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Environmental Changes in the Maritimes

(edited by: J. G. OGDEN III and M. J. Harvey)

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THE ARCHAEOLOGY OF SOME NOVA SCOTIAN INDIAN CAMPSITES

J. S. Erskine
Wolfville, Nova Scotia

(Received for publication Jan. 9, 1971)

Abstract. Campsites at Tusket Falls, Yarmouth Co., Gaspereau Lake, Kings Co., Bear River, Digby Co., and Little Narrows, Cape Breton, have been explored. These comprise two phases of the Archaic period and several sequences of change in transition from Archaic to Woodland cultures. An attempt has been made to clarify the Period of Confusion, 1000 B.C.-A.D. 1000

Previous explorations of campsites of Indians in Nova Scotia have been made which have indicated that the southwestern area of the Province is the richest in artifacts of their cultures. However little is known of the archaeology of Indians in Nova Scotia apart from the discovery of some artifacts by Smith and Wintemberg in 1913-14 (1), the explorations of the author in 1957-59 (2, 3) and the important excavations at Debert (4-6). The results of explorations during 1961-66 are herewith reported.

Tusket Falls, Yarmouth County

The Tusket River used to have valuable runs of salmon and gaspereaux, and the rapids at the foot of a small lake coincided with the top of the tide to complete the perfect fishing-place. The shores and banks on either side were rocky and steep and unsuitable for camping, but the top of the western bank had a flat area of about two acres with a small brook at the north end. The western half was occupied by some houses and a road; the eastern half was a triangular field where a variety of Indian artifacts had previously been found.

To determine the organization of the camp, I laid out a line at right angle to the road and dug one square yard in three. The gravelly soil had been ploughed occasionally for two centuries to a depth of 9 inches. I found random chips but no remaining structure except occasionally the base of a hearth beneath the ploughline. In one such hearth, 23 yards from the road, I found a short side-notched point with the tip broken. It resembled the "Brewerton" pattern but was much too short, and the side-notches had been ground, not chipped (Fig. 4). It belonged to the Laurentian period.

Along the edge of the stone wall where the plough had not been able to reach my only find was a small quartzite arrowpoint with a broken stem similar to those from the Mersey River and Indian Island, Merigomish. As they were common here, I named the type "Tusket". Beneath them were a few quartz points, roughly triangular but not sharply tipped. They were unfamiliar to me, but they closely resembled "Shield Archaic" points as illustrated by Ritchie (7).

Gaspereau Lake, Kings County

The summer of 1965 had been very dry, and Gaspereau Lake had almost ceased to exist. For the first time, I saw a narrow marshy beach clear of the water which had covered it for 40 years. A test-hole indicated that it had been occupied by Micmacs. We already have a fair picture of their period, but, as almost every site has some new item to contribute, this one was explored.

Once in Queens County I had dug a site in which 3 successive cultures had moved progressively up the slope to avoid the rising sea. This site reversed the process as the oldest camps were highest on the slope. Evidently that had been the beach of the period, limited above by the forest and below by the level of the lake. As the overflow from the lake slowly wore down the granite dyke at the outlet, another stretch of beach emerged, while the forest above moved down to occupy the part no longer subject to floods. Excavation was thus complicated by the position on the slope and the depth from the surface.

No charcoal, pottery or bone had survived 40 years of immersion which hampered dating. Therefore I tried a geological measurement. A few yards above the top of the site was a rock escarpment which probably was the level of the lake at the end of the ice-age. I divided the difference in altitude into 15 sections of 1000 years each. If the erosion of the outlet had been consistent, this might have been reasonably accurate. There had however been other outlets from the lake.

The first signs of occupation appeared at the level of 3000 B.C., but deepest in this section were two random pieces. One was a smoothed curved piece of stone which told nothing except that it had not been brought in by flood-water. The other was the failure of a large clumsy point. An effort at producing a stem suggested the Laurentian period, but the crudity and the green chert from which it was made, suggested the more ancient fishing culture of the Mersey high terrace.

Above these was a camp of 3 hearths, dug down about 10 inches as in all subsequent wigwams. Two of them were separated by 6 yards, and if these had been occupied at the same time, the wigwams would have been rather smaller than that of the average Micmac. Two of these hearths had been used as caches for winter tools, and spring floods had deposited silt such that they had not been recovered. This was especially valuable as it showed that each cluster of artifacts belonged to the same date. They included large, heavy spearpoints with triangular stems (Fig. 1). These could have been used only for thrusting. The stems were designed to slip from the shaft and to remain in the wound. This fits only the technique of winter hunting of the moose in deep snow and would have been useless in other seasons. There were also two net-weights, which were crude rectangles of stone notched at each side. No remains of nets have been found in Nova Scotia, but in New York State one has survived and was associated with similar net-weights (7). As they had been cached with other winter tools, this suggests fishing through the ice. A neat, slender, side-notched point of chalcedony was probably the tine of an eel-spear.

The tip of a slate knife was found along with the crude spearpoints. The Laurentian culture seems always to have delighted in art. Their elaborate "atlatl-weights" for balancing spear-throwers and their stone effigies of animals, common to the south and west of us, are rare here, but Nova Scotia is the home of slate knives. These may be simple fish-knives, or they may be broader and with stems threaded for lashing to a haft of knife or spear, or they may be elaborate and long beyond any practical use. This knife-tip came from such a masterpiece and was of green and white slate, bevelled to a flat hexagon with the tip an obtuse angle not intended for work. My crude calculation of dates placed this Early Laurentian culture between 3000 and 2000 B.C.

The next culture down the slope was also Laurentian but showed a complete change in pattern. There were no more wigwam hearths. The wigwams seem to have formed a line, north and south, with a row of hearths on either side to be used for cooking as well as for smoking fish. The equal importance of the opposite lines of hearths suggested that gaspereaux, which run during the period of easterly winds, were as important as the salmon which belong to the west winds, because only the leeward hearth would not endanger the wigwam.

The spearpoints of this "Middle Laurentian" culture were smaller than those of the earlier, and their stems were either parallel-sided or narrowest at the edge of the blade so that they would not slip from the shaft (Fig. 2). We have here a different form of hunting with the spear thrown by hand or atlatl. We know only the winter spearpoints of the Early culture and only the summer spearpoints of the Middle culture. The lack of hearths in their wigwams shows that they did not occupy this site in winter.

The site was rich with adzes which were usually thin, concave and ground only at the cutting edge. There were also a few flat celts. Great flakes of quartzite may have served as wedges, and there were oval, grooved and flat hammers for driving them. A single broken gouge was found. Two broken slate knives of common type were in this area, but their depth showed them to have been abandoned on the beach of the earlier culture. Here the slate knife seemed to have been replaced by a Brewerton-type point (Fig. 3) which was not sharp at the tip and somewhat diagonal at base. The favoured stone for these was honey-like quartzite from glacial drift.

A few miles up the lake, another Middle Laurentian site had been eroded by the ice, and an atlatl-weight, two gouges and a "plummet", the refined form of the net-weight, had been found previously. It seems likely that the two sites belonged to the same band with one site in summer and the other in winter when the forest would have protected them from the north wind. The plummet supports the theory of winter net-fishing. The period of Middle Laurentian fell in the 2000-1000 B.C. section.

The next section of the site was very disappointing. The period 1000-1 B.C. is haunted by a dozen subcultures, yet only two of these have provided us with adequate sites. It would have been of great value to have found here a representative tool-kit of even one more culture. In fact, we found only one point, medium-small and side-notched, which we call "Brighton" (Fig. 11). Only two points, both in fishing sites and without shellfish remains, have been found. Each might belong to the Shield Archaic group of this period but the evidence is quite inadequate.

The most abundant artifacts in this section were of the Tusket culture, but the numbers cannot be considered comparable as these were arrowpoints, not spearpoints, required in much greater numbers and much easier to flaw in the making. Almost all were of Blomidon stone — jasper, chalcedony, quartz, agate and even amethyst (Figs. 13, 14) Other tools which might have given us some inkling of Tusket culture were missing.

The Tusket phase seems to have disappeared before the Micmacs whose occupation of this site covered a greater area than their known 1000 years warranted. They also confused other periods by renovating and enlarging salmon hearths of earlier cultures and scattering their cached contents. On the other hand, they let three gaspereau hearths fill with peat. They must have been numerous, at least in the salmon run, but the greater part of their wigwam sites had been wholly or partially eroded by water and ice and had been buried in rotten sawdust. Not so much as a bead was found to tell of occupation during the French period, but a part of a 19th century crock showed that they had returned in the hungry centuries to follow.

Bear River, Digby County

In 1957-59 we excavated a site near the mouth of Bear River (2). The original excavation had covered 4 subsites. Three of them were shelves on the hillside levelled for winter occupation, and the fourth was a mere fringe of a summer site eroded by the sea. The oldest culture found had been that of "Lower Bear River", a Late Laurentian culture much influenced by Owasco pottery and Maine shellfish culture. Their occupation was estimated as 500-150 B.C.

They were replaced by the "Upper Bear River" culture which also took over the coast of Queens County. By radiocarbon dating, their arrival at this site was about 150 B.C. Their departure was estimated as not later than A.D. 200. A single Indian Gardens (Micmac) point had been found in the first test-hole, but no occupation by this people could be traced until after the French period. Then we found relics of French convent training in the form of embroidery scissors and thimbles, brass rings, and the great buttons of ceremonial cloaks, as well as porpoise vertebrae carved into counters for gambling games. These were followed by shipbuilders' spikes and cracked chinaware. Then these ceased.

The new discovery in 1965 was of masses of shell in an abandoned pasture on the hillside above. Here we found relics of an industrial development. Four large hearths had served to dry or smoke clams against the winter. Three of them were deep trenches with mounds of shells on either side; a fourth had a cross-trench as well to profit by every wind. Adzes were common, and two of them had been driven into the ground to await another season, probably August and September, as clams were not eaten in the early summer. Only an occasional unfinished tool or cluster of chips gave a hint as to the culture involved. Our uncertain conclusion was that two of the hearths had been Upper Bear River and two Indian Gardens. In a shallow wigwam site at one side there was a single Tusket point, and in a clam hearth there was a point which may have been Lower Bear River but which probably had nothing to do with the industry.

We had been aware that these people shifted their wigwams to the beach in summer, though they often cooked in small stone-framed hearths on their winter sites. There had been a large site beside the beach, but the greater part of it had been carted away for fertilizer. However, we found a patch of 9 square yards which was intact.

At the extreme north edge, in a sandy area without clamshells, there were two broken points of unknown types (Figs. 5, 6) though definitely of the Late Archaic period of confusion. In a shell-rich layer above these was an unfinished tool like those found in the Upper Bear

River clam-hearths. Then for a depth of 7 inches there were Tusket arrowpoints with slender stems, and finally the uppermost 3 inches held the corner-notched points of the Micmacs. This resolved the problem of why the Micmacs had not occupied this site as they had all the others. They had, indeed, been here, but only in summer when they had camped on the beach.

Little Narrows, Cape Breton

On my first enquiry about Indian sites in Cape Breton, I was referred to Little Narrows, known to all Indians though usually considered by them to be a workshop rather than a campsite.

The site was on a sandspit beside a tidal lake. Indians have camped there in this century to spear and smoke eels.

Here there was pottery of the northern Point Peninsula type unlike that common in southern sites. A few arrowpoints and a broken long spearpoint were found, but it was impossible to be sure of their relationship. At last I found two-thirds of a wigwam site. It was shallow but fairly rich in artifacts, and I found 6 points. Later I realized that I had dug through 3000 years in those 6 inches. One point was a Brewerton of Middle Laurentian, one Shield Archaic (Fig. 7), one Brighton, one like a Long Lamoka (Fig. 12), two of Indian Gardens (Fig. 15, 16) and a brass ring.

Seven years later, someone spaded the site superficially. As margins and the deep smoking hearths had not been reached, these were then re-excavated. It was difficult work and largely unrewarding except in the depths where there remained the hollows of smoking hearths and broken artifacts of some unfamiliar culture. A hearth was cleared which lacked the usual potsherds and we found an unfamiliar diamond-shaped tool (Fig. 8). Such a tool had been attributed to the Beothuks of Newfoundland, and this fitted. The Micmacs of the North Shore and Cape Breton assert that they drove the Red Indians, the Beothuks, from Nova Scotia to Newfoundland. I had always imagined that the Laurentians had been driven out by the Micmacs, but here was this Shield Archaic culture with its broken Steubenville points (Fig. 9) coming in between. The recent excavation at Port au Choix had shown that the Laurentians were in Newfoundland by 2300 B.C. Had the Shield Archaics ousted the remaining Laurentians from Cape Breton and then been ousted in their turn by the Micmacs?

The Period of Confusion, 1000 B.C.-A.D. 1000

There can be little doubt that this period resulted from the introduction of Mexican culture into the Ohio Valley, probably by a small body of missionaries rather than settlers. Their religion, agriculture, organization and practice of war spread by acculturation and resulted in the expulsion of the many bands that did not adopt agriculture. A first wave of migration seems to have reached Nova Scotia from Maine and a later wave from the St. Lawrence Valley. This suggests the expansion of the Iroquois, but unfortunately the prehistory of these areas is less well-known than that of Nova Scotia. Byers (8) recorded a sequence in shore-camps with (a) no shellfish, (b) oysters and quahogs, (c) clams as well. We also have observed this sequence, but it is complicated by the northern wave which seems to have lacked all shellfish culture, and it is further complicated on the South Shore by the rarity of oysters and quahogs. Lacking adequate information, we may simplify the confusion by grouping the subcultures which seem closely related as follows.

Southern Invaders 600 B.C.-A.D. 200

Late Laurentian. No pottery. Oysters and quahogs eaten but no clams. Oyster culture is known only from Indian Island at Merigomish, and Whynacht Cove at Mahone Bay, but the scanty artifacts in each do not correspond, whereas points similar to those of Whynacht Cove have been found at Port Joli, Queens Co. (which has no oysters), Bear River and Newville Lake, Cumberland Co. Port Joli and Shinimicas River have yielded flat gouges which may belong here.

Clam Cultures. Clams eaten and dried; Owasco pottery; confined to shores. This includes Lower and Upper Bear River and perhaps Maccan which, though somewhat inland, had points very like those of Upper Bear River. The layer above the Oyster culture at Indian Islaı. , Merigomish, had a single Tusket point among clamshells. Although the Tuskets seem to have been northern invaders, they may have carried clam culture to Merigomish. The pottery of the period is northern.

Northern Invaders ?-A.D. 1000

Shield Archaic. This culture is best known from Little Narrows and a site at North Aspy (MacDonald – unpublished). Neither has been dated. There is also a caribou campsite on the escarpment overlooking Tracadie Harbour. The inhabitants seem to have had no pottery and to have eaten no shellfish. They are associated with Steubenville points of two types (Figs. 9, 10) and with Brighton (Fig. 11) and Long Lamoka (Fig. 12) though less certainly. If these can be grouped together, we find this culture on North Shore and South Shore and on fishing sites somewhat inland. In a shallow layer at Port Mouton, two teeth of a buried woman were found. The molar was flat, which indicates that she had not been eating clams; the incisor was worn down to the gum, perhaps by chewing skins which is a northern custom.

Tusket. Not dated. This culture first brought in bows and arrows, but in Prince Edward Island the collected artifacts seem to show a complete transition from Middle Laurentian to Tusket, from spear to bow. It seems likely that the culture that we know as Tusket evolved not far from the Chignecto Peninsula. It seems to have infiltrated other cultures without attacking them.

Indian Gardens — Micmac. The legends of this people include contacts with the Mohawks on the St. Lawrence River and an ephemeral start at corn culture. We have no carbon-dates before A.D. 1050, but the small square-based points seem to belong to two or three centuries earlier (Fig. 15) than the fan-based type (Fig. 16). They overran all other cultures, but, probably by taking over the women of the conquered, they adopted the food patterns and the pottery of their predecessors. This meant eating shellfish in the area west of Merigomish and Musquodoboit and avoiding it east of that line.

Acknowledgments. The author acknowledges with thanks financial support for this investigation from The National Museum of Canada.

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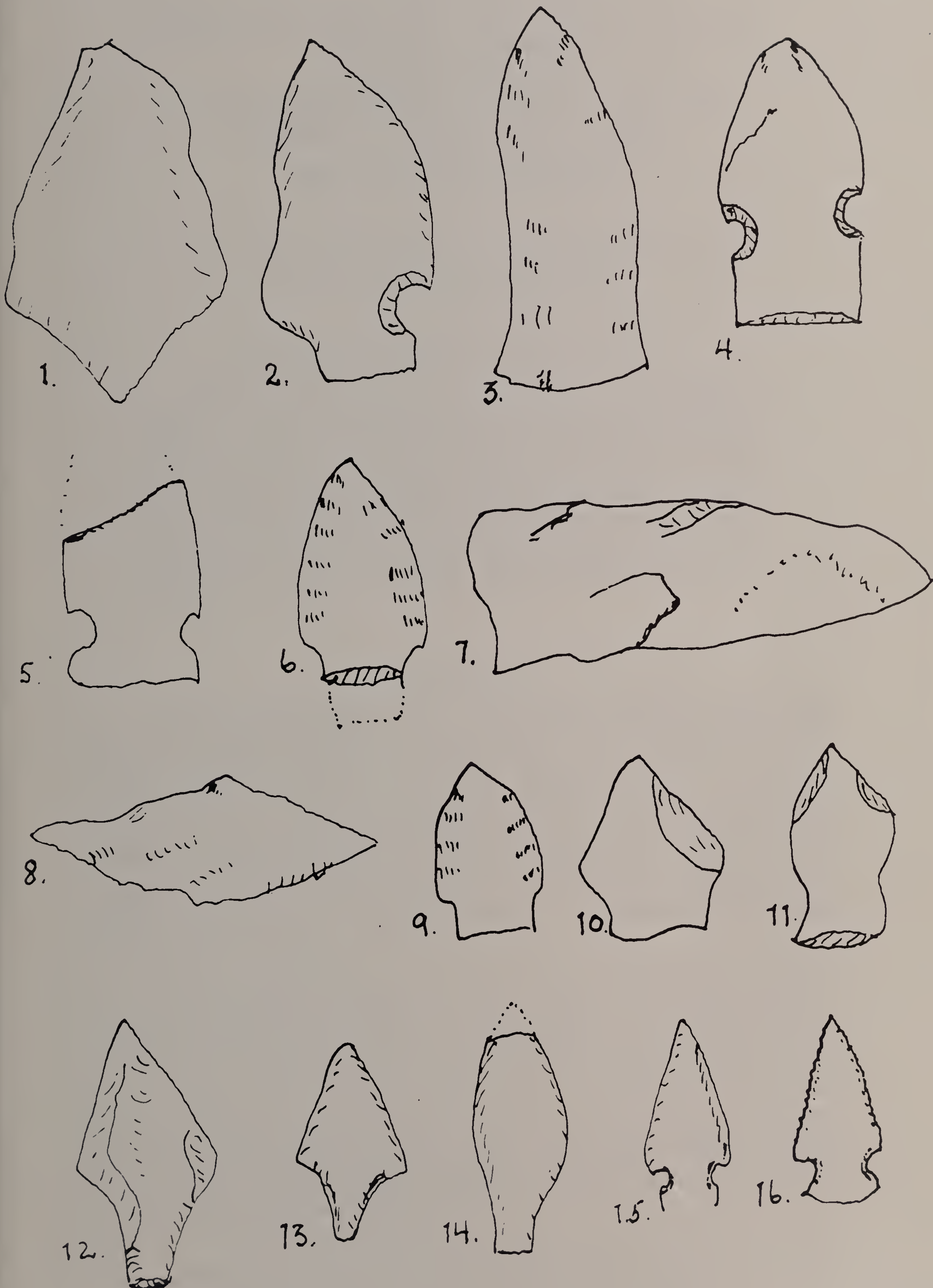
Figs. 1-16. Types of Artifacts (all X 1/2)

1. Early Laurentian. Gaspereau Lake, Kings County.
2. Middle Laurentian. Gaspereau Lake, Kings County.
3. Brewerton type, Middle Laurentian. Gaspereau Lake, Kings County.
4. Brewerton type, Middle Laurentian. Tusket Falls, Yarmouth County.
5. Late Laurentian fragment. Bear River, Digby County.
6. Late Laurentian, stem broken. Bear River, Digby County.
7. Shield Archaic. Little Narrows, Cape Breton.
8. Shield Archaic. Little Narrows, Cape Breton.
9. Steubenville point. Little Narrows, Cape Breton.
10. Steubenville point. Port Mouton, Queens County.
11. Brighton point. Brighton, Digby County.
12. Long Lamoka point. Little Narrows, Cape Breton.
13. Tusket point. Bear River, Digby County.
14. Tusket point. Bear River, Digby County.
15. Early Indian Gardens. Little Narrows, Cape Breton.
16. Indian Gardens. Little Narrows, Cape Breton.



Figs. 1-16 (see p. 8)

INVESTIGATIONS OF THE MARINE ALGAE OF NOVA SCOTIA. IX. A PRELIMINARY SURVEY OF THE FLORA OF BRAS D'OR LAKE, CAPE BRETON ISLAND[1]

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(Received for publication March 26, 1971)

Abstract. The algal flora of Bras d'Or Lake is in general restricted to a narrow fringe which extends from the shoreline to a depth of 3-4 m. A total of 92 species and varieties were identified during the survey. Two algal associations were evident; in one the species were the same as those of the open coastal area of Cape Breton Island, and in the other the species were similar to those of other warm-water habitats in Nova Scotia and Prince Edward Island. Ecological conditions in the lake have an apparent effect on the morphology of many of the species, and three free-living ecads were recorded.

Introduction

Bras d'Or Lake, Cape Breton Island, with a surface area of 1050 km^2 and a shoreline length exceeding 500 km, is the largest inland sea on the east coast of North America. Although this body of water is a unique biological habitat, it has been largely ignored as an area of investigation. The only comprehensive study was undertaken by Geen (1965) in which he assessed the primary productivity of the lake. He presented little information on the fauna and flora, nothing on the benthic algae, but some valuable data on the physical and chemical conditions of the lake.

Limited observations on the benthic marine algae were made by Bell and MacFarlane (1933*a, b*) who pointed out that ecological conditions of Bras d'Or Lake were unlike those of the open ocean, and that the flora was atypical and more like that of a deep tide pool of the upper littoral zone. Very few species were recorded by these authors who nevertheless noted certain similarities with the flora of Hudson Bay (Bell and MacFarlane 1933*c*). More recently Adey (1966) recorded a warm-water, crustose coralline *Phymatolithon laevigatum* in East Bay (private communication 1970).

[1] Issued as NRCC No. 11886.

Description

The Bras d'Or Lake area was glaciated and the bedrock of sedimentary shale, sandstone and conglomerate with some volcanic rock is superficially overlain with till (Geen 1965). The shore of the lake is composed of mud, sand, gravel and boulders whereas the bottom is generally covered with a sand-silt mixture with few large emergent boulders. The lake is an exceptionally deep body of water; St. Andrew's Channel exceeds 250 m in depth, and maximum depths in the other basins are 50 to 100 m.

Bras d'Or Lake is joined with the Atlantic at three constricted points – St. Peter's, St. Andrew's and Great Bras d'Or Channels. The bottom rises abruptly at the channel entrances, and at St. Peter's the connection is through a lock system. Consequently, exchange of water with the open sea is very limited, and current action in the lake is negligible. The tidal amplitude in the lake is less than 0.3 m. Hence there is no intertidal zone, and the only wave action is from local winds. Salinity in the open lake ranges from 20-25‰ (Geen 1965), but in the numerous barachois ponds the salinity is more variable and may approach that of freshwater (Smith and Rushton 1962-63). Surface temperatures during summer are consistently from 15-20 °C. With the exception of Great Bras d'Or Channel, the lake freezes over during winter.

None of the major basins is anaerobic, and Geen (1965) found 5-8 mgm/l of oxygen in the deepest parts of St. Andrew's Channel. The barachois ponds may however be anaerobic near the bottom (Smith and Rushton 1962-63). Aerobic conditions throughout the water column, together with limited exchange of water with the open sea, suggest that primary production *in situ* and transport of organic materials into the lake are minimal. This is consistent with Geen's estimate of an annual production of 55 gm C/m^2 with daily rates in the order of 100-300 gm C/m^2. The major primary producers during summer months are nannoflagellates, predominantly cryptomonads, but during fall, winter and early spring the phytoplankton is composed of diatoms and dinoflagellates similar to those in the surrounding ocean. Geen's analyses indicated that dissolved nitrogen and phosphorus were low in the photic zone, and bioassays suggested that phosphorous and iron were present in limiting concentrations.

Methods

During the summer of 1970 we made intensive observations and collections throughout Bras d'Or Lake. A total of 45 stations was established (Fig. 1) which included sites in all basins of the lake. Most stations were reached in a shallow-draft power boat, although in some areas we used a small car-top boat.

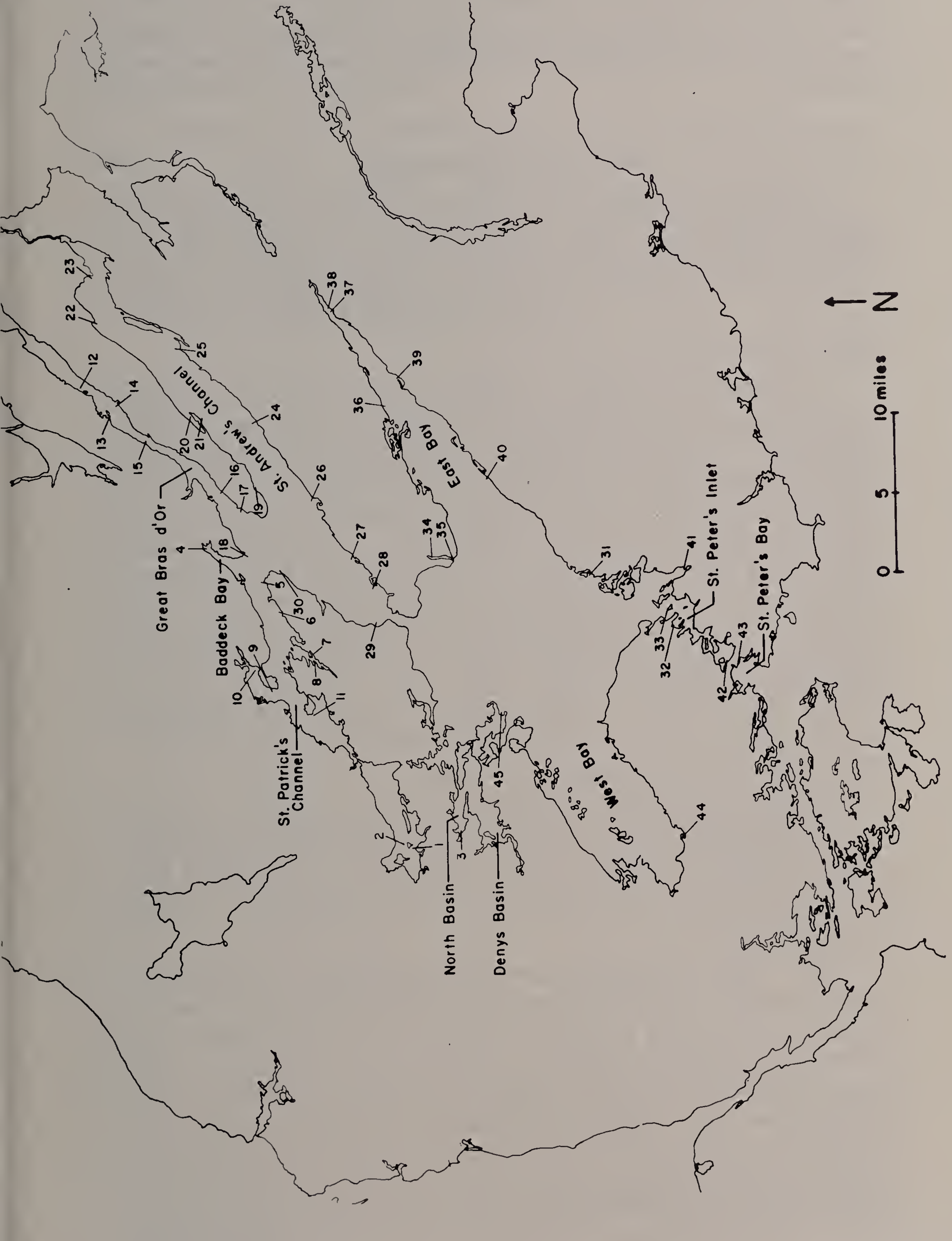


Fig. 1. Bras d'Or Lake, C.B.I. indicating collecting sites.

We employed SCUBA only occasionally. Most of the plants were in shallow water and observations could be made from the surface and collections by free-diving. The plants were either mounted on site or preserved in formalin for later observations in the laboratory. Voucher specimens have been deposited in the Marine Algal Herbarium of this Laboratory.

Observations and Discussion

A total of 92 species and varieties of benthic marine algae were recorded during our survey. These include 31 Rhodophyceae 31 Phaeophyceae, 23 Chlorophyceae and 7 Cyanophyceae. Three are new records for Nova Scotia. A listing of species together with the reproductive structures present and distribution within the lake is presented in Table I.

The algal flora in general occupied a narrow band which extended from the shoreline to a depth of 3-4 m, and in no place was the plant cover dense. The quantity of the benthic vegetation is therefore low, and undoubtedly their contribution to the productivity of the lake is small. The shallowness of the vegetation in Bras d'Or Lake is unusual compared with open coastal areas. Throughout most of the lake there was an appreciable accumulation of fine sediments which formed an unstable substratum, and frequently we noted large emergent boulders covered with algae in areas otherwise free of vegetation. In addition the suspended sediment undoubtedly reduced the amount of submarine illumination available for plant growth. Not uncommonly the angiosperm *Zostera marina* occupied areas of silt and mud. It was the most abundant plant in the lake and occurred at all stations and tended to grow at greater depths than other species.

We have recognized two distinct associations of algae in Bras d'Or Lake. One comprised species common to the adjacent open sea, and the other of shallow, warm-water plants characteristic of protected bays such as those along the north shore of the province and in Prince Edward Island.

The former association consisted predominantly of fucoids. *Fucus vesiculosus* was the most abundant species and frequently formed a narrow band near the shoreline. *Ascophyllum nodosum* was common and tended to occupy a zone below *F. vesiculosus.* In some areas, and especially along St. Andrew's Channel, *A. nodosum* was the deepest, major alga present. *Fucus serratus* was restricted to Great Bras d'Or Channel, and even here it occurred in patches along the east side of the Channel. *Laminaria agardhii, Chondrus crispus* and *Phyllophora membranifolia* were distributed generally throughout the lake although absent in the more shallow, muddy areas. *Chorda filum* was a common and abundant species of both associations. Other characteristic summer annuals were *Sphaerotrichia divaricata, Chordaria flagelliformis,* and *Dictyosiphon foeniculaceus.* The perennials were thickly covered with epiphytes which included species from the warm-water association such as *Erythrotrichia carnea, Goniotrichium alsidii, Ceramium fastigiatum* and *Polysiphonia subtilissima.*

Species common in the warm-water association were free-floating ecads of *Gracilaria foliifera, Ahnfeltia plicata* and *Ascophyllum nodosum.* Other characteristic species of this association were *Bryopsis hypnoides, Dasya pedicellata, Ceramium fastigiatum, Stilophora rhizodes* and the large form of *Sphaerotrichia divaricata.* The most common blue-green alga was *Calothrix confervicola* which formed a thick layer on various algae and on *Zostera.*

The flora of Great Bras d'Or Channel was similar to that of the open coast of Cape Breton Island. In general these species were characteristic of St. Andrew's Channel and extended into West Bay and the western portion of East Bay. Progressing into East Bay the oceanic species disappeared and the algal vegetation became very poor indeed. Here the flora consisted predominantly of *Z. marina* with a few small epiphytes and some *C. filum.* Species of the warm-water association were characteristic of the flora of St. Patrick's Channel, Deny's Basin and North Basin. The bottom in these areas tended to be more muddy and *Z. marina* was the dominant component. In St. Peter's Inlet the flora was poorly developed and resembled that of the upper reaches of East Bay. The vegetation of St. Peter's Bay was similar to that of the rest of Chedabucto Bay. None of the oceanic species was, however, observed beyond the first lock of the canal.

It is evident that conditions of temperature, salinity, water movement, absence of tides and perhaps nutrients have considerable influence on the vegetation of Bras d'Or Lake. This is reflected not only in the composition of the flora, but also in morphological variation amongst some of the species. *Fucus vesiculosus* tended to become bushy and branched from the base. Vesicles were either lacking or collapsed, and some plants resembled *F. spiralis* including the shape of the receptacles. The colour tended towards reddish-brown, and the plants were poorly attached. Extreme variability was noted amongst plants of this species. A broad form of *Fucus,* probably *F. distichus* subsp. *evanescens,* was commonly encountered. There was little apparent variation amongst plants of *F. serratus* which resembled those of the open coast. The distribution of this species within the lake was restricted to Great Bras d'Or Channel and was not seen beyond Station 30 (Fig. 1). The limited penetration of this species may be the result of ecological barriers. More likely migration is still occurring as it is along the open coast.

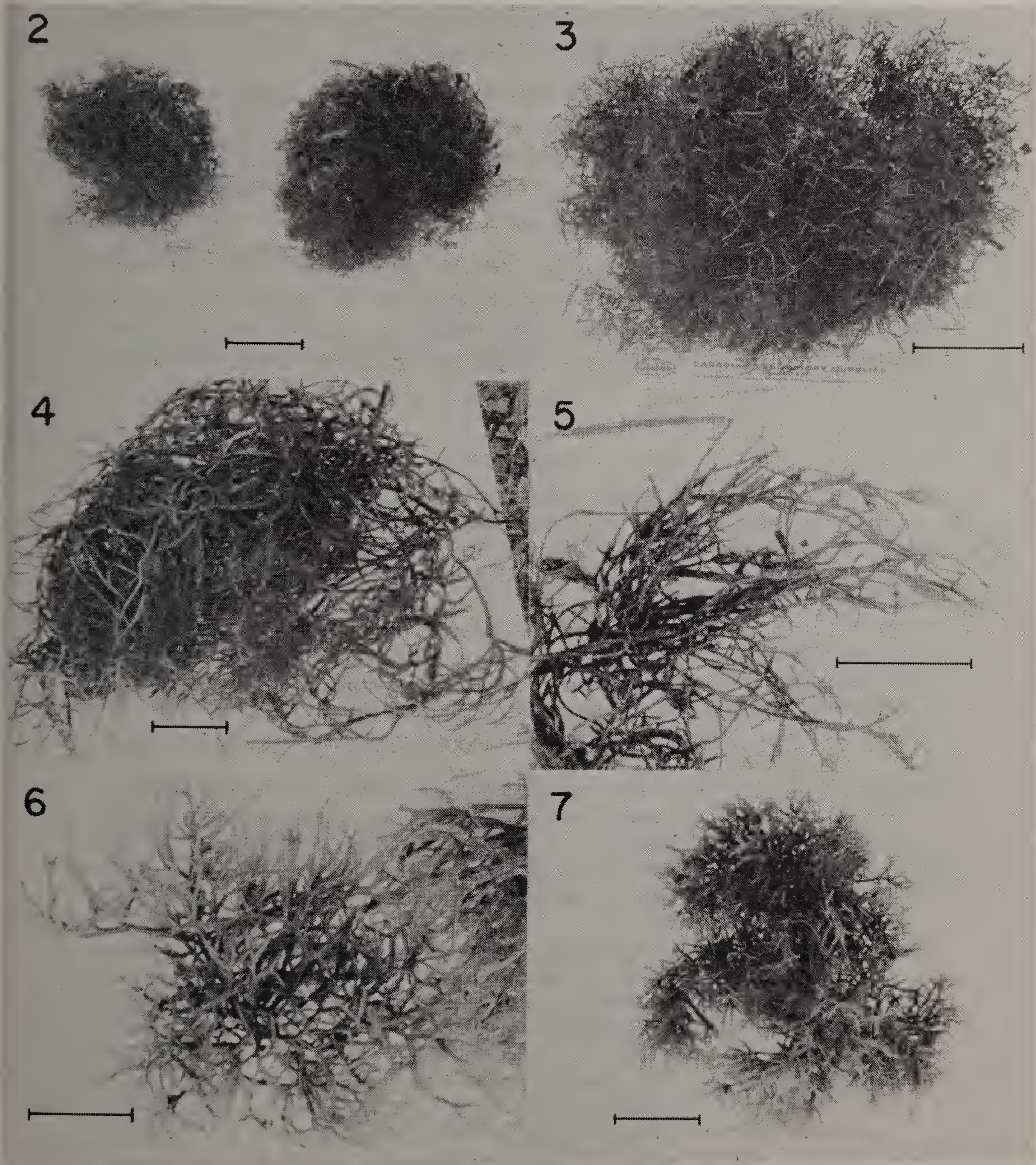
Ascophyllum nodosum was bushy, much branched and vesicles were either present or absent. The plants were yellowish and receptacles were absent or poorly developed. In more protected areas the free-living ecad *scorpioides* (Hornemann) Reinke (Figs. 4, 5) was present. Clumps of entangled plants were present at Stations 4 and 10 in St. Patrick's Channel (Fig. 1) on a shallow, muddy bottom. The plants were strongly branched, mostly lateral with main axes obscured and the branches cylindrical to somewhat flattened. The apices occasionally forked (Fig. 5) and the vesicles were few and small. The last two characters suggest that our specimens are intermediate with ecad *mackaii* (Turn.) Cotton, but we have insufficient material to form definite conclusions. Previous records for northeastern North America are given by Taylor (1957, as *A. nodosum* f. *scorpioides*), MacFarlane (1952, as *A. mackaii*) and South and Hill (1970, as the "beach form" of ecad *mackaii*).

A free-living form of *Ahnfeltia plicata* was found in St. Patrick's Channel also at Station 4. The plants formed rigid, strongly branched tufts or dense mats up to 15 cm in diameter (Figs. 2, 3). The regular mode of dichotomous branching of this ecad, which distinguishes it from the attached plants of the open coast, resembles f. *furcellata* Collins (Taylor 1957). We noted only a small population in the lake. The only published record of free-living *Ahnfeltia* of which we are aware is given by Chapman (1970) for the Sarema and Khiuma Islands in the Soviet Union.

We reported previously on the free-living ecad of *Gracilaria foliifera* var. *angustissima* from Pomquet Harbour, Antigonish Co. (Edelstein *et al.* 1966). Specimens collected in Bras d'Or Lake (Figs. 6, 7) were smaller than those from Pomquet. In the barachois pond at Station 34, where the salinity was 15 ‰, the plants were very much reduced in size. They formed small, dense balls up to 5 cm in diameter with strongly proliferating, short cylindrical branches most of which were dichotomous. In addition the following halophytic phenograms were present: *Potamogeton bupleuroides* Fernald, *Ruppia maritima* L. v. *longipes* Hagstrom and *Zannichella palustris* L. v *major* (Boennighausen) Koch.

The morphology of *Laminaria agardhii* along most of Great Bras d'Or and St. Andrew's Channel was normal. An atypical habit was noted throughout the rest of the lake. These plants were pale and stunted with extremely thin blades. *Chondrus crispus,* which was sparsely distributed, tended to become greenish, and the plants were relatively small.

In the Atlantic Provinces *Nemalion helminthoides* is rare and the populations sparse. This species was found at several sites in the lake and at Station 6 there was a very dense population. The plants,



Figs.

2, 3. *Ahnfeltia plicata* – free living form. Fig. 2. A ball-form. Fig. 3. A mat-form.

4, 5. *Ascophyllum nodosum* ecad *scorpioides.*

5. Same as Fig. 4 showing vesicles and forked tips.

6, 7. *Gracilaria foliifera* var. *angustissima.*

Scale bar for Figs. 2-5 and 7 is 5 cm.
Scale bar for Fig. 6 is 2 cm.

attached to the vertical surface of rock, formed a thick band about 50 m long and 7-10 cm broad at the waterline. This is the most abundant occurrence of this species we have encountered.

The great diversity of habitats in Bras d'Or Lake presents a unique opportunity for extensive ecological observations. Moreover, with the exception of the area around Baddeck, we saw little evidence of pollution in the lake. Ecological surveillance should be undertaken to ensure that this condition is preserved.

Acknowledgments. We thank Miss Carolyn J. Bird for preparation of specimens for the herbarium and Messrs. W. R. Crosby and D. J. Johnson for assistance with the plates. We are especially grateful to Mr. J. Bailey, a NRC summer student, for his invaluable assistance in the field.

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Table I

Species found, reproductive structures present and distribution according to collecting site as in Fig. 1

Rhodophyceae	
Acrochaetium emergens[3] (Rosenvinge) Weber-van Bosse	9
Acrochaetium microfilum Jao	16 36 39
Acrochaetium zosterae Papenfuss	3 4 5 10 11(M) 12 16 22 23 38 39
Ahnfeltia plicata (Hudson) Fries	3 4 5 14 16 17 22 23 24 25 26 27 28 29 30 31 35 40 44 45
Antithamnion americanum (Harvey) Farlow	5 23
Bonnemaisonia hamifera Hariot[4]	5 12 13 14 15 16 17 22 23 24 25 26 27 28 29 30 43
?*Callithamnion* sp.	5 13
Callithamnion byssoides Arnott	26 29 30
Ceramium rubriforme Kylin	1(Cy) 2(Cy T) 3 9(T) 10(T) 11(Cy) 22 23 29(T) 30 38(Cy) 39 42 43(Cy)
Ceramium fastigiatum Harvey	1(T) 2 3 4 5 7 9 10 11 23 26 30 34 38(T S) 39 42 44
Chondrus crispus Stackhouse	2 5 6 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 33 35 40 44 45
Cystoclonium purpureum (Hudson) Batters	15(Cy) 23 30
Cystoclonium purpureum v. *cirrhosum* Harvey	26 29
Dasya pedicellate (C. Agardh) C. Agardh	1 2 9
Erythrotrichia carnea (Dillwyn) J. Agardh	4 5 6 7 11 15 16 22 23 26 29 30 36
Goniotrichum alsidii (Zanardini) Howe	2 3 4 10 11 12 13 15 16 23 26 29 31 36 38 39 44
Gracilaria foliifera (Forsskål) Börgesen v. *angustissima* (Harvey) Taylor	2 3 4 5 7 10 34 38
Hildenbrandia prototypus Nardo	9(T) 42
Kylinia collopoda (Rosenvinge) Kylin	2
Nemalion helminthoides (Velley) Batters	2 6(S) 12
Phyllophora brodiaei (Turner) Endlicher	13 16(N) 29(N)
Phyllophora membranifolia (Goodenough et Woodward) J. Agardh	2 5 6 11 16 17 22(Cy) 23(T) 24 25 26 27 28 29(Cy) 30(T) 44
Polyides rotundus (Hudson) Greville	26
Polysiphonia sp.	1 4 11 31 36 38 41 43
Polysiphonia harveyi Bailey	4 5 7 9 10
Polysiphonia nigrescens (Hudson) Greville	2 13 15 16 22 23 24 25 26 27 28 30 38 39 43 45
Polysiphonia subtilissima Montagne	3(T) 4(Cy) 5 7 9 23 30 31 34(T) 35

Polysiphonia urceolata (Lightfoot) Greville	29
Porphyra umbilicalis (Linnaeus) J. Agardh	12 13 43
Rhodochorton penicilliforme (Kjellman) Rosenvinge	16(M) 26(T) 29 36 44(M)
?*Rhodomela confervoides* (Hudson) Silva	4 13 15 42 44 45
Encrusting corallines	5 12 16 23 24 25 27 28

Phaeophyceae

Ascophyllum nodosum (Linnaeus) Le Jolis	1 3 4 5 6 9 10 11 12 13 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 37 38 39 41 42 43 44 45
Chorda filum (Linnaeus) Stackhouse	1 3 4 5 6 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31 32 33 36 37 39 40 41 42 44 45
Chordaria flagelliformis (O. F. Müller) C. Agardh	2 5 6 10 11 12 13 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 35 39 40 41 42 44
Desmarestia aculeata (Linnaeus) Lamouroux	16[1]
Desmotrichum undulatum (J. Agardh) Reinke	13 26 44
Dictyosiphon foeniculaceus (Hudson) Greville	2 6 10 12 13 15 16 17 18 19 20 22 23 24 25 26 27 28 31 35 36 42 44 45
Ectocarpus sp.	1 4 9 10 11 12 13 14 15 16 17 29 30 33 36 39 44
Ectocarpus confervoides (Roth) Le Jolis	5(Ps)
Ectocarpus confervoides v. *hiemalis* (Crouan) Kjellman	3(Ps) 5(Ps) 22(Ps) 23(Ps) 24(Ps) 25(Ps) 26(Ps) 27(Ps) 28(Ps) 38(Ps)
Ecotcarpus confervoides v. *siliculosus* (Dillwyn) Kjellman	34(Ps)
Elachista fucicola (Velley) Areschoug	5 12 13 20 22 30 36 44
Farlowiella onusta (Kützing) Kuckuck	3(Ps) 7 38(Ps)
Fucus distichus Linnaeus subsp. *evanescens* (C. Agardh) Powell	5 29 35
Fucus serratus Linnaeus	5[2] 12 14 16 17 30(R) 43
Fucus vesiculosus Linnaeus	1 3 5 6 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 26 27 28 30(R) 31 32 33 35 36 37 38 39 40 41 42 44 45
Fucus vesiculosus v. *sphaerocarpus* J. Agardh	5 45
Giffordia sp.	11
Laminaria agardhii Kjellman	5 12 13 15 16 17 19 29 30 45
Leathesia difformis (Linnaeus) Areschoug	16
Litosiphon pusillus (Carmichael) Harvey	3(Us Ps) 7(Us Ps)

Myriotrichia filiformis Harvey	13 16 26
Petroderma maculiforme (Wollng) Kuckuck	36 38
?*Phaeostroma pustulosum* Kuckuck	36(Ps)
Punctaria plantaginea (Roth) Greville	6(Us) 20 22 26 29 30 35 44 45
Ralfsia clavata (Harvey) Crouan	1(Us)
Ralfsia verrucosa (Areschoug) J. Agardh	5 9 16 23 24 25 27 28 31 33 36 38 39 40 41 42
Scytosiphon lomentaria (Lyngbye) Link	2 10 12 13 31 40 41 45
Sphacelaria cirrosa (Roth) C. Agardh	2 3 5 6 7 10 11 12 13 14 15 16 20 22 23 26 29 30 31 38 39 40 42 44 45
Sphacelaria plumosa Lyngbye	13 31 34
Sphaerotrichia divaricata (C. Agardh) Kylin	1 2(Us) 4 5 6 9 10 11 12 13 14 16 17 20 22 23 24 25 26 27 28 29 30 31 32 33 35 36 37 38 39 40 42 44 45
Stilophora rhizodes (Turner) J. Agardh	2(Us) 3 9(Us) 26(Us)

Chlorophyceae

Bryopsis hypnoides Lamouroux	4
Bolbocoleon piliferum N. Pringsheim	2 42
Chaetomorpha aerea (Dillwyn) Kützing	13 15 22
Chaetomorpha linum (O. F. Müller) Kützing	26 29 31
Chaetomorpha melagonium (Weber et Mohr) Kützing	26 29 31
Cladophora sp.	2 10 15 22 40 41
Cladophora glaucescens[3] (Griffiths ex Harvey) Harvey	34 41 42
?*Cladophora rudolphiana*[3] (C. Agardh) Harvey	22 31
Cladophora rupestris (Linnaeus) Kützing	34 35
Endoderma cladophorae Hornby	42
Enteromorpha clathrata (Roth) Greville	1 11
?*Enteromorpha compressa* (Linnaeus) Greville	34 38
Enteromorpha intestinalis (Linnaeus) Link	2 3 9 36 41 43
Enteromorpha linza (Linnaeus) J. Agardh	34 36 38
Enteromorpha plumosa Kützing	2 3 4 7 34 38 42
Enteromorpha prolifera (O. F. Müller) J. Agardh	36 38
Monostroma oxyspermum (Kützing) Doty	34
Pringsheimiella scutata (Reinke) Marchew	2
Stichococcus marinus (Wille) Hazen	2
Ulva lactuca Linnaeus v. *latissima* (Linnaeus) de Candolle	3 4 9 10 42

Brackish water species

Chara vulgaris Linnaeus	34
Mougeotia sp.	3
Spirogyra sp.	3 34

Cyanophyceae

Anabaena cylindrica Lemmermann	9 10 12 22 26 30 31
Aphanocapsa marina Hansgirg ex Foslie	13
Calothrix confervicola [(Roth) C. Agardh] Bornet et Flahault	3 5 6 9 10 11 12 13 15 16 22 23 26 29 30 36 38 39 42 44
Isactis plana [(Harvey) Thuret] Bornet et Flahault	12 13 23 26
Lyngbya sp.	2 4 9 11 23 33 43 44
Rivularia atra [Roth] Bornet et Flahault	9 10 26 30 31 39 42
Spirulina subsalsa [Oersted] Gomont	7 33

Ps = plurilocular sporangia; Us = unilocular sporangia; R = receptacles; Cy = cystocarps; T = tetraspores; M = monospores; S = spermatia; N = nemathecia.

[1] Detached specimen
[2] A single plant
[3] New record for Nova Scotia
[4] The tetrasporic phase *(Trailliella intricata).*

PROCEEDINGS OF MEETINGS

Session 1968-1969

Meetings and communications during the year were as follows.

1st Ordinary Meeting, October 15, 1968
"The evolution of hydrofoils for the open-seas craft H.M.C.S. Bras d'Or" by M. Eames, Defence Research Establishment (Atlantic).

2nd Ordinary Meeting, November 12, 1968
"The Arctic white whale: general biology and tagging experiments" by P. F. Brodie, Dalhousie University,

"The use of small submarines in ecological research" by K. H. Mann, Fisheries Research Board — Halifax Laboratory,

"Derivatives of phytol: occurrence and biochemistry" by R. G. Ackman, Fisheries Research Board — Halifax Laboratory.

3rd Ordinary Meeting, December 9, 1968
"The effects of bark moisture on the development and survival of a species of bark beetle" by G. E. Beanlands, Dalhousie University,

"Subatomic particles" by D. Kiang, Dalhousie University.

4th Ordinary Meeting, January 13, 1969
"Why is plutonium?" by G. T. Meaden, Dalhousie University.

5th Ordinary Meeting, February 10, 1969
"Visual image processing by machine and by man" by D. A. Winters, N. S. Technical College.

6th Ordinary Meeting, March 10, 1969
"Adaptive predictive control systems" by D. J. Chaisson, Defence Research Establishment (Atlantic),

"The wandering of the boreal forest" by J. C. Ritchie, Dalhousie University.

1st Extraordinary Meeting, March 24, 1969 (jointly with St. Mary's University)
"Industrial melanism" by E. B. Ford, Oxford University.

7th Ordinary Meeting, April 7, 1969 (jointly with the Valley Chapter)
"Moult hormones of the lobster, yem tree and house fly" by M. Gilgan, Fisheries Research Board — Halifax Laboratory,

"Observations on the role of entomologists in India" by F. T. Lord, Agricultural Research Station, Kentville, N.S.

2nd Extraordinary Meeting, April 21, 1969
"Man's antiquity in Africa" by H. B. S. Cooke, Dalhousie University.

8th Ordinary Meeting, May 12, 1969

"Cellular events in the development of an insect virus" by E. L. Drake, Dalhousie University,

"Structure and mechanical properties of electro-deposited nickel-iron alloy foil" by R. D. MacInnes, N. S. Technical College,

"Automatic analysis of the foetal electro-cardiogram" by H. Wolf, Dalhousie University.

108th Annual General Meeting, May 21 1969

The President, Dr. J. H. Greenblatt, was in the chair and delivered the following address.

In preparing this report of the highlights of the past season, I read those prepared by the previous four presidents contained in Volume 26, part 3, of our proceedings and I was impressed by the fact that the central problem dealt with by past councils remains relatively the same in spite of the considerable effort devoted to its solution. This is the problem of making our Institute an effective forum of communication between the different people engaged in scientific work in the area and between them and the general public. In the presidential report of 1965-66, Dr. Masson presented statistics of attendance at meetings over a 25-year period starting in 1941 and he pointed out that the average over the years was roughly 40, having been as low as 20 at the start of the period and peaking at 55 in the mid-fifties. When these figures are viewed against the large and continual increase in numbers of people engaged in scientific work in the area during the same period, it is easy to see why the councils of the Institute have spent so much time reflecting on the purpose and worthwhileness of our organization and how it can be more effective, etc.

For the past few years we have broadly followed the policy of stressing quality and greater generality in our programs rather than quantity and specialization with the hope that such an approach would produce an interesting program. We have also been on the lookout for papers that would be of interest to a wider, more public audience. In the eight ordinary meetings we held this past year, one of which was with the Valley Chapter, and the two extraordinary meetings, I believe we have accomplished our objectives. Attendance at our regular meetings ranged from 19 to 35 and was much higher for our two extraordinary meetings. Our overall average was above the figure of 40 from Dr. Masson's graph. The success of our extraordinary meetings indicates the greater interest manifested in more general topics and this is confirmed by the large public attendance at our most successful meeting, the presentation by Dr. Cooke, where attendance was over 200.

The total number of papers presented during the year, including the extraordinary meetings, was 17 and the fields represented were: Engineering 4, Chemistry 2, Physics 1, Bio-Physics 1, Biology 5, Bio-Chemistry 3, and Paleontology 1.

At the 107th business meeting a revised draft of our constitution and by-laws was presented for approval but ran up against the formidable analytical abilities of those present at the meeting, with the result that the draft was returned to the committee for rewording. Your present council, after a short wrestle with the problem, decided to engage the advice of an expert and sought advice from Professor Donald of Dalhousie University Law School on the matter. Professor Donald informed us that, as we were an incorporated body, only the original act of incorporation belonged in a constitution and all other matters were properly by-laws. In the version submitted for your approval this evening, Professor Donald has gathered together the material of our old constitution and by-laws in an orderly and businesslike set of by-laws using intent and flexibility as guiding principles.

A significant milestone of the year was the signing of an agreement with Dalhousie University to properly house and look after the Institute's collection in the Dalhousie Library. The outline of the agreement was presented to the members of the Institute at the 107th business meeting and the final agreement incorporated suggestions of the meeting and some changes suggested by the University. The agreement contains a saving clause by which the Institute can terminate the agreement when and if it desires. While the collection is in the Dalhousie Library it will be properly identified as a holding of the Institute.

During the year the proceedings of meetings over the past four years were published as Volume 26, part 3, of our proceedings. Our editor, Dr. E. G. Young, also successfully negotiated for the printing and publishing of Part II of the Flora of Nova Scotia, including a substantial sale of the published Flora to the Nova Scotia Museum. The Province of Nova Scotia had expressed considerable sympathy with this project but to date the special grant we have asked for to finance Part II of the Flora has not yet been granted. However, at the moment the Flora is at the printers and as a result of our editor's management of the project we may cover our financial commitment from existing funds and the museum sale.

I would like to conclude my remarks by expressing to the council my pleasure in working with them and my appreciation of their support. I would particularly draw your attention to the efforts of our secretary and treasurer who have done a considerable amount of work on our behalf. I also want to thank the general membership for their interest and support and I hope this interest will continue in the forthcoming year.

The Treasurer, M. Falk reported

Receipts	10,336.90
Expenditures	1,032.82
Permanent Fund	529.62
Total cash assets as of May 15, 1969	$12,798.13

Receipts include items of grants of $1,500 from the Provincial Government and $8,000 from the N.S. Museum towards the cost of publication of Vol. 26, Part 4 of the Proceedings.

