The Marine Macroalgal Flora of Brier Island, Nova Scotia, Canada

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by

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From May to October 2017, seaweeds were identified in the field and laboratory from 20 sites around Brier Island, Nova Scotia. While most sites were intertidal rocky shores, there was one small salt marsh and one eelgrass bed included in the study and some subtidal sampling via SCUBA and snorkeling. The Brier Island seaweeds were made up of 152 species and varieties of which 62 were red algae, 44 were green algae, 44 were brown algae, and two species were xanthophytes. Four species were new records for eastern Canada: *Cladophora liniformis, Colaconema bonnemaisoniae, C. endophytica,* and *Elachista stellaris,* all of which were previously recorded from New England. The flora included eight non-native species of which *Colpomenia peregrina* and *Bonnemaisonia hamifera* (both gametophytic and tetrasporophytic stages) were abundant at two or more sites. The invasive *Codium fragile* subsp. *fragile* occurred as a single drift specimen. Brier Island has greater species richness than similarly sized areas in the Canadian Maritimes, with relatively higher numbers of red algae and a Cheney floristic index of 2.4.

RÉSUMÉ

Garbary, D.J., Bird, C.J., Hymes, B. and H. Vandermeulen. 2018. Les macroalgues de l'île Brier en Nouvelle-Écosse (Canada). Rapp. tech. can. sci. halieut. aquat. 3288: viii + 54 p.

De mai à octobre 2017, des algues marines provenant de 20 sites autour de l'île Brier, en Nouvelle-Écosse, ont été identifiées sur le terrain et en laboratoire. Bien que la plupart des sites étaient des littoraux rocheux intertidaux, un petit marais salé, un herbier de zostère marine ainsi qu'un échantillonnage infratidal réalisé par plongée en apnée et avec tuba ont été inclus dans l'étude. Les algues de l'île Brier comptaient 152 espèces et variétés, dont 62 algues rouges, 44 algues vertes et 44 algues brunes; 2 des espèces repérées appartenaient au groupe *Xanthophytes*. Au total 4 espèces ont été observées pour la première fois dans l'est du Canada : *Cladophora liniformis, Colaconema bonnemaisoniae, C. endophytica* et *Elachista stellaris*. Elles avaient toutes été signalées précédemment en Nouvelle-Angleterre. La flore comprenait 8 espèces non indigènes, dont *Colpomenia peregrina* et *Bonnemaisonia hamifera* (toutes deux aux stades gamétophytique et tétrasporophytique) étaient abondantes à 2 sites ou plus. L'espèce envahissante *Codium fragile*, sous-espèce *fragile*, était présente sous la forme d'un seul spécimen dérivant. L'île Brier, dont le nombre d'algues rouges est relativement supérieur à celui des autres espèces, possède une plus grande richesse en espèces que les régions de taille semblable des Maritimes et un indice de qualité floristique de Cheney de 2.4.

INTRODUCTION

The marine macroalgal flora of Brier Island was initially investigated by Edelstein *et al.* (1970) as part of a detailed floristic and seasonal study of Digby Neck and adjacent Long and Brier Islands. While the Brier Island flora was not listed separately, the subsequent review of seaweed distributions for the Bay of Fundy by Wilson *et al.* (1979) mapped 66 species from Brier Island including 30 Rhodophyta, 9 Chlorophyta and 27 Phaeophyceae. No comprehensive account of the algae followed, although more focused observations of individual species and single sites were undertaken as part of more geographically wide-ranging studies. For example, Novaczek and McLachlan (1989) carried out a single transect on Brier Island at North Point, as part of an extensive transect study of rocky intertidal shores of the Maritime provinces. However, the results for Brier Island were merged with those of other sites in the outer Bay of Fundy. Further physiological and ecological studies were carried out on *Palmaria palmata* (e.g. Garbary *et al.* 2012), *Prasiola stipitata* (Kang *et al.* 2014); *Ascophyllum nodosum* and *Vertebrata lanosa* (Garbary 2017a); and *P. crispa* (Garbary and Hill 2017). There are complementary floristic studies from the western side of the Bay of Fundy in both Canada and the United States of America. These include South *et al.* (1986) for Passamaquoddy Bay, Bates *et al.* (2009) for coastal New Brunswick, Mathieson *et al.* (2009) for Cobscook Bay, Maine, and Mathieson (2018) for northeastern coastal ('downeast') Maine. Here we present a list of the seaweeds of Brier Island based on sampling from May to October 2017, and discuss our findings in the context of seaweed distributions in the Maritime Provinces and adjacent northeastern United States. This new species list provides a detailed account for an area that has received little attention for about 50 years.

2.0 MATERIALS AND METHODS

2.1 Area Description

Brier Island has a circumference of about 24 km (Fig. 1). It has a boreal climate, and as a consequence of being surrounded by the cold waters and large tides of the Bay of Fundy, its maritime climate tends to have cooler summers and milder winters than the rest of Nova Scotia. The island is sparsely settled with a single community of Westport (population *ca.* 220), where economic activity focuses on fishing and ecotourism. Much of the terrestrial landscape consists of secondary growth of boreal forest (mostly black spruce) undergoing secondary succession from abandoned agricultural and logging activity. There are extensive peatlands, some of which are inhabited by *Geum peckii* (Blaney 2010, Larue 2016, Hill *et al.* 2018). The western side of the island has a fringe of coastal heaths in which the invasive *Rosa rugosa* Thunberg has become abundant (Fig. 2) and is outcompeting both herbaceous and shrubby vegetation on the coastal fringe (Garbary *et al.* 2013).

The bedrock is the endpoint of a basalt ridge that extends 200 km along much of the southern shore of the Bay of Fundy (Roland 1982). The intertidal zones (Tables 1, 2) are mostly exposed basalt bedrock and boulder fields (Figs. 2, 3) with numerous rock pools (Figs. 4-6). The shores include steep cliffs rising about 10 m above the intertidal zone, gently sloping shores comprising boulder fields (Figs. 3, 7-9), a single sandy beach (Fig. 10), and some muddy-gravel shores associated with the village of Westport (Fig. 11). A salt marsh (*ca.* 2 ha) on the landward side of the main road at Westport is part of the drainage from the eutrophic Big Meadow Bog into the ocean. In addition, two tiny remnants of salt marsh (each *ca.* 20 x 10 m) dominated by *Spartina alterniflora* Loisel. remain on the seaward side where Big Meadow Bog drains into Grand Passage via a culvert (Fig. 11). A single eelgrass bed occurs in the low intertidal and shallow subtidal zone at Westport and is bounded on the seaward side by an active salmon aquaculture facility (Fig. 11). Artificial substrata of concrete at the government wharf and ferry terminal, a floating dock in the main harbour, and numerous pilings associated with fishing industry wharfs and fish shacks provide extensive wood substrata. Remnant pilings from the destruction caused by the February 2, 1976 Groundhog Day gale are also scattered along the shorefront of Westport.

2.2 Sampling

Marine algae were collected between May and October 2017 around Brier Island (Fig. 1, Tables 1, 2). The primary sites (i.e., Western Light, Little Pond Cove, Big Pond Cove, Northern Light, Westport shore and eelgrass bed) were visited multiple times. One to three people visited a site on a tide and attempted to collect all of the species present. Field work was carried out such that collections were undertaken during periods that overlapped with spring tides. Arrival at each intertidal site was typically planned for about 60-90 min before low water, and lasted until about 30 min after low water. Repeated visits to each site allowed collectors to become familiar with individual rock pools and rock outcrops so that specific microsites with particular species could be examined. Collecting effort was concentrated in rock pools and the lower intertidal zone (to *ca.* 1 m above chart datum) where species richness is highest. Many conspicuous algae were simply noted in the field at each site, and general collections were taken to a field laboratory on Brier Island to identify species requiring microscopic evaluation, and to examine large plants for epiphytic and endophytic taxa. Algae were typically processed while fresh, with voucher specimens prepared for deposit in regional herbaria at ACAD and STFX. Microscopic species were prepared as semi-permanent slides in 40% clear corn syrup. Subtidal collections were carried out by snorkeling at low water in July, and some additional collections were made in late August and early September by SCUBA divers from the Department of Fisheries and Oceans collecting at *ca.* 10 m depth (Table 1). We used the floristic index of Cheney [1977; = (#green algae + # red algae) / # brown algae] to compare other regional floras.

Mathieson and Dawes (2017) was the primary resource for keys and descriptions, although Brodie *et al.* (2007) was especially useful for green algae, Bird and McLachlan (1992) for red algae, and Fletcher (1987) for brown algae. Keys in Sears (1998) and Villalard-Bohnsack (2003) were also useful. Authorities for all algal species identified are given in Appendix 1.

3.0 RESULTS

3.1 Site Descriptions

There were four primary ecological units associated with the intertidal zone of Brier Island: (1) the built environment along the shorefront along Westport village, (2) the salt marsh associated with the drainage of the Big Meadow Bog, (3) the bed of *Zostera marina*, and (4) the rocky intertidal starting at the northwestern limit of Westport village and extending clockwise around North Point, along the entire western and southern shore of the island to Gull Rock Point. Individual sites associated with ecological units are further described below, with number #4 being discussed as five separate collecting sites: Northern Light, Pero Jack Cove, Western Light, Little Pond Cove and Big Pond Cove (Table 2, Appendix 1).

Northern Light (Figs. 4-6)

Northern Light extended about 200 m parallel to the shore and had an intertidal zone that varied from 60-145 m long. The eastern and western sides of the site consisted of large expanses of basalt bedrock with tidal pools at various elevations. The upper pools were shallow and had extensive populations of green ulvalean algae. The extensive intervening beach was a large boulder field with shallow pools mostly covered in ulvoids and filamentous green algae (upper shore). Scattered boulders had extensive populations of *Porphyra / Pyropia* that merged into denser fucoid populations (mid shore) with diverse green, red and brown macrophytes. The low intertidal and shallow subtidal zones had a fringe of laminarians (*Alaria, Laminaria*, and *Saccharina*) with occasional fronds of *Saccorhiza*.

The high intertidal zone had several large boulders with various filamentous, sheet and tubular green algae, and one of these rocks had the only population of *Pseudothrix borealis* (44°17.21’N, 66°20.62’W). There was a large population of *Prasiola stipitata* (44°17.21’N, 66°20.62’W) that remained conspicuous throughout the summer and early fall despite the unshaded conditions. Northern Light was the only site that had all species and subspecies of *Fucus* identified for the island: *Fucus distichus subsp. distichus, F. distichus subsp. edentatus, F. distichus subsp. evanescens, Fucus spiralis,* and *Fucus versiculosus*. Populations of the high rock pool *F. distichus subsp. distichus* were uncommon and limited to a few pools; *F. spiralis* was often uncommon and easily confused with upper intertidal forms of *F. vesiculosus*. Several large rock pools (e.g. 44°17.24’N, 66°20.37’W) had particularly lush populations of kelp and the filamentous green alga, *Chaetomorpha melagonium*.

