HABITAT IDENTIFICATION OF CRITICAL SPECIES
IN THE QUODDY REGION OF THE GULF OF MAINE

VOL 1

TEXT
HABITAT IDENTIFICATION OF CRITICAL SPECIES IN THE QUODDY REGION OF THE GULF OF MAINE

Compiled and submitted by

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ABSTRACT

The Gulf of Maine Council on the Marine Environment, the U.S. Fish and Wildlife Service Gulf of Maine Project, and the Huntsman Marine Science Centre cooperatively supported two pilot Projects to map habitats of important species in eastern coastal areas of Canada and the U.S.A. The pilot projects in Great Bay, New Hampshire and in Passamaquoddy Bay, New Brunswick (now extended to the "Quoddy Region") were intended to develop methods for selection of species for evaluation, for identifying and rating the habitats of the species selected, for determining regionally important habitats based on that information, and for use of the maps and associated information in resource conservation.

Initial analysis for the Quoddy Region, using the methodology described for all species and developing a single composite map, was not sensitive enough to indicate differences between "critical" as opposed to "important" habitat areas for most species. Following discussions with the Review Board, appointed by the GOM Council to assess the usefulness of the reports, it was decided to separate the 27 species selected into two groups: (a) those species not restricted by tidal influences or "open water" species; and (b) those species associated with the littoral, or supra-littoral or sub-littoral regions of the coastline, or "coastal" species.

Two composite maps were developed, one for each group of species. These are much more useful than the original, single, composite map in that they address the two quite different spheres of human activity: one linked to open water, such as undersea exploration for oil or gas and shipping lanes; the other linked to coastal areas development such as aquaculture sites and recreational marinas.
Completion of a project of this magnitude would not have been possible without the help of a great many people. The 12 experts, identified elsewhere in the body of this report, were instrumental in providing the information that is contained herein. Their hard work and expert advice were a *sine qua non* in the production of this report.

The diligence, computer skills, and long hours provided by Mr Roland Baker, who digitised all the habitat areas, are also greatly appreciated. and the contribution of ICION Industries, *Inc.*, through the guidance of Ms Catherine MacKenzie and Mr Paul Currie and the significant contribution of Mr Jeff Walker in producing the maps, is gratefully acknowledged.

Mr Bill Ayer (New Brunswick Department of Environment), Dr Arnold Banner (U.S. Fish and Wildlife Service), and Dr John Allen (Executive Director, Huntsman Marine Science Centre) all provided support, help, and encouragement which was greatly appreciated.

The help of Ms Susan Hill, H.M.S.C., with typing and collating much of this report is also gratefully acknowledged as is the support of Dr Barbara MacKinnon, Katherine and Hilary who did not complain about my staying out late.

Finally, the patience and understanding of Mr Don Pohl and the Gulf of Maine Council in extending the project completion date is both acknowledged and greatly appreciated.

M.D.B. Burt
Associate Director,
Huntsman Marine Science Centre.
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Table 1. Integrated list of the 27 species selected as being most important in the Quoddy Region.

Table 2. List of 18 species selected showing "Importance rating", "Habitat value", "Relative area value" and the product of these three numbers resulting in the "Habitat importance score" for each sub-set of each species living in open water.

Table 3. List of 9 species selected showing "Importance rating", "Habitat value", "Relative area value" and the product of these three numbers resulting in the "Habitat importance score" for each sub-set of each species living in coastal areas.
INTRODUCTION

The aim of this study was to identify and delineate the habitats of those species deemed to be most important in Passamaquoddy Bay and its extension to the Quoddy Region in the Gulf of Maine. By doing this, it would provide factual information that could be crucial in the protection of these important species through protection of their habitat. In many cases, the habitat of one species is shared by other species; by using a system that allows the various habitats to be examined through overlays, it is possible to identify the overlaps and to quantify the sensitivity of each part in the whole region. As demands continue and increase for development and utilisation of our coastal resources by several different interest groups (e.g. Aquaculture, Fisheries, Harbour development, Shipping, Ecotourism) and as our coastal system is impacted by several other activities which are also increasing (e.g. Urban development, Human waste disposal, Run-off contaminants from Agriculture, Forestry, Pulp and paper mills, and Mining operations as well as Long Range Transport of Atmospheric Pollutants) it is increasingly essential that the value of these coasts and adjacent waters, in supporting species we consider to be important, be determined and recognised.

Initially all species were considered together as having habitats in the same area (Quoddy Region). However, it became clear that those species inhabiting "open water" had little or no overlap with what could be considered as littoral species (including supra-littoral and sub-littoral species). Furthermore, it was clear that there are two quite different spheres of human activity: one relating to such off-shore activities as underwater exploration for minerals or oil and establishment of shipping lanes for supertankers; the other relating to coastal development for aquaculture sites, recreational marinas, or land-based industries. To be of optimum use, each of these spheres of activity should be addressed separately with the development of a composite habitat map that included only those species appropriate to the area of potential utilization.

To this end, 18 species including: the four whales and the porpoise, the four birds, the five fishes, as well as scallops, shrimps, copepods, and lobsters were all considered to be open water (including small, off-shore islands for bird breeding habitat) species. The other nine species: sea urchins, sand dollars, blue mussels, periwinkles, clams and the four plant species, were all considered to be coastal species (i.e. with intertidal habitats including supralittoral and sub-littoral areas).

The Gulf of Maine Council has taken the lead in identifying critical habitats in a number of specific areas. The work of Dr Arnold Banner and Dr Jon Libby, in identifying important habitats in the Lower Casco Bay Watershed, is an elegant example of this (Banner and Libby, 1995). The present study, along with another study by Dr Banner and Dr Gerald Hayes on Great Bay, hopefully, will provide further useful information on the habitats of species we consider to be important to these different regions. By modelling the distribution of each species in relation to certain physical habitat requirements such as temperature, salinity, depth, and substrate, it should be possible to determine potential distributions of these species throughout the Gulf of Maine.
In this report, the species chosen are grouped according to their taxonomic affinities to facilitate comparison between them. The five marine mammals are grouped together, followed by the four birds, and then by the five fish species. The nine invertebrates (2 echinoderms, 4 molluscs, and 3 arthropods) come next followed by the only angiosperm and finally the three algal species. The experts involved were: L.Murison (mammals), A.W.Diamond and K.Mawhinney (birds), W.B.Scott (fishes), W.E.Hogans, G.Pohle and L.Van Guelpen (invertebrates), G.Chmura (angiosperm), C.Bird, J.Fegley, J.McLachlan and R.Vadas (algae).