The Editor, E. G. Young, reported the publication of Volume 26, part 3, in December 1968, and the receipt of the complete manuscript of the Flora of Nova Scotia, Part II, by A. E. Roland and E. C. Smith. The latter will be published as Volume 26, part 4, which is presently in press.

The Librarian, Miss E. M. Campbell, reported the transfer of some holdings of the Institute to the new building of the N.S. Research

Foundation in Dartmouth and of other material to Dalhousie University where it is being processed.

Officers and others elected for the session 1969-70 were

President .... A. C. Neish
First Vice-President .... M. L. Cameron
Second Vice-president .... W. E. Jones
Secretary .... N. Cuthbertson
Treasurer .... M. Falk
Editor .... E. G. Young
Council — R. G. Ackman, J. E. Blanchard, A. G. McInnes, K. H. Mann, D. W. Russell and P. J. Wangersky
Auditors .... J. E. Stewart, J. R. Dingle

PROCEEDINGS OF MEETINGS

(Valley Chapter 1968-1969)

1st Ordinary and Annual Business Meeting, October 7, 1968

Officers elected for the year 1968-69 were

President .... Miss H. J. Herbert
Vice-president .... J. Basaraba
Secretary .... K. Harrison
Treasurer .... Maria Rostocka
Councillor .... K. Stewart

"Problems in the evolution of the Basidiomycetes: The *Hydnaceae*" by K. A. Harrison.

Special Meeting, October 28, 1968 (jointly with Acadia University)

"Long range transport in plants" by D. C. Spanner, Bedford College, London, England.

2nd Ordinary Meeting, December 2, 1968

"The cocoa industry of West Africa" by A. D. Pickett. Honorary membership in the Institute was awarded to D. U. Hill, J. F. Hockey, A. D. Pickett and R. W. Tufts for long and distinguished service.

3rd Ordinary Meeting, January 6, 1969

"Fertility and hatchability of hen's eggs" by F. G. Proudfoot,

"Organization and structure of international biological programmes" by W. T. A. Neilson.

4th Ordinary Meeting, February 3, 1969

"Chemical fossils: the most ancient hydrocarbon in rock" by G. R. Stevens, "On relationships of sea slugs, science and a sabbatical" by S. J. Bleakney.

5th Ordinary Meeting, March 3, 1969

"Anterior lung biopsy in the diagnosis of obscure pulmonary disease" by J. J. Quinlan,

"A demonstration of atypical Mycobacteria and Mycobacterian tuberculosis" by Helen Morse and J. E. Hiltz.

6th Ordinary Meeting, April 7, 1969 (jointly with parent society)

"Moulting hormones of the lobster, yem tree and house fly" by M. Gilgan,

"Observations on the role of entomologists in India" by F. T. Lord.

PROCEEDINGS OF MEETINGS

Session 1969-1970

Meetings and communications during the year were as follows.

1st Ordinary Meeting, October 20, 1969

"Canadian science policy in transition" by F. R. Hayes, Dalhousie University.

2nd Ordinary Meeting, November 10, 1969

"Enzyme production by chemical deception of micro-organisms" by R. G. Brown, Dalhousie University.

3rd Ordinary Meeting, December 8, 1969

"The importance of the equation $dx/dt = f(t)x$" by W. J. Archibald, Dalhousie University.

Joint Meeting with the Chemical Institute of Canada, January 12, 1970

"A chemist's impressions of South America and South Africa" by J. K. N. Jones, Queen's University, Kingston, Ont.

4th Ordinary Meeting, February 9, 1970

"The chemistry of silicates" by C. R. Masson, National Research Council, Halifax.

5th Ordinary Meeting, March 9, 1970

"Hudson '70 — Halifax to the South Shetland Trench" by P. J. Wangersky, Dalhousie Institute of Oceanography.

6th Ordinary Meeting, April 13, 1970 (jointly with Valley Chapter)

"Predator-prey systems and high-seas fisheries. Can we catch more fish?" by L. M. Dickie, Marine Ecology Laboratory, Bedford Institute,

"The unnatural history of our ubiquitous sea-slugs" by J. S. Bleakney, Acadia University.

7th Ordinary Meeting, May 11, 1970

"Hallucinogenic agents: their identity and mechanism of action" by J. G. Aldous, Dalhousie University.

109th Annual General Meeting, May 18, 1970

The President, A. C. Neish, was in the chair and delivered the following address.

> The Institute has had 186 paid up members during this past year comprised of 96 ordinary members, 26 associate members, 2 student members, 24 life members and 38 members in the Valley Chapter. In addition there are 22 ordinary members and 11 associate members who have not paid their dues for this year.
>
> The 1969-70 session started with a very successful meeting (attendance 110) at which Prof. Ronald Hayes gave a critical discussion of

Canada's science policy. There were eight ordinary meetings in all. A policy of having only one speaker at a meeting was followed except for the joint meeting with the Valley Chapter which featured a buffet supper followed by two talks in the general area of marine biology. A joint meeting was held in conjunction with the Chemical Institute of Canada, addressed by J. K. N. Jones, F.R.S., who was a tour speaker for the C.I.C. Other ordinary meetings featured talks in biology, oceanography, physics, chemistry and pharmacology. The average attendance at these meetings was 44. There were 8 Council meetings, with an average attendance of 9 members.

The policy of having only one speaker at a meeting probably gives a smaller audience with a higher level of interest. The attendance varied between 23 and 43 for meetings other than the three special ones mentioned above. However after these smaller meetings most of the audience stayed for coffee and continued discussions for another half hour or so. These coffee discussions do not occur after large special meetings.

We did not arrange any extraordinary meetings this year. The joint meeting with the C.I.C. happened to fall on the regular date for an ordinary meeting. The graduate student night was not held because students do not show much interest in the Institute.

This was not a particularly scintillating year in the history of the Institute, but it probably represents a level of activity that can easily be maintained. During the 108 years of operation of this society we have seen the emergence of scientific research as a profession. When this society was founded, and for many years thereafter, scientific research was pursued for its own sake by people who earned their living by other means. Now we have people who earn their living solely by doing scientific research — and quite a large proportion of the scientists in the Halifax area fall into this category. Their professional needs are served much better by societies operating on a national or international scale. However many of these people have an interest in science which extends beyond their specialty and can benefit from meetings such as are organized by the Institute. Most of our membership consists of professional scientists or academics whose research is heavily supported by government funding. We no longer reach the amateurs of science in any considerable numbers. In the future it would be desirable to foster such contacts.

In general we can hold two types of meetings: (1) Meetings of broad interest which would be attractive to the general public, (2) Meetings of interest to more specialized groups with over-coffee discussions.

We probably should have both types of meeting — and take pains to advertise the wide-appeal meetings so non-members would be encouraged to attend.

Both types were held during the past year. In the future it might be better to give more emphasis to meetings of the first type.

The Treasurer, M. Falk, reported

Receipts	1,967.34
Expenditures	12,108.90
Permanent Fund	529.62
Total cash assets as of April 28, 1970	S 2,656.57

The Editor, E. G. Young, reported the publication of Volume 26, part 4, of the Proceedings in December 1969, in all 475 pp., at a cost to the Institute of $2.88 per copy.

The Librarian, Miss E. M. Campbell, reported a revision of the list of exchanges and correspondence with some to inform them of the new annual institutional membership of $5.00. Processing of holdings of the Institute at Dalhousie University is continuing prior to moving to the Killam Memorial Library.

Officers and others elected for the session 1970-71 were

President . . . . M. L. Cameron
First Vice-president . . . . W. E. Jones
Second Vice-president . . . . J. E. Blanchard
Secretary . . . . N. Cuthbertson
Treasurer . . . . A. G. McInnes
Editor . . . . E. G. Young
Council – R. G. Ackman, R. F. Brown, K. H. Mann, D. W. Russell, B. Wright and G. Mitchell
Auditors . . . . J. R. Dingle, W. J. Dyer

PROCEEDINGS OF MEETINGS

(Valley Chapter 1969-1970)

1st Ordinary Meeting, October 6, 1969

"Recent advances in food processing" by R. Stark,

"Spawning and early life of the mackeral in the Gulf of St. Lawrence" by P. Arnold.

2nd Ordinary Meeting, November 3, 1969

"The effect of thalidamide on the development of the sternum" by M. Gibson.

3rd Ordinary Meeting, December 1, 1969

"Recent vulcanism in Iceland" by G. Stevens,

"The utilization of skeletal mineral for egg shell formation by the domestic hen, *Gallus domesticus*" by A. Cox.

4th Ordinary Meeting, January 5, 1970

"The concept of mass" by R. Bishop,

"A computer scientist looks at numerical taxonomy" by D. Bonyun.

5th Ordinary Meeting, February 3, 1970

"The application of low oxygen levels to fruit and vegetable preservation" by C. Eaves,

"How unique is water?" by M. Peach.

6th Ordinary and Business Meeting, March 2, 1970

"Spirometry" – a film,

"Chronic obstructive emphysema – a 10 year survey" by J. J. Quinlan,

"Pulmonary function – tests and blood gas analysis, a demonstration" by G. Kloss,

"Modern development in inhalation therapy" by E. Crossen.

Officers and others elected for the year 1970-71 were

President	K. Stewart
Vice-president	D. Stiles
Secretary	F. Bent
Treasurer	T. Haliburton
Executive	M. Rostoca
	J. Basaraba (past president)

PROCEEDINGS

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Investigations of the Marine Algae of Nova Scotia. X. Distribution of *Fucus Serratus* L. and Some Other Species of *Fucus* in The Maritime Provinces*

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(Received for publication 24 January, 1972)

Abstract

The distribution of *Fucus serratus* in the Maritime Provinces has changed markedly during the past century. It is now common in the Northumberland Strait, eastern Prince Edward Island, Cape Breton I. and the Tusket I. area. The most common and abundant species of *Fucus* in the Maritime Provinces is *F. vesiculosus* which is found in a wide variety of habitats. Other species of *Fucus* found in this area are *F. edentatus, F. distichus* ssp. *distichus* and ssp. *evanescens* and *F. spiralis*. These species are widely distributed but only locally abundant and usually restricted to specific habitats.

Seven species of Fucus have been recorded from the east coast of North America as occurring in the Atlantic Provinces (Taylor 1957, South and Cardinal 1970). None of these species is endemic to the western Atlantic. Powell (1957) has suggested that *F. edentatus* Pyl., *F. evanescens* C. Ag. and *F. filiformis* Gmel. are subspecies of *F. distichus* L., and this has been generally accepted (Parke and Dixon 1968, South and Cardinal 1970). The validity of *F. miclonensis* Pyl. is doubtful, and it was recently merged with *F. distichus* ssp. *distichus* (Lee 1968). Distributional records for the Maritime Provinces were provided by Bell and MacFarlane (1933*a, b*), MacFarlane and Bell (1933) and MacFarlane (1952). Colinvaux (1970) recorded the species of *Fucus* in New Brunswick along the shores of both the Northumberland Strait and the Bay of Fundy. General floristic accounts inclusive of species of *Fucus* are available for Halifax Co. (Edelstein and McLachlan 1966), the Digby Neck area (Edelstein *et al.* 1970) and Newfoundland (Lee 1968).

During the past several years we have made extensive collections throughout the Maritime Provinces (Fig. 1 and Table I), and it is now possible to present updated distributional records for the species of *Fucus*. We have been especially interested in *F. serratus* which has a very restricted distribution. *F. vesiculosus* is certainly the most common and widely distributed species in our area whereas

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*F. edentatus** is more restricted although locally abundant. *F. spiralis*, *F. distichus* ssp. *distichus* and ssp. *evanescens* are confined to specific, isolated habitats.

Fucus serratus L.

In Europe, *F. serratus* is a common and abundant alga. In North America, it is found only in the Maritime Provinces, especially in Nova Scotia and Prince Edward Island. This is the only species of *Fucus* for which there are records of major changes in distribution. Robinson (1903) postulated that *F. serratus* was introduced from Europe in ballast, possibly around the turn of the 19th century, although it was not recorded by Harvey during his visit to the Maritimes in 1850. The first collections were made at Pictou on the Northumberland Strait in 1869 (Hay and MacKay 1887), and by 1886 plants were common around Pictou and Pictou Island (near Site 11, Fig. 1).

Robinson's extensive survey of *F. serratus* in 1903 revealed a dense population which extended from Pugwash Harbour (Site 8) eastward for 250 miles to Eastern Harbour (Cheticamp, Site 27) Cape Breton I. The plants penetrated the Strait of Canso as far as Mulgrave, but were apparently absent from the Cape Breton shore of the Strait. Robinson failed to locate any specimens along the New Brunswick coast of the Northumberland Strait, and found only an isolated population in Prince Edward Island, at Murray Harbour (near Site 109). He concluded that *F. serratus* was absent from the Bay of Fundy and the Atlantic coast of Nova Scotia. In 1907, Robinson also reported *F. serratus* as absent around Canso (Site 65).

Bell and MacFarlane (1933) completed their survey of the Maritime Provinces in 1931 which revealed that the distribution of *F. serratus* had extended considerably beyond that reported earlier by Robinson (1903, 1907). The reported range in 1931 included the entire mainland shore of the Northumberland Strait to Miramichi Bay, the west shore of Cape Breton I. to Cape St. Lawrence (near Site 29), and an isolated population on the Atlantic coast just south of Ingonish (Site 36); it was apparently absent in Chedabucto Bay. They also reported this species as relatively abundant all around Prince Edward Island (see their map 5, p. 277). Roscoe (1931) did not record *F. serratus* in her survey of St. Paul's I. In 1948 MacFarlane (1952) noted this species in a limited area in the Tusket Islands, Yarmouth Co. (Site 92), and in 1954 she found the alga near Canso in eastern Guysborough Co. (MacFarlane and Milligan 1966).

Our recent observations show that changes in the distribution of *F. serratus* have occurred during the past several decades. Contrary to the report of Bell and MacFarlane (1933), we have not encountered *F. serratus* along the New Brunswick shore of the Northumberland Strait except for a few scattered plants at Cadman Point (Site 4); proceeding eastward an extensive population was first noted around Coldspring Head (Site 7). Our observations are confirmed by those of Colinvaux (1970) and A.R.A. Taylor (private communication). Possibly the sandy to muddy substrata together with the considerable outflow of freshwater, render this area unfavourable for *F. serratus*. This species has

*We refer herein to this taxon as a separate species based on other considerations (Edelstein and McLachlan, unpublished).

also been reported from the Gaspé and Bay of Chaleur (Gauvreau 1956) but not by Cardinal (1967) who considers the previous identifications to be in error.*

In agreement with previous reports, including more recent observations by MacFarlane (1965), we found *F. serratus* continuously along the Northumberland Strait in Nova Scotia and the west shore of Cape Breton I. The known range can now be extended around Cape North and along the eastern shore of the Island to White Point (Site 32). At this locality the alga was replaced by dense beds of *F. distichus* ssp. *evanescens*. *F. serratus* reappeared around Ingonish and extended southward to Whelan Point (Site 47). Thereafter the density of this species was much less and only a single specimen was found amongst dense beds of ssp. *evanescens* at Mira Bay (Site 50). The Atlantic coast of Cape Breton I. is not only extremely exposed, but subject to erosion by ice throughout the winter. Moreover, the shore is often steep and the littoral zone narrow. Beds of *F. serratus* in this area were usually confined to the sublittoral and ranged from just below low water to 4 to 5 m. Between sites 36 and 40 (Table I) the shore is of rolling stones, and the population of *F. serratus* was some distance offshore. Previously we recorded this species in Bras d'Or Lake from the entrance of Great Bras d'Or Channel to a point near Baddeck (McLachlan and Edelstein 1971).

F. serratus presently occurs along both shores of the Strait of Canso and is relatively abundant throughout Chedabucto Bay. We have not observed the alga along the Atlantic coast of Nova Scotia beyond the Canso area, and conclude that little westward movement has taken place during the past 2 decades. We noted a large luxuriant population of *F. serratus* in St. Peter's Bay, but failed to locate the alga from a point near L'Ardoise (Site 55) eastward to Mira Bay. Thus *F. serratus* has spread along the Atlantic shore of Cape Breton I. both southward from Cape North and eastward from the Strait of Canso. The population may eventually become continuous around Cape Breton I.

We have been unable to confirm the report of Bell and MacFarlane (1933*a*) that *F. serratus* encircles Prince Edward Island. We did find a contiguous population from Cable Head (Site 115) to East Point (Site 111) and thence westward to Cape Egmont (Site 128). There was no evidence of the alga along the north shore west of Cable Head to North Point (Site 123) and southward to Egmont Bay (Sites 127 to 128). Extensive underwater surveys in this area have been made by D.J. Scarratt and his associates who confirm our observations (private communication). In addition A.R.A. Taylor and L.A. Hanic have studied sublittoral communities within this region and they too have failed to record *F. serratus* (private communications). We are unable to offer a satisfactory explanation for the apparent disappearance of *F. serratus* from the western portion of the province where it had been reported as relatively abundant (Bell and MacFarlane 1933*a*). Freshwater run-off in this area is negligible and the substratum is generally firm and supports commercial quantities of *Chondrus crispus* Stackh.

*A report by O.A. Doiron and R. Branch [Final report on northern New Brunswick Irish moss survey. Project No. 402-72. Dept. of Fisheries and Environment. Fisheries Development Branch, Caraquet, N.B. 1972. (mimeographed),] circulated after this paper was submitted for publication, states that *F. serratus* is present off Miscou I., Caraquet I., and Blue Cove in the Bay of Chaleur.

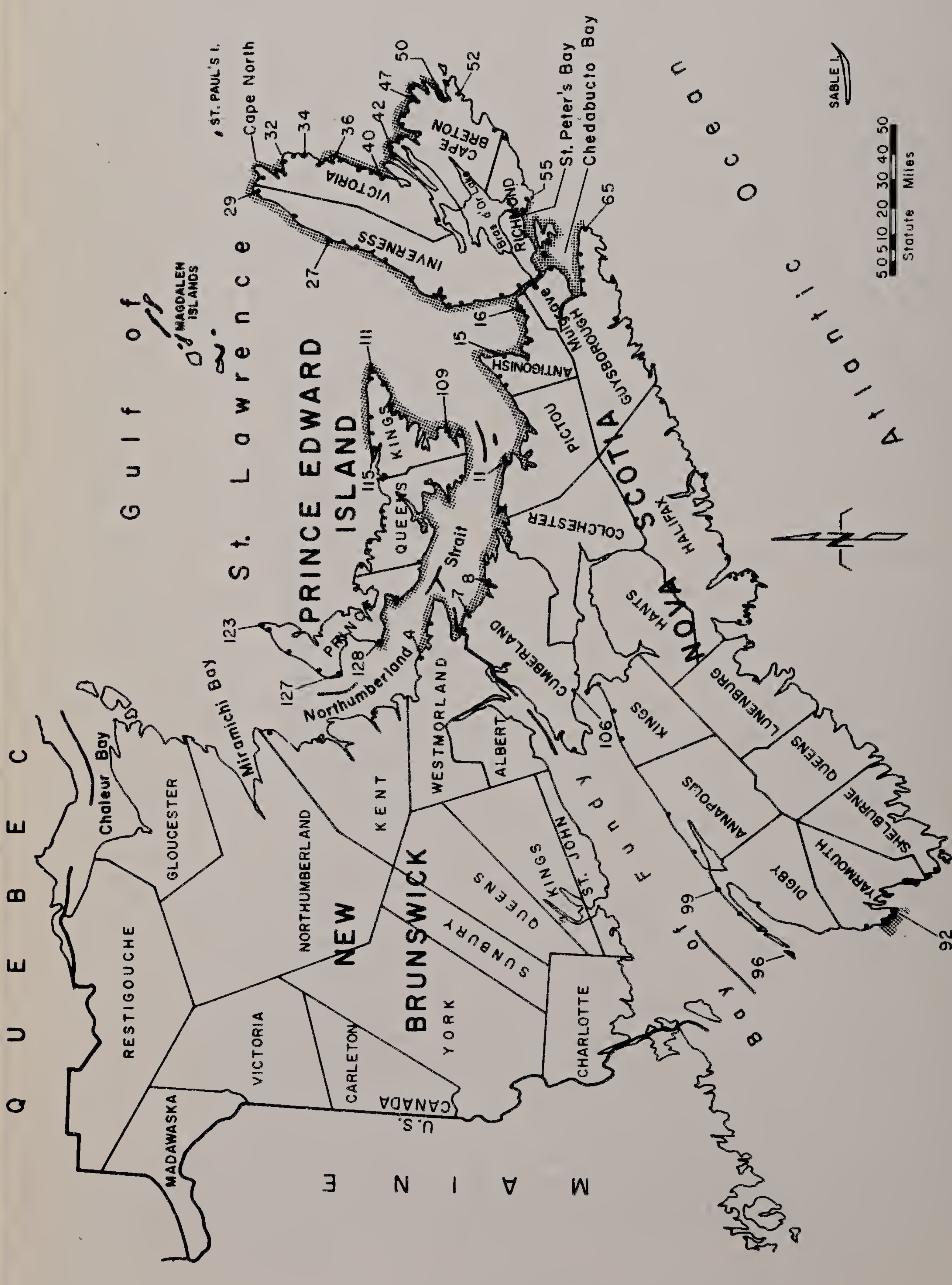

Fig. 1. Location of collecting sites in the Maritime Provinces as referred to in Table I. The present distribution of *F. serratus* is shown by stippling.

Table I
Locations of Collecting Sites

Northumberland Co., N.B.:
1. Point Sapin
2. Richibucto Head
3. Cocagne Head

Westmorland Co., N.B.:
4. Cadman Point
5. Murray Beach

Cumberland Co., N.S.:
6. Tidnish Dock
7. Coldspring Head
8. Pugwash
9. Malagash Point

Pictou Co., N.S.:
10. Cape John
11. Caribou Island
12. Merigomish Island

Antigonish Co., N.S.:
13. Arisaig
14. Georgeville
15. Lakevale
16. Cape Jack

Inverness Co., N.S.:
17. Troy Beach
18. Long Point
19. Ragged Point
20. Port Hood
21. Mabou Beach
22. Green Point
23. Inverness
24. Chimney Corner
25. Cap Le Moyne
26. Grand Etang
27. Cheticamp
28. Pleasant Bay
29. Meat Cove

Victoria Co., N.S.:
30. Bay St. Lawrence
31. South Harbour
32. White Point
33. New Haven
34. Black Brook
35. Ingonish, North Bay
36. Ingonish, South Bay
37. Wreck Cove
38. Little River Cove
39. North Shore
40. Indian Brook
41. Tablehead

Cape Breton Co., N.S.:
42. Point Aconi
43. Florence
44. Sydney Mines
45. New Victoria
46. Lingan
47. Whelan Point
48. MacDonald Point
49. Cow Bay
50. Mira Bay
51. Main à Dieu
52. Louisburg
53. Belfry Lake

Richmond Co., N.S.:
54. Fourchu
55. L'Ardoise
56. Rockdale
57. Bay of Rocks
58. Creighton Island
59. Janvrin Island

Guysborough Co., N.S.:
60. Cape Argos
61. Dort's Cove
62. Peas Brook
63. Queensport
64. Half Island Cove
65. Canso
66. Whitehead
67. Tor Bay
68. Country Harbour
69. Port Bickerton

Halifax Co., N.S.:
70. Moosehead
71. Owl's Head

72. Clam Bay
73. Martinique Beach
74. Lawrencetown
75. Cow Bay
76. Black Rock, Halifax Harbour
77. Herring Cove
78. Portuguese Cove
79. Gill Cove
80. Ketch Harbour
81. Fink Cove
82. Polly Cove
83. Peggy Cove
84. Paddy Head

Lunenburg Co., N.S.:
85. Bayswater
86. New Harbour
87. Lunenburg

Shelburne Co., N.S.:
88. Stoney Island
89. West Head
90. Lower Wood Harbour

Yarmouth Co., N.S.:
91. St. Ann Point
92. Tusket Island
93. Pinkney Point
94. Chebogue Point
95. Chegoggin Point

Digby Co., N.S.:
96. Pond Cove, Brier Island
97. Tommy Beach
98. Sandy Cove
99. Gulliver's Cove

Annapolis Co., N.S.:
100. Delap Cove
101. Port George

King's Co., N.S.:
102. Harbourville
103. Hall's Harbour
104. Scots Bay
105. Cape Split

Colchester Co., N.S.:
106. Ramshead River
107. Spicer's Cove

Kings Co., P.E.I.:
108. Guernsey Cove
109. Cody Point
110. Red Point
111. East Point
112. North Lake
113. Shipwreck Point
114. Swallow Point
115. Cable Head
116. Savage Harbour

Queens Co., P.E.I.:
117. Dalvay
118. Stanhope
119. Brackley
120. Rustico
121. Cavendish
122. Tryon Head

Prince Co., P.E.I.:
123. North Point
124. Nail Pond
125. Cape Gage
126. Cape Wolfe
127. West Point
128. Cape Egmont - Red Head
129. Sea Cow Head

Queens Co., P.E.I.:
130. Point Prim
131. Bell Point

In our survey of the Magdalen Islands, Gulf of St. Lawrence (unpublished results), we did not encounter *F. serratus,* despite an abundance of other species typical of the Gulf, including *C. crispus*. Cardinal (1966) also did not list *F. serratus* amongst the species he examined from these islands.

The apparent stability of the population of *F. serratus* in the Tusket I. area is one of the more surprising facts to arise from our investigation. The extent of *F. serratus* here was determined more than 20 years ago, and our observations suggest there has been relatively little subsequent migration. We do not know how *F. serratus* was introduced into southwestern Nova Scotia but it is reasonable to assume that it came from the Gulf of St. Lawrence.

Apart from the areas already mentioned, there is no evidence of the presence of *F. serratus* at other localities in eastern North America. It was reported once from Newburyport, Mass. during the last century (Farlow 1891). The specimens were either erroneously identified, or the population never became established.

Fucus vesiculosus L.

This is the most common species of *Fucus* in the Maritime Provinces and occurs in a wide variety of habitats, from exposed rocky shores to very protected muddy salt marshes (McLachlan and Edelstein 1971). The morphology of the plants is extremely variable, and well-developed vesiculate specimens were abundant only on the open, rocky coast. In general this species occupied the zone above *Ascophyllum nodosum* (L.) Le Jolis in protected sites and above *F. edentatus* in exposed areas where the latter was present. *F. vesiculosus* was always found associated with *F. serratus* although generally higher in the intertidal zone. On gently sloping shores the two species were frequently intermixed, especially in shallow tide pools. Specimens of *F. vesiculosus* in the Gulf of St. Lawrence were poorly developed and morphologically different from those along the Atlantic coast and the Bay of Fundy. At some sites along the west shore of Cape Breton I. only, we found a narrow form of *F. vesiculosus* somewhat similar to f. *limicola* Coll. described from muddy and salt-marsh habitats (Taylor 1957). In St. George's Bay (Sites 15 to 16), v. *sphaerocarpus* J. Ag. and v. *spiralis* Farl. were collected in addition to specimens similar to f. *gracillimum* Coll.

Fucus edentatus Pyl.

F. edentatus was common along the Atlantic Coast of Nova Scotia from Canso to Lunenburg Co. in the mid-littoral zone to about 3 m below low water. This species favoured an exposed rocky shore with a gentle slope, and disappeared whenever the rock gave way to sandy or muddy substrata. Well-developed populations were recorded in western Halifax Co. and plants up to 0.6 m in length have been noted (Edelstein and McLachlan 1966). In the Bay of Fundy a dense cover of this fucoid has been reported for Digby Neck (Sites 96 to 99) and New Brunswick (Edelstein *et al.* 1970, Colinvaux 1970). It was absent from protected, muddy areas, as around the head of the Bay. Even where a solid substratum was present, as along the Parrsboro shore (e.g. Site 106), this species was rare or seemingly absent, possibly because of the large amount of silt. Apart from a few doubtful specimens, we did not find *F. edentatus* either in the Northumberland Strait or around Cape Breton I. It was also apparently absent from the Yarmouth area where *F. serratus* was common. The different pattern of distribution may result from differences in exposure although competition cannot be excluded as a factor.

Fudus distichus L. ssp. **distichus**

This sub-species was confined to rock pools high in the littoral zone and therefore showed a rather discontinuous pattern of distribution. On the Atlantic coast well-developed populations were common in Halifax Co. (Table 1). We did not encounter the alga north of Louisburg (Site 52) although it was reported from St. Paul's I. (Roscoe 1931). Isolated, small groups of plants were found along Digby Neck (Edelstein *et al.* 1970). A detailed ecological study (Edelstein *et al.* unpublished) showed that morphological features of ssp. *distichus* were modified by depth of the pool, degree of exposure, etc. The apparent absence of this species along the Northumberland Strait may be due to lack of suitable habitats and to ice erosion.

Fucus distichus ssp. **evanescens** (C.Ag.) Powell

Our information on this subspecies is meagre. It has been recorded as abundant along the Atlantic coast of Nova Scotia (MacFarlane and Milligan 1966), but we have seldom encountered large populations except in Shelburne and Yarmouth Co. This subspecies does not seem to coexist with *F. serratus*. Ssp. *evanescens* was usually found in protected habitats and was locally common even in salt marshes. Lack of stable substrata is apparently not a limiting factor in distribution for sizeable plants were noted in sandy as well as muddy areas.

Fucus spiralis L.

This species was restricted to exposed, rocky shores; it was usually found in depressions that provided protection from direct surf action. *F. spiralis* occupied a narrow band in the extreme upper littoral zone above *F. vesiculosus*. It also occurred at sites with *F. serratus*, in which case the zonation was similar to that described for the British Isles (Burrows and Lodge 1953). In general *F. spiralis* was relatively uncommon, and even when present was represented by few specimens; in the Maritimes we noted the best-developed populations in Halifax Co. Under extreme conditions of surf action dwarf forms were found. Like *F. distichus* ssp. *distichus*, *F. spiralis* was absent in areas of gravel, sand and mud.

Summary

There has been an extensive spread of *F. serratus* throughout the Northumberland Strait, eastern Prince Edward Island and around Cape Breton I. since it was first noted at Pictou about a century ago. Significant changes in the distributional pattern have occurred in the last 40 years. These include not only the population of new areas, but ostensibly the disappearance of the species from extensive areas of western Prince Edward Island and the New Brunswick shore of the Gulf of St. Lawrence. The disappearnace of *F. serratus* from these areas is rather surprising and difficult to explain. According to Miss C.I. MacFarlane (private communication) there is no doubt that the 1933 distribution map (Bell and MacFarlane 1933*a*) was prepared accurately. The spread of

species along the Atlantic coast has been slow, and the population on the Tusket I. seems to be stable. Quite probably *F. serratus* will colonize areas presently unoccupied. Transplant experiments may help elucidate some of the problems of this species along the Atlantic coast has been slow, and the population in the Tusket I. area seems to be stable. Quite probably *F. serratus* will colonize areas presently unoccupied. Transplant experiments may help elucidate some of the problems of migration in this species. Remarks concerning other species of *Fucus* should be regarded as preliminary only. Our observations do however agree with corresponding observations made in the British Isles and elsewhere in Europe.

Acknowledgments

We thank Drs. D.J. Scarratt, A.R.A. Taylor and L.A. Hanic for making unpublished information available to us. We are especially grateful to Miss Taina Tuominen and Mr. J. Bailey, for excellent assistance in the field and for preparation of herbarium specimens.

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The Recent Mammals of Kejimkujik National Park

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Abstract

The mammalian fauna of Kejimkujik National Park in southwestern Nova Scotia was systematically sampled during the summer of 1971. An aerial survey for deer and moose abundance and distribution was flown in February 1972. Thirty-four species of mammals were found to occur within the Park.

Kejimkujik National Park, 147 square miles of wild country in the interior of southwestern Nova Scotia, is characterized by wooded hills, shallow, rock-strewn lakes and rivers, with abundant marshes and flood plains. Remnants of the Park's glacial history are evident in boulder fields, drumlins and eskers. The climate of the park, due to mixing of air masses from the Atlantic Ocean and continental North America, is marked by cooler summers, longer autumns, milder winters, later and shorter springs and more precipitation than comparable mainland latitudes.

Kejimkujik lies within two forest districts described by Loucks (1960). The northeastern half of the Park, including the Kejimkujik Lake basin is in Loucks' LaHave District of the Sugar Maple-Hemlock-Pine Zone. The southwestern half of the Park lies in Loucks' Fisher Lake-Halifax District of the Red Spruce-Hemlock-Pine Zone. Division between the two corresponds closely to the margin between the deeper, richer slate-argillite soils in the Kejimkujik Lake basin and the more shallow, infertile quartzite-granite soils of the western uplands (Loucks 1960).

The forest of the LaHave District is mainly beech, *(Fagus grandifolia),* sugar maple *(Acer saccharum),* and red oak *(Quercus borealis),* with white pine *(Pinus strobus)* abundant on lower slopes and valley floors. Red spruce *(Picea rubens)* and hemlock *(Tsuga canadensis)* are found on moist sites, and white pine forms pure stands on abandoned fields (Loucks 1960:116). In the Fisher Lake-Halifax District, white pine, red spruce and hemlock are the common species on areas that have not been burned. Beech, sugar maple and red oak cover exposed slopes and hill tops, and fire stands of red oak, red maple *(Acer rubrum),* and white birch *(Betula papyrifera)* are abundant. Balsam fir *(Abies balsamea)* and black spruce *(Picea mariana)* dominate moist sites (Loucks 1960:131).

Kejimkujik Lake lies in the centre of the traditional Micmac canoe route between the Bay of Fundy and the Atlantic coast, and this migratory people used the Park area seasonally as a hunting ground. The first European settlements were established in the early 1800's. Logging for the ship-building industry was begun in the area about the same time, and forest-cutting for various species continued until the Park was established in 1964. Few areas have escaped the influence of forest-cutting or fire, and much of the forested area of the Park is now a rich mixture of second growth mixed wood and mixed softwood.

The purpose of this study was to inventory the mammalian fauna of Kejimkujik National Park, and describe, in general terms, the abundance, distribution and habitat preferences of each species.

I am grateful to the Superintendent and staff of Kejimkujik National Park for co-operation and assistance in all stages of the fieldwork. Messrs. Ross Dobson, Robert Gray and Richard Howie of Parks Canada provided valuable introductory information on the natural and human history of Kejimkujik, for which I am in their debt. The help of Mr. Gaston Tessier of the Canadian Wildlife Service was invaluable in preparatory stages of this project. He with Mr. Phillip Youngman of the National Museum of Canada spent long hours confirming our field identification of specimens. Dr. R.L. Peterson of the Royal Ontario Museum advised on details of distribution. Messrs. Britt Roscoe, John Maxwell, Terry Shewchuk and Arthur Morgan were members of the field crew. Their conscientious attention to detail throughout a long and sometimes trying field season was greatly appreciated. The study was financed jointly by Parks Canada and Canadian Wildlife Service.

Methods

No systematic ecosystem classification of the Park existed at the start of this study. Because much of the Park is complex second growth, without obviously dominant life form, for purposes of this study much of the Park forest was categorized merely as mixedwood or mixed softwood. Other ecosystems, such as heath meadows, river flood-plains, pure hardwood and conifer stands were considered, where definable, as separate habitat classifications.

Thirty-four sampling areas (Fig. 1) were each sampled for 500 trap-nights with Museum Special snaptraps during the summer of 1971. Trap lines 25 chains long, consisting of 50 stations at half-chain intervals, two traps to a station, were set for 5 consecutive nights in each area. Traps were baited with a mixture of peanut butter, rolled oats and bacon grease, and were continuously relocated within a 25-foot radius of each station to maximize capture rate. Habitat types and dates sampled are listed in Table 1. Air photographs detailing specific location of each sampling area and black-and-white photographs of vegetational cover of each area are on file in a report to Parks Canada (Wood 1972).

In August, arboreal sets, using large snaptraps, were made for red and flying squirrels in mixedwood (34 trap-nights), red oak (42 trap-nights), white pine (55 trap-nights) and mixed spruce and pine (62 trap-nights). Sets for mink, muskrat and weasel (239 trap-nights), using Conibear and Oneida steel traps were made in seven areas of the Park, and mist netting for bats was carried out for 5 evenings over lawns, marshes and streams (Wood 1972).

Table I
Collection areas and dates of sampling habitat types.

HABITAT TYPE	COLLECTION AREAS	DATES SAMPLED
Black Spruce Bog	1,20	May 18-23, June 29-July 4
Heath Meadow	10,16,18	June 2-7, 15-20, June 29-July 4
River and Lake Flood-Plains	8,30	May 26-31, July 25-30
Grassy Islands	24	July 10-15
Stream and River Banks	8,14,21,26,28	June 2-7, 9-14, July 4-9, 10-15, 20-25
Lake Shore	17,34	June 15-20, Aug. 14-19
Old Field	2,32	May 10-14, July 25-30
Park Roadside	31	July 25-30
Spruce Barren	27	July 20-25
White Pine	33	August 9-14
Balsam Fir	3	May 18-23
Hemlock	7,12	May 26-31, June 9-14
Mixed Softwood	13,22,29	June 9-14, July 4-9 20-25
Mixedwood	4,19,23	May 18-23, June 29-July 4, July 4-9
Red Oak	5,6,11	May 18-23, 26-31, June 2-7
Beech	15,25	June 15-20, July 10-15

All specimens were weighed, measured, aged, and sexed, and data on reproductive activity and general body condition were recorded. Skulls were saved from all specimens, and museum study skins prepared from most. Skulls and skins were identified and catalogued at the National Museum of Canada.

An aerial survey of the Park for deer and moose was conducted on February 3, 1972, using a Cessna 172 and two observers. A total of 219.5 miles of survey lines, spaced 0.67 miles apart, was flown at an altitude of 300 feet (Fig. 2). A strip 300 feet wide was observed on either side of the aircraft, giving a total observed area of 25.0 square miles (17% of the Park area).

Reference used for nomenclature and classification was Roland (1945) for plants and Peterson (1966) for animals.

Table II
Percentage distribution by habitat type of small mammals captured in Kejimkujik National Park, Nova Scotia, 1971

SPECIES CAPTURED	Black Spruce Bog	Heath	Flood Plain	Grassy River Islands	Stream and River Banks	Lake Shore	Old Fields	Park Roadside	Spruce Barren	White Pine	Balsam Fir	Hemlock	Mixed Softwood	Mixedwood	Red Oak	Beech	TOTAL NUMBER CAPTURED
Clethrionomys gapperi	8	2	2	T	13	4		T	2	7	3	8	11	21	16	3	389
Microtus pennsylvanicus	1	2	14	46	18	2	9		4				2				116
Sorex cinereus	13	10	8		24		3		5	13		2	13	11			63
Zapus hudsonius	3	3	16	3	47	3	12		3	3			6				32
Blarina brevicauda					7	28	21					7		14		21	14
Tamias striatus	7		20		7	7		7	7	7			27	7	7		15
Peromyscus leucopus		16			16								32	16	16		6
Peromyscus maniculatus														100			2
Sorex palustris			20		80												5
Napaeozapus insignis													75			25	4
Synaptomys cooperi					25						25	25	25				4
Glaucomys volans														50	50		2
Condylura cristata					100												1
Lepus americanus					100												1
Sorex fumeus						100											1

Table III
Percentage species composition by habitat type of small mammals captured in Kejimkujik National Park. Nova Scotia, 1971

SPECIES CAPTURED

HABITAT TYPES	*Clethrionomys gapperi*	*Microtus pennsylvanicus*	*Sorex cinereus*	*Zapus hudsonius*	*Blarina brevicauda*	*Tamias striatus*	*Peromyscus leucopus*	*Peromyscus maniculatus*	*Sorex palustris*	*Napaeozapus insignis*	*Synaptomys cooperi*	*Glaucomys volans*	*Condylura cristata*	*Lepus americanus*	*Sorex fumeus*	TOTAL NUMBER MAMMALS CAPTURED
Black Spruce Bog	73	2	20	2		2										41
Heath	44	11	33	6				6								18
Flood Plains	18	46	13	13		8			3							39
Grassy River Islands	2	96		2												56
Stream and River Banks	45	19	14	14	1	1		1	4		1		1	1		111
Lake Shore	64	8		4	16	4									4	25
Old Field		55	10	20	15											20
Park Roadside	50					50										2
Spruce Barren	41	29	18	6		6										17
White Pine	73		22	3		3										37
Balsam Fir	92										8					13
Hemlock	91		3		3						3					33
Mixed Softwood	66	3	12	3		6		3		5	2					64
Mixedwood	85		7		2	1	2	1				1				96
Red Oak	95					2		2		6		2				66
Beech	76				18											17

Results and Discussion

A total of 655 small mammals, comprising 15 species, were caught in the snap-trap program. Table II illustrates the percentage distribution by habitat type of each of the 15 species collected and Table III shows the percentage species composition by habitat type of animals captured.

The general abundance of all species increased as the summer progressed as reflected in captures per trap-night (Table IV). Therefore direct comparison of capture rates between habitat types as an indication of relative abundance, cannot be made because habitat types were sampled at different times. However, the data probably illustrate habitat selection by the more common species and species composition within the habitats sampled.

Arboreal sets for squirrels produced one red squirrel *(Tamiasciurus hudsonicus).* Mink, muskrat and weasel sets produced one ermine weasel *(Mustela erminae).* Mist netting for bats produced three little brown bats *(Myotis lucifugus)* and two eastern long-eared bats *(M. keenii).*

Table V gives the numbers of species present in the Park by orders and genera. Hypothetical species are not included. The following list describes the mammals of Kejimkujik National Park, using results of this study as well as observations recorded throughout periods in the field, findings of previous investigators and records on file in the Park headquarters (Mullen 1970). Estimates of abundance and habitat preference are included where such data were available.

Table IV
Monthly trap effort and unit capture

	May	June	July	August
Total trap-nights	4000	4500	7500	1000
Number of animals captured	88	117	396	54
Captures per trap-night x 100	2.2	2.6	5.3	5.4

Table V
Generic distribution of mammalian species in Kejimkujik National Park.

ORDER AND GENERA	NUMBER OF SPECIES
Insectivora (insect eaters)	
Sorex (shrews)	3
Blarina (shrews)	1
Condylura (moles)	1
Chiroptera (bats)	
Myotis	2
Lasionycteris	1
Pipistrellus	1
Lagormorpha (rabbits and hares)	
Lepus (hares)	1
Rodentia (rodents)	
Tamiasciurus (red squirrels)	1
Tamias (chipmunks)	1
Glaucomys (flying squirrels)	2
Castor (beaver)	1
Peromyscus (mice)	2
Synaptomys (bog lemmings)	1
Clethrionomys (red backed vole)	1
Microtus (meadow vole)	1
Ondatra (muskrat)	1
Zapus (meadow jumping mouse)	1
Napaeozapus (woodland jumping mouse)	1
Erethizon (porcupine)	1
Carnivora (flesh eaters)	
Vulpes (red fox)	1
Ursus (black bear)	1
Procyon (raccoon)	1
Mustela (weasel and mink)	2
Martes (fisher)	1
Lutra (otter)	1
Lynx (bobcat)	1
Artiodactyla (ungulates)	
Odocoileus (deer)	1
Alces (moose)	1
TOTAL	34

Class **MAMMALIA**

Order **Insectivora**

Family **Soricidae**

Sorex cinereus Kerr — Common or Mask Shrew

Common throughout the Park. The most abundant non-rodent collected. Found in a wide variety of habitat types, but most common in stream and river-bank areas. Prefers moist areas with considerable ground cover. Significantly lacking from balsam fir, beech and oak communities, and open lake-shore and roadside areas. Absence from grassy river islands was probably due to seasonal flooding of these areas.

Sorex fumeus Miller - Smoky Shrew

One specimen was taken in 1971, a sexually mature male, on the eastern shore of Kejimkujik Lake. This is the first record of this species from the Park, but records exist from surrounding areas of southwestern Nova Scotia (Peterson 1966) where abundance is described as quite sporadic. The smoky shrew appears to be uncommon in Kejimkujik.

Sorex palustris Richardson — Water Shrew

Relatively common in open, moist habitat types, but not nearly as abundant as *Microtus, Clethrionomys* or *Sorex cinereus* in these areas.

Microsorex hoyi (Baird) — Pygmy Shrew

Peterson (1966) described four locations in southwestern Nova Scotia where pygmy shrews have been taken, three near Digby and one, of a capture in 1895, at Caledonia, Queens County, just east of the Park. The current status of *Microsorex* in the Park is not known. Since water-trapping, the only effective way to capture the species (Peterson 1966) was not used in 1971, and this shrew has been described as a rare mammal all over North America (Anthony 1928), it is impossible to conclude whether or not it is present in the Park.

Blarina brevicauda (Say) — Big Short-tailed Shrew

Common in many habitat types, particularly old-field and lake-shore associations. Found to a lesser extent in beech woods, mixed woods and on stream and river banks. Sheldon (1936) considered this "one of the most common of the small mammals" of the area and Dodds *et. al* (1969) took large numbers from the Tobeatic Game Sanctuary southwest of the Park.

Family **Talpidae**

Condylura cristata (Linnaeus) — Star-nosed Mole

Probably moderately common throughout moist areas in the Park. One specimen taken on a stream bank, and another captured and carried home by a domestic cat just outside the Park. Dodds *et al.* (1969) took four in the Tobeatic Game Sanctuary.

Order **CHIROPTERA**

Family **Vespertilionidae**

Myotis lucifugus (LeConte) — Little Brown Bat

Very commonly seen in open areas of the Park. Roosts in caves, buildings and other sheltered areas (Peterson 1966). Three specimens collected in this study. Sheldon (1936) also considered this species to be common.

Myotis keenii (Merriam) — Eastern Long-eared Bat

Two specimens collected in this study and another in the Park collection. Mullen (1970) concluded that it was probably fairly common in more remote areas of the Park.

Lasionycteris noctivagans (LeConte) — Silver-haired Bat

Probably rare. None collected in this study. The Nova Scotia Museum of Science has one specimen of this species, and it is from the Park area (Bleakney (1965a).

Pipistrellus subflavus (Cuvier) — Eastern Pipistrelle

Probably uncommon. This species was not recorded from Nova Scotia until 1959, when one specimen was taken at Grafton Lake in the Park. Since then two have been recorded from the Tobeatic Game Sanctuary (Bleakney 1965b).

Lasiurus borealis (Muller) — Red Bat

A possible migratory visitor to the Park, though not recorded. Two specimens have been taken at sea off southwestern Nova Scotia (Bleakney 165a).

Lasiurus cinereus (Beauvois) — Hoary Bat

A possible migratory visitor to the Park, though not recorded. Three specimens have been taken near Halifax (Bleakney 1965a).

Order **LAGOMORPHA**

Family **Leporidae**

Lepus americanus Erxleben — Snowshoe Hare

Common throughout the Park, but not abundant during the summer of 1971. Favoured habitat is areas of young softwood and mixedwood with dense brushy cover. Uncommon in mature forest where undergrowth is sparse (Wood, unpublished).

Order **RODENTIA**

Family **Sciuridae**

Tamiasciurus hudsonicus (Erxleben) — Red Squirrel

Common throughout the Park, but not abundant during 1970 (Mullen 1970) or 1971. Work in other areas suggests population fluctuations related to cone abundance (Wood 1967). During 1971, most observations were made in mature softwood and mixedwood areas. Only two specimens were collected during this study.

Tamias striatus (Linnaeus) — Eastern Chipmunk

Common in most areas of the Park, particularly in mixed softwood type, but also in bogs and grassy areas, mixedwood, white pine and red oak. This species was abundant in 1971. Sheldon (1936) and Bleakeny (1958) also noted great abundance of chipmunks in the area.

Glaucomys volans (Linnaeus) — Eastern Flying Squirrel

Two specimens of flying squirrels were collected in this study: one, a pregnant female, just southeast of Grafton Lake; the other, a male in breeding condition, south of Peskawa Lake. Both have been identified as eastern flying squirrels, not previously recorded in the Maritimes (Wood and Tessier, 1974).

Glaucomys sabrinus (Shaw) — Northern Flying Squirrel

This species has been collected in a number of locations in Nova Scotia, including the Park area (Peterson 1966). One specimen in the Park collection was taken in 1969 at Jacques Landing, just upstream from the point where the Mersey River flows into Kejimkujik Lake. Another, at the University of Michigan, was collected in Queens County, probably within or just south of the Park. These specimens, both adult males, have been identified as *G. sabrinus* on the basis of pelage characteristics and measurements (Wood and Tessier, 1974).

Flying squirrels are probably common in the Park, but are seldom seen because of their nocturnal habits. The relative abundance of the two species is not known because of the low incidence of observation.

Family **Castoridae**

Castor canadensis Kuhl — Beaver

Beaver had almost disappeared from Nova Scotia by 1907, when they became totally protected. By the 1930's the population was expanding in the western part of the province. Beaver were abundant in western Nova Scotia until 1945, when the population declined again (F.C. van Nostrand, pers. comm.). Beaver are common in the northeastern area of the Park, where soils are deeper, but less common in the southwest where soils are shallower and less fertile. P. Tufts (pers. comm.) indicated beaver seldom build dams in southwestern Nova Scotia, but live most often on large flood plains which have woody vegetation. Tufts pointed out the difficulty of censusing beaver in southwestern Nova Scotia, because while most colonies build conspicuous lodges, others den in stream and lake banks; and while most colonies store large food caches for winter consumption, some colonies do not store winter food.

Family **Cricetidae**

Peromyscus maniculatus (Wagner) — Deer Mouse

Not abundant during 1971 when only two specimens were collected. Mullen (1970) indicated that the species has been very numerous in the past. Sheldon (1936) described *Peromyscus spp.* as being very numerous in certain years, however, in 1933, very few were evident in the park area. Both of our specimens were taken in mixedwood.

Peromyscus leucopus (Rafinesque) — White-footed Mouse

Six specimens of this species were collected in 1971, in a variety of cover types. Dodds *et al.* (1969) found in the Tobeatic Game Sanctuary that of 110 specimens of *Peromyscus spp.* collected, 59% were *P. leucopus*, 19% *P. maniculatus* and the remainder could not be identified to species. Sheldon (1936), who made no distinction between the two species, noted that Peromyscus spp. was very abundant in some years, but scarce in others.

The white-footed mouse is an example, along with *Glaucomys volans*, of a small mammal whose occurrence in the Maritimes is restricted to southwestern and central Nova Scotia. Its range elsewhere in eastern North America extends only as far north as southern Ontario and Quebec, and southern Maine (Hall and Kelson 1959).

Synaptomys cooperi Baird — Southern Lemming Mouse

Uncommon occurrence during 1971, with only four specimens collected, in a variety of cover types. Sheldon (1936) also found them very scarce and Dodds *et al.* (1969) found them uncommon in the Tobeatic Game Sanctuary.

Clethrionomys gapperi (Vigors) — Red-backed Mouse

Abundant in the Park in 1971. Taken in every habitat type except old fields, but most common in forested areas, particularly mixedwood and red oak stands. This was the most abundant mammal taken in 1971. Sheldon (1936) remarked on population fluctuations of this species in the area; in 1928 and 1933 they were very numerous and in 1929 very scarce.

Microtus pennsylvanicus (Ord) — Meadow Vole

Abundant in treeless habitats in the Park, particularly grassy river islands, stream and river banks and flood plains. Completely lacking from most forested areas. This was the second most abundant mammal collected during 1971. Sheldon (1936) noted years when they were very abundant, and one year (1933) when they were very scarce. Dodds *et al.* (1969) found this species to be the most abundant mammal collected during their study in the Tobeatic Game Sanctuary in 1965-66.

Ondatra zibethicus (Linnaeus) — Muskrat

None were collected in the present study, but several were observed during the summer, and their houses and feeding stations were common in marshy areas throughout the Park.

Family **Zapodidae**

Zapus hudsonicus (Zimmermann) — Meadow Jumping Mouse

Moderately abundant in all treeless habitat types, and also occurred at lower densities in mixed softwood and white pine types. Sheldon (1936) and Dodds *et al.* (1969) both found the species to be moderately common in the area.

Napaeozapus insignis (Miller) — Woodland Jumping Mouse

Uncommon in Park. Four specimens taken in 1971, all in heavily forested areas. Sheldon (1936) and Dodds *et. al.* (1969) both found this species to be less common than the meadow jumping mouse.

Family **Erethizontidae**

Erethizon dorsatum (Linnaeus) — Porcupine

Porcupines and evidence of their activity such as feeding, droppings, runways and dens were commonly observed in all regions of the Park. Sheldon (1936) and Dodds *et. al.* (1969) also found porcupines to be very numerous in the region.

Order **CARNIVORA**

Family **Canidae**

Canis lupus (Linnaeus) — Timber Wolf

Extirpated in Nova Scotia about the end of the 19th century (Dodds *et. al.* 1966).

Vulpes vulpes (Linnaeus) — Red Fox

Several red foxes were observed during the study. A den was observed in the Park in which young were produced in both 1970 and 1971. The red fox is probably fairly common in occurrence throughout most areas of the Park, but not in great abundance. Sheldon (1936) noted that foxes were very scarce in the 1920's and early 1930's.

Family **Ursidae**

Ursus americanus (Pallas) — Black Bear

Bears and their sign were common throughout all regions of the Park in 1971. Bears used to congregate at the park garbage dump until it was filled in 1971 and garbage carried out of the Park for disposal. Several incidents of bears disturbing garbage pails in campgrounds occurred in 1971, but none had serious consequences. Sheldon (1936) concluded that bears were "fairly abundant in the wildest parts of the country".

Family **Procyonidae**

Procyon lotor (Linnaeus) — Raccoon

One specimen was collected, after being struck by a car eight miles north of the Park entrance. Another juvenile was captured in a mink trap, in the Park, and released uninjured, and a raccoon skeleton was found on the bank of Grafton Brook. No other observations were made during 1971, and few tracks were seen in muddy stream banks. No incidents of raccoons disturbing food at campsites were reported, which indicates low abundance. Sheldon (1936) made no mention of the species in the Park area. The numbers of raccoons in the Park are probably low.

Family **Mustelidae**

Mustela erminae Linnaeus — Ermine

One specimen was taken in 1971. No others or signs of their activity were seen. Sheldon (1936) noted that "trappers often catch them in winter" in the Park area. Dodds *et. al.* (1969) reported one from the Tobeatic Game Sanctuary. Ermine are probably uncommon in the Park.

Mustela vison Schreber — Mink

No mink were collected or observed in 1971. Sheldon (1936) observed that they were very numerous around lake shores. Two were observed in the Park in 1968 and two in 1969 (Mullen 1970). Mink are probably not common in the Park.

Martes americana (Turton) — Marten

This species, which once occurred in the area, was probably wiped out of the park area by overtrapping.

Martes pennanti (Erxleben) — Fisher

No observations were made in 1971. The fisher was greatly reduced in numbers by overtrapping several decades ago (P. Tufts, pers. comm.). The Nova Scotia Department of Lands and Forests released several in the Tobeatic Game Sanctuary and they seem to have become re-established there (Benson 1959). One was trapped at the head of Grafton Lake, near the Park, in the winter of 1968-69 (Mullen 1970).

Mephitis mephitis (Schreber) — Striped Skunk

Skunks, once fairly numerous in Nova Scotia, were apparently eradicated from the province by distemper in the 1920's and 1930's (Dodds 1969). The present range of the skunk in Nova Scotia lies east of a line from Windsor to Halifax, but seems to be expanding towards the Park.

Lutra canadensis (Schreber) — Otter

Otter are uncommon in the park area. None were observed in the present study, but Mullen (1970) indicated that two or three are sighted each year. Sheldon (1936) described this species as "practically unknown" in the area, but stated that "an occasional pair has been seen on Little and West Rivers."

Family **Felidae**

Felis concolor — Cougar

No reliable evidence exists of cougars in western Nova Scotia, but Peterson (1966) includes the park area as part of its former range. The animal was thought to have been extirpated in eastern Canada around 1860, but in recent years evidence has been accumulating of a low population in New Brunswick and parts of eastern Nova Scotia (B.S. Wright, pers. comm.).