Northern Light had 99 identified species with 14 species found only here (Table 4). This was the most species-diverse site. Although Table 4 includes Pero Jack Cove and Western Light with Northern Light, all the species and unique species occurred at the latter site (except for the terrestrial *Prasiola crispa* at Western Light, Garbary and Hill 2017).

Pero Jack Cove

Pero Jack Cove (known locally as Peajack Cove) had an extensive cobble and boulder beach with large outcrops of bedrock rising at least 10 m on the eastern and western sides of the cove. There was a small streamlet that drained a wetland/heath system; where this flows over the upper reaches of the intertidal there were extensive populations of bladed and filamentous green algae. Fucoids dominated the midshore and there was a diverse mixture of red perennials and kelp species. Several pools near low water had extensive populations of *Bonnemaisonia hamifera* (both gametophytes and tetrasporophytes).

Western Light (Fig. 7)

The collection site near Western Light comprised a well-defined cove with bedrock reefs and islets 100-150 m offshore providing wave protection. The cliffs and west-facing shore provided extensive protection from summer insolation, with an intertidal zone up to 100 m wide. The site provided a mix of bedrock outcrops up to 10 m high, an extensive boulder field covered in fucoids (mostly *Ascophyllum nodosum*) and a rock platform in the low intertidal zone with high algal diversity. Several high intertidal rock pools had high algal diversity. Over the entire survey about 75 species were found. Despite the high diversity, there were no unique species present A population of large (up to 25 cm diameter) *Colpomenia peregrina* was the most distinctive feature of the site.

Little Pond Cove (Figs. 8-9)

Only the eastern portion of Little Pond Cove was explored. With an intertidal zone of over 500 m, this gently sloping shore provides the largest single rocky intertidal expanse on Brier Island. In its upper reaches it is an extensive boulder field with dense populations of fucoid algae in which there are numerous shallow 10-30 cm deep pools up to 5-8 m in maximal extent. The pool bottoms comprised a mix of densely packed sand/gravel to bedrock. The eastern side of the cove has a basal ridge 2-4 m high above the adjacent tidal flats, with occasional promontories elevated above the high tide mark. This ridge separated Little Pond Cove from Big Pond Cove. With 88 species, this site had the second highest species richness.

Big Pond Cove (Fig. 10)

While Big Pond Cove is bounded on the eastern and western sides by cobble/boulder fields, the north part of the cove consists of a sandy beach that forms a barrier with Big Pond. Seasonally, there is typically a shallow channel that provides drainage from Big Pond that is successively opened and closed by wave action. In the summer of 2017 the channel did not open and there was flooding of the shores. While storm action might introduce seawater into Big Pond, there was no conspicuous growth of marine or brackish-water seaweed. The barrier beach and its approaches from the west have become extensively colonised by invasive *Rosa rugosa* (Garbary *et al.* 2013)

Some collections were made of algae that grew on rocks that emerged from the sand; however, most species listed for this site were drift material. Two species that were found only in the drift based on single thalli were *Codium fragile* (see below) and *Halosiphon tomentosum*.

Gull Rock Point (Fig. 3)

Only a small portion of the shore on Gull Rock Point was explored in this study. This shore comprised *ca.* 200 m facing Big Pond Cove. The site has an almost continuous cover of *Ascophyllum nodosum* on the mid-shore boulders and bedrock outcrops. The lower shore has numerous shallow pools with a substratum ranging from sand to cobble. There were conspicuous clumps of *Ahnfeltia plicata* and dense populations of *Bonnemaisonia hamifera* (both phases) in the July sample. Further exploration towards the tip of the peninsula is required to gain a better picture of biodiversity on this part of the island.

Grand Passage, Westport Village (Fig. 11)

Westport village stretches almost 2.5 km along the shores of Grand Passage, with the entire extent reinforced with a rock wall above the high tide mark to protect the main road and the village from wave exposure and flood tides. *Ascophyllum*- and *Fucus*-covered boulder fields and basal bedrock outcrops dominated the eastern 0.7 km where a steeper slope results in an intertidal zone of *ca.* 30-100 m and includes a stone breakwater and a wharf used both for fishing boats and the whale-watch tourist boats. This was followed by *ca.* 0.2 km of muddy sand around the outlet of the Big Meadow Bog with an intertidal zone of about 300 m that has patches of fucoid-covered rocks and ulvoids in the drainage channel. Barnacles on rocks and pilings, and scattered clam shells on the sediment surface often hosted endozoic green algae, e.g., *Gomontia polyrhiza*. Beginning in the low intertidal is the island's only eelgrass bed (described below). Contiguous with this soft-sediment shore is a tidal salt marsh system.

The next 700 m of shoreline has many fish shacks and wharves and includes the main harbour and the ferry terminal. These structures extend into the intertidal and there were localized boulder fields, numerous algae-covered pilings and concrete walls. While sediment and pollution may limit algal diversity, around 40 species of attached and drift algae were found here on a single intertidal survey. Excluding the eelgrass bed, 56 species occurred over the six-month survey (Appendix 1). These were mostly on scattered rocks or vertical pilings.

North of the ferry terminal there were only a few jetties, and the intertidal zone was only about 50 wide with a substratum of continuous cobble with scattered pilings that are the remains of former jetties. Some boulder fields had extensive populations of *Fucus vesiculosus* and *A. nodosum*. The only population of the introduced brown alga *Melanosiphon intestinalis* occurred on an isolated decaying piling. There was a diversity of natural and man-made substrata. Scattered larger boulders had populations of mixed green and red sheet- or filament-forming algae that were common in the upper intertidal zone and at the base of the shore-reinforcing rock wall.

Westport Eelgrass Bed (Fig. 11)

The single eelgrass bed on Brier Island occurs in the muddy sand substratum at the base of the drainage system for Big Meadow Bog. It starts about 150 m from the top of the shore extends *ca.* 150-200 m parallel to the shore. Its upper reaches comprised plants about 0.5 m in length that were exposed on spring tides. Deeper plants have shoots 1 m or more in length. This eelgrass bed was partially bounded on the seaward side by an active salmon aquaculture facility. The full extent of the bed cannot be determined without further mapping from the Grand Passage side.

Eelgrass typically has an extensive epiflora of multicellular algae that are often limited to this substratum. Many of these species were represented among the 29 species identified. This site had the second highest percentage of uniquely occurring species for all of our study sites (28% of species, Table 4). Further collections later in the fall may reveal additional species.

The proximity of the eelgrass bed to the salmon aquaculture cages may be limiting the growth of epiphytic macroalgae. The presence of the salmon cages in this shallow portion of Grand Passage may have led to eutrophication of the eelgrass bed and the subsequent growth of extensive epiphytic chain-forming diatoms may have limited macroalgal diversity.

Big Meadow Bog Salt Marsh (Fig. 11)

The Brier Island salt marsh system comprises two tiny fragments of *Spartina alterniflora* marsh (each about 200 $m^{2,}$) in the upper intertidal (on the harbour side of the road) and a more extensive marsh (*ca.* 2 ha) on the landward side that is part of the drainage system for Big Meadow Bog. Despite the limited extent of the marsh, a number of habitat specific seaweeds occurred on driftwood, mud surfaces, and rocks, and as floating mats in a large pool. A total of 12 species were found. Of these, three green algae (*Capsosiphon fulvescens*, *Cladophora liniformis* and *Ulva torta*) and two *Vaucheria* species were found only in this habitat. Some habitat generalists occurred here as well as being associated with rocky shores, i.e., *Blidingia minima*. While occasional drift fronds of *Ascophyllum nodosum* and *Fucus vesiculosus* were found, the salt marsh ecads of these species were not observed (e.g. *A. nodosum* f. *scorpioides*; *F. vesiculosus* f. *volubilis*).

Several factors will impact the integrity of the salt marsh systems. The small beds *Spartina* on the Grand Passage shore is deteriorating likely as a result of sea level rise. There are areas where the *Spartina* is no longer living and the remnant root/rhizome system of non-living peat is exposed. Interior pools with their scarped margins and exposed rhizomes suggest that the peat is being diminished from within. The main salt marsh is not pristine in that some infilling has occurred and the drainage system is eutrophic as a result of a large colony of Herring Gulls (up to 3000 pairs) that has nested in Big Meadow Bog (BMB) each summer since 1980 (Hill *et al.* 2018). Mobilisation of methyl mercury from decomposition of the gull guano is also occurring (Kickbush *et al.* 2018). Restoration of the bog by the damming of drainage ditches should restore the bog hydrology and reduce the effects of the gulls. Further study of the algae is warranted to evaluate changes in community structure as the nutrient status of BMB moves toward its pre-gull state.

As of spring 2018, a boardwalk is being constructed through the salt marsh as a contribution to public education and ecotourism. Long-term impacts of construction and human incursions into the marsh will remain to be determined.

3.2 Floristic Summary

Over 1,100 identifications of 152 species and varieties of marine and brackish water macroalgae were recorded from Brier Island (Appendix 1). These species included 62 red algae, 44 green algae, 44 brown algae, and two species of *Vaucheria* (Xanthophyceae). Of these species, over 35 were new for Digby Neck, 12 were new for the Bay of Fundy, and three were new records for Canada (Table 3).

Three distinct intertidal habitats were explored: (1) the rocky intertidal zone of the west side of the island, (2) the bed of *Zostera* in Grand Passage, and (3) the salt marsh at Westport. The majority of species occurred on the rocky west side (121 species with 69 exclusive), 38 species (8 exclusive) were found in the eelgrass bed, and 15 species (7 exclusive) were found in the salt marsh (Appendix 1). Two species, *Melanosiphon intestinalis* and *Peyssonnelia rosenvingii* were found only on artificial structures in Westport village; the former was associated with an old piling north of the ferry terminal, and the latter grew on concrete at the ferry terminal.

Two intriguing endophytic algae were found for the first time in eastern Canada: *Colaconema endophyticum* and *C. bonnemaisoniae* (Figs. 12, 13). Both species were previously recorded in the northwestern Atlantic Ocean only south of Cape Cod (Mathieson and Dawes 2017). The former species had very small cells (< 10 µm long) and the single parietal chloroplasts were devoid of pyrenoids. The latter species had much larger cells (15-30 µm), each with a single parietal chloroplast and pyrenoid. *C. endophyticum* was found once in *Dictyosiphon foeniculaceus* in the subtidal zone south of Northern Light on the Fundy shore. *C. bonnemaisoniae* was more common and observed ten times in the gametophytic phase of *Bonnemaisonia hamifera*, and was particularly conspicuous in the hooked branches of its host when host tissue was bleached or senescent. While no attempt was made to quantify the occurrence of *C. bonnemaisoniae*, only a few specimens of the host gametophytes were required to find the endophyte. Accordingly, it must be fairly common. Another endobiotic species is the rare *Acrochaetium endozoicum* (Fig. 14). It occurred in a bryozoan epiphytic on *Chaetomorpha melagonium* in a low shore rock pool. This was only the second record of this species in Canada. The single previous Canadian record is from the sublittoral zone of Halifax County (Edelstein *et al.* 1969).