**METHODOLOGY**

Selection of species:

Initially, 15 species were to be chosen from the 30, top-ranked species included in a list of 161 species identified as being "important" species in the Gulf of Maine. This list was compiled by members of a Habitat Panel and published in 1994 (USF&WS, 1994). In order to select the 15 species to be examined in the present study, a number of scientists, whose combined expertise covered all 161 species on the above list, as well as several individuals and organisations known to have an interest in one or more of the species listed, were invited to attend a workshop. Dr Arnold Banner, who had completed a similar project for Casco Bay (Banner and Libby, 1995) was also invited to attend and help with the development of suitable protocols. This workshop was held at the Huntsman Marine Science Centre in March, 1996, a report of which is included as Appendix I. Although the Gulf of Maine list of species, generated and ranked by the Habitat Panel described above, was useful in helping to focus on "important" species in the Quoddy Region, it was clear that some species which were ranked lower than the top 30 for the Gulf of Maine, *sensu lato,* were of considerable "importance" to the Quoddy Region, *sensu stricto.* This resulted in the generation of two lists as described in Appendix I and a total of 27 species to be examined with respect to the habitat they occupy in the Quoddy Region. These 27 species were not integrated at that time. However, using the same ranking criteria and numerical assignations as were used by the Habitat Panel in ranking the 161 species on their list, an integrated list of the 27 species, selected and ranked for the present study, was developed (Table 1).

In view of the potential incorporation of Cobscook Bay, ME in the study area (Quoddy Region), a meeting was held in Bangor, ME with members of the U.S.Fish and Wildlife Service, who also kindly provided meeting facilities. Discussions were held with those able to attend in order to determine whether there were other important species that should be added to the list or whether any of those already listed should be dropped for reasons not apparent earlier. A number of experts from Maine, including Dr Banner and Dr R.Vadas, who had been invited to attend that meeting were unable to do so due to severe weather conditions. As a result of the Bangor Meeting, the inclusion of Cobscook Bay as part of the study area was confirmed but neither additions nor deletions were made to the list of 27 species already generated.
Team of Experts:

A second workshop at Huntsman was held in July, 1996 to which were invited a selected number of scientists (Appendix II) whose combined expertise related to the 27 species selected. Each one had been contacted earlier and had indicated their willingness to determine habitat boundaries for one or more of the 27 species listed. The specific objective of this workshop was to ensure that each expert would know what was expected and would provide the information in a manner that was compatible with the methodology to be used in generation of habitat maps by ICOIN Industries Inc. To that end, Ms C. MacKenzie (Washburn and Gillis, Inc.) also attended the meeting and explained in some detail the process to be used with maps that were to be generated for the experts. The development of these maps at a scale of 1:24,000, although desirable, turned out to be too costly and after considerable discussion (and much later) the decision was made to use the charts published by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Coast and Geodetic Survey, Numbers 13392, 13394, and 13398. As much of the information required was not available in the literature, many of the experts found the initial time-frame severely limiting as they had to collect and generate some of the data themselves.

Area chosen:

The enlisted experts were provided with the three charts identified above. These charts have a scale of 1:50,000 and cover the area identified and agreed to by the experts present at the first workshop. This area, called herein the Quoddy Region, represents the marine coastal waters, to head of tide, enclosed by: longitude lines 66.40min to 67.20min on chart 13398, which includes Passamaquoddy Bay and the Deer Island Archipelago; longitude lines 66.35min to 67.15min on chart 13394, which includes the Wolves Islands, Cobscook Bay, and the northern tip of Grand Manan; and longitude lines 66.36min to 67.18.5min on chart 13392, which includes the rest of Grand Manan, part of the lower Bay of Fundy and Machias Seal Island.

Habitat identification and delineation:

Each of the experts provided polygons on each of the three charts indicating the habitat boundaries of each of the species for which they were responsible. These boundaries were determined using published literature as a basis but supplemented and complemented to a large extent by the expert knowledge that each person had of the species involved and its distribution within the study area. Where appropriate, the habitat for some species was sub-divided into "critical" or "important" areas (e.g. breeding areas and feeding areas) to allow for some discrimination in determining the numerical anthropogenic value for each sub-set of the whole habitat area. In addition, based on the known habitat requirements (such as temperature, salinity, substrate, shelter, competitors, predators, etc.) of some species, further areas were designated as "presumed suitable", even in the absence of published records, but based on personal knowledge of such areas. It must be emphasized, however, that information on species records, or on environmental parameters that might have predictive value, simply does not exist for some areas. In
such cases, accordingly, there is no distinction between "absent" per se and "no information", especially on a finer scale. The various habitat areas delineated by the team of experts were subsequently digitised to facilitate the production of habitat maps for each individual species and the final two composite maps showing the overlaps for these species in each of the two groups referred to above (i.e. open water species and coastal area species).

**Determination of anthropogenic value for each species habitat:**

Some species were considered to be more important than other species based on the criteria listed and used by the Habitat Panel (USF&WS, 1994). In order to try and quantify the degree of this "importance", all 27 species were ranked using the criteria developed by the Habitat Panel, as indicated above, and given a "Species Rating" This rating was normalised (pro-rated) and converted to a scale of 1-8. Table 2 shows the values assigned and the product value for each species.

The quality of the habitat itself (Habitat value), based on either the type of use of the habitat (e.g. breeding area, feeding area) or the number of individuals known to frequent the area, was also given a numerical value (1-8).

Some species had much smaller habitat areas than other species and hence loss of any unit area could be much more detrimental to one species, with a limited habitat area, than to another species with a much larger, extended area. To avoid comparing "apples and oranges", the area of habitat for each species, accordingly, was assessed in relation to either the area of open water or the approximate coastal area, determined as the coast-line length x 50 m which provided a numerical value for each habitat. This numerical value or "Relative area score" was also normalised to a scale of 1-8.

The product ("Species product") of the three factors above (i.e. Species rating x habitat value x and relative area score) was used to generate the colour scheme for the habitat maps.

This method is similar to that used by Banner and Libby (1995) for the Casco Bay Project with a final "Habitat Importance Score" based on the product of the three values (each ranging from 1 to 8). This score could range from 1 (1x1x1) to 512 (8x8x8). One important difference, however, between the present study and that of Banner and Libby relates to the much larger areas occupied by the marine aquatic species chosen in the present study which resulted in 25 of the 27 species having similar and very low relative values for their habitat as compared to two of the bird species which were restricted to small islands (Machias Seal and the Wolves). This resulted in low composite scores for the 25 species, all below 65, compared to over 350 for the two bird species in our initial analysis. By separating the species into two groups (i.e. those inhabiting "open water" and those inhabiting "coastal areas"), the relative area scores changed significantly, especially for the coastal area species thereby giving a better range of values. The various values are provided in Table 2 for the open water species and in Table 3 for the coastal area species.
When choosing the colour allocation for the maps using a simple arithmetic scale, this resulted in species showing similar colours for breeding areas, for example, as well as for feeding areas. By using a log scale, however, this problem was resolved to a major extent and to enhance, further, analysis of each map, differences in habitat importance as reflected by a colour shade difference are outlined in black. It must be understood, however, that although these areas are shown as discrete polygons, no such distinct boundaries exist in the sea! In some cases, these polygons simply indicate approximate, general areas where the species in question, such as whales for example, may be more numerous. This clearly indicates a greater preference for that area which, accordingly, makes it more important in terms of being protected.

References


### TABLE 1

**Integrated species list in order of priority to the Quoddy Region**

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<th>E</th>
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CETACEANS
SPECIES SELECTED FOR DELINEATION OF HABITAT

CETACEANS IN THE QUODDY REGION

LAURIE MURISON

Managing Director
Grand Manan Whale and Seabird Research Station
Box 9 North Head, Grand Manan, NB, Canada, E0G 2M0
Phone 506-662-3804/Fax 506-662-9804
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General factors affecting distribution

Cetaceans are migratory mammals often travelling several thousand kilometres a year. Often we are unsure of aspects of their biology, life history, etc. and best estimates must be employed. Species that can be individually identified, such as right and humpback whales, help to shed light on some of the unknowns and allow us to determine length of stay, frequency of occurrence, movement patterns, life history aspects, etc.