Lynx rufus (Schreber) — Bobcat

No specimens were collected nor observations made of this species in 1971. Sheldon (1936) however, noted that they were "plentiful around Kejimkujik Lake . . . especially the Mount Tom country", and Dodds *et al.* (1969) observed that they "have been numerous for the past six years", but noted that their numbers fluctuate in Nova Scotia. I saw one near Kejimkujik Lake in July 1967 and one near Loon Lake during the aerial survey in February 1971. There are three recorded sightings in park files, and observations of scats are common. Considering the secretive nature of this species, it is not surprising that few are sighted. The bobcat is probably relatively abundant throughout most of the Park.

Order **ARTIODACTYLA**

Family **Cervidae**

Odocoileus virginianus (Zimmermann) — White-tailed Deer

White-tailed deer bones have been found in Indian middens from circa 1000 AD (Erskine 1960), but they appear to have been absent from Nova Scotia when French settlers arrived in the early 1600's. Deer were re-introduced to western Nova Scotia in the 1880's and 1890's and the population grew until the mid-1940's, when it began to decline. Sheldon (1936) found them very common in the area. Presently the population of western Nova Scotia is low, but appears stable.

Thirty-three deer were observed during the aerial survey of February 3, 1972, distributed as shown on Figure 2. It was possible to observe deer only in hardwood and open mixedwood stands. As they were readily distinguishable I was confident that few were missed in those habitats, but deer under the heavy softwood canopy would not have been observed. However, probably few deer were in the softwood areas, because on the day of the survey the weather was clear, not cold (20F), with little wind, and snow accumulation was only 5-6 inches. Because approximately 1/6 of the Park area was covered in this survey, we estimated a minimum of 200 deer occupied the Park at that time.

The deer population of the Park is concentrated in winter in two areas, as shown in Figure 2; the Mount Tom Brook-Minard Bay area, and the Big Dam Lake-Little River-Central Lake area.

Alces alces (Linnaeus) — Moose

Moose were described as very numerous in the area by Sheldon (1936). In recent years they have become rare, probably because of the parasite *Paralapastrongylus tenuis* carried by the introduced deer. There are indications that moose are gradually increasing again (Mullen 1970). Four sightings were made in spring 1970 (Mullen 1970). In May 1971, the carcass of a young cow (2-3 years old) in good physical condition, was found in the shallow water of Peskowesk Lake. Apparently she had fallen through the spring ice and drowned. In October 1971, a cow and bull were seen together near Joe Tom Bog, and several were observed in the Tobeatic Game Sanctuary in November 1971. None were seen during thé aerial survey in February, 1971.

Rangifer tarandus (Linnaeus) — Caribou

This species was extirpated from Nova Scotia in the last years of the 19th century. Previous to that caribou were quite numerous in the region of the Park.

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Fig. 1 Map of Kejimkujik National Park showing locations of mammal sampling areas.

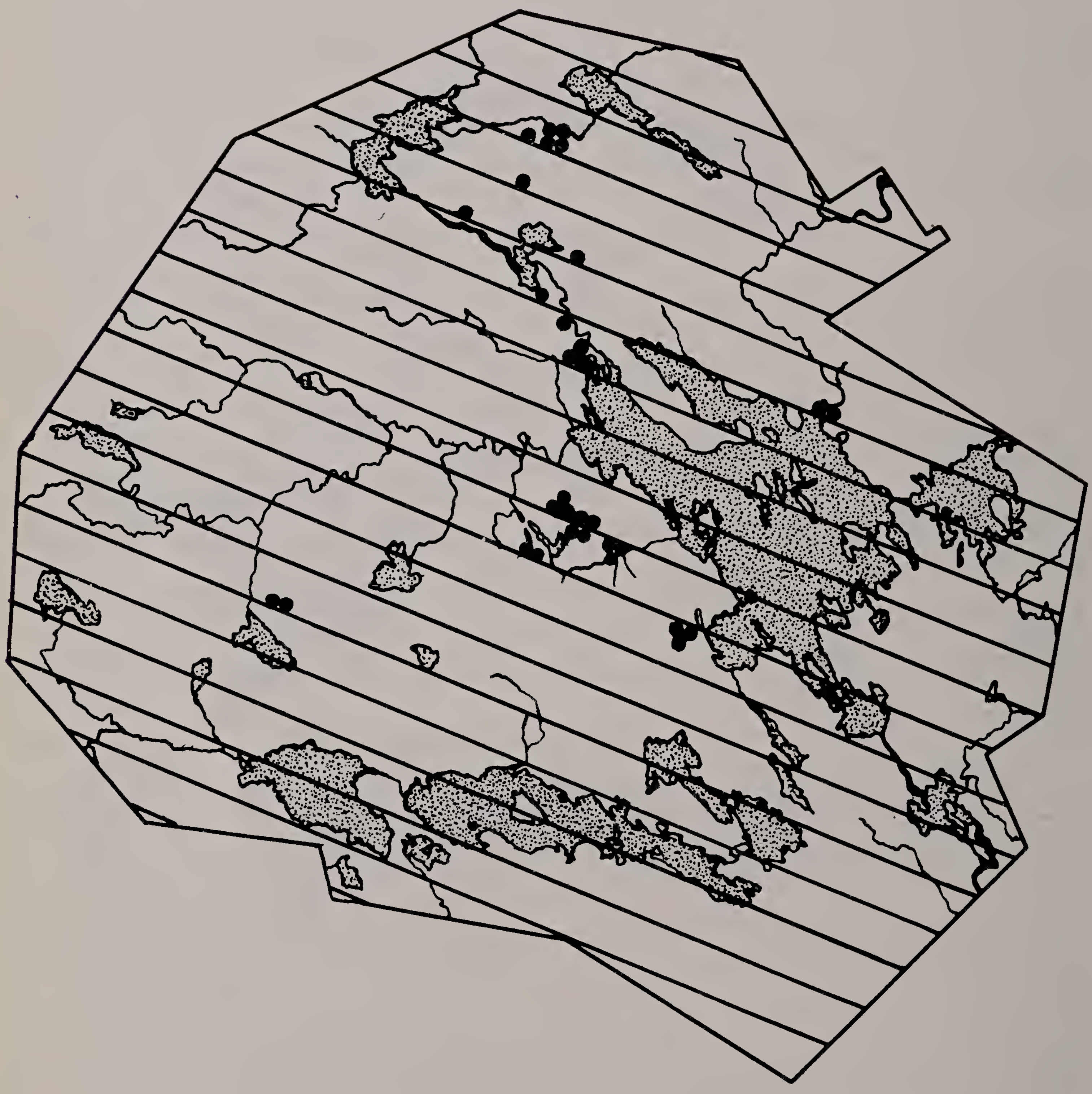

Fig. 2 Map of Kejimkujik National Park showing aerial flight lines and locations of deer observations (solid circles).

A New Species of *Chaetomium* From Soil in Nova Scotia*

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(Received for publication 13 June 1973)

During the summers of 1967, 1968 and 1969, a species of *Chaetomium (Chaetomiaceae, Ascomycetes)* was isolated a number of times from the soil from permanent pasture at Nappan, Nova Scotia. These isolates did not agree with any previously published description, thus a new species is proposed. The species has strongly umbonate spores, which are reminiscent of those of *C. flavum* Omvik, but they are smaller. The fungus was grown on 2% malt agar for characterization.

Chaetomium umbonatum Brewer sp. nov.
Peritheciis superficialibus, atro-brunneis, globosis vel subglobosis, 255-285µ, ostiolatis. Pilis terminalibus longis, sinuatis vel solute convolutis in totum, basi latis 2.5-3µ, galbanis, eseptatis, cum granulis luteis vestitis. Pilis lateralibus undulatis, basi latis 3µ, cum granulis luteis vestitis. Ascis octosporis, clavatis, 43-49 (46.5) x 10-13.5 (11)µ. Ascosporis biseriatis, olivaceo-brunneis, inequaliter liminoformis, utrinque fortiter umbonatis, 8.5-10 x 5-6µ, a latere depressis, saepe in cirrhos prolatis. HOLOTYPUS: ex terra cultus, Nova Scotia, 1967. In Herbario IMI (138895); siccus ex vitro.

Perithecia superficial, dark brown, globose to subglobose, 255-285µ, ostiolate. Terminal hairs very long, sinuous to loosely coiled for entire length, 2.5-3µ wide at base, greenish-yellow, non-septate, covered with yellow granules. Lateral hairs undulate, 3µ wide at base, covered with yellow granules. Ascus 8-spored, club-shaped, 43-49 (46.5) x 10-13.5(11)µ. Ascospores biseriate, olive brown, irregular lemon shape, strongly umbonate at both ends, 8.5-10 x 5-6.5µ, compressed in side view, often forming cirrhi.

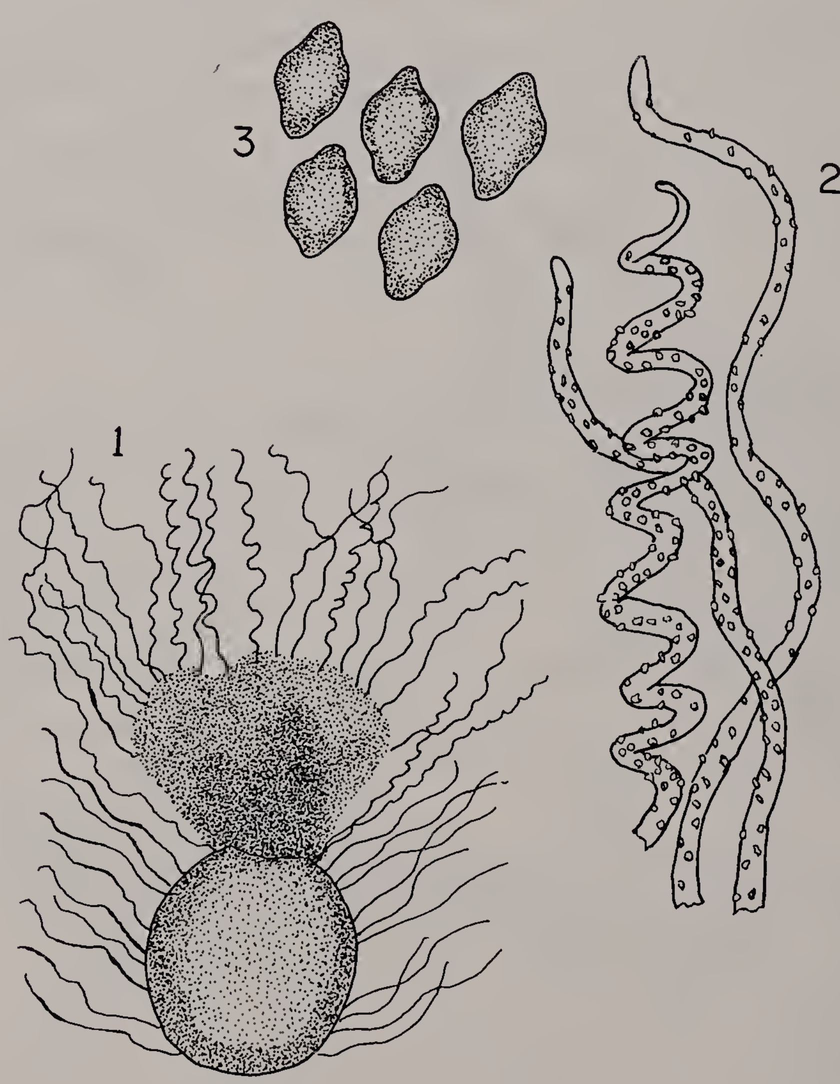
HOLOTYPE: isolated from soil, Nova Scotia, 1967. Dried specimen deposited in the herbarium at the Commonwealth Mycological Institute (Herb IMI 138895).

Cultures on malt agar grow rapidly. Initially the aerial mycelium is sparse, but as the cultures age, they may become somewhat overgrown with greyish-white hyphae. The cultures of some isolates rapidly become overgrown with yellowish-brown mycelium. Subsequent sub-cultures from these may be non-fruiting and the agar medium develops a deep golden-brown coloration.

*Issued as NRCC 13790

Acknowledgments

I wish to thank Drs. C. Booth and D.L. Hawksworth for examining this isolate and confirming that it is an unreported species. I also wish to thank J.P. Atherton for correcting the Latin diagnosis.



1. *Perithecium of Chaetomium umbonatum* x 65.
2. Terminal hairs x 600.
3. Ascospores x 1050.

Variation in the Northern Rough Periwinkle, *Littorina saxatilis* (Olivi) in Nova Scotia

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Abstract

Samples of *Littorina saxatilis* (Olivi) were taken at nine stations along the Atlantic coast in Halifax and Lunenburg Counties, Nova Scotia. The animals in these samples were examined for diagnostic characters in order to find the magnitude of variation that occurred and the relationships between Nova Scotian and European forms of *L. saxatilis*. On the basis of shell breadth to length ratio, shell sculpture, pigmentation of the head and tentacles and the form of the penis, it was possible to distinguish three forms of *L. saxatilis*, called A, B and C. These forms roughly correspond to named European forms as follows: Form A - *L. s. tenebrosa tenebrosa* (Montagu); Form B - *L. s. tenebrosa similis* (Jeffreys) and Form C - *L. s. neglecta* (Bean). More than one of these forms occurs in the populations at some of the stations. The populations examined showed some degree of variation but were apparently not as varied as certain populations described from Europe.

Introduction

The northern rough periwinkle, *Littorina saxatilis* (Olivi), occurs commonly on the shores of the North Atlantic and Arctic Oceans. It characteristically occupies the middle and upper tide levels on shores with a stable substratum. In Europe, the species extends from the southern bays of Novaya Zemlya (Zenkevitch, 1963), south to Gibraltar, the Azores (Thorson, 1941) and the Mediterranean. It is present on all of the intermediate coast, including the British Isles, Faroes, Iceland and South Spitzbergen. In the Baltic Sea, the distribution is as far east as the west coast of Rügen (Stresemann, 1957).

In North America, *Littorina saxatilis* occurs in the Canadian Arctic, east of the MacKenzie Delta (Dall, 1919), West Greenland (Thorson, 1951) and Baffin Island (Ellis, 1955), and extends southward along the coast to New Jersey, U.S.A. (Bequaert, 1943). Stephenson and Stephenson (1952) give the most southerly record at Beaufort Inlet, North Carolina. Wells (1965), has shown that the extensive sand beaches and higher water temperatures south of New Jersey effectively prohibit the southerly extension of *Littorina littorea* (L.) populations. These barriers would similarly restrict *Littorina saxatilis*

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which has boreal-arctic distribution and lacks a planktonic laval stage for dispersal. Littorinids reported from the North American west coast as *Littorina saxatilis* are considered to be forms of *Littorina sitkana* Philippi (Bequaert 1943, and Urban 1962).

Over its wide geographic and habitat range, *Littorina saxatilis* shows great variation in the morphology of the shell as well as in ecology and reproductive biology. As a result many subspecies and varieties have been described. The complex synonymy that appeared in the earlier literature was effectively clarified by Dautzenburg and Fischer (1912), who redescribed the various forms as subspecies and varieties of a single species, *Littorina saxatilis.* Despite this, such synonyms as *Littorina rudis* (Maton) have continued in use by many authors. In Europe, there has been renewed interest in the variation of *Littorina saxatilis,* particularly of populations on the shores of France, the Iberian Peninsula and the British Isles (Fischer-Piette and Gaillard, 1960, 1961, 1966 and 1968; Fischer-Piette *et al.* 1966; Fischer-Piette *et al.* 1963 and 1964, Fischer-Piette *et al.* 1961; and James 1968 a and b).

There are six subspecies of *Littorina saxatilis* and, of these, three have been further differentiated into varieties, largely on the basis of shape and sculpturing of the shell. These subspecies are listed in Table I. All other names referring to *Littorina saxatilis* are considered to be synonymous with the appropriate subspecies.

Table I

A list of the names and authors of subspecies and varieties of *Littorina saxatilis* (Olivi) currently in use. (After James, 1968).

SUBSPECIES	VARIETY
L. saxatilis saxatilis (Olivi, 1792).	
L. saxatilis rudis (Maton, 1797)	*rudis*, 1797.
	rudissima Bean, 1844
	nigrolineata Grey, 1839
	jugosoides James, 1968
L. saxatilis jugosa (Montagu, 1803)	*jugosa* Montagu, 1803
	rudissimoides James, 1968
	tenuis James, 1968
	attenuata Dautzenburg and Fischer, 1912
L. saxatilis tenebrosa (Montagu, 1803)	*tenebrosa* Montagu, 1803
	similis Jeffreys, 1865
	patula Thorpe, 1844
	elata Dautzenburg and Fischer, 1912
L. saxatilis neglecta (Bean, 1844)	
L. saxatilis gronlandica (Menke, 1830)	

In addition to the subspecies and varieties listed in Table I, there are 21 names assigned to distinct colour-forms. These are listed in Table II. Several of these colour-forms occur throughout the subspecies and varieties. Some are illustrated in the figures given by Dautzenburg and Fischer (1962).

Colour is one of the most variable characters of *Littorina saxatilis*. Fischer-Piette *et al.* (1963) describe two populations with extreme colour diversity; one having 164 colour variations in 400 specimens and the other, 155 variations in 468. Specimens were frequently found to have the characteristics of more than one of the colour-forms listed in the table.

Table II

A summary of the names of Colour-forms of *Littorina saxatilis* (Olivi), occuring in the literature. These colour-forms generally are found throughout the different subspecies and varieties.

NAME	COLOURATION	AUTHORITY
L. s. albida	Uniform white	Dautzenburg, 1887
L. s. zonaria	White or yellow with brown bands	Bean, 1844
L. s. bi-zonaria		James, 1963
L. s. tessellata	White and grey tesselations	Dautzenburg, 1893
L. s. interupta	White with dark brown hyphens	Fischer-Piette *et al*, 1961
L. s. bi-interupta		Fischer-Piette and Gaillard, 1963
L. s. flammulata		Dautzenburg and Fischer, 1912
L. s. hieroglyphica	White background with brown or grey designs	Fischer-Piette *et al*, 1961
L. s. lineata	Pale yellow with brown lines	Dautzenburg and Fischer, 1912
L. s. fusca	Uniform brown	Dautzenburg and Fischer, 1912
L. s. sanguinea	Uniform red	Dautzenburg and Duronchoux, 1900
L. s. mineata	Uniform brick red	Dautzenburg and Fischer, 1912
L. s. aurantia	Uniform yellow-orange	Dautzenburg, 1887
L. s. fulva	Uniform fawn	Monterosato, 1872
L. s. lutea	Uniform lemon	Dautzenburg and Duronchoux, 1900
L. s. tractibus	Light background with light brown hyphens	Fischer-Piette *et al*, 1961

Table II Continued

L. s. maculata	Black with light-yellow or grey patches	Fischer-Piette and Gaillard, 1963
L. s. trifasciata	Two light and two dark bands	Dautzenburg and Fischer, 1912
L. s. nojensis	Uniform green-grey to green-yellow	Fischer-Piette and Gaillard, 1964
L. s. nigrolineata	Light background with fine dark spiral lines, only in *L. s. rudis nigrolineata*	Grey, 1839

Tessellations may be described as alternately arranged light and dark areas, in a spiral mosaic.

Hyphens may be described as elongate, narrow, broken light and dark lines.

James (1968) has considered *L. s. trifasciata* and also a further colour form *L. s. fasciata*-Dautzenburg, as synonymous with *L. s. zonaria*.

Fischer-Piette *et al.* (1964) and James (1968a) have described the characteristics of shell, radula, number of penial glands, head pigmentation and size of emerging juveniles, together with the habitat and larval trematode parasites of each subspecies and variety. The authors admit, and in fact describe, the wide variation that occurs within a defined subspecies or variety. These variations are particularly apparent when different populations are contrasted. In their 1964 paper. Fischer-Piette *et al.* summarize as follows:

"(a) some populations are homogeneous with respect to shell character and others in similar environmental conditions are heterogenous.
(b) some heterogeneous populations have intermediates between extremes but others, again in similar conditions, do not.
(c) stations with similar topography may have populations with widely different shell characters.
(d) populations of varieties occur discontinuously and randomly in regions with apparently different topography.
(e) some variations in shell characters, which are usually correlated with changes in the environment, may sometimes occur without, with apparent disregard for or even against, such changes.

These observations further illustrate the extreme variation of *L. saxatilis* and the difficulty in trying to understand the causes of this variation."

Fischer-Piette and Gaillard (1966) have further shown that a progressive colour change toward darker forms has taken place during a period of from one to 16 years in some populations on the coasts of France and Spain. They do not, however, speculate on the causes for this change.

There have been very few descriptions of the variation of *L. saxatilis* in North America. Bequaert (1943), in a review of the genus *Littorina* in the western Atlantic, examined diverse *L. saxatilis* specimens but found it difficult to distinguish the different subspecies and varieties. No consistent differences were found between the southern forms and those northern forms that had been identified as *L.s. gronlandica. L. s. jugosa* was considered to be a form with few, but well-defined spiral ridges on the shell, whereas *L. s. vestita* (Say) and *L. s. obligatus* (Say) had similar shells but with less well-defined ridges. *L. s. tenebrosa* was described by Bequaert as having a thinner and more elongate shell, and as living in brackish water creeks and marshes. Gould (1870) has listed *L. s. obligatus* as a synonym of *L. s. rudis*, and *L. s. vestita* as a synonym of *L. s. tenebrosa.* Coleman (1932) considered the synonymy of *L. saxatilis* but confined his statistical treatment to a comparison of European and North American *Littorina obtusata* (L.).

Littorina saxatilis has been frequently reported from the shores of Nova Scotia. Published records are summarized by LaRocque (1953). Occurrences are also cited for the upper tidal zone of the Bay of Fundy, Minas Channel and Cobequid Bay by Bousfield and Leim (1959), and for southern and western shores as "very common along rocky shores at high water level, and in estuaries among eel grass", by Bousfield (1958). Gowanloch and Hayes (1926) give a brief description of *L. saxatilis* at Halifax, Nova Scotia and St. Andrews, New Brunswick. The wall of shells is described as thin, but thick in gross appearance due to the coarse texture and spiral ridges.

> "The shell is very variable in texture, ranging from a smooth appearance with no spiral ridges visible to the unaided eye, to a coarse looking shell with or without spiral ridges. The colour is extremely variable, and may be various shades of white, red or black, or a colour combination"

Stephenson and Stephenson (1954), during their studies of the intertidal zone in Nova Scotia and Prince Edward Island, recorded two distinct forms of *L. saxatilis* which they called "types A and B". "Type B" resembled *L. obtusata* in general shell form and was present at several localities including exposed rocks at Peggy's Cove, Nova Scotia. "Type A" had a more sharply pointed shell and was more widely distributed, though commonly occurring with type B.

The recent studies of variation in characters and ecology of *L. saxatilis* in Europe have provided a good basis for similar studies in North America. A study was made of some populations in Nova Scotia with the object of relating them to their European counterparts.

Methods

Studies were made of *L. saxatilis* populations at nine localities on a variety of shores in Halifax and Lunenburg Counties, Nova Scotia. These localities are listed in table III and indicated on the map, Figure I. Sample size varied from 50 to 250 individuals, with a total of 958 snails being examined. Collections were made at random, and without any special reference to tide level.

The individual snails in each sample were examined for anatomical characters and notes and measurements were made as follows:

(a) shell dimensions. Measurements of the length and breadth were made to the nearest 0.25 mm. Shell-length is the distance from the apex to the lower margin of the aperture, through the axis of the shell. Breadth is the greatest distance through the body whorl, at right angles to the shell axis.
(b) Shell whorls. The number of shell whorls was noted.
(c) Shell colour. The colour of each shell was described according to the list in Table II, or by direct reference to the colour or colour-combination where no trivial name is given.
(d) Shell sculpture. Shell sculpture is described by use of an index: 0 (smooth) to 3 (coarse ribbed) which roughly correspond to the stages shown in Figure 2.

Table III

The localities in Halifax and Lunenburg Counties, Nova Scotia where samples of *L. saxatilis* were collected for examination of variation in characters.

STATION NO.	LOCALITY	DATE	HABITAT	NUMBER OF SNAILS EXAMINED
1	Lawrencetown Lake	3 May 1967	Salt marsh	50
2	Point Pleasant Park, Halifax	12 Aug. 1968	Exposed boulder beach	100
3	Sandy Cove	28 Feb. 1968	Exposed rocky shore	107
4	Prospect Cove	28 Feb. 1968	Sheltered boulder beach	100
5	Peggy Point	29 Mar. 1968	Exposed rocky shore	97
6	Indian Harbour	29 Mar. 1968	Sheltered rocky shore	107
7	Mason Cove	28 Apr. 1968	Sheltered boulder beach	97
8	Queensland	29 Nov. 1967	Exposed boulder beach	50
9	Blue Rocks	3 Oct. 1967	Sheltered rocky shore	250

(e) Pigmentation of the head and tentacles. Indices have also been assigned to describe stages in the degree of pigmentation of the snail's head and tentacles. These stages, A to F, are shown in Figure 3. Intermediates occur but these have been grouped with the closest stage illustrated. In some males the penis is pigmented as well as the head and tentacles. This system was defined for use in the present investigation before James (1968) published a similar system for British *L. saxatilis*. The two systems are compared in Table IV.

(f) The number of penial glands. The number of mucus glands on the penis of each male was counted. These glands are arranged in one, two or rarely three rows.
(g) Brood pouch contents. *Littorina saxatilis* is ovoviviparous, and the eggs, embryos and larvae are retained during their development in a pouch-like expansion of the oviduct. The young were counted and any abnormalities such as sinistral and dentalioid shell forms, as described by Thorson (1946), were noted.
(h) Larval trematode infections. The infection of any individual snail by larval trematodes was noted. The parasites were named using the key and descriptions of James (1968b). Only specimens with a shell length greater than 3.0 mm were used in this study.
Parts of the nine samples taken for examination are now in the collection of the Nova Scotia Museum, under accession number 1968-z-60.

Table IV

The stages in the development of pigmentation on the head and tentacles of *Littorina saxatilis* used by James (1968a) and the approximately equivalent stages used in the present investigation.

JAMES (1968a) INDEX	RECENT INVESTIGATION INDEX
1	A
2	—
3	B
4	—
5	C
6	D
7	—
8	E
9	—
10	F
11	—

Results and Discussion

The nine samples of *L. saxatilis* collected along the Atlantic coast, in Halifax and Lunenburg Counties, Nova Scotia, were examined for anatomical characters. Each title (a to h) will be considered separately. Examples of the specimens from these stations are shown in Figure 10. These illustrate some of the shell characters encountered in the samples.

a) Shell dimensions. The maximum shell length and the ratio of shell breadth to shell length in each of the nine samples are shown in Table V.

The range in shell lengths is not great but at Station 1, a salt marsh, the snails are distinctly smaller than those at other stations. The maximum shell length was only 5.00 mm. The largest specimens, with a shell length of 14.00 mm were found at Station 5, a very exposed situation. The shells collected at the other stations, which were either sheltered or exposed, had maximum shell lengths of from 8.75 to 10.50 mm. The variation in maximum shell length between these stations is most probably related to environmental conditions.

Table V

The maximum shell length, average ratio of shell breadth to shell length and number of shell whorls of *L. saxatilis* collected at nine stations on the Atlantic coast of Nova Scotia.

STATION NO.	MAXIMUM SHELL LENGTH (mm)	AVERAGE RATIO OF SHELL WIDTH TO SHELL LENGTH (Range of Ratios)	NUMBER OF SHELL WHORLS
1	5.00	1: 1.27 (1.00 - 1.67)	4
2	8.75	1: 1.29 (1.12 - 1.48)	4 - 5
3	10.50	1: 1.37 (1.13 - 1.57)	4 - 6
4	9.00	1: 1.41 (1.18 - 1.63)	5 - 6
5	14.00	1: 1.28 (1.14 - 1.44)	4 - 5
6	10.50	1: 1.33 (1.13 - 1.71)	4 - 6
7	10.00	1: 1.44 (1.16 - 1.67)	4 - 6
8	9.25	1: 1.30 (1.11 - 1.45)	4 - 6
9	12.00	1: 1.35 (1.16 - 1.69)	4 - 6

Remane and Schlieper (1958) recorded a decrease in the maximum size attained by *Buccinum undatum* (L.) from marine to brackish waters, and noted that this was also true, but to lesser degree, for littorinids. Such observations would indicate that the conditions of salinity, temperature, etc., found in brackish waters either reduce longevity or stunt growth in these animals.

The values for average ratio of shell breadth to shell length show a difference in the proportion of the shells between each of the nine samples. The ratios at sheltered marine localities such as Stations 4 and 9 are larger than those from exposed locations such as Stations 2 and 5 and from the salt marsh, Station 1. That is, the shells from sheltered marine locations have relatively higher spires than do those from exposed localities and the salt marsh.

Stephenson and Stephenson (1954) used shell shape to distinguish two forms of *L. saxatilis*, which they called "type A" and "type B". The difference in shell shape is shown by comparing the shell breadth to shell length ratios of specimens of "type A" from Mason Cove (Station 7) and of "type B" from Peggy Point (Station 5). The "type A" has a ratio of 1: 1.44, whereas the "type B" has a ratio of 1: 1.28. The distinction of the two populations is clearly seen in Figure 4, where the shell breadth to length ratios have been plotted against shell length. It may be seen from the illustrations of the "type B" shell in Figures 10/11 and 12, that the smaller shell breadth to length ratio results from an enlargement of the body whorl and aperture. This aperture can accommodate a larger foot and since this character would be an advantage in situations exposed to wave action, selection would increase the proportion of "type B" in the population. Bequaert (1943) has suggested that a difference in the ratio of breadth to length that he observed in *L. saxatilis* was associated with the sex of the individual. Females would require a larger body whorl to accommodate the brood pouch. This hypothesis was tested in the sample collected at Sandy Cove (Station 3), which was a mixture of high-spired and short-spired individuals. The ratios of shell breadth to shell length are shown in Figure 5. No difference between the dimensions of males and females can be seen, although there is a wide range of breadth to length ratios in the sample.

b) Number of shell whorls.

The results show no great variation in the number of shell whorls. The range from four to six whorls shown in Table V, is associated with the range in shell length. That is, the number of shell whorls increases with shell length.

c) Shell colour.

The shell colour forms found in the nine samples are listed in Table VI, and some examples are illustrated in Figure 10. The majority of the forms distinguished could be associated with named forms which are included in Table II. A small proportion, however, are listed according to their colour because they could not be confidently associated with any of the named forms. One single example from Station 9, being white with a single brown spiral line apparently has not been previously described. (Figures 10/22). There was only little colour variation in most of the samples and in two cases this may have been a result of selection by predators. At Queensland (Station 8) and Mason Cove (Station 6) the only colour forms present were *L. s. fusca, L. s. fulva* and *L. s. lutea* all of which blend fairly well with the colour of the weathered granite. The more distinctly coloured forms would be more easily seen against this background. In direct contradiction to this situation, the greatest colour range was found at Blue Rocks (Station 9), where the snails are completely exposed and conspicuous against a dark slate background. Fischer-Piette *et al* (1963) found wide colour variation in some populations in Europe, both on exposed rock surfaces and in deep crevices. They attribute the wide range of colour in these populations to their isolation by physical barriers. The mode of reproduction and development of *L. saxatilis* does not allow wide dispersal of the offspring and mixing of populations. In the population, the various genetic combinations are always present and they are manifested in situations where there is little selection by predators. This, however, does not explain why such selection should be more severe in one population compared with another.

The wide range of colour variation at Blue Rocks includes individuals with combinations of named forms. This may be a permanent combination with one

Table VI

The occurence of various colour forms of *L. saxatilis* collected at nine stations on the Atlantic coast of Nova Scotia. The named forms are defined in Table II. The values are percentages of the total number of individuals in each sample.

COLOUR FORM	STATION NUMBER 1	2	3	4	5	6	7	8	9
L. s. albida	—	12.0	0.9	10.0	—	0.9	—	—	10.5
L. s. zonaria	—	9.4	9.4	8.0	1.0	5.6	—	—	14.0
L. s. tessellata	+	25.0	—	11.0	24.8	33.6	—	—	9.5
L. s. interupta	—	—	—	2.0	—	—	—	—	18.5
L. s. fusca	—	27.0	0.9	18.0	—	24.3	78.4	—	23.5
L. s. sanguinea	—	—	—	—	—	—	—	—	1.0
L. s. aurantia	—	—	—	1.0	—	0.9	—	—	0.5
L. s. fulva	—	5.0	—	25.0	42.3	12.1	21.6	88.0	7.0
L. s. lutea	—	—	—	—	—	—	—	12.0	0.5
L. s. maculata	—	—	0.9	—	10.3	—	—	—	—
L. s. zonaria/tessellata	—	—	2.8	—	—	—	—	—	—
**L. s. zonaria/grey*	—	—	—	—	—	—	—	—	0.5
Uniform grey	—	10.0	—	4.0	—	—	—	—	7.5
Uniform olive green	—	4.0	—	—	—	—	—	—	—
Red brown	—	—	—	6.0	—	—	—	—	1.0
Yellow brown	—	—	—	3.0	—	1.9	—	—	—
Fawn with a dark band	—	—	—	—	—	2.8	—	—	—
Brown with dark spiral lines	—	15.0	—	12.0	—	17.8	—	—	5.0
White with a single brown line	—	—	—	—	—	—	—	—	0.5
Corroded shells	+	—	85.1	—	11.6	—	—	—	—

*showing a distinct colour change during life

Table VII

The shell sculpturing found in *L. saxatilis* collected at nine stations on the Atlantic coast of Nova Scotia. The extent of sculpturing is indicated by the reference numbers 0 to 3 (from no sculpturing to maximum sculpturing, see Fig. 2). The values are percentages of the total number of individuals in each sample.

STATION NO.	THIN SHELLS	SOLID SHELLS	OCCURRENCE OF EACH TYPE OF SCULPTURING %				SHELLS SHOWING CHANGE OF SCULPTURING DURING LIFE		
			0	1	2	3	1 to 0	2 to 0	3 to 0
1	+	—	100.0	—	—	—	—	—	—
2	+	—	84.0	11.0	4.0	1.0	—	—	—
3	—	+	94.4	2.8	2.8	—	—	—	—
4	+	—	—	8.0	41.0	51.0	—	—	—
5	+	—	34.0	—	57.7	8.2	—	—	—
6	+	—	61.7	2.8	15.9	17.8	—	—	—
7	+	—	1.0	—	3.1	95.9	—	—	—
8	—	+	78.0	22.0	—	—	—	—	—
9	+	—	24.5	9.5	7.5	49.5	1.5	1.0	6.5

Table VIII

The extent of head pigmentation found in *L. saxatilis* collected at nine stations on the Atlantic coast of Nova Scotia. The extent of pigmentation is indicated by the reference letters A to F (from minimum to maximum pigmentation, see fig. 3). The values are percentages of the total individuals in each sample.

EXTENT OF PIGMENTATION	OCCURRENCE AT EACH STATION, %								
	1	2	3	4	5	6	7	8	9
A	—	—	0.9	—	2.1	—	—	—	—
B	—	12.0	15.9	3.0	16.5	5.6	4.1	2.0	0.5
C	—	57.0	57.0	30.0	45.4	32.7	9.3	26.0	21.5
D	4.0	27.0	21.5	45.0	32.0	42.1	21.6	54.0	54.5
E	96.0	4.0	4.7	21.0	4.1	18.7	12.4	18.0	16.0
F	—	—	—	1.0	—	0.9	52.6	—	4.0
Undetermined	—	—	—	—	—	—	—	—	3.5

pattern imposed upon another as in the example with *L. s. zonaria* and *tessellata* (Figure 10/28), or a distinct change of colour following a seasonal growth interruption. An example of the latter is the change from *L. s. zonaria* to uniform grey. Such combinations of colour were also encountered by Fischer-Piette *et al* (1963).

d) Shell sculpture.

Shell sculpturing ranged from completely smooth (0) to coarse ridged (3) as illustrated in Figure 2. The sample from Station 1 contained only smooth shells, but the others had various sculptural forms (Table VII). When a comparison is made between populations from extremes of environmental conditions there is an indication of some relationship between ridged shells and exposure to wave action. The shells at Station 1 were all smooth (0), whereas at the exposed Station 5, 66% of the shells were ridged (2 and 3). It might be deduced that the shells are reinforced by the ridges and that this feature would be selected in very exposed habitats. However, a further comparison made with the shells from Station 7 does not support this. At this Station, in very sheltered conditions, 99% of the shells were ridged (2 and 3).

In the sample from Blue Rocks (Station 9) there were examples of change from ridged to smooth shell during the life of an individual. This change was always associated with a growth interruption, similar to the changes in shell colour observed in the same sample.

e) Pigmentation of the head and tentacles.

The extent of head pigmentation in *L. saxatilis* collected at the nine sampling Stations is shown in Table VIII. The stages (A to F) are illustrated in Figure 3. In all but two cases the most commonly occurring stages were C or D, being represented by from 42.0 to 57.0% of the individuals in each sample. At Station 7, a sheltered rocky shore, 52.6% of the snails had pigmentation at stage F, and at Station 1, a salt marsh, 96.0% had pigmentation at stage E. In all samples, except that from Station 1, there was a wide variation in the extent of pigmentation.

James (1968a) found some differences in the extent of pigmentation which could be related to the different subspecies of *L. saxatilis* in Britain. In the nine samples taken in Nova Scotia, only those populations at Stations 1 and 7 show any marked differences from the others.

It was also noted by James (1968a) that pigmentation became darker with age. Table IX shows the occurrence of pigmentation stages B to F throughout the size range of the sample taken at Station 9. The stages C and D are best represented in the sample and occur at all intervals of shell length. Darker forms, to stage F, occur less commonly in individuals of intermediate shell length, and the lightest form B, occurs only in one of the largest individuals. This result does not support the view that pigmentation becomes darker with age, but would apparently support the idea that the extent of pigmentation on the head and tentacles was characteristic for subspecies or forms of *L. saxatilis*.

f) The number of penial glands.

In the samples of *L. saxatilis* taken in Nova Scotia, males were found to have one, two or rarely three rows of penial glands. These results are given in Table

Table IX

The occurence of the stages B to F in extent of head pigmentation through the size range a sample of *L. saxatilis* collected at Station 9 on 3rd October 1967. These Stages are illustrated in Fig. 3.

SHELL LENGTH 0.6 mm INTERVALS	NUMBER IN EACH SIZE GROUP					
	n	B	C	D	E	F
1.75	1	—	1	—	—	—
2.25	11	—	4	7	—	—
2.75	13	—	7	6	—	—
3.25	23	—	7	15	1	—
3.75	9	—	4	5	—	—
4.25	13	—	3	7	2	1
4.75	10	—	2	3	3	2
5.25	16	—	3	11	2	—
5.75	15	—	5	6	3	1
6.25	17	—	4	10	3	—
6.75	18	—	2	11	4	1
7.25	10	—	3	4	3	—
7.75	11	—	3	7	—	1
8.25	8	—	2	4	2	—
8.75	13	—	5	6	2	—
9:25	12	—	3	6	1	2
9.75	13	—	3	8	2	—
10.25	10	—	2	8	—	—
10.75	8	—	1	5	2	—
11.25	7	1	1	5	—	—
11.75	1	—	—	1	—	—
12.25	4	—	—	4	—	—

X. Examples from specimens with glands in a short, single row (from Station 1), a long, single row (from Station 7) and a double row (from Station 5) are shown in Fig. 6.

At Stations 1, 2, 6, 8 and 9 all individuals had glands in a single row, the number varying from 0 to 18. The mean number of penial glands for all males in each sample ranged from 5 to 11, these extremes being for Stations 1 and 8 respectively.

At the other Stations (3, 4, 5 and 7) there was a mixture of individuals with single or multiple rows of penial glands. At Stations 4 and 7 there were only one and two examples respectively, with a double row of glands. At Stations 3 and 5 about half of the males in each sample had glands in double or triple rows. There were between 5 and 19 glands in the first row and 1 to 18 glands in the second row. The single example with three rows of glands, had four glands in the third row.

Table X

The penial gland arrangements in *L. saxatilis* collected at nine stations on the Atlantic coast of Nova Scotia. The mucus glands occur on the penis in either a single or multiple rows.

	STATION NUMBER								
	1	2	3	4	5	6	7	8	9
With a single row of of glands. (n)	26	33	24	38	21	43	42	27	87
$\bar{x}$ number of glands	5	8	8	11	11	10	13	11	9
range of numbers	4-9	0-17	0-15	0-17	0-20	0-15	4-19	6-18	2-17
With a double or triple row of glands (n)	—	—	25	1	18	—	2	—	—
row No. 1 $\bar{x}$ number	—	—	11	11	12	—	8	—	—
range of numbers	—	—	5-19	11	5-19	—	7-9	—	—
row No. 2 $\bar{x}$ number	—	—	4	2	4	—	6	—	—
range of numbers	—	—	1-8	2	1-8	—	5-6	—	—
row No. 3 $\bar{x}$ number	—	—	4	—	—	—	—	—	—
range of numbers	—	—	4	—	—	—	—	—	—

Of the Stations sampled, 3 and 5 were the most exposed to wave action, and there may be an association between the *L. saxatilis* with multiple rows of penial glands and such habitats. The other distinct penial gland arrangement, a short, single row, found at Station 1, may also be associated with a form of *L. saxatilis* living in salt marshes. James (1968a) has shown that in *L. s. rudis,* the number of penial glands is reduced on sheltered shores as compared to exposed shores.

g) Brood pouch contents.

Although females carrying embroyonic snails or brood were found in all nine samples taken, examinations of the brood were only made at Stations 1, 3, 5, 6, 7 and 9.

The stages in the development of eggs and embryos of *L. saxatilis* were studied by Berry (1961). The periodic release of batches of eggs into the brood pouch and their retention during development results in there being a range of developmental stages within any individual female. The number of embryos present varies with the season of the year. The nine samples from Nova Scotia were not all taken at the same time of the year, but broods were always found.

All stages of development were observed, from eggs to juveniles about to be released. Various deformities were detected, including sinistral shell coiling and the open coiling (*dentalioid*) and plane spiral coiling (*planorbioid*) forms described by Thorson (1946). None of the abnormal forms was common however. Some examples are illustrated in Fig. 7. The shell breadth of juveniles at the time of release from the parents brood pouch was from 0.5 mm to 0.75 mm.

The mean number of brood occuring at 0.5 mm intervals of shell length of females at each station is given in Table XI. For all the stations there was an overall increase in the number of brood with increase in size (and age). The range extends from the minimum of three juveniles in adults of 3.50-3.99 mm shell length, to 206 in adults of 12.00-12.49 mm shell length. In Fig. 8 the mean number of brood have been plotted against shell length for the samples from station 1, 5, and 7. A relationship between the numbers of brood and the size of the female is clearly implied.

h)Larval trematode infections

The larvae of seven species of digenetic trematodes were found in *L. saxatalis* at the nine stations sampled. These species were *Parvatrema homeotecnum* James, *Himasthla littorinae* Stunkard, *Microphallus pygmaeus (Levinsen), Microphallus similis* (Jagerskiold), *cercaria roscovita* Stunkard, Podocotyle atomon (Rudolphi) and *Cryptocotyle lingua* (Creplin). All are previously known from *L. saxatalis* at other localities.

Table XI

The mean number of embryonic snails in brood pouches of female *L. saxatilis* at six stations on the Atlantic coast of Nova Scotia. The mean number is given for all snails in each group at 0.5 mm intervals of shell length.

	STATION NO.					
SHELL LENGTH 0.5 mm INTERVALS	1	3	5	6	7	9
3.50 - 3.99	11.3	—	—	3.0	—	—
4.00 - 4.49	12.1	—	—	20.5	—	—
5.00 - 5.49	13.5	—	—	7.0	—	26.5
5.50 - 5.99	25.5	—	—	23.3	—	23.2
6.00 - 6.49	—	—	—	27.7	9.0	48.4
6.50 - 6.99	—	22.0	—	37.2	13.7	35.3
7.00 - 7.49	—	26.0	—	31.6	4.0	74.7
7.50 - 7.99	—	12.3	—	79.5	26.0	41.0
8.00 - 8.49	—	39.3	23.0	—	21.0	4.0
8.50 - 8.99	—	25.8	42.8	113.0	34.0	63.0
9.00 - 9.49	—	33.0	55.0	79.0	60.5	49.7
9.50 - 9.99	—	31.6	46.6	52.0	48.5	35.3
10.00 - 10.49	—	22.0	60.1	—	7.0	6.0
10.50 - 10.99	—	29.3	61.7	—	—	144.3
11.00 - 11.49	—	18.0	76.0	—	—	3.0
11.50 - 11.99	—	—	102.7	—	—	78.0
12.00 - 12.49	—	—	206.0	—	—	—
12.50 - 12.99	—	—	55.0	—	—	45.0
13.00 - 13.49	—	—	—	—	—	—
13.50 - 13.99	—	—	—	—	—	—
14.00 - 14.49	—	—	179.0	—	—	—

One or more of these species was found at Stations 1, 2, 5, 6, 7 and 9. No parasites were found at Stations 3, 4 and 8. The results are summarised in Table XII. The greatest diversity of parasite fauna occurred at the most sheltered localities, Stations 1, 7 and 9. The high infection level of 39.2% at Station 9 was due to the presence of large numbers of gulls attracted by discarded wastes of local fish processors.

Of the seven trematode species, three occurred at only one of the stations. *Parvatrema homeotecnum* occurred at Station 1, *Himasthla littorinae* and *Cryptocolyle lingua* at Station 9. The other four species were found in *L. saxatilis* from a variety of shores.

Table XII

The occurence of larvae of seven species of digenetic trematodes in *L. saxatilis* collected at nine stations along the Atlantic coast of Nova Scotia. The number of *L. saxatilis* infected with each species is given.
Some species were double infected with two species of parasite.

	STATION NUMBER								
	1	2	3	4	5	6	7	8	9
Total snails in sample	50	100	107	100	97	107	97	50	250
Parvatrema homeotecnum	2	—	—	—	—	—	—	—	—
Himasthla littorinae	—	—	—	—	—	—	—	—	1
Microphallus pygmaeus	1	3	—	—	—	—	1	—	3
Microphallus similis	—	—	—	—	1	—	2	—	22
Cercaria roscovita	—	—	—	—	—	4	2	—	—
Podocotyle atomon	2	—	—	—	—	—	1	—	1
Cryptocotyle lingua	—	—	—	—	—	—	—	—	63
double infections	—	—	—	—	—	—	1	—	7
Total snails infected	5	3	—	—	1	4	7	—	98
% infection (all species)	10.0	3.0	—	—	1.0	3.7	7.2	—	39.2

Intraspecific Classification of *L. Saxatilis* In Nova Scotia

Many of the descriptions of the subspecies and varieties of *L. saxatilis* in Europe have been based upon characters of the shell and habitats. The recent work of James (1968 a and b) has used many other characters for forms occurring in Britain, and this has been a most useful guide in the present study.

The examination of the nine samples for particular characters reveals the presence of three distinct forms of *L. saxatilis* in the Lunenburg-Halifax counties area of Nova Scotia. The size and shape of the shell, as used by Stephenson and Stephenson (1954) to distinguish their "Types A and B", were the most useful distinguishing characters. The distinction was made clearer, however, when shell proportions were related to the pigmentation of head and tentacles, the number of penial glands and the shell sculpturing. These features have been combined in Fig. 9 for Stations 1, 5 and 7. Stations 5 and 7 are the recorded localities for "Types A and B". It will be seen that the three populations can be clearly distinguished.

The possible synonyms, and the characters of the three forms of *L. saxatilis* may be summarized as follows:-

Form A. Synonyms: Type A (Stephenson and Stephenson, 1954), *L. s. tenebrosa tenebrosa* (Montagu, 1803). The shells were thin and either smooth or ridged with maximum length of 14.0 mm and breadth to length ratio of 1: 1.44. The head pigmentation was mostly of stages D, E and F and males had a mean number of nine penial glands arranged in a single row. This form was abundant on fairly exposed to sheltered rocky shores.

Form B. Synonyms: Type B (Stephenson and Stephenson, 1954), *L. s. tenebrosa similis* (Jeffreys, 1865). The shells were generally thin and smooth or ridged. The maximum recorded shell length was 14.0 mm and shell breadth to length ratio was 1: 1.28. The head pigmentation was mainly of stages B, C and D. Males had penial glands arranged in two rows with 12 glands in the long row and 4 glands in the short row. The form occurred on very exposed rocky shores.

Form C. Synonym: *L. s. neglecta* (Bean, 1844). The shells were thin and smooth, with maximum shell length of 5.0 mm and shell breadth to length ratio of 1: 1.27. The head pigmentation was mostly stage E and males had a mean number of five penial glands arranged in a single row. This form was extremely abundant in salt marshes and eel grass ponds.

From this preliminary examination and from the descriptions given by Bequaert (1943), *L. saxatilis* does not appear to be as variable in North America as it is in Europe. There is no geographic continuity between the European and North American populations but *L. s. gronlandica* is known from both continents and *L. s. gronlandica*, *L. s. rudis* and *L. s. tenebrosa* are known from Iceland (Thorson, 1941). In Iceland, *L. s. tenebrosa* is recorded as a brackish water form which intergrades with the other two subspecies. *L. s. tenebrosa* is the name commonly given to forms living in eel grass beds on both sides of the Atlantic, particularly in Denmark (Thorson, 1946 and Muus,1967) and New England (Dexter, 1947 and Hunninen and Cable, 1943). James (1968a) does not describe *L. s. tenebrosa* from this habitat in Britain but does record *L. s. neglecta* from salt marshes. The latter is the most common form in salt marshes and eel grass beds in Nova Scotia.

In Nova Scotia there seems to be a close relationship between the forms described. Certainly there is mixing of forms A and B at some localities (e.g. Station 3) and possibly also between forms A and C in sheltered situations (e.g. Station 9). James (1968) has suggested lines of evolution of the subspecies and varieties of *L. saxatilis* in Britain. He indicates a gradation between *L. s. tenebrosa similis* and *L. s. tenebrosa tenebrosa* with different grades of exposure to wave action. Also, a main evolutionary line from *L. s. tenebrosa tenebrosa* to *L. s. neglecta* is indicated. Both of these ideas are supported by the forms and habitats of *L. saxatilis* in Nova Scotia.

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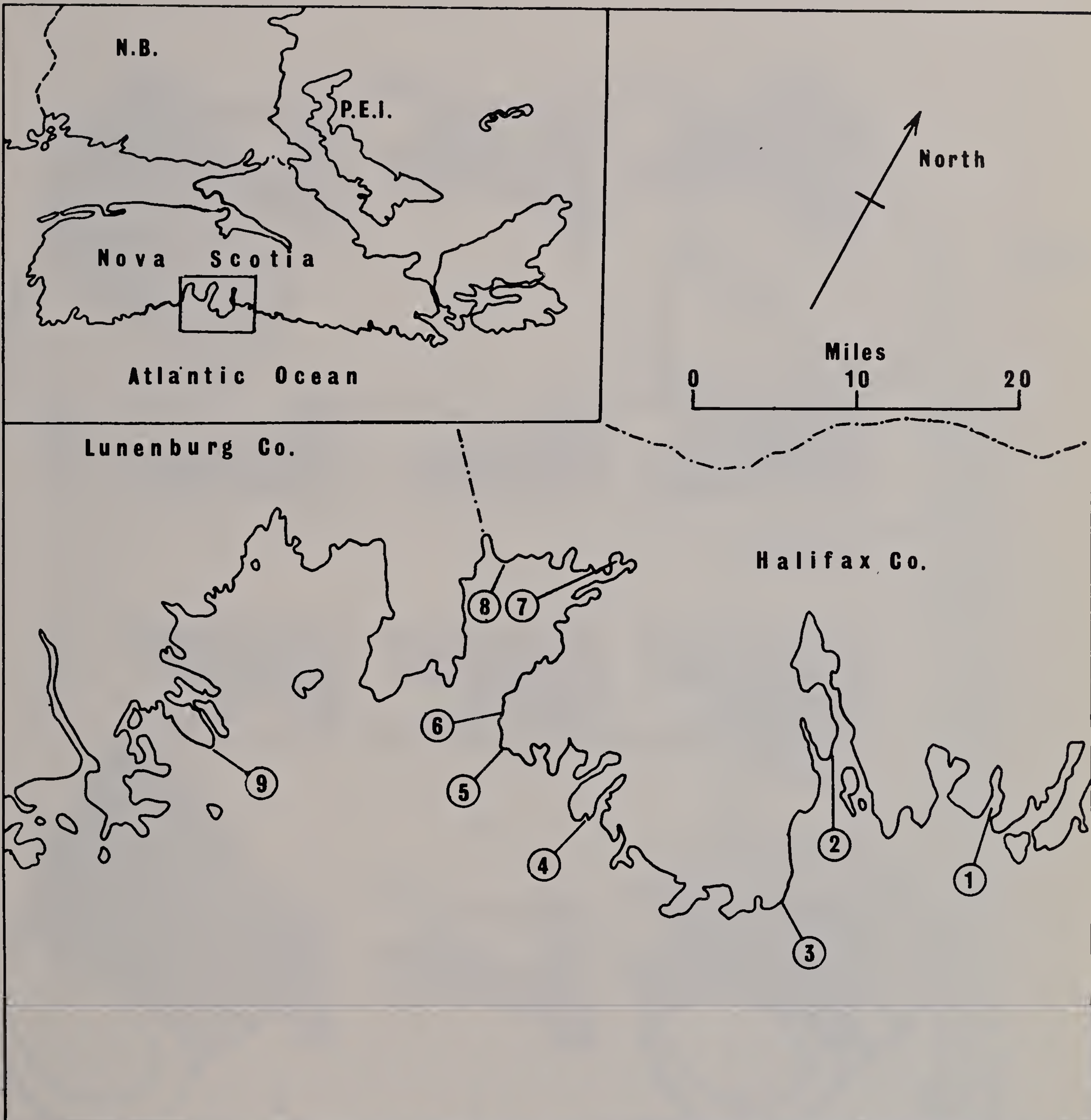

Fig. 1 A map of part of the shore line of Halifax and Lunenburg Counties, Nova Scotia. Single samples of *L. saxatilis* were collected at each of the stations, 1 to 9 between May 1967 and August 1968, for determination of variation in characters.

