# THE TWIN BAYS INITIATIVE:
# THE POTENTIAL FOR A NEARSHORE PROTECTED AREA IN ST. MARGARET'S BAY

## AN ECOLOGICAL ASSESSMENT

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## NEARSHORE ECOSYSTEMS: THE POTENTIAL FOR CONSERVATION

The importance of marine and coastal environments for Canada cannot be overemphasised. Three oceans border this country along more than 243 000 kilometres of coastline. Approximately 5 million square kilometres of water fall within Canadian jurisdiction. For hundreds of years, such expansiveness and vastness was equated with boundlessness – both in terms of the oceans' resources and its ability to be unaffected by anthropogenic assaults. We are now learning that this is not the case. Over-exploitation, ocean dumping, nutrient input, introductions of exotic species, and the physical destruction of coastal and aquatic structures have led to profound (and sometimes irreversible) changes to the system.

The coastal zone, the area in which up to 70 percent of the world's human population lives, is where much of this pressure, stress, and destruction originates. While there is a general understanding of what the coastal zone encompasses, there appears to be no real consensus on its definition. Indeed, Carter (1996, 38) lists a myriad of scientific definitions that range from the very precise and the very vague:

1. the broad zone between the landward and seaward limits of marine and terrestrial influences;
2. the land-sea interface;
3. a region of transition between two environments, the land and the sea;
4. a narrow band skirting all coastlines wherein land and sea influence each other;
5. the band of dry land and adjacent ocean space (water and submerged land) in which ecology and use directly affect ocean space, and vice versa;
6. at least to the edge of the continental shelf;
7. the area of associated aquatic ecosystems and those portions of tributaries draining into the estuary up to the historic height of migration of fish to spawn or the historic head of tidal influence, whichever is higher; and
8. islands or small nations.

Moreover, it could be argued that such areas

1. contain both terrestrial and aquatic components;
2. have terrestrial and aquatic boundaries that depend on the amount of influence each environment has on the other; and
3. vary in width, depth, and/or height (Kay and Alder, 1999).

The lack of structure and steadfast rules to determining coastal boundaries reflects the transitory nature of the environment. Clearly, the definition adopted will depend on the actual area under consideration as well as the information that is available.

While tropical coastal ecosystems (particularly that of coral reefs, mangrove forests, and seagrass beds) have been heralded as "rainforests of the oceans," such transitional areas in the temperate zone are also characterised by diverse and productive ecosystems. The nearshore coastal waters of the south-shore of Nova Scotia are no exception.

The need to effectively manage these areas has not been lost on the Canadian government. Indeed, Parks Canada has recognised the importance of marine and nearshore zones and has acknowledged that a representative marine park system is required if these areas are to be conserved. Building on the World Conservation Union's (IUCN) definition of marine protected areas[i], the National Marine Conservation Areas (NMCA) Program of Canada seeks "to represent the full range of marine ecosystems found in Canada's Atlantic, Arctic and Pacific oceans, and the Great Lakes" (Parks Canada, 2003, 1).

Based on a tiered system of zonation and different levels of protection, NMCAs are areas that are managed for sustainable use. Such an approach to management and conservation means that some activities (such as fishing) may be allowed in the various zones (or some of them), but only if they are not detrimental to the environment or counter the area's ultimate objective of conservation and maintaining ecosystem integrity.[ii] While "marine" connotes a purely water-based system, NMCAs may also extend into the coastal zone and include wetlands, estuaries, and islands. In that sense, NMCAs represent a management effort that at once recognises the linkages between and seeks to connect two very different but closely integrated environments – land and water. Integration, however, should go beyond the ecological. Stakeholders should be involved throughout the entire process of identification, design, implementation, and management. According to Parks Canada (2003, 1), "partnerships with regional stakeholders, coastal communities, Aboriginal peoples, provincial or territorial governments and other federal departments and agencies" are essential.

The objectives of the NMCA programme, as per Parks Canada (2003, 1) include:

1. to represent the diversity of Canada's oceanic and Great Lakes environments;
2. to maintain ecological processes and life support systems;
3. to provide a model for sustainable use of marine species and ecosystems;
4. to encourage marine research and ecological monitoring;
5. to protect depleted, vulnerable, threatened or endangered marine species and their habitats;
6. to provide for marine interpretation and recreation; and
7. to contribute to a growing worldwide network of marine protected areas.

These areas are to be established under the National Marine Conservation Areas Policy and the Agency's goal is to represent all of the country's 29 marine regions within the system plan. NMCAs are established first by identifying key or representative marine areas as candidates. This requires (as per Parks Canada, 2003, 2) taking into account:

1. geologic features;
2. marine features;
3. marine and coastal habitats;
4. biology; and
5. archaeological and historic features.

Potential NMCAs are then selected from this group of candidates based on their

1. quality of regional representation;
2. relative importance for maintaining biodiversity;
3. protecting critical habitats of endangered species;
4. exceptional natural and cultural features;
5. existing or planned marine protected areas;
6. minimising conflict with resource users;
7. threats to the sustainability of marine ecosystems;
8. implications of Aboriginal claims and treaties;
9. potential for education and enjoyment; and
10. value for ecological research and monitoring (Parks Canada, 2003).

The entire process requires the support of federal, provincial/territorial governments, local communities and stakeholders, and Aboriginal peoples. Consultation is essential during all of these steps. Only after the feasibility of the area has been assessed and the area is approved, is an agreement negotiated and the NMCA is established. Clearly, the process is long and requires substantial understanding of not only the ecology of the area, but also the socio-economic and political conditions.

As of 2003, only three NMCAs have been established in Canada: Fathom Five National Marine Park in Georgian Bay, Ontario; Saguenay-St. Lawrence Marine Park, Quebec; and Pacific Rim National Park, British Columbia. Five more are expected to be established over the next five years, including The Gully, off the coast of Nova Scotia. Two other sites have been recommended, leaving two more to still be identified.

The Canadian Parks and Wilderness Society-Nova Scotia (CPAWS-NS) has proposed several potential Atlantic Canadian NMCA sites, including Iles de la Madeleines in southwest Bay of Fundy; St. Margarets Bay and Mahone Bay area (and more specifically from Pennant Point south to Pollock Point) along the south shore of Nova Scotia (Appendix 1); and the south coast region of Newfoundland.

The south shore of Nova Scotia[iii], with its limited fishing pressure, historical significance, importance as a popular tourist destination, and its ecology all suggest that this area could potentially be an NMCA. Of course, public support is critical if the initiative is to be successful.

This document is a first look at the twin bay's coastal ecology. Information gaps still exist and further information should be collected on the area's oceanography. Furthermore, the document is based on information found in published documents and on the Internet. Researchers (including those in the Bedford Institute of Oceanography and the various universities in the province) should also be consulted to collect additional information. Furthermore, aquaculture occurs in some inshore areas within the study region. The impact of these ventures can be significant – both in terms of their ecological impact on the nearshore a in terms of stakeholder support for and conservation-oriented initiative.

Even as a preliminary study into the feasibility of a nearshore protected area in the St. Margaret's Bay-Mahone Bay area, how this process begins will influence how it is viewed and whether it is accepted in the future. Adopting a process that is transparent and participatory is critical. Contextural action research (CAR) may provide such a strategy. CAR is based on a

> Collaborative consultation process between *outside researchers* acting as facilitators and catalysts, and *inside stakeholders* engaged in addressing issues of immediate significance to their lives. The *participatory* nature of contextural action research engages participants, collaborating as co-researchers, in: the definition of the critical research questions using both local and global perspectives; the framing of these questions in their own context; the design of the process used to address the research issues; the decision-making regarding whom should be involved/invited to participate; and the evaluation of the data and knowledge generated as well as the success and "failures" associated with interventions aimed at social change….The participation of insiders in the design and practice of the research leas to the development of learning strategies that reflect the actual nature of the problem as it is understood by those most directly involved, as well as the ways in which it is informed from an external and analytic perspective (Franklin, 1998, 55; Franklin's emphasis).

Preliminary steps to gauging community acceptance of the idea of creating an NMCA in the south shore may begin with a public education and awareness campaign. The purpose, roles, and impacts (environmental and socio-economic) of an NMCA must be clearly understood by the stakeholders before an informed decision of whether or not to support such an initiative can be made. People must also be aware of the various management strategies (including those that are more collaborative and participatory in nature) that are possible for the area. Moreover, it must be clearly shown that the "establishment of management tools such as coastal or marine protected areas, catch quotas and size limits for fisheries, prohibitions on the use of certain threatened species, and environmental impact assessments….[are not necessarily] instruments for preventing economic growth" (Jorge, 1997, 51).

Stakeholders must be identified and they may include those from the fishing industry (including the aquaculture industry), tourism industry, government (provincial and municipal) agencies, local/regional nongovernmental organisations (NGO), and other community members who may not fit into these categories. Meetings with individual stakeholder groups should be supplemented with one-on-one informal interviews, information seminars and workshops, and larger public/community meetings.

Baseline ecological, socio-economic, and legislative information must be collected. While this document provides some of the ecological data, those who work in the area (particularly the fishers) can help to fill in the some of the data gaps. Moreover, involving stakeholders in the data collection process allows them to directly contribute to the initiative.

While there will undoubtedly be people or sectors that are not supportive and while they may be difficult to work with, listening to and addressing their concerns may help to create a foundation that can be built upon the future. If there is an overwhelming rejection of the proposal by most of the stakeholders, the creation of an NMCA in that area may not be viable at this time.

It should be noted that ecologically, the Pennant Point to Pollock Point area is not pristine. At the same time, it is habitat to the endemic Atlantic Whitefish, nursery grounds to a number of fish and invertebrate species, and is the breeding grounds for a countless number of sea and shorebirds, including the endangered Roseate Tern and the Piping Plover. Moreover, with public support, an NMCA in this region may provide an example of how different stakeholders from diverse social, economic, and political backgrounds can work together to make such an initiative successful.

Despite a call for a national marine conservation area system, government funding and personnel are still limited. Indeed, while there are over 150 protected areas (either fully or partially marine) in Canada, they represent only 0.613 percent of the country's oceans. Moreover, only three of these 150 have met the management levels advocated by CPAWS and the World Wildlife Fund (Jessen and Hazell, 2001). The role of the NGO is becoming increasingly critical and CPAWS-NS can play an important role in facilitating discussion and initiating the process.

## An Ecosystem Approach

### Temperate Rocky Shores[iv]

One of the most turbulent of areas within the nearshore environment is found on rocky shores. In eroding habitats, the high energy of waves and tides and their interaction with the sea floor causes silt, clay, and sand particles to lift into the water column, thereby leaving bedrock and boulders exposed. In contrast, in areas which are more sheltered (sedimenting habitats), particles may be deposited to form beaches or create environments that are conducive to the settlement and growth of rooted macrophytes.

Rocky shores can be divided into two distinct categories:

1. the intertidal zone; and
2. the subtidal zone.

#### The Intertidal Zone

The intertidal zone is the area between the high and low tides while the subtidal zone is defined as the area that lies below the lowest water line. Even though these two zones interact, the limitations are important – each zone creates a habitat that is suitable for the establishment and survival of specific aquatic flora and fauna.

The intertidal zone can be further subdivided into horizontal bands, with the upper limit of organism distribution primarily determined by their abilities to withstand air exposure. Lower limits tend to be based on organism interaction. These subdivided zones include:

1. the upper, or supralittoral; and
2. the middle, or eulittoral.

The upper limit of the supralittoral zone is dependent on the strength of wave action – it is "at the limit of the influence of sea spray" (Mann, 2000, 179). Thus, the zone is wider in areas of strong wave action and less so in more sheltered regions. Primary producers include lichens, cyanobacteria, and microscopic green algae; seaweeds are not common. Herbivores may include snails of the family Littorinidae (genera *Littorinidae* and *Melanerita*).

The eulittoral zone ranges from the low water mark of spring tides to the upper limit of complete immersion. The primary producers of the mid-intertidal are usually Fucoid brown algae (also called rockweeds). Indeed, in temperate regions, the upper eulittoral often consists of an understory of small red algae and corallines that are found under a canopy of rockweeds (for example, *Fucus* or *Pelvetia*). Barnacles are the most common animals of the upper eulittoral. The lower eulittoral, meanwhile, is more biologically diverse. Again, however, Fucoid brown algae, including *Fucus*, *Ascophyllum*, *Himanthalia*, and *Cystoseira*, remain common.

- PREDATION AND COMPETITION

In terms of consumers, the factors that tend to influence an organism's occurrence in the high- and mid-intertidal zones appear to be associated with their abilities to withstand temperature changes and desiccation. Thus, molluscs generally tend to dominate the intertidal zone. Filter feeders, such as mussels, oysters, and barnacles, compete with rockweeds for space. Other smaller filter feeders (for example, bryozoans and hydroids) are attached directly onto the algae. Limpets and gastropods, meanwhile, actively feed on the algae while free-swimming amphipods use it as shelter from wave action and desiccation.

Predators that inhabit the intertidal zone may be either sessile or mobile and may include seastars (which feed on both bivalves and gastropods) and crabs, respectively. Soft-bodies predators (for example sea anemones [*Actinia*] and nudibranchs [*Archidoris*]) can be found in areas that are less prone to desiccation, such as under the rockweed canopy. Moreover, sea birds prey upon these invertebrate consumers during low tide while many fish species may prey upon them during high tide.

The role of keystone species in maintaining diversity within communities is critical. Two hypotheses – one based on an ecological time scale and the other on an evolutionary time scale – have been put forth to describe this important relationship:

1. the predation hypothesis of species diversity – "Selective predation on dominant competitors can maintain relatively high local species diversity over ecological time, by preventing the dominant competitor from monopolizing the major resource (food or space)" (Menge and Sutherland, 1976 c.f. Mann, 2000); and
2. the competition hypothesis of species diversity – "[I]f an environment is stable over a long period of time, interspecific competition selects for increased specialization of species, which serves to reduce competition intensity. This creates a situation in which additional species may invade the community, thus increasing species diversity" (as per Sanders,1968 c.f. Mann, 2000).

- RECRUITMENT

Some scientists have argued that while competition and predation are important factors in determining community and ecosystem function, the role of recruitment should not be ignored. In areas where recruitment is a predictable event, predation and competition tend to be the determining factors of community structure. In situations, however, where recruitment is more erratic or patterns less certain, recruitment, itself, could be the key factor in species interaction. In essence, Mann (2000, 189) explains that "[i]f species A arrives before B, it may succeed in occupying all available space in a disturbed area, whereas in other years or at other sites, B may arrive before A and produce a different outcome." In addition, recruitment rates and patterns can be influenced by both ecological (the density and composition of the species already settled) and oceanographic (for example, currents and upwellings).

- DISTURBANCE

Species may become "optimally adapted" (Mann, 2000, 187) to certain ecological conditions if those conditions remain stable for a substantial amount of time. Through competitive exclusion, those optimally adapted species will dominate the area's resources (both in terms of food and space). In contrast, on an evolutionary time scale, exposure to unstable and stressed environments and disturbance (which may include at the micro level, floating logs, ice, predation, and/or patch formation) have led to greater genetic and species diversity since changing environmental conditions promote the emergence of a variety of traits, characteristics, and interactions.

**THE SUBTIDAL ZONE**

Temperate subtidal coastal zones are often dominated by various species of brown algae, commonly known as kelps. While there are a multitude of different brown algal species that inhabit the subtidal zone, they can be categorised into the three principle groups of *Laminaria*, *Ecklonia*, and *Macrocystis* – each with their own general distribution patterns. That is, *Ecklonia* can be found along the south coast of Australia and the east coast of South Africa. *Macrocystis*, meanwhile, is found along the coast of California as well as along the south Pacific and Atlantic coasts of South America. *Laminaria*, however, is found on both sides of the temperate North Atlantic and around the Chinese and Japanese coasts. Thus, it is the *Laminaria* that is of particular importance to Nova Scotia.

Kelps tend to inhabit areas of little sediment but high turbulence and, in turn, areas of substantial light penetration and nutrient availability. Studies (Gerard, 1982; Gerard and Mann, 1979; Koehl and Alberte, 1988 c.f. Mann, 2000) have indicated that kelp blades assume stream-lined forms in more turbulent waters which helps to decrease their drag co-efficient and makes them less prone to being torn during storms. This smoothness, however, also decreases the kelp blade's surface area and thus the penetration of light and nutrient renewal. In more sheltered areas, blades develop frills that enable increased nutrient uptake, although they are also more fragile and susceptible to destruction during storms or turbulent water conditions. In terms of light absorption, brown algae are able to change their pigment and the relative proportion of different pigments so as to enhance photosynthesis at a range of depths. Nutrient availability is perhaps the limiting growth factor for subtidal algae. Dissolved nitrogen is available during winter months, but is deficient during the summer. *Laminaria* is able to absorb nitrogen in the winter and store it for use in the summer when light increases. Thus, the combination of water movement, light, and nutrients allows kelps to have relatively high levels of annual primary production that may exceed $1000gCm^{-2}y^{-1}$ (compared to 100 to $300gCm^{-2}y^{-1}$ net productivity of intertidal phytoplankton). Much of the production is eventually of which is ultimately released as particulate and dissolved organic matter (POM and DOM, respectively).

Assuming an ecosystem approach to kelp-dominated subtidal zones, the relationship among kelp primary production, kelp POM and DOM, and the organisms (invertebrates and their predators) that live and use these areas is significant. Filter-feeding organisms (including mussels and barnacles), that live in and around kelp beds, obtain much of their nourishment from kelp-produced POM and DOM. In turn, organisms (including seastars, rock fish, lobster, and seabirds) prey on these invertebrates and, in the nature of all ecological and hierarchical systems, these predators are affected by increases and decreases in prey numbers as well as by changes in their distribution.

- PREDATION

Herbivores in kelp beds are diverse. They include, among others, periwinkles, limpets, amphipods, and isopods. Their impact on kelp beds is relatively limited since they tend to primarily graze on the small algae that grow on the subtidal rocks or on the stipes. Sea urchins, however, have the potential to exert much influence over kelp distribution and even their survival – so much so that Mann (2000) argues that sea urchins are the most important herbivore on kelp beds.

When kelp is abundant, sea urchins tend to feed on kelp drift and live in areas where they are protected from predators, such as in crevices or under boulders. During times when urchins are abundant and the detritus cannot support the entire population, they emerge to form aggregations and graze directly on the kelp. In extreme cases, entire kelp beds can be destroyed and areas where only encrusting coralline macroalgae remain are created. During the 1970s, sea urchins consumed entire kelp beds along the Nova Scotian Atlantic coast. Many people believed that the urchin population would decline after they had exhausted their food supply and the habitat would re-gnerate to its former state. In some areas, however, the urchins continued to dominate by apparently feeding on benthic microalgae. Kelp beds did not return for another 11 years – and only after a disease outbreak decimated the urchin population.

Three theories have been proposed to explain sea urchin outbreaks:

1. the removal of predators from the environment allows urchin populations to grow;

   During the late 1960s, St. Margarets Bay, Nova Scotia was speckled with urchin-dominated barren grounds. At the same time, fishers were heavily exploiting lobsters (*Homarus americanus*). It was suggested that these lobsters were keystone species and that there was a positive correlation between high densities of lobsters, low densities of urchins, and dense kelp beds. In contrast, when population densities of lobsters were low, sea urchin densities were high and kelp beds were scarce. Both field and laboratory experiments indicate that while lobsters may prefer crabs and mussels, they do prey on sea urchins (in large quantities) when abundant.
2. urchin populations naturally expand until they are checked by disease; and
3. urchin populations overgraze when environmental conditions (including temperature variations, wave energy) support heavy recruitment.

Clearly, the role of anthropogenic impacts on these subtidal environments and ecological relationships has been significant – cod, haddock, pollock, sea cows, and lobsters have been (and continue to be) heavily exploited and many large fish species have been extirpated from inshore waters. At the same time, however, It is important to note that while fisheries-related exploitation may be a leading factor, all three of these theories may help to explain growths in sea urchin populations and the subsequent impacts on kelp beds, community structure, and inter-specific dynamics.

## SANDY BEACHES[v]

Sandy beach systems can be divided into three distinct zones:

1. the subtidal;
2. the intertidal; and
3. the sand dune.

Zonation is created through dynamic interaction and equilibrium with the source of the sand, itself. The primary source for sand is the land – the earth erodes and currents and wave action that move parallel with the coast carry these particles away. Cliff-side erosion and/or the skeletal remains of marine organisms also contribute, though to a lesser degree, to beach development. The size of sand particles, the average height of the waves that wash onto the shore, the transport those particles (either away from or onto the coast), and the tidal range also influence the physical form of the beach system. Such factors lead beaches to be dissipative (produced through large waves and fine sand), reflective (produced through small waves and coarse substrate), or an intermediary of the two. In essence, the form that the beach ultimately takes is created through a dynamic system (and balance) of accretion and erosion.

Sediment size also affects the sands overall ability to filtrate water. That is, within the intertidal zone, waves wash over the shore and water sinks into the sand. As the water drains back into the ocean, nutrients are filtered out and used by the organisms living within the sand column (the interstitial community). At the subtidal level, however, water is forced into the sediment by wave pressure. Similar to the filtration process in the intertidal zone, as long as the sediment is not too fine, nutrients filter through the particles and are used by the interstitial community that includes bacteria and meiofaunal organisms.

### PRIMARY PRODUCERS

While the fauna and flora of sandy beaches may seem non-existent, the ecosystem houses a wide array of both macro- and micro-faunal organisms with diatoms are one of the system's most abundant. Diatoms may accumulate at the surf zone of the dissipative or intermediate beaches and species may include *Aulacodiscus*, *Chaetoceros*, *Asterionella*, and/or *Anaulus*. In order to survive the surf environment, they migrate from the sand to the water column in the morning and return to the sediment in the evening (this is done through wave and tidal action).

Diatoms, along with macrophyte detritus provide important sources of food for consumer populations. Although seaweeds do not tend to grow directly on sandy sediment, rocky headlands and their associated seaweed beds are usually close-by; the same waves that carry sand particles and aid in diatom migration also carry and deposit POM and/or DOM from macrophytes into the sediment. The overall primary production for these systems (including the surf zone and the area just beyond this zone) is relatively high – on the order of about $500gCm^{-2}y^{-1}$ or approximately equivalent to rockweed bed primary production.

### CONSUMERS

Consumers that exist in sandy beach ecosystems can be divided into those found in the surf and intertidal zones.

- SURF ZONE

Within the surf zone, consumers can be further subdivided into:

1. planktonic and bentho-planktonic;
2. benthic animals; and

3. fishes.

- PLANKTONIC

Large crustaceans, including penaeid prawns and mysids, often dominate. Horizontal and vertical migrations are common, with some prawn species moving offshore to release young or during violent storms. Others tend to spend the day in sediment and in the water column at night. Zooplankton are believed to be opportunistic feeders and will feed on phytoplankton, detritus, or animal food.

- BENTHIC ANIMALS

Studies indicate that there is relatively little diversity of macrofauna within the surf zone. Diversity, however, increases with distance from surf zone to the inshore. Bivalves and clams appear to be particularly abundant where diatom populations are also plentiful. Moreover, while meiofauna do occur in the surf zone, abundance appears to peak in the intertidal zone, where most of the water is filtered through the sediment.