The identification of *Elachista stellaris* was somewhat problematic because the identification keys are based primarily on host identity. Our material was a common epiphyte on *Vertebrata lanosa* and was identified seven times in the collections. The thalli were very small relative to *E. fucicola*, and only 1-2 mm high. A single clump of the host sometimes had five or six thalli. In both Europe and North America, *E. stellaris* is reported from a variety of hosts but neither *Ascophyllum* nor *Fucus* which are regarded as the only hosts for *E. fucicola* (Fletcher 1987, Mathieson and Dawes 2017). Host switching of *E. fucicola* onto *V. lanosa* remains a possibility.

Two species of *Vaucheria* were present in the salt marsh: *V. intermedia* and *Vaucheria* sp., which, in the absence of gametangia, could not be identified to species. Its narrow filaments (*ca.* 20 µm) and the absence of summer reproduction suggest *V. minuta* Blum & Conover, but further collections are needed to confirm this identification (see Mathieson and Dawes 2017).

Cladophora liniformis (Figs. 15, 16) formed an extensive floating mat in a high pool in the salt marsh at Westport, where it was the dominant species and mixed with *Ulva torta* (new for Digby Neck). *C. liniformis* was not previously recorded from Nova Scotia, and previous records from eastern Canada were questioned by South (1984).

DISCUSSION

Species richness in the Maritime Provinces and Gulf of Maine

The 152 species and varieties of seaweeds identified on Brier Island in 2017 show a relatively diverse flora in a limited geographic area. This is 60% the 254 species of red, brown and green seaweeds for the Bay of Fundy reported by Wilson *et al.* (1979) for New Brunswick and Nova Scotian shores through to Cape Sable Island (Table 5). This difference in species richness can be explained by the much larger area and greater diversity of habitats in the Bay of Fundy as a whole. In addition, the Wilson *et al.* inventory included historical collections made over more than 50 years; thus, the greater likelihood of including rare taxa.

A primary objective of this work was to compare the current flora on Brier Island with the detailed study by Edelstein *et al.* (1970). This was based largely on collections from Digby Neck, with only limited sampling undertaken on Brier Island. The species identified in that study and other incidental collections on Brier Island in the intervening years were mapped by Wilson *et al.* (1979). While the algal distributions from Edelstein *et al.* (1970) for Brier Island (as given in Wilson *et al.* 1979) were clearly limited because of collection intensity, many of those species can reasonably be expected to occur on Brier Island today. This list includes five brown algae: *Punctaria tenuissima* (C.Agardh) Greville [as *Desmotrichum undulatum* (J.Agardh) Reinke], *Entonema polycladum* (Jaasund) Jaasund, *Eudesme virescens* (Carmichael ex Berkeley) J.Agardh, *Microspongium globosum* Rienke, and *Myriotrichia clavaeformis* Harvey (as *M. filiformis* Harvey). A sixth species *Stragularia clavata* (Harvey) Hamel (as *Ralfsia bornetii* Kuckuck) is now considered to be the sporophytic phase of Scytosiphonaceae (see Mathieson and Dawes 2017). In addition, there were one green alga, *Ulva rigida* C.Agardh, and three red algae, *Harveyella mirabilis* (Reinsch) F.Schmitz & Reinke, *Hydrolithon farinosum* (J.V.Lamouroux) Penrose & Y.M.Chambelain, and *Leptophytum leave* Adey. Most of these algae could reasonably be expected to occur on Brier Island. Of these, *Hydrolithon farinosum* is typically found as an epiphyte on *Zostera marina* Linnaeus during fall and winter (Mathieson and Dawes 2017), for which we had only limited collections.

South *et al.* (1988) reported 176 species from Passamaquoddy Bay. While this was more than the 150 species we found on Brier Island, theirs was over a collection area at least several orders of magnitude greater, and encompassing habitats (e.g., estuaries) not found on Brier Island. Their study was based also on extensive subtidal sampling via SCUBA with experienced phycologist-divers, including a specialist on crustose coralline algae. Moreover, the total for that list included many species that were not found specifically in the study area but were assumed to be present based on reports from the outer Bay of Fundy. While more species might be found on Brier Island with winter collections and more extensive subtidal sampling, our number of summer species is unlikely to be significantly increased.

The bed of *Z. marina* has endured two major environmental impacts since the 1970s that could well have limited species richness. The first was storm damage from the Groundhog Day gale (2/2/1976) that destroyed the waterfront of Westport and sent seawater across 3 km of the island through the low-lying Big Meadow Bog. This would have severely impacted the eelgrass bed. Subsequently, a salmon aquaculture facility was installed adjacent to the *Z. marina* bed, with possible effects on trophic levels. The extensive diatom growth we observed on leaf blades may have limited colonisation of epiphytic macroalgae. Even in its current state, *Z. marina* provided a habitat for 38 species, mostly as leaf epiphytes. The single collection of *Derbesia marina* was an unattached mat from within the eelgrass bed. Should storm action or sea-level rise cause a major breach in the barrier beach at Big Pond Cove, this would create a large area suitable for colonisation by *Z. marina* and its epiphytes.

Some species that we did not record for Brier Island relative to the Edelstein *et al.* (1970) inventory may result from algal seasonality. Hence *Porphyra linearis* Greville, *Ulvella parasitica* (Oltmanns) R.Nielsen, C.J.O'Kelly & B.Wysor (as *Acrochaete*), and *Chlorochytrium dermatocolax* Reinke were found only in the winter, and this may explain why these species were not found in the current study.

In Nova Scotia and the southern Gulf of St. Lawrence, three additional species lists of marine algae have been compiled for limited geographic areas: Bras d'Or Lake, Pomquet Harbour, and the north shore of Prince Edward Island (Table 5). These sites have radically different geology (Roland 1982), tidal and temperature regimes, and extensive winter ice relative to Brier Island. All have lower diversity (85 to 131 species) even though Bras d'Or Lake and Prince Edward Island have much greater cpastlines. Only Cobscook Bay in Maine, with a much larger coastline, has an equivalent species richness to Brier Island (148 vs 152).

The Cheney (1977) index for the floras in Table 5 ranges from 1.6 to 2.4, suggesting that these floras are all boreal, with cold-water affinities. It is of note that Brier Island has the highest value (2.4), with Cobscook Bay close at 2.2. This suggests that the Brier Island flora is underrepresented in brown algae. The inventories of species in Edelstein *et al.* (1970) and Wilson *et al.* (1979) recorded from Digby Neck that were not found in the current study include ten green algae, 24 brown algae, and nine red algae. Should all of these species occur as well on Brier Island it would raise the species number to 184, more than the 176 species from Passamaquoddy Bay on the opposite side of the Bay of Fundy. In addition, it would lower the Cheney index to 1.8, consistent with other regional floras.

While the Edelstein *et al.* (1970) algal list for Brier Island (as given in Wilson *et al.* 1979) was clearly limited because of collection intensity, many of those species can reasonably be expected to still occur on Brier Island (Appendix 2). This list includes six brown algae: *Desmotrichum undulatum*, *Entonema polycladum*, *Eudesme virescens*, *Microspongium globosum*, *Myriotrichia clavaeformis*, and *Stragularia clavata* (as *Ralfsia bornetii*). There were one green alga, *Ulva rigida*, and three red algae: *Harveyella mirabilis*, *Hydrolithon farinosum*, and *Leptophytum leave*. Most of these could reasonably be expected to occur on Brier Island. One problematic species is *Hydrolithon farinosum* that is typically found as an epiphyte on *Zostera marina* (Mathieson and Dawes 2017). The bed of *Z. marina* had two major environmental impacts; the first would have been storm damage from the Groundhog Day Gale (Feb. 2, 1976) that destroyed the waterfront of Westport and sent seawater across 2.1 km of the island through the low-lying Big Meadow Bog. The only potential habitats for *Z. marina* are the shallow waters of Westport Cove and Big Pond Cove at the coastal areas adjoining Big Meadow Bog. Subsequently, a salmon aquaculture facility was installed adjacent to the site occupied by the current bed of *Z. marina,* and extensive diatom growth on these shoots may be limiting colonisation of epiphytic macroalgae onto the eelgrass leaves.

Seaweed phenology

It was beyond the scope of this work to provide a detailed account of seaweed seasonality and phenology. Since a number of species were identified only once, e.g. *Acrochaetium endozoicum* and *Pseudothrix groenlandica*, it is difficult to interpret seasonal patterns. The upper intertidal and splash zones had greater algal cover in May and June, and small-bladed and filamentous green algae became sparser in late summer (e.g. *Prasiola stipitata*). The brown alga *Isthmoplea sphaerophora* was common in May and June, and was apparently absent later in the summer. Filamentous Ceramiaceae, e.g. *Antithamnionella floccosa* and *Scagelia pylaisaei* also declined in abundance in late summer. See Edelstein *et al.* (1970) for more extensive accounts of seasonality and reproductive phenology on Digby Neck, and Mathieson & Dawes (2017) for a regional perspective.

Introduced seaweeds

Mathieson and Dawes (2017) provided a list of 32 introduced species for the northwest Atlantic Ocean. Seven of these were found on Brier Island: *Codium fragile* subsp. *fragile*, *Colpomenia peregrina*, *Melanosiphon intestinalis*, *Ulonema rhizophorum*, *Bonnemaisonia hamifera*, *Ceramium secundatum*, and *Dumontia contorta* (Table 6). Several of these species appear to be naturalized (e.g., *M. intestinalis*, *U. rhizophorum*, *Ceramium secundatum*, and *D. contorta*) without invasive properties. One non-native, invasive species in Nova Scotia, *Fucus serratus* Linnaeus, that we might have expected, has yet to arrive. The introduction and spread of *F. serratus* in Nova Scotia was discussed by Edelstein *et al.* (1971-1973), and the closest reported populations are in southwestern Nova Scotia, about 50 km south from Brier Island (Wilson *et al.* 1979).

Bonnemaisonia hamifera (Figs. 17, 18)

The abundance of both the tetrasporophytic and gametophytic phases of the introduced species *Bonnemaisonia hamifera* was among the floristic surprises. Neither life-history stage of this species was recorded by Edelstein *et al.* (1970) or Wilson *et al.* (1979) for Digby Neck, and the nearest recorded populations were in the Yarmouth area, about 75 km south from Brier Island. In 2017, it would have been difficult to avoid these tetrasporophytic plants (i.e., the *Trailliella*-phase) in a general collection from any rocky shore on the island where it formed distinct epiphytic ‘pom-pom’ tufts up to several cm in diameter or occurred as scattered filaments in most rock pools. In subtidal collections, it was associated with kelp holdfasts and diverse red algae. Similarly, the gametophytic stage occurred at every site, and fragments were common in the drift or attached via their hooked branches to other macrophytes. In mid- to low-intertidal rock pools it was abundant and seemed to replace the expected populations of *Ceramium virgatum*.