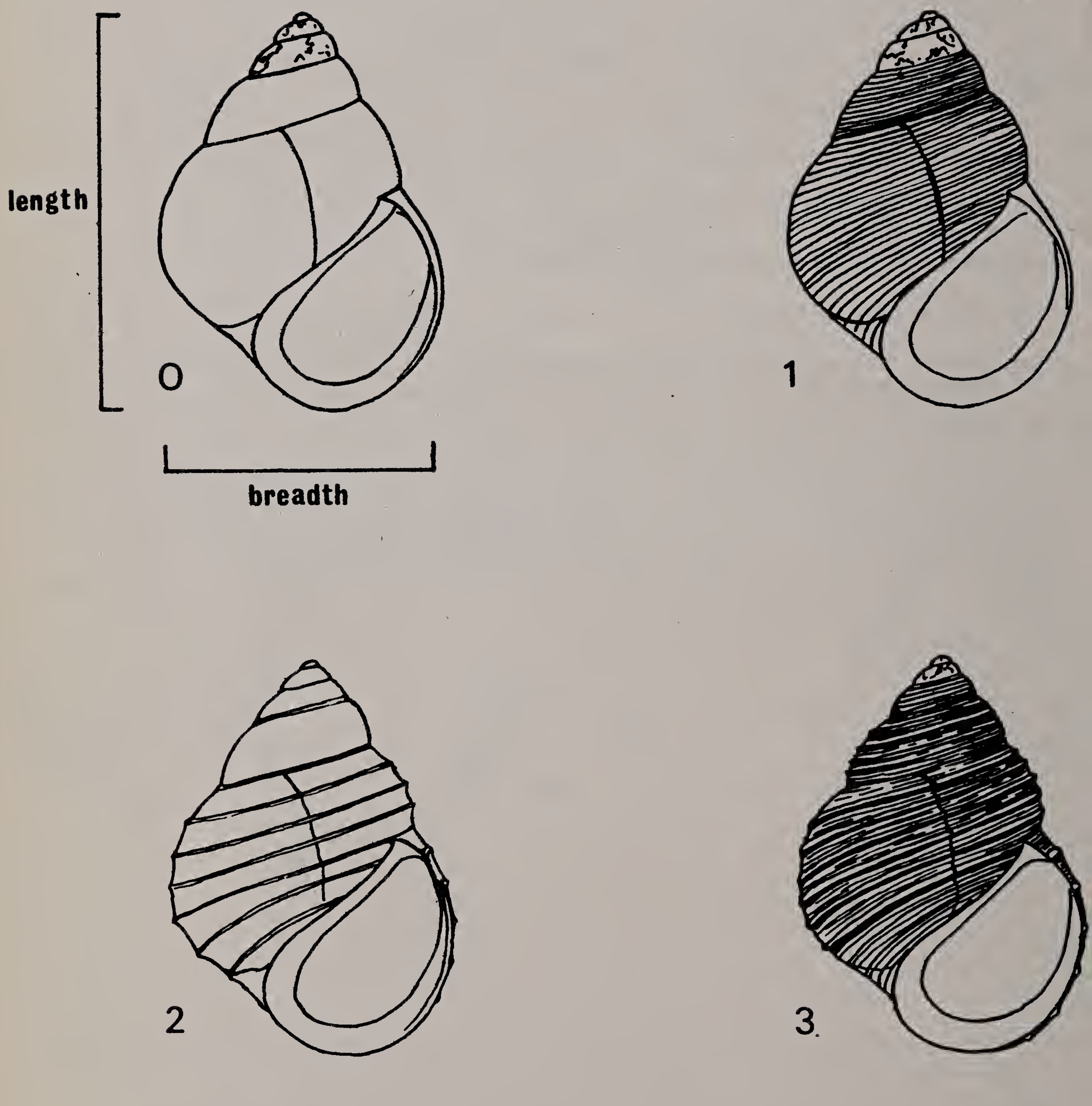

Fig. 2 Shell sculpture in *L. saxatilis*. The four stages in degree of development of shell sculpturing observed in Nova Scotia specimens are shown. The index numbers 0-3 are used to describe the sculpturing of individual specimens. The main shell dimension, length and breadth, used to describe shell shape are shown.

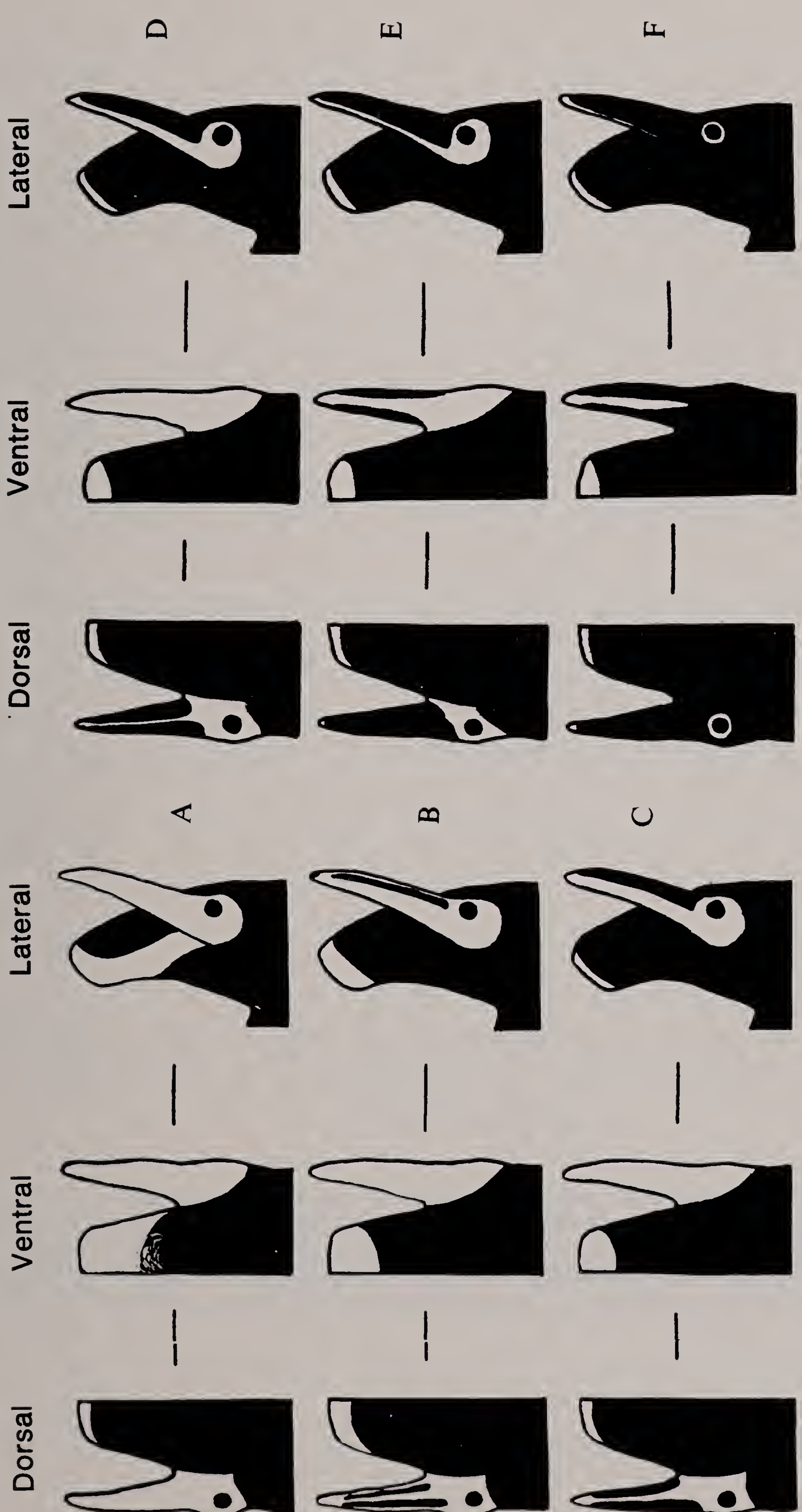

Fig. 3 Pigmentation patterns on the head of *L. saxatilis*. The six stages shown occured throughout samples collected at nine stations in Nova Scotia. The index letters A-F are used to define the degree of pigmentation.

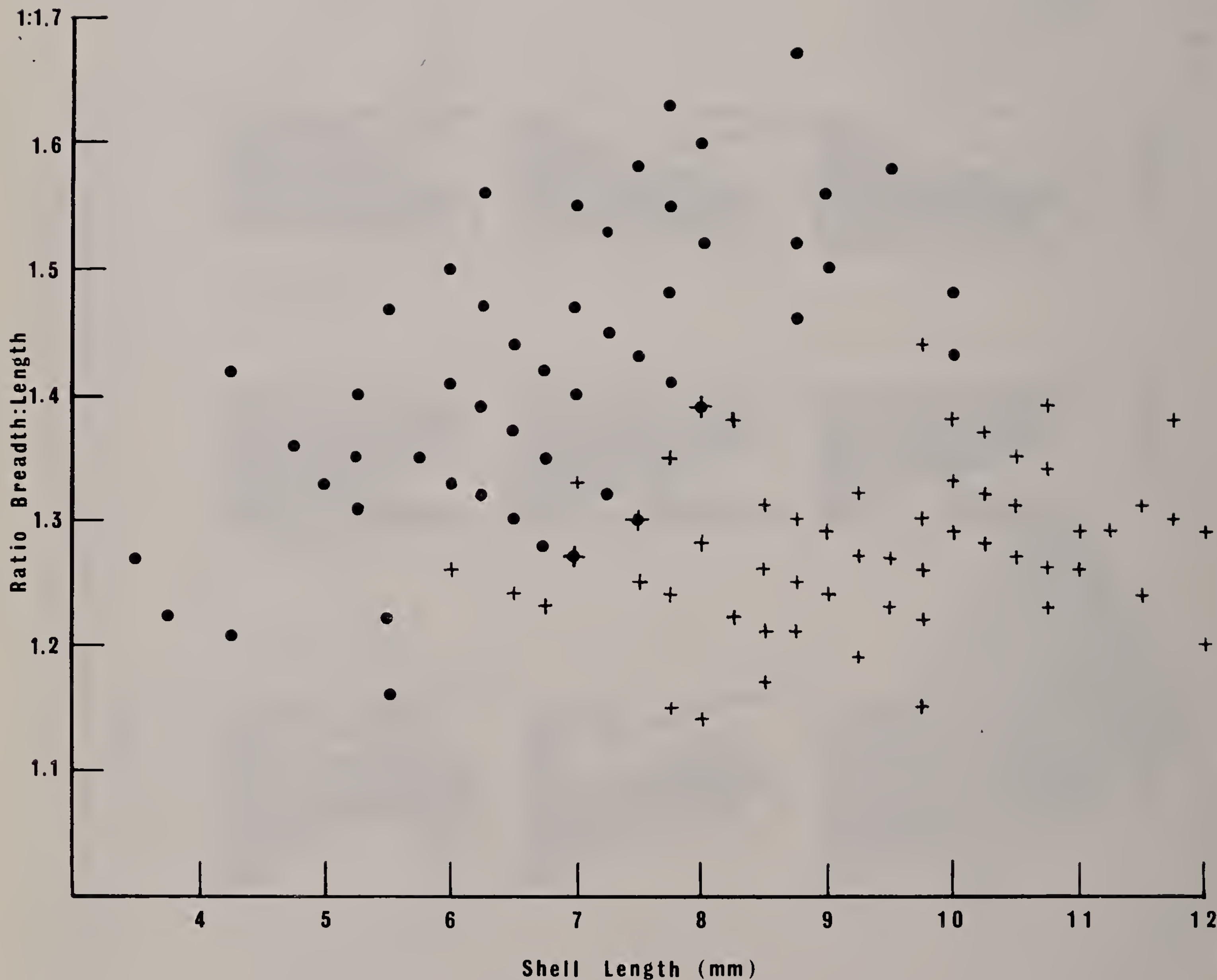

Fig. 4 The relationship between shell length and shell breadth to length ratio of *L. saxatilis* at two stations with different environmental conditions. Station 5, at Peggy Point, is a rocky shore exposed to wave action. Station 7, at Mason Cove, is a sheltered rocky shore. Both samples were taken in March 1968. Peggy Point data are plotted as crosses (+), Mason Cove data, as dots (●).

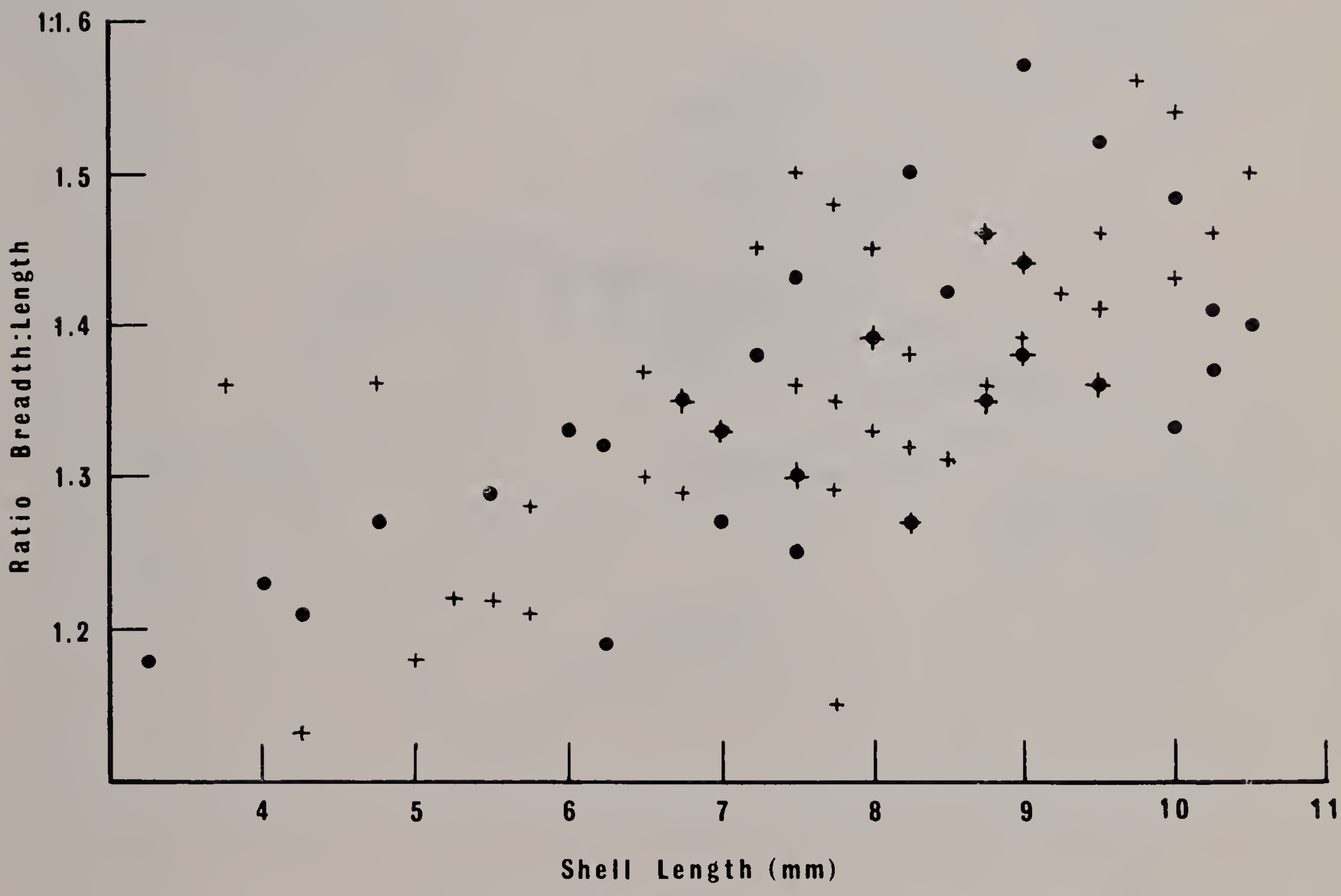

Fig. 5 The relationship between shell length and shell breadth to length ratio of male and female *L. saxatilis*. The values are all taken from the same sample, collected at Sandy Cove (Station 3) on 28 February 1968. Males are plotted as crosses (+), females as dots (●).

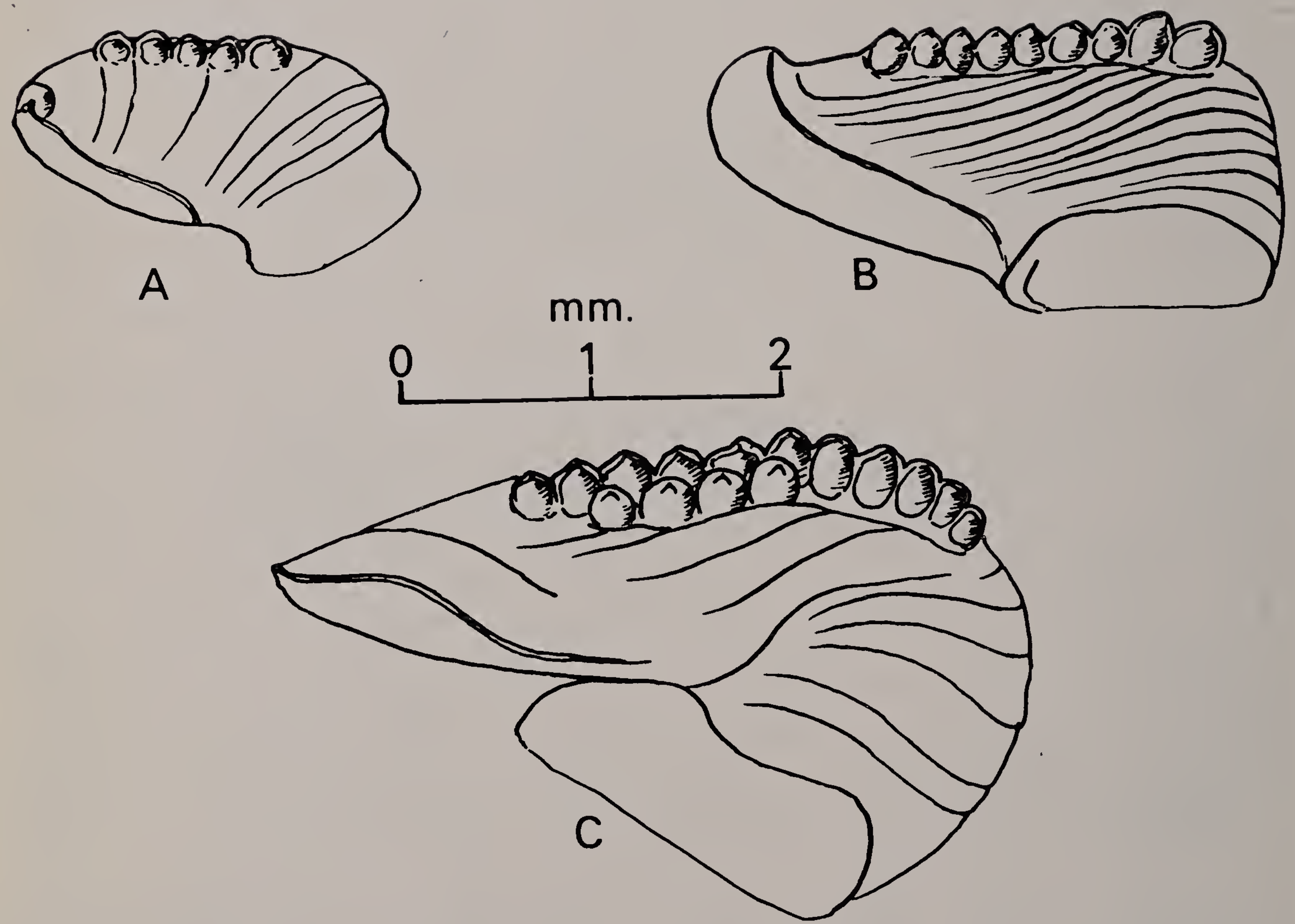

Fig. 6 The form of the penis in selected examples of *L. saxatilis* from three localities in Nova Scotia. A. A specimen from Lawrencetown (station 1) which has a single row of five glands. B. A specimen from Mason Cove (station 7) which has a single row of nine glands. C. A specimen from Peggy Point (station 5) which has a double row of glands; eleven in the long row and four in the short row.

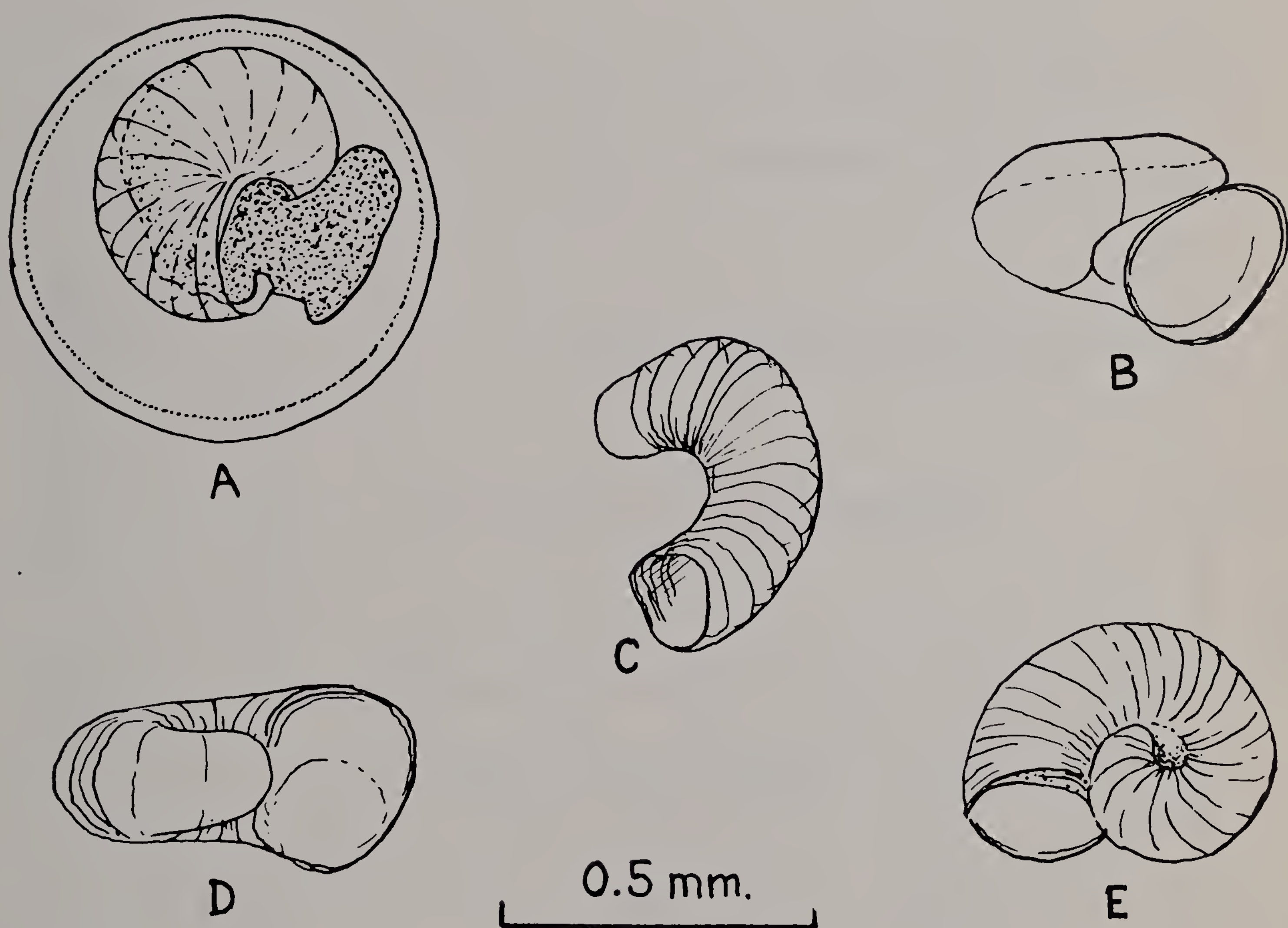

Fig. 7 Examples of juvenile *L. saxatilis* taken from the brood pouches of selected females collected from stations along the Atlantic coast of Nova Scotia. A. An embryo developing inside an egg capsule. B. A juvenile shell at the time of hatching. C. An embryonic shell with open coiling (named *dentalioid* by Thorson, 1946). D. An embryonic shell having a plane spiral (named *planorbioid* by Thorson, 1946). E. An embryonic shell having sinistral coiling.

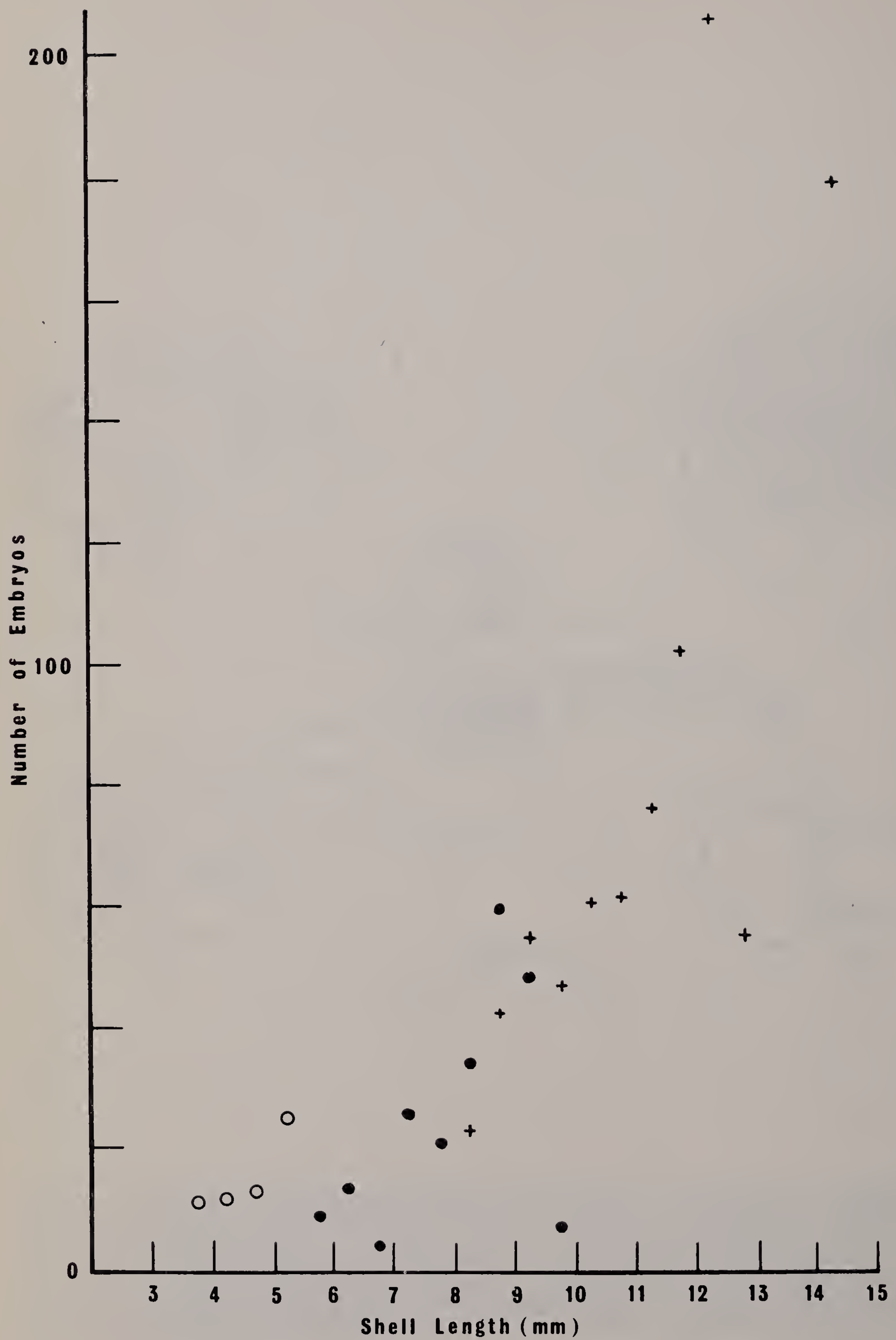

Fig. 8 The mean number of embryonic snails in brood pouches of female *L. saxatilis* at three Stations on the Atlantic coast of Nova Scotia. The mean number is given for all snails in each group at 0.5 mm intervals of shell length. Lawrencetown Lake (Station 1) data are plotted as circles (o), Peggy Point (Station 5) data as crosses (+) and Mason Cove (Station 7) data as dots (●).

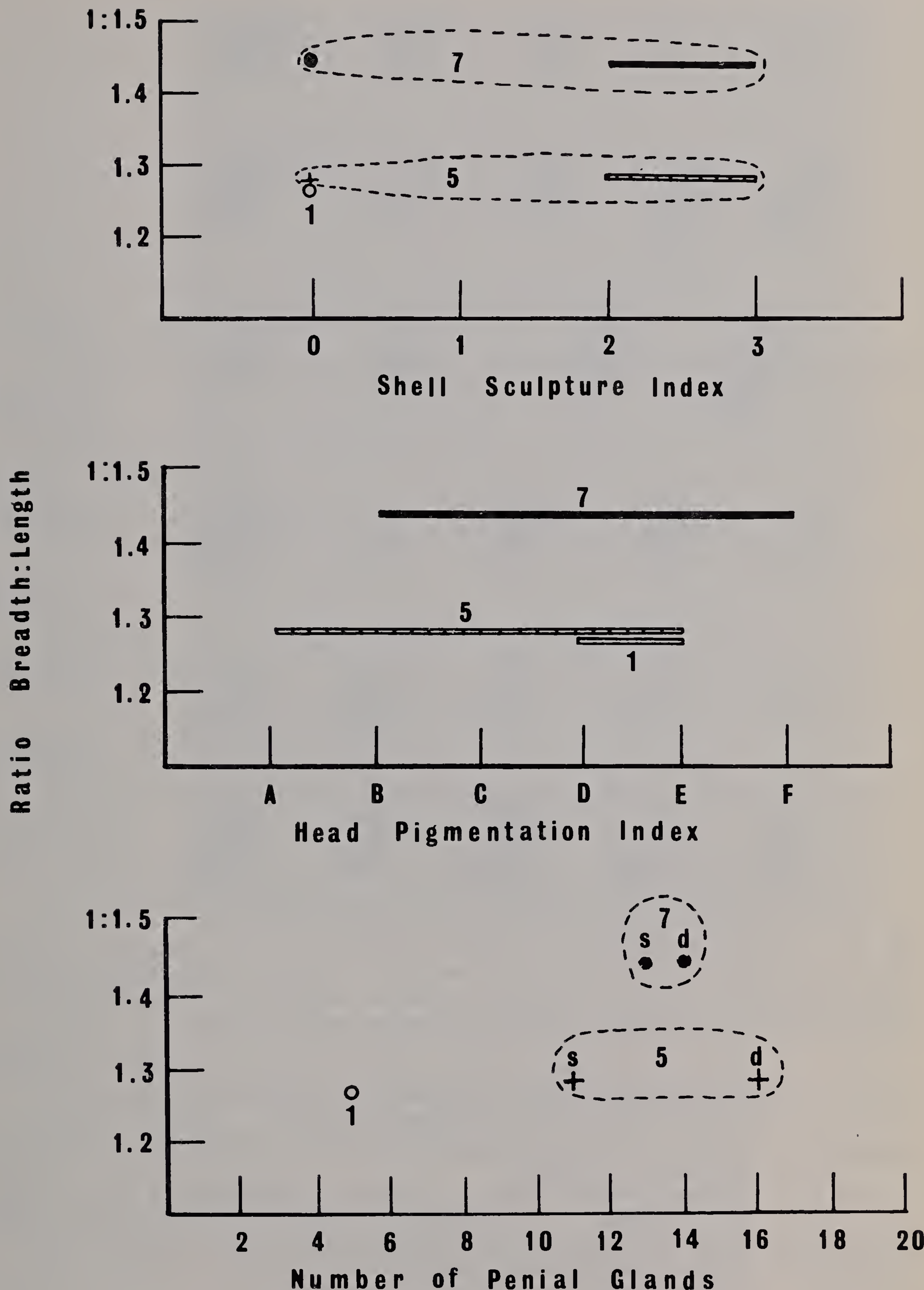

Fig. 9 Shell sculpturing, head pigmentation and number of penial glands shown in relation to shell breadth to length ratios for samples from Stations 1, 5 and 7. The mean numbers of penial glands in specimens with a single row(s) and those with a double row (d) are shown separately.

Fig. 10 Examples of the shells of *L. saxatilis* collected at nine stations along the Atlantic coast of Nova Scotia, from May 1967 to August 1968. These examples illustrate the range of shell proportions, sculpturing and colour encountered in the collections. Photograph is approximately life size.

1 and 2.	Station 1, Lawrencetown Lake, Halifax Co. Form C.
3 and 4.	Station 2, Black Rock, Point Pleasant Park, Halifax. Both are form A. Specimen 3 is *L. s. albida.*
5, 6 and 7.	Station 3, Sandy Cove, Halifax Co. Specimens 5 and 6 are form B and 7 is form A.
8, 9 and 10.	Station 4, Prospect, Halifax Co. All are form A. Specimen 9 is *L. s. zonaria.*
11 and 12.	Station 5, Peggy Point, Halifax Co. Both are form B.
13 and 14.	Station 6, Indian Harbour, Halifax Co. Both are form A.
15 and 16.	Station 7, Mason Cove, Halifax Co. Both are form A.
17.	Station 8, Queensland, Halifax Co.
18 to 29.	Station 9, Blue Rocks, Lunenburg Co. All are form A. 18 is *L. s. albida,* 19 and 20 are *L. s. fulva,* 21 is a pale *L. s. zonaria,* 22 is unnamed (white with a thin brown line), 23 is *L. s. interupta,* 24 is *L. s. maculata,* 25 is *L. s. tessellata,* 26 and 27 are *L. s. zonaria,* 28 is a combination of *L. s. zonaria* and *tessellata,* and 29 is *L. s. fusca.*

PROCEEDINGS OF MEETINGS

Session 1970-1971

Meetings and communications during the year were as follows:

1st Ordinary Meeting, 19 October 1970
"Upon this rock I shall build my — What?", L.G. Vagianos, Dalhousie University.

2nd Ordinary Meeting, 9 November 1970
"Hudson '70 — Its organisation and execution", C.R. Mann, Bedford Institute of Oceanography.

3rd Ordinary Meeting, 14 December 1970
"Genetic engineering — fact and fancy", S.D. Wainwright, Dalhousie University.

4th Ordinary Meeting, 11 January 1971
"Operation oil" W. Ford, Bedford Institute of Oceanography.

5th Ordinary Meeting, 8 February 1971 (at St. Mary's University)
"The measurement of poverty among Micmac Indians of Nova Scotia", P. Kasselbaum, St. Mary's University.

6th Ordinary Meeting, 8 March 1971
"The geology of the Nova Scotia shelf", L.H. King, Bedford Institute of Oceanography.

Extraordinary Meeting, 19 March 1971 (Jointly with Dalhousie University Physics Department)
"Our universe — the known and the unknown", J.A. Wheeler, Princeton University.

7th Ordinary Meeting, 5 April 1971 (jointly with the Valley Chapter, Acadia University)
"Inborn metabolic errors of children in the Maritimes", M.W. Spence, Dalhousie University.
"Light-growth reactions in plants" G. Curry, Acadia University.

8th Ordinary Meeting, 10 May 1971
"JOIDES deep sea drilling project and Leg 12", A. Ruffman, Bedford Institute of Oceanography.

110th Annual General Meeting, 17 May 1971
The President, Dr. M.L. Cameron, was in the chair and delivered the following address.

> The Nova Scotian Institute of Science has had a quiet year. It was found necessary to call a General Meeting in October to amend the by-laws with respect to membership on Council. This shows how difficult it is to foresee possible accidents. As a result of the amendment Dr. Russell replaced Dr. MacInnis as Treasurer although Dr. MacInnis retained his seat on Council.

There has been no significant change in membership during the past year. There are in good standing 108 Ordinary Members, 31 Associate Members and 20 Institutional Members in the parent body, some 40 members in the Valley Chapter and some two dozen Life Members. Although it is good to see the Institute maintaining its numbers, it would be better to see an increase in membership.

One life membership was awarded this year to Mr. John Erskine of the Valley Chapter. Mr. Erskine has been one of the most active members of the Institute since the Valley Chapter was opened, and it was a pleasant duty to help in the award of his life membership.

There were 8 Ordinary Meetings during the year (one at Acadia University with the Valley Chapter) and one Extra-ordinary Meeting (in association with the Physics Department of Dalhousie University). Attendance at the Ordinary Meetings varied between 18 and 53 with an average of 35. This shows no change from the previous year.

In his President's Address last year, Dr. Neish suggested the holding of more meetings having an appeal to a wider audience in order to encourage the attendance of non-members (as well as of members). He also noted that single papers were better received than two or more papers on a single programme. Your Council kept these suggestions in mind in planning programmes for the past year. All meetings except the joint meeting with the Valley Chapter had a single paper. Of the papers given at Ordinary Meetings, 3 were on various aspects of oceanography, 2 on human genetics and heredity, 1 on plant physiology, 1 on the *Arrow* oil disaster and 2 on subjects not usually dealt with at recent meetings of the Institute (1 on the problems of communication in Science, 1 on work currently being done on social conditions among the Micmacs of Nova Scotia). The Extra-ordinary Meeting at which Dr. Wheeler spoke on *Our Universe — the Known and the Unknown* was a rare delight.

It appears from the above summary that several of our meetings this past year were of the wide-appeal kind. Yet the attendance at them was not unusually large. We do not yet seem to be reaching a public which surely is interested in such subjects as oil pollution control, genetic engineering and the problems of communicating between ourselves. I leave it as a challenge to our next Council to wrestle with the problem of getting an interested public to attend our meetings.

I am sure the Institute wishes me to mention the unusual and wholly deserved honour conferred recently on our Past President. Dr. A.C. Neish is only the third member of the Institute from Nova Scotia to be made a Fellow of the Royal Society, and we wish him many happy years in his Fellowship.

I wish to thank the Council for a pleasant year, and particularly the band of old faithfuls who let no difficulties of weather or business keep them away from the monthly meetings.

The Treasurer, D.W. Russell reported

Receipts	1071.20
Expenditures	435.33
Total cash assets as of May 14, 1971	3,292.44

The Editor, E.G. Young reported that Volume 27, Part 1 of the Proceedings was in the hands of the printers and would be mailed in June. Prices of publication have risen considerably.

The Librarian, Miss E.M. Campbell, reported the transfer of our holdings and the exchange list files to the Science Library, Dalhousie University had been completed.

Officers and others elected for the session 1971-72 were

President	W.E. Jones
First Vice-President	J.E. Blanchard
Second Vice-President	R.G. Ackman
Secretary	N. Cuthbertson
Treasurer	D.W. Russell

Editor	E.G. Young
Council	R.F. Brown, J.R. Dingle, W.J. Dyer, A.Y. MacLean, E.L. Mills, G. Mitchell, A. Taylor, and B. Wright
Auditors	J.R. Dingle, W.J. Dyer

PROCEEDINGS OF MEETINGS

(Valley Chapter 1970-1971)

1st Ordinary Meeting, 5 October 1970

"Lasers" D. Stiles, Acadia University.

"The pulse technique in acoustics" A. Law, Acadia University

2nd Ordinary Meeting, 2 November 1970

"A survey of Acadian settlements", J.S. Erskine, Wolfville.

"Carotenoids in plants, animals and bacteria", J. Bessaraba, Acadia University. (Because of a storm the December programme was postponed until the January meeting)

3rd Ordinary Meeting, 4 January 1971

"Observations on the world poultry congress, Madrid, Spain, 1970", F.G. Proudfoot, Kentville Agricultural Research Station.

"Copper ore deposits", H. Nathan, Acadia University.

4th Ordinary Meeting, 1 February 1971

"Histogenesis of the tibiotarsus in insulin-treated chicks", M.A. Gibson, Acadia University.

"Trace elements in plants and soils: their use in prospecting", J. Colwell, Acadia University.

5th Ordinary Meeting, 1 March 1971

"Spontaneous pneumothorax" J. Quinlan, N.S. Sanatorium, Kentville.

"Corticosteroids in treatment of tuberculous tracheobronchial disease", A. Laretei, N.S. Sanatorium, Kentville.

"Ryfampin — a new drug in the treatment of tuberculosis", D.H. Holden, N.S. Sanatorium, Kentville.

6th Ordinary Meeting, 5 April 1971 (joint meeting with the Halifax Chapter)

"Inborn metabolic errors of children in the Maritimes", M.W. Spence, Dalhousie University.

"Light-growth reactions in plants", G. Curry, Acadia University.

Officers and others elected for the session 1971-72 were

President	D. Stiles
Vice-President	F. Forsythe
Secretary	J. Basaraba
Treasurer	T. Haliburton
Councillor	Maria Rostocka

PROCEEDINGS OF MEETINGS
Session 1971 - 1972

Meetings and communications during the year were as follows:

1st Ordinary Meeting, 4 October 1971

"Can you take the pulse of parsnips?", D. Fensom, Mount Allison University.

2nd Ordinary Meeting, 8 November 1971

"Advances in quantitative chromatography as applied to pollutants" R.W. Frei, Dalhousie University.

3rd Ordinary Meeting, 13 December 1971

"Darwin, Haeckel and the Origin of Life", J. Farley, Dalhousie University.

4th Ordinary Meeting, 4 January 1972

"Seaweeds, sea urchins and lobsters", K.H. Mann, Bedford Institute of Oceanography.

5th Ordinary Meeting, 14 February 1972

"Studies on lunar dust", A. von Volborth, Dalhousie University.

6th Ordinary Meeting, 13 March 1972

Affinity chromatography in the purification of biochemical substances", I. MacDonald, Dalhousie University.

"Research in chemical lasers", T.L. Pollock, Dalhousie University.

"The codworm problem in the Maritimes", G. McLelland.

7th Ordinary Meeting, 10 April 1972 (jointly with the Valley Chapter, in Halifax)

"The permeability of fruit tissues to gases", F. Forsythe, Agricultural Research Station, Kentville.

"Genetics and biochemistry in tuberculosis treatment", D.W. Russell, Dalhousie University

8th Ordinary Meeting, 8 May 1972

"Oyster culture in Nova Scotia", R. Drinnan, Bedford Institute of Oceanography.

111th Annual General Meeting, 17 May 1972

The President, Dr. W.E. Jones, was in the Chair and delivered the following address.

As most Past Presidents have done when preparing their annual reports, I read over the comments made at earlier Annual General Meetings. The problems of membership, attendance, finances and style of meeting have been with us for a number of years. A number of approaches have been made to each problem with varying degrees of success. The outcome seems to be a rather stabilizing effect on the overall impetus of the Institute. It seems now that only by some major drive or influence on the part of each individual member will increase in any of the functions of the Institute result.

To date for this year the Ordinary paid-up members number 84, of these 4 are new members with 17 members 1 year in arrears. There are 28 Associate Members paid up, with 11 in arrears. At this time last year the numbers paid up were: Ordinary Members 96, Associate Members 37. There are no Student Members. We have 11 paid-up Institutional Members with 15 in arrears as compared to 21 paid-up last year.

Our meetings during the past year followed the established policy of single invited papers, followed by informal coffee sessions. Of the 8 ordinary meetings two varied from this format. The sixth ordinary meeting consisted of three papers presented by post-doctoral fellows and students of Dalhousie. The seventh ordinary meeting was our joint meeting with the Valley Chapter at which two papers were presented. The attendance at the meetings varied from 16 to 55 with an average of 36. One speaker, Professor D.S. Fensom, was invited from our sister province, New Brunswick, to be the special lecturer for our opening meeting. Unfortunately, because of a number of conflicting events, only 16 were present to hear one of our most interesting and entertaining speakers. Partly because of the very poor turnout at this meeting, your Council approved the preparation by the Secretary of large posters of various colours to display future meetings of the Institute. I believe that these posters, placed by members in conspicuous places in the scientific buildings, were of considerable importance in improving attendance at the following meetings of the year. I further feel that these notices aroused an interest in many non-members of the Institute. On several occasions I was approached after meetings and asked questions like: "What is the Institute? What are its aims and how does one become a member?" I feel that this is an indication of one area where each member has a responsibility which many of us are not fulfilling — that of contacting new people and arousing their interest in the Institute.

The topics discussed at the ordinary meetings were varied in scope and institute of origin. The areas and places of origin were:

Biology	1
Biochemistry	2
Chemistry	2
Geochemistry	1
History of Science	1
Agricultural Research Station Kentville	1
Dalhousie University	6
Department of Fisheries, Bedford Institute	1
Marine Ecology Lab — Bedford Institute	1
Mount Allison University	1
NRC — Dalhousie	1

Our joint meeting with the Valley Chapter was held in the new Biology Building of the Life Sciences Center, Dalhousie. It was preceded by a reception in the top floor lounge where all enjoyed a visit to the greenhouses and a magnificent early evening view of the North West Arm. The reception was followed by a buffet dinner in the lounge.

Forty eight members and guests were present for the dinner, talks and tour of the Psychology, Oceanography and Biology sections of the Center.

The Institute has been honoured this year to have been asked to publish as part of its Proceedings, the communications which will be presented at the Symposium on the topic "*Chondrus crispus*" to be held in conjunction with the annual meeting of the Canadian Botanical Association and the Canadian Society of Plant Physiologists later this year in Halifax. Financial grants to assist in this publication have been received from a number of sources.

Our treasurer has given you a summary of our financial position. He has pointed out to your Council several times during the past year that a future Council may soon have to consider an increase in fees in order to maintain the Institute. This is perhaps not unexpected, since, despite increasing costs, an increase in membership fee has not occurred for a number of years.

Considering that no extraordinary meetings were held during the past year, our average attendance of 36 ranks well with the averages of 42, 40, 40 and 35 given for the years '67-'68, '68-'69, '69-'70 and '70-'71, indicating a stabilization in attendance. The membership figures show a discouraging decrease in interest.

The stabilization in attendance, the decrease in overall membership, the small interest shown by possible new members and the increased need for funds makes one ponder the outcome of present trends. It seems regrettable to me that the second largest scientific community in Canada, much of whose growth has occurred in the past ten years, has an Institute of Science whose growth over the same period has been stagnant or on the decrease.

I feel that it is the responsibility of every member in good standing to foster in his fellow scientists a knowledge of and interest in the Institute. If we are not able to do this in order to obtain new members and new ideas the inevitable will occur.

I wish to thank all members of Council who have been so helpful throughout the past year. A special thanks is due to our Secretary for the time and effort used in surmounting many difficulties, thus ensuring that 1971-72 was a well organized and rewarding year for the Institute.

My best wishes to the new President and Council.

The Treasurer, D.W. Russell reported

Receipts	1419.85
Expenditures	1596.49
Permanent Fund	533.20
Total cash assets as of May 16, 1972	3235.18

With rising costs for printing and postage and a drop in income it had not been possible to transfer any fund to the Publication Fund as directed at the previous Annual Meeting. If the present trends continue he predicted a deficit of $350 by the end of 1972-73.

The Editor, E.G. Young, reported that Volume 27, Part 1 had been printed and issued. Preparation of Part 2 was being deferred pending clarification of the financial position following publication of the "*Chondrus crispus*" Symposium.

The Librarian, Miss E.M. Campbell, reported that our holdings are now located in the Science Library, Dalhousie University, and are being used by borrowers across Canada. Ten new exchanges have been secured.

Officers and others elected for the session 1972-73 were

President	J.E. Blanchard
First Vice-President	R.G. Ackman
Second Vice-President	P.J. Wangersky
Secretary	N. Cuthbertson
Treasurer	D.W. Russell
Editor	M.J. Harvey
Council	R.F. Brown, D.S. Davis, J.R. Dingle, W.J. Dyer, A.Y. MacLean, E.L. Mills, G. Mitchell, and A. Taylor
Auditors	J.R. Dingle, W.J. Dyer

PROCEEDINGS OF MEETINGS

(Valley Chapter 1971-72)

1st Ordinary Meeting, 4 October 1971

"The reactions of O_2 ($^1\Delta g$) with N and H atoms", J. Roscoe, Acadia University.

2nd Ordinary Meeting, 1 November 1971

"Systemic insecticides in woody plants", D. Pree, Agricultural Research Station, Kentville.

"An illustrated talk about a recent trip to a scientific conference in Moscow, U.S.S.R.", M. Peach, Acadia University.

3rd Ordinary Meeting, 6 December 1971

"The effects of chemicals on the metabolism of the body", a panel discussion by Ned Chase, Kentville; E. Cleveland, Fundy Mental Health Clinic; E. Hansen, Acadia University; Ronald Stuart, Wolfville; and Rev. H. Taylor, Director of the Institute of Pastoral Training.

4th Ordinary Meeting, 3 January 1972

"Design of a free fall oceanographic instrument", J. Brown, Acadia University.

"Stratigraphy of the Miller Creek Formation", L. Thorpe, Acadia University.

5th Ordinary Meeting, 7 February 1972

"Study of female fashion from an Indian tribe in Idaho", D. Pree, Acadia University.

5th Ordinary Meeting, 6 March 1972

"Quinacrine hydrochloride in the management of malignant pleural effusion", J. Quinlan, N.S. Sanatorium, Kentville.

"Medications used in inhalation therapy", E. Crossan, N.S. Sanatorium, Kentville.

"Laboratory demonstration of the fluorescence microscope", G. Kloss and Helen Morse, R.T.T. N.S. Sanatorium, Kentville.

6th Ordinary Meeting, 10 April 1972 (joint meeting with the Halifax Chapter, in Halifax)

"The permeability of fruit tissues to gases", F. Forsythe, Agricultural Research Station, Kentville.

"Genetics and biochemistry in tuberculosis treatment", D.W. Russell, Dalhousie University.

Officers and others elected for the session 1972-73 were

President	F. Forsythe
Vice President	C. Maclatchy
Secretary	F. Bent
Treasurer	T. Haliburton
Councillors	Maria Rostocka, D. Stiles

PROCEEDINGS OF MEETINGS

Session 1972-73

Meetings and communications during the year were as follows:

1st Ordinary Meeting, 16 October 1972
"Ocean mining", B.D. Loncarevic, Atlantic Geosciences Centre, Bedford Institute of Oceanography.
2nd Ordinary Meeting, 8 November 1972 (at St. Mary's University)
"Local expansion rate of the universe — the observational problem", R. Racine, University of Toronto.
3rd Ordinary Meeting, 11 December 1972
"Forecasting the weather", R. Dexter, Meteorology, Maritime Command, Halifax.
Extraordinary Meeting, 3 January 1973 (jointly with the Royal Astronomical Society of Canada (Halifax Branch), at St. Mary's University)
"The quincentenary of the birth of Nicholas Copernicus" Wilhelmina Iwanowska, Nicholas Copernicus University, Torun, Poland.
4th Ordinary Meeting, 8 January 1973
"The measurement of blood-flow in arteries and veins", A.E. Marble, Dalhousie University and Nova Scotia Technical College.
5th Ordinary Meeting, 12 February 1973
"Nuclear power in Canada — present and future", E.C.W. Perryman, Atomic Energy of Canada Ltd., Chalk River.
6th Ordinary Meeting, 12 March 1973
"Tidal power development", a panel discussion with J.J. Laffin; C. Garrett; G. Baker and J.S. Bleakney.
7th Ordinary Meeting, 9 April 1973 (jointly with the Valley Chapter at Acadia University)
"Pheromones in insect control", C.R. MacLellan, Agricultural Research Station, Kentville.
"A fisheries scientist visits Japan", W.J. Dyer, Fisheries Technological Station, Halifax.
112th Annual General Meeting, 14 May 1973

The President, J.E. Blanchard, was in the chair and delivered the following address:

> The Presidential address this year will begin with some of the more prosaic details of the year's activities. The membership of the Institute has been much the same as in past years. There were four new members. The attendance at our meetings has remained much the same in spite of an excellent program consisting of reviews of recent scientific and technological developments. Perhaps the highlight of the year was a joint meeting with the Royal Astronomical Society of Canada (Halifax Branch) to celebrate the Nicholas Copernicus

Quincentennial. The meeting was addressed by the distinguished Polish astronomer, Dr. W. Iwanowska. A substantial part of the scientific program this year was devoted to the subject of sources of energy. In all, eight meetings were held.

Members of the Institute of Science were grieved to learn earlier this year of the death of Dr. J.H.L. Johnstone, Honorary Life Member. During his long scientific career at Dalhousie University he was one of the more active promoters of Institute affairs. He was particularly active in encouraging student participation and was responsible for a large student membership in past years. I shall not review Dr. Johnstone's many contributions to Nova Scotian and Canadian science at this time except to say that I, and all who knew him, will miss him greatly.

This year arrangements were completed for the publication of the Seaweeds Symposium held in Halifax during 1972 at the annual meeting of the Canadian Botanical Association and the Canadian Society of Plant Physiologists. The publication was made possible by generous financial support from a number of organizations. This support is much appreciated and I am sure all those who contributed scientifically, technically and financially will be well pleased with the work our editors have done. The publication of other symposia is under consideration.

These are our accomplishments this past year. What plans should we have for the future? This is not a new topic. The Institute has not grown with the Nova Scotian scientific and technical community. We have been concerned with relevance for a number of years. Our present meeting format is a result of this. I personally think it should be continued and if proper occasions arise greater attempts should be made to interest a much wider audience than our mmorship. Like most other aspects of our society, science is being critically examined and the most vocal of these examiners are non-scientists. Science can best be explained by scientists. Of a great scientist Einstein once wrote:

> "In my view there is but one way to bring a great scientist to the attention of the larger public: it is to discuss and explain, in language which will be generally understood, the problems and the solutions which have characterized his lifework. This can only be done by someone who has a fundamental grasp of the material . . ."

We all have a responsibility as scientists and engineers to explain our accomplishments to the larger public. The Institute of Science can provide a forum for this. Thank you.

The Treasurer, D.W. Russell reported

Receipts	$4950.85
Expenditures	500.46
Permanent Fund	534.88
Total cash assets as of May 9, 1973	7683.99

The Editor, M.J. Harvey, reported that the *Chondrus crispus* Symposium would be ready for distribution in June as a Supplement to Volume 27 of the Proceeding. The next publication should be Volume 27 Part II for which two papers were in hand.

The Librarian, Miss E.M. Campbell, reported that a revised list of our exchanges has been prepared. There were 120 requests for interlibrary loans during the year and considerable correspondence with regard to the Supplement to Volume 27. Our holdings are being arranged and indexed in the Dalhousie Science Library where they are distinguished by the Institute's bookplate.

Officers and others elected for the session 1973-74 were:

President	R.G. Ackman
First Vice-president	P.J. Wangersky
Second Vice-president	G. Mitchell
Secretary	N. Cuthbertson
Treasurer	D.S. Davis
Editor	M.J. Harvey
Council	R.F. Brown, K. Hellenbrand, B. Loncarevic, A.Y. MacLean, E.L. Mills, A. Taylor.
Auditors	J.R. Dingle, W.J. Dyer

PROCEEDINGS OF MEETINGS

(Valley Chapter 1972-73)

1st Ordinary Meeting, 2 October 1972

"Ground level variations of the background radioactivity during the sun eclipses of July 1970 and 1972", G. Stevens Acadia University.

2nd Ordinary Meeting, 6 November 1972

"Baffin Island — a mini-exploration", D. Toews, Acadia University.

3rd Ordinary Meeting, 4 December 1972

"North American blueberries", S. van der Kloet, Acadia University.

"Blueberry research in Eastern Canada", I. Hall, Agricultural Research Station, Kentville.

4th Ordinary Meeting, 8 January 1973

"The development of new cultivars in tree fruits", D. Crowe, Agricultural Research Station, Kentville.

"Flame plasma . . . too hot to handle" D. MacLatchy, Acadia University.

5th Ordinary Meeting, 5 February 1973

"Topography and climatic effects on organochloride pesticide residues in the Habitant Creek watershed", G. Burns, Acadia University.

"Structural petrology of lava flows in Iceland", S. Atkinson, Acadia University.

6th Ordinary Meeting, 5 March 1973

"Pleural biopsy — 100 cases", W. Crossen, N.S. Sanatorium, Kentville.

"Prescalene fat-pad biopsy — 218 cases", J. Quinlan, N.S. Sanatorium.

"The tuberculin test", H. Holden, N.S. Sanatorium.

7th Ordinary Meeting, 9 April 1973 (joint meeting with the Halifax Chapter at Acadia University)

"Pheromones in insect control", C.R. MacLellan, Agricultural Research Station, Kentville.

"A fisheries scientist visits Japan", W.J. Dyer, Fisheries Technological Station, Halifax.

Officers and others elected for the year 1973-74 were:

President	C. MacLatchy
Vice-president	H. Specht
Past-president	F. Forsythe
Secretary	F. Bent
Treasurer	T. Haliburton
Councillor	Maria Rostocka

J.H.L. JOHNSTONE

The many friends of Dr. J.H.L. Johnstone were sad to learn of his sudden death while he was holidaying in Mexico last winter (1972-73). Prior to his death he appeared to be in good health and at 83 still possessed the physical vigour, the alert mind and the progressive ideas which characterized his whole life. We expected him to have a lifetime at least as long as his mother's — 106 years.