Management concerns vary interspecifically, although pressure from hunting (past and present), entanglement in fishing gear, ship collisions and habitat degradation are important factors. Habitat requirements also vary interspecifically.

Cetacean distributions are affected by many factors, some are daily, others are seasonal. Plotting critical habitat is contingent on: (a) prey distribution and all of the variables which affect prey; (b) human activity; and (c) the biology of the species and other biological factors. Summarized, factors which affect cetacean distribution include:

A. Distribution/availability of prey. This is affected by an enormous range of factors:

a. Tidal variation: Given the large tidal range in the Bay of Fundy, currents can be very strong and affect swimming behaviour. As well, food distributed in the water column may be carried as much as 16 kilometres between high/low cycle (Murison data) or be well mixed throughout the water column depending on the tide phase. Cetaceans will move with the direction of the tide but turn and feed into the current. Usually movements are greater and cetaceans range over a wider distribution on large spring tides.

b. Oceanographic features: Upwellings, convergence zones, bottom topography, thermal stratification, can concentrate prey.

c. Vertical migration/diel variations: Many prey species have diel variations in distribution and densities, which may affect foraging behaviour of cetaceans.
d. Prey availability elsewhere: Cetaceans may choose to stay in another feeding area if prey availability is optimal, despite high prey availability in the BOF. Social aspects may also play a factor.

e. Weather: Strong winds, swell, freshwater run off, turbidity, alters prey distribution/availability and thermal stratification.

f. Season variation: This affects water temperature, salinity, thermal stratification which in turn affect prey availability and distribution.

g. Warm Gulf Stream influence: This can bring squids, menhaden, etc.; also changing the thermal stratification regime.

h. Cold Labrador Current: This prevents some prey species from occurring in areas of cold currents and possibly bringing Arctic species into the Bay of Fundy; also changing the thermal stratification regime.

B. Human activities and possible effects:

Human activities include many threats to cetaceans. These can be summarized as:

1. **Shipping** - noise, collision, habitat exclusion
2. **Aquaculture** - sound alarms, change in prey distribution, boat traffic/noise, habitat changes/exclusion
3. **Fishing** - entanglement, competition for prey, collision
4. **Recreational boating** - harassment, noise, collision
5. **Whale watching** - harassment, noise, collision
6. **Aerial activity** - noise disturbance
7. **Diving** - harassment
8. **Underwater explosions** - exclusion from areas, deafness, injury
9. **Construction** - noise disturbance, injury
10. **Hydrographic surveys** - noise exclusion, deafness
11. **Bridges/causeways** - collision, confusion, prey redistribution, altering habitat, ice debris
12. **Dredging** - collision with barges, altering habitat, noise
13. **Contamination/oil spills** - toxic materials, organic waste, exclusion from areas
14. **Hunting** - historical significance in most cases
15. **Coastal development** - increased turbidity, runoff, contamination, noise

C. Other biological factors:

Intraspecific: Age, reproductive status, social behaviour, habituation, sex

Interspecific: Predators, competition, algal (toxic) blooms, disease, parasites
Right Whale - *Eubalaena glacialis*

**GENERAL CONSIDERATIONS:**

**BREEDING:** Calves are born from December through February in waters off Georgia and Florida, following 14 month gestation (there isn't agreement on the actual gestation period, this is the current guesstimate). Courtship groups are common from August through December in the Bay of Fundy (BOF). These may lead to pregnancy but they also seem to be social activity. Females have a minimum of 3 years between calves. In the mid 1990s the calving interval increased to 4-5 years for unknown reasons. Sexual maturity for females ranges from 7-10 years, although one female was as young as five and many females are 12-15 years before having their first calf (single births only).

**FEEDING:** Food is mostly copepods, krill and associated zooplankton skimmed from the water by long baleen plates with fine hair fringes. Calves nurse for 6 to 12 months and then separate from their mothers. While still nursing, calves practise filter feeding by August. Right whales are thought to fast largely during the winter. Right whales seldom feed at the surface in the Bay of Fundy, unlike Cape Cod Bay and the Great South Channel where plankton is often concentrated at the surface. Right whales are seen rinsing their baleen on the surface in the Bay of Fundy.

**MIGRATION:** Pre-whaling range of right whales in the NW Atlantic was Iceland to Florida, however, the Bay of Fundy is now a final destination for many of the right whales on their northward migration, although many interchange with an area between Browns and Roseway Banks. Right whales do not stay in an area for the entire season but "explore" other regions, often singly, which makes them difficult to find, given their long dive times (10-30 min). Satellite tracking of right whales in 1989 showed that they can travel 2000km in 45 days. A mother/calf pair tagged in the BOF travelled to Barnaby Bight and back, a male moved from the BOF through the Gulf Stream to a seamount, passing through waters 30°C; and another male travelled from the BOF to southern Nova Scotia to Emerald Banks. All were tracked for 45 days or less. Recent satellite tracking in 1996 has followed whales as they moved north from Florida waters. It is not known where most right whales winter other than females which are giving birth. An area encompassing southern Georgia and Florida is the preferred calving waters. This area has only been studied since 1985.

**POPULATION ESTIMATES:** Right whales are individually recognizable and approximately 350 have been identified for the western North Atlantic. The catalogue is maintained by the New England Aquarium, Boston, MA. There were 150 right whales identified in 1996; 185 in 1995; 145 in 1994; and 120 in 1993. During the 1980s the numbers were usually between 30-50 per year. Right whale numbers were severely depleted by intensive commercial whaling in the past.

**TIME OF OCCURRENCE:** June through December in the Quoddy Region. This is longer than for most of the 1980s when they arrived in late July and stayed until late October.
HABITAT CONSIDERATIONS:

HYDROGRAPHY:

DEPTH: Habitat within continental shelf usually. Right whales are found to the east of Grand Manan in water of depths 100m and greater, and the water column is stratified, with the exception of Clarks Ground which is between 10-50m. Right whales, particularly mother/calf pairs, wander widely in the Quoddy Region with the exception of Passamaquoddy and smaller Bays.

TIDES: Right whales sometimes feed in convergence zones which form during the flood or ebb depending on bottom topography. Plankton is carried up to 10km over a tide cycle (high-low or low-high) in a NE-SW or SW-NE orientation, respectively. Right whales, while moving with the tide, turn and filter against the current.

CURRENTS: Right whales infrequently feed in turbulent, fast moving waters in the Bulk Head Rip, Clarks Ground. Copepods accumulate in the Grand Manan Basin because of a summer circulation pattern and a weakly stratified water column.

WATER QUALITY:

TEMPERATURE: They tolerate a wide range of temperatures (0-30C). Temperature preferences are for thermally stratified waters or convergence zones where plankton accumulate.