- FISH

According to Mann (2000), fish communities within the surf zone are variable. Generally, however, between 25 and 95 species may migrate in and out of the area throughout the year and between two to eight species may live in the surf zone throughout the year. Some species may take advantage of the zone's abundance of planktonic food and its high turbulence (and the protection that it affords from predators) and use it as a nursery area.

- INTERTIDAL ZONE

Consumers within the intertidal zone can be divided into:

1. macroinvertebrates; and
2. interstitial communities.

- MACROINVERTEBRATES

Crustaceans (amphipods and isopods) tend to dominate the upper intertidal and the exposed beach shores. Molluscs (primarily bivalves), meanwhile, tend to dominate the lower levels and the intermediate shores. Polycheates tend to be limited to medium- or low-energy, fine-grained shores.

In terms of biomass, McLachlan (1990 c.f. Mann, 2000) suggests that low-energy reflective beaches contain fewer species and the lowest biomass while high-energy dissipative beaches have the highest species diversity and the greatest biomass. Moreover, McLachlan (1990 c.f. Mann, 2000) found a positive correlation between logarthmic benthic biomass and wave height. These observations may be due to the efficiency of dissipative beaches in filtering organic particles from the waves and hence support more productive food webs and greater macrofaunal biomass.

- INTERSTITIAL COMMUNITIES

As seawater is filtered through the beach sediment, DOM and POM accumulate in the interstices. This matter is used by bacteria that are then consumed by protozoa and other meiofauna. According to Mann (2000), meiofauna biomass increases with increasing wave action.

**MACROPHYTIC ACCUMATIONS**

Kelp and other seaweeds from rocky subtidal habitats often become stranded on close-by beaches. These seaweeds may become shredded and/or consumed by crustaceans, other invertebrates, and bacteria. In turn, another layer to the beach ecosystem food web may be added when shorebirds feed on these organisms.

**ESTUARINE BENTHIC SYSTEMS**[vi]

Estuaries mark the point where fresh and salt water meet. In terms of the estuarine benthic system, the bottom area between the high tide and subtidal zone are usually characterised by sand or mud flats. It functions as a site for nutrient regeneration and for secondary production that is used by such predators as bottom-feeding fish and crustaceans.

#### PRIMARY PRODUCTION

Both diatoms and blue-green algae are dominant primary producers within the microalgal communities that occur at the intertidal zone of estuaries. Diatoms, however, tend to predominate in areas of higher salinity while blue-green algae prefer areas with greater fresh water input. While community composition is variable, the microalgae that do occur within this zone must be able to withstand changes in exposure, salinity, and sediment types – all of which depend on currents and wave action.

Other important sources of benthic organic matter include phytoplankton from the water column, rivers that carry and deposit organic matter, detritus from near-by macrophyte beds, and oceans that bring living and dead organic matter through tides and circulation. In areas where filter feeder populations are substantial, these organisms contribute to organic bottom deposits (primarily through their feces). Sewage discharge, agricultural practices, and other anthropogenic activities also represent important sources of organic matter. Depending on the communities that actually occur in this zone, organic carbon input into the system could range from 30 to $300gCm^{-2}y^{-1}$.

#### PROCESSING ORGANIC CARBON AND REGENERATING NUTRIENTS

In the bioturbation process, organic matter becomes buried in the sediment through the mixing actions of larger invertebrates. These invertebrates can be classified as:

1. shredders or browsers (including amphipods, isopods, and some gastropods) that graze on organic detritus and whose feces are either deposited on the sediment or lifted into the water column;
2. suspension feeders or filter feeders (including bivalve molluscs, sponges, ascidians, and fan worms) that remain buried in the sediment and feed by extending their feeding organs into the water column thereby drawing nutrients and organic matter out of the water into the sediments; and
3. deposit feeders (including polycheate worms, many gastropods, halothurians, and crusteaceans) that either feed at depth and defecate at the surface or feed at the surface and defecate at depth. Regardless, the system used, with the help of natural water movement, and because of their need for oxygenated water, a several centimetre thick layer of well-oxygenated sediment is created. The depth of this layer is determined by a number of factors, not the least of which are the amount of carbon in the sediments, the level of turbulence of the water column, and the amount of sediment mixing (and hence oxygenation) done by the invertebrates inhabiting the system. The organic matter that has been buried below this aerobic layer supports bacteria that use the oxygen, deposit dark-coloured sulfides, and eventually create a deeper, dark anaerobic layer.

POM and DOM in the aerobic layer is broken down by bacteria. The bacteria, in turn, are preyed upon by meiofauna. In sediments that are sandy and fine-grained, the invertebrate diversity is great and may include ciliates, tardigrates, turbellarians, gastrotrichs, oligochaetes, harpacticoid copepods, and ostracods. In muddier sediments, the limited space between particles leads to a relatively poorer invertebrate composition.

Fermenters convert the complex organic carbon in the anaerobic layer into low-molecular-weight organic compounds (for example, lactate or acetate, propionate or alcohol). Only a small amount of energy is released at this time. The low-molecular-weight organic compounds are then further broken down by the sulfate reducers (to create hydrogen sulfide, carbon dioxide, and water). Denitrifyers also break down the low-molecular-weight organic compounds to form nitrate. Methanogens then take these products (including those created by the fermenters) and reduce them to methane. The gas rises through the substrate only to be oxidised again by the aerobic bacteria. Thus, as Mann (2000) notes, sediment communities recycle nutrients and produce food (in the form of invertebrates) that are used by humans and other natural predators, including fish and crab.

#### SECONDARY PRODUCTION

Organic matter may either be decomposed by bacteria and re-used by primary producers, or it may be used by such secondary producers as invertebrates and fish. Key secondary producers within the benthic zone include polychaete worms, crustaceans, and small bivalves. Within a complex food web, these organisms are preyed upon by fish, crabs, and other larger vertebrate and invertebrate organisms. Within the estuarine intertidal sediments, small crustaceans are an important food source for shore birds, including those that are migrating between breeding and over-wintering grounds.

- COMMON ESTUARINE NEKTON

Eels, herring-like fish (Clupeidae), anchovies, salwater catfish, killifish, basses, drums, croakers, trough, salmon, flounders (Pleuronectidae), silversides, blennies, sculpins, surfperch, and majarras are all common fish found in temperate estuaries. Important swimming invertebrates include crustaceans, particularly shrimps and swimming crabs which are represented in almost all temperate estuaries. Eupahusiid crustaceans (or krill) occur in the midwater and tend to provide food for fish, birds, and marine mammals.

- FISH

Fish vary in their adaptations to estuarine environments and their changing salinities, strong currents, and on the variable nektonic components. The dynamic nature of estuarine environments has led to the extensive movements among many fish species.

Fish can be divided into four main categories based on their migration patterns:

1. estuarine residents;
2. saltwater spawners;
3. estuarine spawners; and
4. anadromous and catadromous species.

- ESTUARINE RESIDENTS

Estuary residents tend to be small fish, such as minnows or killifishes and gobies. These fish live near the bottom of shallow water and feed on small invertebrates. The total number of estuary year-round residents is approximately ten percent of the total number of fish species.

- SALTWATER SPAWNERS

These fish enter estuaries either to use them as nursery grounds or as feeding and growth grounds as adults.

- ESTUARINE SPAWNERS

Estuarine spawners tend to visit estuaries specifically to spawn. Winter flounders are one example of such a species. This species enters estuaries to lay eggs along the bottom during the winter and early spring months. The young will stay in the estuaries during their first year and then usually move into the salt water thereafter.

- ANADROMOUS AND CATADROMOUS SPECIES

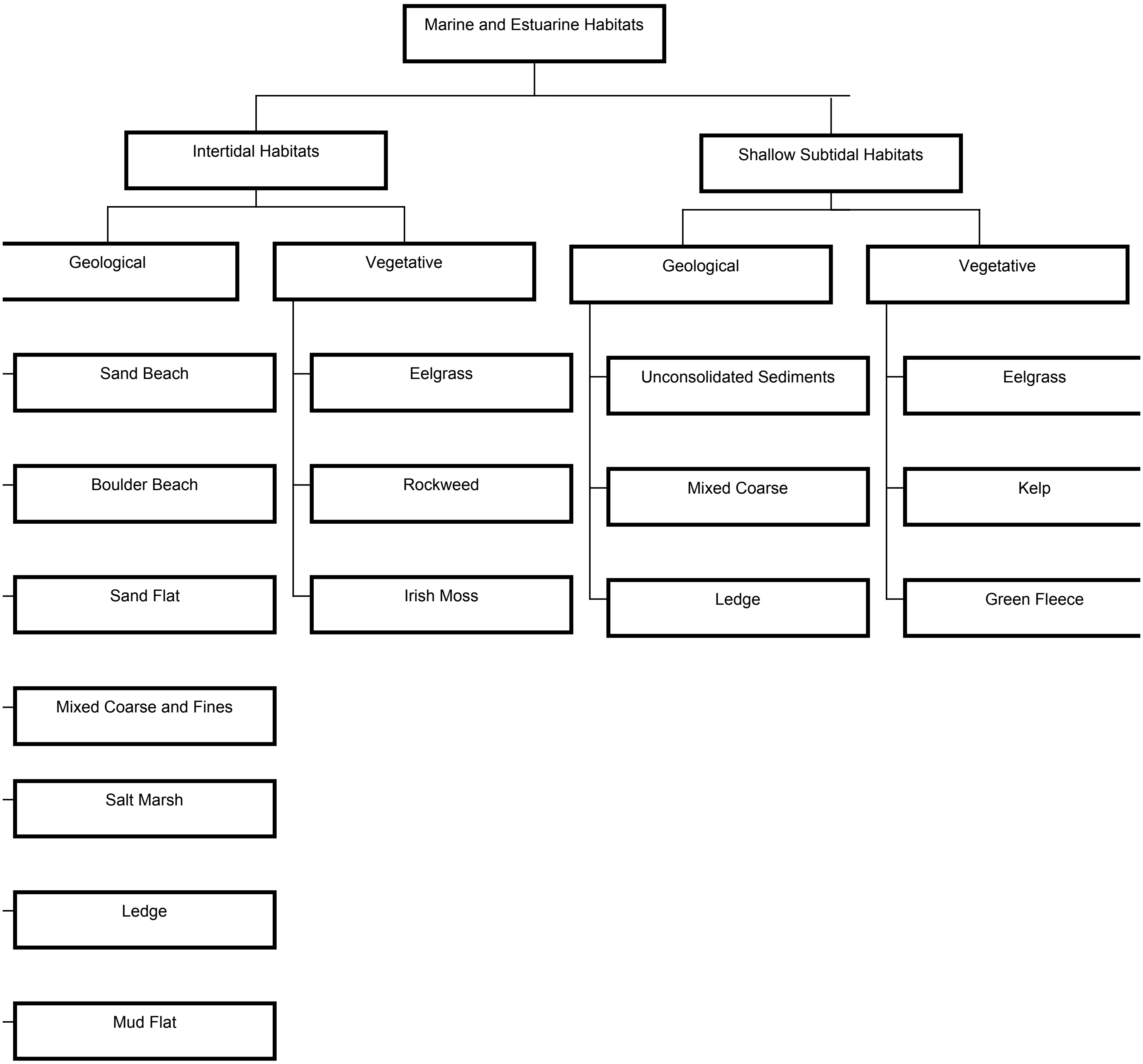
Anadromous species migrate from salt to fresh water for spawning. Catadromous species, meanwhile, migrate from fresh to salt water to spawn. Anadromous species are more common than catadromous species in temperate latitudes and this may be because these areas are generally more productive – fish will spawn in the fresh/estuarine water but leave for the more productive salt water to feed and grow. In contrast, tropical oceans tend to be less productive than estuarine areas, thus leading to spawning in the saltwater environment and growth and feeding in the fresh and estuarine waters. Another explanation may be related to predation. Large fish may not be able to follow small and young fish into the shallow estuary and river waters. Moreover, dense macrophytic growth in these zones may not only help hide the young, but also provide an important source of food. Examples of anadromous species include salmon, striped bass, and four members of the herring family [alewife (*Alosa pseudoherengus*), blueback herring (*Alosa aestivalis*), hickory shad (*Alosa mediocris*), and American shad (*Alosa sapidissima*)] Spawning usually occurs above the limit of saltwater penetration.

- COMMERCIAL FISH AND SHELLFISH PRODUCTION
  - ESTUARINE INFLUENCES

Catches of commercial fish and shellfish are often positively influenced by river runoff into estuaries. High river runoff in the spring may stimulate primary and secondary production through upwelling. In contrast, heavy runoff during summer months may create a barrier to the upwelling nutrients and thus limit productivity. Fish and shellfish catch may also be affected by the surface area of lagoons and estuaries. Regardless, productivity of estuarine environments is relatively high with total global catch of estuarine-dependent species (including shrimps, prawns, salmons, oysters, mussels, menhaden, and milkfish) ranging between five and eight million tonnes. In addition, these areas are often considered important feeding and/or nurseries grounds.

## ECOSYSTEM COMPONENTS

### MARINE PLANTS




(Adapted from Ward, 1999)

**GREEN FLEECE (*CODIUM FRAGILE*)**

*Codium fragile* is an invasive green alga. It was introduced to Nova Scotia during the late 1980s-early 1990s. The algae is believed to be endemic to the northwest Pacific and was accidentally introduced to the east coast of North America from western Europe on the hull of a boat. It has been suggested that *C. fragile* moved along the coast via incursions of warm water from the Gulf Stream (Bird, Dadswell, and Grund, 1993). It was first collected at Graves Shoal, Mahone Bay, Lunenburg County in December 1991. Only one year later, it was found throughout Mahone Bay and as far east as Prospect Bay, Halifax County. Since then, it has extended further north along the province's Atlantic coast and has rapidly become one of the more dominant and persistent seaweeds of the rocky subtidal zone and it occupies both hard- and soft-bottom substrates.

Bird, Dadswell, and Grund (1993) suggest that temperature appears to be the limiting factor to green fleece growth and reproduction. Minimum temperatures for vegetative growth have been reported to range between ten and 13$^{o}$C and between 12 and 15$^{o}$C for gamete formation (although the algae can also reproduce vegetatively). These temperatures must be sustained for enough time if the species is to become established. It appears as though the species has approached it northern limit although there is some concern that if it reaches the Gulf of St. Lawrence, it will spread widely and quickly because of the area's warm surface water temperatures.

Scheibling and Anthony (2001) state that the *C. fragile*'s dominance and abundance varies within and among different regions. One possible explanation for this variation may be related to the abundance of herbivores that prey on and potentially regulate the algae. Sea urchins (*Strongylocentrotus droebachiensis*) have played a critical role in influencing coastal seaweed coverage throughout the Atlantic coast of Nova Scotia. High population densities of these invertebrates have over-grazed kelp (*Laminaria* spp.) beds and have led to the creation of "urchin barrens" that become dominated by crustose coralline algae. These barrens can remain for decades although dramatic declines in sea urchin populations (usually decimated by disease) may allow kelp beds and other seaweeds to recolonise the areas. During these recolonisation periods, green fleece is among the first to settle and it often impedes kelp from becoming re-established.

Scheibling and Anthony (2001) examined whether sea urchins could be used to regulate *C. fragile* populations. According to their findings, however, sea urchins strongly prefer *Laminaria* spp. over *C. fragile*. As fronts of sea urchins enter the shallow intertidal zone from deeper water, they consume kelp beds. Scheibling and Anthony (2001) predict that upon encountering mixed kelp and *C. fragile* stands, the sea urchins would first consume the *Laminaria* and leave patches of *C. fragile*. At low sea urchin densities, this may lead to a patchwork of C. fragile and coralline-encrusted rock. At high densities, however, *C. fragile* is most likely consumed along with the kelp and thereby creating urchin barrens. Continued grazing would impede recolonisation by *C. fragile* as well as other seaweeds. The potential for sea urchins to take longer to feed on and completely remove *C. fragile* from the intertidal zone may slow the conversion of seaweed beds (regardless of their composition) into barrens. At the same time, it has been predicted that the presence of *C. fragile* will also slow the recovery (if it is even possible) of barrens into kelp-dominated seaweed beds.

Studies conducted within the Pennant Point to Pollock Point area include:

Bird, C.J.; Dadswell, M.J.; Grund, D.W. 1993. "First Record of the Potential Nuisance Alga *Codium fragile* ssp. *tomentosoides* (Chlrophyta, Caulerpales) in Atlantic Canada" in Proceedings of the Nova Scotia Institute of Science. 40: 11-17.

Garbary, D.J.; Jess, C.B. 2000. "Current status of the invasive green alga *Codium fragile* in eastern Canada" in Journal of Phycology. 36(3):23-24.

Scheibling, R.E.; Anthony, S.X. 2001. “Feeding, growth and reproduction of sea urchins (*Strongylocentrotus droebachiensis*) on single and mixed diets of kelp (*Laminaria* spp.) and the invasive alga *Codium fragile* ssp. *tomentosoides*” in Marine Biology. 139: 139-146.

**EELGRASS (*ZOSTERA MARINA*)**

Eelgrass is a vascular flowering plant that has roots, stems, and leaves. *Zostera marina* may either be an annual or perennial plant. The former reproduces only sexually through the production and releasing of seeds while perennials may reproduce either sexually or asexually (through vegetative growth).

*Z. marina* is located in the mud flats, sand flats, mixed course, and fine environments of the low intertidal and shallow subtidal. They can also be found in sheltered coves, bays, inlets, and shallow tidal rivers. Although both *Chondrus* spp. and *Z. marina* both occur in the same depth range, in terms of substrate, the areas that are suitable for *Z. marina* tend not to be for *Chondrus* spp. – *Chondrus* spp. prefer rocky bottoms, while *Z. marine* is most often found on muddy bottoms. While eelgrass beds are light-limited and tend to occur in relatively shallow depths that range from two to five metres, they can survive in waters that are up to ten metres deep. Seedling growth, morphology, and survival may also be influenced by the shade produced by the canopy of mature eelgrass. That is, in the presence of an eelgrass canopy, seedlings tend to produce long, thin leaves that have a smaller surface area than those growing in the absence of such a canopy. Shading (in combination with a corresponding increase in competition with mature plants for nutrients) may also limit density.

The ecological role of eelgrass beds is diverse: they stabilise substrates; absorb nutrients from sediments; limit erosion; help to control wave energy; and reduce water currents. Their blades are used as food by invertebrates, fish, and birds and they contribute to organic biomass as detritus. This detritus is recycled back into the coastal food web by providing food for microbial organisms that, in turn, is a food source for invertebrates, fish, and birds. The blades also become covered with microscopic plants, bacteria, and grazers. In addition, epiphytes, snails, and larvae also use the eelgrass blades as attachment sites. The beds provide shelter from predation and wave action in addition to providing shade from the sun and its radiation. They also act as nursery grounds for bivalves, fish, shellfish, and lobsters. It should also be noted that many of these species that seek shelter and food in the eelgrass beds are also commercially important. In essence, *Z. marina* adds an important level of ecological and structural complexity to the coastal marine environment.

Eelgrass beds are highly sensitive to disturbance and development. They are threatened by shading as well as by the removal and/or disturbance of habitat through dredging, filling, water impoundment, and sediment loading. Pollution and re-suspension of sediments may also negatively impact eelgrass communities.

Studies conducted within the Pennant Point to Pollock Point area include:

Keddy, C.J. 1987. “Reproduction of Annual Eelgrass: variation among habitats and comparison with perennial eelgrass (*Zostera marina*)” in Aquatic Botany. 27: 243-256.

Mann, K.H. 1973. “Relationship between morphometry and biological functioning in three coastal inlets of Nova Scotia” in Cronin, L.E. (ed.). Estuarine Research. Volume I: Chemistry, Biology, and the Estuarine System. New York: Academic Press, Inc.

Mann, K.H. 1972. “Ecological energetics of the seaweed zone in a marine bay on the Atlantic Coast of Canada. I. Zonation and biomass of seaweeds” in Marine Biology. 12: 1-10.

Robertson, A.I.; Mann, K.H. 1984. "Disturbance by ice and life-history adaptations of the seagrass *Zostera marina*" in Marine Biology. 80: 131-141.

Stephenson, R.L.; Tan, F.C.; Mann, K.H. 1986. "Use of stable carbon isotope ratios to compare plant material and potential consumers in a seagrass bed and a kelp bed in Nova Scotia, Canada" in Marine Ecology Progress Series. 39: 1-7.

Ward, A.E. 1999. Maine's Coastal Wetlands. www.state.me.us/dep/blwq/vol1pt4.pdf. Accessed: 15 May 2003.

### ROCKWEED (*ASCOPHYLLUM NODOSUM*)

*Ascophyllum nodosum* are perennial brown algae that dominate the intertidal zone throughout the Pennant Point to Pollock Point area. Indeed, in many Atlantic intertidal areas, these seaweeds may comprise up to 80 percent of the shore. They are attached to rocks and boulders by a long-lived and strong holdfast and their fronds may grow up to three metres in length. Compared to other rockweed species, and *Fucus* spp. in particular, these rockweeds tend to be found in more sheltered areas – this is not so much related to *Fucus*' inability to survive in sheltered areas, but rather the competitive dominance of *A. nodosum*. While *A. nodosum* can withstand the high pressures of coastal wave action, in areas that are exposed to or have been scoured by ice, they are often mixed with (and sometimes replaced in the short-term by) the faster-growing but shorter-lived *Fucus* spp. Once the *A. nodosum* has been re-established, it tends to exclude *Fucus* spp. usually through shading.

*A. nodosum*'s reproductive structures (containing either egg or sperm producing tissue) are held in receptacles that form on the sides of their shoots. The gametes are released in the late spring or early summer. The germlings that ultimately form are vulnerable to both grazing and wave action. Recruitment through sexual reproduction is therefore sporadic. Regardless, the majority of new shoots are produced asexually from holdfast basal tissue.

*A. nodosum*'s cover may be negatively affected by storms, ice, pollution, and coastal development (which may result in changes to the seabed, the removal of boulders, or siltation).

While rocky shores in general provide habitat for fish, it is the vegetated areas that tend to act as fish nurseries. At the invertebrate level, rockweed beds support communities (which are characterised by seasonal variation) of littorinid snails, shore crabs, amphipods, copepods, isopods, gastropods, nematodes, turbellarians, and bivalves – many of which are preyed upon by fish and birds.

*A. nodosum* can be harvested by using knives, rakes, and mechanical suction harvesters and processed for anthropogenic use. They can be consumed by both humans and animals, used for fertiliser, and act as a source of alginate (which used in food products, cosmetics, and medicines). While these rockweeds are harvested along the coast of much of mainland Nova Scotia and the southern shore of New Brunswick, the south shore of Nova Scotia is only infrequently harvested.

Studies conducted within the Pennant Point to Pollock Point area include:

Cousens, R. 1982. "The Effect of Exposure to Wave Action on the Morphology and Pigmentation of *Ascophyllum nodosum* (L.) Le Jolis in South-Eastern Canada" in Botanica Marina. 25:191-195.