Dr. Johnstone, a pupil of Pictou Academy, received his master of science degree at Dalhousie and earned his Ph.D. at Yale University in 1916. During the same year he joined the armed forces, fought in France as a captain of the Royal Canadian Engineers and with the British forces at Salonika. He was mentioned in dispatches and returned to Dalhousie a Member of the Order of the British Empire in 1919.

Here he started a fruitful career as a university teacher and researcher. He rose from the rank of instructor in 1919 to full professor in 1926. His academic career was again interrupted when World War II broke out. The Royal Canadian Navy was faced with many scientific problems of which at the start of the war the German magnetic mine was the most menacing.

On February 21, 1940, Dr. Johnstone and his colleague Dr. G.H. Henderson were called upon to find a defence against this weapon. They turned one of their university rooms into a naval research laboratory and thus laid the seed of the now firmly rooted Defence Research Establishment.

Dr. Johnstone's diary of those days, sketchy notes jotted down in the midst of feverish activity, show that within 15 days an instrument had been built to test the magnetic state of a ship. A week later the first ship to be protected against magnetic mines, the Fleur-de-Lis, was being wired at the Halifax Shipyards to the specifications of the two professors.

When Dr. Henderson left for England, Dr. Johnstone carried on by himself. His department flowed over to the now demolished Naval Ordnance building at the Dockyards and its staff grew rapidly. Most of the work was done in Halifax, but Sydney was also wiring ships against magnetic mines, so this involved much commuting between the two ports. Work on a defence against acoustic mines was also effective and Dr. Johnstone tackled many other scientific problems facing the navy. By the end of 1941 his Naval Research Establishment was a vigorous youngster.

He resumed his academic career after the war, first as head of Dalhousie's department of physics, later also as dean of the Faculty of Graduate Studies.

From 1958 on, although in semi-retirement, Dr. Johnstone played a major role during the construction of the Sir James Dunn Science Building and the new quarters for the Nova Scotia Research Foundation.

E.W. Guptill

A.C. NEISH

Arthur Charles Neish, President of the Nova Scotia Institute of Science 1969-70 and a Distinguished Research Scientist of the National Research Council of Canada, died on September 7, 1973 of cancer. Art Neish was born on July 4, 1916 in Granville Ferry, Nova Scotia. In 1935 while at the Agricultural College in Truro he won the Governor General's medal and a scholarship to MacDonald College where he subsequently specialized in chemistry and to a lesser extent in botany, obtaining the B.Sc. degree in 1938. McGill University awarded him the M.Sc. degree in 1939 for work done at MacDonald College with Professor W.D MacFarlane on the isolation and composition of chloroplasts, and the Ph.D. degree in 1942 for work done under the direction of Professor Harold Hibbert at the Pulp and Paper Research Institute on the Chemistry and biochemistry of plant tumors. After a year as sessional lecturer at MacGill, he joined the Division of Applied National Research Council, Ottawa in 1943 as a member of a group studying the properties and production of 2, 3 butanediol by fermentation. This was a war-time project directed at production of possible precursors for rubber. When the Prairie Regional Laboratory Opened in 1948, Art was transferred to Saskatoon as head of the fermentation section. In 1957 he formed a plant biochemistry section and became its first head. He applied the radiotracer technique to the determination of pathways employed by bacteria to ferment hexoses and pentoses and later to the biosynthesis of plant polysaccharides, lignin, and phenylpropanoid compounds. These investigations established that phenylalanine is the source of carbon for the synthesis of lignin.

In 1961, he was transferred to the Atlantic Regional Laboratory where in 1962 he succeeded Dr. E. G. Young as Director. Under his stewardship the facilities of the laboratory were enlarged, a program of co-operative research and graduate student instruction with Dalhousie University organized, and a seaweed culture station established. In his last four years of active research, Art developed methods for growing Irish moss in tanks. It was his objective to bring the power of modern biology and chemistry to bear on these plants and to establish a viable seaweed industry in the Maritimes.

Art Neish's accomplishments brought him many honors. In 1972 the Queen appointed him as an Officer of the Order of Canada. He was the second person to be honored by the National Research Council as a Distinguished Research Scientist. Mount Allison and McGill Universities awarded him honorary Doctors of Science degrees. He was a fellow of the Chemical Institute of Canada, of the Royal Society of Canada, and of the Royal Society, London. In 1968-69, Art Neish was President of the Canadian Society of Plant Physiologists and in 1970, the first recipient of the Society's Gold Medal.

Art is survived by his wife, the former Dorothy Ann Ray of Montreal, a daughter, Nancy (Mrs. Allan Prowse), three sons, Iain, Gordon and Douglas, and by his mother, two sisters and a brother.

F.J. Simpson

PROCEEDINGS

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The First A.C. NEISH MEMORIAL LECTURE

by
R.H.F. Manske

The first A.C. Neish Memorial Lecture was held at Dalhousie University on October 21, 1975 under the joint sponsorship of the A.C. Neish Memorial Trust and the Nova Scotian Institute of Science. The lecturer was Dr. R.H. Manske, Adjunct Professor, University of Waterloo. Honored guests included Mrs. A.C. Neish, Mr. and Mrs. Iain Neish, Mr. Douglas Neish, and other members and friends of the Neish family. Dr. W.D.Jamieson, President of the Institute, was Chairman. Dr. C.R. Masson, Chairman of the Board of Trustees, gave a short appreciation of the life and work of Dr. Neish and a brief account of the purposes of the Trust. On behalf of the Trustees, he presented Mrs. Neish with a bound montage, prepared by Mrs. I.M. Hilchie, with excerpts from unsolicited letters of tribute to Dr. Neish. The speaker was introduced by Dr. A.G. McInnes and thanked by Dr. Ronald Hayes. The meeting was followed by a reception in the Faculty Club, Dalhousie Univeristy. The Lecture was given also in Ottawa on October 24 and in Saskatoon on November 13, 1975.

Introductory Remarks

C. R. Masson

Our purpose here this evening is to honor the memory of Arthur C. Neish, formerly Director of the Atlantic Regional Laboratory and Distinguished Research Scientist of the National Research Council of Canada. The death of Dr. Neish, just over two years ago, deprived us of a great scientist and a distinguished son of Nova Scotia.

Art Neish, as most of us knew him, was born in Granville Ferry in 1916. He received his early education at various schools in Nova Scotia, and attended the Nova Scotia Agricultural College in Truro. There he won the Governor General's Medal and was awarded a scholarship for Macdonald College in Quebec. He took his bachelor's training there and was awarded the B.Sc. degree in Agriculture by McGill University in 1938.

As a youth, Art wanted to be a lobster fisherman or a farmer and went to university largely to please his parents. His interest in research was first aroused when he saw freshwater algae through a microscope for the first time; it's fitting that later he should become an international authority on the subject of marine algae.

Art took his master's degree at Macdonald College in 1939 under W.D. MacFarlane and his Ph.D. in 1942 at McGill, under Harold Hibbert. He subsequently joined the staff of the N.R.C., in the Division of Applied Biology, where he worked with Adams and Ledingham on a project associated with the war effort - the production of butanediol by the fermentation of natural products. This was a subject which continued to interest him for many years and to which he made many contributions. It is possible that this work may have economic significance for the future. as a route to the synthesis of fuels.

He moved to Saskatoon in 1948 as Head of the Fermentation Section and later Head of the Plant Biochemistry Section of the Prairie Regional Laboratory of the N.R.C. His work there on fermentation processes, and later on the carbohydrate metabolism of bacteria and on the biosynthesis of cellulose, lignin and related compounds, using radioactive tracers, is noted for its originality and ingenuity, and has won him international distinction. It is beyond our purpose and scope at this meeting to consider his many contributions to plant biology and biochemistry generally, and I would merely refer to the excellent review of his life and work published last year by J.K.N. Jones in *Biographical Memoirs of Fellows of the Royal Society.*

Art returned to Nova Scotia in 1961 and the following year he was appointed Director of the Atlantic Regional Laboratory, on the retirement of Dr. E. Gordon Young. Under his direction, the laboratories in Halifax were considerably expanded and arrangements were made for some of the staff at ARL to hold honorary positions on the staff of Dalhousie University. It was during this time that he became keenly interested in the possibility of growing seaweeds on a commercial scale (particularly Irish moss) and a seaweed culture station was set up on the Atlantic coast, near Sambro. During the last few years of his life he devoted almost his full time to this work and lived to see its success. He demonstrated for the first time that seaweeds could be grown, without their holdfasts, in an artificial environment and paved the way for commercial developments in this branch of the science of mariculture. This work is being continued at ARL and also has been taken up by his oldest son, Iain, who has established a commercial venture in New Brunswick for the growing of dulse under controlled conditions. We are particularly pleased that Iain and his wife, Michelle, are able to be with us tonight.

Art Neish received many honors during his lifetime. He was a Fellow of the Chemical Institute of Canada and was selected to give the Merck Lecture of the C.I.C. in 1957. He was a Fellow of the Royal Society of Canada. He was President of the Canadian Society of Plant Physiologists in 1968-69 and was the first person to receive the Society's Gold Medal in 1970. He received honorary degrees from Mount Allison University in Sackville and from McGill University. He was elected a Fellow of the Royal Society in 1971. In 1972 he was appointed "Distinguished Research Scientist" of the National Research Council and is only the second person to receive this honor. He became an Officer of the Order of Canada in 1973.

Although first and foremost a scientist, Art Neish had many other interests. He was direct and forthright in his views and always believed that the best way to get things done was to set the example himself. He was always an active person and took a keen interest in a variety of sports. I have heard many accounts of his curling exploits on the rinks in Saskatoon. Bowling and golf were also among his activities. As a student he played rugby and soccer and received the "most valuable athlete" award from the N.S. Agricultural College. Those of us who knew him well will remember his keen interest in sailing and the two boats which he and his sons built at their home in Halifax. It's been placed on record (with what authority I have been unable to verify) that his attempts to play the bagpipes were not crowned with the same success as his other activities. Perhaps this was merely a lack of appreciation on the part of his audience!

After his death in September 1973, many of his friends in the scientific community and elsewhere expressed a desire to contribute to a memorial in his name. A Trust Fund was set up for this purpose with the intention that the income from the Fund would be used in some way in keeping with his ideals and aspirations. The way in which this can be done is flexible and many possibilities are open to us. The Trustees decided that, initially, the purposes of the Trust would be well served by instituting a series of lectures, to be known as the *A.C. Neish Memorial Lectures,* which would be given from time to time in Canada by distinguished scientists. The first Lecture is being given this evening under the auspices of the Nova Scotian Institute of Science. As you know, Art served on the Council of the Institute for many years and was its President during 1969-70. It is particularly appropriate that the first Memorial Lecture should be sponsored by the Institute and I wish to thank the Institute for its co-operation with us in this venture.

One of the more pleasant aspects of the activities of the Board of Trustees has been the correspondence we have had with former friends and colleagues of Dr. Neish throughout the world. Letters of tribute concerning Dr. Neish as a person and a scientist have been received from all corners of the globe. The Trustees have prepared a montage with excerpts from these letters and, on their behalf, I would like to ask Mrs. Neish to accept this as a memento of this occasion. It is entitled "Letters of Tribute. Arthur Charles Neish, 1916-1973" and the inscription reads: "Presented to Mrs. A.C. Neish on the occasion of the first A.C. Neish Memorial Lecture, Halifax, N.S., October 21, 1975. These unsolicited letters of tribute were received by the Board of Trustees during establishment of the A.C. Neish Memorial Fund".

And now, Ladies and Gentlemen, I hand the meeting over to Dr. Gavin McInnes, who will introduce the speaker of the evening.

Introduction to Dr. R.H.F. Manske

A.G. McInnes

Before introducing tonight's speaker, I would like to take a few moments to mention what I believe are the underlying reasons why the Board of Trustees decided that the initial tributes to Arthur Neish should be in the form of public lectures on the broader aspects of science.

In spite of the material well-being and leisure which science (and compound interest) have won for mankind, there still exists a deep-rooted and widespread irrational fear and distrust of science. Why should this be? I believe there are two basic causes. Firstly, the ever increasing body of scientific knowledge seems incompatible with the unique, central and noble role which Man has assigned to himself in the Universe, and secondly, there are misuses of knowledge for which science is held to be ultimately responsible. In recent times these issues have caused scientists to acknowledge that they may have special responsibilities to society in as far as their specialized knowledge is concerned, and to realize that if the climate for science is to be improved, and the dangers from its misuse reduced, they must place their work in the public domain so that it can be understood and its implications examined by non-scientists and scientists alike. The function of the A.C. Neish Memorial Lectures is therefore to foster understanding of science by providing the opportunity for members of the public to hear the views of distinguished scientists on the broader aspects of science and by giving them a chance to express their opinions during a question period. I am sure that this format would have pleased Arthur Neish as he was always deeply concerned about the future devolopment of science and its impact on society.

Tonight's speaker, Dr. Richard Helmuth Fred Manske, has not only attained pre-eminence in the scientific world but has made significant contributions to the business and academic life of Canada.

Born in Germany, Dr. Manske came to Canada in 1906, at the age of five. Later, he obtained his B.Sc. and M.Sc. degrees from Queen's University, and then went to England as an 1851 Exhibition Scholar to work for his Ph.D. degree at Manchester under Sir Robert Robertson. His interest in alkaloids, a branch of organic chemistry on which he is an international authority, undoubtedly dates from the work he did for his Ph.D. degree. However, in the introduction to a lecture he delivered to the Chemical Institute of Canada some years ago, Dr. Manske indicated that his interest in alkaloids occurred at a much earlier age. I quote "My first acquaintance with alkaloids was at the age of 16 months. I was victim of a disturbing kind of infant insomnia and instead of sucking my thumb or my bottle I became excessively vociferous. My mother was a peaceloving woman and discovered that tincture of laudanum relieved my insomnia and relaxed my tension. I slept long and peacefully and became a model child".

After leaving Manchester, Dr. Manske spent a year as a Research Chemist with General Motors Corporation, and then did post-doctoral research at Yale for three years prior to becoming the first chemist employed by the National Research Council (1931) to do laboratory work. Over the next 12 years he not only did brilliant research, which was recognized in the form of a D.Sc. degree from Manchester University in 1937, but also helped develop the National Research Council's Chemistry Division which became one of the worlds great centers of fundamental research.

In 1943 Dr. Manske joined the Dominion Rubber Company (now Uniroyal Ltd.) and established that company's research laboratories at Guelph. Under his direction the Uniroyal laboratories developed many marketable products including fungicides and bacteriocides. He remained at Uniroyal until his retirement in 1966, after which he became adjunct professor at the University of Waterloo. For a brief period also, Dr. Manske served as a professor at Carleton University, and helped organize that University's Department of Chemistry. Although ostensibly in retirement he still remains active in research both on campus and also at Guelph. Over the past fifty years he has written more than 150 research papers plus many reviews, and is founder, contributor and editor of "The Alkaloids", a publication regarded as a definitive survey of research in this field - the fifteenth volume of which was published this year.

Dr. Manske has been the recipient of many honors in recognition of his pioneering achievements, but I will mention only a few highlights. He was medallist of the Chemical Institute of Canada in 1959, the highest honor that the chemical community of Canada can confer on one of its members, and he was President of the Chemical Institute from 1963-64. The Cleveland Section of the American Chemical Society awarded him the 1973 Morley Medal — a signal honor. Dr. Manske's distinguished career also includes honorary degrees from McMaster and Queen's Universities, and he is a Fellow of the Royal Society of Canada.

Dr. Manske became a Canadian citizen in 1924, the same year that he married. They have two married daughters and five grandchildren. We are delighted that Mrs. Manske also was able to come to Halifax and to be with us tonight.

Soon after settling in Guelph, the Manske's purchased a house located on about five acres of land. The property also had an old greenhouse on it, and Dr. Manske became interested in growing orchids, a subject on which he has become something of an authority. This early interest gradually developed to the commercial scale. His large greenhouses supplied Cattleya and Cymbidium orchids to florists in southern Ontario and as far east as Montreal. The techniques he uses are particularly interesting, and can only be compared to those used in bacteriology. From the time seeds are sown on a sterile, nutrient medium until plants come into bloom takes about six or seven years. Although he has given up the business aspect Dr. Manske still grows high quality orchids as a hobby and displays them at orchid shows. His attempts to produce a successful hybrid have at last been successful, and it is really in this area that his interests lie. The Manske's were charter members of the Orchid Society of Southern Ontario.

Dr. Manske's concerns have always extended far beyond the problems of research, and he is well-known in scientific circles for his breadth of knowledge and interests, and for his discourses on the general theme "science and philosophy" during which he exhorts scientists to have concern for the social implications of their work, and urges philosophers and humanists to increase their knowledge of science. Though well past retirement age, and though a gentle person by nature, Dr. Manske's eyes sparkle at the thought of controversy or a heated debate. His achievements and personal qualities make him an outstanding choice for the first A.C. Neish Memorial Lecture, and we are honored by his acceptance of our invitation.

Ladies and Gentlemen, it is with great pleasure that I introduce Dr. Manske who will give his views about "Science, Society and Survival".

Science, Society, and Survival

R.H.F. Manske

Fates do not always deal kindly with human souls, a redundant observation put into dramatic form by Sophocles. Consider a situation in which the roles of Neish and Manske are reversed. Imagine, if you can, that it is the Manske Memorial Lecture and that A.C. Neish is giving it. I assume that everybody would be happier, everybody, that is, except R.H. Manske. Under the circumstances I take full advantage of the fate that has been my lot and I give this address with great pleasure, humbly and fully aware of the honor occasioned by doing so.

The many scientific contributions of merit and the administrative duties of import that A.C. Neish fathered are in the records and I do not propose to deal extensively with them. They have been acknowledged by learned societies in the form of memberships and medals, by universities in the form of honorary degrees, and by scientists in the respect he has earned. His thorough training in organic and biochemistry was put to practical and theoretical use in the study of plant tumors, in bacterial and mycological fermentation, in the biosyntheses of many plant products, in the culture of marine algae, and in other relevant disciplines. There was always the well planned experiment, the careful observation, the critical assessment, the reasoned conclusion, and finally the precise publication. These are the marks of a scientist worthy of the name and A.C. Neish bore it confidently but modestly. The world is a better one for him having lived in it.

The life sciences, biology and biochemistry, loom ever larger in these decades of the 20th century. Less spectacular than nuclear physics, with its mushroom cloud, the life sciences are the very stuff of our living and an understanding of what takes place in the living cell is germane to our survival, so much so that not only scientists are involved, but politicians and theologians are getting into the act. I deem it right therefore that we should attempt some kind of assessment of the status of our civilization with respect to its involvement in science and the impact that science has had and is likely to have. The term science has been often defined, sometimes cryptically and at other times in a whole volume. For the present purpose it suffices to define science as the objective study of our enviornment. Newton, without necessarily defining science, possessed a compelling drive to find order in what appeared to be chaos, to distil from a vast inchoate mass of materials a few basic principles that would embrace the whole and define the relationships of its component parts. Thomas Aquinus has written, "There can be no place for contradiction in a quest for truth! To tolerate contradiction instead of avoiding it is to be indifferent to truth". This, by its very nature, implies that we will never know the whole truth but that we will approach complete knowledge only asymptotically. I recall the early attempts to formulate a cosmogony founded largely on pseudotheological preconceptions.

You are familiar with the Platonic and Aristotelian views of the cosmos and how Copernicus revived the helio-centric theory of Aristarchus of Samos; how Galileo and Kepler laid the foundation for Newton's synthesis; and how Einstein modified it without destroying Newtonian gravitation. Parallel progress in geology and biology led to Darwin's great achievement, and in the realm of chemistry we progressed from the Arabic Alchemists to the discovery of 92 elements. The discovery of oxygen and the interaction of elements to form compounds was a truly great achievement. It is this particualr aspect of science and of chemistry that I wish to dwell upon. Chemistry now plays an important role in every conceivable occurrrence in life processes. Viruses are crystallizable organic compounds; genes are helices of chains of amino acids with sugars, phosphates, and other nitrogen-carbon compounds; those messengers that come from the endocrine glands are derivatives of isoprene as is rubber; those accessory food factors that we call vitamins are simple or very complex organic compounds which sometimes need another element to be formed (cobalt); the colors of flowers, the flavors of drinks, the foods that sustain us, the drugs that cure us, the drugs that harm us, these are but a few of the compounds, largely organic, that are the stuff of life. It is the organic chemist who learns about these compounds and it is the biochemist who learns how they react with each other and how they function in the cell; how their transformations give rise to energy; how their presence stimulates or retards an action; how they transmit characters from one generation to another; how they provide nerve stimuli so that we can see even in color; how they aid in the union of sperm and ovum; and in fact how virtually every life process is mediated by some specific chemical compound or compounds.

Even so, it is not my aim nor my privilege to sing the praises of chemistry or more specifically of organic chemistry. Parenthetically though I remind you of the birth of anesthetics. Originally alcohol was about the only such pain alleviator. It was followed by one of the oxides of nitrogen, by chloroform, by ether, and more recently by the local acting cocaine. It was the last named, which by a series of brilliant researchers, gave us our modern anesthetics, both general and local. Even a major surgical operation is no longer a painful one. I wonder how many of my audience are old enough to have experienced a tooth extraction without the benefit of an anesthetic!

But there are unforseen and probably unforseeable consequences of the advance of science even though we live less painfully and longer. The prolongation of the life of the possessors of genetic and heritable defects defeats the natural process by which many of these carriers of defects are eliminated before they can transmit their defects to following generations. We have the knowledge and the tools to prevent such transmissions but politicians are too timid to apply them and scientists are too voiceless to arouse political action.

It is rare that scientists made themselves heard on matters of human concern, and when they do they are often pilloried by the churches and by priviledged groups. The world population problem is possibly the greatest unsolved one in the long history of humanity. It is, of course, associated closely with the world food supply. In every minute of every day of every year, *etc.*, seven people die of starvation. Since I began this address 105 people have died that way. But let us note that even if there were sufficient food to feed everyone adequately, problems associated with increased population would still be with us. It would be only a matter of a few centuries before every square meter of the earth's surface would be occupied by one human being. And note that these statements are not those of the doomsters but are mathematically certain. These are profound facts and if we do not heed them soon our so-called energy crisis will pale into insignificance. It has been estimated that many more species have become extinct in the last 200 million years than are in existence today. In virtually all of the examples, which have been studied in detail, the end of a species has been the result of overspecialization and the inability to adapt to a changing environment. Does man too face the same fate? Even those species that have disappeared because of man's action failed because they could not adapt to a new environment.

We live in an era in which practically all human activity is dependent upon some aspect of science or its daughter, technology. Our eating habits are conditioned by synthetic additives and much of our food comes out of a can; our homes are heated and cooled by gadgets that are activated by electronics; our travel is controlled by gadgets dependent upon the second law of thermodynamics and more electronic gadgets; our news comes to us via electromagnetic waves mediated by still more electronic gadgets; we are amused, entertained, disgusted, or left indifferent by the play of light on and in a vacuum tube; we hear music, good, bad, or just noise, from a vibrating diaphram again mediated by electronic gadgetry; much of our sexual activity is or should be mediated by organic chemicals; our ills, real or imaginary, are tempered by still more organic compounds; we go to sleep on sedatives and awake on stimulants. I do not praise this dependence on science nor do I condemn it. But I, for one, would not like to revert to an existence without the amenities wrought by science. Strangely enough there are two important forms of human activity in which science has had no recognizable impact; I have in mind, of course, religion and politics, both activites making full use of the gadgets without absorbing any of the philosophy of science.

This then calls for some comments upon the nature of science. At the risk of being repetitive I emphasize that the function of science is not one to generate amenities even though the by-products are amenities in abundance. Science is an intellectual exercise directed to understanding the universe around us. It is not concerned with values, esthetics, ethics, purpose, or morals. These are human inventions and are possessed in abundance by scientists, many of whom justly concern themselves with ethical issues not only because these men are intuitively ethical, but because they have information that has relevance to controversial issues. But science, *per se,* is a creative effort in the same way that writing a poem or composing a symphony are creative efforts. The building materials of science are of only one kind, facts - facts that incidentially never are absolute but are accessible to anyone skilled in the art of observation. As science progresses and as our measurements improve, so we approach ever closer to the asymptotic absolute. Having garnered facts, pointer readings as Eddington called them, we attempt to correlate two or more of them and having done so we call it a theory and write an equation. This *modus operandi* is that of Pythagoras and we have yet to find anything better. Hopefully the equation will reveal ideas or further truths not readily apparent without it and then we put the theory under stress. A scientific theory rapidly ceases to be science unless it lives dangerously, open always to rebuttal and to revision. Unless there is in the theory a hint at experiments which may disprove it, it is useless as a tool of science.

For some years now there has been a hint from many quarters that scientists have discovered and are discovering too much. The nuclear bomb was instrumental in bringing about this attitude and indeed the exponential proliferation of nuclear capabilities is cause for worldwide concern. But that famous Einstein equation was not conceived with a view to anihilate Hiroshima. Rather it was an intellectual exercise of superhuman brilliance, and if such intellectual exercise is discouraged or halted we are in the intellectual doldrums. The Lysenko case in the U.S.S.R. is a good example. You will recall that Lysenko attempted to put the study of biology on a Marxist — Leninist basis. I repeat that science, *per se,* is not concerned with ends but scientists, members as they are of all humanity, are and should be so concerned. The list of those who have done so is a long and an honorable one. But in spite of their logic and their obvious dedication they have had only minimal influence. There are evident reasons for their lack of impact. Not only are powerful lobbies interested in the proliferation and sale of military hardware, but society has evolved no political mechanism for shunting armament expenditures to human and humane projects. While the journeys to the moon are technological achievements of spectacular moment, they have added little to scientific knowledge and the promised fall-out has not given rise to noticeable amenities. "In short man is not grown up enough to be trusted with nuclear reactors", a quotation from Sir George Porter who continued "Twenty years also I felt that the world was getting better socially. But the world is now nearer to anarchy than it has been for a century. What chance is there that man will survive even one half-life of plutonium".

It is now more than 10 years ago that I attempted, feebly it transpired, to have a scientific society expend some of its expertise on the sociopolitical issues of our times. As chemists we have expert knowledge on a host of disciplines and by combining our labors with biologists, physicists, ecologists, climatologists, and statisticians we could provide possible means of dealing with current and foreseeable problems of society. It is unlikely that problems associated with population increase will find political or theological solutions. (210 people have died of starvation since I began my talk!)

Nor will the destruction of our environment be halted by methods currently in vogue. Were each of our great problems separate ones not related to each other the solutions of at least some might be achieved by political methods now available. But pollution is intimately related to population, to energy, to nuclear technology, to food supply, to virtually all of our activities and these are each related to the others. From here it appears as though our civilization, in the Toynbee sense, is in a curve typical of biological growth. It is S-shaped and is well illustrated by the growth of yeast cells in a medium suitable for their growth. They increase at an exponential rate polluting their environment with alcohol until it kills them (around 12%) or they use their food (sugar) until there is none left. In either case growth ceases abruptly and only a few cells survive and those in the form of spores. We are doing precisely to our environment what yeast cells do to theirs, but we have nothing equivalent to the spores of yeast to provide future generations in a changed and habitable environment.

Historically peoples have devastated an area and then moved to another, frequently by conquest, but conquest is of no survival value if there are no virgin lands to conquer. In passing, I recall that someone in the United States of America did not rule out the possibility of taking the Arab oil by force should industry in America be in jeopardy because of another oil embargo in the Near East. Except for this oil rich area there are few lands that are worth conquering. It would seem therefore that, if we wish to survive, we will have to husband our resources and cease polluting our environment. These are hard facts and the remedy requires strong medicine. Are we willing to face a zero growth rate? It means that the so-called underdeveloped countries have little prospect of raising their standard of living while we retain our affluence. I have no answers, except some generalities; but as a scientist committed to the objective method, I am confident that there are solutions, not spectacular ones but realistic ones that may gestate slowly. It is, I urge, the duty of scientific societies to formulate plans and to compel their adoption. And be it understood that the arrival at a concensus is not a prerequisite for action. Historically it has been the minority that foresaw problems and offered solutions. The majority often see no need for change, almost by definition. Change would be inevitable if the majority favored it.

Let me change the subject a bit and consider the present state of science and hazard a look into the near future. In organic chemistry we are approaching the point where structural problems find easy, almost routine, solutions. Even the proteins have largely revealed their secrets and it is almost possible to write the structural formula for a gene. While it is still science fiction there is talk of genetic engineering. Should we succeed in solving problems of population, energy, and nuclear annihilation we will inevitably face new problems and among these I can envisage genetic control.

It has been possible and feasible to cleave DNA and splice it into a carrier molecule thus making it possible to transfer genetic information from one organism to an unrelated one. There the DNA replicates and expresses itself. Genes from a toad were incorporated into *E. coli* (Scientific American, July 1975, p. 25)

But let me go on record as one who welcomes the continuous presence of important problems. A society in which all possible problems have been solved and which puts a premium on conformity would be one without change and therefore without progress. It would be as exciting as an anthill. My plea is therefore, not necessarily the solution of all problems, but rather an attack on them by objective assessment of facts and procedures. This was the *modus vivendi* of A.C. Neish, who happily integrated scientific research and discovery with technological disciplines. Were it not for their practical application his scientific contributions could stand alone. Were it not for his scientific contributions, his practical applications could stand alone on their merit. Scientists have much to learn from him, and many are of course advocates, but that portion of society which is not aware of the scientific method is woefully apathetic.

I take the liberty, and pleasure, of quoting from *Chance and Necessity* a volume from the pen of Jacques Monod. "In the course of three centuries, science, founded upon the postulate of objectivity, has won its place in society — in men's practice but not in their hearts. Modern societies are built upon science. To it they owe their wealth, their power, and the certitude that tomorrow even greater wealth and power will be ours if we so wish. But there is this too: just as an initial 'choice' in the biological evolution of a species can be binding upon its entire future, so the choice of scientific practice (an unconscious choice in the beginning) has launched the evolution of culture on a one-way path; on to a track which nineteenth-century scientism saw leading infallibly on to a vast blossoming for mankind whereas what we see before us today is an abyss of darkness.

Modern societies accepted the treasures and the power offered them by science. But they have not accepted, they have scarcely even heard, its profounder message: the defining of a new and unique source of truth and the demand for a thorough revision of ethical premises, for a complete break with the animist tradition, the definitive abandonment of the 'old covenant', the neccessity of forging a new one. Armed with all the powers, enjoying all the riches they owe to science, our societies are still trying to live by and to teach systems of values already blasted at the root by science itself. No society before ours was ever torn apart by such conflicts. In both primitive and classical cultures the animist tradition saw knowledge and values stemming from the same source. For the first time in history a civilization is trying to shape itself while clinging desperately to the animist tradition in an effort to justify its values, and at the same time abandoning it as the source of knowledge, of truth. The 'liberal' societies of the West still pay lip-service to, and present as a basis for morality, a disgusting farrago of Judeo-Christian religiosity, scientistic progressism, belief in the 'natural' rights of man, and utilitarian pragmatism. The Marxist societies still profess the materialist and dialectical religion of history; on the face of it a more solid moral framework than that of the liberal societies but perhaps more vulnerable by virture of the very rigidity which up to now has been its strength. However this may be, all these systems rooted in animism exist outside objective knowledge, outside truth, and are strangers and fundamentally hostile to science, which they are willing to use but do not respect or cherish. The divorce is so great, the lie so flagrant, that it can only obsess and lacerate anyone who has some culture or intelligence or is moved by that moral questioning which is the source of all creativity. It is an affliction, that is to say, for all those who bear or will bear the responsibility for the way in which society and culture will evolve.

The sickness of the modern spirit is this lie at the root of man's moral and social nature. It is this ailment, more or less confusedly diagnosed, that provokes the fear if not the hatred — in any case the estrangement — felt toward scientific culture by so many people today. Their aversion, when openly expressed, is usually directed at the technological by-products of science: the bomb, the destruction of nature, the soaring population. It is easy, of course, to answer that technology and science are not the same thing and moreover that the use of atomic energy will soon be vital to mankind's survival; that the destruction of nature denotes a faulty technology rather than too much of it; and that the population soars because millions of children are saved from death every year. Are we to go back to letting them die?" I have repeatedly inferred that many of our problems ultimately require political solutions and that politicians are either unaware of the implications or unwilling to take courageous actions. I do not retract this accusation but I do not at the same time condemn them entirely. Politics, as is well known, is the art of the practical and few politicians would survive a second election if they were to advocate some of the long range programs that objective assessment might recommend. We do not get a better government than we deserve, and until scientists and other men of goodwill prepare society for taking it 'on the chin' we will have band aid measures enacted by an expedient parliament. (315 people have died from starvation since I began this talk). May I, in closing, summarize my thesis by a quotation; "Eventually we will run out of food to feed ourselves, fuel to warm ourselves, and air to breath. This is something we must learn to live with".

A COMPARISON OF THE FEEDING AND NESTING REQUIREMENTS OF THE GREAT CORMORANT *(PHALACROCORAX CARBO* L.) AND DOUBLE-CRESTED CORMORANT (*P. AURITUS* LESSON) IN NOVA SCOTIA

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A comparison was made of nesting and foraging requirements of the Great Cormorant *(Phalacrocorax carbo)* and Double-crested Cormorant *(P. auritus)* in Nova Scotia.

P. carbo bred solely on barren islands and cliffs while *P. auritus* preferred to nest in trees on small islands. Occasionally, both species shared bare, rocky islands, in which case *P. carbo* nested around the boulder-strewn edges and *P. auritus* formed dense colonies on the tops. Nest-site segregation probably is related to species' sizes.

Diets determined from regurgitated pellets and from partly digested fish vomited by young birds showed: (1) *P. auritus* took more species of fishes than did *P. carbo;* (2) *P. auritus* utilized all species important to *P. carbo* plus large numbers of several others; (3) the relative frequencies of fish species common to both varied between birds; moreover, *P. auritus* took significantly smaller individuals of each of these species than did *P. carbo*; (4) *P auritus* took large numbers of eel-like fish not caught by *P. carbo*; (5) *P auritus* took large numbers of very small species, effectively reducing its mean prey size.

Diet dissimilarities mostly were the result of different foraging habitats. *P. auritus* fed both in shallow seawater (mean depth 5 m) and in freshwater; *P. carbo* was strictly marine, preferring deeper water (mean depth 11 m). However, the secretive eel-like fish, consumed solely by *P. auritus*, occupy a wide depth range, which suggests that foraging techniques also differ between cormorants. These different feeding depths and methods undoubtedly influence the mean diving times, mean resting times, and the ratios of these means, each of which differ significantly between species. As both species, outside of their area of range overlap, occupy very similar niches, it is proposed that their diet differences in Nova Scotia result from past competition.

Introduction

The cormorants comprise a highly successful, globally distributed family of fisheating birds represented by 28 species. Four occur in Canada of which two, the Doublecrested Cormorant (*Phalacrocorax auritus* Lesson) and the Great Cormorant *(Phalacrocorax carbo* L.), breed along the Atlantic coast. Both are prominently represented in coastal Nova Scotia where I have undertaken a comparative study of their nesting and feeding habits. Such investigations have been carried out previously for the individual species and reveal marked similarities in their niches. However, only *P. auritus* has been well studied in the area of sympatry (although notes for Nova Scotia are scanty). Relevant information on North American *P. carbo* is totally lacking.

It is my aim to assess niche overlap between these two cormorants both by analyzing their selections of nest sites and by determining the species and frequencies of their prey. I examine the differences found in terms of morphology and behavior of the birds, and consider some evolutionary implications. More practically also, it is my purpose to document the diets of these species in the light of the constant concern about their effects on fisheries.

Previous Knowledge of *P. carbo* and *P. auritus*

Investigations of cormorant biology have usually been prompted by economic concern over their effect on commercially important fishes. Such studies have been documented in Canada (McLeod and Bondar 1953), Scotland (Mills 1969), the Netherlands (van Dobben 1952), Russia (Dement'ev *et al* 1966), Australia (Serventy 1938), and New Zealand (Duncan 1968). The cormorants most frequently involved in the studies are *P. auritus* in North America and *P. carbo* in Europe.

The natural history of *P. auritus*, the eastern North American subspecies, has been the topic of two monographs, by Lewis (1929) and by Mendall (1936); these and other studies have been summarized concisely in Palmer (1962). According to these, *P. auritus* is primarily a ground-nesting bird, occasionally nesting in trees. It usually feeds in saltwater in the Atlantic region, occasionally venturing into freshwater. Taverner (1915) in Gaspé, Lewis (1929) in the Gulf of St. Lawrence, Mendall (1936) and Scattergood (1950) in Maine, Lewis (1957) in Nova Scotia, and Dunn (1975) in New Hampshire have recorded wide ranges of marine fishes in its diet, although the importance of individual species varied with location. Bottom-dwelling fishes were most favored, with myoxocephaline sculpins and pleuronectids occurring in all studies. South of Gaspé, the cunner *(Tautogolabrus adspersus)* represented over 40% of total numbers in some samples. Various gadids, the rock gunnel (*Pholis gunnellus)* and clupeids, particularly the alewife *(Alosa pseudoharengus)* were also of widespread importance. Freshwater fishes such as common sucker *(Catostomus commersoni)*, cyprinids including golden shiner *(Notemigonus crysoleucas)*, sticklebacks *(Gasterosteus* sp), and yellow perch *(Perca flavescens)* were also found by Lewis (1957). Small numbers of Crustacea such as shore crab *(Cancer irroratus)*, spider crab *(Hyas coarctatus)*, amphipods, and shrimp were noted along with remains of annelids and squid, probably representing digested-out remnants of fishes' diets. The diet of the western subspecies, *P. a. albociliatus*, has recently been investigated by Robertson (1974) who found that two species of gunnel, *Apodichthys flavidus* and *Pholis laeta,* and the Pacific sand launce, *Ammodytes hexapterus*, were heavily consumed along with shiner seaperch, *Lymatogaster aggregata,* and snake prickleback, *Lumpenus sagitta.*

Knowledge of breeding biology, behavior, and population dynamics of *P. carbo* comes principally from studies of the central European race, *P. c. sinensis*, a smaller, more lacustrine, more tree-nesting bird (see Haverschmidt 1933; Portielje 1927; Kortlandt 1938; 1940; 1942) than *P. c. carbo.* Such information is scanty for the nominate race (see Witherby *et al.* 1943; Bannerman 1959; and Palmer 1962) although Erskine (1972) recently reported on phenology of the North American bird and found it to nest much earlier than *P. auritus. P. c. carbo* usually breeds on small, bald islands and cliffs. It occasionally nests in trees, for example on Lough Cutra, Co. Galway, Eire (Ruttledge in Bannerman 1959) and Durrell Point, P.E.I. (Godfrey 1954). It is largely a marine shoal feeder, although also venturing into freshwater in Britain. Descriptions of feeding habits in the New World consist of passing remarks by Lewis (1927) for Labrador and Salomonsen (1950) for Greenland that myoxocephaline sculpins were taken. In Europe, the following workers studied diets of marine feeding *P. carbo:* Steven (1933) in Cornwall, Pearson (1968) in the Farne Islands, Rae (1969) and Mills (1969) in Scotland, West *et al* (1975) in Ireland, and Madsen and Sparck (1950) in Denmark *(P. c. sinensis)*. Again species and proportions varied, but ground fish were in the vast majority. Pleuronectids were well represented in all studies with gadids of some importance in all but one. Various clupeids and the viviparous blenny *(Zoárces viviparus)* appeared regularly in three studies while salmonids, labrids, eels *(Anguilla anguilla)*, sand launce *(Ammodytes* spp), and gobies *(Gobius* spp) were important in individual areas though not widespread. Mills (1965) found brown trout *(Salmo trutta)*, Atlantic salmon *(Salmo salar)*, perch *(Perca Fluviatilis)*, and eel to be important prey species in freshwater in Scotland; these species were also noted by West *et al* (1975) although Irish cormorant feed much more heavily on marine fishes. Van Dobben (1952) in a detailed study of the feeding of Dutch *P. c. sinensis* found that the eel, roach *(Teuciscus rutilus)*, ruffe *(Acerina cernua)*, and bream *(Abramis brama)* were the principal prey. Moreover, he compared prey frequencies with actual fish frequencies in the Ysselmeer, showed a preference for larger fish, particularly eels, and illustrated influences of weather and season on diet composition. Crustaceans were reported by all of the previous workers. Steven (1933) found particularly large numbers of shrimp *(Crangon* sp) and prawn *(Pandalus* spp) implying that they were actively captured.

Competition between the two species is implied by the overlap of nesting habitat and food species. Lack (1945) studied this question in *P. carbo* and the Shag *(P. aristotelis)* in England and found them ecologically quite distinct. However, these species belong to separate behavioral groups (continental and marine, respectively) as outlined by van Tets (1965). More recently, Scott (1973) described differences in habitat requirements of sympatric Brandt's Cormorants *(P. penicillatus)* and Pelagic Cormorants *(P. pelagicus)*, both of the marine group. A unique feature of the present study is that both cormorants are continental forms.

Study Area

Although the entire Nova Scotian coast was searched for cormorant colonies, this study was carried out principally on two islands off the town of Mushaboom, Halifax County, on the eastern shore during the summers of 1971 and 1972 (Fig. 1). Approximately 32 pairs of *P. auritus* nested in black spruce *(Picea mariana)* on Little Horse Island (50 x 150 m), along with Herring Gulls *(Larus argentatus)*, Great Black-backed Gulls *(Larus marinus)* and Common Eider *(Somateria mollissima)*. Seventeen pairs of *P. carbo* nested farther offshore on a small exposed rock (30 m diameter) off Guilford Island, with two pairs of Great Black-backed Gulls and a pair of Common Eider. Two other colonies were located 10 km to the east: *P. carbo (ca* 230 pairs) on West Brothers Island and *P. auritus (ca* 210 pairs) on an islet off another Horse Island, hereafter termed Big Horse Island. I visited these occasionally but their highly exposed location frequently made regular trips impossible. The substrate is rocky, and around all islands the depth of water is relatively shallow, to about 10 m, dropping rapidly farther offshore. Many shoals are also found throughout the region.

Methods

During the spring and summer of 1971, every cormorant colony in coastal Nova Scotia was located, censused, and described (Lock and Ross, 1973; Fig. 1), and a qualitative assessment was made of the suitability of each area for cormorant breeding. However, detailed studies of nest-site selection and feeding strategies took place in the main study area.

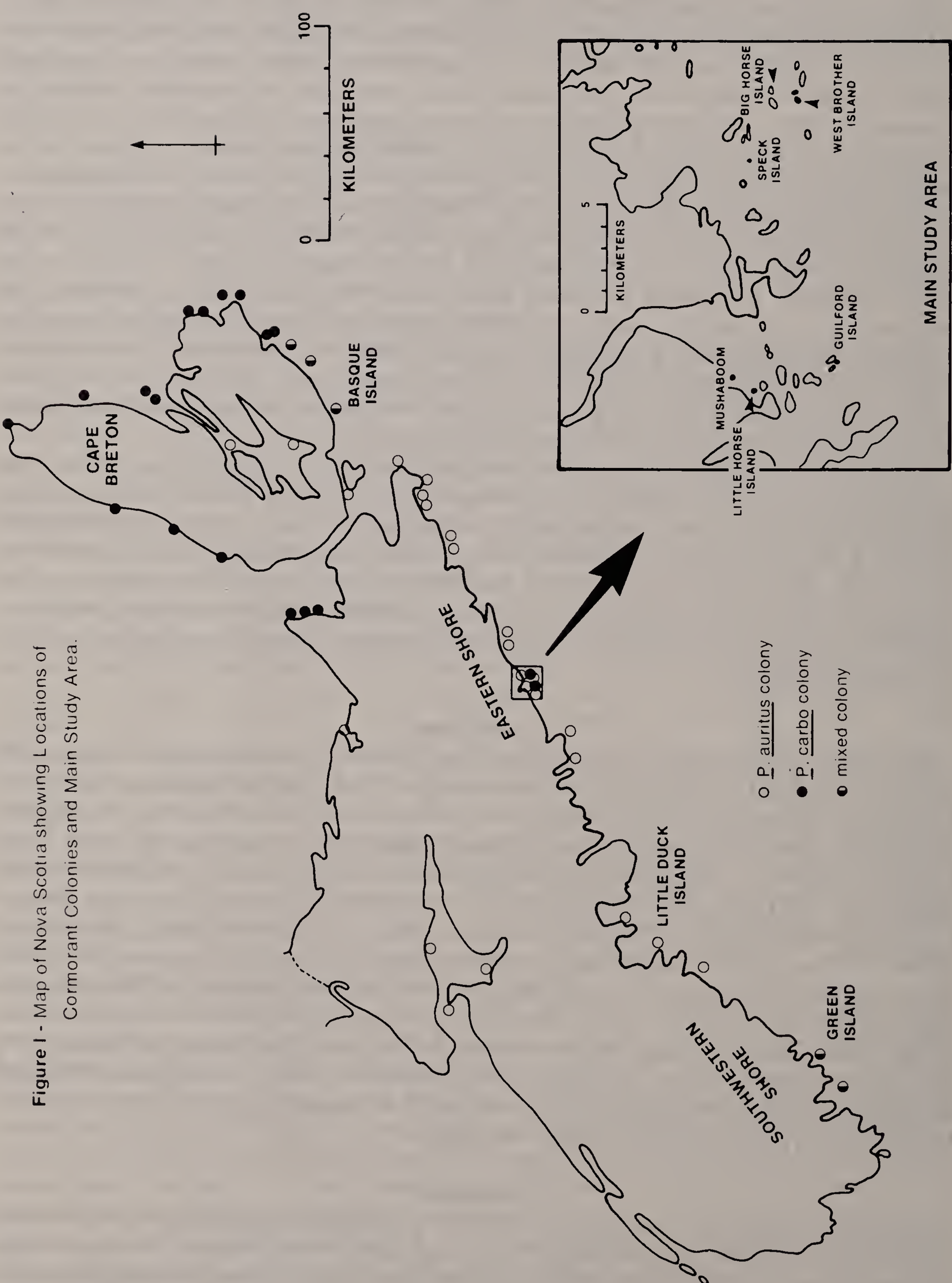

Figure I - Map of Nova Scotia showing Locations of Cormorant Colonies and Main Study Area.

Diets were determined principally from material found in pellets regurgitated round the nest. The oval pellets, ranging from 4 to 7 cm long, contained otoliths, larger undigested fish bones, rocks, and invertebrate remains (such as crab claws and polychaete mandibles), encased in a thick mucous membrane which is sloughed off from the stomach wall during regurgitation. Van Dobben (1952) found that pellets held the remains of a single fishing expedition, the usual daily number for a nesting cormorant. Neither Madsen and Sparck (1950) nor van Dobben found any indication that undigested remains were stored more than one day in the stomach or that any were ejected with the faeces. I found that pellets were rapidly devoured by scavenging gulls and crows so that those collected represented the cormorant's diet for that or the previous day. Examination of partly digested food, vomited by young cormorants when disturbed, provided further data on diet.

Regurgitations were collected and preserved initially in 5% buffered formalin; ethanol was later used. Each pellet was kept separate so that there should be no mixing of contents. The pellets' contents were sorted in trays under an illuminated magnifying glass, examined and, when necessary, measured by optical grid (one grid unit equals 0.071 mm) under a dissecting microscope.

Systematic collection of regurgitations and data on vomits were made on the two colonies off Mushaboom during the summer of 1971 in three sampling periods: May 30 - June 12; June 20 - July 4; and July 12 - July 22 respectively. Visits to each colony were made no oftener than every second day to minimize disturbance. Occasionally, owing to weather and sea conditions, colonies could not be visited for up to five days. Collections of pellets or at least observations of vomits were also made on other Nova Scotian colonies during the summers of 1971 and 1972.

Fish identification was possible using otoliths (fish ear-stones), which are species-specific, are digestion-resistant and, being white, are easily located. Moreover, their lengths are linearly related to fish length in a given species. A fish contains only a single pair of useful otoliths, one being the mirror image of the other. Totalling the number of otolith pairs and unpaired singles would thus give a minimum estimate of fish numbers in a sample. As occasionally only one member of a pair was found, the relationship between otolith disappearance and size was tested by comparing frequencies of pairs and singles in two arbitrary length ranges, 0-50 and 50-100 grid units. The differences between such frequencies for large and small otoliths were not significant at the 5% level for either species (χ^2 test for 2 x 2 table). Moreover, comparison of the two 2 x 2 tables by another χ^2 test (Pielou 1974, for examples) showed no significant difference in these frequencies between cormorants. Loss of otoliths, either through digestion, breakage or separation after regurgitation, could also mean fish going unrepresented. Assuming that each otolith in a given size range has an equal chance of being lost, the following expression can be derived for the number of fish unrepresented in a sample (see Ross 1973, for derivation).

$$\text{Fish lost} = \frac{b^2}{4a}$$

where b = the number of fish represented by pairs of otoliths, and
a = the number represented by singles.

Percentage fish loss was calculated for groups of all otoliths of the two size ranges found in each study period. Although percentages ranged from 3.8 to 18.3, nine of the twelve values were under 10%. As otoliths less than 1.8 mm long were not found, vomits were checked for the occurrence of small otoliths. One species with small otoliths, the cunner, was thus found to be very important in the diets of both cormorants. Therefore, the presence of this species was determined from its dorsal pharyngeal tooth plate whose width indicated fish size.

During the summer of 1971, diving and resting times were recorded for both species by watching the foraging bird continually with binoculars while dictating into a tape recorder the moments of surfacing and diving. Fishing depths were determined during the summer of 1972, using a depth sounder operated from a small boat.

Four *P. carbo* were collected off the Guilford Island colony on June 10, 1972, and four *P. auritus* specimens were obtained from the Federal Department of the Environment. These had been collected during June 1972 from the St. Mary's River and their stomachs removed to check on salmon depredation. All were weighed, then measurements recorded as follows: routine length of wing, tail, exposed culmen, and tarsus as in Godfrey (1965); *toe*: from end of the tarsus to the tip of the longest toe; *leg*: length of femur and tibia; *head*: distance from the preoccipital process to the most distal tip of the nail of the bill, the depth of the complete bill at the dorsal point of appearance of the exposed culmen, the depth of the hook of the beak from the tip dorsally to the most elevated level of the nail, the width across the maximum cranial bulge, and the distance between the squamosal processes; *vertical gape*: perpendicular distance from palate at cranio-facial hinge to point of maximum distension of the gular region; *horizontal gape:* maximum laterally distended width between the lower mandibles.

Areas were computed for the opened foot, the extended wing and the spread tail, using the weight of paper tracings. Maximum cross-sectional area of the body was estimated by measuring width and depth, then substituting these in the formula for the area of an ellipse. These various measurements were used to calculate parameters of diving and flying ability.

Results

Breeding Habitat In Table I, the number of Nova Scotian colonies of each cormorant as well as the total number of breeding pairs are listed for the various habitat types. Two of the *P. auritus* colonies, recorded as arboreal, were composed predominantly of tree-nesters with some on the ground near fallen trees. Of the ground-nesters, one colony of *P. carbo* and two of *P. auritus* were found at the bases of dead and fallen trees. The remaining ground colonies were located on small, rocky, barren islands, of which five were occupied by both species.

Table I. Breeding habitats

Type of habitat	No. of colonies		No. of breeding pairs	
	P. carbo	*P. auritus*	*P. carbo*	*P. auritus*
Spruce trees on small islands	0	21	0	2839
Pilings	0	1	0	88
Level ground on small islands	11	8	1059	1190
Cliffs - mainland	7	0	307	0
Cliffs - island	5	0	627	0
	23	30	1993	4117

Certain nesting situations are clearly exclusive to each species in Nova Scotia. Only *P. auritus* uses trees or, in one case, old pilings, while *P. carbo* is the sole cliff dweller. The level ground of barren islands is the only nesting habitat common to both. However, since Godfrey (1954) found *P. carbo* breeding in trees and *P. auritus* on cliffs in Prince

Edward Island, it appears that these birds can utilize a wide range of breeding habitats elsewhere. A comparison of the locations of colonies with available nesting sites in Nova Scotia is necessary to determine if a preference exists.

Figure 1 reveals a patchy distribution of both species with substantial overlap only along the Atlantic coast from eastern Cape Breton Island to the southwestern shore. Unfortunately, the past history of cormorants in Nova Scotia is poorly known, owing either to lack of observation or to difficulties of previous observers in distinguishing the two species. My sole conclusion about the nesting preferences of allopatric cormorants is that the habitat utilized is the only one available in that location, example, cliff-nesting of *P. carbo* along the coast of western and northern Cape Breton, or the island-nesting of *P. auritus* in the Bras d'Or Lakes and Bay of Fundy. Similarly, in the area of sympatry, the five mixed colonies in Cape Breton and southwestern Nova Scotia are all on small barren islands, the only possible sites. However, along the eastern shore a large number of suitable small islands, both treed and barren, are unoccupied. Here *P. auritus* is an exclusive tree-nester. Moreover, it is well known in this area that, when these cormorants eventually destroy their trees with their droppings and by ripping off living branches, they move to nearby treed islands and do not breed as a colony on the ground, thus demonstrating a propensity for arboreal nesting. In contrast, the two colonies of *P. carbo* in this area are both on the ground, suggesting a preference for ground nesting.

A comparison of the censuses by Lewis (1957) and by Lock and Ross (1973) provides good examples of such preferences. Lewis recorded large colonies of tree-nesting *P. auritus* on both West Brother and Speck island, whereas Lock, 16 years later, found the trees mostly dead on both islands; no *P. auritus* occurred on West Brother and only a few remained on Speck. He found a large tree-nesting colony on nearby Big Horse Island, and *P. carbo* was nesting among upturned tree roots on West Brother.

The five mixed colonies were also examined for differences in nesting habitat. During aerial surveys I noted a clumped distribution of the species. To study segregation, I visited Basque Island and Green Island, both of which are flat-topped with rapidly shelving boulder-strewn sides. *P. auritus* bred in dense colonies on the exposed tops while *P. carbo* was situated around the edges, often sheltered behind rocks.

Food Studies Results of pellet analysis from the main study have been pooled for each study period (Tables II, III). Another diet composition based on vomits from nestlings is presented in Table IV. These show that 16 fish species were taken by *P. auritus* while *P. carbo* utilized only 11; nine were common to both. Comparison of the two methods of diet determination show that rock gunnel, a fish taken exclusively by *P. auritus*, was vastly under-represented in pellets. It was, in fact, a major prey of this cormorant, constituting between 25 and 50% of the fishes consumed. Other species important only to *P. auritus* were wrymouth *(Cryptacanthodes maculatus)* and a class of fish named "small gadoids" that could not be completely identified. As many as 50 individuals of this group could occur in a single pellet. An annotated list of fish species preyed on by cormorants in Nova Scotia is provided in Appendix I; this includes all available records.

All six of the dominant prey species of *P. carbo* also were consumed by *P. auritus*. To find whether relative frequencies of these fishes differed between cormorants, the frequencies of the six species (Tables II and III) were listed for both cormorants in a 2 x 6 contingency table for each study period. A χ^2 test for homogeneity (Bailey 1959) was then performed on each table to ascertain whether ratios of the two frequencies of the six fish species varied. Differences in these compositions were highly significant ($P < 0.001$) in the three periods, indicating different preferences of the cormorants among these species and/or different availability of the fishes.

