance of marine algae.

Observations on these forms were made during the summer of 1926. The study was confined to the plants growing in fourteen selected tide pools. These pools were all within easy reach of the St. Andrew's Biological Station. They were representative of every part of the tidal zone, and at the same time they were chosen so as to be as varied as possible in regard to other factors such as size, depth, exposure to the sun and waves, etc. The necessary records were made during the first two weeks of June. These included a rough map of each pool, measurements of depth, size etc., position in the tidal zone, and an inventory of the more conspicuous species of marine algae in each pool. These species included; *Enteromorpha prolifera*, (Fl. Dan.), J. G. Agardh; *Phyllitis fascia*, Kutz; *Scytosiphon lomentarius*, Ag.; *Fucus vesiculosus*, L.; *Ascophyllum nodosum*, Le Jolis; *Halosaccion ramentaceum*, Ag., Var. *gladiatum*, Eaton; and *Chondrus crispus*, (L.), Stack.

The pools were kept under constant observation till the first of September. The plants of *Fucus*, *Ascophyllum* and *Chondrus* were still present at the end of the period; but the plants of *Enteromorpha*, *Phyllitis*, *Scytosiphon* and *Halosaccion*, gradually disappeared, till by the middle of July they had almost gone, and by the middle of August there were none of them left in the pools. There are three common ways in which the removal or death of such plants is brought about, namely, (*a*) they may be broken off by the waves or ice and washed away, (*b*) they may be eaten by some marine animal and (*c*) the plants in their regular life cycle may decay and their decayed bodies be washed away in a more or less disintegrated condi-

tion. The ways in which the plants under observation became removed from these pools were different for each species, and will be given in detail below. There was, however, one common characteristic, they were all mutilated by the common periwinkle (*Littorina*), and when this animal had cut nearly through a frond, that frond usually broke off at the weakened spot. The observations made on each species were as follows:—

The *Enteromorpha* was growing epiphytically on *Scytosiphon*. Thus when the *Scytosiphon* broke away, the *Enteromorpha* was washed away too. At that time however the *Enteromorpha* appeared to be alive and growing normally.

Phyllitis, before fruiting took place, had a smooth tough surface. Sporulation took place during the last part of June and first part of July. At the start of this fruiting the cortical cells over the whole surface of the frond grew out to form what looked like short rows of spores at right angles to the surface. These spores were then given off from the distal ends of these rows or short filaments. After this took place, the texture of the frond was no longer firm, but became soft and easily broken; and what is more important this softening, disintegrating and consequent weakening took place throughout nearly the whole frond at once. Naturally in this weakened condition the plant did not long withstand either the feeding activities of the periwinkle or the action of the waves; and when it was thus washed away, it was in a more or less macerated condition.

Scytosiphon fruited during June. When fruiting was in progress, long sterile hairs grew out from the surface. These hairs floating in the water looked like a halo completely enveloping the frond. The spores were given off from the surface as in *Phyllitis*, except that there were in addition single celled paraphyses interspersed among the sporangia. When fruiting was over the long sterile hairs disappeared, the cells throughout the tissues of the frond became less compact and less resistant; but the paraphyses remained, so that the frond still possessed a fairly smooth surface of closely packed paraphyses.

Thus so far as I could observe, the disintegration of the tissues did not play such an important part in the removal of this plant as it did with either *Phyllitis* or *Halosaccion*. The important things with this plant were that the frond was very long and slender, and consequently easily broken; also the stipe connecting the frond with the hold-fast was very slender. As a result the periwinkle did not have to take a very big bite out of the side of either the frond or the stipe to cut either of them nearly through. So it is not surprizing that the fronds of this species broke off and floated away either whole or in very large pieces. Also if a frond happened to be left alone by the periwinkles it sometimes remained attached and unchanged in appearance for quite a while after spore-discharge was over. A few of these undisfigured fronds were still to be found in the pools until nearly the middle of August; and one or two of these still retained their maximum length. One could be reasonably sure regarding this last observation because the original tip of a frond of *Scytosiphon* is very easily recognized. Thus although disintegration of the tissue undoubtedly played some part in the weakening and consequent destruction of the fronds of this species, the most conspicuous factors were the feeding activities of the periwinkle and wave-action, with the result that the tissues were only partially macerated at the time of removal.

Halosaccion died from the tip of the frond towards the base or holdfast. This was coincident with the ripening of the tetraspores, and ripening started at the distal end of the frond. When these spores were ripe they were set free by the complete breaking down of the tissues surrounding them. In this way the tissues became washed away in a completely macerated condition. This process continuing with the advance of the season, made the frond gradually shorter and shorter till finally there was nothing left.

There were some facts observed which are of general interest. One was in regard to certain tide pools in which there was always a current of water, due to the fact that some pool at a higher level drained through each of these lower pools.

In all those where a current of water existed, the algae lasted longer and fruited later, than the forms growing in pools where no current existed. The pools under observation were sufficently numerous and varied to make possible a fairly complete comparison in regard to this point; and it appeared quite evident that the current was the controlling factor in lengthening the life of these plants and not position in the tidal zone, depth or size of the pool or exposure to light. Of course the current would influence the temperature and oxygen supply, but these points were not investigated.

The records as given above do not apply to these species throughout the range. For instance, long after *Phyllitis* had disappeared from the pools, there was a luzuriant growth of the same species just appearing on the break-water only a few yards from the shore where these pools were located. Also there were other species observed which had growing periods partially overlaping the period during which this study was conducted; that is, there were species which were disappearing during June and others just starting in July and August. From this it is evident that similar studies could be made in regard to a great many other species of marine algae, and that these studies should extend through the whole year.

From these records it is seen that *Enteromorpha prolifera*, *Phyllitis fascia*, *Scytosiphon lomentarius*, and *Halosaccion ramentaceum*, var. *gladiatum* in the course of their life cycle disappear from any one location; and that with these species this disappearance is brought about as follows:—wave-action operates in the removal of all four, and it is the chief factor with *Scytosiphon* and *Enteromorpha* growing epiphytically on *Scytosiphon*. The fronds of all four species are mutilated and eaten by the periwinkle. Decay or decomposition "in situ" takes place in the cases of *Phyllitis* and *Halosaccion*, although *Phyllitis* is sometimes washed away in fairly large decaying pieces. This decay or decomposition "in situ" is not so marked with either *Enteromorpha* or *Scytosiphon*.

The facilities provided by the Biological Board of Canada at the St. Andrew's Station, made these studies possible.