Cousens, R. 1986. "Quantitative Reproduction and Reproductive Effort by Stands of the Brown algae *Ascophyllum nodosum* (L.) Le Jolis in South-eastern Canada" in Estuarine, Coastal and Shelf Science. 22: 495-507.

Department of Fisheries and Oceans. 1998. "Rockweed in the Maritimes" in DFO Science Stock Status Report. C3-57.

Garbary, D.J.; Burke, J.; Lining, Tian. 1991. "The *Ascophyllum*/*Polysiphonia*/*Mycosphaerella* Symbiosis. II. Aspects of the Ecology and Distribution of *Polysiphonia lanosa* in Nova Scotia" in Botanica Marina. 34: 391-401.

Johnson, S.C.; Scheibling, R.E. 1987. "Reproductive patterns of hapacticoid copepods on intertidal macroalgae (Ascophyllum nodosum and Fucu vesiculosus) in Nova Scotia, Canada" in Canadian Journal of Zoology. 65:129-141.

Johnson, S.C.; Scheibling, R.E. 1987. "Structure and dynamics of epifaunal assemblages on intertidal macroalgae *Ascophylllum nodosum* and *Fucus vesiculosus* in Nova Scotia, Canada" in Marine Ecology Progress Series. 37: 209-227.

Mann, K.E. 1972. "Ecological energetics of the seaweed zone in a marine bay on the Atlantic Coast of Canada. I. Zonaton and biomass of seaweeds" in Marine Biology. 12: 1-10.

Metaxas, A.; Hunt, H.L.; Scheibling, R.E. 1994. "Spatial and temporal variability of macrobenthic communities in tidepools on a rocky shore in Nova Scotia, Canada" in Marine Ecology Progress Series. 105: 89-103.

Metaxas, A.; Scheibling, R.E. 1994. "Changes in Phytoplankton Abundance in Tidepools over the Period of Tidal Isolation" in Botanica Marina. 37: 301-314.

Ward, A.E. 1999. Maine's Coastal Wetlands. www.state.me.us/dep/blwq/vol1pt4.pdf. Accessed: 15 May 2003.

**ROCKWEED (*FUCUS* SPP.)**

As a rockweed with a relatively high light requirement, *Fucus* spp. is found within the high eulittoral zone of the more exposed intertidal rocks throughout the study area. *Fucus* spp. are brown algae that use small holdfasts to attach onto rocky substrates. Their flat blades may grow up to one metre and contain air bladders that buoy the algae near the water's surface. Reproduction can occur sexually (through the development of zygotes) or vegetatively (through the production of adventive embryos or adventitious branches) and may take place year-round.

*Fucus* spp. are primary producers and play an important role in the converting of inorganic nutrients into organic matter for ecological as well as commercial use. The algae also tend to break apart and drift into the nearshore to form deposits of organic detritus that in turn provides the basis of one of the coastal system's food web. That is, the detritus is consumed by bacteria, small marine invertebrates (including, but not limited to, tubellarians, nematodes, annelids, gastropods, bivalves, copopods, isopods, and amphipods), and insects that are in turn preyed upon by fish, birds, and mammals. Rockweed beds also provide important shelter for coastal inhabitants by protecting them from desiccation, fluctuating temperatures, wave action, and predation. They may also serve as nursery areas for important commercial fish and shellfish species (including, but not limited to, Pollock, lobsters, and sea urchins).

Rockweed beds (including both *Fucus* spp. and *Ascophyllum nodosum*) have both direct and indirect commercial value – they can be harvested, processed, and sold as food, converted into fertiliser and other agricultural products, and used as a stabiliser for cosmetics and food.

*Fucus* spp. are able to withstand severe conditions and flourish in areas of high wave action. They are, nevertheless, negatively impacted by coastal development that may block essential light, remove rocks, and/or increase siltation and pollution. Their ability to recover from disturbance depends on its severity (that is, whether all species present were removed, if some species remained after the disturbance, and/or whether the entire holdfast was removed) as well as on the species' own ability to recover (its life history). Nevertheless, *Fucus* spp. tend to be the most abundant and structurally important species during re-colonisation/recovery events. Competition, whether it be with other algae or mussels, appears to have minimal impact on *Fucus* spp,'s abilities to re-establish in the short-term. In essence, the rockweed's own properties and traits with regards to regeneration appear to play a more important role. In the long-term, however, *Fucus* spp. has a relatively short life-cycle and once other algae have become established (for example *A. nodosum* in the mid-eullitoral or *Chondrus crispus* in the low eulittoral), fucoid germlings are suppressed. In general, seaweed abundance is believed to be primarily controlled/regulated by herbivores (which control ephemeral algal competition) and carnivores (which control herbivory). Of course, such an observation is not true in all cases and intraspecific competition (adults vs. juveniles) may also play a significant role in recruitment.

An interesting study (McCook; Chapman, 1991) was conducted on community succession following an ice-scour. This study examined the relationships between *Fucus vesiculosus* L., mussuls (*Mytilus edulis* L.), barnacles (*Semibalanus balanoides* L.), and crustose alga (*Hildenbrandia rubra* Sommerfelt). Results indicated that the *Fucus* spp. canopy plays an important role in determining and maintaining community structure. The role of the canopy is both physical and biotic. That is, the canopy shelters organisms that live and use the area from wave action, high temperatures, desiccation, and freezing. For example, in absence of the canopy, whelk predation on mussels was reduced (since whelk's rely on the canopy for shelter) and mussel numbers increased. It should be noted, however, that it appears as though mussels do not out-compete *Fucus* spp. in the absence of whelk (although this generalisation does not apply to all conditions at all successional stages).

McCook and Chapman (1991) attribute changes in herbivore composition to changes in canopy cover: a loss of canopy resulted in an increase in *Littorina rudis* and a decrease in *L. obtusata* and amphipods. McCook and Chapman (1991) suggest that the increase in *L. rudis* may be due to either its more resistant form to wave exposure or a release from competition with *L. obtusata* (which is more abundant under canopy). Recruitment of *Fucus* spp. and ephemeral algae is also enhanced with canopy removal since it may help to shelter herbivores, provide shading, and in turn, promote intraspecific and interspecific competition for resources. According to this study, neither canopy cover nor mussel density affected the crustose alga *H. rubra*, a hardy non-obligate under-story species.

Studies conducted within the Pennant Point to Pollock Point area include:

Barker, K.M.; Chapman, A.R.O. 1990. "Feeding preferences of periwinkles among four species of *Fucus*" in Marine Biology. 106: 113-118.

Bird, N.L.; McLachlan, J. 1976. "Control of formation of receptacles in *Fucus distichus* L. subsp. *distichus* (Pheophyceae, *Fucales*)" in Phycologia. 15(1): 79-84.

Chapman, A.R.O. 1989. "Abundance of *Fucus spiralis* and ephemeral seaweeds in a high eulittoral zone: effects of grazers, canopy and substratum type" in Marine Biology. 102:565-572.

Cousens, R. 1986. "Quantitative Reproduction and Reproductive Effort by Stands of the Brown Alga *Ascophyllum nodosum* (L.) Le Jolis in South-eastern Canada" in Estuarine, Coastal and Shelf Science. 22: 495-507.

Denton,A.B.; Chapman, A.R.O. 1991. "Feeding preferences of gammerid amphipods among four species of *Fucus*" in Marine Biology. 109: 503-506.

Edelstein, T.; McLachlan, J. 1975. "Autecology of *Fucus distichus* ssp. *distichus* (Phaeophyceae: *Fucales*) in Nova Scotia, Canada" in Marine Biology. 30: 305-324.

Johnson, S.C.; Scheibling, R.E. 1987. "Reproductive patterns of hapacticoid copepods on intertidal macroalgae (*Ascophyllum nodosum* and *Fucus vesibulosus*) in Nova Scotia, Canada" in Canadian Journal of Zoology. 65: 129-141.

Johnson, S.C.; Scheibling, R.E. 1987. "Structure and dynamics of epifaunal assemblages on intertidal macroalgale *Ascophyllum nodosum* and *Fucus vesiculosus* in Nova Scotia, Canada" in Marine Ecology Progress Series. 37: 209-227.

Mann, K.H. 1972. "Ecological energetics of the seaweed zone in a marine bay on the Atlantic Coast of Canada. I. Zonation and biomass of seaweeds" in Marine Biology. 12: 1-10.

McCook, L.J.; Chapman, A.R.O. 1997. "Patterns and variations in natural succession following massive ice-scour of a rocky intertidal seashore" in Journal of Experimental Marine Biology and Ecology. 214; 121-147.

McCook, L.J.; Chapman, A.R.O. 1992. "Vegetative Regeneration of *Fucus* Rockweed Canopy as a Mechanism of Secondary Succession on an Exposed Rocky Shore" in Botantica Marina. 35: 35-46.

McCook, L.J.; Chapman, A.R.O. 1991. "Community succession following massive ice-scour on an exposed rocky shore: effects of *Fucus* canopy algae and of mussels during late succession" in Journal of Experimental Marine Biology and Ecology. 154: 137-169.

Metaxas, A.; Hunt, H.L.; Scheibling, R.E. 1994. "Spatial and temporal variability of macrobenthic communities in tidepools on a rocky shore in Nova Scotia, Canada" in Marine Ecology Progress Series. 105: 89-103.

Parker, T.; Chapman, A.R.O. 1994. "Separating the grazing effects of periwinkles and amphipods on a seaweed community dominated by *Fucus distichus*" in Ophelia. 39(2): 75-91.

Ward, A.E. 1999. Maine's Coastal Wetlands. www.state.me.us/dep/blwq/vol1pt4.pdf. Accessed: 15 May 2003.

Worm, B.; Chapman, A.R.O. 1998. "Relative effects of elevated grazing pressure and competition from a red algal turf on two post-settlement stages of *Fucus evanescens* C. Ag" in Journal of Experimental Marine Biology and Ecology. 220: 247-268.

Worm, B.; Chapman, A.R.O. 1996. "Interference competition among two intertidal seaweeds: Chondrus crispus strongly affects survival of *Fucus evanescens* recruits" in Marine Ecology Progress Series. 145: 297-301.

**KELP (*LAMINARIA* SPP., *ALARIA* SPP., *AGARUM* SPP., *CHORDA* SPP., *SACCORHIZA* SPP.)**

Kelp are brown algae that are found in the low intertidal and shallow subtidal in areas of moderate to high wave action. They are intolerant of desiccation and flourish in depths of up to 20 to 30 metres. Through the use of a holdfast, these seaweeds are able to attach onto rocks, boulders, and other coarse environments.

Kelp are cold-water plants and can only reproduce in waters colder than 13$^{o}$C. Vegetative reproduction and growth is greatest when both nutrients and light are readily available. These plants can grow up to three metres and maximum growth tends to occur between late winter (even when light levels are low and the potential for destructive ice scours is great) and summer.

Primary productivity of kelp beds is one of the highest in the world. They convert inorganic nutrients into organic matter that can then be used by secondary consumers. The habitat that they provide for other coastal organisms is also important: they provide shelter from wave action and predation, nursery grounds for fish, shellfish, and lobsters, and protection from harmful light radiation. Sea stars and other invertebrates take advantage of the microhabitat the kelp's holdfast provides while the blades are a source of food for snails, amphipods, chitons, limpets, and sea urchins. The majority of kelp net production, however, enters coastal food webs as detritus with the bacteria and small invertebrate that feed on this detritus being consumed by fish, birds, and mammals.

Apart from harvesting, processing, and selling kelp as a health food and stabilising agent, the seaweed is also of indirect importance – commercially important species (including lobster [*Homarus americanus*], sea urchins [*Strongylocentrotus droebachiensis*], and herring [*Clupea harengus*]) rely on the habitat and shelter that it provides. Studies (Guerinot, M.L., Fong, W., and Patriquin, D.G., 1977; Mann, 1973; Moore and Miller, 1983; Novaczeck and McLachlan, 1986; Scheibling and Anthony, 2001; Wharton and Mann, 1981) have indicated that grazing sea urchins play a significant role in influencing kelp abundance and distribution. Increases in sea urchin density tend to be matched with a decrease in kelp abundance. Mann (1973) suggests that sea urchin populations may be controlled by predation and outbreaks of the invertebrate may be due to a reduction in their predator's population. In the case of the south shore of Nova Scotia, the lobster may be the sea urchin's key predator. Human predation on lobsters has resulted in declining population levels and may have allowed for population explosions of sea urchins. Such explosions may have, in turn, resulted in over-grazing of kelp beds.

The barrens that are created after destructive sea urchin over-grazing may lead to a loss of productivity and/or a loss of habitat which may further impact lobsters. Wharton and Mann (1981) suggest that lobsters find fewer invertebrates to feed on and juvenile lobsters are more vulnerable to predators in these barren underwater lands. Both of these factors decrease lobster recruitment and landings.

Thus, over-exploitation of lobster stocks may allow sea urchin populations to increase dramatically since sea urchin predation pressure is eased (the same could also be said of commercial finfish species that also feed on sea urchins). In turn, sea urchins over-graze on kelp beds and have the potential to convert once lush areas into barrens, thereby creating habitats that are not conducive to lobster recruitment or survival and the cycle continues.

Managing kelp beds therefore requires careful management of lobster (and finfish) and sea urchins. Wharton and Mann (1981) indicate that kelp beds in the past were much more extensive along the south shore of Nova Scotia. By restoring kelp beds and controlling sea urchin populations, an increase lobster populations result. Moore and Miller (1983) caution that it could take years for kelps to recover even in the absence of sea urchins.

The role of zonation of seaweeds in distribution, competition, and predation should not be ignored. That is, in shallow water, *Laminaria* spp. appears to dominate over *Agarum* spp. (a kelp that ranks low on sea urchin's grazing preferences). In deeper water, where light intensity is lower and where rocky substrate tends to give way to softer materials, *Laminaria* spp. do not grow as quickly and sea urchins preferentially feed on these beds faster than they can be replaced. *Agarum* spp., meanwhile, is able to take over some of the space lost by the *Laminaria* spp.

In terms of anthropogenic impacts on kelp beds, shading, pollution, over-harvesting, and the removal or disturbance of habitat through dredging, blasting, removal of boulders, dragging, and sedimentation all threaten kelp beds.

Studies conducted within the Pennant Point to Pollock Point area include:

Mann, K.H. 1973. "Seaweeds: Their Productivity and Strategy for Growth" in Science. 182(4416): 975-981.

Mann, K.H. 1972. “Ecological energetics of the seaweed zone in a marine bay on the Atlantic Coast of Canada. I. Zonation and biomass of seaweeds” in Marine Biology. 12: 1-10.

Mann, K.H. 1972. “Ecological energetics of the seaweed zone in a marine bay on the Atlantic Coast of Canada. II. Productivity of the seaweeds” in Marine Biology. 14: 199-209.

Metaxas, A.; Hunt, H.L.; Scheibling, R.E. 1994. “Spatial and temporal variability of macrobenthic communities in tidepools on a rocky shore in Nova Scotia, Canada” in Marine Ecology Progress Series. 105: 89-103.

Metaxas, A.; Scheibling, R.E. 1994. “Changes in Phytoplankton Abundance in Tidepools over the Period of Tidal Isolation” in Botanica Marina. 37: 301-314.

Miller, R.J.; Mann, K.H. 1971. “Production Potential of a Seaweed-Lobster Community in Eastern Canada” in Journal of the Fisheries Research Board of Canada. 28(11): 1733-1738.

Moore, D.S.; Miller, R.J. 1983. “Recovery of macroalgae following widespread sea urchin mortality with a description of the nearshore hard-bottom habitat on the Atlantic coast of Nova Scotia” in Canadian Technical Report of Fisheries and Aquatic Sciences. 1230.

Novaczek, I.; McLachlan, J. 1986. “Recolonization by Algae of the Sublittoral Habitat of Halifax County, Nova Scotia, Following the Demise of Sea Urchins” in Botanica Marina. 29: 69-73.

Smith, B.D. 1988. “Comparison of Productivity Estimates for *Laminaria* in Nova Scotia” in Canadian Journal of Fisheries and Aquatic Sciences. 45: 557-562.

Stephenson, R.L.; Tan, F.C.; Mann, K.H. 1986. “Use of stable carbon isotope ratios to compare plant material and potential consumers in a seagrass bed and a kelp bed in Nova Scotia, Canada” in Marine Ecology Progress Series. 30: 1-7.

Ward, A.E. 1999. Maine’s Coastal Wetlands. www.state.me.us/dep/blwq/vol1pt4.pdf. Accessed: 15 May 2003.

Wharton, W.G.; Mann, K.H. 1981. “Relationship Between Destructive Grazing by the Sea Urchin, *Strongylocentrotus droebachiensis*, and the Abundance of American Lobster, *Homarus americanus*, on the Atlantic Coast of Nova Scotia” in Canadian Journal of Fisheries and Aquatic Sciences. 38: 1339-1349.

### IRISH MOSS (*CHONDRUS CRISPUS*)

*Chondrus crispus* is a common red algae that is found in the rocky intertidal zone (where there is wave action) as well as in the subtidal (where wave action is less pronounced). It may also occur in the under-story of *Laminaria* spp. zones. Also known as carrageen, *Chondrus crispus* is one of the most common seaweeds along the North Atlantic coastline. A crustose holdfast allows the algae to attach onto rocky substrates while its branching fronds allow for nutrient uptake. The colour of the algae is dependent on the nutrients and the amount of light available – the more nutrients available, the darker the pigmentation. While yellow or green Irish moss is not in itself cause for concern since the marine plant is able to grow in habitat with low nutrient availability, lighter coloured moss in areas where it used to be dark may indicate denitrification, changes in water movement, or increased shading by other marine flora. *Chondrus crispus* reproduce both vegetatively and sexually (by releasing carpospores and tetraspores into the water column during summer and early fall months).

Abundance of Irish moss is significantly less than it was 20 or 30 years ago. These seaweed beds are also smaller and thinner than those of the past. This decline may be attributed to harvesting pressures (Irish moss is harvested along Nova Scotia's Atlantic Coast with handrakes), to changes in nutrients, and/or changes in light concentration.

Irish moss beds provide (along with other seaweed species) important shelter, feeding, and nursery grounds for invertebrates, fish (including herring [*Clupea harengus*]), shellfish, and lobster (*Homarus americanus*).

When dried, Irish moss can be used in medicines, cosmetics, and as a stabilising agent in foods.

Studies conducted within the Pennant Point to Pollock Point area include:

Canadian Atlantic Fisheries Scientific Advisory Committee. 1983. "Advice on the Management of Irish Moss (*Chondrus*) Stocks off Southwestern Nova Scotia" in CAFSAC Advisory Document. 83/5.

MacKenzie, D. 2001. "Evolving trends in marine algae populations, seagrasses and other intertidal organisms: Signs and symptoms of a mounting nitrogen deficit in the ocean?" in The Starving Ocean. www.fisherycrisis.com/seaweed.html. Accessed: 15 May 2003.

Mann, K.H.1972. "Ecological energetics of the seaweed zone in a marine by on the Atlantic Coast of Canada. I. Zonation and biomass of seaweeds" in Marine Biology. 12: 1-10.

Sharp, G.J.; Roddick. 1982. "Catch and effort trends of the Irish moss (*Chondrus crispus* Stackhouse) fishery in southwestern Nova Scotia, 1978 to 1980" in Canadian Technical Report of Fisheries and Aquatic Sciences. 1118.

**IMPORTANT MARINE PLANT SPECIES WITHIN THE PENNANT POINT TO POLLOCK POINT AREA:**

| Species | Class | Zonation |
|---|---|---|
| Green Fleece (*Codium fragile*) | Chorophyceae | Subtidal (hard and soft substrates) |
| *Cladophora* spp. | Chlorophyceae | |
| Sea lettuce (*Ulva lactuca*) | Chlorophyceae | Intertidal (rocky and muddy substrates) |
| Eelgrass (*Zostera marina*) | Liliopsida | Lower intertidal and shallow subtidal (mudflats, sandflats, mixed coarse, and fine environments) |
| Rockweed (*Ascophyllum nodosum*) | Phaeophyceae | Intertidal (rocky substrates) |
| Rockweed (*Fucus* spp.) | Phaeophyceae | Exposed intertidal (high eulittoral on rocky substrates) |
| Kelp (*Laminaria* spp.; *Agarum* spp.; *Chorda* spp.; *Saccorhiza* spp.) | Phaeophyceae | Lower intertidal and shallow subtidal (rocky and coarse substrates) |
| Sausage weed (*Scytosiphon lomentaria*) | Phaeophyceae | Intertidal (rocky and exposed substrates) |
| Sea colander (*Agarum cribrosum*) | Phaeophyceae | Subtidal |
| *Leathesia difformis* | Phaeophyceae | Lower intertidal (grows epiphytically on Chondrus crispus and Corallina officinalis) |
| Irish Moss (*Chondrus crispus*) | Rhodophyceae | Intertidal and subtidal (rocky substrates) |
| Coral weed (*Corallina officinalis*) | Rhodophyceae | Lower intertidal |
| Dulse (*Rhodymeria palmate*) | Rhodophyceae | Intertidal (lower to mid-littoral to deep water) |
| Banded weed (*Ceramium* spp.) | Rhodophyceae | Intertidal and shallow subtidal (various substrates) |
| *Polysiphonia lanosa* | Rhodophyceae | Intertidal (grows epiphytically on Ascophyllum nodosum) |
| Tube weed (*Polysiphonia* spp.) | Rhodophyceae | Intertidal (rocky substrates) |
| Lacy red weed (*Euthora christata*) | Rhodophyceae | Extreme lower intertidal and tidepools (grows epiphytically on coarse seaweeds [for example, kelp]) |

## MARINE INVERTEBRATES

### AMERICAN LOBSTER (*HOMARUS AMERICANUS*)

American lobsters range along the Atlantic coast from Labrador south to North Carolina. While the rocky intertidal zone of coastal waters provides important habitat to the species, lobster can also be found in the deeper, offshore waters of the continental shelf.

Female lobsters release fertilised eggs 11 to 13 months after mating and usually in the summer. These eggs attach onto the lobster's pleopods and develop for a further nine to 11 months. They hatch between May and October, with warmer temperatures inducing earlier hatching. The distribution and abundance of the larvae are dependent on the distribution of the spawning females as well as on such environmental conditions as water currents, temperature, salinity, light intensity, and larval mortality. The larvae are planktonic from late May to October and appear to undergo vertical migration on a daily basis (remaining in deeper waters during the night, but close to the surface during the day). Natural mortality is high at this stage (the average annual survival rate is estimated at approximately 0.9%).

Inshore juvenile and adult American lobsters seek shelter from predation among the rocks, crevices, and vegetation that are found on coastal sand-rock, bedrock-rock, mud-rock, mud-silt, and clay-silt substrates. In areas where there are no natural crevices, they will excavate areas under seafloor objects (as particularly seen offshore). Inshore lobsters tend to be solitary and only rarely share shelter. Offshore lobsters, however, often share shelters – such behaviour may be influenced by the scarcity of appropriate habitat.