Table II. Summary of numbers and percentages of fish found in *P. carbo* pellets during the main study, 1971

Fish species	30 May-12 June Actual numbers	Percent-age	20 June-4 July Actual numbers	Percent-age	12 July-22 July Actual numbers	Percent-age	Overall percentage
Pollock	28	20.7	76	26.6	51	22.1	23.8
Cunner	29	21.5	119	41.6	122	52.8	41.4
Winter Flounder	13	9.7	40	14.0	20	8.6	11.1
Long-horned Sculpin	22	16.3	13	4.2	5	2.1	6.0
Short-horned Sculpin	35	25.9	14	4.8	17	7.4	10.1
Cod	6	4.5	16	5.5	14	6.2	5.5
Plaice	1	0.7	4	1.4	1	0.4	0.9
Smelt	-	-	1	0.4	-	-	0.2
Small Gadoids	1	0.7	3	1.1	1	0.4	0.8
Ocean Pout	-	-	1	0.4	-	-	0.2

Table III. Summary of the numbers and percentages of fish found in *P. auritus* pellets during the main study, 1971. The "small gadoid" class has been omitted from the percentage calculation in order to make this column more comparable to that of **Table II** for the larger fishes

Fish species	30 May-12 June Actual numbers	Percent-age	20 June-4 July Actual numbers	Percent-age	12 July-22 July Actual numbers	Percent-age	Overall percentage
Pollock	129	37.6	47	29.0	52	21.4	30.5
Wrymouth	79	23.1	46	28.4	48	19.8	23.3
Short-horned Sculpin	50	14.5	17	10.6	64	26.3	17.5
Winter Flounder	30	8.8	7	4.3	10	4.1	6.3
Cod	18	5.3	5	3.1	7	2.9	4.0
Long-horned Sculpin	3	0.9	3	1.8	3	1.2	1.2
Cunner	27	7.9	27	16.7	55	22.7	14.7
Smelt	1	.3	—	—	—	—	0.1
Rock Gunnel	1	.3	8	4.9	4	1.6	1.7
Ocean Pout	—	—	1	0.6	—	—	0.1
Herring	—	—	1	0.6	—	—	0.1
Common Sucker	3	.9	—	—	—	—	0.4
Silver Hake	1	.3	—	—	—	—	0.1
Small Gadoids	17	NA	353	NA	414	NA	NA

Table IV. Summary of contents of cormorant vomits from nestlings observed in the main study area during the summer, 1971 (12-22 July)

	Cormorant Species			
	P. carbo		*P. auritus*	
Fish species	Numbers	%	Numbers	%
Cunner	38	71.7	5	16.2
Sculpins (ssp)	7	13.2	8	25.8
Pollock	1	1.9	0	0
Winter Flounder	4	7.5	0	0
Rock Gunnel	0	0	15	48.4
Wrymouth	0	0	1	3.2
Sand Launce	0	0	1	3.2
Eel	0	0	1	3.2
Herring	3	5.7	0	0

Otolith length (or tooth-plate width of cunner) were recorded for all examples of the six dominant species plus wrymouth found in pellets. The frequency distributions of these dimensions were examined for each cormorant in the three study periods (see Ross 1973) and observations are summarized in Appendix I. The means of the various distributions for the six dominant species are presented in Table V. In all but one of the 18 pairs of means, those for *P. carbo* are larger than those for *P. auritus*, indicating that *P. carbo* took significantly larger fish ($P < 0.0001$, sign test).

Table V. Mean length of otoliths (pharyngeal tooth plate width for cunner) of the six important fishes taken by both cormorant species. All measurements are in grid units

Cormorant species and study period	Pollock	Cod	Winter Flounder	Long-horned Sculpin	Short-horned Sculpin	Cunner
30V-12VI						
P. carbo	94.5	120.7	47.1	82.2	74.6	184.8
P. auritus	80.7	72.5	43.3	82.0	52.6	149.1
20VI-4VII						
P. carbo	91.8	115.6	41.9	80.9	76.1	168.1
P. auritus	77.9	79.8	27.9	59.0	62.9	145.6
12VII-20VII						
P. carbo	76.5	120.8	40.4	75.9	63.8	146.1
P. auritus	80.2	100.3	36.2	73.7	52.4	143.1

Lists of fish remains also were made at other cormorant colonies, including West Brother and Green island for *P. carbo*, and Big Horse, Little Duck, Basque and Green islands for *P. auritus*. Diet compositions were broadly similar to those found in the main study although several new species were encountered. However, at the *P. auritus* colony at Little Duck Island, the proportion of cunner was much higher than in the Mushaboom area (79% as compared to 15%). Observations also have been made of the diet of *P. auritus* on the St. Mary's River. Lewis (1957) identified the contents of 20 stomachs while I checked five stomaches of birds shot by technicians of the Department of the Environment in 1972. Small fish such as sticklebacks and cyprinids were very important.

The cormorants also regurgitated various items other than fish. Rocks occurred in 66 and 48 % of the *P. carbo* and *P. auritus* pellets respectively. Gastropods, seaweeds, and sand dollars also were eaten, for unknown reasons. Other molluscan, crustacean and annelid remains most likely represent the diets of captured fish. Rock crabs, *Cancer irroratus*, with some spider crabs, *Hyas coarctatus*, were represented in considerably different proportions in pellets of the two cormorants (11% for *P. carbo* compared to 1% for *P. auritus)*. This suggests either that the fish eaten had different diets or that *P. carbo* was actively hunting crabs. The former appears to be more probable as crab remains were almost always associated with those of large sculpins, but in three instances crabs in *P. carbo* pellets bore punctures in their carapaces possibly caused by the nail of the bird's beak. Bivalve remains, mainly blue mussels, *(Mytilus edulis)*, were also much better represented in *P. carbo* pellets, reflecting the larger percentage of cunner taken.

Diving Behavior Differences in mean depth (Table VI) were highly significant ($P < 0.001$, Mann-Whitney U-test). This result is supported by the fact that *P. carbo* was rarely observed fishing near shore and invariably flew toward open water to forage. *P. auritus* was often encountered diving just beyond the surf. A good example was provided by the *P. carbo* and *P. auritus* of West Brother and nearby Big Horse Island respectively. *P. carbo* moved almost exclusively westward from their colony to feed around outer shoals; *P. auritus* flew north toward the main shoreline when foraging.

Table VI. Observations on depth and rhythm of diving activity

Foraging depth (m)

Species	Mean depth	Range	N
P. carbo	10.7	4.6-19.8	22
P. auritus	4.7	1.5- 7.9	25

Diving and resting times

Species	Mean diving time in sec.	Mean resting time in sec.	N	Ratio of mean diving and resting time
P. carbo	51.0	13.9	34	3.67: 1
P. auritus	25.1	10.3	86	2.43: 1

Differences in mean diving times, mean resting times and dive/rest ratios (Table VI) were also highly significant ($P < 0.001$, Mann-Whitney U-test). Diving times undoubtedly correlate with feeding depths, while the resting time would reflect the recovery period after these exertions. Interestingly, the dive/rest ratios are highly dissimilar, suggesting differences in either physiological efficiencies or underwater behavior.

Comparative Morphology Means of each of 14 linear measurements were determined for both *P. carbo* and *P. auritus* and the ratios taken for each pair. The average of these ratios of means *(P. carbo: P. auritus)* is 1.17:1, with a range of 1.07:1 - 1.36:1. The extreme values are associated with tail length and cranial bulge which both showed much smaller differences than expected (1.07:1) and with vertical gape which was proportionally much greater for *P. carbo* (1.25:1). The ratios of the three beak measurements, exposed culmen (1.36:1), depth at exposed culmen (1.26:1), and hook depth (1.26:1) were consistently greater than average.

Mean weight of the four specimens of *P. carbo* was 3480 g with a range of 3090 - 3714 g. As the four *P. auritus* specimens had their stomachs removed, their whole weight was first estimated by adding 15% to their eviscerated weight. Their mean estimated weight was 1860 g with a range of 1786 - 1928 g which is similar to findings of Lewis (1929) and Mendall (1936).

Calculations concerning diving and flying abilities are listed in Table VII. Storer (1971) indicated that underwater speed and manoeuvrability are functions of the ratio of maximum cross-sectional area to foot area. The difference between species is striking, implying that *P. auritus* travels faster and/or more efficiently under water. Aerial efficiency and manoeuvrability are guaged from wing loading (body weight divided by total area of wings and tail). *P. auritus* carrys less weight per unit area of flight surface than *P. carbo*. This is expected for birds of similar proportion differing only in size, since weight varies as the cube and area as the square of linear dimension.

Table VII. Calculated parameters of diving and flying ability

	P. carbo		*P. auritus*	
	Range	Mean	Range	Mean
Wing loading (g/cm^2)	1.37-1.51	1.44	0.88-1.10	0.98
Ratio of cross-section to foot area	1.38-1.79	1.57	1.18-1.23	1.21

Discussion

Pronounced differences in the breeding and feeding requirements of *P. auritus* and *P. carbo* result from morphology and feeding behavior of these species.

Nest sites are distinctive in Nova Scotia since *P. auritus* largely utilizes trees while *P carbo* is an exclusive ground-nester. Along the Atlantic coast, *P. auritus* nests mainly in trees and only occasionally on the ground. However, in other sections of its range ground-nesting predominates, although trees are used wherever possible (Palmer 1962). *P. carbo* has tree-nesting races, *e.g.*, *P. c. sinensis* (Kortlandt 1942; van Dobben 1952) but this behavior is exceptional in *P. c. carbo.* As both species belong to the group of cormorants characterized by this arboreal capability (see van Tets 1959), it appears that the tree-nesting propensity was ancestral but has since been suppressed in *P. c. carbo*. Clearly, the primary advantage of arboreal nesting to *P. auritus* is protected from terrestrial predators. Ground nesting itself provides little benefit to *P. carbo* other than a reduced chance of young falling out of the nest. Instead, I proposed that *P. carbo* breeds on the ground because it finds tree nesting difficult, possibly because its greater weight strains branches or increased wing loadings leads to landing problems. However, its large size is of advantage as it allows greater metabolic efficency which, considering the cormorant's wettable plumage (Rijke 1968), is important if cold waters are to be fished. Moreover, this could explain why *P. carbo* remains year round in or near the breeding range, and does not undergo a lengthy migration like *P. auritus*.

Present-day competition cannot be invoked as a mechanism to segregate nest sites as preferences of the two Nova Scotian cormorants do not change outside of the area of range overlap. It initially appeared that some degree of competitive displacement might occur on mixed colonies where the limited, suitable breeding habitat has forced both to share a barren island. However, even here different nesting sites appear to be preferred. I observed that *P. auritus* on the Blue Gull Rock colony did not occupy vacant nesting sites of the type used by *P. carbo*, suggesting a preference by *P. auritus* and not a simple physical exclusion by the larger, earlier nesting *P. carbo*. However, Erskine (1972), in tracing the history of the *P. carbo* colony at Crystal Cliffs, noted that *P. auritus* initially bred there and was replaced by *P. carbo*. In contrast, the Cape Tryon, P.E.I. colony has contained both species since 1941; although proportions fluctuate, neither species is approaching extirpation. As detailed observations of the nesting sites of these colonies have not been made, further speculation is not warranted.

Food spectra of the two cormorants show a degree of overlap as expected; however, differences exist which are remarkable for such similar species.

1) *P. auritus* preys on a larger number of fish species than *P. carbo*. In the main study area, *P. auritus* took 16 species and *P. carbo* only 11, while, based on all records in Nova Scotia, the numbers were 23 and 13 respectively.
2) *P. auritus* utilizes all the important species taken by *P. carbo* plus large numbers of several other species. The proportions of the various common species differ greatly between the two birds.
3) *P. auritus* takes a large number of eel-like fish not caught by *P. carbo*. These include wrymouth, rock gunnel, sand launce and American eels.
4) *P. auritus* takes significantly smaller individuals than does *P. carbo* of the fish species common to both cormorants; however, the differences in mean sizes of the various species are small. *P. auritus* also takes substantial numbers of much smaller species such as rock gunnel, stickleback, sand launce, mummichog, and an undertermined group described as "small gadoids". These further reduce the mean prey size of this species.

The observed differences in diet result primarily from dissimilarities in foraging habitats. The greater diversity of prey of *P. auritus* is largely the result of its feeding in fresh as well as saltwater; *P. carbo* is strictly marine. In the sea, *P. carbo* fishes at an average depth of 11 m as opposed to 5 m for *P. auritus*. Correspondingly, the latter forages closer to shore where it would more often encounter the smaller fish species, *e.g.*, mummichog and stickleback. It also might find the "small gadoids" here, possibly fry of squirrel hake *(Urophycis chuss)* or tomcod *(Microgadus tomcod)* which inhabit estuaries or very shallow water (Bigelow and Schroeder 1953). It is unlikely that *P. carbo* deliberately rejects these small species. The depth difference also could account for the greater proportion of the deeper-water, long-horned sculpin taken by *P. carbo* and the presence of American plaice in its diet.

Habitat differences do not explain why *P. auritus* specializes in taking eel-like fishes, as these occupy a wide depth range. However, considering the complete absence of this group from the diet of *P. carbo*, it appears that *P. auritus* must have a different foraging technique which allows the capture of these secretive, burrowing fish.

The larger *P. carbo* with its disproportionately larger beak and more voluminous gullet is clearly better adapted for the taking of larger fish including such difficult species as long-horned sculpins which have powerfully erectile head spines. The smaller *P. auritus*, with its much smaller beak, is well designed for catching and manipulating small fish and can probe more easily down holes and around rocks in search of eel-like fish. Moreover, the greater speed and manoeuvrability of this species, implied by its ratio of cross-section to foot area, also would be advantageous in the pursuit of small, darting fish.

The form and life habits of fish taken by both cormorants in other areas are largely similar to those found in the present study although naturally fish species vary with location. However, in Great Britain, *P. carbo* takes eels and rock gunnel while not utilizing them here. It is not known whether this results from different foraging behavior of the cormorants or different availability of these fish. The British *P. carbo* also eats considerably more crustaceans (Steven 1933) which are minimally important here.

The two species differ strikingly in diving behavior, largely because of differing hunting depths. *P. carbo* dives for approximately twice as long, rests on the surface slightly longer, and has a much larger dive/rest ratio (3.67:1) as compared to *P. auritus* (2.43:1). The findings for *P. auritus* agree with casual notes made by Lewis (1929) and Mendall (1936); however, the observations on *P. carbo* differ considerably from those published for the British bird, which usually dives for 20-30 sec, as opposed to an average of 51 sec, here, and probably never ventures below 9.5 m (Dewar in Witherby *et al* 1943). Stonehouse (1967) in a study of various New Zealand cormorants found that *P. c. novaehollandiae*, in 2-3 m of water, had a mean diving time of 21 sec, mean resting time of 7 sec, and a dive/rest ratio of these means of 3.0:1. Depth undoubtedly accounts for these dissimilar diving times. The differing dive/rest ratios of *P. carbo* and *P. auritus* are difficult to interpret without knowing underwater behavior and lengths of diving sessions. Stonehouse (1967) considered that this ratio indicated physiological efficiency in New Zealand cormorants. However, I concur with Scott's (1973) contention that such a conclusion based on field studies may not be warranted as the birds usually work well within their physiological limits. These limits could probably only be determined in the laboratory. Therefore, in the present study, no conclusions or speculation on this aspect will be advanced.

Although *P. carbo* and *P. auritus* are largely different ecologically in Nova Scotia, it is problematic whether these dissimilarities are fortuitous or result from competition. Lack (1945; 1971) supports the former theory and Andrewartha and Birch (1954) the latter in considering the niches of the highly similar *P. carbo* and *P. aristotelis* in Great Britain. Pearson (1968), in examining this situation for the Farne Islands, stated that competition may occur under adverse conditions but does not appear to exist at present. Lack's conclusion was also supported in a brief review of Holarctic cormorants by Cody (1973).

From the present study, I propose that competition occurred when *P. carbo* invaded *P. auritus* range in Atlantic Canada. It is likely that *P. auritus* was the original colonizer of this area, judging from its greater abundance in Eastern Canada, very wide North American distribution, and pleistocene fossil record (Wetmore 1956; Brodkorb 1958). *P. carbo* probably arrived later, since it has smaller numbers, an extremely restricted North American range, and no fossil record. Moreover, North American and British *P.*

carbo are morphologically identical which would be expected only if these populations had been recently separated. However, from Lack's (1945) description of its habitat, *P. carbo* in Britain forages in the same shallow-water marine and freshwater environments as does *P. auritus* in Nova Scotia. All other races of *P. carbo* also prefer this environment (Serventy 1938; van Dobben 1952; Rand 1960; Williams 1964; Dement'ev *et al* 1966; Stonehouse 1967; Etchecopar and Hue 1967). Since the *P. carbo* in the present study is solely marine and fishes greater depths than in Britain, it appears likely that competition from the better-established *P. auritus* led to the evolution of a preference for deeper water by *P. carbo.* The possibility exists that *P. carbo* was preadapted to this foraging area during colonization of Greenland and Iceland prior to invasion of North America. This cannot be conclusively checked in the literature although Salomonsen (1950) described it as a shallow-water bird in Greenland.

Central to the hypothesis that competition induced separation of the two species is the concept that food was limiting. Considering the present number of cormorants, their opportunistic nature, and the general abundance of the fishes on which they feed, it seems most unlikely that this would be the case. However, it is well known that cormorant numbers were vastly reduced by human disturbance (Gross 1945; Erskine 1972). In the past, with less human interference, numbers may have been much higher, strengthening the interaction of the two cormorants and leading to resource partitioning.

The size relationship of the birds, particularly their beaks, is in the range noted by Hutchinson (1959) and elaborated by MacArthur (1972) for closely related sympatric species; this is usually associated with different prey sizes (Hespenheide 1971). The size difference of these cormorants could have been one of the factors which moderated their interaction sufficiently to favor ecological segregation rather than extinction of one of them. The ratio of beak sizes (approx. 1.2:1) occurs in other pairs of cormorant species such as *P. aristotelis* and *P. carbo* in Great Britain and *P. penicillatus, P. auritus* and *P. pelagicus* on the Pacific coast of Canada.

The different dates of clutch initiation (Erskine 1972) may be further manifestation of past competition for food. Although it was not investigated, separation of laying and hatching dates could serve to separate peak food demand periods for the cormorants.

The suggested mechanisms by which ecological segregation of *P. carbo* and *P. auritus* were accomplished involve considerable circumstantial evidence and speculation. Further evidence would be provided by a wider study of the habitat requirements of each species throughout its whole range. Studies of foraging behavior, diving physiology, and metabolic rate would aid in defining each species' advantageous attributes.

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Appendix I

Annotated list of fish species taken by cormorants in Nova Scotia.

Atlantic Cod *(Gadus morhua)*

Taken in small but roughly equal numbers by both cormorants. May be uncommon in the shallow waters fished by them. The frequency distributions of otolith length indicate a wide range of sizes taken with little evidence of modal points.

Pollock *(Pollachius virens)*

Large, highly visible schools throughout the Mushaboom area. Well represented in both cormorants' diets in approximately equal amounts *(eg,* 23.8% of fish taken by *P. carbo*). Length distributions show major peaks in both June study periods, probably representing second summer fish. The few larger otoliths could be those of third summer fish. During July study period another modal point, suggesting fry, appears in both distributions.

"Small Gadoids"

Taken in large numbers by *P. auritus* (51.2% of all fish recorded in main study). Assumed to be gadid fry as aging of otoliths indicate fish of the year.

Cunner *(Tautogolabrus adspersus)*

Very abundant and widely distributed in shallow water among rocks and around holdfasts of marine algae. The most important species in the diet of *P. carbo,* making up 41.4% of total numbers and occurring in 80% of the pellets examined. Relatively fewer taken by *P. auritus.* Proportions of Cunner eaten increased during the study periods by an equal amount in both species. The frequency histograms of pharyngeal tooth plate widths reveal a broad, fairly uniform distribution, resulting from the slow growth of this fish which allows many year classes to be eaten.

Rock Gunnel *(Pholis gunnellus)*
A small eel-like species of great importance to *P. auritus* (25-50% of total numbers).

Wrymouth *(Cryptacanthodes maculatus)*
A little-known, secretive blenny consumed exclusively by *P. auritus* and representing as much as 20% of its diet in the main study. Frequency distributions show a wide range of sizes, suggesting the slow growth of the species. Readings of some otoliths revealed fish aged up to 7 years were consumed.

Long-horned Sculpin *(Myoxocephalus octodecemspinosus)*
Caught in larger numbers by *P. carbo* (10.1% of fish taken) than *P. auritus*. A wide range of sizes are taken.

Short-horned Sculpin *(Myoxocephalus scorpius)*
Much more important to *P. auritus* than to *P. carbo*. Proportions vary considerably with study period, (from 10.6 - 26.3% of larger fish taken by *P. auritus*). A wide variety of sizes taken.

Winter Flounder *(Pseudopleuronectes americanus)*
Of moderate importance to both cormorants although a slightly larger percentage taken by *P. carbo* (11.1%). A restricted range of otolith sizes found, possibly owing to the cormorants' ability to handle only smaller fish.

Herring *(Clupea harengus)*
Large schools common in the summer in the Mushaboom area. As only small numbers were taken by both cormorants, capture probably occurred when birds fortuitiously pass through schools while diving for the bottom.

American Smelt *(Osmerus mordax)*
A schooling species usually restricted to coastal regions. Very small numbers taken by both cormorants.

American Eel *(Anguilla rostrata)*
Very small numbers taken by *P. auritus*.

Silver Hake *(Merluccius bilinearis)*
One taken by *P. auritus* in main study.

American Sand Launce *(Ammodytes americanus)*
One recorded for *P. auritus* in main study, although more important at Green Island.

Ocean Pout *(Macrozoarces americanus)*
Taken rarely by both cormorants. A specimen weighing 630 g was regurgitated by a *P. carbo* nestling on West Brother Island.

American Plaice *(Hippoglossoides platessoides)*
Taken rarely by *P. carbo* in the main study.

Gaspereau *(Alosa pseudoharengus)*
Taken in small numbers by *P. auritus* from Basque Island and the St. Mary's River although probably very important during spawning run.

Mummichog *(Fundulus heteroclitus)*
Of minor importance to *P. auritus* on Basque Island.

Mackerel *(Scomber scombrus)*
Two individuals regurgitated by *P. carbo* nestlings on West Brother Island. Probably caught by chance, like Herring.

Grubby *(Myoxocephalus aeneus)*
Two individuals regurgitated by *P. auritus* nestlings on Basque Island.

Sticklebacks *(Gasterosteus sp)*
Of major importance to *P. auritus* on St. Mary's River. Occurred in 18 of 25 stomachs examined.

Common Sucker *(Catostomus commersoni)*
A freshwater species occasionally straying into estuaries. Taken in small numbers by *P. auritus* in main study.

Golden Shiner *(Notemigonus crysoleucas)*
This and other unidentified cyprinids taken occasionally by *P. auritus* on St. Mary's River. Occurred in 7 of 25 stomachs.

Yellow Perch *(Perca flavescens)*
Of minor importance to *P. auritus* on St. Mary's River. Occurred in 3 of 25 stomachs.

White Perch *(Roccus americanus)*
Lewis found one taken by *P. auritus* on St. Mary's River.

A MODEL FOR A SIMPLE DIFFUSION PROCESS

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The problem of determiming the amount of a given substance that has diffused into one life form given that a known amount has diffused into a second similar life form under the same conditions is studied under the assumption that: free molecular diffusion is the only process involved, the mass diffusion coefficients are known constants and the external concentration of the diffusing substance remains constant. The solution of this *comparative diffusion problem* is obtained in terms of the external concentration value and the physical properties of each life form for the special case of a cylinder-cylinder configuration of the pair. The properties of this solution are then determined for all reasonably small and sufficiently large values of the external concentration value. This study represents a first attempt to resolve what appears to be a new class of diffusion problems.

Introduction

The biologist is often confronted with the task of maintaining an important plant free from intruding parasites and epiphytes. He may find manual separation awkward, time consuming, or even damaging to his object of study. In this case, the possibility of having the host-intruder system immersed for a brief time in a solution containing chemicals so as to reach lethal concentration in intruder while inflicting as little damage as possible to the host is certain to be worth his consideration, especially if the damage done is insignificant. However, to be able to use such a method efficiently certain questions, arising quite naturally in this context, have to be answered. Assuming that the lethal concentration τ necessary to neutralize the intruder is known, one has to know the duration of exposure of the host-intruder system to the chemical in use when the concentration $c > \tau$ is given. More importantly, since only the smallest possible concentration of the same substance should be permitted to enter the host, one has to know whether long exposures with smaller concentrations or short exposures with correspondingly larger concentrations are preferable. In the present paper we discuss these questions in the case of a cylinder-cylinder configuation of the host-irtruder system in which the following hypotheses hold:

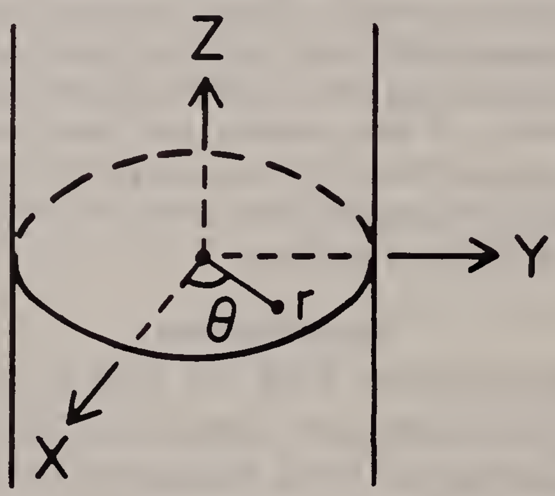
1. The process by which the toxic chemical is taken in by both life forms is free molecular diffusion.
2. The diffusion coefficient is a constant for each life form (and is known *a priori* or can be determined experimentally).
3. The concentration c of the toxic chemical remains unchanged during the exposure of host-intruder to it.

Similar analyses, under less stringent assumptions, *eg* when diffusion and reaction occur simultaneously or the process is membrane dependent *etc.* are certainly possible. However, for this initial simplified model assumptions 1 - 3 are maintained throughout.

The cylinder-cylinder configuration

In this configuration the valuable and unwanted life forms are represented by two cylinders A and B of radius r_A and r_B respectively. The cylinders are considered to be infinite in length or, if of finite extent, have ends which do not permit diffusion.

For a given cylinder of base radius r_o, let C(r,t) denote the molar concentration (g - moles/cm³) of diffused chemical at time t (sec) at each point a distance r (cm) from the center of the cylinder after it has been immersed in a solution containing a molar concentration c of the toxic chemical. Then according to assumptions 1 and 3, C(r,t) is a solution of the initial-boundary value problem for the diffusion equation*



$$(1)\qquad \begin{cases} C_t = k\,(C_{rr} + C_r/r) & 0 < r < r_o\,,\ t > 0 \\ C(r_o,t) = c\,, & t > 0 \\ C(r,0) = 0\,, & 0 < r < r_o \end{cases}$$

where k is the mass diffusion coefficient (cm²/sec) for the given cylinder and $C_r \equiv \frac{\partial C}{\partial r}, C_t \equiv \frac{\partial C}{\partial t}$. If one also wanted to take into account a reaction process which produced or eliminated the diffusing chemical, then the diffusion equation would be

$$C_t = k(C_{rr} + C_r/r) + R$$

where R(r) would be the molar rate (g - moles cm^{-3} sec^{-1}) of production or elimination of c at r. Problem (1) can be solved by the technique of separation of variables.

* The differential equation in (1) is called Fick's second law of diffusion or the diffusion equation (Bird *et al* 1960,) and is the equation (in polar coordinates) often used for the analysis of diffusion in solids or stationary liquids; k is a measure of the molar diffusion flux, which is the number of moles of the chemical that pass through a unit area of the material in unit time and depends on temperature, pressure, and composition of the material.

Substitution of $C(r,t) = c + R(r)T(t)$ into the differential equation and boundary condition in (1) gives

$$(2) \qquad \frac{T'}{kT} = \frac{1}{R}\left(R'' + \frac{R'}{r}\right) = -\lambda^2 \ , \ 0 < r < r_o \ , \ t > 0$$

$$R(r_o)T(t) = 0 \ , \ t > 0$$

where λ is the separation constant and $R' = \frac{dR}{dr}$. $T' = \frac{dT}{dt}$.
It follows that for each $j = 1,2,...$

$$R_j(r)T_j(t) = J_o(\lambda_j r) \exp(-\lambda_j^2 kt)$$

satisfies (2) with $\lambda = \lambda_j$ where the eigenfunctions

$J_o(\lambda_j r) = \sum_{n=0}^{\infty} \left[(-1)^n(\lambda_j r/2)^{2n} \quad (n!)^{-2}\right]$ are the Bessel functions of order zero and the corresponding eigenvalues λ_j satisfy $J_o(\lambda_j r_o) = 0$. The unique solution of (1) is then expressed in terms of that linear combination of the $R_j(r)T_j(t)$'s for which $C(r,0) = 0$, $0 < r < r_o$. Thus

$$C(r,t) = c + \sum_{j=1}^{\infty} a_j J_o(\lambda_j r) \exp(-\lambda_j^2 kt)$$

where for each $j = 1,2,...,$

$$a_j = (2/(r_o J_1(\lambda_j r_o))^2) \bullet \int_o^{r_o} r J_o(\lambda_j r) \bullet (-c)dr$$

$$= -2c/(\lambda_j r_o J_1(\lambda_j r_o)) \ ,$$

the integration following from the special property of Bessel functions: $\frac{d}{dx}(x^\nu J_\nu(x)) = x^\nu J_{\nu-1}(x)$, ν real. The above series and its derivatives converge absolutely and uniformly with respect to r and t ($t \geq t_o$, $t_o > 0$), and its sum $C(r,t)$ is a continuous function of r and t for $0 \leq r \leq r_o$, $t > 0$. One consequence of this is that the series can be integrated termwise without affecting its convergence. Integration of $C(r,t)$ over a representative segment of unit length of the given cylinder and subsequnet division by the volume of that segment (πr_o^2) gives the mean concentration M of the toxic chemical in the sement at time t

(3) $$M(t,r_o,c) = \left(2\pi \int_0^{r_o} rC(r,t)\,dr\right) / \pi r_o^2$$
$$= c\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_o^2 \lambda_j^2} \exp(-\lambda_j^2 kt)\right).$$

and $M(t,r_o,c)$ satisfies: $0 < M(t,r_o,c) < c$ for every c and $t > 0$, $M(0,r_o,c) = 0$ and $M(t,r_o,c)$ is a continuous, strictly increasing function of $t > 0$ for fixed c with $\lim_{t\to\infty} M(t, r_o,c) = c$.

Applied to cylinders A and B, (3) gives

$$M(t,r_B,c) = c\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_B^2 \alpha_j^2} \cdot \exp(-\alpha_j^2 k_B t)\right)$$

and

(4) $$M(t,r_A,c) = c\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_A^2 \left(\frac{r_B}{r_A}\alpha_j\right)^2} \cdot \exp\left(-\left(\frac{r_B}{r_A}\alpha_j\right)^2 k_A t\right)\right)$$
$$= c\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_B^2 \alpha_j^2} \exp(-\alpha_j^2 k_B \rho t)\right)$$

where $\rho = \frac{r_B^2 k_A}{r_A^2 k_B}$ and $M(t, r_A, c)$ and $M(t,r_B,c)$ are the mean concentrations of the toxic chemical in the representative segments of A and B after their immersion in the solution at time $t = 0$, k_A, and k_B are the diffusion constants for A and B, and α_j are the eigenvalues, $J_o(\alpha_j r_B) = 0$, $j = 1,2,\ldots,$. Let $t = T(c)$ denote the time required for $M(t,r_B,c)$ to attain the value τ for a given value of $c > \tau$ (clearly c must be chosen such that $c > \tau$ since $M(t,r_B,c) < c$ for all t). Then

(5) $$M_B(c) \equiv M(T(c), r_B,c)$$
$$= c\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_B^2 \alpha_j^2} \exp(-\alpha_j^2 k_B T(c))\right) = \tau, \; c > \tau$$

and $M_A(c) \equiv M(T(c), r_A, c)$ is the mean concentration of toxic chemical in the valuable component at time $t = T(c)$. This function $T(c)$ is a continuous, strictly decreasing function of $c > \tau$. Indeed, if we set $G(T,c) = M_B(T, r_B, c) - \tau$, $c > \tau$, then

$$G(T,c) = 0, \quad \frac{\partial G}{\partial c} = 1 - \sum_{j=1}^{\infty} \frac{4}{r_B^2 \alpha_j^2} \exp(-\alpha_j^2 k_B T) > 0$$

$$, \quad \frac{\partial G}{\partial T} = c \sum_{j=1}^{\infty} \frac{4 k_B}{r_B^2} \exp(-\alpha_j^2 k_B T) > 0$$

and by the Implicit Function Theorem (Courant 1947), $T'(c)$ exists and

$$T'(c) = -\left(\frac{\partial G}{\partial c} \Big/ \frac{\partial G}{\partial T}\right) < 0, \; c > \tau .$$

From (5) it also follows that $\lim_{c \to \infty} T(c) = 0$ and $\lim_{c \to \tau^+} T(c) = \infty$. The really important question, of course, is how does $M_A(c)$ vary as a function of that c (and corresponding $T(c)$) for which $M_B(c) = \tau$, since this will determine the procedure to be used in the operation of the process. A partial answer to this question is given by the following theorem and is illustrated in Figure 1. Unfortunately, the strictly decreasing ($\varrho < 1$) and strictly increasing ($\varrho > 1$) behavior of $M_A(c)$ could not be established for all values of $c > \tau$, but only for all reasonably small and sufficiently large values of the external concentration c. However, all the numerical and theoretical evidence to date suggests that this is actually the case.

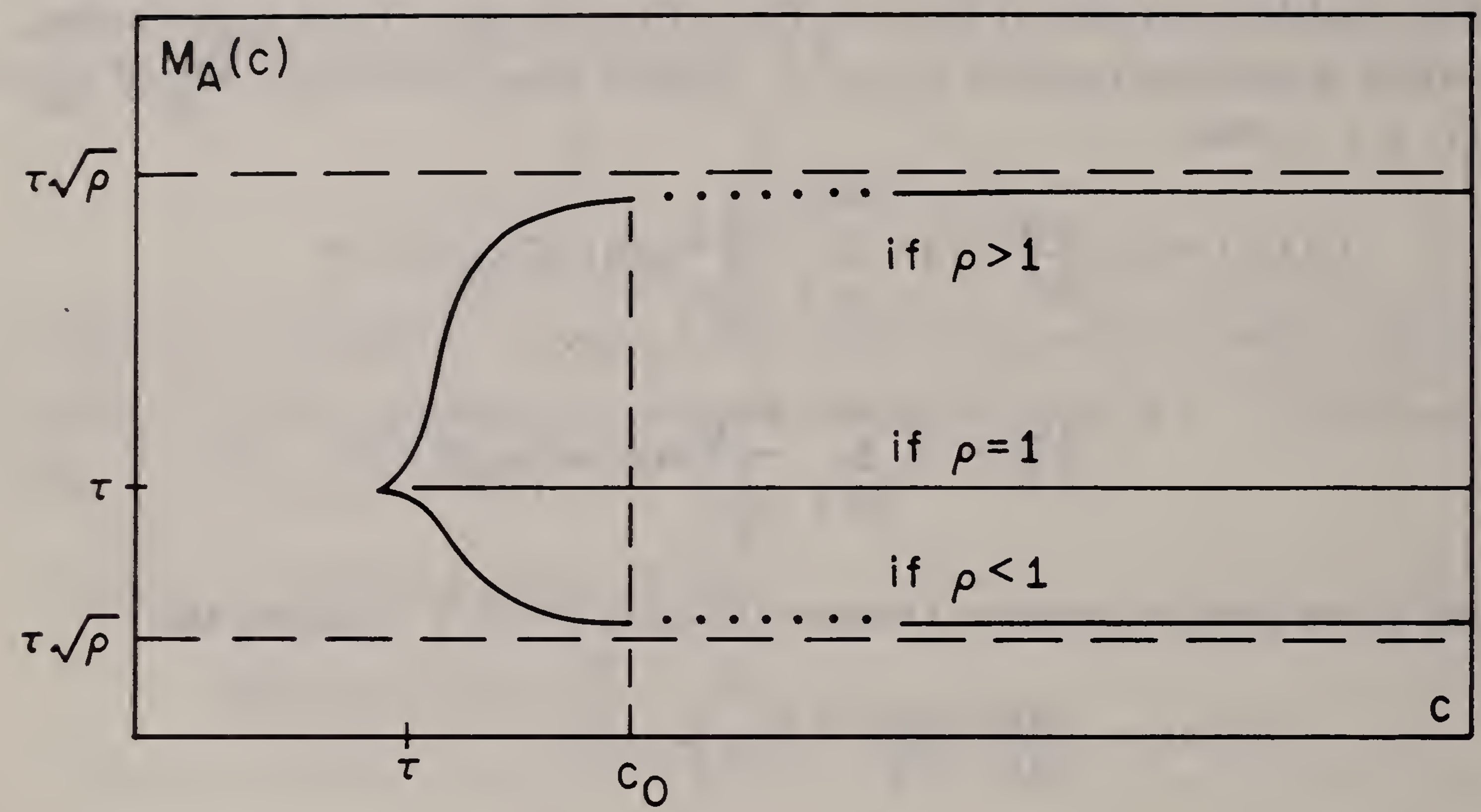
Theorem 1 $M_A(c)$ is a differentiable function of $c > \tau$ which is strictly decreasing for $\varrho < 1$, $\tau < c < c_0$ and strictly increasing for $\varrho > 1$, $\tau < c < c_0$ where c_0 is given by $T(c_0) = 1/(\alpha_1^2 k_B)$ with $T(c)$ given implicitly by (5). In addition, $M_A(c)$ satisfies

(i) $\lim_{c \to \tau^+} M_A(c) = \tau$

(ii) $\lim_{c \to \infty} M_A(c) = \tau\sqrt{\varrho}$

where $\varrho = r_B^2 k_A / r_A^2 k_B$.

Proof. It follows from the differentiability of $T(c)$ that $M_A(c)$ is a differentiable and continuous function of $c > \tau$. By (4),



$$\text{(6)}\quad M_A(c) = c\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_B^2\,\alpha_j^2}\exp(-\alpha_j^2 k_B \varrho\, T(c))\right),\ c > \tau$$

where the explicit dependence on c can be removed using (5), that is, by replacing c by

$$c = \tau/\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_B^2\,\alpha_j^2}\exp(-\alpha_j^2 k_B\, T(c))\right).$$

Then (6) becomes

$$\text{(7)}\quad M_A(c) = F(T(c)) = \tau\,\frac{\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_B^2\,\alpha_j^2}\exp(-\alpha_j^2 k_B \varrho\, T(c))\right)}{\left(1 - \sum_{j=1}^{\infty} \frac{4}{r_B^2\,\alpha_j^2}\exp(-\alpha_j^2 k_B\, T(c))\right)}$$

The remaining properties of $M_A(c)$ are determined from F(T) . F(T) can be written in the form

$$F(T) = \tau\,\frac{\sum_{j=1}^{\infty} \frac{1}{\alpha_j^2}\left(1 - \exp(-\alpha_j^2 k_B \varrho\, T)\right)}{\sum_{j=1}^{\infty} \frac{1}{\alpha_j^2}\left(1 - \exp(-\alpha_j^2 k_B T)\right)}$$

If we differentiate F(T) w.r.t. T > 0 , then F'(T) $\gtrless$ 0 leads to the corresponding inequality

$$\frac{\varrho T \sum_{j=1}^{\infty} \exp(-\alpha_j^2 k_B \varrho T)}{\sum_{j=1}^{\infty} (1-\exp(-\alpha_j^2 k_B \varrho T))/\alpha_j^2} \gtrless \frac{T \sum_{j=1}^{\infty} \exp(-\alpha_j^2 k_B T)}{\sum_{j=1}^{\infty} (1-\exp(-\alpha_j^2 k_B T))/\alpha_j^2}$$

or, denoting the R.H.S. by ϕ (T) to

$$\phi(\varrho T) \gtrless \phi(T).$$

Now computing

$$\phi'(T) = \frac{\sum_{j=1}^{\infty} (1-\alpha_j^2 k_B T)\exp(-\alpha_j^2 k_B T)}{\sum_{j=1}^{\infty} (1-\exp(-\alpha_j^2 T))/\alpha_j^2}$$

$$- \frac{T \sum_{j=1}^{\infty} \exp(-\alpha_j^2 T)}{(\sum_{j=1}^{\infty} (1-\exp(-\alpha_j^2 T))/j^2)^2}$$

it follows easily that

$$T \geq 1/(\alpha_1^2 k_B)$$

$$\Rightarrow \phi'(T) < 0$$

$$\Rightarrow \phi(\varrho T) \gtrless \phi(T) \text{ for } \varrho \lesseqgtr 1$$

$$\Rightarrow F'(T) \gtrless 0 \quad \text{for } \varrho \lesseqgtr 1$$

$$\Rightarrow \frac{d}{dc} M_A(c) = F'(T)\, T'(c) \lesseqgtr 0 \text{ for } \varrho \lesseqgtr 1$$

(recall, T' (c) < 0 for all c > τ).

Therefore

$$(8) \quad \operatorname{sgn}\left[\frac{d}{dc} M_A(c)\right] = \begin{cases} -1 \text{ for } \varrho < 1, \tau < c < c_0 \\ +1 \text{ for } \varrho > 1, \tau < c < c_0 \end{cases}$$

since $T(c) \geq T(c_0)$ for all $\tau < c \leq c_0$ (see Fig. 1, $\tau < c < c_0$) , where c_0 is given by $T(c_0) = 1/(\alpha_1^2 k_B)$ and $T(c_0)$ is given implicitly by (5).

Unfortunately, no straightforward procedure has yet been found to prove that (8) is true for all $c > \tau$.

The first of the required limits is a consequence of (7) and the fact that $\lim_{c \to \tau^+} T(c) = \infty$. Thus

$$\lim_{c \to \tau^+} M_A(c) = \lim_{T \to \infty} F(T) = \tau .$$

For the second limit we use L'Hospital's rule. Thus,

$$\lim_{c \to \infty} M_A(c) = \lim_{T \to 0^+} F(T)$$

$$= \lim_{T \to 0^+} \tau \varrho \left(\frac{\sum_{j=1}^{\infty} \exp(-\alpha_j^2 k_B \varrho T)}{\sum_{j=1}^{\infty} \exp(-\alpha_j^2 k_B T)} \right)$$

and the required limit follows from the well known result (Watson 1952) that for large N

$\alpha_j r_B \varepsilon (\pi (j - \frac{1}{4}), (\pi (j + \frac{1}{4}))$ for all $j \geq N$ and from the result

$$\int_0^{\infty} e^{-x^2} dx = \sqrt{\pi}/2$$

This proves the theorem.

The following example is intended to give a more precise picture of the behavior of M_A (c) (*cf* Fig 1) for a particular set of values for k_A , k_B , r_A , r_B , and τ and suggests one area in which the results obtained here might be applied. Since little is known regarding the prediction of values for the mass diffusion coefficients for particular substances and the corresponding toxic chemicals, a more specific example would require some experimentation to determine values for these diffusion coefficients and τ . Here values for these constants have been assigned (International Critical Tables) on the basis of what one might reasonably expect from the types of substances involved. However, it should be pointed out that an approximation to the value k for a particular substance and corresponding toxic chemical can be obtained directly using formula (3). Thus, if the given substance (which is assumed to be cylindrical in shape with radius r_0) is immersed for a fixed time t_0 in a solution containing a known molar concentration c of the toxic chemical and if after time t_0 , the total amount (number of moles) c_0 of the chemical which has diffused into a representative segment of unit length can be determined, then (3) gives

$$c_0 = \pi r_0^2 M(t_0, r_0, c) = \pi r_0^2 c(1 - \sum_{j=1}^{\infty} \frac{4}{r_0^2 \lambda_j^2} \exp(-\lambda_j^2 k t_0))$$

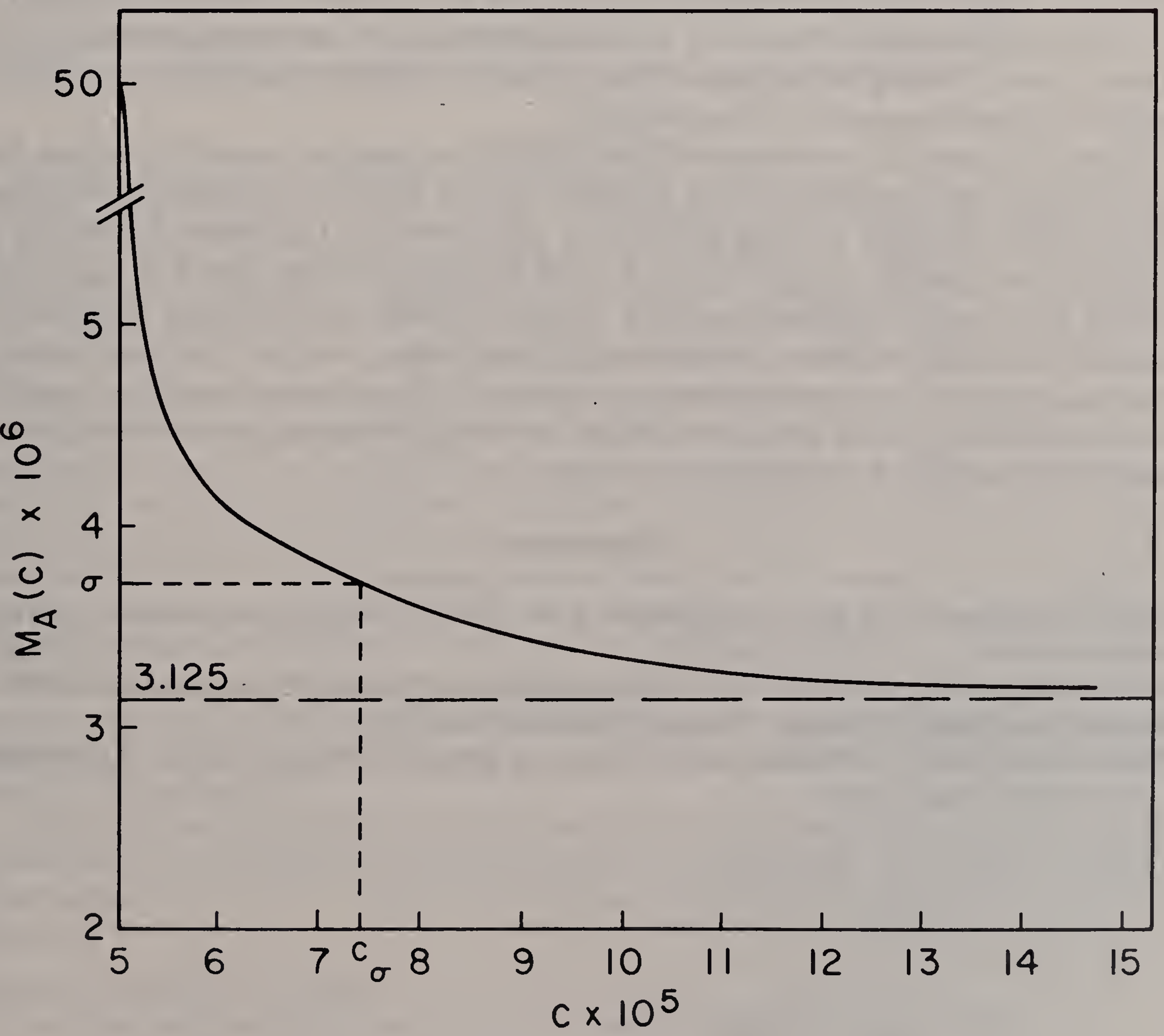
which can be solved for k.

An example, some recent studies off the coast of Nova Scotia, have involved the cultivation of a commercially valuable seaweed (*Gracilaria* sp) which is densely intertwined by an epiphyte (*Enteromorpha intestinalis*). One process which might be used to eliminate the effect of the epiphyte without actual physical separation is the immersion of the entangled mass in a solution containing a chemical which is toxic to the epiphyte and possibly also toxic to the valuable component. A choice of the toxic chemical might by $CuSO_4$. Approximating the seaweed and epiphyte by cylinders A and B of radius $r_A = 0.4$ cm. and $r_B = 0.025$ cm. respectively and setting

$$k_A = k_B = .35 \times 10^{-5} \text{ cm.}^2/\text{sec.}$$

$$\tau = .00005 \text{ gm. moles./cm.}^3$$

gives from (5) and (6),



If the sensitivity of the valuable life form σ (the minimum mean molar concentration of the toxic chemical which produces permanent damage) is known and satisfies $\sigma \geq t$, then there is considerable freedom in the choice of c and one would choose it so as to attain a small concentration of the toxic material in the host. If, however, σ satisfies, $\sqrt{\varrho}\,\tau < \sigma < \tau$, then there is a $c = c_\sigma$ such that $M_A(c) < \sigma$ for all $c > c_\sigma$ and for such c the host will absorb a sublethal amount of toxicity.

Discussion

The main result of our analysis - the general description of $M_A(c)$ as a function of c - suggests that the best strategy in the application of toxicity to the removal of unwanted life forms depends on whether $\varrho < 1$ or $\varrho > 1$. In the first case a brief exposure to a high concentration is indicated. Of course an upper limit on that concentration will usually be imposed by technical and other considerations, the obvious one resulting from the difficulty of controlling extremely brief exposures. More importantly, since $M_A(c)$ represents an average concentration it is possible that parts of the host plant may temporarily receive a lethal dose of the chemical. Since upon removal from immersion the averaging of concentration occurs rather rapidly, it seems safe to assume that in most cases little damage will be inflicted on the host. When this is not so then an additional, empirically determinable, upper limit for c would have to be imposed.

In the second case, *ie* $\varrho > 1$, a concentration close to but not substantially greater than τ would be indicated. Here again it might be necessary to avoid inordinately long exposures as impractical.

Finally, it must be remembered that ours is an idealized model in which the hypothese of the geometric shape and the type of diffusion (absence of reaction between the chemical and the plants *etc*) are essential. This notwithstanding it may still be feasible to make use of it in situations where there is reason to believe that these hypotheses are not entirely invalid. In such cases it would be necessary to run a series of preliminary experiments in which the constants of the model would be approximately determined. These in turn could be used to fit a graph of $M_A(c)$ as a function of c so as to enable the experimenter to determine the procedure he would like to adopt.

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STUDIES ON *GRACILARIA:* ECOLOGY OF AN ATTACHED POPULATION OF *GRACILARIA* SP. AT BARRACHOIS HARBOUR, COLCHESTER CO., N.S.*†

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In situ observations were made on an attached population of *Gracilaria* sp. at Barrachois Harbour, Colchester Co., Nova Scotia. The growing season, characterized by water temperatures close to 20°, was less than 3 months. Sporelings transplanted to the field became reporductively mature within 6-10 weeks. Reproductive periodicity of the population was noted; release of tetraspores, first observed in late June, and release of carpospores, initiated at the end of July, continued until late September. Reproductive peak of the population occurred in early August. In contrast to free-floating populations, percentage of gametophytes and sporophytes was similar. Senecence was noted in late August. Plants overwintered as 'stump' plants that resumed growth upon increasing light and temperature in spring. Spore germination and survival of sporelings at low temperatures were demonstrated.

Introduction

Species of *Gracilaria* Greville are cosmopolitan in distribution, and a single species, *Gracilaria* sp (Chapman *et al* in press), is recorded from the Maritime provinces (C. Bird *et al* 1977a). *Gracilaria* sp is a common species of larger rhodophycean algae occurring in the lower Gulf of St. Lawrence with a biomass in excess of 4 $kg.m.^{-2}$ having been recorded (C. Bird *et al* 1977b). However, the distribution of this species is limited apparently to shallow, warm-water embayments (C. Bird *et al* 1977a; Edelstein *et al* 1967).

In the Maritime provinces, *Gracilaria* sp occurs largely as free-floating populations. The plants are large, often profusely branched and commonly 10-30 cm in length. These populations usually are stabilized either by entanglement amongst eel grass, *Zostera marina* L. var. *stenophylla* Aschers. & Graelsw., or entwined by byssal fibers of species of mussels (Goldstein 1974). However, in most populations a few attached specimens, with basal holdfasts, may be found on suitable substrata such as small rocks and shells.

Observations in the Maritime provinces and elsewhere in the world suggest that free-floating populations of species of *Gracilaria* are commonly infertile or asexual, and are maintained mainly through vegetative propagation. Contrariwise, attached populations are characterized by both asexual and sexual generations, and reproduction undoubtedly is mainly, if not exclusively, through spores (Causey *et al* 1946; Kim 1970; Simonetti *et al* 1970; Stokke 1957).

The occurrence of a wholly attached population of *Gracilaria* in Barrachois Harbour, Colchester Co. (C. Bird *et al* 1977a) provided an opportunity for detailed ecological observations in a habitat different from those in which this alga normally has been reported.

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†Part of this study was presented in a M.Sc. thesis, Acadia University, 1975.

Materials and Methods

An attached population of *Gracilaria* at the pond head of Barrachois Harbour, Colchester Co. was studied *in situ*, using SCUBA, at regular intervals over a two-year period, 1974 and 1975. For comparison, periodic examinations also were made on a predominantly free-floating population of this species at Mill River, Prince Co., Prince Edward Island.

Surface samples of water were obtained by filling plastic bottles held just beneath the surface of the water; subsurface samples by diving to the bottom before opening. Temperature of the water was recorded by inserting a thermometer into the bottle soon after collection; a hydrometer was used for salinity determinations.

The zone of *Gracilaria* was delimited by laying a horizontal transect across the channel at the mouth of the harbor. A study line of 90 m of polypropylene was laid parallel with the channel in the zone of *Gracilaria*, and anchored every 15 m with a concrete buliding block. Using randomly chosen positions on the line, length and density measurements of *Gracilaria* were taken by placing a 1-m^2 quadrat, constructed of 0.25-in, stainless-steel tubing, between these points. The quadrat was bisected with a rod of tubing allowing two divers to record simultaneously over an area of manageable size. Maximum length of plants was determined by holding a ruler against the base of the plant at substrate level. Total number of plants in the quadrat was regarded as density. Sanded, white Arborite and a leaded pencil were used to record observations.

Production of spores in *Gracilaria* during July, August, and September was determined by examining branches from plants in quadrats as described above. One branch was removed from each plant as close to the main axis as possible, and only plants above 3 cm tall and having more than one erect frond were sampled. Branches were collected in the upper half of a wide-mouth bottle, flamed at the cut surface to form a ridge over which a fine nylon mesh bag was held in place by a metal screw band.

Fertility of *Gracilaria* sp at Mill River was examined in early August, 1975. A 100 m marked transect line was laid perpendicular to the shore starting at the high water mark. At depths of approximately 1.0 and 2.0 m plants within a 0.5 m quadrat were collected for determination of fertility ratio. All plants with holdfasts within each quadrat were examined. In these samples a large number of detached plants was collected but only a handful were studied. In addition 6 quadrats were cleared parallel to the shore at a depth of 0.5 m.

Actual fertility ratios for Barrachois and Mill River populations of *Gracilaria* sp were determined in the laboratory by recording the number of plants that were male, cystocarpic, tetrasporic, or infertile. For the population at Barrachois, potential fertility ratios were obtained by incubating the remaining infertile branches in culture for periods up to 6 weeks. Conditions of incubation have been described previously (N. Bird *et al* 1977).

Transplantation experiments were carried out at Barrachois using sporelings of *Gracilaria* sp grown in laboratory culture (N. Bird *et al* 1977) on oyster or scallop shells having centrally drilled holes. These sporelings, with fronds about 10 mm long, were transplanted to the field. Shells were strung on cable (Northern Electric Station Z wire) spaced by knots in the wire or thick-walled rubber tubing. The cable was anchored to the study line, and suspended vertically by a small buoy so that sporelings were positioned approximately 0.5 m above the study line. The softer scallop shells proved unfavorable, since they wore easily where in contact with the cable. Shells with sporelings also were nailed to the substrate by 15-cm galvanized nails.