Chen *et al.* (1970) described the vegetative development of gametophytic plants directly from the *Trailliella*-phase, and this might account for the abundance of gametophytes on Brier Island. Alternatively, the abundance of the gametophytic phase of *B. hamifera* might also reflect warming of the Bay of Fundy (Hebert *et al.* 2018). Breeman *et al.* (1988) showed that the life history of *B. hamifera* in Europe was regulated by both temperature and daylength. Tetrasporangia formed when water temperatures were over about 11°C and daylength was less than 12 h of light. We suggest that appropriate conditions for tetrasporangial production had been reached in late summer and fall of 2016, and that the resulting tetraspores produced the gametophytes that we observed in 2017. Whereas tetrasporophytes were present in our mid-May collections, the larger gametophytic phase was not noted until late June. That is, the gametophytes that we observed appeared not to have overwintered as large plants, but must have developed in late spring to early summer. This seems inconsistent with the finding of gametophytes in winter along the Atlantic coast of Nova Scotia (Chen *et al.* 1969). We saw no thalli with male or female gametangia, or cystocarps, although spermatangia, carpogonia and rudimentary pericarps have been recorded from Nova Scotia (Chen *et al.* 1969, 1970; Bird 1980). In addition, none of the tetrasporophytic thalli we observed had produced tetrasporangia by early October. In view of this, it will be interesting to see if gametophytes of *B*. *hamifera* will continue to be as abundant.

Colpomenia peregrina (Fig. 19)

Colpomenia peregrina was abundant at two sites on the west side of Brier Island, at Little Pond Cove and Pero Jack Cove. Formerly, it was considered rare on the Atlantic coast of Nova Scotia (Bird and Edelstein 1978) where it was found only at a few widely separated locations, in the sublittoral zone down to 3-5 m. It has since become a regularly occurring species in Halifax County where it is brought up by SCUBA divers (B. Hymes personal communication). On Brier Island the species was found in July-August at low water on spring tides, attached to *Mastocarpus stellatus* and *Corallina officinalis,* with many thalli out of the water. Thalli were up to 20 cm in diameter. Despite considerable wave exposure on the west side of the island, the two locations were protected from waves by offshore rock outcrops and nearby headlands. Green *et al.* (2012) described the southward extension of *C. peregrina* in the northwest Atlantic Ocean, and it now occurs as far south as Cape Cod. The findings on Brier Island represent an almost 100 km extension of the distribution from previous records in southwestern Nova Scotia. The abundance of *C. peregrina* may suggest aggressive colonisation, as the species is considered a potential oyster-thief in Maine (Green *et al.* 2012) and the Mediterranean Sea (Verlaque *et al.* 2015). However, with its general lack of robustness in thallus structure, it is unlikely to become an aggressive invasive species on the exposed shores of Brier Island.

Melanosiphon intestinalis

Melanosiphon intestinalis, first reported by Edelstein *et al.* (1970a, b) as a new record for eastern North America from Digby Neck, is now known from Long Island (New York) to Labrador (Mathieson *et al.* 2008; Mathieson and Dawes 2017). On Brier Island, it was found on a single exposed piling in Westport village, and fronds were 1-2 cm long. One of us (CJB) recalls that this species was previously abundant on the wall of the local ferry terminal (*ca.* 1970). Extensive searches there and elsewhere on Brier Island failed to locate additional populations. In addition, thalli were mostly less than 1.5 cm long and about 1 mm wide, suggesting that the species may be on the verge of extirpation from environmental or competitive interactions.

Codium fragile subsp. *fragile*

Codium fragile subsp. *fragile* has an extensive distribution along the Atlantic Coast of Nova Scotia from Yarmouth to Canso and in the southern Gulf of St. Lawrence (Watanabe *et al.* 2010). These distributions were likely based on independent introductions in Mahone Bay (Bird *et al*. 1993) and Prince Edward Island (Garbary *et al.* 1997, Hubbard and Garbary 2001). We found a single frond (*ca.* 12 cm high) on the last collecting period in October amongst extensive mounds of seaweed wrack at Big Pond Cove. This suggests either that it had been transported a long distance as drift, or that a population on Brier Island had only recently been established. The SCUBA diving by DFO in late August/early September at eight locations found no *C. fragile*; if any populations are present, they are likely to be limited. The nearest known populations are in southwestern Nova Scotia (*ca.* 100 km from Brier Island; Watanabe *et al.* 2010). The species is well established in the Gulf of Maine (Mathieson *et al.* 2003), and the frond on Brier Island may also have arrived via drift from northern Maine where it has been found in Cobscook Bay (Mathieson *et al.* 2010).

Unidentified red crust (Fig. 20)

A single sample of a thin, non-calcified red crust was found by DFO divers at Gull Rock Point at *ca.* 10 m depth. This collection might be the tetrasporophytic, crustose phase of a bladed red alga [e.g. *Turnerella pennyi* (Harvey) F.Schmitz], or a free-living crustose species (e.g. *Cruoria* sp.). Without reproductive structures (e.g. tetrasporangia), this collection cannot be identified based on morphology. Regardless, no similar crust was included in the Digby Neck flora (Edelstein *et al.* 1970).

CONCLUSIONS

For its size, Brier Island provides relatively species-rich communities of marine macroalgae in a limited geographic space. The three main community types of rocky intertidal zone, salt marsh and eelgrass beds all contribute unique species to the overall diversity of over 150 species of seaweeds (Table 4). The limited seasonality of our collecting effort and the previous records of over 40 additional species (Appendix 2) from Brier Island and nearby locations, suggests that the flora suggests may be on the order of 200 species. Given the relative isolation of the western shoreline of the island, its relatively pristine nature, and the already protected nature of key adjacent terrestrial habitats, Brier Island warrants consideration for protection of its coastal marine habitats.

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Table 1. Sites on Brier Island sampled for seaweed biodiversity and sampling dates. Primary sites were visited multiple times on low tides. Secondary sites visited once on poor tide, or by SCUBA. Coordinates indicate approximate midpoint on the shore taken from Google Earth. Sites listed counterclockwise from Northern Light. See Figure 1 for locations. All sampling times are from 2017.

Site	Latitude (°N)	Longitude (°W)	Dates sampled (day/month)
Primary sites			
Northern Light	44°19.19’	66°20.64’	13/5, 2/6, 23/6, 27/7, 2/9, 6/10
Pero Jack Cove	44°15.97’	66°22.07’	24/6
Western Light	44°14.94’	66°23.46’	1/6, 22/6, 25/7, 7/10
Little Pond Cove	44°14.35’	66°22.71’	11/5, 25/6, 26/7, 28/8, 8/10
Big Pond Cove	44°14.35’	66°22.28’	12/5, 24/6, 6/10
Gull Rock Point (east side of Big Pond Cove)	44°14.15’	66°22.22’	29/7
Grand Passage (Westport)	44°15.90’	66°20.95’	10/5, 21/6, 22/6, 26/6, 23/7, 28/7, 31/8, 8/10
Westport eelgrass*	44°15.62’	66°20.94’	23/7, 27/8[#], 29/8[#], 7/10
Westport salt marsh*	44°15.56’	66°21.15’	4/6, 22/7, 6/10
Secondary sites			
North of Peajack Cove	44°16.30’	66°21.99’	13/5
Westport, floating dock[1]	44°15.50’	66°20.84’	21/6
Hog Cove	44°13.92’	66°22.23’	21/6
Peters Island[#]	44°15.52’	66°20.19’	27/8
Gull Rock[#]	44°11.28’	66°25.21’	28/8
Whipple Point[#]	44°14.38’	66°22.96’	28/8
Gull Rock[#]	44°12.29’	66°23.90’	28/8
Northwest Ledges[#]	44°21.09’	66°21.77’	29/8
Seal Cove[#]	44°17.26’	66°20.75’	29/8

Gull Rock (east side)#	44°12.80’	66°23.10’	30/8
Gull Rock (west side)#	44°12.84’	66°23.32’	30/8
North Point (east side)	44°16.90’	66°20.46’	3/9

*Coordinates from centre of habitat/site

#DFO SCUBA sampling

[1]floating dock pulled ashore – unknown provenance

Table 2. Summary of primary physical features of sampling sites. Width of site refers to portion of shore explored. Site length refers to the length of the intertidal zone.

Site	Width of site (m)	Site length (m)	Primary substratum	Comments
Northern Light	180	140	Boulder fields, bedrock, tidal pools	Most wave-exposed site
Pero Jack Cove	80	100	Boulder field, bedrock, freshwater inflow	
Western Light	50	75	Boulder field, bedrock	Extensive platform at low water, extensive shade
Little Pond Cove	100	500	Boulder field, bedrock, numerous shallow pools	Wave-protected by ridges of bedrock
Big Pond Cove	400	wrack	Sandy gravel beach with some cobble	Used for wrack collection
Gull Rock point	200	60	Boulder field with low pools	
Grand Passage (Westport)	1500	50-100 m	Boulder fields, mud, wood pilings, concrete walls, floating dock	Low wave-exposure
Westport eelgrass bed	>100	N/A	Eelgrass in muddy sand	Requires spring tides
Westport salt marsh	100	150	Marsh mud/peat, sides of drainage channel, high pools with floating mats	Limited exchange via culvert

Table 3. New distribution records for Brier Island and associated geographic areas.

Species	Eastern Canada	Bay of Fundy	Digby Neck	Comment
Chlorophyta				
Blidingia subsalsa?			+	Requires culturing to distinguish from *B. ramifera* (Garbary and Barkhouse 1987)
Capsosiphon fulvescens			+	
Chaetomorpha picquotiana			+	
Chlorochytrium cohnii			+	
Cladophora liniformis		+	+	High marsh pool; new record for Nova Scotia
Codium fragile subsp. *fragile*		+	+	Single drift specimen
Derbesia marina			+	
Eugomontia sacculata		+	+	
Percursaria percursa			+	
Prasiola crispa		+	+	See Garbary and Hill (2017)
Pseudendoclonium dynamenae			+	
Pseudothrix borealis			+	
Tellamia contorta			+	
Ulothrix laetevirens			+	
Ulothrix subflaccida		+	+	
Ulva torta			+	
Ulvella repens?			+	Endophyte in *Elachista fucicola*
Rhodophyta				
Acrochaetium endozoicum		+	+	Endozoic in bryozoan
Acrochaetium humile		+	+	
Acrochaetium luxurians		+	+	
Acrochaetium minimum		+	+	
Acrochaetium parvulum		+	+	
Bonnemaisonia hamifera			+	Abundant gametophytes and tetrasporophytes
Coccotylus hartzii			+	

Colaconema bonnemaisoniae	+	+	+	Common endophyte in *Bonnemaisonia hamifera*
Colaconema endophytica	+	+	+	Rare endophyte in *Dictyosiphon*
Colaconema daviesii			+	
Erythrotrichia carnea			+	
Lithothamnion glaciale			+	
Pneophyllum fragile			+	
Rhodomela lycopodioides			+	
Rhodophysema georgii			+	
Scagelia pylaisaei			+	
Phaeophyceae				
Colpomenia peregrina			+	Abundant at several sites
Dictyosiphon eckmannii?			+	
Ectocarpus siliculosus var. *pygmaeus*			+	
Elachista stellaris?	+	+	+	Epiphyte on *Vertebrata lanosa*
Sphacelaria rigidula?			+	
Spongonema tomentosum			+	
Xanthophyceae				
Vaucheria intermedia		+	+	
Vaucheria sp.	?	?	+	Non-reproductive

Table 4. Total number of species at each site and number of species only at that site (in parentheses). Sites on the western side of the island grouped into sites: 1) from Northern Light to Western Light, and 2) from Little Pond Cove to Gull Rock Point. Note: eelgrass bed and salt marsh are habitats found at but excluded from the counts from the village shore.