Inshore lobsters will migrate (usually less than 100 metres) from shallow to deeper waters during storms. Seasonal migrations have also been observed among eastern Canadian stocks – they tend to migrate short distances to deeper waters during the winter and to more shallow areas during the summer. Furthermore, Atlantic lobsters appear to have limited home ranges although larger lobsters seem to migrate greater distances than smaller ones. It has also been noted that offshore lobsters also tend to migrate farther than those found in the coastal zone. MacKenzie and Moring (1985) suggest that lobster movements may be influenced or triggered by water temperature changes. There appears to be little inter-mixing among adjacent communities.

Juvenile and adult lobsters prey on bottom invertebrates, crabs, sea urchins, mussels, polychaetes, periwinkles, and sea stars. They also consume fish and plants and scavenge for food. Although lobsters may prefer crabs to sea urchins and sea stars, Ennis (1973 c.f. MacKenzie and Moring, 1985) found that the latter made up a larger proportion of the lobster's diet during the moulting season (perhaps because of their high calcium concentrates) than during other times of the year. Mann (2000) further suggests that the American lobster is a keystone species in the south shore of Nova Scotia and helps to control sea urchin populations. Generally, feeding activity slows during the fall and is low during the winter.

American lobsters are preyed upon by many different types of bottom-feeding fish, including Atlantic cod, sharks, wolfish, and pollock. Juveniles and adults are predominantly harvested by licensed Canadian fishermen in the inshore during open seasons. Based on current regulations, no new licenses have been recently awarded and fishing has been limited to only small boats using traps (with size limits). In addition, berried females may not be retained and there is a set lobster minimum size. That is, lobsters must reach at 81 millimetres in carapace length before they may be legally caught – most lobster take seven to eight years to reach this minimum length. Off southwest Nova Scotia, most lobsters mature between 90 and 100 millimetres carapace length. It should also be noted that there is a small offshore lobster fishery that uses larger traps.

American lobster landings have increased during the 1980s. Such an increase has been partly attributed to environmental changes (for example, warmer water temperatures) that have improved the survival rate of both larvae and juveniles. During the fall of 1997 and the winter of 1998, population densities decreased. During this time, a colder and less saline water mass (the

Labrador Slope Water) moved along the Scotian Shelf and the Gulf of Maine. This water mass may have stressed the lobster populations, although it is not known for certain. It is believed that inshore recruitment was also have been high during the 1980s and early 1990s and this may have resulted in record landings during those two decades. The inshore fishery is not under quota or monitored at dockside. This means that there is little information available on catch location for the inshore fishery. Lobster fishing, however, does occur off Peggy's Cove, within St. Margarets Bay and Mahone Bay, and near the LaHave River estuary.

Studies conducted within the Pennant Point to Pollock Point area (and those that provide related natural history/ecological information) include:

Cady, F.F.; Chandler, R.A. 1976. "Historical statistics of landings of inshore species in the Maritime Provinces, 1947-1973" in Fisheries and Marine Services Research Development Technical Report. 639.

Department of Fisheries and Oceans. 2003. "Offshore Lobster (LFA 41): Integrated Fishery Management Plan, 1999-2000." www.mar.dfo-mpo.gc.ca/fisheries/res/imp/99offlob.htm. Accessed: 27 May 2003.

Department of Fisheries and Oceans. 1996. "Eastern and South Shore Nova Scotia Lobster LFAs 31-33" in DFO Atlantic Stock Status Report . 96/117E.

Mann, K.H. 2000. Ecology of coastal waters: with implications for management. Malden: Blackwell Sciences.

MacKenzie, C.; Moring, J.R. 1985. "Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North Atlantic) – American Lobster" in U.S. Fish and Wildlife Service Biological Report. 82 (11.33).

#### JONAH CRAB (*CANCER BOREALIS*)

The Jonah crab is found along the Atlantic coast from Nova Scotia to South Carolina and the Bermudas. They are found in the shallow intertidal waters to depths of up to 800 metres. Those in Nova Scotian waters, however, tend to be found in depths that range between 50 and 300 metres and in waters of eight to 14$^{o}$C. Substrate preferences include rocky bottoms as well as those that are more sandy or clay. They feed on other invertebrates including mussels, snails, and sea stars.

Most male Jonah crabs reach maturity at 90-100 millimetres carapace width while females mature at 85 millimetres. Studies indicate that mean carapace width of males increases with depth.

Female crabs brood their eggs on the swimmerets located under their abdomens. After being released (usually during the warmer months of the year), larvae undergo several plankton stages in the water column before they settle to the bottom. These larvae may be transported considerable distances from their release location by ocean currents.

During the late 1980s, vessels under 65 feet were fishing for Jonah crab. Low yields and insufficient markets eventually forced the fishery to close. Efforts to restart the industry, however, began in 1996 in southwest Nova Scotia. This effort was permitted under combined exploratory Rock and Jonah crab permits. The fishing area had been divided into the inshore (zero to 12 miles) and midshore (12 to 50 miles). After consultation with the Southwest Nova Scotia Advisory Board and exploratory licence holders, it was found that there were marginal returns for inshore rock crab fishers. There were also some conflicts with the inshore lobster fishery (Jonah crab and lobsters co-exist). Amendments to the Management Plan in 1997 removed the distinction between inshore and mid-shore zones. Nevertheless, within the Pennant Point to Pollock Point study area, four licensed holders were involved in the exploratory fishery in a zone west of Pennant Point and within 12-50 miles of the coastline. The exploratory fisheries took place during the closed lobster seasons and a minimum catch size of male carapace widths was set at 130 millimetres. The fishery is still relatively new and is still being developed.

Studies conducted within the Pennant Point to Pollock Point area (and those that provide related natural history/ecological information) include:

Department of Fisheries and Oceans. 1996. "Inshore Gulf of Maine Jonah Crab (*Cancer borealis*)" in DFO Atlantic Fisheries Stock Status Report. 96/111E.

Reeves, A.; Eagles, M. 2003. "The 1998 Rock and Jonah Crab Integrated Fishery Management Plan – Southwest Nova Scotia Scotia-Fundy Fisheries Maritimes Region." www.mar.dfo-mpo.gc.ca/fisheries/res/imp/98snsrjc.html. Accessed: 27 May 2003.

#### SNOW CRAB (*CHIONOECETES OPILIO*)

The snow crab ranges from Greenland to the Gulf of Maine and can be found at depths between 20 and 310 metres (but predominantly between 70 and 280 metres). They are usually found on muddy or sand-mud substrates and in areas where summer bottom water temperatures are less than seven degrees Celsius (although they seem to prefer water temperatures of less than three degrees Celsius).

While both male and female snow crabs moult, they do not undergo the process throughout their lives. Indeed, females stop growing after they have acquired a wider abdomen (for carrying eggs) while males stop growing after they acquire large claws on their first pair of legs. Females produce eggs and carry them under their abdomens for approximately two years. These eggs hatch in late spring or early summer. After a short pelagic larval stage of between 12 and 15 weeks, young snow crabs settle on the bottom. An additional eight or nine years will pass before snow males will reach legal fishing size.

Although the snow crab inshore fishery started in 1966 off the northwest part of Cape Breton, it was not until 1994 that harvesting of the species began off the southwest coast of Nova Scotia with four licenses and a 30 trap limit; snow crab fishing activity that year was minimal. Since then, catch rates have increased from two kilograms per trap haul in 1995 to 11.4 kilograms per trap haul in 1999. At the same time, total seasonal effort has decreased from 12 500 trap hauls in 1995 to less than half of that (6 000 trap hauls) in 1999. Highest catch rates were between January and April in 1998 and 1999.

It should be noted that snow crab distribution and population abundance are sporadic. Indeed, it appears as though Nova Scotia (and particularly southwest Nova Scotia) is at the southern limit of the species' distribution. In 1999, the Department of Fisheries and Oceans conducted an exploratory trap survey to determine the distribution of adult and young crabs. While the trap survey may not have completely reflected snow crab population structure, results indicate that there is a limited distribution of the crab in southwest Nova Scotia, with populations found in the midshore region south of the St. Margarets Bay and the LaHave River-Pollock Point area. The lack, however, of scientific information does not allow a total allowable catch to be calculated, but current Nova Scotian fishing effort levels are believed to appropriate.

Studies conducted within the Pennant Point to Pollock Point area (and those that provide related natural history/ecological information) include:

Department of Fisheries and Oceans. 2003. "Eastern Nova Scotia Snow Crab Integrated Fishery Management Plan – Scotia-Fundy Sector, Maritimes Region CFA 20-22 2000, CFA 23-24 2000-2002." www.mar.dfo-mpo.gc.ca/fisheries/res/imp/2000snocrab.htm. Accessed: 27 May 2003.

Department of Marine Resources and Fisheries. 2000. “Southwestern Nova Scotia Snow Crab” in DFO Science Stock Status Report. C3-65(2000).

**SEA URCHIN (*STRONGYLOCENTROTUS DROEBACHIENSIS*)**

The green sea urchin is found throughout the shallow rocky substrate of the intertidal zone of Atlantic Canada. Sea urchins spawn in the spring and the larvae are planktonic for approximately two months before they settle on the sea floor.

Sea urchins are one of the most important invertebrates that inhabit kelp (*Laminaria* spp.) beds. They may exist in two forms within these intertidal habitats. That is, when kelp is abundant, sea urchins will tend to live in crevices or close to rocks, boulders, and other areas where they are protected from predators (including lobsters). Sea urchins feed on dead fish, sponges, mussels, barnacles, algae, and decaying matter. They also consume the kelp blades that break off naturally because of wave action. When sea urchins, however, are more abundant, they emerge from their shelters and form large aggregations (a defense mechanism against predation). In extreme cases, these aggregations may consume and/or destroy entire kelp beds and may covert the areas into significantly less productive, coralline communities. Indeed, such destruction has occurred over hundreds of kilometres of the Atlantic coast of Nova Scotia.

Three factors may help to control the abundance of sea urchins:

1. sea urchin populations may be controlled by predation (including predation by otters on the west coast of North America and by lobster and fish on the east coast);
2. sea urchin populations may be controlled by disease and environmental conditions favourable for the spread of disease (including warm coastal water temperatures); and
3. sea urchin populations may grow and overgraze kelp when environmental conditions support heavy recruitment (including warm water temperatures and wave energy).

On the east coast of North America, sea urchins are preyed upon by crabs, sea stars, snails, fish, and lobsters. In a relatively new fishery, they are also harvested by commercial fishers. The fishery began in 1989 and increased significantly in 1994 when their market price increased. Sea urchins may only be harvested by divers and the fishery is further regulated by minimum sizes limits (50 millimetres shell diameter), open seasons (generally October through April), licenses that are restricted to zones, and culling that must occur at sea. In an effort to implement a more “habitat-based” approach to management rather than one based on stock size, the Department of Fisheries and Oceans made harvesting zones smaller. They also encouraged fishers to fish near their home and limited the number of fishers that share the same fishing ground. The Department (1997, 2) states that individual zones

> eliminate competition for the resource and free the fisher to harvest the resource at optimum times dictated by development, price, and weather. It also rewards the fisher personally for any work done to enhance the productivity of the zone. Because fishers are not competing for the same resource they are willing to share information on harvest and enhancement methods, and have done so.

In order for this approach to work, distribution of sea urchins and kelp beds must be determined. During the mid- and late-1990s, this information was collected through diving surveys along the Atlantic coast of Nova Scotia as well as from reliable fishers. In the study area of Pennant Point to Pollock Point, there was a mix of large kelp beds, overgrazed urchin barrens, and areas with balanced sea urchin populations and kelp coverage. Harvesting areas that are over-stocked with sea urchins may help to control populations, restore kelp bed coverage, and encourage or permit lobster recruitment and settlement.

Studies conducted within the Pennant Point to Pollock Point area include:

Department of Marine Resources and Fisheries. 2003. "Green Sea Urchin Conservation Harvesting Plan 1996-1997 Southwest Nova Scotia and Eastern Nova Scotia." www.mar.dfo-mpo.gc.ca/fisheries/res/chp/eng/0871.html. Accessed: 27 May 2003.

Department of Marine Resources and Fisheries. 1996. "Nova Scotian Sea Urchin" in DFO Atlantic Fisheries Stock Status Report. 96/130E.

Mann, K.H. 2000. Ecology of coastal waters: with implications for management. Malden: Blackwell Sciences.

A 2001 study conducted by the Marine Invertebrate Diversity Initiative (Vardy, 2001) listed some of the marine invertebrates that could be found in the Peggy's Cove area. The identified species were found in published literature and in the Nova Scotia Museum of Natural History's collection.

| Species | Order | Phylum |
|---|---|---|
| *Halichondria* sp. | Halichondridae | Porifera |
| Garland Hydroid (*Sertularia pumila* L.) | Thecata | Cnidaria |
| Northern Red Anemone (*Tealia felina* L.) | Actiniaria | Cnidaria |
| Frilled Anemone (*Metridium senile* L.) | Actinaria | Cnidaria |
| **EURYTEMORA AFFINIS** | Calanoida | Arthropoda |
| **TEMORA LONGICORNIS** | Calanoida | Arthropoda |
| **TEMORA STYLIFERA** | Calanoida | Arthropoda |
| **MICROSETELLA ROSEA** | Harpacticoida | Arthropoda |
| **EVADNE NORDMANNI** | Cladocera | Arthropoda |
| Water Flea (*Podon polyphemoides*) | Cladocera | Arthropoda |
| Twelve-scaled Worm (*Lepidonotus squamatus* L.) | Phyllodocida | Annelida |
| Paddle Worm (*Phyllodoce maculata* L.) | Phyllodocida | Annelida |
| Fifteen-scaled Worm (*Harmothoe imbricata*) | Phyllodocida | Annelida |
| Hard-tube Worm (*Spirorbis borealis*) | Sabellida | Annelida |
| *Neanthes succinea* | Aciculata | Annelida |
| Common Sea Star (*Asterias vulgaris*) | Forcipulata | Echinodermata |
| Blood Star (*Henricia sanguinolenta*) | Spinulosida | Echinodermata |
| Daisy Brittle Star (*Ophiopholis aculeate* L.) | Ophiurida | Echinodermata |
| Green Sea Urchin (*Strongylocentrotus droebachiensis*) | Echinoida | Echinodermata |
| Hairy Hermit Crab (*Pagurus arcuatus*) | Decapoda | Mandibulata |
| American Lobster (*Homarus americanus*) | Decapoda | Mandibulata |
| Isopoda (*Idotea balitica*) | Isopoda | Mandibulata |
| Isopoda (*Idotea balitica*) | Isopoda | Mandibulata |
| Little Shore Isopod (*Jaera* | Isopoda | Mandibulata |

| | | |
|---|---|---|
| *marina*) | | |
| Scud (*Gammarus tigrinus*) | Amphipoda | Mandibulata |
| Scud (*Gammarus oceanicus*) | Amphipoda | Mandibulata |
| **MARINOGAMMARUS FINMARCHICUS** | Amphipoda | Mandibulata |
| Amphipod (*Casco bigelowi*) | Amphipoda | Mandibulata |
| Scud (*Gammarus locusta*) | Amphipoda | Mandibulata |
| Tubicolous Amphipod (*Ampithoe rubricata*) | Amphipoda | Mandibulata |
| Planktonic Amphipod (*Pontogeneia inermis*) | Amphipoda | Mandibulata |
| Tubicolous Amphipod (*Corophium volutator*) | Amphipoda | Mandibulata |
| Green Crab (*Carcinus maenas* L.) | Amphipoda | Mandibulata |
| Rock Crab (*Cancer irroratus*) | Amphipoda | Mandibulata |
| Northern Rock Barnacle (*Balanus (Semibalanus) balanoides* L.) | Thoracica | Mandibulata |
| Goose Barnacle (*Lepas fascicularis*) | Thoracica | Mandibulata |
| Small Copepod Crustacean (*Oithona similes*) | Cyclopoida | Mandibulata |
| Tortoiseshell Limpet | Archeogastropoda | Mollusca |
| Smooth Periwinkle | Mesogastropoda | Mollusca |
| Common Periwinkle | Mesogastropoda | Mollusca |
| Rough Periwinkle | Mesogastropoda | Mollusca |
| Banded Chink Shell (*Lacuna vincta*) | Neogastropoda | Mollusca |
| Atlantic Dog Whelk (*Nucella lapillus*) | Neogastropoda | Mollusca |
| Arctic Rock Borer (*Hiatella arctica*) | Myoida | Mollusca |
| Horse Mussel (*Modiolus modiolus* L.) | Pteroconchida | Mollusca |
| Blue Mussel (*Mytilus edulis* L.) | Pteroconchida | Mollusca |
| **MYTILUS TROSSULUS** | Pteroconchida | Mollusca |
| Jingle Shell (*Anomia simplex*) | Pteroconchida | Mollusca |

**IMPORTANT MARINE INVERTEBRATE WITHIN THE PENNANT POINT TO POLLOCK POINT AREA:**

| Species | Class | Spawning Period | Adult and Juvenile Distribution | | Important Associations with other Marine Organisms |
|---|---|---|---|---|---|
| | | Timing | Zonation and Substrate | Within Study Area (confirmed) | |
| American Lobster (*Homarus americanus*) | Crustacea | Summer | Inshore intertidal and offshore; Found on rocky and vegetated areas as well as in some open areas | Peggy's Cove area; St. Margarets Bay; Mahone Bay; LaHave River estuary | Strongly associated with kelp (*Laminaria* spp.) as well as with sea urchins (*Strongylocentrotus droebachiensis*) (perhaps more indirectly with the latter) |
| Jonah Crab (*Cancer borealis*) | Crustacea | Spring to summer | Inshore intertidal and offshore; Found on rocky, sandy, and muddy areas | Nearshore west of Pennant Point | Co-exist with Atlantic lobsters (*Homarus americanus*); also associated with Rock Crabs (*Cancer irroratus*) |
| Rock Crab (*Cancer irroratus*) | Crustacea | Spring to summer | Inshore intertidal and offshore; found primarily in shallow-water bays and in open sand or sand-mud bottoms | Peggy's Cove | Assocated with Jonah Crabs (*Cancer borealis*), Snow Crabs (*Chionoecetes opilio*), and American lobsters (*Homarus americanus*) |
| Snow Crab (*Chionoecetes opilio*) | Crustacea | Late spring to early summer | Inshore intertidal and offshore; Found on muddy or sandy-muddy areas | South of St. Margarets Bay; South of the LaHave River estuary-Pollock Point area | Occurs with Jonah Crabs (*Cancer borealis*), Rock Crabs (*Cancer irroratus*), and with Atlantic lobsters (*Homarus americanus*) |
| Sea Urchin (Strongylocentrotus droebachiensis) | Echinodermata | Spring | Shallow intertidal; Found on rocky areas | Throughout the study area | Strong relationship with kelp (*Laminaria* spp.) and Atlantic lobsters (*Homarus americanus*) |

| | | | | | |
|---|---|---|---|---|---|
| Ocean Quahaug (Arctica islandica) | Pelecypoda | Year round, peaking between July and September | Shallow intertidal to offshore; Found within muddy to sandy areas and less abundantly in clay and gravely areas | Inshore St. Margarets Bay, Off the Aspatogan Peninsula; Off the LaHave Islands | |
| Atlantic Surf Clam (Spisula solidissima) | Bivalvia | Late June to August | Inshore and offshore; Often found on sandbars at or just below the low water mark | South of the LaHave Islands | Preyed upon by large groundfish and some species of whelk |
| Sea Scallop (Placopecten magellanicus) | Bivalvia | Summer to late fall | Nearshore (just below the intertidal mark to the intertidal zone) to offshore; Found on most substrata including rocky and vegetated areas | Mahone Bay | Symbiotic relationship with juvenile red hake (*Urophycis chuss*) which live inside the mantle cavities of the sea scallops |
| Atlantic Jack Knife (*Ensis directus*) | Bivalvia | Around early June | Intertidal and subtidal; Prefers gently sloping beaches with shifting sand; Also found in mud and gravel substrates | St. Margarets Bay south to the LaHave River estuary (intertidally) | Associated with other bivalves including softshell (*Mya arenaria* L.) and surf clams (*Spisula solidissima*) |
| Blue Mussel (*Mytilus edulis* L.) | Bivalvia (Pelecypoda) | Difficult to predict | Littoral to sublittoral zones of estuarine environments; Also found in deeper waters; Found on rocky and gravely substrates | LaHave River estuary | Competitively dominant to barnacles; An important consumer of marine plankton and food source for sea stars, whelks, crabs, and marine birds |

| | | | | | |
|---|---|---|---|---|---|
| Periwinkle (*Littorina littorea*) | Mesogastropoda | | From the high water mark to depths of up to 40 metres; Found on diverse substrata ranging from rock to sand | Throughout the study area | Feeds on a myriad of micro- and macroalgae as well as on early settlement stages of sessile invertebrates; Feeding activity can have significant influence over benthic hard-bottom community structure |

## MARINE FISH

### AMERICAN EEL (*ANGUILLA ROSTRATA*)

American eels are catadromous species that inhabit lakes, rivers, and estuaries throughout the Maritimes. Their abundance is proportional to the size and productivity of the river system. Size at maturation of the eels varies on geography and sex with males being smaller than females. Spawning occurs between August and December and peak migration from river systems to the ocean occurs in September and October. Larger females tend to lay more eggs and it has been estimated that a 45 centimetre-long female will release approximately two million eggs while one that is 113 centimetres long can lay up to 20 million eggs. Studies indicate that eels will die after spawning.

The eggs develop into larvae and drift over the continental shelf where they develop into glass eels. These eels will eventually move towards the shore and by the time they have reached Nova Scotia's estuaries (usually between May and June), they have become pigmented elvers. Their movement upstream could take up to four years and they may remain in freshwater for five to 15 years, depending on the area's feeding and environmental conditions which influence their growth rate.

In terms of abundance, female yellow eels (immature adult eels) tend to dominate the upper regions of river systems while their male counterparts tend to populate the estuarine areas. Jessop (2000) indicates that sex determination may be dependent on environmental conditions. That is, when population densities are high or if environmental conditions (for example, highly acidic and poorly productive habitats, as found in East River, Chester), most eels tend to be male. In addition, large river systems may be predominantly female while smaller ones may have a higher proportion of males.

Yellow eels are known to migrate upstream, especially during the summer-winter transition when some summer areas may be unsuitable for over-wintering. Eels become less active in colder water temperatures and noticeably so when temperatures fall below 11$^{o}$C. They hibernate during the winter months in muddy river bottoms.

Eels have small home ranges in which they forage. They use smell to locate prey and as carnivores, they consume a variety of organisms, including fish and such invertebrates as crayfish, insects, and snails. They are also subject to predation and are especially vulnerable when small.