SALINITY: Right whales are not seen in areas of low salinity, although in December, 1994, a right whale calf did spend over a week in the Delaware River swimming as far as Philadelphia before disappearing, presumably back to sea, after many rescue attempts. Typically, areas of higher salinity have larger copepods in the BOF. Salinity can affect buoyancy of plankton.

POLLUTION: Mercury, heavy metal, pesticide/herbicide contamination potential, and loose rope, plastic film may be ingested or caught in baleen.

BIOTA:

PREY: Right whale distribution is strongly correlated with copepod movements and to a smaller extent euphausiid movements. Right whales feed at depth in the day and at the surface at night (negatively phototactic). When copepod concentrations are disrupted because of strong winds, right whale distribution is similarly changed.

PREDATORS: Sharks (including great white), killer whales. Indirect human interactions include fixed fishing gear entanglements and ship collisions which can be fatal. See Harvesting Activities/Industry.

COMPETITORS: Copepod and krill feeders such as herring, basking sharks, seabirds, sei whales, finbacks, humpbacks, young porpoises.

KNOWN DISTRIBUTION IN QUODDY REGION: Most of the Quoddy Region is used infrequently. However, it remains important because of this whale’s endangered status. Boaters and fishers must be aware of the possibility of encountering a right whale to avoid any harassment or injury to the whale. In 1981 the area south of the Wolves was frequented by right whales. Since then right whales are only seen for a day or so in this area each year. Mother/calf pairs occasionally use inshore and shallow areas. Shallow areas used by right whales include: Machias Seal Island in 1996, a mother/calf pair off Great Duck Island in 1994, a mother/calf pair in the Long Eddy Rip in 1993, a single
whale off Long Island in the early 1980s. Right whales have been seen from the Grand Manan ferry on occasion between the Wolves and Swallowtail. Passamaquoddy Bay is not an important area; there are no known records of right whales from this Bay. A mother/calf pair did travel through Head Harbour Passage, however, and under the Lubec Bridge in the early 1980s.

**MANAGEMENT CONCERNS:**
**HARVESTING ACTIVITIES:** A mother and calf were trapped in a herring weir in Whale Cove in 1976, and a calf was trapped in a weir in Bradford Cove 1996. Right whales easily become entangled in fishing gear such as gill nets and lobster gear. Lines are sometimes caught in the baleen as the whales skim feed. Right whales in Argentina actively investigate fixed structures. This behaviour may compound entanglement problems. Right whales were hunted to near extinction largely for valuable oil and baleen, plates, beginning over 800 years ago. Whalers systematically targeted right whales in the eastern North Atlantic before moving to the western side, then the Pacific Ocean and finally the Antarctic. By 1935, right whale numbers were so low that the League of Nations convinced most countries to stop hunting these whales with a full ban in place by 1937. Since that time some whales have been killed in the Pacific in the 1960s under scientific permit, and an alarming revelation by Russian scientists indicated that protected whales, including right whales, had been illegally hunted in the North Pacific and Antarctic until the mid-1980s.

**OUTFALLS:** Coastal contamination, pollution

**PROTECTED AREAS:** Right Whale Conservation Zone, Grand Manan Basin, NW 44° 45'N, 66° 35'W; NE 44° 45'N, 66° 18'W; SW 44° 30'N, 66° 35'W; SE 44° 30'N, 66° 18'W. Another right whale conservation zone exists on Roseway Basin, between Browns and Baccaro Banks, southern Scotian Shelf. In the USA, three areas have been designated as critical habitat.

**INDUSTRY:** Potential collision from shipping/boating traffic. Harassment from whale-watching activities. Oilspill contamination of feeding area.

**APPLICABLE LAWS, REGULATIONS, BEST MANAGEMENT PRACTICES:**
Right whales are protected from commercial whaling, first by a proposal of the League of Nations in 1935 (full protection in 1937) and then by the International Whaling Commission.

In Canada, right whales are listed as "Endangered" by COSEWIC (Committee on the status of Endangered Wildlife in Canada); however, the Canadian Wildlife Service (CWS), which deals with endangered terrestrial animals, has no involvement with marine mammals. CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) regulations apply to import and export of right whale parts. The management of marine mammals is the responsibility of the Department of Fisheries and Oceans; the Fisheries Act, prevents harassment, hunting, etc. under the Marine Mammal Regulations. In June 1993, the Canadian Hydrographic Service (CHS) agreed to delineate right whale conservation zones on all relevant nautical charts and publish the associated...
notice to mariners and shipping directions (see Protected Areas). The Canadian Coast Guard (Fundy Traffic Control) notifies shipping interests in the Bay of Fundy of the presence of right whales, directly and through a notice to shipping. When crossing Conservation Zones, right whales should be treated as another vessel. Right whales are not aware of ships until very close.

In the United States, the right whale was listed as endangered throughout its U.S. range under the Endangered Species Conservation Act of 1969 (replaced by the Endangered Species Act (ESA) of 1973). The Marine Mammal Protection Act of 1972 legislates human activities which affect marine mammals in the U.S., including harassment, hunting, import, export, etc. The National Marine Fisheries Service (NMFS) has jurisdiction over marine mammals.

Under the ESA, a Northern Right Whale Recovery Team (appointed July, 1987) developed a Recovery Plan (draft in February, 1990, Final Recovery Plan, December, 1991). A copy of the plan may be obtained from the National Marine Fisheries Service, Office of Protected Resources, Marine Mammal Division - Recovery Plans, 1335 East-West Highway, 6th floor, Silver Spring, MD, 20910-3226. The major actions recommended (in order of importance) are:

* Reduce or eliminate injury or mortality caused by ship collision.
* Reduce or eliminate injury and mortality caused by fisheries and fishing gear.
* Protect habitats essential to the survival and recovery of the northern right whale.
* Minimize effects of vessel disturbance.
* Continue international ban on hunting and other directed take.
* Monitor the population size and trends in abundance of the northern right whale.
* Maximize efforts to free entangled or stranded northern right whales and acquire scientific information from dead specimens.

U.S. Recovery Actions undertaken include:

* Dredge projects (SE coast) require observers to watch for right whales when dredges are moving to and from spoil dump sites. Dump site designation subject to consultation, as are Outer Continental Shelf oil and gas activities.

* Research conducted on population dynamics, migration patterns, habitat requirements and utilization, contaminant patterns, habitat requirements and utilization, contaminant analyses. Maintenance of an individual photo-identification system is ongoing.

* NMFS identifies spring areas of concentration of right whales in the Great South Channel off Cape Cod, Massachusetts, with notice to mariners - NOAA Weather Radio and MNFS fishery special broadcast frequency for updated whale locations.
Southeastern United States Right Whale Recovery Plan Implementation Team was formed to mitigate ship strikes on right whales in wintering and calving grounds. Program components include education and notification of mariners, and Early Warning Network, and research providing information required for management decisions. Monitoring efforts include the US Navy, Coast Guard, researchers and volunteers.

NMFS designated three areas (Cape Cod Bay, Great South Channel, and the calving ground off the Florida/Georgia coast) as critical habitat for the northern right whale on June 3, 1994.