Phylum or Class	Northern Light to Western Light	Little Pond Cove to Gull Rock Point	Westport	Eelgrass bed	Salt marsh
Chlorophyta	23 (4)	16 (2)	19 (3)	9 (1)	10 (3)
Rhodophyta	46 (5)	40 (3)	22 (2)	20 (3)	0
Phaeophyceae	31 (5)	32 (4)	15 (3)	(4)	0
Xanthophyceae	0	0	0	0	2
Totals	99 (14)	88 (9)	56 (8)	29 (8)	12 (5)

Table 5. Comparison of the seaweed flora of Brier Island with other localized floristic lists in Nova Scotia, New Brunswick and Maine indicating species numbers of Chlorophyta (G), Phaeophyceae (P), Rhodophyta (R), and Xanthophyceae (X). The Cheney (1977) floristic index, (#R + #G) / #P is provided for each flora (see text for discussion).

Flora	G	B	R	X	Total	Index
Brier Island	44	44	62	2	152	2.4
Digby Neck[1]	33	61	52		146	1.4
Bay of Fundy[2]	62	93	99		254	1.7
Passamaquoddy Bay[3]	45	58	68		171	1.9
Cobscook Bay[4]	38	46	64		148	2.2
New Brunswick[5]	16	25	31		72	1.9
Bras d'Or Lake[6]	23	31	31		85	1.7
Pomquet Harbour[7]	39	44	32	5	120	1.6
Prince Edward Island (north shore[8])	19	50	52		131	1.6

[1] Edelstein *et al.* 1970 (duplicate records based on life history phase removed)
[2] Wilson *et al.* 1979
[3] South *et al.* 1988 (numbers based on only summer collections)
[4] Mathieson *et al.* 2010
[5] Bates *et al.* 2009 (numbers based on strictly intertidal observations)
[6] McLachlan and Edelstein 1970
[7] Bird *et al.* 1976
[8] Bird *et al.* 1983

Table 6. Current and projected status of non-native species for northeastern North America found on Brier Island.

Species	Comment
Codium fragile subsp*. fragile*	Single frond in drift; population may not yet be established
Bonnemaisonia hamifera	Both gametophytic and tetrasporophytic plants present and abundant- may be invasive
Ceramium secundatum	Common – appears naturalized
Colaconema bonnemaisoniae	Common endophyte in *B. hamifera*, likely arrived in North America with host gametophytes
Colpomenia peregrina	Abundant at two sites but unlikely to be invasive – appears naturalized
Dumontia contorta	Common and naturalized
Melanosiphon intestinalis	Single small population – may become extirpated
Ulonema rhizophorum	Epiphyte on *Dumontia* – naturalized with host

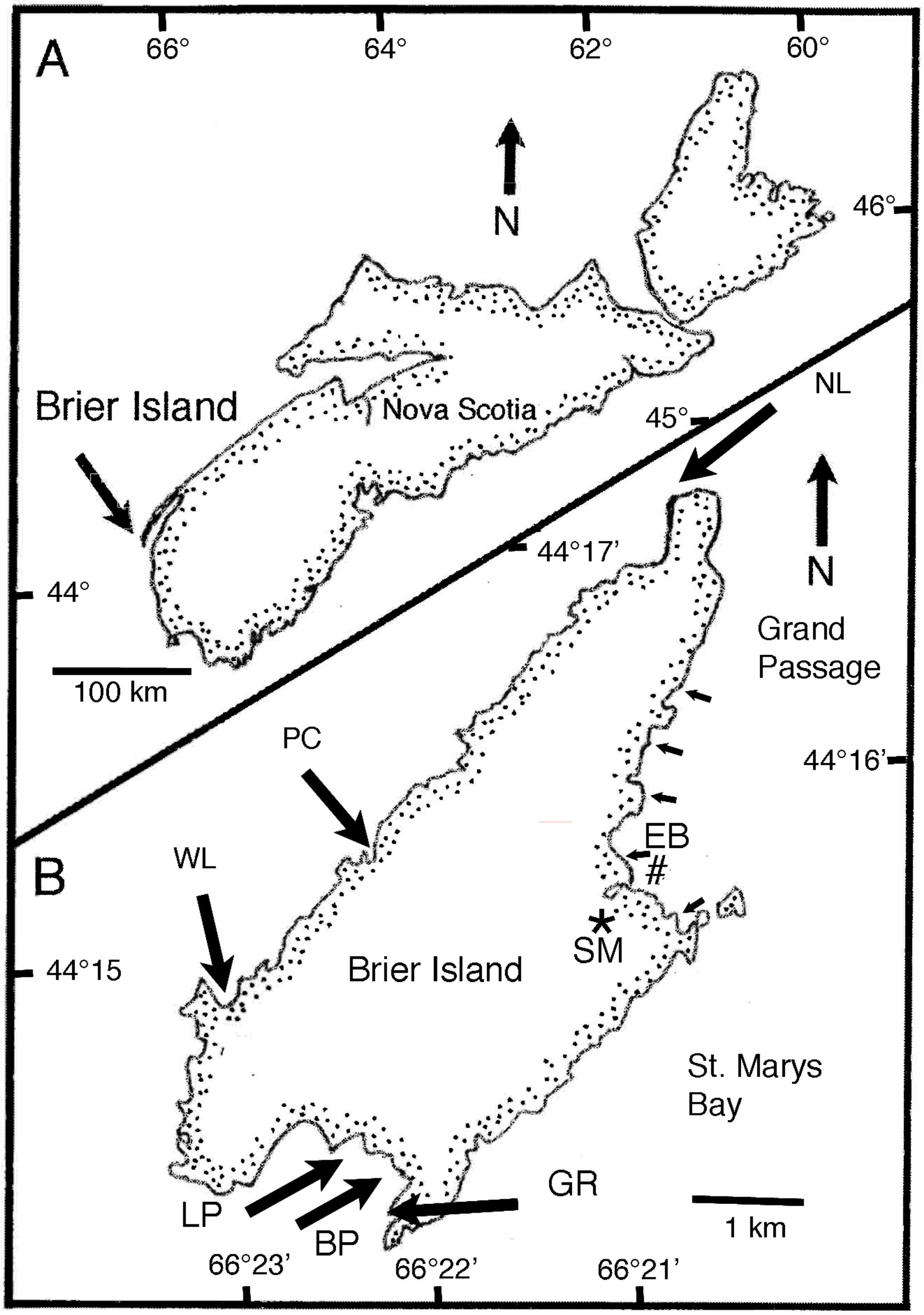

Figure 1. Map of Nova Scotia (A) with Brier Island (B) indicating major collection sites (large arrows) and shoreline of Westport village explored (small arrows). Abbreviations: NL, Northern Light; PC, Pero Jack Cove; WL, Western Light, LP, Little Pond Cove; BP, Big Pond Cove; GR, Gull Rock Point; SM, salt marsh (*); EB, eelgrass bed (#).

Figure 2. Typical coastal fringe on Brier Island with *Rosa rugosa* and basalt bedrock.

Figure 3. Gull Rock Point looking eastward across Big Pond Cove with basalt bedrock and extensive boulder field with dense intertidal populations of fucoids dominated by *Ascophyllum nodosum* and *Fucus vesiculosus*.

Figure 4. Google Earth image of North Point with Coast Guard Station (red roofs) and Northern Light showing extent of shoreline examined (double-headed arrow) and selected rock pools with diverse algae (*) shown in Figures 5-6).

Figure 5. Low intertidal rock pool at Northern Light with emergent *Laminaria digitata*.