The fishing industry surrounding this species has developed since 1989 and there is a small-scale commercial fishery for large eels throughout the Maritimes, including the area between Pollock Point and Pennant Point. The most popular methods to catch eels include baited pots, hoop nets, and weirs. While American eel catches vary by province, Ontario, Quebec, Prince Edward Island, New Brunswick, and Nova Scotia have all seen a decline in landings. Such a decline may be partly due to an actual decrease in elver (small version of an adult eel) abundance that may have been negatively impacted by changing oceanic conditions, habitat destruction (for example, by damming of rivers) and obstruction (for example, turbines), and historical excessive fishing pressure. Declining eel catches has led to some efforts to institute a management plan at national and international levels. Such a management plan aims to better understand and balance eel exploitation during its different life stages. Jessop (2000) indicates that the American eel's life cycle is complex and complicates fishery regulations. At the same time, creating and implementing fishery regulations is complicated, primarily because of the American eel's complex life cycle (as per Jessop, 2000):

1. adult eels that leave rivers to spawn are not necessarily always replaced with returning elvers;
2. the rate of elver return to rivers varies between years and may be influenced by oceanic environmental conditions;
3. adult growth rates vary both geographically within river systems and between years;

4. the factors determining the onset of maturation are unclear;
5. age and sex are difficult to determine; and
6. mathematical models have not been very successful.

It must also be recognised that fishing yellow eels within a river system reduces the abundance of silver eels (sexually maturing eels) and fishing both yellow and silver eels reduces the overall spawning stock of that river.

While American eels occur throughout the Pennant Point to Pollock Point area, valuable stocks are found in East River, Chester, LaHave River, Lunenburg County, and Medway River, Lunenburg County.

Studies conducted within the Pennant Point to Pollock Point area include:

Department of Fisheries and Oceans. 1996. "Eel Fisheries in the Maritimes (*Anguilla rostrata*)" in DFO Atlantic Fisheries Stock Status Reprot. 96/14E.

Jessop, B.M. 2000. "American Eel" in Underwater World. Ottawa: Communications Directorate – Department of Fisheries and Oceans.

#### ATLANTIC HERRING (CLUPEA HARENGUS)

Atlantic herring is a pelagic schooling species. While little is known of stock structure and migration patterns, it is understood that they do home to discrete locations to spawn. These locations may be either offshore or nearshore – in the spring, spawners tend to move to the shallow nearshore waters while fall spawners reproduce in the deeper offshore waters. Fall spawners, however, have also been found in the coastal waters of southwest Nova Scotia. Herring appear to prefer sand as spawning substrate although spawning may also occur over gravel, rock, and/or clay.

As of 1998, the largest spawning grounds in the lower regions of Halifax County and Lunenburg County were found in: Terrance Bay; West Dover; between East Ironbound Island and Pearl Island; between Cross Island and Big Duck Island; and the area around West Ironbound Island.

Fall spawners are believed to be up to 50 percent more fertile than spring spawners. This high productivity has been attributed to warmer waters and greater food availability during the summer months before spawning compared to the water conditions of March and April. Egg, larval, and juvenile mortality are relatively high and survival appears to depend on a number of factors. For example, the level of predation on eggs can significantly affect future population sizes of herring – eggs are eaten by mackerel and groundfish (such as cod, haddock, and various types of flounder). Larvae and juveniles may grow more quickly in warmer temperatures and more slowly when year-old herring are abundant.

Aquatic species that have been identified by fishers as being particularly associated (in percent frequency) with herring include (in descending order, as per Crawford, 1979) mackerel (21), cod (16), gaspereau (13), squid (9), porpoise (9), whale (8), pollock (6), seal (4), dogfish (4), haddock (2), red feed (2), sculpin (1), and jelly fish (1). Adult herring are filter feeders and prey upon tiny crustaceans, such as copepods and euphausiids. They also consume eggs, larvae, and other small organisms. In turn, herring are preyed upon by cod, silver hake, salmon, tuna, sharks, dogfish, squid, sea birds, seals, and whales. Fishing, however, continues to have the largest impact on stock size. The industry is based on set gill nets and trap nets in Halifax and Lunenburg Counties. In addition, fishing effort in these counties were among the highest (an average of 127 days for Halifax, Lunenburg, Queens, and Shelburne Counties) with the season generally beginning in early May and ending in late October (exact dates vary depending on fishing location). Crawford (1979) notes that in 1979 and earlier, catches were the greatest just prior to the spawning period.

In a survey conducted in 1998 (Clark *et al*., 1998), fishers indicated that there has been a decline in the number of herring in the inshore region of eight main counties: Bras d'Or Lakes; Richmond; Victoria; Guysborough; Halifax; Lunenburg; Queens; and Shelburne. Some fishers suggested that seiners have had a significant and detrimental effect on herring populations and associated fisheries. Indeed, prior to the 1960s, herring were primarily caught by small boats using gill nets, traps, or weirs. More recently, however, purse seiners have caught the majority of the herring offshore. Increased offshore effort has resulted in reductions in (and even collapses of) the inshore herring fishery.

The Department of Fisheries and Oceans (DFO) have identified two major management difficulties:

1. Distribution: ideally, the DFO would like the fisheries to be managed in such a way that full advantage is taken of mobile gear and its ability to pursue and harvest herring outside of the spawning beds. At the same time, the DFO recognises that local spawning runs must continue to be "sufficiently stable" (DFO, 1982) and abundant to support a sustainable inshore fishery.
2. Maintaining a high yield but avoiding over-fishing: there are two principal types of overfishing:
   i. Yield over-fishing: fish are caught at too small a size and the growth potential of the fish is not realised; and
   ii. Recruitment over-fishing: too many immature juveniles are taken before they spawn thereby "resulting in insufficient spawning and fewer numbers of young than parents" (DFO, 1982).

Herring stocks have experienced increased fishing pressure especially since the collapse of the cod and northeastern Atlantic herring stocks (Crawford, 1980). Finding that crucial balance between conservation of spawning stocks (and future spawning stocks) and exploitation is essential. The lower extent of Halifax County and Lunenburg County (in its entirety) represent important spawning and nursery areas that must be accounted for within any management plan.

Studies conducted within the Pennant Point to Pollock Point area include:

Clark, K.J.; Rogers, D.; Boyd, H.; Stephenson, R.L. "Questionnaire Survey of the Coastal Nova Scotia Herring Fishery, 1998" in Canadian Stock Assessment Secretariat Research Document. 99/137.

Crawford, R.H. 1980. "A biological analysis of herring from the Atlantic Coast of Nova Scotia and eastern Northumberland Strait" in Manuscript and Technical report series. 80-03.

Crawford, R.H. 1979. "A biological survey of the Nova Scotia herring fishery, 1979" in Manuscript and Technical Report Series. 79-05.

Department of Fisheries and Oceans. 2002. "4VWX Herring" in Stock Status Report. B3-03 (2002).

Department of Fisheries and Oceans. 1982. "Atlantic Herring" in Underwater World. Ottawa: Communications Directorate – Department of Fisheries and Oceans.

**GASPEREAU – BLUEBACK HERRING (*ALOSA AESTIVALIS*) AND ALEWIFE (*ALOSA PSEUDOHARENGUS*)**

Both the blueback herring and the Alewife are anadromous fish of the Clupeida family and are collectively referred to as "gaspereau". The two species can be differentiated by eye diameter, body depth, and peritoneum colour. Commercial landings, however, tend to be reported as alewife due to the appearances, capture methods, and times of spawning of the alewife and the blueback herring.

Gaspereau migrate from the sea to rivers (usually their natal rivers) in the spring to spawn and this tends to be triggered by changes in water temperature. While both species spawn in rivers throughout Nova Scotia, blueback herring occur in fewer rivers and are less abundant where there is co-occurrence with alewives. It should also be noted that some alewives are land-locked and therefore spend their entire lives in the freshwater.

Alewife spawning usually begins when water temperatures range between five and ten degrees Celsius and between ten and 15°C for the blueback herring. There is, however, overlap in spawning seasons between the species. Where the two are sympatric, spawning habitat appears to be spatially isolated. Alewives tend to spawn in areas of limited or slower water movement, such as in slowly moving parts of streams, in ponds, or in lakes. Substrates include gravel, sand, submerged vegetation, and detritus. There are conflicting reports on whether alewives ascend rivers farther than blueback herring – Loesch (1987) states that they do not, while Crawford, Cusack, and Parlee (1986) state that they do (presumably because of the lower temperatures). Blueback herring, meanwhile, prefer those areas with a faster flow and hard substrate (although soft substrates and detritus are used in slower-flowing tributaries and flooded low-lying areas). Such habitat preference could explain the alewife's prominence in many of the Maritime's smaller rivers – they spawn in the headwater ponds and lakes while blueback herring tend not to.

Studies (Kissil, 1974; Libby, 1982 c.f. Stone, Jessop, and Parker, 1992) indicate that alewives that arrive earliest to spawn tend to be the largest and oldest of both the stock and age group. This may be because these fish are faster and stronger than the younger individuals. Males tend to outnumber the female alewives, but the difference is not statistically significant (Stone, Jessop, and Parker, 1992).

In terms of repeat-spawning fish, there must be adequate supplies in order to ensure that population fluctuations and unfavourable environments do not threaten the stock. Stone, Jessop, and Parker (1992) state that older and repeat-spawning blueback herring proportions tend to be higher than those of alewives and this difference may be attributed to lower exploitation rates of the former.

Juveniles may remain in the areas where spawning occurred while other may move upstream in the summer. Juvenile alewives are abundant in surface waters in September and October before they emigrate to open ocean. Juvenile blueback herring, meanwhile, are abundant in surface waters throughout their time in freshwater. Between June and November of their first year, herring will migrate from their freshwater-estuarine nurseries.

Shortly after spawning (by mid-July), most of the adult alewives and blueback herrings return to the sea. While older fish have been found up to 100 kilometres offshore in such areas as Emerald Bank and Georges Bank, older alewives have been found in Nova Scotia's inshore waters.

Adult gaspereau are opportunistic feeders and forage primarily on zooplankton. They will also prey upon fish and insect eggs and larvae. They tend to feed at night and follow the diel movements of zooplankton in the water column. Neither species feeds extensively during spawning migrations. Larvae and juvenile individuals (of both species) feed on small cladocerns and copepods. They will feed on larger species as they become bigger.

Gaspereau herrings have been historically and commercially exploited for both food and bait in lobster, crab, cod, haddock, pollock, and mackerel fisheries. In an effort to help maintain stocks, passages through fish migration obstructions (such as mills and hydroelectric dams) must be built. Fishing seasons have also been introduced which allow for closed periods and fishing gear restrictions. Efforts have also been made to reduce agricultural, municipal, and industrial water pollution and grey water runoff.

Gaspereau have been found within and are known to spawn in the Pennant Point to Pollock Point area. More specifically, spawning stocks have been documented in the LaHave River system and the Medway River system.

Studies conducted within the Pennant Point to Pollock Point area (and those that provide related natural history/ecological information) include:

Crawford, R.H.; Cusack, R.R.; Parlee, T.R. 1986. "Lipid content and energy expenditure in the spawning migration of alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*)" in Canadian Journal of Zoology. 64: 1902-1907.

Department of Fisheries and Oceans. 1997. "Gaspereau Maritimes Region Overview" in DFO Science Stock Status Report. D3-17.

Department of Fisheries and Oceans. 1986. "Alewife" in Underwater World. Ottawa: Communications Directorate – Department of Fisheries and Oceans.

Loesch, J.G. 1987. "Overview of Life History Aspects of Anadromous Alewife and Blueback Herring in Freshwater Habitats" in American Fisheries Society Symposium. 1: 89-103.

Pardue, G.B.1983. "Habitat suitability index models: alewife and blueback herring" in U.S. Department of the Interior Fish and Wildlife Service. FWS/OBS-82/10.58.

Stone, H.H.; Jessop, B.M.; Parker, H.A. 1992. "Life History characteristics of alewives and blueback herring from five Nova Scotia rivers, 1985" in Canadian Manuscript Report of Fisheries and Aquatic Sciences. 2136.

#### POLLOCK (*POLLACHIUS VIRENS* L.)

Pollock are a pelagic inshore and offshore fish that can be found in waters up to 200 metres in depth. In the northwest Atlantic (with particular regard to those populations in Canadian waters or those that frequent them), spawning takes place between September and April (with peaks from December to February) on the Scotian Shelf, off the coast of Cape Breton, and in Massachusetts Bay. Larvae hatch from the pelagic eggs and remain offshore for at least three or four months. Juvenile pollock (age zero and older [and thus including larvae]) then move inshore into the shallow intertidal and subtidal zones of New England, southern Nova Scotia, and along the coasts of Bay of Fundy. Whether this movement occurs by drifting or through active migration remains unclear.

Clay *et al*. (1989) suggests that larval pollock grow as they move inshore to the bays and estuaries. Clay *et al*. (1989) notes that fish processing plants can be found along the coastline of Nova Scotia and young pollock have been observed to congregate in the areas where the plants discharge fish protein into the ocean. They feed on small fish and crustaceans (primarily on species found within the algal habitat of the rocky intertidal) and grow rapidly in size.

The macroalgae in the rocky intertidal and subtidal zones of the Nova Scotian coast also provide shelter, protection from predation, and foraging areas for the juvenile fish. Juveniles tend to remain in the inshore for the first two or three years of their lives. Densities of pollock in the intertidal zone are influenced by season, time of day, and tidal action. Rangeley and Kramer (1995b) note that while pollock densities were not significantly different among open and algal-covered areas of the inshore, they are either rare of absent from larger-scale open inshore habitats (or those that are predominantly sandy or muddy). Moreover, pollock that were observed in open habitat (usually on low-rising tides and on high- and low-falling tides when shelter and habitat availability is low or is reduced) were rarely solitary. Instead, pollock tend to aggregate in open areas; such formations reduce predator-related mortality. In more sheltered and vegetated areas, pollock tend to disperse.

Studies (Rangeley and Kramer, 1995b) indicate that the rocky and vegetated areas of the intertidal potentially provide important refuge from predators as well as areas that can be used as nursery grounds. Activities that detrimentally affect the macroalgae of the coastal zone (including that between Pollock Point and Pennant Point) will also negatively impact pollock populations.

A tagging study conducted by Clay *et al*. (1989) of pollock confirms a population at Northwest Cove, Lunenburg County.

Studies conducted within the Pennant Point to Pollock Point area (and those that provide related natural history/ecological information) include:

Clay, D.; Stobo, W.T.; Beck, B.; Hurley, P.C.F. 1989. "Growth of Juvenile Pollock (*Pollachius virens* L.) along the Atlantic Coast of Canada with Inferences of Inshore-offshore Movements" in Journal of Northwest Atlantic Fisheries Science. 9: 37-43.

Rangeley, R.W.; Kramer, D.L. 1995a. "Tidal effects on habitat selection and aggregation by juvenile pollock *Pollachius virens* in the rocky intertidal zone" in Marine Ecology Progress Series. 126: 19-20.

Rangeley, R.W.; Kramer, D.L. 1995b. "Use of rocky intertidal habitats by juvenile pollock *Pollachius virens*" in Marine Ecology Progress Series. 126: 9-17.

**CUNNER (*TAUTOGOLABRUS ADSPERSUS* WALBAUM)**

Cunner are saltwater fish that prefer the rocky and vegetated areas of coastal shores. While they occur in the intertidal zone, they can also be found up to depths of almost 100 metres on offshore banks.

These fish become sexually mature once they reach approximately 54 to 60 mm in length or at one or two years in age. They spawn along the Atlantic coast of Nova Scotia primarily in late July and August. They settle in an area after approximately three weeks and remain at the site for the first one or two years of their demersal life.

Young cunner feed on zooplankton and small benthic invertebrates, but preferentially prey on amphipods and isopods. During the night, cunner enter a state of inactivity and seek shelter in the structure that the surrounding macroalgae, pilings, rocky reefs, and wreckage sites provide. They also become torpid during the winter when water temperatures reach approximately five degrees Celsius.

Studies (Tupper and Boutilier, 1997) indicate that juvenile cunner do not show preference for habitat type at settlement and that settlement patterns are not related to density of post-recruitment juveniles or adults. Rather, post-settlement processes appear to regulate among-habitat distributions of the fish and density patterns appear to be primarily influenced by differential survival instead of differential settlement.

It is suggested that recruitment success varies depending on the habitat that the cunner settles – more complex habitats allow for greater success. Predation also decreases with increased habitat complexity. At the same time, while eelgrass may be beds may provide the most effective shelter from predators, young cunner do not tend to use the habitat – presumably because they quickly outgrow the habitat soon after settlement. Furthermore, Tupper and Boutilier (1997) maintain that there is intraspecific competition for limited shelter sites. In terms of growth rate, ecological theory suggests that "fish should select for the habitat that maximizes energy gain (growth), while minimizing the risk of mortality (Tupper and Boutilier, 1997, 234). In the case of a study conducted in St. Margarets Bay, Nova Scotia, while young cunner experienced greatest growth in seagrass/eelgrass beds, they experienced significantly reduced predation risk on rocky reef, cobble, or sandy bottoms. This may be because, as previously stated, they soon outgrow the protection that the vegetated environment provides. There appears to be a trade-off between protection and growth and the environment ultimately chosen by young cunner to inhabit; which strategy is most effective remains unclear. Tupper and Boutilier (1997, 234) do suggest, however, that "in terms of replenishing the adult population, reef and cobble habitats might be viewed as supplying larger numbers of small individuals, each with a higher risk of mortality, while seagrass habitat might be viewed as supplying fewer numbers of large individuals, each with a higher chance of survival."

Studies conducted within the Pennant Point to Pollock Point area include:

Tupper, M.; Boutilier, R.G. 1997. "Effects of habitat on settlement, growth and predation risk and survival of a temperate reef fish" in Marine Ecology Progress Series. 151: 225-236.

Tupper, M.; Boutilier, R.G. 1995. "Effects of conspecifics density on settlement, growth and post-settlement survival of a temperate reef fish" in Journal of Experimental Marine Biology and Ecology. 191: 209-222.

#### ATLANTIC SALMON (*SALMO SALAR*)

Atlantic salmon is an anadromous fish that enters Nova Scotia's rivers and streams usually between November and May while actual spawning occurs in October and November. Spawning runs include both grilse (salmon that have spent a year at sea) and older salmon. Grilse usually survive at least one spawning season and may spawn three or four more times thereafter – usually returning to the same stream or river where they were spawned. After spawning, Atlantic salmon will return to the ocean to recondition.

Salmon eggs tend to incubate over the winter months and will hatch in April as alevins. These young salmon will emerge from the nest site (usually found on gravel-bottoms) in late May and begin to feed primarily on the larvae of aquatic insects. Depending on their size, the young fish (parr) will lay claim to territory – the size of which often depends on that of the fish and may range from one to several square metres. Although growth in freshwater is slow, parr will spend up to three years in this environment before they reach the smolt stage and begin to migrate to the open ocean. It is during this time that their growth rate increases substantially – primarily because of the physiological changes that they experience and from greater abundance of food that is available downstream. At this stage, Atlantic salmon will feed on herring, capelin, alewives, lance, small mackerel, and smelt as well as on crustaceans such as shrimp, squid, and amphipods. Euphausiids are also preyed upon when available. Salmon are not immune to predation and as parr, they are preyed upon by fish-eating birds and eels. Meanwhile, larger fish, including cod, pollock, tuna, swordfish, and sharks are the alevins' primary predators.

The status of Atlantic salmon fish stocks has not been good and in 2002, returns fell short of expectations. Low returns have been attributed to low marine survival. The Department of Fisheries and Oceans has set a conservation threshold reference point which refers to the amount of egg depositions required to ensure the long-term sustainability of the stock. Within the rivers found within the Pennant Point to Pollock Point area (including, but not necessarily limited to, the LaHave River, Gold River, and Petite Rivière), salmon returns did not meet conservation levels in 2001. A 2002 salmon stock status report (DFO, 2002) stated that returns for all rivers except the LaHave River (which was supported by hatcheries) were once again not expected to meet the requirements for that year. It should be noted that declines in stock have been reported since 1986.

The rivers found along the southern shore of Nova Scotia, and specifically those found between Pollock Point and Pennant Point, are generally of lower productivity and organic-acid stained. Acid precipitation has combined with other environmental conditions to produce rivers that tend to be toxic to salmon. Some of these rivers (including the LaHave) have been further impacted by hydroelectric dams and domestic water use.

In 2001, only two user groups harvested Atlantic salmon – Aboriginal peoples and recreational fishers. Aboriginal peoples were given priority to harvesting the species (if conservation requirements were met) and levels of exploitation were based on communal needs for food/subsistence, as well as for social and ceremonial purposes. The rivers within the Pollock Point-Pennant Point area were only open from 1 June to 15 July in 2001 to anglers who practised hook and release (namely, in LaHave River and Gold River). All commercial fisheries remained closed in 2001. The fact that both small and large salmons have historically contributed to egg deposition (and equally so) have led to such fisheries limitations and closures.

As Shaefer *et al.* (2002) state, most salmon stocks along Nova Scotia's Atlantic coast have either been extirpated or are at risk of being extirpated. Any river that currently supports salmon populations also acts as a nursery area and is worthy of careful consideration and management. Such rivers include the LaHave River, Gold, and Petite Rivière as well as their estuaries.

Studies conducted within the Pennant Point to Pollock Point area include:


Amiro, P.G.; Jensen, H. 2000. "Impact of Low-Head Hydropower generation at Morgans Falls, LaHave River on Migrating Atlantic Salmon (*Salmo salar*)" in Canadian Technical Report of Fisheries and Aquatic Sciences. 2323.

Department of Fisheries and Oceans. 2002. "Atlantic Salmon Maritime Provinces Overview for 2001" in DFO Science Stock Status Report. D3-14 (2002).

Department of Fisheries and Oceans. 2001. "Atlantic Salmon Maritime Provinces Overview for 2000" in DFO Science Stock Status Report. D3-14 (2001).

Department of Fisheries and Oceans. 2000. "Atlantic Salmon Maritime Provinces Overview for 1999" in DFO Science Stock Status Report. D3-14 (2000).

Department of Fisheries and Oceans. 1999. "Atlantic Salmon Maritime Provinces Overview for 1998" in DFO Science Stock Status Report. D3-14 (1999).

Department of Fisheries and Oceans. 1988. "The Atlantic Salmon" in Underwater World. Ottawa: Communications Directorate – Department of Fisheries and Oceans.

Gray, R.W.; Cameron, J.D. 1980. "Juvenile Atlantic salmon stocking in several Nova Scotia and southern New Brunswick salmon streams, 1971-79" in Canadian Data Report of Fisheries and Aquatic Sciences. 202.

Gray, R.W.; Cameron, J.D.; Jefferson, E.M. 1978. "Population densities of juvenile Atlantic salmon in several Nova Scotia streams" in Fisheries Marine Services Data Report. 105.

Korman, J.; Marmorek, D.R.; Lacroix, G.L.; Amiro, P.G.; Ritter, J.A.; Watt, W.D.; Cutting, R.E.; Robinson, D.C.E. 1994. "Development and Evaluation of a Biological Model to Assess Regional-Scale Effects of Acidification on Atlantic Salmon (*Salmo salar*)" in Canadian Journal of Fisheries and Aquatic Sciences. 51: 662-680.