A Rapid Response Team of scientists has been formed to free any right whales entangled in fishing gear. A Large Whale Take Reduction Committee met in January, 1997, to discuss interactions with fisheries and large whales (including right whales) in U.S. waters. Numerous recommendations were made for the lobster fishery, groundfish gill nets, swordfish drift nets, etc.
Right Whale (*Eubalaena glacialis*) Profile

**Temperature:**
Wide range of tolerance.

**Salinity:**
Usually not found in areas of low salinity, exceptions may occur during migration and winter months.

**Depth:**
Usually in water more than 100m deep; common in one area of Quoddy Region (exception) where depth is only 10-50m deep.

**Substrate:**
(Not applicable).

**Prey:**
Mostly copepods, krill and other zooplankton.

**Predators:**
Large sharks and killer whales. Fixed fishing gear entanglements may cause death. Ship collisions responsible for 1 in 3 recorded deaths.

**Reproduction:**
Courtship groups occur in Quoddy Region (August-December); gestation period thought to be about 14 months. Calves are born off Florida and Georgia (December-February). Females become sexually mature at 5-15 years of age (average 7-10 years); minimum of 3 years between calves. Sperm competition in males. Multiple births not recorded.

**Habitat:**
Northern migration as far as Iceland, Newfoundland, Gulf of St. Lawrence; remnant population most common in Bay of Fundy and Scotian Shelf from June through Mid-December. Some females and juveniles winter off Georgia/Florida. Cape Cod Bay and Great South Channel are important feeding areas in the late winter and spring.

**Growth:**
Young learn to filter copepods while still nursing (6-12 months). Probably do not feed during winter (fasting period). About 4.5m at birth, 7.5m by late fall. Maximum length about 17m. Lifespan >60 years (maximum age as yet unknown).
Humpback Whale - *Megaptera novaeangliae*

**GENERAL CONSIDERATIONS:**

**BREEDING:** Humpbacks have their calves in the Caribbean from January-March. Gestation is about 11 or 12 months. Mating behaviour is not observed while they are in this region (BOF), which is limited to winter months; however, mothers with calves are often seen, and pregnant females will be present in these waters. Females may become pregnant every year but usually calves are born 2-3 years apart. Calves are nursed for 10-12 months. Females become sexually mature between 5-6 years but as early as 4 years (single births only).

**FEEDING:** Humpbacks are feeding primarily on juvenile herring and krill while in the BOF. Humpbacks in the Gulf of Maine (GOM) feed on juvenile herring, sand lance, krill, and other small fish. Humpbacks may feed at night or during the day sometimes employing bubble nets to corral herring. Humpbacks fast in the winter on the calving/breeding grounds. Humpbacks which remain in northern waters continue to feed. Humpbacks are lunge or gulping feeders, filtering prey from water with baleen.

**MIGRATION:** Humpbacks migrate as far north as Labrador and Greenland and occasionally Baffin Island. However, many of the humpbacks in this area are seen most years and it is thought that this area is probably the northern limit of their migration. There are 5 distinct regions where humpbacks occur in the summer and this area (BOF) is included in the Gulf of Maine/Scotian Shelf region. Humpbacks are seldom seen outside these regions. Most calves are born in an area called the Silver/Navidad Banks in the Caribbean. Mating also occurs after the calves are born. An intensive project (YONAH) studied western North Atlantic humpbacks for several years in the Caribbean.

**POPULATION ESTIMATES:** Humpbacks are individually recognizable. The catalogue is maintained by Allied Whale, College of the Atlantic, Bar Harbour, ME. During the early 1980s census studies carried out on the winter range gave an estimate of 2000-4000 humpbacks for the western North Atlantic. In 1988 a population estimate of 5000 was calculated for the western North Atlantic using capture-recapture methodology from fluke photographs. Estimates for the Gulf of Maine are 300-500 individuals. Up to 24 individual humpbacks have been observed in one day by whale watchers off Grand Manan Island. Possibly up to 100 humpbacks may visit this area in a year. Humpback numbers were severely depleted by commercial whaling.

**TIME OF OCCURRENCE:** May through December, although humpbacks have been seen in all months of the year. Those seen in the winter are probably whales not engaged in mating, immature whales, resting females, or elderly whales.

**HABITAT CONSIDERATIONS:**

**HYDROGRAPHY:**

**DEPTH:** Habitat usually within continental shelf. Humpbacks are mostly found in water less than 100m in the summer but move to deeper water offshore in the fall with the increase in krill. Humpbacks have been seen with mud on their backs indicating that they
dive as deep as water in the Quoddy region. A humpback stranded and died in the upper reaches of St. Mary's Bay, NS, in 1995.

**TIDES:** Humpbacks sometime feed in convergence zones which form during the flood or ebb depending on bottom topography or island effects. Humpbacks often turn and feed into the tidal current while moving with the tide.

**CURRENTS:** Humpbacks feed in turbulent, fast moving waters in the Bulk Head Rip, Clarks Ground.

**WATER QUALITY:**

**TEMPERATURE:** They tolerate a wide range of temperatures, some remaining in the study area in the winter when temperatures are cold. Temperature preferences probably relate to prey preferences. Prey is often concentrated in interface between thermally-mixed and stratified water. It is speculated that humpbacks tolerate higher water temperatures in the winter longer than most baleen whales because they can disperse body heat from their long flippers.

**SALINITY:** Humpbacks generally avoid waters with low salinity; rarely do humpbacks venture into estuarine areas, although in the Pacific one whale has repeatedly visited a river emptying into San Francisco Bay.

**POLLUTION:** Mercury, heavy metal, pesticide/herbicide contamination potential. Also, ingestion of plastic when feeding and rope can be trapped in baleen plates.

**BIOTA:**

**PREY:** Humpback distribution may be correlated with herring and euphausiids movements to deeper water in the day (negatively phototactic); inshore and to the surface at night.

**PREDATORS:** Sharks (including great white), killer whales. See Harvesting Activities/Industry.

**COMPETITORS:** Herring and krill feeders such as ground fish, sharks, seabirds, minkes, finbacks, porpoises, white-sided dolphins, seals.

**KNOWN DISTRIBUTION IN QUODDY REGION:** Critical feeding areas for humpbacks include the Bulk Head Rip and Clarks Ground, Great Duck Ledge north to Fish Head, the Southern Wolves, the Grand Manan Channel. Humpbacks usually do not enter the Deer Island and Passamaquoddy Bay areas, preferring areas east of Campobello and White Horse Islands. Winter distribution of herring may keep humpbacks close to shore.

**MANAGEMENT CONCERNS:**

**HARVESTING ACTIVITIES:** Humpbacks have been trapped in herring weirs in Whale Cove, Dark Harbour, and Great Duck Ledge. Humpbacks are sometimes entangled in fixed fishing gear and tow lines, buoys, etc. and may suffer damage if they free themselves. A humpback was entangled in a gill net set near the Wolves in the early 1990s. The whale was successfully released after being towed to Campobello and lifted partly out of the water to cut the netting off. Salmon aquaculture sites may affect humpback distribution because of boat activity, sound alarms, and habitat changes. Humpbacks have been protected from commercial whaling since 1964, although a subsistence hunt did take place from Bequia, St. Vincent until at least 1989.
OUTFALLS: Coastal contamination, pollution

PROTECTED AREAS: None

INDUSTRY: Potential of collision from shipping/boating traffic. Harassment from whale watching activities. Oil spill contamination of feeding areas.