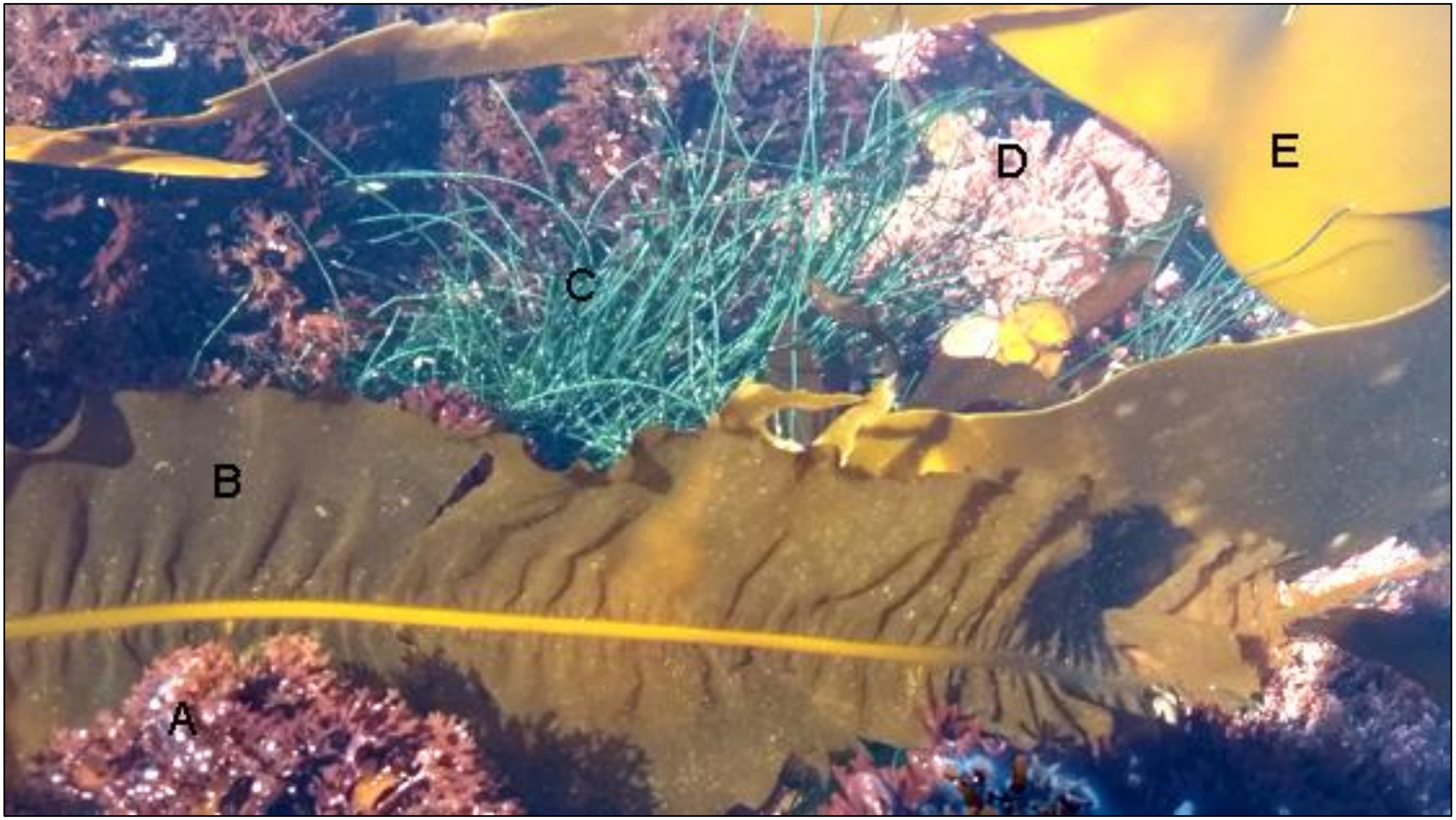

Figure 6. Rock pool at Northern Light with lush growths of *Chondrus crispus* (A), *Alaria esculenta* (B), *Chaetomorpha melagonium* (C), *Corallina officianalis* (D), and *Laminaria digitata* (E).

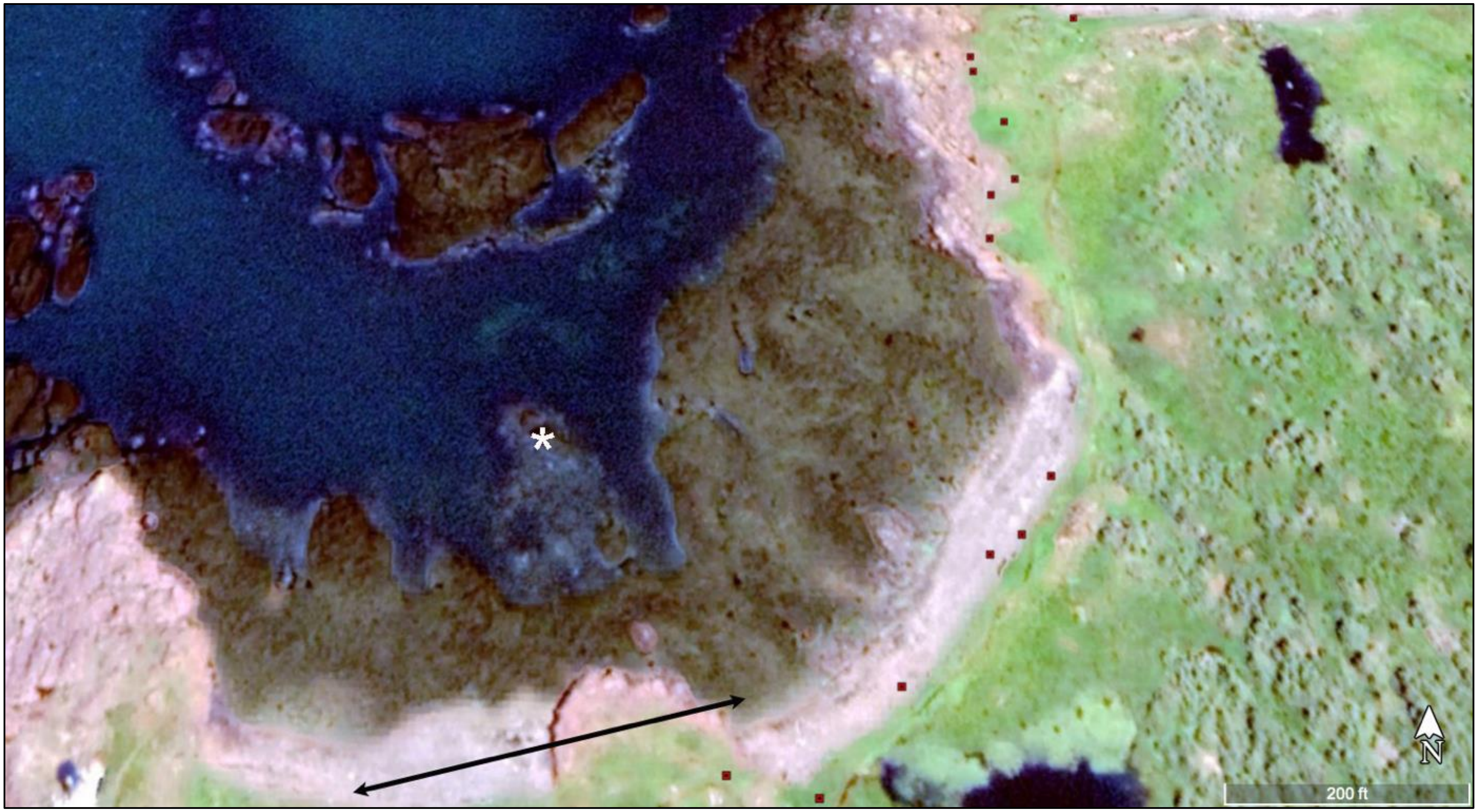

Figure 7. Google Earth image of wave-protected shore at Western Light indicating portion of shore surveyed (double-headed arrow) and platform near low water (asterisk).

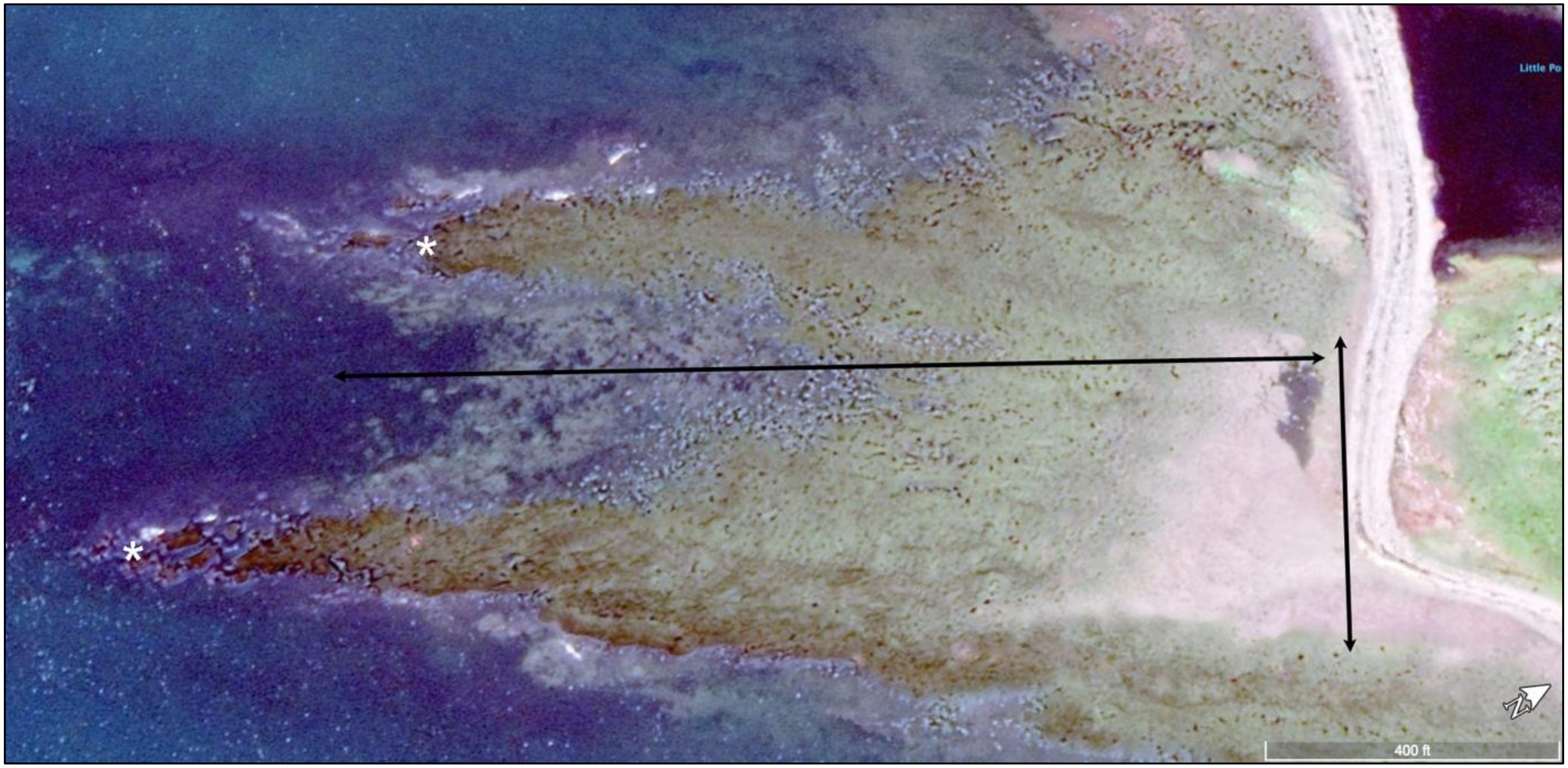

Figure 8. Google Earth image of shore at Little Pond Cove near low water showing extensive intertidal zone (double-headed arrows), numerous rock pools and basalt ridges (*)

Figure 9. Low intertidal zone at Little Pond Cove with numerous pools and a high diversity of algal species.

Figure 10. Big Pond Cove at low tide with abundant wrack showing barrier beach (arrow) with *Rosa rugosa* and seepage (*) from Big Pond; only site where *Codium fragile* was collected (see text).

Figure 11. Google Earth image of portion of Westport village indicating approximate extent of eelgrass bed (double-headed white arrow), two remnant patches of salt marsh (single headed arrows) high pools in salt marsh (*). Note salmon aquaculture cages in Grand Passage.