O'Neil, S.F.; Stewart, D.A.; Newbould, K.A.; Pickard, R. 1991. "1988 Atlantic Salmon Sport Catch Statistics – Maritime Provinces" in Canadian Data Report of Fisheries and Aquatic Sciences 852.

Peterson, R.H.; Gale, D. 1991. "Fish species associations in riffle habitat of streams of varying size and acidity in New Brunswick and Nova Scotia" in Journal of Fish Biology. 38: 859-871.

Schaefer, H.L.; McCullough, D.; Johnston, S.K.; Duggan, D.R. 2002. Significant Habitats Atlantic Coast Initiative (SHACI) – SHACI Unit 11: Sydney Bight. Dartmouth: Department of Fisheries and Oceans – Oceans and Coastal Management Division, Oceans and Environment Branch.

**ATLANTIC WHITEFISH (*COREGONUS HUNTSMANI*)**

The Atlantic whitefish (formerly Acadian whitefish, *Coregonus canadensis*) is an anadromous species that was endemic to southwest Nova Scotia, and specifically to two river watersheds – the Tusket River watershed, Yarmouth County and the Petite Rivière watershed, Lunenburg County. Unfortunately, populations of the species have not been found in the former watershed for the past two years. Fish populations of 744 Nova Scotian lakes were surveyed between 1964 and 1981 by the Department of Fisheries and Oceans, the Canadian Wildlife Service, and the Nova Scotia Department of Lands and Forests; none of the lakes surveyed contained the Atlantic whitefish. It has been suggested, however, that the fish species may have occurred in the Medway river watershed at one time.

Atlantic Whitefish have adapted to a freshwater habitat within the Petite Rivière watershed. It is uncertain whether this population was ever anadromous. Upstream migration was prevented since the construction of a hydro-electric dam at the foot of Hebb Lake in 1901. Regardless, Atlantic whitefish are saltwater-tolerant and this indicates that there is potential for movement between Nova Scotian watersheds.

Little is known about the spawning period and locations of Atlantic whitefish. Nevertheless, it is believed that spawning most likely takes place in the Petite Rivière lakes during the winter months. Spawning behaviour and early life history/ecology of this fish species has never been observed in the field (although some work has been conducted at the Mersey Biodiversity Centre in Milton, Queens County by the Department of Fisheries and Oceans).

No information is available on the survival of Atlantic whitefish *in situ*. Laboratory work suggests that there is a high mortality rate among juveniles, although studies have only been conducted for a few years.

Information concerning the behaviour and adaptability of Atlantic whitefish is limited. Reports indicate that they occur in schools in the Petite Rivière watershed. In terms of population size, available information suggests that populations found in lakes within the watershed (namely in Minamkeak, Milipsigate, and Hebb lakes) are small. For example, only 200 to 250 Atlantic Whitefish were reported around the Milipsigate Lake outlet in the spring of 2000. These fish may prey/feed on plankton (Cladocera) flying ants (Hymenoptera), dragonfly nymphys (Odonata), adult Hemiptera and beetles (Coleoptera), Cladocera, mayfly nympths (Ephemeroptera), diptera pupae, and banded killifish (*Fundulus diaphanous*).

Acidification threatens Atlantic whitefish populations. Indeed, it is believed that acidification was one of the principal factors that led to the demise of the Tusket River population. Liming could be used as one method to offset acidification, although it may not be feasible for extended period of times. Atlantic Whitefish are also negatively affected by water level fluctuations, and introductions of non-native fish predators and competitors (including brook trout [*Salvelinus fontinalis*] and smallmouth bass [*Micropterus dolmieu*]). Lakeshore development and increased boating activity also pose significant threats to the watershed's population. Angling continues to take place within the watershed and this could potentially further diminish population levels.

The significance of the Atlantic whitefish is substantial: its tolerance of seawater and warm water as well as its genetic makeup make it unique from other whitefish species. Fishers also describe it as an "excellent table fish" with a good flavour. The species was the first to be designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Unfortunately, since the last assessment by COSEWIC in 1983 and by the World Conservation Union in 1996, Atlantic Whitefish populations have been on the decline. Ecologically and socially, the extinction of this endemic species would represent a significant loss.

Studies conducted within the Pennant Point to Pollock Point area include:

Edge, T.A. 1984. "Preliminary Status of the Acadian Whitefish, *Coregonus canadensis*, in southern Nova Scotia" in The Canadian Field Naturalist. 98: 86-90.

Edge, T.A.; Gilhen, J. 2001. "Updated Status Report on the Endangered Atlantic Whitefish, *Coregonus huntsmani*" in The Canadian Field Naturalist. 115: 635-652.

Grevatt, G. 2003. "Saving a species: Queens County centre preserves endangered Atlantic whitefish" in The Chronicle-Herald – The Mail Star. 24 May. E8.

**TROUT (BROOK TROUT – *SALVELINUS FONTINALIS*; RAINBOW TROUT – *ONCORHYNCHUS MYKISS*)**

Brook trout are native to eastern North America and are Nova Scotia's most common trout. It occurs in both fresh and saltwater as well as inshore and offshore. Many populations will leave freshwater for the sea – some of which are ultimately commercially harvested.

While migrations of sea-run trout are variable, they tend to swim downstream to the ocean between late April and early June. They usually remain relatively close to their home stream for approximately two months before they return to the freshwater. It should be noted that brook trout do not necessarily migrate to the sea every year.

Brook trout spawn in the fall, usually from September to November and primarily in hard- or gravel-bottomed streams, and less frequently in lakes. Young trout will emerge from the gravel bottom after they are approximately three or four centimetres in length. They reach maturity between two and four years (or 10 to 20 centimetres in length).

This species of trout feeds on a variety of organisms, including plankton, insects, snails, clams, and fish. The size of their prey increases as they themselves grow. Growth is more rapid for sea-run trout as their diet is mostly comprised of fish.

Brook trout are important component of the recreational fishery industry. In response to such high demand, the Department of Fisheries and Oceans instituted a hatchery and distribution programme and from 1999 to 2000, approximately 1.3 million fish were distributed to numerous rivers, streams, lakes, and even the marine environment in and around Nova Scotia and extensively so within the Pennant Point to Pollock Point area.

Unlike brook trout, rainbow trout are an introduced species. It is native to western North America and was brought to (and widely stocked throughout) Nova Scotia 1899. Rainbow trout prefer the cool and clear stream and lake waters, although it can also tolerate warm water. Similar to brook trout, rainbow trout may migrate to the sea in the spring when they are between one and four years in age. These migrating trout may remain in the sea for several years before they return to the streams (with a relatively high degree of homing) to spawn.

The species spawns in the spring from March to May in shallow and gravel-bottomed streams. The rainbow trout young take longer than the brook trout to emerge from the substrate (between five and eight weeks) and also take longer to mature (three to five years or when they reach 15 to 40 centimetres in length).

Rainbow trout is commonly used in fish farming and have not become established in the wild. Populations appear to be sustained through somewhat sporadic stocking efforts and are harvested primarily by recreational fishers. Rainbow trout have been introduced to streams and rivers in the Pennant Point to Pollock Point area, although not to the same extent as brook trout.

Studies conducted within the Pennant Point to Pollock Point area include:

Brandt, V. 2001. "Annual Fish Distribution Report 2000" in Manuscript and Technical Report Series. 2001-01.

Brandt, V. 2000. "Annual Fish Distribution Report 1999" in Manuscript and Technical Report Series. 2000-01.

Brandt, V. 2000. "Annual Fish Distribution Report 1998" in Manuscript and Technical Report Series. 99-02.

Brandt, V. 1998. "Annual Fish Distribution Report 1997" in Manuscript and Technical Report Series. 98-01.

Department of Fisheries and Oceans. 1988. "Trout in Canada's Atlantic Provinces" in Underwater World. Ottawa: Communications Directorate – Department of Fisheries and Oceans.

McNeill, A. 1997. "Annual Fish Distribution Report 1996" in Manuscript and Technical Report Series. 97-01.

McNeill, A. 1996. "Annual Fish Distribution Report 1995" in Manuscript and Technical Report Series. 96-01.

**ATLANTIC MACKEREL (*SCOMBER SCOMBRUS* L.)**

Atlantic mackerel is schooling pelagic species that is comprised of two principal populations on the Northwest Atlantic. That is, a southern population spawns in April and May between Cape May and Long Island along the United States seaboard while a northern population spawns during June and July in the southern area of the Gulf of St. Lawrence. As a migratory species, both mackerel populations move from their offshore over-wintering ground (the principal one being Georges Bank) inshore to spawn. The northern population will arrive along the Atlantic coast of Nova Scotia in mid-May on their way north to their main spawning ground. Younger mackerel will arrive in the area a little later and may spend the entire summer along Nova Scotia's coast. Duration of daylight and water temperature appear to control, or at least influence, the timing and destination of the migrations.

Most Atlantic mackerel are sexually mature by four years of age (although some may be mature at two years and at about 30 centimetres in length). Spawning takes place in open surface waters usually in June and July when water temperatures average 12$^{o}$C. While between 200 000 and 500 000 eggs per female are fertilised, the eggs experience an estimated mortality rate of 50 percent per day. Those that survive to the larval stage are also threatened by predation by groundfish and pelagic fish (including mackerel and other larvae at high densities) and temperature fluctuations (particularly drops in temperature). Indeed, even adult mackerel are affected by temperature drops and up to 20 percent of adult mackerel die from causes other than fishing; they are preyed upon by sea animals (including whales, seals, and sharks), cod, squid, and seabirds. Mackerel, meanwhile, are both selective and filter feeds; they feed on plankton (small crustaceans, fish eggs, and larvae) as well as on small fish (notably capelin, juvenile herring, and mackerel).

In terms of fishing pressure, mortality rates vary depending on the level of effort exerted by both Canadian and international fleets. For example, during the early 1970s, it was estimated that approximately 44 percent of mackerel four years of age and over were captured each year. In contrast, by 1979, the rate was about 14 percent because there was no major international fishery. The fishing season within the Pennant Point to Pollock Point area is short – mackerel tend to move through the area relatively quickly during spring migration to the Gulf of St. Lawrence. The larger individuals usually only stay for a few days and as the migration season passes, progressively smaller fish pass through the area. Thus, the smaller and younger fish tend to be caught. The fishery is dominated by weirs and gill nets that are cast from small boats operated by fishers who also tend to fish other species (including lobster, herring, and groundfish). While some of the fish caught are processed and sold for consumption, mackerel is also the preferred bait for the snow crab and tuna fisheries.

The implications of such a fishing strategy, and particularly the fishing of small, young mackerel can be profound. According to legislation (as of 1999 – subsection 48.2B of the Atlantic Fisheries Act), mackerel that are shorter than 25 centimetres can be kept if they account for more than ten percent of all the mackerel taken at the time of the catch. A study conducted by Gregoire (1999) shows that over 90 percent of the fish caught (25 centimetres in length) in St. Margarets Bay were immature. Gregoire (1999) suggests that the minimum length is too low and should be increased to 28.4 centimetres in order to ensure that the stock is not over-exploited.

The northern population of Atlantic mackerel are closely linked with the sourthern fish stocks. For example, northern and southern mackerel stocks often over-winter in the same region. There is, however, only limited information on the level of intermixing and competition between stocks. Nevertheless, the stocks should not be managed in isolation.

Studies conducted within the Pennant Point to Pollock Point area include:

Department of Fisheries and Oceans. 2002. “Atlantic Mackerel of the Northwest Atlantic – Update (2001)” in Status Stock Report. B4-04 (2002).

Department of Fisheries and Oceans. 1985. “Atlantic Mackerel” in Underwater World. Ottawa: Communications Directorate – Department of Fisheries and Oceans.

Gregoire, F. *et al*. 1999. “Maturity at length and age in Atlantic mackerel (*Scrober scrombus* L.) sampled in St. Margarets Bay, Nova Scotia, in 1996” in Canadian Report of Fisheries and Aquatic Sciences. 2278.

### IMPORTANT FISH SPECIES WITHIN THE PENNANT POINT TO POLLOCK POINT AREA:

| Species | Family | Location | | | | |
|---|---|---|---|---|---|---|
| | | Adults | Spawning | Eggs | Larvae | Juveniles |
| American Eel (*Anguilla rostrata*) | Anguillidae | Catadromous – lakes, rivers, and estuaries with migration to continental shelf | Continental shelf from August through December | Continental shelf | Continental shelf | Continental shelf with migration to estuaries, rivers, and lakes |
| White Sucker (*Catostomus commersoni*) | Catostomidae | Freshwater lakes and streams with migration upstream | Upstream to smaller streams and rivers (with shallow gravel riffles) from May through June | Upstream | Upstream | Upstream with migration downstream |
| Atlantic Herring (*Clupea harengus*) | Clupeidae | Pelagic with some populations migrating to the nearshore | Offshore or nearshore during the fall | Offshore or coastal waters | Offshore or coastal waters | Offshore of coastal waters (with migration to the offshore) |
| Gaspereau – Blueback Herring (*Alosa aestivalis*) Alewife (*Alosa pseudoharengus*) | Clupeidae | Anadromous – Open ocean with migration to rivers and streams | Rivers and streams during the spring (Blueback herring – faster flowing areas; Alewife – slower flowing areas, lakes, and ponds) | Rivers, streams, lakes, and ponds | Rivers, streams, lakes, and ponds | Rivers, streams, lakes, ponds, and migration to the open ocean |
| American Shad (*Alosa sapidissima*) | Clupeidae | Anadromous – offshore with migration into rivers | Rivers during the spring through July | Rivers | Rivers | Rivers with migration to the ocean in the fall |
| Banded Killifish (*Fundulus diaphanus*) | Cyprinodotidae | Lakes, ponds, rivers, and estuaries with sandy, fine-grained bottoms | Vegetated areas | Vegetated areas | Vegetated areas | Vegetated areas of ponds, rivers, and estuaries (?) |
| Pollock (*Pollachius virens* L.) | Gadidae | Pelagic – inshore and offshore | Offshore from September | Offshore | Offshore with drifting and/or | Coastal waters (vegetated, rocky, and |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | through April | | active migration to coastal waters (vegetated and rocky, areas) | sometimes more open areas) with migration to the open ocean |
| Fourspine Stickleback (*Apeltes quadracus*) | Gasterosteidae | Coastal and brackish waters and sometimes found in-land in lakes | Coastal and brackish areas with dense filamentous algal cover from May through July | Coastal and brackish areas with dense algal cover | Coastal and brackish areas with dense algal cover | Coastal and brackish areas (?) |
| Threespine Stickleback (*Gasterosteus aculeatus*) | Gasterosteidae | Anadromous – over-winter in deep water and migrate into rivers, streams, and still waters (vegetated) | Brackish water or ascend into freshwater streams (vegetated areas, in clearings among the vegetation, or on open areas close to shore) from April through July | Streams and estuaries | Streams and estuaries | Streams and estuaries with migration to the marine or brackish environment |
| Ninespine Stickleback (*Pungitius pungitius*) | Gasterosteidae | Mainly in marine-brackish water | | | | |
| Brown Bullhead (*Ictalurus nebulosis*) | Ictaluridae | Freshwater in shallow, muddy areas of lakes and ponds as well as in larger, slow-moving streams | Freshwater during the spring (from late April or May) | Freshwater | Freshwater | Freshwater |
| Tripletail (*Labotes surnamensis*) | Labotidae | Pelagic – is semi-migratory and is found primarily in coastal tropical and subtropical areas | Along the coast in bays, sounds, and estuaries during the summer with peaks in July | Coastal in vegetated areas of bays, sounds, and estuaries | Coastal in vegetated areas of bays, sounds, and estuaries | Coastal in vegetated areas of bays, sounds, and estuaries |
| Cunner (*Tautogolabrus* | Labridae | Coastal waters and offshore | Coastal waters | Coastal waters | Coastal waters | Coastal waters (rocky and |

| | | | | | | |
|---|---|---|---|---|---|---|
| *adspersus*) | | banks with migration to coastal waters | (rocky and vegetated areas) from July through August | (rocky and vegetated areas) | (rocky and vegetated areas) | vegetated areas) |
| Striped Bass (*Morone saxatilis*) | Moronidae | Anadromous – coastal areas, including rivers, estuaries, and inshore waters with migration to freshwater | Primarily upriver (although sometimes in brackish water) from May through June | Upriver | Upriver | Upriver with migration downstream to lower reaches of rivers and estuaries (usually to gravel-bottomed areas with some current); further migration along the Atlantic coast may occur |
| Striped Mullet (*Mugil cephalus*) | Mugilidae | Inshore and coastal (prefer sandy bottoms or mud bottoms with dense vegetation) with migration offshore | Offshore | Offshore | Offshore | Offshore with migration to inshore and/or coastal areas |
| Lamprey | Petromyzontidae | Freshwater | Upstream to small tributaries (with shallow, gravely riffles) | Upstream in quiet waters | Upstream with migration downstream and settle in small burrows | Downstream of rivers and lakes, settle on hosts and become parasitic |
| Atlantic Smelt (*Osmerus mordax*) | Osmeridae | Anadromous – nearshore saltwater environments including estuaries, lakes, and streams as well as offshore with migration up streams | Upstream during the spring | Drift downstream to deep waters | Drift downstream to deep waters | Nearshore and deep waters |
| Atlantic Salmon (*Salmo salar*) | Salmonidae | Anadromous – pelagic in the open ocean with migration to rivers and streams | Rivers and streams from October through November | Rives and streams | Rivers and streams | Rivers and streams with migration to the open ocean |
| Atlantic Whitefish (*Coregonus huntsmani*) | Salmonidae | Freshwater (river watershed) – | Freshwater (river watershed) | Freshwater (river watershed) | Freshwater (river watershed) | Freshwater (river watershed) – |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Petite Rivière | – Petite Rivière probably during the winter months | – Petite Rivière | – Petite Rivière | Petite Rivière |
| Trout – Brook Trout (*Salvelinus fontinalus*) Rainbow Trout (*Oncorhychus mykiss*) | Salmonidae | Rivers and streams and may migrate to either the nearshore or offshore | Brook Trout – rivers, streams, and sometimes lakes from September through November; Rainbow Trout – streams and lakes from March to May | Brook Trout – rivers, streams, and lakes; Rainbow Trout – streams and lakes | Brook Trout – rivers, streams, and lakes; Rainbow Trout – streams and lakes | Brook Trout – rivers, streams, and lakes; Rainbow Trout – streams and lakes |
| Atlantic Mackerel (*Scomber scombus* L.) | Scombridae | Pelagic – with migration to coastal areas | Coastal areas (primarily the Gulf of St. Lawrence) in June and July | Coastal areas (primarily the Gulf of St. Lawrence) | Coastal areas (primarily the Gulf of St. Lawrence) | Coastal areas and the open ocean – migration occurs both ways |
| Chub Mackerel (*Scomber japonicus* Houttuyn) | Scombridae | Pelagic in coastal areas and deep waters (those in coastal areas will migrate to open waters) | Open waters in late spring through early summer | Open waters on the surface | Pelagic in open water | Pelagic in deep and coastal waters |

## SEACOAST AND FRESHWATER WETLAND BIRDS[vii]

While a myriad of birds line Nova Scotia's coastal Atlantic shores and its offshore waters, including some that inhabit (and forage in) terrestrial environments, this section focuses on birds that can be characterised either as "seacoast" or "freshwater wetland." More specifically, this section applies to those birds that can be found within the study area of Pennant Point to Pollock Point.

### GREATER SHEARWATER (*PUFFINUS GRAVIS*)[viii]

The Greater Shearwater is summer visitant to Nova Scotia. It is commonly found in the offshore waters of eastern and southern Nova Scotia from late May to early November. During the early 1970s, large numbers of the species regularly occurred in late August and early September off Brier Island. These birds may have been feeding on krill swarms. By the late 1970s, however, numbers declined in the late 1970s, despite the presence of krill.

Breeding occurs in the south Atlantic in the Tristan da Cunha islands as well as on the Falkland Islands. Up to five million Greater Shearwaters may migrate up the North American coast to Georges Bank, the Scotian Shelf, and the Grand Banks. Fishers often encounter them far off the Nova Scotian coast during the summer and they have been observed in the Pennant Point to Pollock Point study area during the summer and early fall months.

### NORTHERN FULMAR (*FULMARUS GLACIALIS* L.)[ix]

The Northern Fulmar is a common visitant to Nova Scotia. The species breeds in Greenland and the eastern Canadian Arctic, although four small colonies have also been found in eastern Newfoundland and southeastern Labrador. In the Nova Scotian region, they are usually found off the southern shore where they feed on the offal from fishing boats. Nevertheless, they have been observed within the Pennant Point to Pollock Point study area.

### SOOTY SHEARWATER (*PUFFINUS GRISEUS*)[x]

The Sooty Shearwater is a common visitant to Nova Scotia. It regularly frequents the province's offshore waters from late May to September with peak numbers reached in August. The Sooty Shearwater breeds in New Zealand and adjacent islands, as well as in the Falkland Islands and on those near Cape Horn. Most of these birds winter in the North Pacific and Peru and only a small portion make their way to the North Atlantic, although some have been observed in the study area.

### LEACH'S STORM PETREL (*OCEANODROMA LEUCORHOA*)

The Leach's Storm Petrels that are found in the Maritimes represent the southern extension of the species' breeding range. All known colonies exist around the Maritime's cold-water coasts and their breeding population includes approximately 100 000 breeding pairs. They tend to breed on islands that are free of terrestrial predators since they are vulnerable while they are both inside their underground burrows and while they are entering them. Indeed, dogs, cats, and rats have all negatively impacted nestling birds and have even extirpated some colonies.

These petrels feed far out on the oceans even during breeding season – males and females take turns incubating their nests while the other forages for food, sometimes for up to five consecutive days. In order to avoid attacks by gulls, the birds will wait for nightfall before returning to their nests.

Eggs are laid from early June to the end of July while petrel young may be found from mid-July to the end of September. Their confirmed breeding range include the Blandford-Bayswater area and (in 1975 as per Brown *et al*. [1975]) Pearl Island.

#### WILSON'S STORM PETREL (*OCEANITES OCEANICUS*)[xi]

The Wilson's Storm Petrel breeds on the Falkland Islands, on the islands in Tierra del Fuego, and along the Antarctic coastline. They migrate north during the summer and have often been observed in Nova Scotia's offshore waters from April to October with peaks in numbers between June and late August. The majority of Atlantic birds winter off New England and southern Nova Scotia. They have been observed with the Pennant Point to Pollock Point area.

#### DOUBLE-CRESTED CORMORANT (*PHALACROCORAX AURITIUS*)

The Double-crested Cormorant breeds in both fresh and salt water and breeding pairs can be found throughout Canada. In the Maritimes, however, it is primarily a coastal breeder with nests located on sea-cliffs or in trees. Since the birds' faeces can kill the trees, there are islands where the cormorant has had to nest on the ground. Breeding distribution is limited by terrestrial predators and distance to food supply (fish). During spring months, the adults and young may move to inland waters, including lakes and rivers.