APPLICABLE LAWS, REGULATIONS, BEST MANAGEMENT PRACTICES:
Humpbacks have been protected from commercial whaling by the International Whaling Commission since 1965.

In Canada, humpbacks are listed as "Threatened" by COSEWIC; CITES regulation apply to imports and exports; Fisheries Act prevents harassment, hunting, etc. under the Marine Mammals Regulations.

In the United States, the humpback whale was listed as endangered throughout its range under the Endangered Species Conservation Act of 1969 (replaced by the Endangered Species Act (ESA) of 1973). The Marine Mammal Protection Act of 1972 legislates human activities which affect marine mammals in the U.S.A., including harassment, hunting, import, export, etc. The National Marine Fisheries Service (NMFS) has jurisdiction over marine mammals.

Under the ESA, a Humpback Whale Recovery Team developed a recovery plan (draft in October, 1989, final report in November, 1991). A copy of the plan may be obtained from the National Marine Fisheries Service, Office of Protected Resources, Marine Mammal Division - Recovery Plans, 1335 East-West Highway, 5th Floor, Silver Spring, MD, 20910-3226. The major actions recommended (in order of importance) are:

* Maintain and enhance habitats used by humpback whales currently or historically
* Identify and reduce direct human-related injury and mortality.
* Measure and monitor key population parameters.
* Improve administration and coordination of recovery program for humpback whales.

The plan emphasizes two major ways to achieve population growth: (1) protection of habitats and (2) reduction of human activities that interfere with annual life cycle processes.

Recovery Actions:

* projects have included: maintenance of photo-identification system to determine reproductive rates; estimation of abundance; determination of genetic relationships; habitat requirements and utilization from both winter mating/calving grounds and summer feeding grounds. Research in North Atlantic coordinated by international effort. Years of the North Atlantic Humpback (YONAH) to determine the population status, stock structure, and habitat use.
Outer Continental Shelf Oil and Gas Lease Sale 149 (Lower Cook Inlet and Shelikof Strait) consultation completed in October, 1993, concluded activity not likely to jeopardize humpback whales.

All reported stranded humpback whales receive priority response by NFMS Regions to maximize data collection.

A New England Implementation Team was formed in 1994.

Humpback entanglements in fishing gear were discussed by the Large Whale Take Reduction Committee which met in the U.S. in January, 1997.
Humpback Whale (*Megaptera novaeangliae*) Profile

**Temperature:** Wide range of tolerance (similar to prey range: herring), sometimes found in Bay of Fundy in winter.

**Salinity:** Avoid waters with low salinity, with possible exceptions during migration.

**Depth:** Usually in waters less than 100m in summer; move to deeper water in the fall (following krill), although will follow herring into waters >10m.

**Substrate:** (Not applicable).

**Prey:** Small herring and euphausiids, as well as sand lance and other small fish.

**Predators:** Large sharks and killer whales. Entrapment in fixed fishing gear may cause death. Occasionally killed by ships. Subsistence fishery in Caribbean ended.

**Reproduction:** Mating occurs in the Caribbean (February-April); gestation period of 11-12 months; calves born January-March in Caribbean (Silver Navidad Banks area). Females mature usually at age 5 - 6 (As early as 4 recorded); usually 2-3 years between calves. Multiple births not recorded.

**Habitat:** Northern migration of some animals as far as Labrador and Greenland; probably a different group to those that enter the Bay of Fundy. Although found in Quoddy Region all year round, most common from May to December. Most winter off Dominican Republic. Probably several separate populations in northwest Atlantic feeding grounds.

**Growth:** Feeding probably limited to northern waters; fasting on breeding grounds during winter. Humpbacks which remain in northern waters over winter, continue to feed. Females up to 16m, males to 15m. Newborns 4.5 - 5m long. Lifespan unknown, possibly 50+ years.
Finback Whale - *Balaenoptera physalus*

**GENERAL CONSIDERATIONS:**

**BREEDING:** Calves are born between December and April after a gestation of about 12 months. Mating would therefore occur on the calving grounds as well. Calves are commonly seen from Maryland to Jeffreys Ledge but no specific area for calving has been found. Females may be pregnant when in this area (BOF) and calves have been seen. Females are usually pregnant every 2-3 years. Calves nurse for about 7 to 11 months. Females are sexually mature at about 5-10 years (single births only).

**FEEDING:** Finbacks feed on krill and juvenile herring while in these waters, consuming prey throughout the day and night by lunge feeding or gulping. Calves begin with plankton such as copepods. Finbacks are thought to fast in the winter, however, finbacks which remain in northern waters continue to feed.

**MIGRATION:** Finbacks come to this area in the summer to feed but the southward migration is not documented. It is thought that many finbacks go to Carolinian waters in the winter but some are seen in the Quoddy region. Individual finbacks repeatedly visit this area, often every year.

**POPULATION ESTIMATES:** Finbacks are individually recognizable but only a few have been catalogued. The catalogue is maintained by Allied Whale, College of the Atlantic, Bar Harbour, ME. It is believed that the finback population in the NW Atlantic consists of 3 or 4 feeding stocks. CETAP estimates for the US continental shelf waters is 5,423. Finback populations were depleted by commercial whaling but are considered abundant compared to right and humpback whales.

**TIME OF OCCURRENCE:** May through December, although finbacks have been seen in all months of the year. Presumably in the winter months, these are immature whales or those not involved in breeding/calving and do not have to migrate to the breeding/calving areas.

**HABITAT CONSIDERATIONS:**

**HYDROGRAPHY:**

**DEPTH:** Habitat within continental shelf usually. Finback whales are mostly seen in waters of all depths in the Quoddy region greater than 10m. Finbacks are usually not seen close to shore, unless the coastline is steep, avoiding shallow areas. Finbacks presumably can dive as deep as any water in the Quoddy region. They are most likely to be found in areas of high topographic variation that are well mixed or contain frontal interfaces between mixed and stratified waters.

**TIDES:** Finbacks feed in convergence zones which form during the flood or ebb depending on bottom topography or island effects. Finbacks often turn into the tide to feed as they move with the tide.

**CURRENTS:** Finbacks frequently feed in turbulent, fast moving waters in the Bulk Head Rip, Clarks Ground, Long Eddy Rip, Head Harbour Passage
WATER QUALITY:
TEMPERATURE: Finbacks tolerate a wide range of temperatures, some remaining in the study area in the winter when temperatures are cold. Prey is often concentrated in interface between thermally mixed and stratified water.
SALINITY: Finbacks are not seen in low salinity areas.
POLLUTION: Mercury, heavy metal, pesticide/herbicide contamination potential. Ingestion of plastic when feeding is also possible.

BIOTA:
PREY: Finback distribution may be correlated with herring and euphausiid movements to deeper water in the day (negatively phototactic); inshore and to the surface at night.
PREDATORS: Sharks (including great white), killer whales. See Harvesting Activities/Industry.
COMPETITORS: Herring feeders such as groundfish, sharks, seabirds, minkes, humpbacks, porpoises, white-sided dolphins, seals.