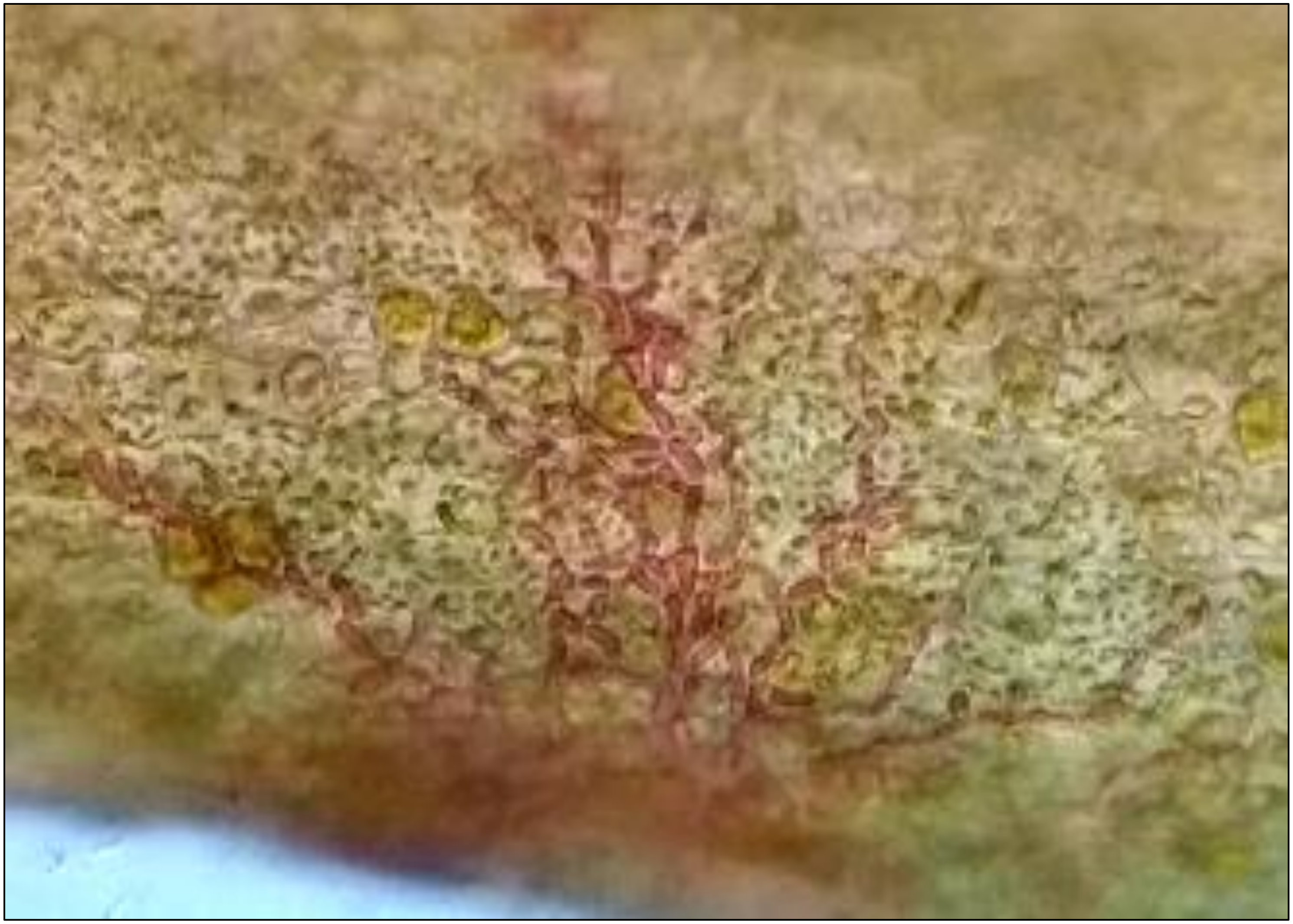

Figure 12. *Colaconema endophyticum* in outer wall of *Dictyosiphon foeniculaceous*. Cells *ca.* 10 µm long each with single chloroplast devoid of pyrenoids.

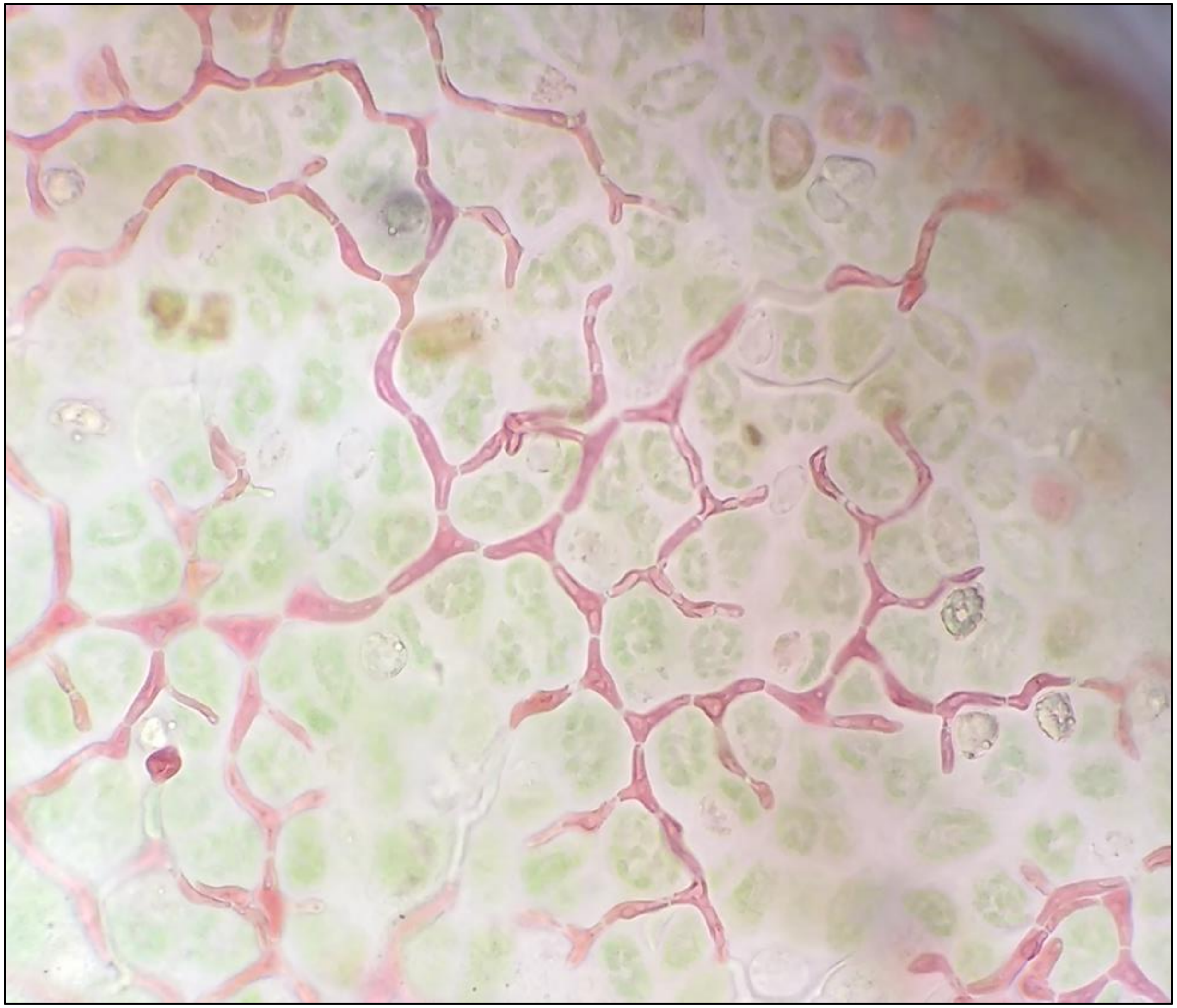

Fig. 13. *Colaconena bonnemaisoniae* in outer wall of *Bonnemaisoniae hamifera*. Cells *ca.* 20-25 µm long, each cell with single chloroplast and pyrenoid.

Figure 14. *Acrochaetium endozoicum* endophytic in outer wall of bryozoan. Individual cells are 5-10 µm long and devoid of pyrenoids.

Figure 15. Floating mat from high marsh rock pool consisting of *Cladophora liniformis* and *Ulva torta*.

Figure 16. Details of branching in *Cladophora liniformis* teased from mat in Figure 15.

Figure 17. Tetrasporophytic stage (*Trailliella*-phase) of *Bonnemaisonia hamifera* showing characteristic ‘pom-pom’ tufts *ca.* 2 cm diameter in rock pool.

Figure 18. Gametophytic stage of *Bonnemaisonia hamifera* in rock pool with the common crustose brown alga, *Ralfsia fungiformis* in background. Red thallus *ca.* 10 cm long and unattached,

Figure 19. *Colpomenia peregrina* attached to various algae and emergent at low water; thalli 5-10 cm diameter.

Figure 20. Unidentified, non-calcified red algal crust. Because it is non-reproductive it is not possible to identify; cells *ca.* 5 µm long.

Appendix 1. List of species of macroalgae and their local distribution on Brier Island in 2017. Note: Eelgrass bed and salt marsh are specific habitats found within Westport which covers the shores along Grand Passage with various natural and built substrates.

Species	Northern Light to Western Light	Little Pond Cove to Gull Rock Point	Westport	Eelgrass bed	Salt marsh
Chlorophyta					
Acrosiphonia arcta (Dillwyn) Gain	P	P			
Acrosiphonia sonderi (Kützing) Kornmann	P				
Acrosiphonia spinescens (Kützing) Kjellman	P	P			
Blidingia marginata (J.Agardh) J.P.L.Dangeard ex Bliding			P		P
Blidingia minima (Nägeli ex Kützing) Kylin	P	P	P		P
Blidingia subsalsa (Kjellman) Kornmann & Sahling ex Scagel			P		
Bolbocoleon piliferum Pringsheim	P				
Capsosiphon fulvescens (C.Agardh) Setchell & N.L.Gardner					P
Chaetomorpha brachygona Harvey	P			P	
Chaetomorpha ligustica (Kützing) Kützing	P	P	P	P	
Chaetomorpha linum (O.F.Müller) Kützing					
Chaetomorpha melagonium (F.Weber & D.Mohr) Kützing	P	P	P		
Chaetomorpha picquotiana Montagne ex Kützing			P	P	P
Chlorochytrium cohnii E.P.Wright			P		
Cladophora liniformis Kützing					P
Cladophora rupestris (Linnaeus) Kützing	P	P			
Cladophora sericea (Hudson) Kützing	P	P			
Codium fragile (Suringar) Hariot subsp. *fragile*		P			
Derbesia marina (Lyngbye) Solier				P	
Eugomontia sacculata Kornmann		P	P		