Results

Barrachois Harbour consists of a salt-marsh estuary with a soft, muddy bottom. A channel, approximately 3-5 m deep, depending on the state of the tide, runs through the middle of the estuary. It begins at the mouth of the harbour and extends for a considerable distance beyond the bridge (Fig.1). The mean tidal amplitude at Barrachois is about 2 m, and the constriction in the harbor results in swift tidal currents. The harbor is covered with ice usually for about 4 months, late December to early April.

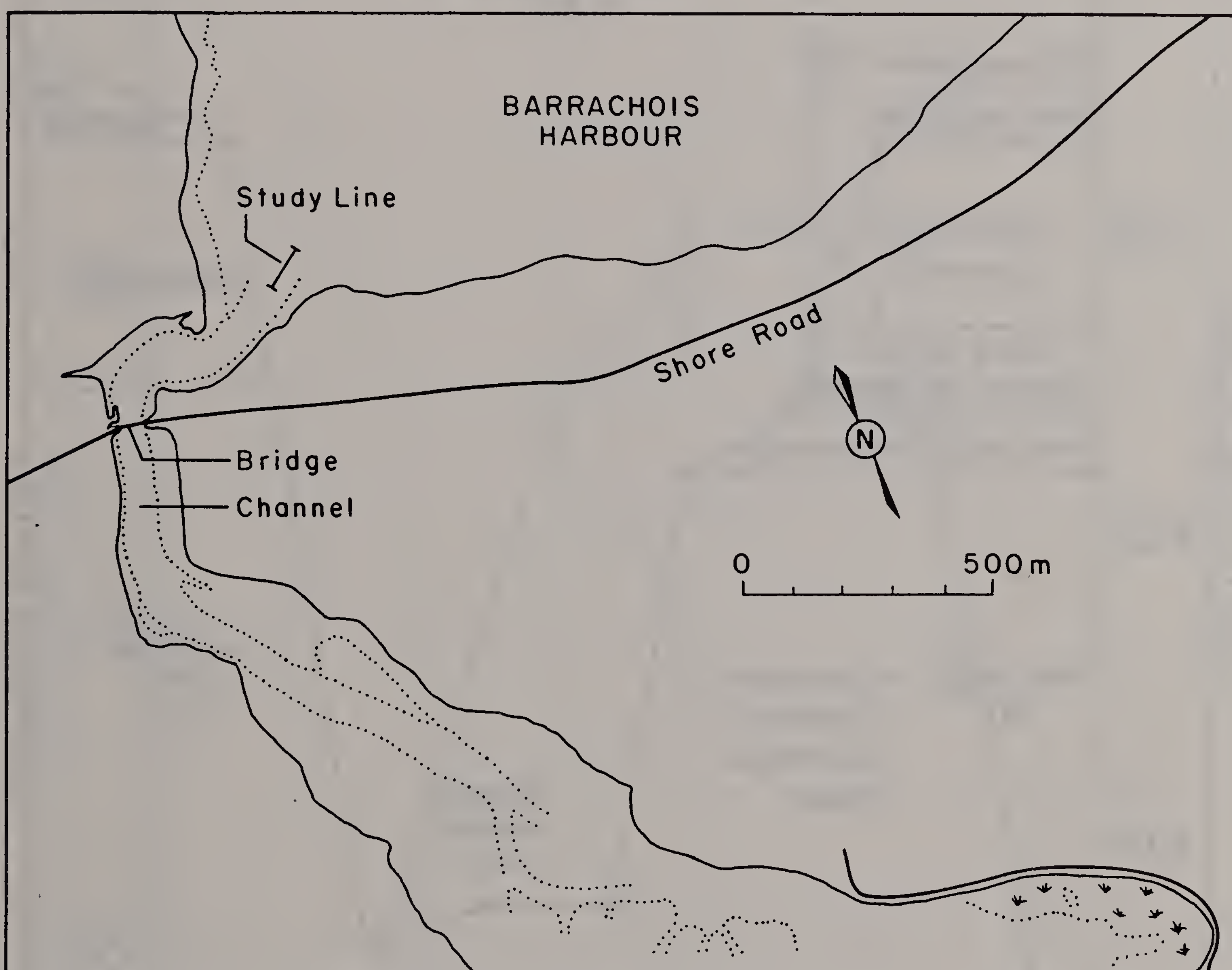

Fig. 1. Pond head of Barrachois Harbour, Colchester Co., N.S.

Vegetation was sparse except where gently sloping sides or shelves offered protection. On one side of the channel vegetation was divided into six distinct zones according to depth at 0.8 m below M.W.L. (Canadian Tide and Current Tables) (Fig 2). The "fine reds" - *Lomentaria baileyana* (Harv.) Farl., *Chondria tenuissima* (Good. et Wood.) C. Ag., *Griffithsia globulifera* Harv., and *Dasya baillouviana* (Gmel.) Mont. were present throughout the five lower zones, while remaining major plant species were restricted to a narrow range of depth. Upper boundary of the zone of *Gracilaria* merged with the lower boundary of the zone of *Z. marina* at a depth of 1.3 m. This 2- m wide zone of transition ended at a depth of 1.6 m, when *Z. marina* became scarce.

The bed of *Gracilaria*, consisting of a mud bottom scattered with rocks and shells suitable for attachment of plants, extended down the slope for 8 m and a depth of 1.8 m. Depths recorded in this zone throughout the study period varied as much as 2 m for tides ranging from 1.2 m below to 0.4 m above M.W.L. Depths recorded along the study line every 15 m ranged from 1.8 - 2.6 m for a tide of 0.5 m below M.W.L. Below this zone vegetation became sparse as the barren channel was neared. Except for the zone of *Z. marina* found at similar depths on both sides of the channel, the opposite side of the channel was barren (Fig 2).

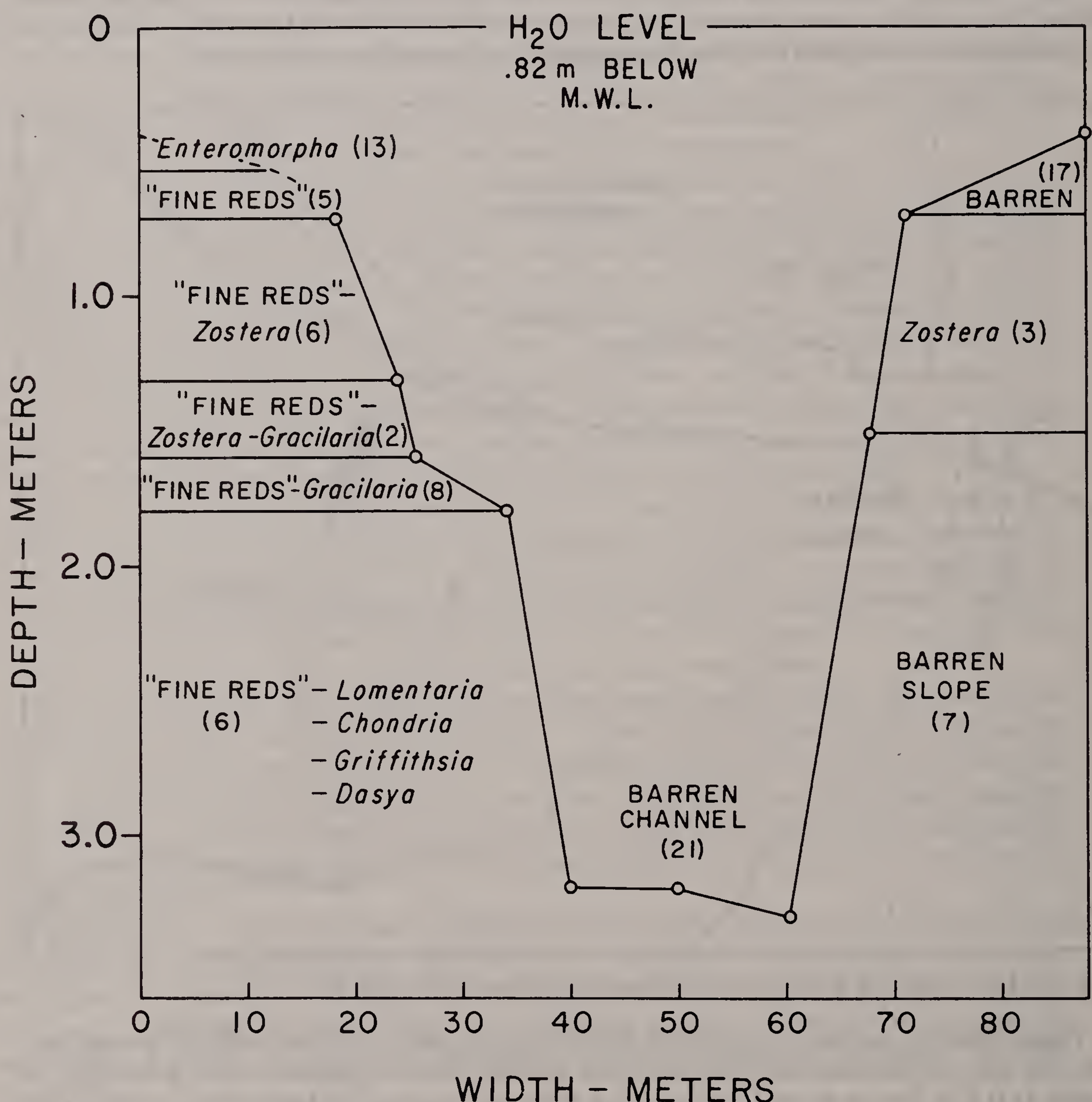

Fig. 2. Horizontal transect across channel at Barrachois showing vegetation zones in relation to depth. Widths (m) of zones are in parenthesis.

The zone of *Gracilaria* ran lengthwise, parallel to the channel (Fig 1). Progressing towards the bay, plants of *Gracilaria* sp became less frequent, being scattered amongst *Z. marina*; below the *Z. marina* zone, fine sand was prevalent.

Gracilaria sp was abundant about 70 m beyond the end of the study line, towards the bridge (Fig 1); in this area plants were found at depths of 0.5 m (1.2 m below M.W.L.). The zone ended as the side of the channel steepened. Estimated area of the zone of

Gracilaria sp was about 1000 m^2. The channel extended for a considerable distance beyond the bridge towards the salt marsh, but *Gracilaria* sp occurred only amongst large rocks near the concrete bridge supports.

Warmest water temperatures, commonly above 20° (Fig 3), occurred from July til

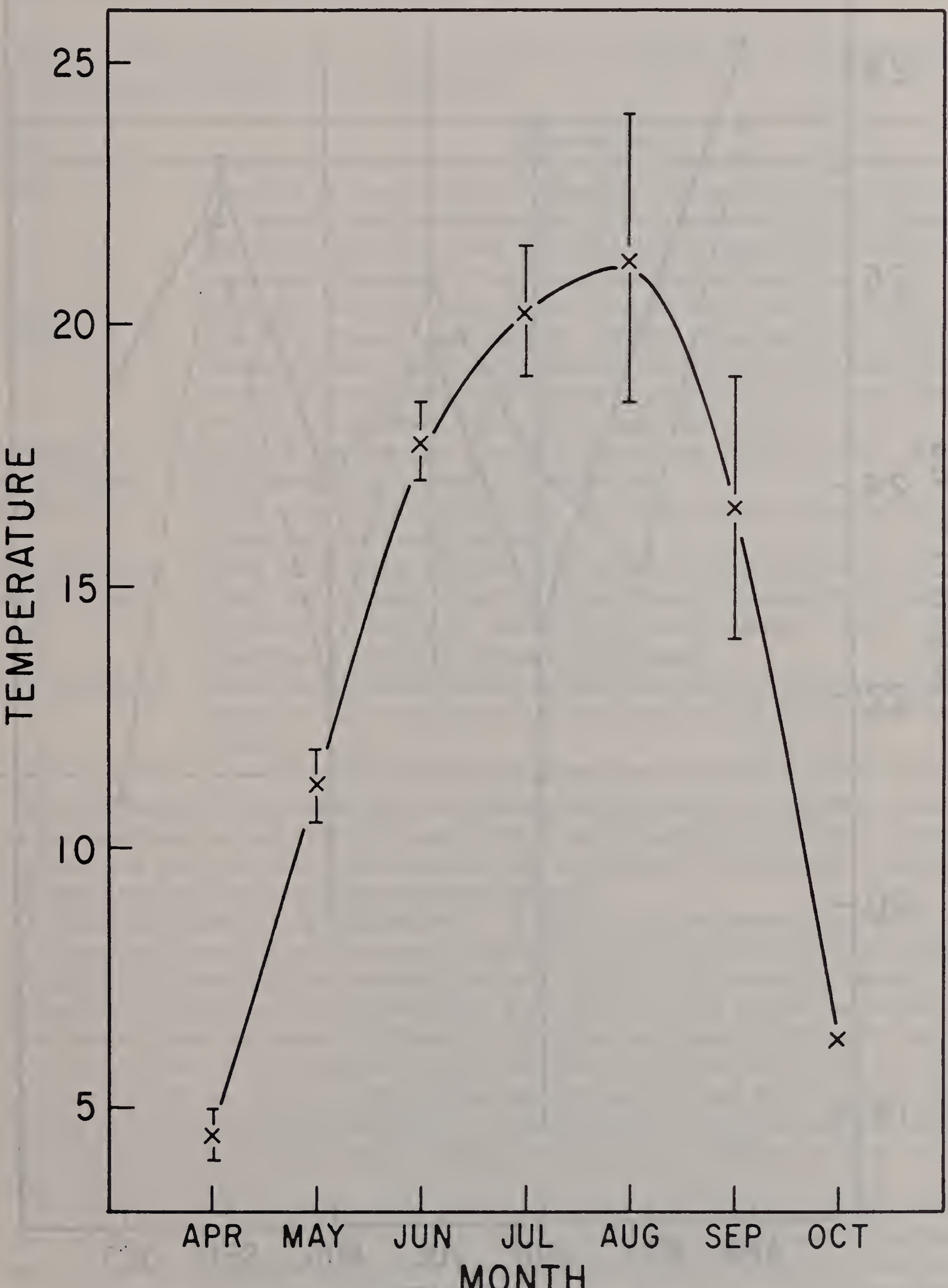

Fig. 3. Range in surface temperature at Barrachois from April to October, 1974.

mid-August. During 1974 a mean salinity of 25°/∞ for surface and bottom samples was determined for a period of 7 months (Fig 4). Similar observations were made from July to September, 1975, with a mean salinity of 29°/∞ being recorded.

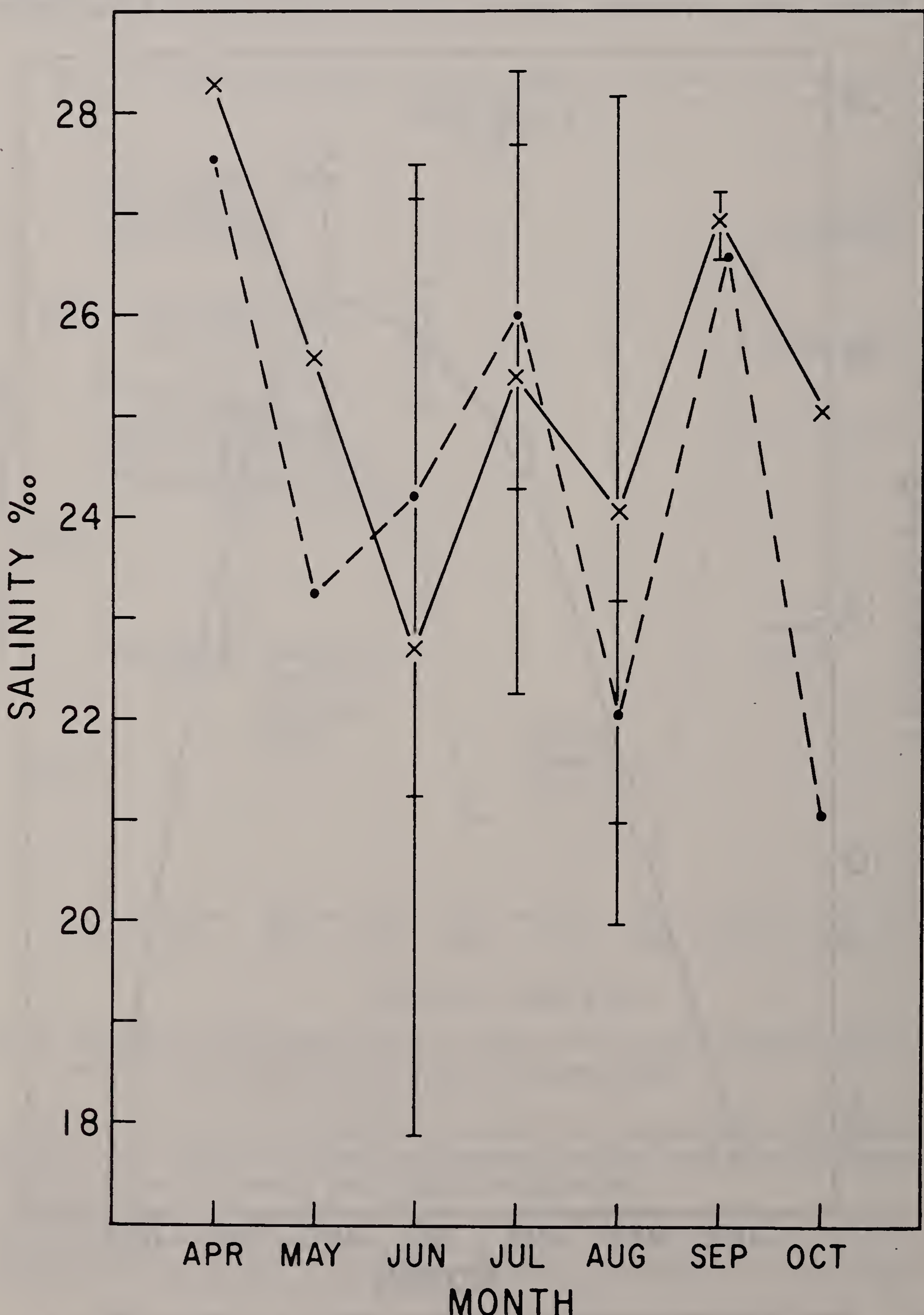

Fig. 4. Range in salinity of water samples taken at Barrachois from April to October, 1974. x——x surface-water sample; • — — • bottom-water sample.

Table I summarizes observations made on *Gracilaria* sp from June to September in 1974 and 1975. Reproductively mature tetrasporophytes, often arising from perennating stumps, were abundant in late June. By the end of July, both fertile sexual and asexual plants were releasing spores. Senescent plants were present by late August, although small, healthy plants were present in September.

Table I. Observations made on the population of *Gracilaria* sp at Barrachois, N.S. from June to September of 1974 and 1975.

Date	Observations
June	Presence of small, heavily epiphytized stump plants consisting of perennating thalli made detection of the population difficult; secondary erect shoots arose from the basal disc of these plants, and clean regenerated branches, often tetrasporic, also were seen.
Early to mid-July	Numerous healthy, bushy plants were present; plant size, although generally small, approached 10cm; reproductively mature tetrasporophytes and male gametophytes were present; sexually immature female gametophytes were also present; in 1975, many plants were found attached to the study line laid in July, 1974.
Late July to early August	Large, fertile sexual and asexual plants were collected; many of the plants were still reproductively immature.
Mid-August	Large, bushy fertile plants were seen; some apical decay was noted; cystocarpic plants were abundant.
Late August to early September	Many small plants were noted; presence of stump plants and large plants with decayed or necrotic upper branches indicated population senescence; majority of female plants were sexually mature; carpospore and tetraspore release still continued.
Late September	Numerous senescent, heavily epiphytized plants were seen; however, many healthy, clean plants also were present; and spore release continued.

In 1974 length of plants of *Gracilaria* sp increased from July to a maximum in early August, and then declined (Fig 5). A similar trend was displayed in 1975 (Fig 6). Density of plants was fairly low with a minimum in July increasing to a maximum in August, although distribution was relatively uniform (Table II).

A majority of plants in a population of *Gracilaria* was potentially capable of becoming reproductive with gametophytes being slightly more abundant than sporophytes. A reproductive maximum was recorded in early August, 1975, owing to increases in mature tetrasporophytes, carposporophytes and males. In late August, a decline in reproductive plants was noted, attributed to the decline in tetrasporophytes and males, with the proportion of carposporophytes remaining about the same (Fig 7). Contrariwise, in 1974 the ratio of infertile plants in late July and late August was similar. Despite the decline in tetrasporophytes in late August to about one-half the earlier value, the ratio of fertile plants did not change owing to the concomitant increase in carposporophytes (Fig 8).

At Mill River, P.E.I., fertility ratios were determined from samples of *Gracilaria* sp taken at depths of 0.5, 1.0, and 2.0 m. At the shallowest depth, the zone of *Gracilaria* began. Plants in this area were attached by holdfasts to shells or rhizomes of associated *Z. marina* or anchored either by byssal fibers of *Mytilus edulis* L. or by rhizomes of *Z.*

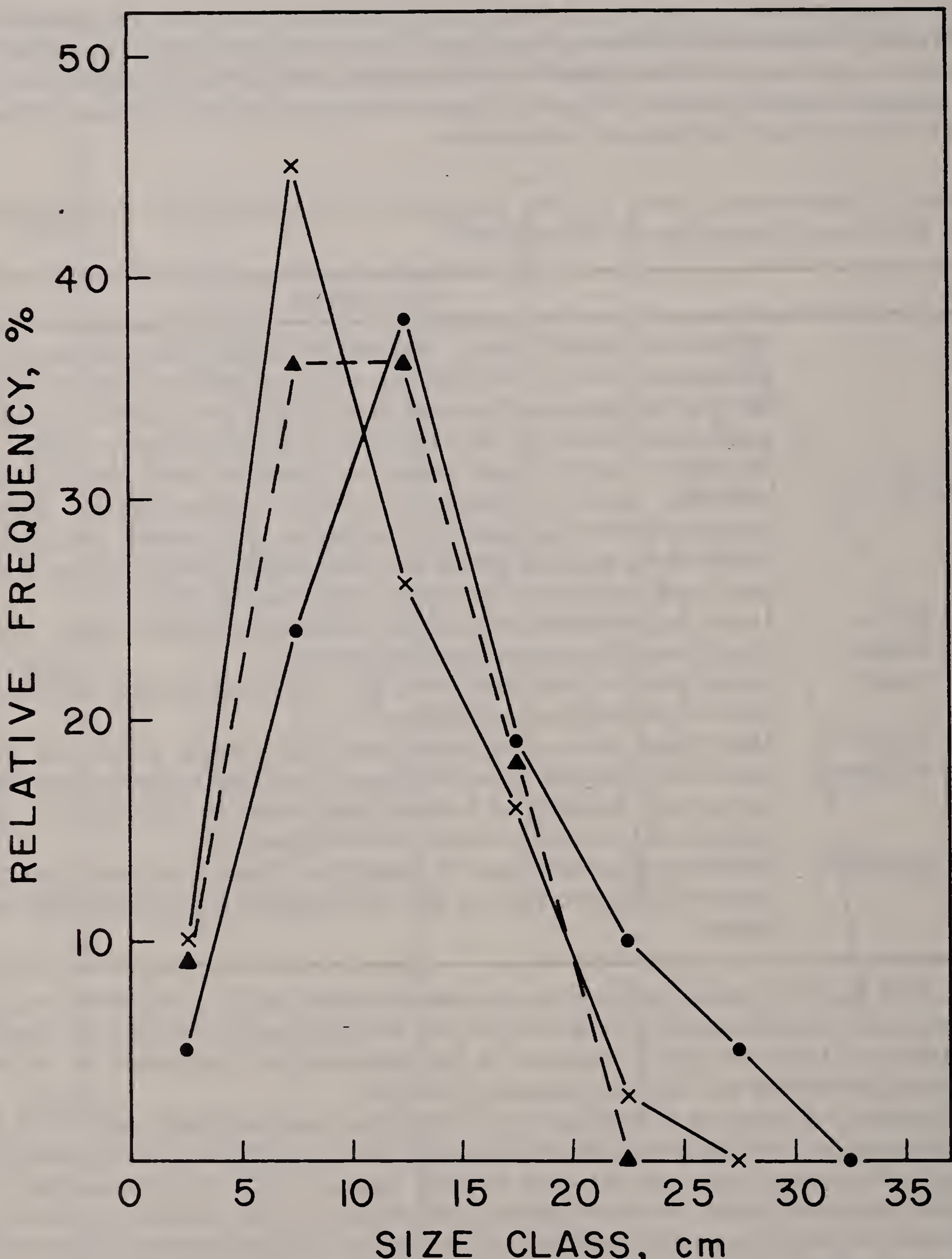

Fig. 5. Relative frequency of quadrats (m^2) containing *Gracilaria* sp of a maximum length in relation to size class at Barrachois during July and August, 1974. Points on graph represent class midpoints. x———x July 15th measurements of plants in 31 quadrats; •———• August 6th measurements of 21 quadrats; Δ —— Δ August 26th measurements of 22 quadrats.

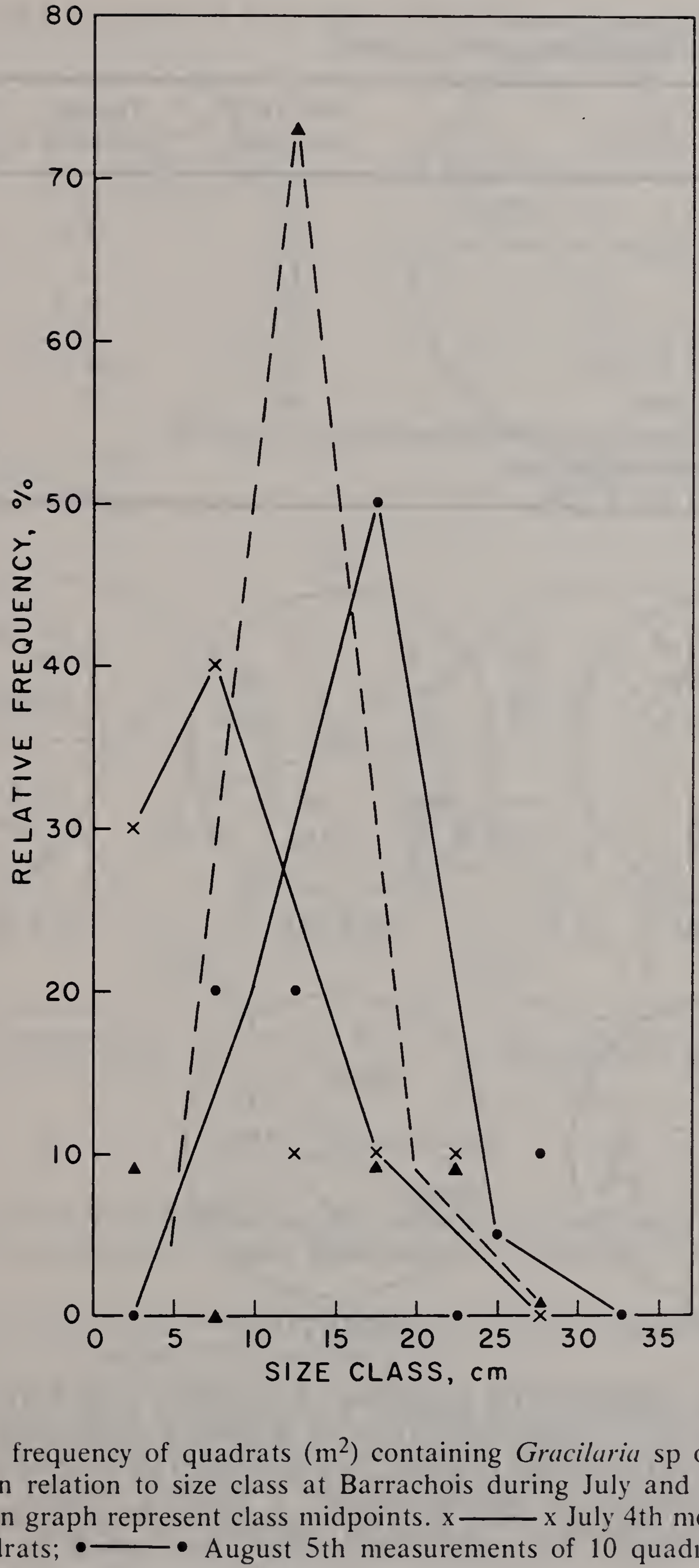

Fig. 6. Relative frequency of quadrats (m^2) containing *Gracilaria* sp of a maximum length in relation to size class at Barrachois during July and August, 1975. Points on graph represent class midpoints. x——— x July 4th measurements of 10 quadrats; •——— • August 5th measurements of 10 quadrats; Δ — — Δ August 28th measurements of 11 quadrats.

Table II. Density measurements of the population of *Gracilaria* sp at Barrachois during July, August and September of 1974 and 1975

Date	Area (m^2) sampled	Density (plants/m^2)	% Occurrence N/N t x 100
July 4, 1975	13	4	77
July 15, 1974	36	3	86
August 5, 1975	12	5	92
August 6, 1974	23	6	91
August 28, 1975	13	7	85
August 26, 1975	25	4	88
September 24, 1974	18	4	94

N = number of quadrats in which *Gracilaria* sp. occurred.
N_t = total number of quadrats.

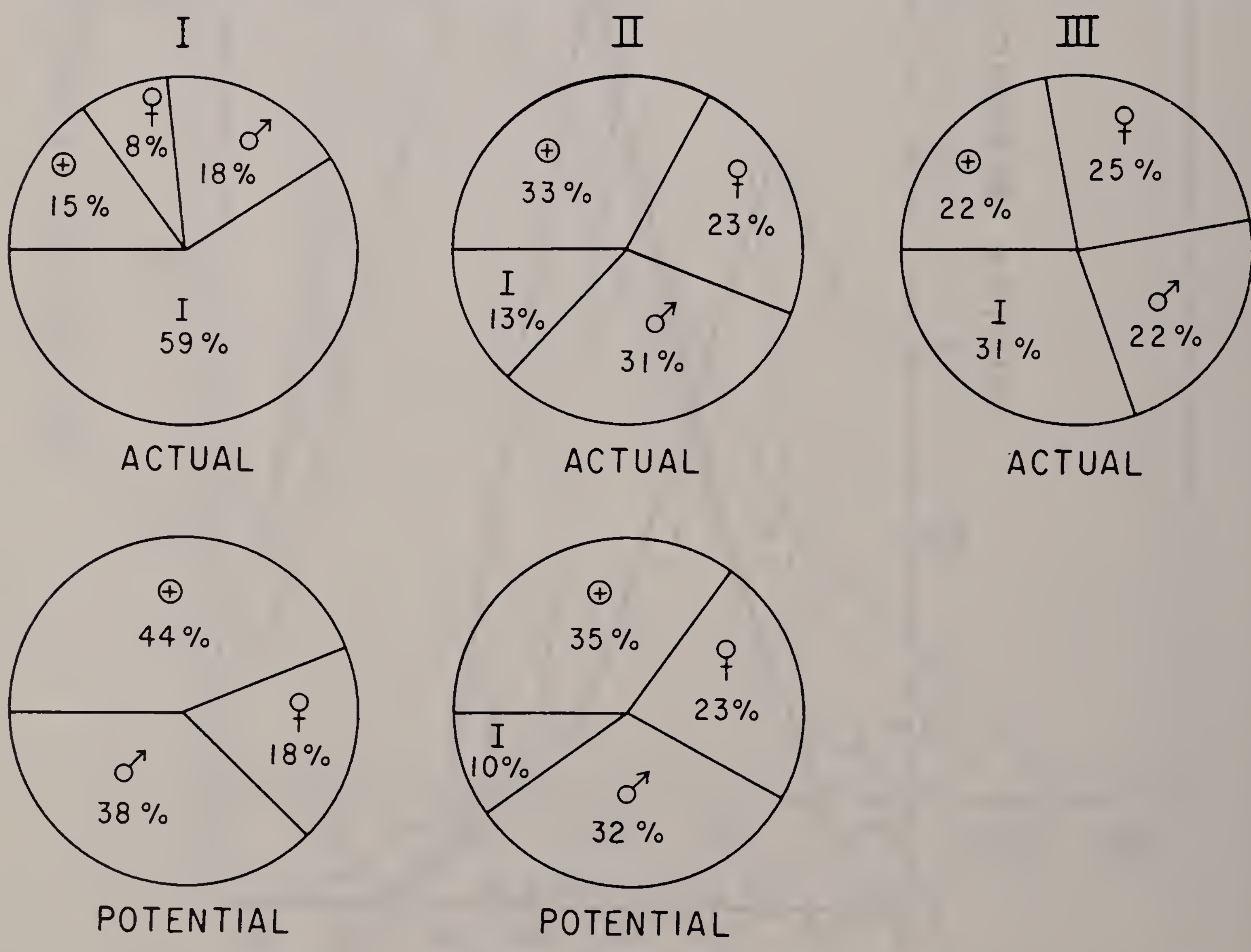

Fig. 7. Fertility ratios of 1975 population of *Gracilaria* sp at Barrachois Harbour. Actual = ratio obtained from excision of apical segments from attached plants (1 segment per plant). Potential = ratio obtained after laboratory incubation of these segments. ⊕= tetrasporophyte; ♀ = female; ♂ = male; I = infertile; I = July 4th collection; II = August 5th collection; III = August 28th collection.

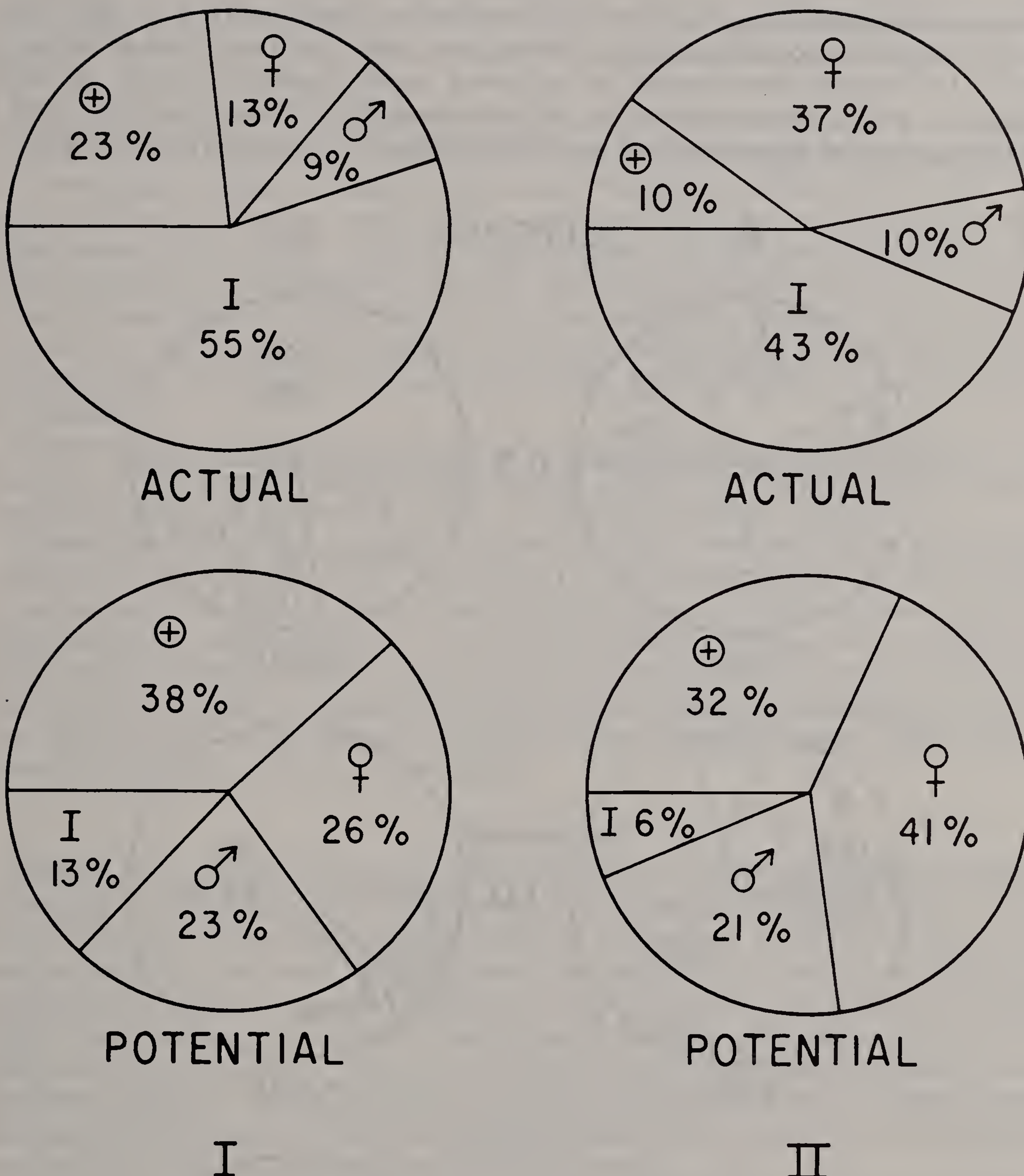

Fig. 8. Fertility ratios of 1974 population of *Gracilaria* sp at Barrachois Harbour. I = July 30th collection; II = August 26th collection. Symbols as in Fig. 7.

marina. *Gracilaria* sp, characterized by large bushy plants often having yellowish apices, was dispersed throughout the *Z. marina* zone.

At a depth of 1.0 m free-floating plants of *Gracilaria* sp had increased in quantity, as had other algal species such as *Ulva lactuca* L., *Sphaerotrichia divarcata* (C. Ag.) Kylin and species of Ceramiaceae. At a depth of 2.0 m a soft, muddy substrate prevailed in contrast to the firm, sandy bottom found at shallower depths. Only free-floating plants were found, occurring in dense clumps consisting of small fragments often entangled with one another by byssal fibers. Many of these plants were bleached in the apical region.

Only a small proportion of plants were attached by basal holdfasts at Mill River. Amongst these attached plants, gametophytes were more numerous than sporophytes (Fig 9). In contrast, free-floating or anchored plants consisted largely of fertile sporophytes, with a slight reduction in the percentage of fertile gametophytes. Also a greater proportion of detached plants was fertile compared to attached plants (Fig 9).

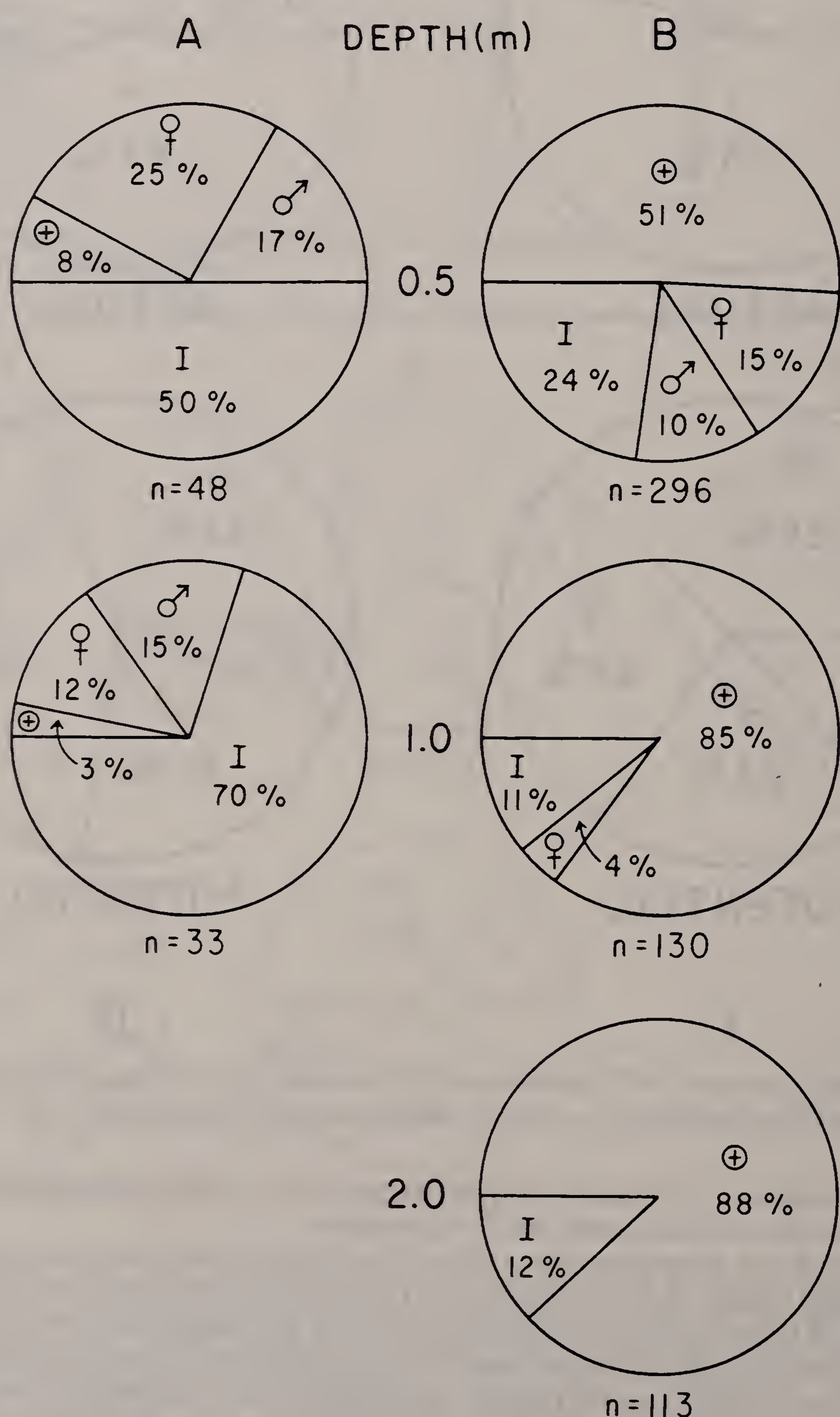

Fig. 9. Fertility ratios of populations of *Gracilaria* sp at Mill River in relation to depth, August 1, 1975. A = attached plants; B = anchored and free-floating plants; n = number of plants sampled. Symbols as in Fig. 7.

Branches with tetrasporangia were collected periodically; these released viable spores when cultured in the laboratory. From the end of June to the end of September in 1974 and 1975, viable tetraspores were released; viable carpospores were released from the end of July to the end of September.

In early June, 1974 sporelings of gametophytes were suspended in the zone of *Gracilaria* and in the channel at Barrachois. Plants in the zone of *Gracilaria* became fertile towards the middle of August after a field incubation period of 10 weeks. These plants attained a minimum length of 15 cm when sexually mature. Relative growth was highest during early August. After 12 weeks, maximum length was 20 cm. These plants were recovered in early November and only slight apical erosion in the upper branches indicated senescence. No differences in size were noted between upper and lower plants on the line. Sporelings transplanted in the channel attained reproductive maturity simultaneously with those in the zone of *Gracilaria*, but averaged only 14 cm in length in 12.5 weeks.

Gametophytic sporelings on shells nailed to the substrate in the zone of *Gracilaria* on July 23rd, 1974 became sexually mature in early September after a period of 6 weeks in the field. Length of plants had increased to 15 cm by the middle of August.

Transplanted sporelings on shells attached to cable were uniform in size although often epiphytized or covered with drift plants. In contrast, sporelings fixed to the bottom remained clean although variable in size, probably owing to silting. For example, after 6 weeks plant size ranged from 2.5 - 15.5 cm. Only plants 12 cm or more in length were fertile. Plants on shells nailed to the substrate overwintered successfully. The following year, however, growth was reduced owing to siltation. Ability of sporelings to overwinter was demonstrated by the presence in early 1975 of numerous large, fertile plants of *Gracilaria* growing attached to the study line.

Discussion

Shallow, warm-water embayments offer protection to free-floating algal macrophytes threatened in more exposed environments with exportation by swift tidal currents. Predominantly free-floating populations of *Gracilaria* occur in these areas where soft, mud bottoms are unsuitable for attachment and vegetative propagtion is favored over recruitment by spores. Attached members of the population are restricted to shallow regions stabilized by *Z. marina* where exposed pebbles and shells provide a firm substrate for attachment (C. Bird *et al* 1977a). However, only attached plants occur at Barrachois Harbour. Large fluctuations in tidal amplitude and strong channel currents prevented establishment of free-floating populations, and *Gracilaria* sp was limited to a narrow shelf protected by *Z. marina* immediately above.

Turbidity reduced light intensity in the zone of *Gracilaria*. However, transplanted plants grew well, both in the zone of *Gracilaria* and in the channel, suggesting that increased hydrodynamic force and instability of the substrate, rather than levels of low light, prevented establishment of the population in the channel.

Constant tidal flow ensured uniform mixing throughout the water column, and prevented vertical salinity and temperature stratification. Growth, enhanced by increased water movement, was rapid during summer months when solar radiation, daylength, and temperature reached maximum values; plants transplanted in late July showed a 4-week reduction in time required for reproductive maturation compared to plants transplanted in early June when water temperatures had not yet reached 20°. Sporelings outplanted in Pomquet Harbour, Nova Scotia (C. Bird *et al* 1977b) also demonstrated that July and August were the most favorable months for growth and reproductive maturation; sporelings outplanted in June became fertile after 10-16 weeks in the field whereas those outplanted in July and August became fertile in 4-8 weeks.

The growing season was less than 3 months. During this period plants matured with a reproductive peak observed in early August. Early maturation of tetrasporophytes in late June enabled release of spores to continue throughout the growing season. Transplantation experiments suggested that there was sufficient time for tetraspores released in early summer to develop into mature gametophytes by late August, a possible explanation for the greater percentage of gametophytes in August, 1974 (Fig 8). Male plants were abundant by mid-July. Contrariwise, in many attached populations of *Gracilaria*, male plants have been reported as scarce or reduced in number compared with female and tetrasporic plants (Jones 1959; Kim 1970; Phillips 1925; Rao 1973). Reproductive peak of carposporophytes was recorded in early August; a longer maturation period being required owing to the necessity of fertilization. Periodicity of production of spores has been noted in several populations of *Gracilaria* spp (Jones 1959; Kim 1970; Rao and Thomas 1974; Saito 1959; Simmonetti *et al* 1970; Stokke 1957), peaks being recorded during seasons of maximum photoperiod and temperature of the water (Jones 1959; Kim 1970) when growth was optimum.

There was insufficient time for sporelings originating from carpospores to reach maturity before water temperatures declined, thus probably limiting growth. However, rapid growth of sporelings reduced the threat of burial and increased chances of survival at low temperatures.

Senescence of the population was noticed following reproductive maturation of carposporophytes. Upper fertile branches of plants eroded resulting in stump plants that overwintered in a state of low metabolic activity. Evidence of necrosis was reported in late August for the free-floating populations at Pomquet Harbour (C. Bird *et al* 1977b). In both populations growth resumed upon increasing light and temperature in the spring.

Thallus perennation was important for survival of the attached population at Barrachois and the predominantly free-floating population at Mill River. A major difference between these populations was the mode of reproduction; the free-floating population, although dominated by tetrasporophytes, depended on vegetative propagation whereas the attached population reproduced via spores and exhibited an alternation of generations.

Population of *Gracilaria* at Barrachois demonstrated a *Polysiphonia*-type life history as shown in laboratory culture (N. Bird *et al* 1977). At Barrachois, gametophytes and sporophytes were abundant with the slightly greater proportion of gametophytes. This is attributed to germination of tetraspores early in the growing season and delayed senescence of gametophytes until late August while less noticeable decay of tetrasporophytes was in progress. Hansen and Doyle (1976) suggest from results of population studies on *Iridaea cordata* (Turner) Bory, that the observed dominance of the tetrasporophyte over the gametophyte is an adaptive response of the life history phase. These workers suggest that this disproportionality may occur in an environment where a majority of tetraspores is unable to germinate and establish a gametrophytic phase, a plausible explanation for observed reproduction behavior of *Gracilaria* sp at Mill River, P.E.I. In addition, carposporophytes are more susceptible to decay than sporophytes (Jones 1959). In comparison, tetrasporophytes suffer only minor loss during the overwintering phase and can resume growth quickly in the spring.

Acknowledgements

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FECUNDITY OF BROOK TROUT *(SALVELINUS FONTINALIS)* FROM A COASTAL STREAM IN PRINCE EDWARD ISLAND

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Ovaries from 55 brook trout *(Salvelinus fontinalis)* from the Dunk River, P.E.I., indicated that 80% of those sampled were mature in the third growing season, and would have spawned in November. Only one large trout was mature in its second growing season. Although egg diameter and fork length and egg diameter and age were poorly correlated, the relationships between the number of ova and fork length, fresh weight and ovary weight were linear and highly significant. Egg production for trout longer than 20 cm was greater than that found for in five similar studies in Canada and the United States. Increased egg production in older fish was attributed to their annual migration to the sea where accelerated growth and development enhanced egg production.

Introduction

Information on brook trout *(Salvelinus fontinalis)* inhabiting coastal streams of Prince Edward Island is relatively scarce and, to our knowledge, no reports have been published on the fecundity of trout that run to the sea in the Atlantic Provinces. The objectives of this study were to establish for female brook trout age at maturity, size of mature eggs, fecundity, and relationships between ovary characteristics and body size, in order to compare the results with similar information for other localities in the United States and Canada.

Description of the Study Area

The Dunk River, 46°21'N, 63°36'W, arises from springs and seepage in Queens County, Prince Edward Island, and flows westerly through predominantly agricultural land in southeastern Prince County to Bedeque Bay. The Dunk River is one of the largest rivers in Prince Edward Island, approximately 43 km. Two dams are barriers to upstream movement of migrating fish. For this study, fish were collected from the Lower Dunk River, between Johnston's Bridge and Scales Pond (Fig. 1).

The Lower Dunk River supports a restricted fish fauna with only eight species of fish present. Three of these are salmonids: the brook trout *(Salvelinus fontinalis)*, the rainbow trout *(Salmo gairdneri)*, and the Atlantic salmon *(Salmo salar)*; other species are the smelt *(Osmerus mordax)*, gaspereaux *(Alosa pseudoharengus)*, American eel *(Anquilla rostrata)*, three spined stickleback *(Gasterosteus aculeatus)*, and white perch *(Morone americana)*.

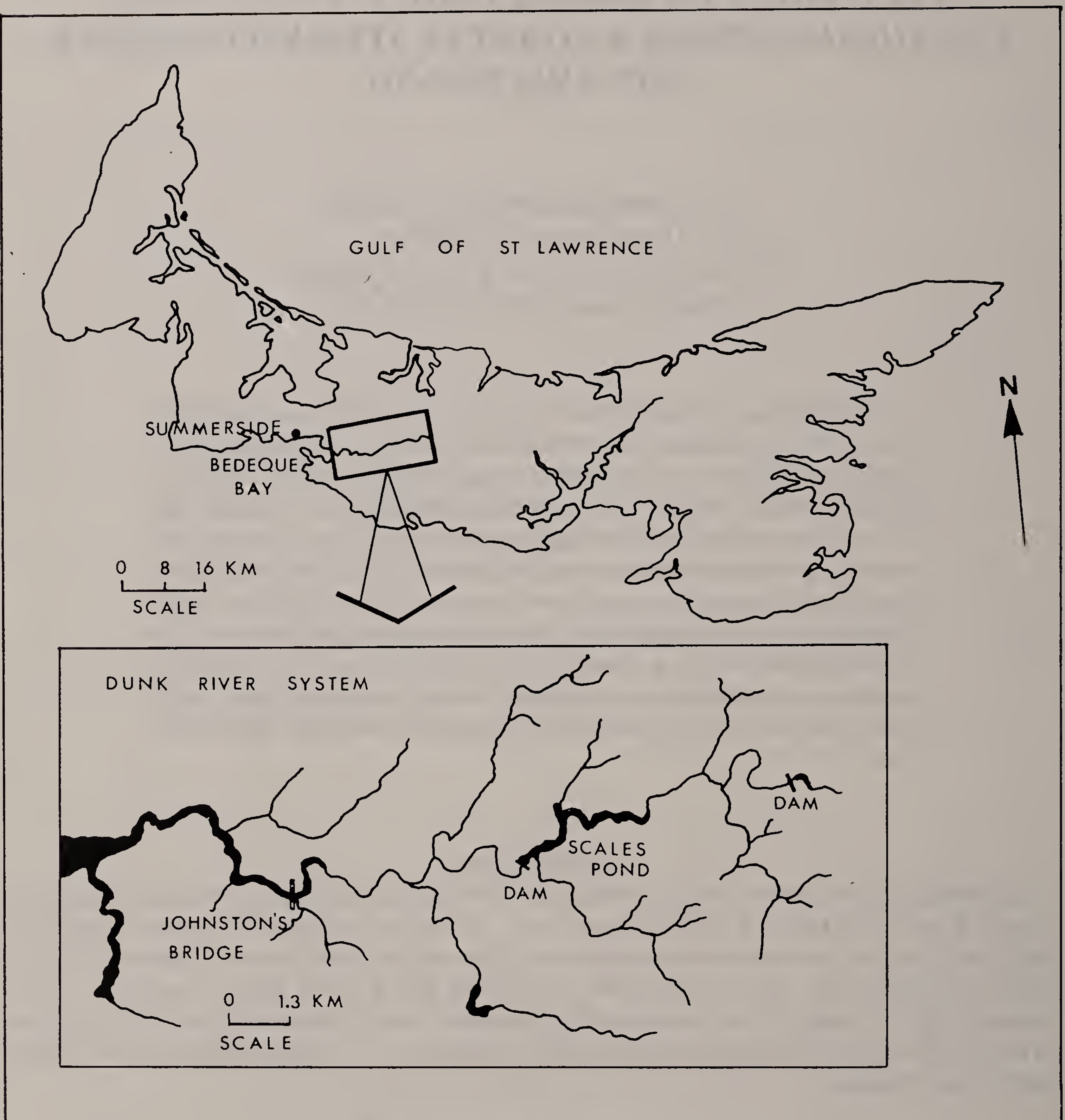

Fig. 1. Location of the Dunk River, Prince Edward Island.

Materials and Methods

Fish Collection and Egg Preservation Female trout were collected immediately before spawning between September 28 and October 25, 1974, using electroshocking and seining methods. All length and weight measurements were to the nearest 0.1 cm and 0.1 g respectively.

After the stage of ovary maturity (Nikolsky 1963) for each trout was determined, the ovaries were removed from the body cavity, wiped dry and weighed to the nearest 0.1 g. Then they were stored in modified Gilson's fluid (Simpson 1951) in separately labelled bottles and allowed to harden for 2-3 months.

Maturity and Egg Diameter Measurements Only ovaries from mature fish were used in egg diameter measurements. Hardened eggs were removed from the ovarian tissue by shaking. Mature eggs were separated using a sieve with a mesh size less than the diameter of the smallest mature egg (2 mm diameter). Diameters of a random sample of 30 eggs from each fish were measured using a stereo-microscope with a calibrated occular micrometer.

Estimation of Egg Numbers A random subsample of 250 eggs from each mature fish was counted, weighed, and the total number of eggs was estimated from the total weight of eggs of each fish. For trout containing over 1,000 eggs, an average of 3 determinations was used. Estimates were checked for reliability by counting all the eggs from six brook trout. A 0.4% difference was found to exist between egg estimates and actual egg counts when a subsample of 250 eggs was used in the calculation procedure. Egg estimates determined from smaller subsamples were less reliable.

Age Determination A sample of scales was taken from captured trout in the region of the lateral line just below the adipose fin. Four or five non-regenerated scales were cleaned and permanently mounted in a glycerin-gelatin mounting solution. Mounted scales were read and aged by at least two individuals on two different occasions. Year marks or annuli were established on the basis of crowded circuli, irregularity of circuli, "cutting-over" of circuli, and length: frequency histograms of scales (Cooper 1951). No single characteristic was completely reliable so a combination of these features was employed.