KNOWN DISTRIBUTION IN QUODDY REGION: Finbacks have critical feeding areas including the Bulk Head Rip, Clarks Ground, Head Harbour, an area between the Southern Wolves and Swallowtail, and Long Eddy Rip. Individual finbacks also frequent the western shore of Grand Manan and the eastern shores of Campobello and White Horse Islands and south to the eastern Maine coast. Passamaquoddy Bay is not an important area with few finbacks venturing into this Bay.

MANAGEMENT CONCERNS:
HARVESTING ACTIVITIES: No records exist of finbacks trapped in herring weirs. A finback was entangled in a pair trawl for ground fish. Fishing gear (rope and netting) was removed from the tail stock of an emaciated finback in Head Harbour Passage in 1996. Most finbacks are strong enough to free themselves from most entanglements. Salmon aquaculture sites may affect finback distribution because of boat activity, sound alarms, and habitat changes. Quotas exist for harvesting finbacks in the North Atlantic.

OUTFALLS: Coastal contamination, pollution

PROTECTED AREAS: None

INDUSTRY: Potential of collision from shipping/boating traffic. Harassment from whale watching activities. Oil spill contamination of feeding areas.

APPLICABLE LAWS, REGULATIONS, BEST MANAGEMENT PRACTICES:
Finbacks are partially protected from commercial whaling through a moratorium on commercial whaling by the International Whaling Commission, although quotas exist for harvesting finbacks in the North Atlantic by the North Atlantic Whaling Association and there are some subsistence hunts.

In Canada, finbacks are listed as "Vulnerable" by COSEWIC; CITES regulations apply to imports and exports; Fisheries Act prevents harassment, hunting, etc. under the Marine Mammals Regulations.
In the United States, the finback whale was listed as endangered throughout its range under the Endangered Species Conservation Act of 1969 (replaced by the Endangered Species Act (ESA) of 1973). The Marine Mammal Protection Act of 1972 legislates human activities which include marine mammals in the U.S.A., including harassment, hunting, import, export, etc. The National Marine Fisheries Service (MNFS) has jurisdiction over marine mammals.

No recovery plan has been prepared under ESA, nor a recovery team established since whaling threats have significantly diminished, and interactions with commercial fisheries and finbacks are not considered a problem at this time. Management activities in the U.S.A. portion of the species' range could only make a minimal contribution to species recovery.

Recovery Actions:

* NMFS has sponsored research off the New England coast to determine species abundance and habitat utilization as part of general surveys of whale species in the area.
Finback Whale (*Balaenoptera physalus*) Profile

**Temperature:** Wide range of tolerance; sometimes found in Bay of Fundy in winter.

**Salinity:** Not found in areas of low salinity.

**Depth:** Found at all depths greater than about 10m.

**Substrate:** (Not applicable).

**Prey:** Primarily small herring and euphausiids.

**Predators:** Large sharks and killer whales.

**Reproduction:** Mating occurs from December to April; gestation period about 12 months. Calves born off Maryland coast (U.S.A.), nurse for 7-11 months. Females mature at > 5 years of age; become pregnant every 2 - 3 years. No distinct calving area has been delineated, single births.

**Habitat:** More common in areas of high topographic variation; upwellings and interfaces, thermally mixed and stratified waters. Movements coincide with herring movements on which they feed. Probably widely dispersed in winter.

**Growth:** Calves feed initially on plankton and larval fishes. As they grow they consume larger items such as euphausiids and young herring. Maximum length in northern hemisphere 24m; southern hemisphere 26.8m. Newborns 6 - 6.5m long. Calves grow rapidly, about 12m at 1 year. Lifespan unknown, possibly 50+ years.
Minke Whale - *Balaenoptera acutorostrata*

**GENERAL CONSIDERATIONS:**

**BREEDING:** A minke whale that was trapped and died in a herring weir in September, 1995, was pregnant. The fetus was 137cm in length, approximately half the average newborn length (280cm). Mating is thought to occur in winter or late spring but has never been observed. Calves are thought to be born from October through March after a 10-11 month pregnancy. Mother/calf pairs are not easily recognized in the summer; many calves are already on their own by the time they are seen in the BOF. Females may have calves every year and are sexually mature at 4 years (single births only). Nursing is less than 6 months.

**FEEDING:** Minkes feed primarily on juvenile herring and krill while in this area and feed both during the day and at night. Minkes primarily feed by gulping or lunging and filtering the seawater with their baleen; minkes have also been observed around herring purse seiners at night, consuming individual herring as they escape from the nets (Murison data). They have also been video taped following bottom trawl ground fish nets catching small individual fish as they escape the net (NMFS video). It is not known if minkes fast during the winter.

**MIGRATION:** Minkes apparently winter south of Bermuda and through the West Indies. Minkes segregate by age/sex classes and juveniles are frequently seen in the BOF. Three of four minkes which died in herring weirs were less than 5.5m. The fourth was a 9m pregnant female (GMWSRS data).

**POPULATION ESTIMATES:** No estimate for eastern Canadian waters is available. CETAP surveys estimated 2006 minke whales from Cape Hatteras to the Canadian border and out to the 1000m depth contour. Debate between whaling and non-whaling interests continues about population estimates in the North Atlantic which range from 30,000 to 87,000.

**TIME OF OCCURRENCE:** May through November; sightings are usually April through November in the Gulf of Maine.

**HABITAT CONSIDERATIONS:**

**HYDROGRAPHY:**

**DEPTH:** Habitat within continental shelf. Minkes are often found in water less than 100m but it is not known how deep they can dive.

**TIDES:** Minkes feed in convergence zones which form during the flood or ebb depending on bottom topography or island effects. Minkes travel in the direction of the tide and often turn to feed into the tide.

**CURRENTS:** The turbulent, fast moving waters around Deer Island may be more energetically demanding than in other areas in the Quoddy region for minkes.

**WATER QUALITY:**

**TEMPERATURE:** Minkes tolerate a wide range of temperatures, arriving in the GOM as early as April when waters are still cold.

**SALINITY:** Minkes are not seen in low salinity areas.
POLLUTION: Mercury, heavy metal, pesticide/herbicide contamination potential. One minke had ingested a plastic lid (GMWSRS data).

BIOTA:
PREY: Minke distribution may be correlated with herring movements, to deeper water in the day (negatively phototactic); inshore and to the surface at night.
PREDATORS: Sharks (including great white), killer whales. (see Harvesting Activities/Industry)
COMPETITORS: Herring feeders such as groundfish, sharks, seabirds, finbacks, humpbacks, porpoises, white-sided dolphins, seals.

KNOWN DISTRIBUTION IN STUDY AREA: Passamaquoddy Bay has low minke numbers with the exception of years when herring densities increase dramatically in this Bay. Although minkes are infrequently seen in Passamaquoddy Bay they are more frequent visitors than other baleen whales. Critical feeding areas include the Bulk Head Rip, Clarks Ground, the Grand Manan Channel (western Grand Manan and eastern Maine), eastern Campobello, White Horse Islands, Head Harbour and Letete Passage. Minkes also use the ledges south of Grand Manan. Minkes do venture into shallow water.

MANAGEMENT CONCERNS:
HARVESTING ACTIVITIES: Minkes have been trapped in herring weirs in Whale Cove, Long Island Bay, Great Duck Ledge, Bradford Cove. Minkes entrapped in herring weirs occasionally die. Potential exists for entrapment in herring purse seines. Salmon aquaculture sites may affect minke distribution because of boat activities, sound alarms and habitat changes. Quotas exist for harvesting minkes in the North Atlantic.