Gayralia oxysperma (Kützing) K.L.Vinogradova ex Scagel et al.			P	P	
Gomontia polyrhiza (Lagerheim) Bornet & Flahault			P	P	
Monostroma grevillei (Thuret) Wittrock	P	P			
Percursaria percursa (C.Agardh) Rosenvinge					P
Prasiola crispa (Lightfoot) Kützing	P				
Prasiola stipitata Suhr ex Jessen	P	P	P		
Pseudendoclonium dynamenae R.Nielsen	P				
Pseudothrix groenlandica (J.Agardh) Hanic & S.C.Lindstrom	P				
Rhizoclonium riparium (Roth) Harvey)			P		P
Spongomorpha aeruginosa (Linnaeus) Hoek	P				
Tellamia contorta Batters		P			
Ulothrix flacca (Dillwyn) Thuret	P		P		
Ulothrix speciosa (Carmichael) Kützing	P				
Ulothrix subflaccida Wille			P		
Ulva compressa Linnaeus			P		
Ulva intestinalis Linnaeus	P	P	P	P	P
Ulva lactuca Linnaeus	P	P	P	P	P
Ulva linza Linnaeus	P	P			
Ulva prolifera O.F.Müller			P		
Ulva torta (Mertens) Trevisan					P
Ulvaria obscura (Kützing) Gayral ex Bliding	P		P	P	
Ulvella repens (Pringsheim) R.Nielsen, C.J.O'Kelley & B.Wysor		P			
Urospora penicilliformis (Roth) Areschoug	P				
Rhodophyta					
Acrochaetium endozoicum (Darbishire) Batters	P				
Acrochaetium humile (Rosenvinge) Børgesen		P		P	

Acrochaetium luxurians (J.Agardh ex Kützing) Nägeli				P
Acrochaetium parvulum (Kylin) Hoyt				P
Acrochaetium secundatum (Lyngbye) Nägeli	P	P		
Acrochaetium sp.	P			
Ahnfeltia plicata (Hudson) Fries	P	P		
Antithamnionella floccosa (O.F.Müller) Whittick	P	P	P	P
Bangia atropurpurea (Mertens ex Roth) C.Agardh	P			
Bonnemaisonia hamifera Hariot	P	P	P	P
Ceramium deslongchampsii Chauvin ex Duby	P	P	P	
Ceramium secundatum Lyngbye	P	P		
Ceramium virgatum Roth	P	P	P	P
Chondrus crispus Stackhouse	P	P	P	
Choreocolax polysiphoniae Reinsch	P	P		
Choreocolax rabenhorstii Reinsch		P		
Clathromorphum circumscriptum Strömfelt) Foslie		P		
Coccotylus hartzii (Rosenvinge) LeGall & G.W.Saunders	P	P		
Coccotylus truncatus (Pallas) M.J.Wynne & J.N. Heine	P			
Colaconema bonnemaisoniae Batters	P	P		P
Colaconema daviesii (Dillwyn) Stegenga	P			
Colaconema endophyticum (Batters) J.T.Harper & G.W.Saunders	P[1]			
Colaconema minimum (Collins) Woelkerling	P			
Corallina officinalis Linnaeus	P	P		
Cystoclonium purpureum (Hudson) Batters	P	P		
Devaleraea ramentacea Linnaeus) Guiry	P	P		
Dumontia contorta (S.G.Gmelin) Ruprecht	P	P	P	P
Erythrotrichia carnea (Dillwyn) J.Agardh	P	P	P	

Euthora cristata (C.Agardh) J.Agardh	P	P	P	
Fimbrifolium dichotomum (Lepechin) G.I.Hansen	P			P
Hildenbrandia rubra (Sommerfelt) Meneghini	P	P	P	
Lithothamnion glaciale Kjellman	P	P		
Mastocarpus stellatus (Stackhouse) Guiry	P	P	P	P
Meiodiscus spetsbergensis (Kjellman) G.W.Saunders & McLachlan		P	P	
Membranoptera fabriciana (Lyngbye) M.J.Wynne & G.W.Saunders	P	P		
Palmaria palmata (Linnaeus) F.Weber & D.Mohr	P	P	P	P
Peyssonnelia rosenvingii F.Schmitz			P	
Phycodrys rubens (Linnaeus) Batters	P	P		
Phyllophora pseudoceranoides (S.G.Gmelin) Newroth & A.R.A.Taylor ex P.S.Dixon & L.M.Irvine	P	P		
Phymatolithon laevigatum (Foslie) Foslie		P		
Phymatolithon lenormandii (Areschoug) Adey	P	P		
Plumaria plumosa (Hudson) Kuntze	P	P		
Pneophyllum confervicola (Kützing) Y.M.Chamberlain				
Pneophyllum fragile Kützing				P
Polyides rotundus (Hudson) Gaillon	P	P		
Polysiphonia elongata (Hudson) Sprengel			P	
Polysiphonia flexicaulis (Harvey) Collins			P	P
Polysiphonia stricta (Mertens ex Dillwyn) Greville	P	P		P
Porphyra umbilicalis Kützing	P	P	P	P
Ptilota serrata Kützing	P	P		

Pyropia leucosticta (Thuret) Neefus & J.Brodie	P		P	
Rhodochorton purpureum (Lightfoot) Rosenvinge	P		P	
Rhodomela confervoides (Hudson) P.C.Silva	P			
Rhodomela lycopodioides (Linnaeus) C.Agardh		P		
Rhodomela virgata Kjellman	P			P
Rhodophysema elegans (P.Crouan & H.Crouan ex J.Agardh) P.S.Dixon		P		
Rhodophysema georgii Batters			P	P
Rubrointrusa membranacea (Magnus) S.L.Clayden & G.W.Saunders	P		P	P
Scagelia pylaisaei (Montagne) M.J.Wynne	P	P	P	P
Titanoderma pustulatum (J.V.Lamouroux) Nägeli	P	P		
Vertebrata lanosa (Linnaeus) T.A.Christensen	P	P	P	
Wildemania amplissima Kjellman) Foslie (C.Agardh) Foslie	P	P		
Unidentified red crust (non calcified)	P[2]			
Phaeophyceae				
Agarum clathratum Dumortier	P	P		
Alaria esculenta (Linnaeus) Greville	P	P		
Ascophyllum nodosum (Linnaeus) LeJolis	P	P	P	
Asperococcus fistulosus (Hudson) W.J.Hooker		P		
Chordaria flagelliformis (O.F.Müller) C.Agardh	P	P	P	
Colpomenia peregrina Sauvageau	P	P		
Desmarestia aculeata (Linnaeus) J.V.Lamouroux	P	P		P
Desmarestia viridis (O.F.Müller) J.V.Lamouroux	P	P		
Dictyosiphon chordaria Areschoug	P			
Dictyosiphon ekmanii Areschoug				P
Dictyosiphon foeniculaceus (Hudson) Greville	P	P		P

Ectocarpus fasciculatus Harvey	P				
Ectocarpus siliculosus (Dillwyn) Lyngbye	P	P		P	P
Ectocarpus siliculosus var. *pygmaeus* (Areschoug) Gallardo					P?
Elachista fucicola (Velley) Areschoug	P	P	P		
Elachista stellaris Areschoug	P	P	P		
Entonema polycladum (Jaasund) Jaasund		P			
Fucus distichus Linnaeus *subsp. distichus*	P				
Fucus distichus subsp. *edentatus* (Bachelot de la Pylaie) H.T.Powell	P	P			
Fucus distichus subsp. *evanescens* (C.Agardh) H.T.Powell	P	P			
Fucus spiralis Linnaeus	P	P	P		
Fucus vesiculosus Linnaeus	P	P	P		P
Halosiphon tomentosum (Lyngbye) Jaasund		P			
Isthmoplea sphaerophora (Carmichael) Gobi	P				
Laminaria digitata (Hudson) J.V.Lamouroux	P	P	P		
Leathesia marina (Lyngbye) Decaisne	P	P			
Melanosiphon intestinalis (De A.Saunders) M.J.Wynne			P		
Microspongium stilophorae (P.Crouan & H.Crouan) Cormaci & G.Furnari		P			
Mikrosyphar polysiphoniae Kuckuck	P				
Myrionema corunnae Sauvageau		P			
Myrionema magnusii (Sauvageau) Loiseaux *nom. inval.*				P	
Myrionema strangulans Greville		P			
Petalonia fascia (O.F.Müller) Kuntze	P		P	P	
Planosiphon complanatus (Rosenvinge) McDevit & G.W.Saunders				P	
Planosiphon zosterifolius (Reinke) McDevit & G.W.Saunders				P	

Protohalopteris radicans (Dillwyn) Draisma, Prud’homme & H.Kawai			P		
Punctaria latifolia Greville		P			
Pylaiella littoralis (Linnaeus) Kjellman	P	P	P	P	
Ralfsia fungiformis (Gunnerus) Sethell & N.L.Gardner	P	P			
Ralfsia verrucosa (Areschoug) Areschoug	P	P	P		
Saccharina latissima (Linnaeus) C.E.Lane, C.Mayes, Druehl & G.W.Saunders	P	P	P		
Sacchoriza dermatodea (Bachelot de la Pylaie) J.Agardh	P	P			
Scytosiphon dotyi M.J.Wynne			P		
Scytosiphon lomentaria (Lyngbye) Link	P	P	P		
Sphacelaria rigidula Kützing		P			
Sphacelaria spp.	P	P			
Spongonema tomentosum (Hudson) Kützing	P		P		
Xanthophyceae					
Vaucheria intermedia Nordsted					P
Vaucheria sp.					P

Appendix 2. Some species potentially present on Brier Island but not found in current survey. Records from Wilson *et al.* (1979) are only for species given for Brier Island rather than for entire Bay of Fundy.

Species	Wilson *et al.* 1979 (Brier I.)	Edelstein *et al.* 1970 (Digby Neck)
Chlorophyta		
Chlorochytrium dermatocolax		+
Halochlorococcum moorei		+
Ochlochaete hystrix var ferox		+
Ulva rigida	+	+
Ulvella parasitica		+
Ulvella repens		+
Ulvella scutata		+
Ulvella viridis		+
Ulvella wittrockii		+
Urospora wormskoldii		+
Phaeophyceae		
Battersia arctica		+
Coilodesme bulligera		+
Desmotrichum undulatum	+	+
Dictyosiphon macounii		+
Ectocarpus penicillatus		+
Entonema alariae		+
Entonema polycladum	+	+
Eudesme virescens	+	+
Laminariocolax aecidioides	+	+
Laminariocolax tomentosoides	+	+
Leptonematella fasciculata		+
Litosiphon laminariae		+
Microspongium globosum	+	+
Microspongium immersum		+
Microsyphar porphyrae		+
Myriocladia clavaeformis	+	+
Petroderma maculiforme		+
Punctaria plantaginea	+	+
Sorapion kjellmannii		+
Sphacelaria cirrosa		+
Sphacelaria fusca		+
Streblonema fasciculatum		+
Streblonema infestans		+
Streblonema parasiticum		+

Rhodophyta		
Antithamnion cruciatum		+
Ceramium diaphanum var. elegans		+
Choreocolax rabenhorstii		+
Clathromorphum circumscriptum		+
Halosacciocolax kjellmanii		+
Halosacciocolax lundii		+
Harveyella mirabilis	+	+
Odonthalia dentata[1]		+
Porphyra linearis		+

[1] Not listed in Edelstein et al. (1970) but shown for Digby Neck in Wilson et al. (1979)