Results

Age and Size at First Maturity Of 55 female brook trout sampled from the Dunk River, 21 were immature second-year (1^+) and third-year (2^+) trout, while 33 were mature and 1 was reproductive (Table I). Only 6% of the 1^+ trout were mature, while 83% were mature by 2^+ and would have spawned in November. One fish with easily expressed eggs was in the reproductive stage (Nikolsky, 1963) and was excluded from Tables III - VI because of possible egg losses during handling. Trout smaller than 15.0 cm did not contain mature eggs. (Table II). Almost all trout (96%) over 20.0 cm in fork length were mature. Based upon the state of gonad development and field observations in 1974, brook trout spawn in the Dunk River in October, November, and as late as December, with a peak in November.

Table I. Relationship between age and maturity of female brook trout from the Dunk River

Age group	Number immature[a]	Number mature[b]
1^+	16	1
2^+	5	24
3^+	0	7[c]
4^+	0	5

[a] With eggs < 2mm.
[b] With eggs > 2mm.
[c] One reproductive, with some eggs > 4 mm and ovary not intact.

Table II. Relationship between fork length and maturity of female brook trout from the Dunk River. Stages defined on Table I.

Fork length (cm)	Number immature	Number mature
10.0 - 14.9	16	0
15.0 - 19.9	4	10
20.0 - 24.9	1	18[a]
25.0 - 29.9	0	3
30.0 - 34.9	0	2
35.0 - 39.9	0	1

[a] One reproductive (eggs >4mm, ovary not intact).

Maturity Index The mean maturity index or gonad as percent body weight for each age-group is presented in Table III. Values ranged from 6.2 - 24.9 with an overall mean of 14.1. The trout with the maturity index of 6.2 had 77 of 945 eggs less than 2.0 mm in diameter. These small eggs were considered to be atretic. Other fish sampled were sufficiently mature to have reabsorbed all atretic eggs.

Diameter of Mature Eggs The mean diameter of mature eggs varied from 2.78 - 4.92 mm for individual trout aged 1^+ and 4^+ respectively (Table III). The meandiameter of eggs lying loose in the body cavity of one trout in the reproductive stage was 4.33 mm. Vladykov (1956) suggested that eggs <4.00 mm are probably not completely mature; however, Wydoski and Cooper (1966) reported that eggs are mature at 3.35 mm. In this study, most trout older than 2^+ had a mean egg diameter >3.35 mm. Only two fish had egg diameters <3.00 mm and they were 16.8 and 26.4 cm in fork length and were 1^+ and 3^+ respectively.

Table III. Relationship between age, maturity, fork length, body weight, gonad as % body weight, egg size, estimated number of ova per fish, estimated number ova per 100 mm fork length and per 100 g fresh weight for brook trout from the Dunk River

Age group	Number mature	Fork length cm		Body weight g		Gonad as % body wt
		Mean	Range	Mean	Range	
1^+	1	16.8	-----	52.2	-----	7.7
2^+	24	20.3	16.4-23.0	94.4	43.0-145.0	13.5
3^+	6	25.6	21.5-30.1	182.6	106.0-282.3	15.6[a]
4^+	2	34.8	30.4-39.3	527.1	357.5-696.7	20.0

[a] 17.5 if one fish with atretic eggs excluded.

Table III. ctd.

Age group	Diameter of ova mm		Estimated number of ova per		Estimated number of ova per	
	Mean	Range	Mean	Range	100 m fork length	100 g fresh weight
1^+	2.78	-----	290	-----	173	556
2^+	3.63	2.93-4.50	461	210-681	227	488
3^+	3.88	2.91-4.74	860	634-1251	336	471
4^+	4.79	4.66-4.92	1826	1277-2376	525	346

Egg Production The estimated mean number of mature eggs (> 2.0 mm diameter) per fish of different ages is shown in Table III. The estimated mean egg production per 100 mm fork length was greater for older trout but per 100 g body weight was less.

The relationship of fecundity to fork length, body weight, and ovary weight was examined through regression analysis. The predictive regressions for each set of data are shown in Figures 2, 3,4. Statistics from the analysis of variance for each of these equations (Table IV) indicate that egg number is more closely related to weight than to length, gonad weight or age.

Table IV. Statistics from the analysis of the variance of the regressions of fecundity on age, fork length, body weight and ovary weight of 33 brook trout from the Dunk River

Source of variation		F ratio	Accountable variation in fecundity (%)
Age		66.7***	68
Fork length	(X_1)	263.2***	89
Body weight	(X_2)	476.4***	94
Ovary weight	(X_3)	256.7***	87

*** Significant at 0.1 % level of confidence.

Discussion

According to Wydoski and Cooper (1966) fast growing brook trout are capable of spawning at the end of their first year, but in our sample only one large 1^+ trout was mature by the end of the second growing season. Reports on the maturity of female trout elsewhere suggest that, as in Prince Edward Island, most trout in the wild do not mature until 2^+ (Table V). The exceptional trout in Lawrence Creek, Wisconsin, had greater growth in the first two years of life than in any other locality, apparently leading to their early gonad maturation.

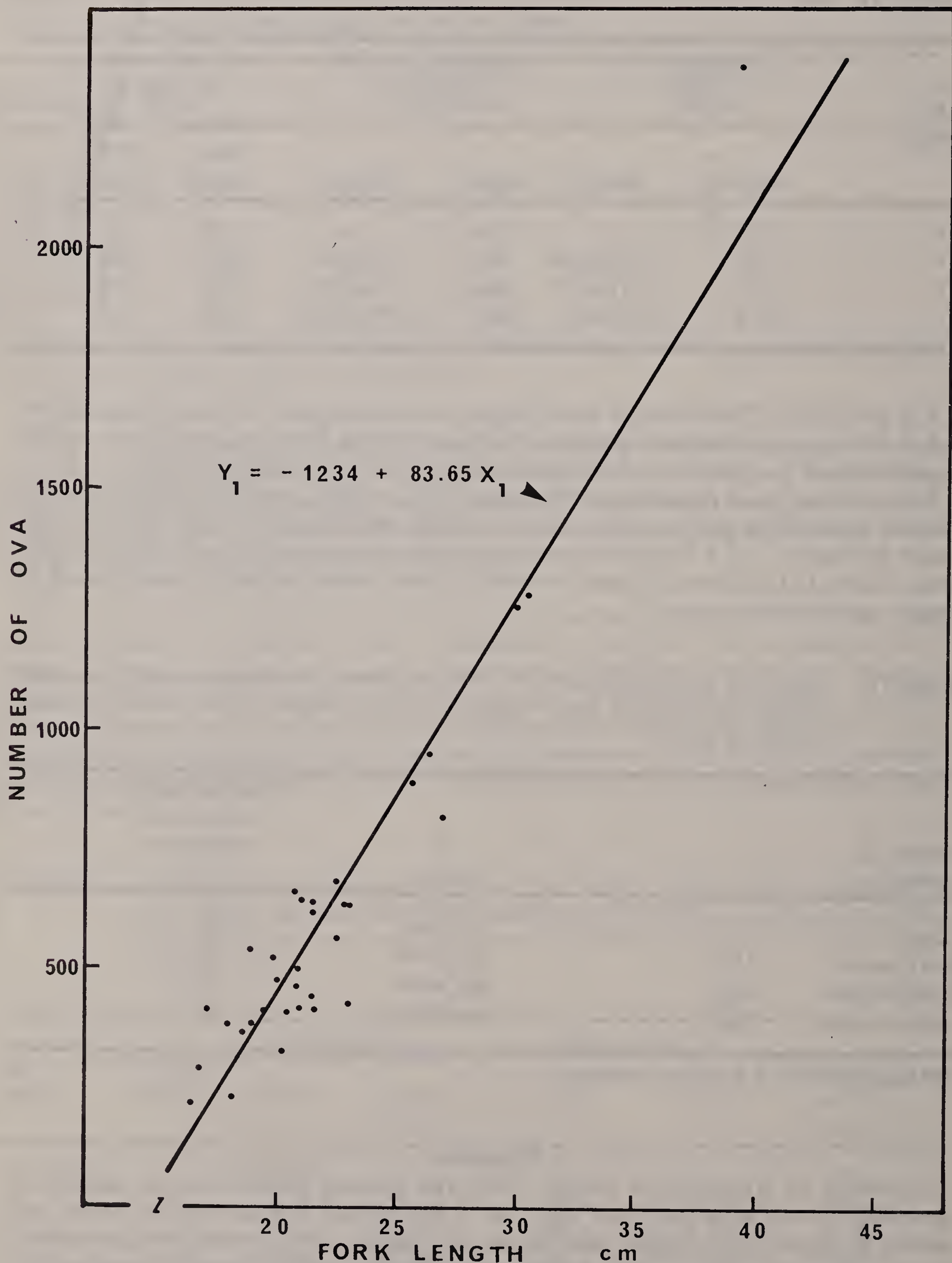

Fig. 2. Scattergram and regression equation for the number of ova and fork length of trout from the Dunk River, P.E.I.

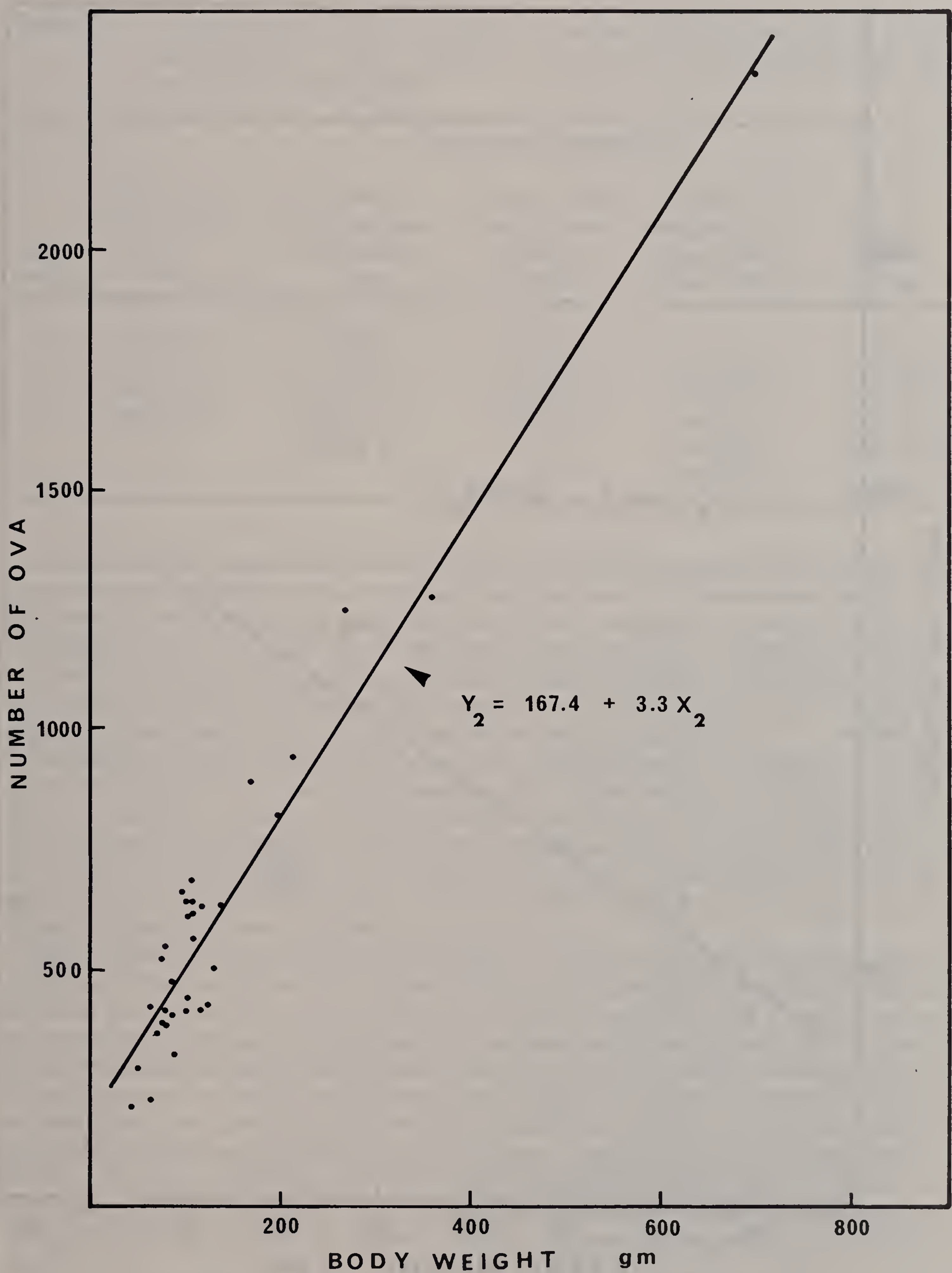

Fig. 3. Scattergram and regression equation for the number of ova and fresh weight of trout from the Dunk River, P.E.I.

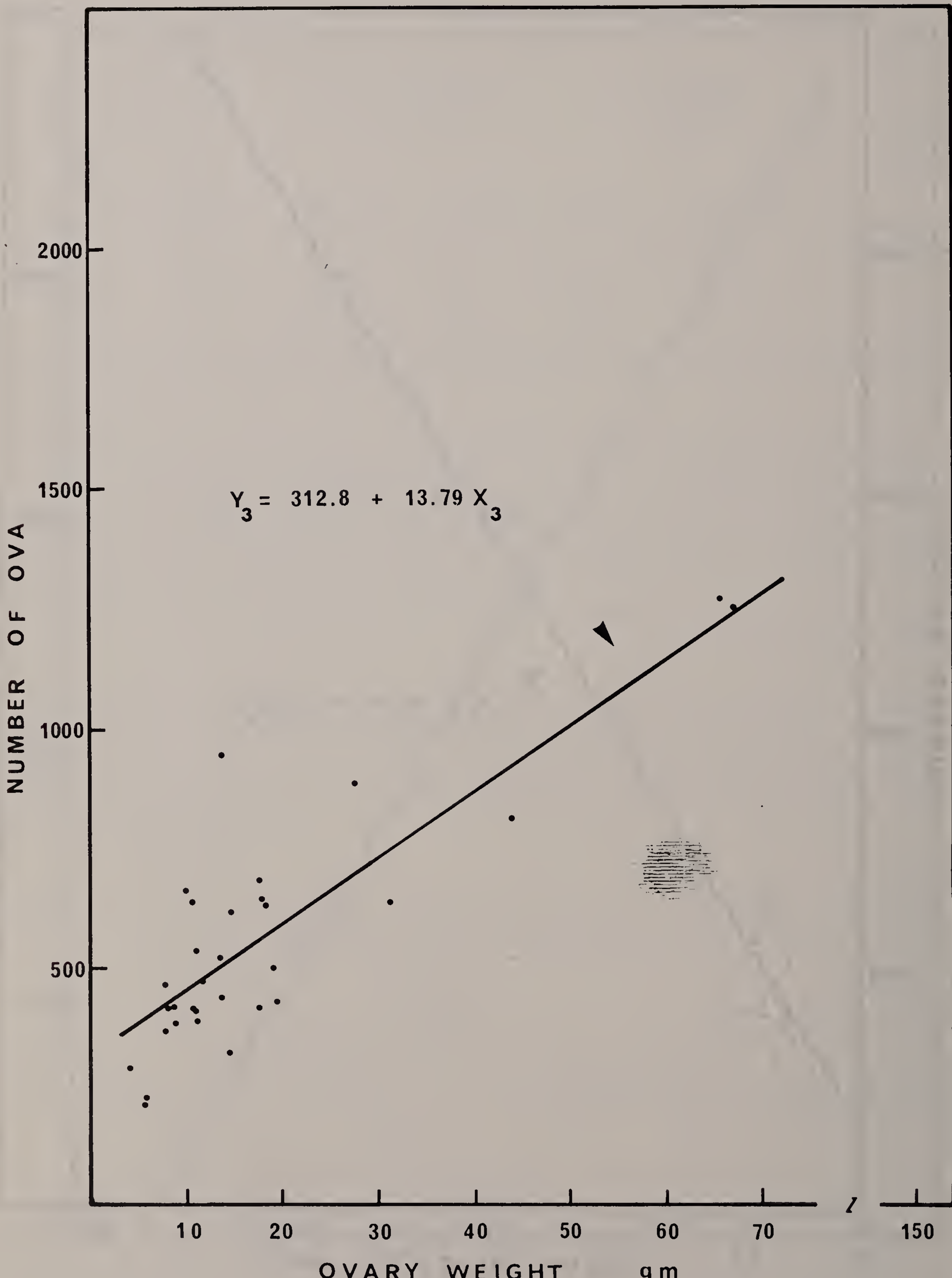

Fig. 4. Scattergram and regression equation for the number of ova and ovary weight of trout from the Dunk River, P.E.I.

Table V. A comparison of the percentage of mature female brook trout in each age-group for 5 areas. Numbers in parenthesis represent the mean fork length for each age-group

	Percentage Mature for:				
Age-group	Wyoming Beaver Ponds (Allen 1956)	Wisconsin Lawrence Creek (McFadden 1961)	Pennsylvania Lingle Stream (Wydoski 1966)	Quebec Matamek Lake (Saunders & Power 1970)	P.E.I. Present Study (1974)
0^+	0 (6.3)	0 (9.8)	0 (7.1)	0	0
1^+	6 (10.8)	83 (18.8)	10 (10.4)	17 (9.6)	6 (16.8)
2^+	82 (15.0)	100 (23.4)	42 (13.1)	68 (12.2)	83 (20.3)
3^+	100 (18.4)	100 (29.5)	100(16.2)	96 (17.2)	100 (25.6)
4^+	—	100 (34.4)	—	99 (20.7)	100 (34.8)
5^+	—	—	—	100 (24.8)	—

The mechanism responsible for early gonad maturation remains unknown, but may depend on some alteration in the functional maturation of the hypothalamic mechanism (Scharrer 1959). In fast growing trout functional maturation of the hypothalamic mechanism may be hastened by the presence of some endogenous factor(s) associated with growth. Alternatively an endogenous growth factor together with the hypothalamic releasing factor acting synergistically to increase the release of gonadotrophins from the pituitary, thereby augmenting gonad maturation may be responsible.

The relative weight of the mature ovary, the "maturity index" of Vladykov, (1956), varies for different populations. In Pennsylvanian streams only 10% of the total weight of the mature fish was gonad (Wydoski and Cooper 1966). In Quebec (Vladykov 1956) the ovary weight averaged 13.6% of the body weight and never exceeded 20%, while in this study, the mean value was 14.1% and was more than 20% in older trout. This suggests that older trout in Prince Edward Island produce a greater mass of eggs per mass of body weight than trout elsewhere.

Egg number at maturation is determined by the amount of follicular atresia. Vladykov (1956) recognized this in speckled trout from Quebec Lakes and reported that follicular atresia may be as great as 40%. Follicular atresia in rainbow trout according to Scott (1962) is increased by food shortage or intraspecific competition. These conclusions were further supported by Bagenal's (1969) fecundity experiments on brown trout.

Only one trout in this study possessed atretic eggs. The general lack of atretic eggs suggests that river conditions favored high productivity. Water chemical analysis for nitrate-N (0.4-3.1 ppm), phosphate (0.01-2.0 ppm), potassium (1.1-3.2 ppm), calcium (14.0-30.0 ppm), magnesium (3.0-13.0 ppm), alkalinity (40-80 mg/1 $CaCO^3$), pH (7.2-7.8), conductivity (102-209 μMHO/cm), and the number of bottom organisms/m^2 (range 2692-5930) during the summer months support this suggestion (unpublished data).

Egg size was only weakly correlated with age or fork length of females in this study. Wydoski and Cooper (1966) also noted little correlation between these parameters. Scott (1962) working with rainbow trout observed similar differences in egg size at maturity. He concluded that mean egg size was genetically determined, following Svardson (1949) who maintained that low intraspecific competition for food and space, would select for increased egg production and smaller egg size. On the other hand, populations with high egg production would create high intraspecific competition among fry, favoring a decreased production of larger eggs in maturing females. Larger eggs produce larger fry that are more robust and more able to survive in highly competitive environments.

Table VI. Comparison of fecundity and egg size for brook trout from Quebec and Prince Edward Island

Fork length (cm)	Quebec[a] Fecundity	Quebec[a] Egg diameter (mm)	P.E.I. Fecundity	P.E.I. Egg diameter (mm)
14.4	109	3.52	—	—
19.4	193	4.19	355	3.45
21.4	271	4.22	564	3.67
24.4	356	4.32	774	3.89
27.4	426	4.16	1024	4.14

[a]Data from Vladakov (1956 p. 819)

In spite of the above reasoning, egg size does not appear to be as greatly influenced by environmental conditions or heredity as is fecundity. There is very little difference in the diameter of eggs for fish of the same size from Quebec and Prince Edward Island (Table VI). The number of eggs produced by trout from Prince Edward Island, however, was generally more than double that of Quebec. Data on fecundity in other regions are summarized in Table VII. The slow growing fish of the infertile Pennsylvania streams and Quebec Lakes have a lower fecundity than do trout from the very fertile streams of Michigan and Wisconsin. The fertility of the Dunk River is probably intermediate between the two groups of fertile and infertile waters. As a result, it is not surprising to find that smaller trout produce intermediate numbers of eggs, (fewer eggs than trout from Michigan or Wisconsin but more eggs than trout from Quebec or Pennsylvania). Early growth and maturation of trout in Prince Edward Island may be further slowed by cooler water conditions and by a generally shorter growing season than elsewhere. However,

Table VII. Comparison of the fecundity of brook trout for five areas

Fork length (cm)	Quebec[a] (Vladykov 1956)	Wyoming[a] (Allen 1956)	Michigan[a] (Cooper 1953)	Wisconsin[a] (McFadden 1961)	P.E.I. (Present Study)
14.4	100	195	215	268	—
19.0	200	349	430	476	355
21.5	300	432	550	591	564
24.0	400	516	670	707	774
27.0	500	616	830	857	1024

[a]Data from McFadden (1961, p. 35).

these limitations are overcome for older and larger trout by movements to the sea. Scale analysis indicated that trout older than 2^+ had spent some time in the estuary. Annual migrations of 2^+ and older fish from the Lower Dunk River to the estuary occur regularly in late winter and early spring. While little is known about their movements in the estuary, their growth during this phase is greatly accelerated and they return to the river in June and July in a very fattened condition. Undoubtedly, fat and protein accumulated during the marine phase is employed in the unusually high egg production in older trout from Prince Edward Island.

Acknowledgement

Financial assistance was provided through the National Research Council of Canada, the University of Prince Edward Island Senate Research Committee, and the Fish and Wildlife Division, Prince Edward Island Provincial Government.

Data on water chemistry were provided through studies conducted by Dr. N. Stewart, Provincial Department of Agriculture and Dr. Leon Loucks, University of Prince Edward Island.

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PROCEEDINGS OF MEETINGS
Session 1973-1974

Meetings and communications during the year were as follows:

1st Ordinary Meeting, 15th October 1973

"Man-powered flight", O. Cochkanoff, Nova Scotia Technical College.

2nd Ordinary Meeting, 12th November 1973

"Aqua-culture and disease", J.E. Stewart, Department of the Environment, Fisheries and Marine Service, Halifax.

Extraordinary Meeting, 22nd November 1973

"The space between the stars", G. Herzberg, National Research Council of Canada, Ottawa.

3rd Ordinary Meeting, 10th December 1973

"Comets, their structure and origin", G. Mitchell, St. Mary's University.

4th Ordinary Meeting, 14th January 1974

"The ill winds of architecture", A. Penney, Nova Scotia Technical College.

5th Ordinary Meeting, 11th February 1974

"An ocean policy", Hon. J. Sauve, Minister of State for Science and Technology.

6th Ordinary Meeting, 11th March 1974

"Analysis for organics in lunar soil", W. Aue, Dalhousie University.

Joint Meeting with the Biological Council of Canada, 21st March 1974

"Environmental problems in Nova Scotia", Hon. G. Bagnell, Nova Scotia Minister for the Environment.

7th Ordinary Meeting, 8th April 1974 (jointly with the Valley Chapter, Dalhousie University)

"Agriculture of China", J.R. Wright, Canada Department of Agriculture, Kentville.

"Fisheries laboratories in Japan", R.G. Ackerman, Department of the Environment, Fisheries and Marine Service, Halifax.

113th Annual General Meeting, 13th May 1974

In the absence of the President, R.G. Ackman, P.J. Wangersky took the chair, no presidential address being delivered.

The Treasurer, D.S. Davis, reported

Receipts	$3,688.17
Expenditures	5,853.28
Permanent Fund	536.89
Total cash assets as of 13th May 1974	5,545.85

The Editor, M.J. Harvey, reported that during the year the supplementary volume, **Chordrus crispus,** had been printed and distributed, and part 2 of volume 27 of the **Proceedings** was awaiting publication. Printing of the monograph on the **Ipswich Sparrow** will be put in hand shortly.

The Librarian, Miss E.M. Campbell, reported that the library has been with the Science Library of Dalhousie University for the last three years, and many constructive changes have taken place. Inter-library loans have increased, and a number of new exchanges have been received. The supplement, **Chrodrus crispus**, has been selling well.

Officers and others elected for the session 1974-1975 were:

President. . . . . P.J. Wangersky
First Vice-President . . . . G.F. Mitchell
Second Vice-President . . . . W. D. Jamieson
Secretary . . . . N. Cuthbertson
Treasurer. . . . . D. Davis
Editor. . . . . M.J. Harvey
Council . . . . W.A. Aue, E.G. Bligh,
R.F. Brown, B.D. Loncarevic,
A.Y. MacLean, Sr. P. Mullen,
Auditors. . . . . J.R. Dingle, W.J. Dyer

PROCEEDINGS OF MEETINGS
(Valley Chapter 1973-1974)

1st Ordinary Meeting, 8th October 1973

"Effect of natural and modified food components on **Clostridium perfringens",** D. Schroder, Canada Department of Agriculture, Kentville.

"Geology of central Africa", D. Keppic, Acadia University

2nd Ordinary Meeting, 5th November 1973

"Tidal power-technical and economic factors", G. Baker, Kentville Advertiser.

3rd Ordinary Meeting, 3rd December 1973

"Whales, dolphins, and porpoises", P. Beamish, Bedford Institute of Oceanography.

4th Ordinary Meeting, 7th January 1974

"The computer as an educational resource", C. Carmen, Acadia University.

5th Ordinary Meeting, 4th February 1974

"The automobile and air pollution", J. Brown, Acadia University.

6th Ordinary Meeting, 4th March 1974

"Breast carcinoma following multiple fluoroscopies with pneumothorax for the treatment of pulmonary tuberculosis", J.J. Quinlan and J.A. Myrden, Nova Scotia Sanatorium.

"Blood-gas analysis and clinical applications", E.W. Crossen, Nova Scotia Sanatorium.

7th Ordinary Meeting, 8th April 1974 (jointly with the Halifax Chapter, Dalhousie University)

"Agriculture of China", J.R. Wright, Canada Department of Agriculture, Kentville.

"Fisheries laboratories in Japan", R.G. Ackman, Department of the Environment, Fisheries and Marine Service, Halifax.

Officers and others elected for the year 1974-1975 were:

President . . . . H. Specht
Vice-President. . . . . S. VanderKloet
Secretary . . . . F.C. Bent
Treasurer. . . . . T. Haliburton
Councillor . . . . M. Rostocka

PROCEEDINGS OF MEETINGS
Session 1974-1975

Meetings and communications during the year were as follows:

1st Ordinary Meeting, 7th October 1974

"The Royal Institution — past and present", M.A.T. Rogers, Oxford University.

Joint Meeting with the Chemistry Department, Dalhousie University, 24th October 1974

"Lap-dissolved projection", D. Harpp, McGill University.

2nd Ordinary Meeting, 20th November 1974 (jointly with the Atlantic Regional Laboratory)

"Fermented foods", C.W. Hesseltine, United States Department of Agriculture, Peoria, Ill.

3rd Ordinary Meeting, 9th December 1974

"The Ipswich Sparrow", I.A. McLaren, Dalhousie University.

4th Ordinary Meeting, 13th January 1975

"Under-water noises of the Arctic", H.M. Merklinger, Defence Research Establishment, Halifax.

5th Ordinary Meeting, 13th February 1975

"Black holes, white holes, and worm holes", R.C. Roeder, University of Toronto.

6th Ordinary Meeting, 10th March 1975

"Scientific evidence and court-room procedures", D.A. Copp, Dalhousie University.

7th Ordinary Meeting, 14th April 1975 (jointly with the Valley Chapter, Acadia University)

"Marine agronomy", F.J. Simpson, National Research Council of Canada, Halifax.

"The littoral environment of Grand Turk Island and Baffin Island", J.S. Bleakney, Acadia University.

114th Annual General Meeting, 12th May 1974

The President, P.J. Wangersky, was in the chair and delivered the following address:

Our program for the year past included eight speakers at the seven regular meetings and two speakers at extraordinary meetings. About half of the speakers were local scientists, and the other half were distinguished visitors. The speakers this year were all good lecturers, speaking on interesting topics. However, the attendance at meetings did not reflect the quality of the lectures. The size of the audience seemed to be related to the point of origin of the speaker, rather than to the interest of the topic or the ability of the speaker. Attendance at talks given by local scientists averaged in the thirties, as compared to audiences in the seventies for visiting speakers. This is doubtless another variation of the definition of an expert as a man who is more than a hundred miles from home. In any event, audiences of this size are surely a sad reflection on our ability to stimulate the interest of the local scientific community, and should cause us to re-examine our reasons for continuing as a society. I will address myself to this question later.

Arrangements have been completed for the first **A.C. Neish Memorial Lecture,** which will be given some time in the autumn. It is to be hoped that local interest in this lecture will be somewhat greater than it has been for the ordinary, or even the extraordinary meetings. With a sufficiently distinguished speaker, it may be possible to get a reasonable amount of pre-lecture publicity from the local radio and television stations. The local newspapers seem committed to a policy of post-lecture publicity only, which may result in better stories, but is of little value in drawing an audience to lectures.

In the past year we completed and distributed the **Ipswitch Sparrow** monograph. Copies should have reached all of the membership. The monograph on **Environmental Change in the Maritimes** is in the final stages of editing, and should appear during the summer. This monograph is supported by a grant from the National Research Council; the financing has been arranged in a manner which will result in no financial gain to the Institute, and so its sales will neither help nor hinder the future publication plans of the Institute. Another volume of the **Proceedings** should soon be published, but the time of issuance must depend upon our ability to pay for it. Beyond these manuscripts, we cannot plan since we cannot foresee our future financial condition.

These comments bring me to the heart of our current problem, the question of money. The costs of printing and distributing meeting notices have steadily increased through the past few years, until we have reached the point where the money brought in by membership dues no longer supports even the cost of meeting notifications. We must therefore request an increase in the membership dues, both private and institutional, in order to cover the costs of conducting these meetings.

However, no reasonable increase in membership fees will help us to finance any future publications. At the present time, we can afford to publish only those papers which come complete with their own financing, papers such as the **Chondrus crispus** and **Environmental Change** symposia. It would be sad, indeed, if we were to be thus reduced to the status of a vanity press.

Our present financial status is that we are essentially flat broke. Our request for an increase in our annual provincial grant was refused, and we received the customary grant of $500, a sum which has not changed in the ten years I have been associated with the Institute. We continue to sell copies of the **Chondrus crispus** symposium, but there are only a few hundred left, and this source of revenue must soon end. We have a considerable inventory of the **Ipswitch Sparrow** monograph; the continuance of our publication program must await the liquidation of this inventory.

Our present straitened circumstances have led me to consider carefully possible new directions for our Institute. It is obvious to anyone attending the meetings with any regularity that the Institute is no longer serving the needs of any large part of the local scientific community. Out of an estimated scientific population of eight hundred, we have managed to enroll only about a hundred members. At most meetings, only a third of these show up; mainly the same third, at that, with the proportion of white hair steadily increasing. At the annual business meeting, we are hard put to make up a quorum.

Considering the way in which the Institute operates at present, it is not surprising that the membership has not increased; there is really no incentive to join. The lectures are open to the public, to anyone interested in the topic and speaker of the evening, and our attendance figures certainly show us that only the extraordinary speaker draws any reasonable representation of the local scientific community. Whatever it is that the local scientists want, it does not seem to be another lecture. The members do receive the publications of the Institute, but until the last few years there were so few publications that in all fairness, they could not be listed as an inducement. Older members will remember the long lapse between parts one and two of the **Flora of Nova Scotia.** As things now stand, there are likely to be even fewer publications in the future.

It seems to me that there are three possible courses for the Institute in the immediate future. We have discussed the expansion of the Institute into the field of community education, through special lectures given at the Nova Scotia Museum, at the local high schools, and perhaps over the local community television station. While such a program has many good points, not the least being the involvement of some of the younger members in such a lecture series, it also requires an administrator, working at least half time. It is not a program which can be carried out by a working scientist in his few spare moments. Regretfully, this possibility must be put aside until more money is available.

We could continue our current program of lectures, since an increase in dues will cover the expense of the lectures, and abandon any pretense of conducting a program of publication. This change in direction would at least let us live within our finances, but would result in our abandonment of the network of exchanges built up over the long history of the Institute. I would hate to see us decide in favor of this option, even though it is the fiscally responsible one. Also, since the lecture series are even now so poorly attended, I suspect this option would ultimately result in the final disintegration of the Institute.

A third choice would be to attempt to increase our schedule of publication, to become an outlet for regional manuscripts, papers valuable in themselves, but too long and too local to be published in the usual scholarly journals. I feel that it is in this direction that the future of the Institute really lies. Most professional societies now support themselves primarily by the earnings of their journals, and I suspect we might be able to do the same.

In order to do this, however, certain changes in our publishing procedures need to be made. We have always published our **Proceedings** by getting bids for each individual number; this was a reasonable procedure when we published one number every two years, but surely we could secure better rates for a more regular publishing schedule. We should also look into the possibility of securing professional help in handling the details of publication. Obviously, we would need a reasonable amount of money to start such a program, more money than we are likely to receive from the province, to judge by historical precedent. The possibility of a Federal grant for this purpose should be investigated at the same time that representations are made, not only to the Nova Scotian provincial government, but also to the governments of the other Maritime provinces.

I do not feel that the lecture program, even though sparsely attended, should be discontinued; one of the great benefits of the Institute is that it serves as a platform for distinguished visitors who are in the area for other reasons. However, the program cannot exist solely as a sometimes thing. The Board must meet regularly, and there must be a regular lecture program, or the machinery for setting up the lectures must inevitably rust away. We must accept the small regular audience as part of the price we must pay for the occasional full house, and we need the Board meetings as a place where planning for future meetings is carried out, and as a point of contact for visiting speakers. If we can establish a regular schedule of publication, accompanied by our customary lecture series and our occasional extraordinary lectures, we may eventually secure enough local support to enable us to venture into the field of community science education. If we cannot do these things, I am afraid our Institute will soon disappear, along with other institutions which no longer serve their original purposes.

As your almost outgoing President, I wish to thank the Board and officers of the Institute for the extraordinary amount of work they have done this year. Most of all, I thank, and I think the Institute as a whole should thank, our outgoing Secretary, Mr. Norman Cuthbertson, who for eight years has kept the Institute running, and without whose incessant labor you might never have been furnished with this written version of the Presidential address.

The Treasurer, D.S. Davis, reported

Receipts	$2.840.40
Expenditures	7,847.70
Permanent Fund	536.89
Total cash assets as of 30th April 1975	513.55

The Editor, M.J. Harvey, reported that part 2 of volume 27 of the **Proceedings** and the monograph on the **Ipswich Sparrow** have been printed and distributed. The third supplement to volume 27, **Environmental Changes in the Maritimes** should be available soon; publication costs were aided by a grant from the National Research Council of Canada.

The Librarian, Miss E.M. Campbell, reported that a number of journals have been incorporated each year into the main science collection in the Science Library of Dalhousie University. These, together with other journals, bulletins, proceedings, and transactions are available to anyone wishing to consult them. **Chondrus crispus** is still selling well, and orders for the **Ipswich Sparrow** are now coming in.

Officers and others elected for the session 1975-1976 were:

President	W.D. Jamieson
First Vice-President	G.W. Mitchell (deferred status)
Second Vice-President	A. Taylor
Secretary	K. Hellenbrand
Treasurer	D.S. Davis
Editor	M.J. Harvey

Council . . . . . W.A. Aue, E.G. Bligh
R.F. Brown (deferred status)
H.A. Ellenberger, B.C. Loncarevic
A.Y. MacLean,
Sr. P. Mullen (deferred status)
F.J. Simpson
Auditors . . . . . J.R. Dingle, W.J. Dyer

PROCEEDINGS OF MEETINGS
(Valley Chapter 1974-1975)

1st Ordinary Meeting, 7th October 1974
"Acoustical sounding of the atmosphere", G. Tillotson, Acadia University.
"Pollution in the Habitant Creek and the Cornwallis River system", D. Stiles, Acadia University.

2nd Ordinary Meeting, 4th November 1974
"Ancient Crete and its palaces", J. Walter Graham, Royal Ontario Museum, Toronto.

3rd Ordinary Meeting, 2nd December 1974
"Tantalum — from the mine into reciprocal space", J. Grice, Acadia University.

4th Ordinary Meeting, 6th January 1975
"Gilbert Island, an example of the agriculture-wildlife conflict", P. Barkhouse, Acadia University.

5th Ordinary Meeting, 3rd February 1975
"The ill winds of architecture", A. Penney, Nova Scotia Technical College.

6th Ordinary Meeting, 3rd March 1975
"Working holiday in the Caribbean", S.V. Anand, Nova Scotia Sanatorium.
"Occupational health and safety", C.R. May, Department of Public Health, Halifax.
"Case report-byssinosis", J.J. Quinlan, Nova Scotia Sanatorium.

7th Ordinary Meeting, 14th April 1975 (jointly with the Halifax Chapter, Acadia University)
"Marine agronomy", F.J. Simpson, National Research Council of Canada, Halifax.
"The littoral environment of Grant Turk Island and Baffin Island", J.S. Bleakney, Acadia University.

Officers and others elected for the session 1975-1976 were:

President . . . . . S. VanderKloet
Vice-President . . . . . T. Haliburton
Secretary . . . . . F.C. Bent
Treasurer . . . . . R. Olsen
Councillor . . . . . M. Rostocka

PROCEEDINGS OF MEETINGS

Session 1975-1976

Meetings and communications during the year were as follows:

1st Ordinary Meeting, 21st October 1975 (First A.C. Neish Memorial Lecture)
"Science, society, and survival", R.H. Manske, Waterloo University.

2nd Ordinary Meeting, 10th November 1975
"Childhood diabetes". B.S. Morton, The Izaak Walton Killam Hospital for Children.

3rd Ordinary Meeting, 8th December 1975
Cancelled owing to illness of the speaker, The Hon. H. D. Hicks.

4th Ordinary Meeting, 12th January 1976
"Nuclear medicine, whats that?" R.H. Martin, Camp Hill Hospital.

5th Ordinary Meeting, 9th February 1976
"Modern techniques in sport analysis—applied research on movements in sports", L. Holt, Dalhousie University.

6th Ordinary Meeting, 22nd March 1976 (jointly with Departments of Geology, Dalhousie University and St. Mary's University)
"There is a chill in the air—evnironmental changes in the Maritimes", J.G. Ogden III, Dalhousie University.

7th Ordinary Meeting, 12th April 1976 (jointly with the Valley Chapter, Dalhousie University)
"Biological constraints on learning—disentangling environmental variables from organismic variables", R. Krane, Acadia University.

115th Annual General Meeting, 10th May 1976
The President, W.D. Jamieson, was in the chair.

The Treasurer, D.S. Davis reported

Receipts	$3,073.97
Expenditures	663.40
Permanent Fund	1.70
Total cash assets as of 3rd May 1976	2,432.92

The financial situation is precarious because of the much higher than expected publication costs; a deficit of about $800 is envisaged.

The Editor, M.J. Harvey reported that additional costs of publication of the **Envirnomental Changes in the Maritimes** accounted to $3,100, with well over half of this amount being recoverable from the authors.

The Librarian, Miss E.M. Campbell, reported that volumes 1-10 of the **Proceedings** are out of print, and volumes 11-18 are broken. Volumes 1-23 are on microfilm, a copy of which is in the Institute's file, the master being at the Canadian Library Association, Ottawa, and prints can be purchased. Sales of supplements **Chondrus crispus** have exceeded 500 copies, the **Ipswich Sparrow** about 150 copies, and **Environmental Changes in the Maritimes** over 75 copies. There are about 250 exchanges for the **Proceedings,** and several societies have discontinued their exchange because of rising costs of publishing.

Officers and others elected for the session 1976-1977 were:

President	W.D. Jamieson
First Vice-President	F.J. Simpson
Second Vice-President	A. Taylor

Secretary . . . . K. Hellenbrand
Treasurer . . . . H.A. Ellenberger
Editor . . . . J. McLachlan
Council . . . . W.A. Aue, E.G. Bligh
H.B.S. Cooke, D.S. Davis
C.B. Lazier, B.P. Loncarevic
I.A. McLaren, S. Whiteway
Auditors . . . . J.R. Dingle, W.J. Dyer

PROCEEDINGS OF MEETINGS
(Valley Chapter 1975-1976)

1st Ordinary Meeting, 6th October 1975

"Natural control of the European Corn Borer", R. Whitman, Nova Scotia Department of Agriculture.

2nd Ordinary Meeting, 3rd November 1975

"Jelly-fish", D. Chapman, Dalhousie University.

3rd Ordinary Meeting, 1st December 1975

"Amphibian gas exchange, the case of the Big Bladdered **Bufo",** D.P. Toews, Acadia University.

4th Ordinary Meeting, 5th Janaury 1976

The meeting was cancelled.

5th Ordinary Meeting, 2nd February 1976

"Feeding ecology of shore birds", P. Smith, Acadia University.

6th Ordinary Meeting, 1st March 1976

"Traumatic rupture of the diaphram, with a case report", J.J. Quinlan, Miller Hospital.

"Film on resuscitation with demonstration", Mrs. K. Daiben and W. Brown, Miller Hospital.

7th Ordinary Meeting, 12th April, 1976 (jointly with the Halifax Chapter, Dalhousie University)

"Biological constraints on learning—disentangling environmental variables from organismic variables", R. Krane, Acadia University.

Officers elected for the session 1976-1977 were:

President . . . . T. Haliburton
Vice-President . . . . A. Campbell
Secretary . . . . F.C. Bent
Treasurer . . . . R. Olsen

ERNEST WILMOT GUPTILL
1919-1976

The death, by drowning, of Ernest Guptill occurred on March 20, 1976. An expert sailor, he was the victim of an accident, highly improbable and wholly unexpected, and therefore very tragic. The immediate reaction was one of refusing to believe that he could have lost his life on the water — and then came the conviction that if it were true a great and irreparable loss had come to all who knew him.

Dr. Guptill was born in 1919 on Grand Manan Island, into the family of a fisherman. His parents believed in the value of a college education and managed to see all the children, three in number, graduate from universities. After Honours Physics at Acadia, Ernest Guptill did advanced work at the University of Western Ontario and McGill University — at McGill he earned his Ph.D. The war was on during most of this period so his research interests were naturally of a practical sort; he became an expert in wave-guide theory and construction, and succeeded in inventing (along with Dr. W.H. Watson) a type of slotted wave antennae of great simplicity and efficiency; it is still in wide use.

Many of his published papers record straightforward measurements of physical properties; his experiments were always examples of elegant and original techniques. His ability to make difficult measurements with the equipment "on hand" elicited the envy and admiration of his colleagues. His greatest satisfaction was in doing an experiment to investigate some effect which everyone took for granted but which no one took the trouble to measure or check. His work on contact potentials and the electric fields in accelerating copper was of this nature.

For ten years Dr. Guptill was Head of the Physics Department at Dalhousie University. This was a period of rapid growth involving the solution of many problems. The fine leadership provided during this crucial period has been of essential service to the Department. He has served on important committees of the National Research Council and was a member of the Board and Executive of the Nova Scotia Research Foundation.

Everyone who knew Dr. Guptill observed that as the years passed his skill as a teacher steadily increased. It was his ambition to do this task as well as possible and he disciplined his life to achieve this end. Beyond a doubt he was uniquely gifted for this role and was at his best, and getting better, at the time of his death.

W.J. Archibald

E. GORDON YOUNG
1897-1976

E. Gordon Young, whose association with the Nova Scotian Institute of Science spanned a period of half a century, died in Halifax on March 24, 1976. Dr. Young was born in Quebec City on January 5, 1897, son of James and Jane (Douglas) Young. Among Canadian biochemists he occupied a unique position: he was the first native-born Canadian, trained overseas, to teach biochemistry in Canada. (Courses called physiological chemistry and agricultural chemistry had been given earlier in Canada at Toronto and Macdonald College by A.B. Macallum and by J.F. Snell, respectively, Canadians who had received graduate training in the United States; courses designated biological chemistry or biochemistry had been taught previously by R.F. Ruttan, V.J. Harding, and A.T. Cameron, Britons trained at home.) Gordon Young saw the formation and growth of most of the present departments of biochemistry in Canadian universities and had personal knowledge of almost every senior biochemist in Canada during the first half-century of the science. Fortunately for posterity, (for he was one of the last links with the founders of the discipline), he worked for ten years, after his retirement, compiling data about Canadian biochemists, writing down his own recollections, collating them with those of others and organizing the material into a history entitled *The Development of biochemistry in Canada* (University of Toronto Press, 1976). No one else could have produced a record with so many personal touches and of such authenticity. His friends were saddened that, although he corrected the proof-sheets, Dr. Young did not live to see the final fruits of this labor of love. They regretted also that he died before receiving the E.W. McHenry Award of the Nutrition Society of Canada, which was awarded posthumously in Halifax on June 16, 1976. This award, which is sponsored by Canada Packers Ltd, recognizes distinguished service in nutrition by a Canadian.

Gordon Young attended Quebec City High School (senior matriculation, 1912) and entered McGill University at the age of fifteen. In 1916 he received his B.A. with First Class Honours in Chemistry and Biology. Gordon spent his summers of 1916 and 1917 at the Marine Biological Laboratories at Woods Hole, Mass. After three years of graduate work with Professor V.J. Harding, in Professor R.F. Ruttan's Department of Organic and Biological Chemistry at McGill, Gordon received his M.Sc. (Chemistry), winning the Governor-General's Medal that year (1919); he won also an 1851 Exhibition Scholarship and further distinguished himself that year by being awarded a Ramsay Memorial Fellowship (1919-1921), being the first Canadian student to receive one.

Young studied for his doctorate at Cambridge University, England, under Sir Frederick Gowland Hopkins, his thesis dealing with the preparation and properties of some pure proteins. Sir Frederick, one of the founders of biochemistry as a distinct field, was at the time famous as a pioneer investigator in the field of nutrition, having isolated tryptophane in 1901, having first recognized the essential nature of certain amino-acids, and having discovered accessory food factors (vitamins, 1906/07). Exposure to "Hoppie's" enthusiastic curiosity about dietary substances doubtless aroused Gordon Young's life-long interest in nutrition.

After spending the summer of 1921 at the Pasteur Institute, Paris, Young returned to Canada as Associate Professor of Biochemistry in the recently reorganized Faculty of Medicine at Western University (now the University of Western Ontario) in London. He taught the first courses in systematic biochemistry given at Western.

In 1924 Young was invited by Dalhousie University to organize for them the newly-created Department of Biochemistry, made possible by a grant from the Rockefeller Foundation. Always a perfectionist, Young built up a department in which high standards of teaching were established; later he managed to overcome many difficulties to provide facilities for research. Dalhousie owes much to the wisdom and vigor of his guidance.

Gordon Young's formal education had not ceased when he received the Ph.D. from Cambridge in 1921. During the summers of 1922 to 1926 he attended lectures in the Medical School of the University of Chicago, completing courses in physiology, neurology, pharmacology, and pathology, and in most of the clinical specialties (medicine, surgery, obstetrics, gynecology, pediatrics and dermatology). Final qualification for the medical degree was never completed because certain clinical specialties were not given during the summer session. Also, Young did not feel that he could take off a whole year from teaching to do the necessary interneship. These studies were not wasted effort, however, as they led to a broad appreciation of the interrelationships between biochemistry and the practice of medicine. His contributions to paramedical knowledge cover a wide range, from the chemistry and biochemistry of proteins and purines to microbial fermentations and from toxicology to human nutrition.

To keep abreast of current developments in biochemistry, Young spent the summer of 1933 at the Sir William Dunn Institute of Biochemistry, Cambridge, England, and the summer of 1938 at the Lister Institute, London.

During the Second World War, Dr. Young directed classified research, connected with chemical warfare, for the Department of National Defence.

Young remained Head of Biochemistry at Dalhousie until 1950 when he resigned to undertake the planning and development of the Atlantic Regional Laboratory of the National Research Council of Canada. He served as Director of the ARL until his retirement in 1962 and as consultant until 1965. He continued as a guest worker at ARL until November 1973.

The laboratory was opened in 1952 and by that time he had initiated active research in various fields of science related to the economy of the Atlantic Provinces. Dr. Young continued his research on proteins and nutrition. He had first displayed his active interest in dietary matters by publishing, in 1931, a study of the nutritional requirements of Canadian college students. In 1948 he presented a paper to the Royal Society of Canada on *Canadian dietary patterns,* 1937-47 and in 1953 published *An appraisal of Canadian nutriture.* His work in this field continued throughout his career and he participated in the recent national survey (1971), by the Department of National Health and Welfare, of the nutritional status of Canadians. These activities have helped to establish dietary standards for Canada and are of value in planning public health programs.

At the Atlantic Regional Laboratory he instigated a broad program of research on the chemistry and biology of marine algae. Although the seaweed industry in Canada today is worth several million dollars annually, seaweed was at that time virtually an untouched natural resource. It was one of the aims of Dr. Young to bring the available resources of his laboratory to bear on the study of these natural products.

Programs were developed on the drying of seaweeds, the composition and properties of seaweed extracts, their potential uses in medicine, agriculture and nutrition, and their mode of growth. Under his direction, and in large measure because of his active participation in research, the Atlantic Regional Laboratory became one of the world's acknowledged centers for algal research. The work he pioneered in this field has been continued and extended by his successors.

In 1948 Dr. Young played a major role in organizing a Conference in Halifax on the Utilization of Seaweeds. The success of this Conference emphasised the need for further meetings at an international level and led to a series of International Seaweed Symposia which have been held regularly in various parts of the world since 1952. Dr. Young played a prominent role in these arrangements and was Chairman of the Fifth International Seaweed Symposium held in Halifax in 1965. In 1973 the Nova Scotian Institute of Science published a volume dedicated partly to Dr. Young in recognition of his work on *Chondrus crispus* (Irish moss), a seaweed which grows abundantly in the coastal waters of Nova Scotia.

Dr. Young served as a member of the Canadian National Committee of the International Union of Biochemistry (1960, 1961) and also on the National Committee of the International Union of Pure and Applied Chemistry. During 1960 and 1961 he represented the Chemical Institute of Canada in the United Nations Educational, Scientific, and Cultural Organization (UNESCO). Always active in the local scientific community, he served for many years on the Council of the Nova Scotian Institute of Science, was its President in 1930-32 and Editor of the *Proceedings of the Nova Scotian Institute of Science* during 1967-72. He was an active member of the Nova Scotia Research Foundation, especially on the Fisheries Committee and the Library Committee.

Many scientific societies recognized Dr. Young's talents and contributions. He was elected to Fellowship in the Royal Society of Canada, the Chemical Institute of Canada, and the American Association for the Advancement of Science. He served as President of the Canadian Physiological Society (1949-50), of the Canadian Biochemical Society (1958-59), of the Canadian Federation of Biological Societies (1959-60), and of the Chemical Institute of Canada (1959-60). Dr. Young was a member of the Biochemical Society (London) since 1920, of the American Society of Biological Chemists (1925), of the American Chemical Society (1934), and was a founding member of the Nutrition Society of Canada. He was a member of the Canadian Council of Nutrition from its inception (1937) until 1956 and served on several national and international committees concerned with nutrition or with food preservation.

Dr. Young was awarded a D.Sc. *(honoris causa)* by Acadia University (1957) and an LL.D. by Dalhousie University (1965).

Dr. Young was an accomplished lecturer. His impromptu comments at scientific meetings were equally felicitous, usually serving to enliven the discussion period. His after-dinner speeches and public lectures were stimulating and enjoyable. One of his more popular lectures, *Adventures of a chemist in crime,* described in lighter vein his experiences as a forensic chemist for the R.C.M.P. His wry humor delighted the audiences as much as the stories appealed to their "detective" instincts. Subsequently he wrote up his medico-legal experiences in a manuscript titled *Adventures of a chemist in search of poisons.* This was not published.

On May 15, 1926, Gordon Young and Madge L. Musgrave, of Sydney, N.S., were married. The warmth of the hospitality of their home in Halifax became notable, for in spite of his many scientific and administrative commitments, Gordon found time to enjoy life. He and his wife shared an appreciation of good literature and of the arts, especially music. They were active members of the Ashburn Golf Club. It may surprise those who knew Dr. Young only through professional contacts to learn that both he and his wife were enthusiastic amateur figure-skaters.

Former students, professional associates, and closer friends will recall with affection his gracious manners and helpful ways. His meticulous grooming and precise speech were outward manifestations of a well-ordered mind. His contributions to Dalhousie University, to the A.R.L., to the science of biochemistry in Canada, and to the seaweed industry will all leave a lasting impression. He will be remembered with respect as a man of character and convictions, of meticulous scholarship, of wisdom and sound judgement.

Dr. Young is survived by his widow, Madge and his sister, Erva, of Quebec City.

D.R.S. Howell
C.R. Masson

Instructions to Authors

The **Proceedings of the Nova Scotian Institute of Science** publishes the proceedings of the Institute and original articles, including notes, pertaining to the natural sciences of the Atlantic Provinces, especially in biology and geology. Acceptance of manuscripts for publication is based on recommendations of referees.

Manuscripts should be typewritten, double-spaced on white paper 21.5 by 28 cm (8.5 by 11 in) with margins of 4 cm (1.5 in). Underline only material to be set in italics, and use capital letters only when letter or words should appear in capitals in the printed paper. The original copy and one duplicate are required. Each page of the manuscript should be numbered, the first page carrying only the title, authors' names and affiliations, and any necessary footnotes.

Spelling should follow that of **Webster's Third New International Dictionary,** and authors are responsible for consistency in spelling.

Abbreviations, nomenclature, and symbols for units of measurements should follow international recommendations. Metric units, SI units, and decimals should be used whenever possible. Use day/month/year sequence for dates. Do not use periods after such abbreviations as "mm, kg, DOE, NRC, etc."

Taxonomic keys should be in alined-couplet form in zoology and paleontology, and in multilevel indent form in botany. Synonomy in botany, zoology, and paleontology should be in the short form — taxon, author, year:page — with full citation in the references.

An abstract of not more than 200 words should precede the body of the text. This should be followed by an introduction, methods, results or observations, discussion, and references. In some cases a combination of these sections may be more effective.

References should be checked with the original article and referred to in the text by author and date, in parentheses. References should be listed alphabetically at the end of the manuscript. Reference to papers in periodicals must include author, date, title, journal, volume number, and inclusive pagination. Serials are abbreviated in form given in **Bibliographic Guide for Editors and Authors** (the American Chemical Society, 1974). For serials not found therein, the abbreviated name in the **World List of Scientific Periodicals** (Butterworths, 1963) is used.

Tables should be numbered with roman numerals, having a brief title, and referred to in the text. Vertical rules should not be used.

Originals of illustrations should not be more than three times the size of the final reproduction, 11 by 18 cm. Figures, including those in plates, are numbered consecutively in arabic numerals, and each referred to in the text. Original drawings, and one set of clean copy, are required and made with india ink on white paper. All lines must be sufficiently thick to reproduce well, and letters and characters sufficiently large to be legible and not less than 1 mm high when reduced.

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