Double-crested Cormorants had been heavily hunted – they had been considered a key competitor for fish even though studies indicate that these birds eat few commercial fish species. By the early 1900s, hunting had reduced them to remnant populations. Recent surveys, however, show a steady increase in population size and there are at least 80 breeding colonies of the bird (or approximately 16 500 birds) in Nova Scotia alone.

The species lays their eggs from the beginning of May to mid-July and young can be found from mid-May to the end of August. As of 1971 (and according to Brown *et al*. [1975]), colonies could be found on Bald, Barren, Southwest, Little Duck, and Indian Islands. More recently, their confirmed breeding range within the study site includes Lower Prospect, the Blandford area, the East River-Chester Acres area, Tancook Island, and Heckman's Island. Probable breeding occurs in the Middle River-Borgel Point area and at the top of the LaHave River. Possible breeding may occur at Peggy's Cove and the Lower LaHave-Kingsburg area.

#### GREAT CORMORANT (*PHALACROCORAX CARBO*)

While the Great Cormorant is found both in temperate and tropical regions, in North America, it only breeds around the Gulf of St. Lawrence and in the Maritimes. Studies indicate that up to 70 percent of the American population breeds in the coastal areas of the Maritimes. They tend to nest on sea cliffs or on low rocky islands in close proximity to fish supplies.

Before European settlement, Great Cormorants were probably more abundant. They were, however, considered competitors for important commercial fish species and were thought to be extirpated from Eastern Canada by the early 1900s. Fortunately, a few colonies persisted on Anticosti Island and these birds helped to gradually re-occupy other areas. There numbers, however, are still low and they continue to be hunted even though they do not pose a competitive threat.

There are approximately 4 500 breeding pairs in Nova Scotia and females lay their eggs from mid-April to early June. Young Great Cormorants can be found from mid-May to late August. Their breeding range is limited to two possible sites – the Hacketts Cove-Glen Margaret area and the Chester Acres-Squid Cove-Chester area.

**GREAT BLUE HERON (*ARDEA HEODIAS*)**
Great Blue Herons are colonial birds that breed across southern Canada. Most herons nest near the coasts in low, patchy woodland and inland nesting appears to affected by limited fish supply in acidic lakes. They often travel far distances (up to 20 or 30 kilometres) from their nesting areas to feed.

Their numbers are most likely limited by food supply rather than predation or hunting. According to the 1980-1981 Maritimes Heron Inventory, there were approximately 80 colonies in Nova Scotia. As of 1992, there were about 1 800 breeding pairs in the province. Great Blue Herons lay their eggs from mid-April to the end of June and their young may be present from the end of May up to the end of July. Their breeding range within the Pennant Point to Pollock Point area is relatively extensive with confirmed breeding sites being noted in the West Pennant-Lower Prospect area, the Bayside area, the East Chester-Squid Cove-Chester area, Tancook Island, the Lunenburg area, Heckmans Island area, and the Petite Rivière Bridge-Green Bay area. Possible breeding may also occur at Peggy's Cove, the Hacketts Cove-Glen Margaret area, the Black Point area, the Middle River-Chester Basin area, and the Lower LaHave area.

**COMMON EIDER (*SOMATERIA MOLLISSIMA*)**
The Common Eider are ducks that breed along the arctic marine coastlines as well as in the boreal waters of Nova Scotia, Maine, and Denmark. These birds winter around the southwest Maritimes and return to breeding sites in April.

The Common Eider prefers islands that are free of predatory mammals and that have shoal waters around rocky islets which ducklings are led to after hatching. They feed on mussels, other shellfish, and invertebrates (including sea urchins) – all of which are characteristic of rocky coasts.

Breeding eiders were abundant before European colonisation of North America. Populations, however, were significantly reduced through unrestricted hunting during the 19$^{th}$ century. In 1916, the species was included in the Migratory Birds Convention and since then, and based on surveys, the bird seems to have recovered to its former numbers. Informal observations indicate that the Common Eider's numbers continue to increase, especially in southwest Nova Scotia. Nevertheless, oil spills near colonies, predation of young by Great Black-backed Gulls, increased hunting, and slow recovery time from years of low breeding success are all potential threats to Nova Scotian stocks.

Common Eider lay their eggs from early May to mid-July and young are found from the end of May to the end of July. Their breeding range within the study area includes both confirmed and possible areas. Confirmed areas are found in the Tantallon-Hubley-Head of St. Margarets Bay area, the Mill Cove-Birchy Head area, the Bayswater-New Harbour-Blandford area, and the Cherry Hill-Pollock Head area. Possible breeding may take place in the Lower Prospect area.

**RED-BREASTED MERGANSER (MERGUS SERRATOR)**
The Red-breasted Merganser reaches its southern breeding limits in the Maritime provinces – it primarily breeds in the boreal and low arctic zones of North America and Eurasia. In the Maritimes, most of its nests are found in low brush and driftwood on coastal islands and sandbars. They are usually found in association with gulls and/or terns and up 50 nests may be found on any one island.

Human habitation on the coastline have led to a decline in breeding population numbers. Conversion of its natural habitat into human settlements and the introduction of domestic animals have all reduced the Atlantic Canadian representation of the species. Unrestricted and unspecific hunting (justified as a protective measure for fishing interests) have also impacted their numbers.

While there are only approximately 300 breeding pairs in Nova Scotia, thousands more travel through their province during their migration to and from Labrador.

Eggs are laid from the end of May to the end of June and young mergansers may be found from late June up to the end of August. There are only two possible breeding sites within the study area – within the Head of St. Margarets Bay area and within the East River-Chester Acres area.

#### OSPREY (*PANDION HALIAETUS*)

The Osprey breeds throughout Canada and the United States although high-density breeding tends to primarily occur in shallow-water coastal areas where they can feed in the open and over water. At the same time, nesting also takes place in-land near lakes that have an abundant supply of fish. Ospreys usually build nests high in trees. Use of power-line poles and artificial nest-platforms, however, is increasing and this may be an indication that there may be fewer suitable nest-trees.

The population was negatively affect by hunting (populations had been decimated before they were legally protected in the 1960s-1970s and by DDT use in New Brunswick during the 1952 to 1967 period. DDT is still being used in South America (the Osprey's over-wintering area).

There are approximately 400 breeding Osprey pairs in Nova Scotia that lay eggs from early May to mid-July. Young occur from the beginning of June up to the end of April. Confirmed breeding sites within the Pennant Point to Pollock Point area include the Pennant Point area, the Hacketts Cove-Glen Margaret area, Boutiliers Point area, the Mill Cove-Birchy Head area, the Chester Acres-Squid Cove area, the Chester Basin-Borgels Poit area, Tancook Island, the Indian Point area, Lunenburg, Heckmans Island, the Bayport-Lower LaHave area, the Crescent Beach-Petite Rivière area, and the Cherry Hill-Pollock Point area. Breeding is probable in the Hubbards area while possible breeding may occur in the Lower Prospect area, the Prospect area, and on Southwest Island.

#### PIPING PLOVER (*CHARADRIUS MELODUS*)

The Piping Plover has specialised habitat requirements that include white sand beaches. The species has a fragmented distribution on the shores of prairie lakes and along the Atlantic coast of Canada and the United States south to North Carolina.

This species nests and rears young on open sandy beaches and its numbers have declined as beaches become more intensively used by people. Indeed, Erskine (1992) maintains that the Maritime Piping Plover population has decreased by half or more because of habitat loss. Moreover, a quarter to half of these provinces' breeding birds are found in National Parks (Kouchibouguac, New Brunswick, Kejimkujik Seaside Adjunct, Nova Scotia, and Prince Edward Island). This complicates their conservation since while the Parks are protected, they are also heavily used. In 1985, the Committee on the Status of Endangered Wildlife in Canada placed the species on its list of endangered species. An increase in public awareness of the bird's life history and nesting requirements have helped its breeding success in some areas.

Only 60 breeding pairs have been found in Nova Scotia. Females lay their eggs from early May to late June and young can be found from the beginning of June to the end of July. Within the study site, confirmed breeding occurs on the LaHave Islands as well as in the Petite Rivière-Green Bay area.

#### WILLET (*CATOPTROPHORUS SEMIPALMATUS*)

The Willet breeds along the Atlantic coast of North America as well as in the Canadian prairies and south to Nebraska and California. Those found in the Maritimes feed primarily in vegetated salt marshes and nest in nearby fields and other open areas. Their distribution, however, is coastal and includes barrier-beach ponds, tidal estuaries, and fringing salt marshes. They migrate to the Maritimes to breed in May; eggs are laid up to mid-July and young can be found from early June to late July.

Only a small population exists in southwest Nova Scotia (and only 600 breeding pairs are found in the province). Numbers were greatly reduced by hunting during the 19th century and by dyking and draining of salt marshes that destroyed some of the available nesting habitat. Conservation-oriented measures that prohibiting hunting of the Willet allowed the species to recover some of their numbers although they are still not considered an abundant bird. The current threat to this vulnerable species comes from land development and alterations to the few salt marshes that they inhabit.

Within the study area, the Willet's confirmed breeding range includes the Prospect-Bayside area, the East River Point-East River-Chester Acres-Chester area, the Silver Point Road-Indian Point-Mahone Bay area, the Lunenburg-Heckman's Island area, the Lower LaHave-Kingsburg area, the Petite Rivière Bridge-LaHave Islands area, and the Cherry Hill-Pollock Point area. Probable breeding may also occur in the Hacketts Cove-Glen Margaret area and the Chester Basin area. Possible breeding sites, meanwhile, may include the Peggy's Cove area.

#### ARCTIC TERN (*STERNA PARADISAEA*)

The Arctic Tern's breeding range extends through the arctic and subarctic and, in some areas, overlaps with that of the Common tern, with which it often shares colonies. Nesting areas tend to face the open ocean and almost all of those within the Maritimes have been found on islands. Large colonies had been documented only in two areas in the Maritimes –on Machias Seal Island, New Brunswick and Sable Island. Smaller colonies are scattered in other areas of the Maritime provinces.

Eggs are laid from late May to early July while young remain in the nest from mid-June up to late August. A total of 3 000 breeding pairs had been observed in Nova Scotia, although some may have been missed during surveying.

Although removal of eggs has been illegal since 1916, humans had exploited Arctic Tern eggs until the 1980s. Plumage was also collected for hats during the late 1800s and this led to a sharp decline in tern numbers. Recovery was only possible after legislation was implemented to protect the species. Indirectly, Arctic Tern populations have also been affected by the fishing industry. Human exploitation of small fishes, including the sand lance, is increasing as stocks of larger fish species are declining. These small fishes, however, are important prey for coastal and marine birds. Thus, while management plans may be necessary in order to ensure that the eastern Canadian breeding population remains sustainable, conservation measures must extend to the habitat or ecosystem level.

Within the study site (that is, within the Pennant Point to Pollock Point area), confirmed breeding areas were found in the Hacketts Cove-Glen Margaret area, the Hubley-Head of St. Margarets Bay area, Pearl Island, the Silver Point Road-Indian Point-Mahone Bay area, the Lower LaHave-Kingsburg areas, and on some of the Mahone Bay islands. Possible breeding may also occur within the New Harbour and Lunenburg areas.

#### COMMON TERN (*STERNA HIRUNDO*)

The Common Tern breeds across Eurasia and North America in both inland and coastal areas. In coastal areas, breeding tends to take place near shallow waters lined with sandy or gravely shores. The Common Tern forages for fish near the shore, unlike the Arctic Tern which forages far out at sea.

Most of the birds found in Nova Scotia are coastal, although some breeding pairs were found at lakes in the southwest region of the province.

Gull predation on tern eggs and chicks is the predominant limiting factor on population size, particularly in a few key colonies. The pressure is so great that by the early 1990s, tern numbers in Nova Scotian had fallen to just 3 000 pairs. This number has aroused concern among some management agencies.

Common Tern eggs are laid from late May to mid-July and chicks are found from late June to early August. The confirmed breeding range in the study area include the Hacketts Cove-Glen Margaret area, the Tantallon-Hubley-Head of St. Margarets Bay area, Peal Island, the Lunenburg area, the Mahone Bay Islands, and the Lower LaHave-Kingsburg area. Possible breeding may occur in the Prospect area, the New Harbour area and the Chester Acres-Squid Cove area.

#### ROSEATE TERN (*STERNA DOUGALLII*)[xii]

The Roseate Tern is more pelagic than the Common Tern and it is found primarily in tropical and warm temperate areas. In many of the regions in which it is found, its status is either “threatened” or “endangered” and predation by gulls at nesting areas and habitat loss to human encroachment have led to further declines in population numbers. They breed in areas that are free of predators and thus most breeding pairs are found on islands. While they had been sporadically found in some parts of the Maritimes, recent survey has indicated that those populations had been extirpated. According to a 1985 report (Erskine, 1992), there were only eight sites within Nova Scotia that were occupied by this tern. Its limited numbers has made it particularly vulnerable and its survival in the area is dependent on active conservation management.

Only 100 breeding pairs have been observed in the Maritimes – all of which were found in Nova Scotia. Females lay their eggs from late June and young Roseate Terns may be found from late June to late July. The Mahone Bay Islands (Westhaver Island) and Wedge Island (within St. Margarets Bay) are the only sites within the Pennant Point to Pollock Point area where this species is known to breed. It should be noted that only ten other sites along Nova Scotia’s Atlantic coast have been observed to house breeding Roseate Tern pairs.

#### BLACK-LEGGED KITTIWAKE (*RISSA TRIDACTYLA*)[xiii]

The Black-legged Kittiwake is more commonly seen in the winter rather than the summer and it occurs in large numbers on offshore waters usually from October through to April. Its nests are constructed from grasses and seaweeds and are held together with mud on narrow rocky ledges. Although it wanders far (one bird that was banded in Iceland during the late 1930s was captured on a trawl off the LaHave Islands, Lunenburg Country) and even though information concerning this species is dated, it could still be said that the Black-legged Kittiwake can be found within the study area.

#### GREAT BLACK-BACKED GULL (*LARUS MARINUS*)

The Great Black-backed Gull is primarily a coastal bird that nests on islands. Its range extends from the North Atlantic Ocean and Greenland to New York. A few inland birds have been noted in eastern Canada. Along the coast of Nova Scotia, birds were not observed in areas of steep shores without islands.

The Great Black-backed Gull population is not considered “common” and breeding populations decreased significantly after European settlement along the coast. Indeed, by 1900, a colony on Lake George was believed to be the only one in existence in the Maritimes. The 1916 Migratory Birds Convention has afforded the species some protection and population size has gradually increased over the last 80 years – so much so that their numbers are growing at the expense of

Herring Gulls that do not breed close to human settlements. Gulls, in general, are also affecting some breeding populations of eiders, terns, and storm-petrels.

There are approximately 30 000 Great Black-backed Gull breeding pairs in Nova Scotia. The females lay their eggs from early April to early June and the young may be found from early May to early August. Their breeding range extends throughout the coastal area of the Pennant Point to Pollock Point study area.

**HERRING GULL (*LARUS ARGENTATUS*)**

The Herring Gull is commonly referred to as "seagull" although it may have originally been an inland bird. It breeds both inland and on the coast in North America. In the Maritime provinces, coastal breeding colonies of adults four years of age or older may range in size from 20 to 200 pairs. There are approximately 25 000 breeding pairs in Nova Scotia.

Predation against gull eggs and young reduced Herring Gulls to remnant populations. They were protected under the 1916 Migratory Bird Convention and since then, they have been able to recover. Large concentrated colonies can also be found around landfills and fish processing plants – sources of year-round food.

Herring Gull eggs are laid from mid-April to late July. Young can be found from mid-May up to early August. Herring Gulls can be found along the coast throughout the study area and throughout the year.

**ICELAND GULL (*LARUS GLAUDCOIDES*)**[xiv]

The Iceland Gull is relatively common in Nova Scotia during the winter and is rarely observed in the summer. They generally arrive from the north in October (and sometimes late September) and have often been sited around the Halifax and Sydney harbours. Most Iceland Gulls leave the province by late April, although it is suspected that some may spend the summer in the area. Iceland Gulls breed in southern Greenland, southern Baffin Island, northwestern Quebec and on islands in northern Hudson Bay. They tend to winter in Europe, Iceland, and eastern North America, including Nova Scotia. Brown *et al*. (1975) state that the species has been observed in the study area.

**ATLANTIC PUFFIN (*FRATERCULA ARCTICA*)**

The breeding population of the Arctic Puffin is centred in Iceland. It extends, however, south into Newfoundland and remnants of its southern extension can be found in Nova Scotia and the other Maritime provinces. The only confirmed breeding site within the study area of Pennant Point to Pollock Point is found on Pearl Island. Erskine (1992) suggests that this population is probably a partial reoccupation of former Maritime breeding sites.

There are only approximately 100 Atlantic Puffin breeding pairs in the Maritimes, two of which were found on Pearl Island during the early 1970s. Atlantic puffins lay their eggs from late May to mid-July and young are present from mid-July to late August.

Atlantic Puffin populations suffered sharp declines since European settlement and the introduction of dogs, cats, and rats. Its nest sites are vulnerable to disturbance and its food supply (and that of many other seabirds) of sand lance and capelin may be threatened by anthropogenic exploitation. Large gulls also prey on the birds and its eggs. These compounding threats are most likely preventing the Atlantic Puffin from re-colonising former breeding areas and/or from substantially increasing its population size.

### **Black Guillemot (*Cepphus grille*)**

The Black Guillemot's breeding range extends from the high arctic to the temperate regions of North America. Its range in the Maritimes, however, is discontinuous with populations occurring around Grand Manan Island, New Brunswick, off Yarmouth County, Nova Scotia, and on Cape Breton Island, Nova Scotia. This species prefers shore areas characterised by boulders and more pairs than surveyed in 1992 may actually exist in these habitats.

Black Guillemots remain in the Maritimes throughout the year, although they do move farther offshore during the winter months when the coasts are icebound. They return to the breeding areas in April where they build nests in rock crannies and crevices. Such cryptic nesting patterns limited past human predation on eggs and the birds in general. Indeed, predation on eggs and seabirds of other species has actually helped this species to increase in population size.

Approximately 750 Black guillemots breed in Nova Scotia. Eggs are laid from the beginning of June to late July and young hatch and remain in the nest from the beginning of July up to early August. Two confirmed breeding sites exist: one was found in the Southwest Cove-Bayswater-Blandford area and the other on Pearl Island. A probably breeding area may be found around Petite Rivière.

### **Murres (*Uria* ssp.)**[xv]

- Common Murre (*Uria aalge*)

Reports concerning Common Murres have primarily been of sitings from between December and April. While they breed along the steep rocky coasts of Portugal north to Iceland as well as on those of New Brunswick north to southwest Greenland, over-wintering occurs in Nova Scotia. The eastern North Ameican population is comprised of approximately 570 000 pairs, of which 550 000 breed in Newfoundland and Labrador although a small colony of 100 pairs can be found on Yellow Murre Rock off the southwest coast of New Brunswick.

The Common Murre has been observed in the study area of Pennant Point to Pollock Point.

- Thick-billed Murre (*Uria lomvia*)

The Thick-billed Murre is commonly sited during the winter and regularly occurs from early December to April. It usually occurs on offshore waters although they are sometimes forced to the coastal areas by storms. Murres that visit Nova Scotia are probably from breeding colonies found in Greenland, Lancaster Sound, and Hudson Strait in the Canadian Arctic.

The Thick-billed Murre has been observed in the study area of Pennant Point to Pollock Point.

### **Razorbill (*Alca torda*)**

On the western North Atlantic coastline, breeding of Razorbills ranges from Maine to Baffin Island and west Greenland. Most of the world's population, however, breeds in Iceland and the British Isles. Indeed, only 5 small colonies have been found in the Maritimes – a region that represents its southern limit. All colony sites are next to cool coastal waters and in Nova Scotia, it is limited to the outer Atlantic coast.

Razorbills do not reach sexual maturity until they are between three and five years old and they may forage for food far from their colonies.

Razorbill numbers have declined significantly since the arrival of European settlers. The birds and their eggs were exploited for food and nesting habitat was often converted into human settlements. Erskine (1992) suggests that, in the past, Razorbills may have bred more widely on islands along Nova Scotia's Atlantic coast.

Four of the five known breeding sites have been legally protected by federal, provincial, or private agencies, but their difficult-to-access nesting areas may be their most effective protective measure. This species is particularly susceptible to oil spills at sea and their small breeding population in Nova Scotia makes it one of the provinces most vulnerable species; there are only 100 breeding pairs in the province.

Female Razorbills lay their eggs during June and young birds can be found from the end of June to mid-July. Pearl Island is the only confirmed breeding site for the bird in the study area. The only other breeding areas in the Maritimes are found at Herford/Ciboux Islands and Margaree Island in Nova Scotia and Yellow Murr Ledge and Machias Sea Island in New Brunswick.

#### NORTHERN GANNET (*MORUS BASSANUS*)[xvi]

The Gannet is a summer visitor to the boreal zone and to the extreme south of the Low Arctic. Despite the presence of apparently suitable nesting habitats and particularly those where prey (mackerel and herring) are available, they do not breed in Nova Scotia. Brown *et al* (1975) suggests that the late Canadian spring may prevent the birds and their chicks from taking advantage of the province's June mackerel run. Nevertheless, they have been observed in the study area (but not as breeding pairs).

#### SHARP-TAILED SPARROW (*AMMODRAMUS CAUDOCUTUS*)

The Sharp-tailed Sparrow is most commonly associated with salt marshes and other brackish environments. Dyking and draining of these fragile ecosystems over the past 40 years have reduced suitable breeding grounds for this species by more than half. Remnant populations have managed to persist within dykes, but most have abandoned the areas because of increased draining and cultivation.

As of 1992, despite continued declines in population numbers, the Sharp-tailed Sparrow has not been placed on the Committee on the Status of Endangered Wildlife in Canada's endangered species list or any other category.

Eggs are laid from the beginning of June to early July. Young may be found from early June to late August. There are only 1 000 breeding pairs in Nova Scotia, some of which can be found in the Pennant Point to Pollock Point study area. Confirmed breeding grounds include the Lower LaHave-Kingsburg area, the Petite Rivière Bridge-Green Bay area, and the Cherry Hill-Pollock Point area. Possible breeding may occur in the Martins Point-Indian Point area as well as in the Lunenburg area.

## IMPORTANT SEACOAST AND FRESHWATER WETLAND SPECIES WITHIN THE PENNANT POINT TO POLLOCK POINT AREA:

| Species | Order | Family | Seacoast or Freshwater Wetland | Number of Breeding Pairs in Nova Scotia | Eggs | Young |
|---|---|---|---|---|---|---|
| Common Loon (*Gavia immer*) | Gaviiformes | Gaviidae | Fresh-water Wetland | 1 200 pairs | Beginning of May to mid-July | Mid- to late July to late September |
| | **Breeding sites within study area**:<br>**Confirmed**: Heckmans Island; Mill Cove area.<br>**Probable**: Borgel Point area; Chester area.<br>**Possible**: Lower LaHave area; Blandford area; Hubbards area; Masons Point area; Glen Margaret-Hacketts Cove area; Bald Rock area. | | | | | |
| Pied-billed Grebe (*Podilymbus podiceps*) | Podicipediformes | Podicipedidae | Freshwater Wetland | 250 pairs | Mid-May to late July | Late May to late August |
| | **Breeding sites within study area:**<br>**Possible**: Indian Harbout-Peggy's Cove area | | | | | |
| Greater Shearwater (*Puffinus gravis*) | Procellariiformes | Procellariidae | Seacoast | N/A | N/A | N/A |
| | **No breeding sites within study area** | | | | | |
| Northern Fulmar (*Fulmarus glacialis*) | Procellariiformis | Procellariidae | Seacoast | N/A | N/A | N/A |
| | **No breeding sites within study area** | | | | | |
| Sooty Shearwater (*Puffinus griseus*) | Procellariiformes | Procellariidae | Seacoast | N/A | N/A | N/A |
| | **No breeding sites within study area** | | | | | |
| Leach's Storm-petrel (*Oceanodroma leucorhoa*) | Procellariiformes | Hydrobatidae | Seacoast | 100 000 pairs | Early June to end of July | Mid-July to end of September |
| | **Breeding sites within study area**:<br>**Confirmed**: Blandford-Bayswater area; Pearl Island | | | | | |
| Wilson's Storm-petrel (*Oceanites oceanicus*) | Procellariiformes | Hydrobatidae | Seacoast | N/A | N/A | N/A |
| | **No breeding sites within study area** | | | | | |
| Northern Gannet (*Morus bassanus*) | Pelecaniformes | Sulidae | Seacoast | N/A | N/A | N/A |
| | **No breeding sites within study area** | | | | | |
| Double-crested Cormorant (*Phalacrocorax auritus*) | Pelecaniformes | Phalacrocoracidae | Seacoast | 16 500 pairs | Beginning of May to mid-July | Mid-May to end of August |
| | **Breeding sites within study area**:<br>**Confirmed**: Lower Prospect area; Blandford area; East River-Chester Acres area; Tancook Island; Bald Island; Barren Island; Heckmans Island<br>**Probable**: Middle River-Borgel Point area; top of the LaHave River area<br>**Possible**: Peggy's Cove area; Tantallon area; Lunenburg area; Lower LaHave-Kingsburg area | | | | | |
| Great Cormorant (*Phalacrocorax carbo*) | Pelecaniformis | Phalacrocoracidae | Seacoast | 4 500 pairs | Mid-April to early June | Mid-May to late August |
| | **Breeding sites within study area**:<br>**Possible**: Glen Maraget-Hacketts Cove area; Chester Acres-Squid Cove-Chester area | | | | | |
| American Bittern (*Botaurus lentiginosus*) | Ciconiformes | Ardeidae | Freshwater Wetland | 1 200 ± 300 pairs | Mid-May to end of July | Early June to mid-August |
| | **Breeding sites within study area**:<br>**Confirmed**: Lower LaHave-Riverport area | | | | | |

<table>
<tr><td rowspan="2">Great Blue Heron<br>(Ardea herodias)</td><td>Ciconiformes</td><td>Ardeidae</td><td>Seacoast</td><td>1 800 pairs</td><td>Mid-April to end of June</td><td>End of May to end of July</td></tr>
<tr><td colspan="6">Breeding sites within study area:<br>Confirmed: West Pennant-Lower Prospect area; Bayside area;<br>Easter Chester-Squid Cove-Chester area; Tancook Island; Lunenburg area;<br>Heckmans Island area; Petite Rivière Bridge-Green Bay area<br>Possible: Peggy’s Cove area; Hacketts Cove-Glen Margaret area; Black Point area;<br>Middle River-Chester Basin area; Lower LaHave area</td></tr>
<tr><td rowspan="2">American Black Duck<br>(Anas rubripes)</td><td>Anseriformes</td><td>Anatidae</td><td>Freshwater Wetland</td><td>13 000 pairs</td><td>Beginning of April to mid-July</td><td>Beginning of May to end of August</td></tr>
<tr><td colspan="6">Breeding sites within study area:<br>Confirmed: From West Pennant to West Dover;<br>Upper Tantallon-Hubley-Head of St. Margarets Bay area; Hubbards area;<br>Mill Cove-Birchy Head area; Aspatogan-Bayswater area; Martins Point area;<br>Lunenburg-Heckmans Island area; Lower LaHave area; LaHave Islands;<br>Cherry Hill-Pollock Point area<br>Probable: Hacketts Cove-Glen Margaret area; Middle River-Chester Basin area<br>Possible: Peggy’s Cove area; Easter River-Chester Acres area</td></tr>
<tr><td rowspan="2">Green-winged Teal<br>(Anas crecca)</td><td>Anseriformes</td><td>Anatidae</td><td>Freshwater Wetland</td><td>1 700 pairs</td><td>Mid-May to end of July</td><td>Early June to end of August</td></tr>
<tr><td colspan="6">Breeding sites within study area:<br>Confirmed: Crescent Beach-Petite Rivière-LaHave Island area<br>Probable: Lower Prospect area; Middle River-Borgel Point area; Lower LaHave area<br>Possible: Hacketts Cove-Glen Margaret area; Hubbards area</td></tr>
<tr><td rowspan="2">Mallard<br>(Anas platyrhunchos)</td><td>Anseriformes</td><td>Anatidae</td><td>Freshwater Wetland</td><td>500 pairs</td><td>Beginning of May to early July</td><td>Mid-May to end of July</td></tr>
<tr><td colspan="6">Breeding sites within study area:<br>Confirmed: Hacketts Cove-Glen Margaret area;<br>Tantallon-Hubley-Head of St. Margarets Bay area; Luenburg area;<br>Lower LaHave area; Top of the LaHave River;<br>Petite Rivière Bridge-Green Bay area<br>Probable: Middle River-Borgels Point area<br>Possible: Wessent Pennant area</td></tr>
<tr><td rowspan="2">Common Eider<br>(Somateria mollissima)</td><td>Anseriformes</td><td>Anatidae</td><td>Seacoast</td><td>8 000 pairs</td><td>Early May to mid-July</td><td>End of May to end of July</td></tr>
<tr><td colspan="6">Breeding sites within study area:<br>Confirmed: Tantallon-Hubley-Head of St. Margarets Bay area; Mill Cove-Birchy Head area;<br>Bayswater-New Harbour-Blandford area; Cherry Hill-Pollock Point area<br>Possible: Lower Prospect area</td></tr>
<tr><td rowspan="2">Common Merganser<br>(Mergus merganser)</td><td>Anseriformes</td><td>Anatidae</td><td>Freshwater Wetland</td><td>500 pairs</td><td>Early April to end of June</td><td>Beginning of June to late August</td></tr>
<tr><td colspan="6">Breeding sites within study area:<br>Confirmed: East River-Chester Basin area; Top of the LaHave River area<br>Probable: Lower Prospect-Prospect area; Middle River-Chester Basin area;<br>Deans Corner-First Peninsula area<br>Possible: Head of St. Margarets Bay area</td></tr>
<tr><td rowspan="2">Hooded Merganser<br>(Lophodytes cucullatus)</td><td>Anseriformes</td><td>Anatidae</td><td>Freshwater Wetland</td><td>60 pairs</td><td>Beginning of May to mid-June</td><td>Beginning of June to end of August</td></tr>
<tr><td colspan="6">Breeding sites within study area:<br>Possible: East River-Chester Acres area</td></tr>
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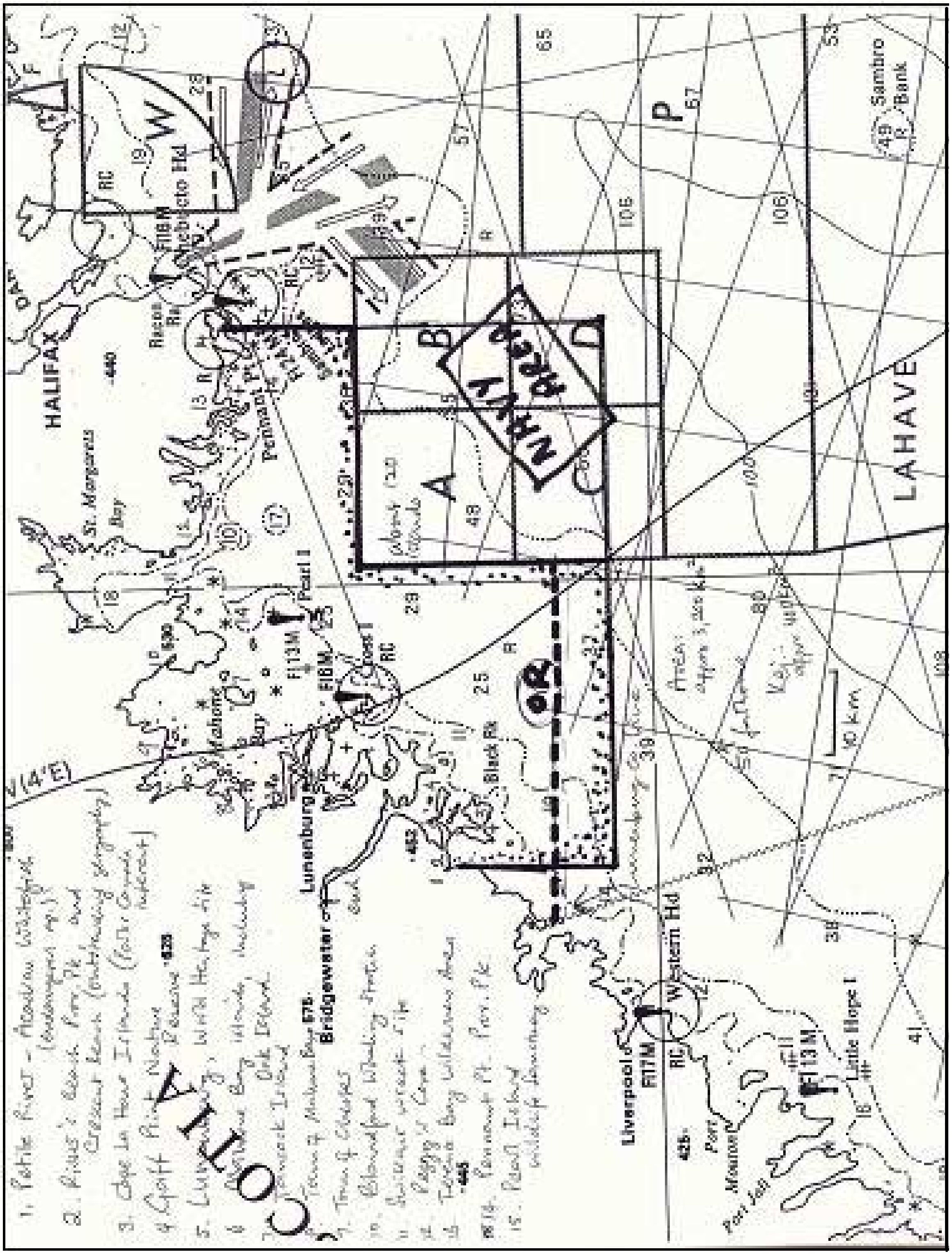
|---|---|---|---|---|---|---|
| Red-breasted Merganser (*Mergus serrator*) | Anseriformes | Anatidae | Seacoast | 300 pairs | End of May to end of June | Late June to end of August |
| | **Breeding sites within study area**:<br>**Possible**: Head of St. Margarets Bay area; East River-Chester Acres area | | | | | |
| Osprey (*Pandion haliaetus*) | Falconiformes | Pandionidae | Seacoast | 400 pairs | Early May to mid-July | Beginning of June to end of April |
| | **Breeding sites within study area**:<br>**Confirmed**: Pennant Point area; Hacketts Cove-Glen Margaret area; Boutiliers Point area; Mill Cove-Birchy Head area; Chester Acres-Squid Cove area; Chester Basin-Borgels Point; Tancook Island; Indian Point area; Lunenburg area; Heckmans Island area; Bayport-Lower LaHave area; Crescent Beach-Petite Rivière Bridge area; Cherry Hill-Pollock Point area<br>**Probable**: Hubbards area<br>**Possible**: Lower Prospect area; Prospect area; Southwest Island | | | | | |
| Piping Plover (*Charadrius melodus*) | Charadriiformes | Charadriidae | Seacoast | 60 pairs | Early May to late July | Beginning of June to end of July |
| | **Breeding sites within study area**:<br>**Confirmed**: LaHave Islands; Petite Rivière Bridge-Green Bay area | | | | | |
| Common Snipe (*Gallinago gallinago*) | Charadriiformes | Scolopacidae | Freshwater Wetland | 15 000 ± 2 000 pairs | Beginning of May to mid-July | Beginning of June to late July |
| | **Breeding sites within study area**:<br>**Confirmed**: Lower LaHave-Kingsburg area<br>**Probable**: Petite Rivière Bridge-LaHave Islands area<br>**Possible**: Prospect area; Hacketts Cove-Glen Margaret area; Chester Acres-Squid Cove area; Lunenburg area | | | | | |
| Spotted Sandpiper (*Actitis macularia*) | Charadriiformes | Scolopacidae | Freshwater Wetland | 6 600 ± 2 100 pairs | Mid-May to late July | Mid-June to mid-August |
| | **Breeding range within study area**:<br>**Confirmed**: Tantallon-Hubley-Head of St. Margarets Bay area; Mill Cove-Birchy Head area; Bayswater-Blandford area; Tancook Island; Lunenburg area; Lower LaHave-Kingsburg area; Petite Rivière Bridge-LaHave Islands area; Cherry Hill-Pollock Point area<br>**Probable**: Hubbards area; martins Point-Silver Point Road area<br>**Possible**: Chester Acres-Squid Cove area; Pearl Island | | | | | |
| Willet (*Catoptrophorus semipalmatus*) | Charadriiformes | Scolopacidae | Seacoast | 600 pairs | Mid-May to mid-July | Early June to late July |
| | **Breeding range within study area**:<br>**Confirmed**: Prospect-Bayside area; Easter River Point-East River-Chester Acres-Squid Cove-Chester area; Silver Point Road-Indian Point-Mahone Bay area; Lunenburg-Heckmans Island area; Lower LaHave-Kingsburg area; Petite Rivière Bridge-LaHave Islands area; Cherry Hill-Pollock Point area<br>**Probable**: Hacketts Cove-Glen Margaret area; Hubley-Head of St. Margarets Bay area; Chester Basin area<br>**Possible**: Peggy's Cove area | | | | | |
| Arctic Tern (*Sterna paradisaea*) | Charadriiformes | Laridae | Seacoast | 3 000 pairs | Late May to early July | Mid-June to late August |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Breeding range within study area**:<br>**Confirmed**: Hacketts Cove-Glen Margaret area; Hubley-Head of St. Margarets Bay area; Pearl Island; Silver Point Road-Indian Point-Mahone Bay area; Mahone Bay Islands; Lower LaHave-Kingsburg area<br>**Possible**: New Harbour area; Lunenburg area | | | | | |
| Common Tern<br>(*Sterna hirundo*) | Charadriiformes | Laridae | Seacoast | 3 000 pairs | Late May to mid-July | Late June to early August |
| | **Breeding range within study area**:<br>**Confirmed**: Hacketts Cove-Glen Margarets area; Tantallon-Hubley-Head of St. Margarets Bay area; Silver Point Road-Indian Point-Mahone Bay area; Pearl Island; Lunenburg area; Mahone Bay Islands; Lower LaHave-Kingsburg area<br>**Possible**: Prospect area; New Harbour area; Chester Acres-Squid Cove area | | | | | |
| Roseate Tern<br>(*Sterna dougallii*) | Charadriiformes | Laridae | Seacoast | 1 000 pairs | Late June | Late June to late July |
| | **Breeding range within study area**:<br>**Confirmed**: Mahone Bay Islands | | | | | |
| Black-legged Kittiwake<br>(*Rissa tridactyla*) | Charadriiformes | Laridae | Seacoast | N/A | N/A | N/A |
| | **No breeding sites within study area** | | | | | |
| Great Black-backed Gull<br>(*Larus marinus*) | Charadriiformes | Laridae | Seacoast | 30 000 pairs | Early April to early June | Early May to early August |
| | **Breeding sites within study area:**<br>**Along the coast of the entire study area** | | | | | |
| Herring Gull<br>(*Larus argentatus*) | Charadriiformes | Laridae | Seacoast | 25 000 pairs | Mid-April to late July | Mid-May to early August |
| | **Breeding sites within study area:**<br>**Along the coast of the entire study area** | | | | | |
| Iceland Gull<br>(*Larus glaucoides*) | Charadriiformes | Laridae | Seacoast | N/A | N/A | N/A |
| | **No breeding sites within study area** | | | | | |
| Atlantic Puffin<br>(*Fratercula arctica*) | Charadriiformes | Alcidae | Seacoast | 100 pairs | Late May to mid-June | Mid-July to late August |
| | **Breeding sites within study area**:<br>**Confirmed**: Pearl Island | | | | | |
| Black Guillemot<br>(*Cepphus grille*) | Charadriiformes | Alcidae | Seacoast | 750 pairs | Beginning of June to late July | Beginning of July to early August |
| | **Breeding sites within study area**:<br>**Confirmed**: Southwest Cove-Bayswater-Blandford area; Pearl Island<br>**Probable**: Petite Rivière Bridge area | | | | | |
| Murres<br>• Common Murre (*Uria aalge*)<br>• Thick-billed Murre (*Uria lomvia*) | Charadriiformes<br>Charadriiformes | Alcidae<br>Alcidae | Seacoast<br>Seacoast | N/A<br>N/A | N/A<br>N/A | N/A<br>N/A |
| | **No breeding sites within study area** | | | | | |
| Razorbill<br>(*Alca torda*) | Charadriiformes | Alcidae | Seacoast | 100 pairs | Beginning of June to the end of June | End of June to mid-July |
| | **Breeding sites within study area**:<br>**Confirmed**: Pearl Island | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Belted Kingfisher (*Ceryle alcyon*) | Coraciiformes | Alcedinidae | Freshwater Wetland | 4 100 ± 1 600 pairs | Mid-May to early July | Early June to end of July |
| | **Breeding sites with study area**:<br>**Confirmed**: Tantallon-Hubley-Head of St. Margarets Bay area; Lower LaHave-Kingsburg area;<br>Petite Rivière Bridge-LaHave Islands area<br>**Possible**: Hacketts Cove-Glen Margaret area; Hubbards area;<br>Silver Road Point-Indian Point-Mahone Bay area; Lunenburg area | | | | | |
| Alder Flycatcher (*Empidonax alnorum*) | Passeriformes | Tyrannidae | Freshwater Wetland | 143 000 ± 20 000 pairs | Mid-June to end of July | Beginning of July to mid-August |
| | **Breeding sites within study area**:<br>**Confirmed**: Lower Prospect area; Prospect area; Mill Cove-Birchy Head area;<br>Martins Point-Indian Point-Mahone Bay area;<br>Petite Rivière Bridge-Green Bay-LaHave Islands area;<br>Cherry Hill-Pollock Point area<br>**Probable**: Head of St. Margarets Bay area; Bayswater-New Harbour area<br>**Possible**: Peggy's Cove area; Chester Acres-Squid Cove area; Chester Basin area;<br>Lunenburg area; Lower LaHave area | | | | | |
| Saltmarsh Sharp-tailed Sparrow (*Melospiza Georgiana*) | Passeriformes | Emberizidae | Freshwater Wetland | 52 000 ± 7 000 pairs | Early may to end of June | Late May to mid-July |
| | **Breeding sites within study area**:<br>**Confirmed**: Hubbards area; Mill Cove-Birchy Head area;<br>Aspatogan-New Harbour-Blandford area;<br>Martins Point-Indian Point-Mahone Bay area;<br>Top of the LaHave River (north) area;<br>Petite Rivière Bridge-Green Bay-LaHave Islands area;<br>Cherry Hill-Pollock Point area<br>**Probable**: West Pennant area; Prospect-East Dover area; Hacketts Cove-Glen Margaret area;<br>Chester Acres-Squid Cove area; Lower LaHave-Riverport area<br>**Possible**: Peggy's Cove area; Chester Basin area | | | | | |
| Sharp-tailed Sparrow (*Ammodramus caudacutus*) | Passeriformes | Emberizidae | Seacoast | 1 000 pairs | Beginning of June to early July | Early June to late August |
| | **Breeding sites within study area**:<br>**Confirmed**: Lower LaHave-Kingsburg area;<br>Petite Rivière Bridge-Green Bay-LaHave Islands area;<br>Cherry Hill-Pollock Point area<br>**Possible**: Hacketts Cove-Glen Margaret area; Martins Point-Indian Point area; Lunenburg area | | | | | |
| Red-winged blackbird (*Agelaius phoeniceus*) | Passeriformes | Emberizidae | Freshwater Wetland | 76 000 ± 15 000 | Beginning of May to early July | End of May to early August |
| | **Breeding sites within study area**:<br>**Confirmed**: Hacketts Cove-Glen Margaret area;<br>Tantallon-Hubley-Head of St. Margarets Bay-Black Point area; Hubbards area;<br>Aspatogan-New Harbour-Blandford area; Tancook Island;<br>Martins Point-Indian Point-Mahone Bay area; Lunenburg area; Heckmans Island;<br>Lower LaHave-Kingsburg area; top of the LaHave River (south) area<br>**Probable**: Peggy's Cove area; Chester Acres-Squid Cove area; Chester Basin area;<br>Top of the LaHave River (north) area | | | | | |

**APPENDIX 1**


HALIFAX
St. Margarets Bay
Pennant Pt
Lunenburg
Bridgewater
Black Rk
Liverpool
Western Hd
Little Hope I
Port Mouton
Sambro Bank
LAHAVE
NAVY AREA

**WORKS CITED**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## ENDNOTES

[i] The IUCN (1992, 7) defines an MPA as "an area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment."

[ii] The Panel on the Ecological Integrity of Canada's National Parks defined the concept of ecological integrity. They state: " 'an ecosystem has integrity when it is deemed characteristic for its natural region, including the composition and abundance of nature species and biological communities, rates of change and supporting processes.' In plain language, ecosystems have integrity when they have their native components (plants, animals and other organisms) and processes (such as growth and reproduction) intact" (Parks Canada, 2000, 1).

[iii] The Pennant Point to Pollock Point area may also be referred to as "the twin bays" – a direct reference to St. Margarets Bay and Mahone Bay. While the potential area extends both northeast and southwest along the coast of these two bays, they nevertheless comprise a significant part of the suggested area.

[iv] This section is based on Mann (2000).

[v] This section is based on Mann (2000).

[vi] This section is based on Mann (2000).

[vii] Information on the breeding of sea and shorebirds comes from (except where otherwise noted) Erskine (1992).

[viii] Brown *et al*. (1975) and Tufts (1986).

[ix] Brown *et al*. (1975) and Tufts (1986).

[x] Brown *et al*. (1975).

[xi] Brown *et al*. (1975).

[xii] Lock *et al*. (1993).

[xiii] Brown *et al*. (1975).

[xiv] Brown *et al*. (1975).

[xv] Brown *et al*. (1975).

[xvi] Brown *et al*. (1975).