OUTFALLS: Coastal contamination, pollution

PROTECTED AREAS: none

INDUSTRY: Low potential of collision from shipping/boating traffic. Harassment from whale watching activities. Oil spill contamination of feeding areas.

APPLICABLE LAWS, REGULATION, BEST MANAGEMENT PRACTICES: In Canada, minkes are not listed by COSEWIC; CITES regulations apply to import and export; Fisheries Act prevents harassment, hunting, etc. under the Marine Mammal Regulations. Quotas exist for harvesting in North Atlantic by North Atlantic Whaling Association and the International Whaling Commission. In the U.S.A., minkes are not listed under the Endangered Species Act; however, all regulations in the Marine Mammal Protection Act apply.
Minke Whale (*Balaenoptera acutorostrata*) Profile

**Temperature:** Wide tolerance (down to 3 or 4°C).

**Salinity:** Not found in low salinity areas (< 26ppt).

**Depth:** All depths within Continental Shelf, even in waters less than 100m.

**Substrate:** (Not applicable).

**Prey:** Primarily small to medium sized herring (distributions/migrations coincide).

**Predators:** Large sharks and killer whales. Entrapments in herring weirs sometimes lead to death.

**Reproduction:** Mating probably from winter to late spring; 10 - 11 month gestation period. Calves born in October - March. Six-month nursing period. Females mature at 4 years of age; may have a calf each year. No distinct calving area delineated.

**Habitat:** Relatively low numbers in Passamaquoddy Bay but more common in Bay of Fundy; critical feeding areas around Grand Manan and between Grand Manan and Campobello Island. Also common in Bay of Fundy east of the Deer Island archipelago. Overwinter south of Bermuda through the West Indies.

**Growth:** Young minke whales feed on krill (euphausiids) and young herring. Usually separated from mothers when they reach the Quoddy Region (i.e. at least 6 months old). Maximum length 10.7m for females, 9.8m for males in southern hemisphere, 9.2m maximum length for northern hemisphere. Newborns 2.4 - 2.8m long. Calves grow rapidly. Lifespan unknown, possibly 30+ years.
Harbour Porpoise - *Phocoena phocoena*

**GENERAL CONSIDERATIONS:**

**BREEDING:** Calves are born in late May and early June. Mating occurs in July; an eleven-month gestation period. Calves have been seen in August that still have fetal folds which suggests that they were born later than the norm (GMWSRS data). Porpoise births have never been observed in the wild but it would be presumed that some porpoises may be born in the BOF. Usually, harbour porpoise females are pregnant and nursing at the same time with a one-month break between parturition and pregnancy. Females become sexually mature at age 3.15 to 6 years (average 3.76 years in BOF), males at 2.6 years.

**FEEDING:** Food is mostly herring, mackerel and other small fishes (capelin, hake, cod, pollock) less than 15cm in length. Squid, hagfish and bottom-living invertebrates are also consumed. Females that are pregnant and nursing have a more varied diet than males and juvenile females. Calves begin eating krill while still nursing. Porpoises must feed throughout the year and do not have an extended fast as in most large mysticetes.

**MIGRATION:** The harbour porpoise population in the Bay of Fundy/Gulf of Maine uses the Quoddy Region in all months, however, individuals do migrate at least to and from the Gulf of Maine (and possibly further) into the Bay of Fundy. Harbour porpoises have been seen as far south as North Carolina in the winter. Porpoises do move as far north as Shepody Bay and Minas Basin and may move through the Quoddy Region in the northeast travel and back again. A porpoise equipped with a satellite tag was tracked from Grand Manan Island to an area near Cape Cod over a 6.5 month period. The animal spent the winter travelling over a small area off the latter. The migration route roughly followed the 50 fathom contour on the western side of the GOM, a track also followed by right whales that had been tracked using satellite equipment. Harbour porpoises may remain in an area for up to a month with little movement, especially in shallow areas, or may travel across the BOF in less than 24 hours. Genetic, pigmentation, skeletal and contaminant studies reflect the separate population of the GOM/BOF porpoises as opposed to Gulf of St. Lawrence and Newfoundland populations.

**POPULATION ESTIMATES:** Harbour porpoises are not easily recognized individually and there is no current count for the Quoddy Region. A 1993 paper (surveys conducted 1991 and 1992) estimated harbour porpoise abundance in the Gulf of Maine/Bay of Fundy at 47,200 (39,500 to 70,600). The 1996 Fundy/Maine estimate (survey in 1995) is 74,000 (41,000 to 109,000). Previous estimates of about 4000 do not include all areas in the Quoddy region, and are based on transects in specific areas, including the ferry crossing from the mainland to Grand Manan and were not meant to indicate population estimates for the entire BOF/GOM population. Populations may have been reduced until the early 1920s because of hunting pressures. Present pressures on populations from deaths in fishing gear are still not agreed upon.

**TIME OF OCCURRENCE:** Year round, number of harbour porpoises peaks in August but high numbers extend from June until the end of December.
HABITAT CONSIDERATIONS:

HYDROGRAPHY:
DEPTH: Habitat within continental shelf. Porpoises are ubiquitous in the Quoddy region, found in all depths of water and are capable of diving to these depths (and deeper, time/depth recorder data), close to shore and offshore. At least one study indicates that porpoises in the Quoddy region avoid water less than 10m deep, possibly because of turbulence in shallow channels. However, a porpoise was observed in the protective, shallow water inside the North Head breakwater, mid-March, 1993 (Murison, data).

TIDES: Harbour porpoises feed in convergence zones which form during the flood or ebb depending on bottom topography or island effects.

CURRENTS: The turbulent, fast moving waters around Deer Island may be more energetically demanding than in other areas in the Quoddy region for porpoises.

WATER QUALITY:
TEMPERATURE: Harbour porpoise densities are highest when water temperature reaches 7-8C and higher, although porpoises are able to withstand all temperature ranges in the Quoddy region.

SALINITY: Harbour porpoises are not seen in low salinity areas but do investigate estuarine sites on flood tide.

POLLUTION: Mercury, heavy metal, pesticide/herbicide contamination.

BIOTA:
PREY: Porpoise distribution may be correlated with herring movements to deeper water in the day (negatively phototactic); inshore and to the surface at night, although depth of dive research has shown, long, deep dives at night.

PREDATORs: Sharks (including great white), killer whales. See Harvesting Activities.

COMPETITORs: Herring feeders such as groundfish, sharks, seabirds, finbacks, humpbacks, minkes, white-sided dolphins, seals.

KNOWN DISTRIBUTION IN STUDY AREA: Passamaquoddy Bay probably has low porpoises numbers with the exception of years when herring densities increase dramatically in this Bay. Harbour porpoises have been seen well into Passamaquoddy Bay including the St. Croix estuary and off Indian Point in St. Andrews. Critical feeding areas include Head Harbour Passage, Letete Passage, Long Eddy Rip, Bulk Head Rip and Clarks Ground. Other areas (ledges south of Grand Manan, Seal Cove Sound, Grand Manan Channel, Whale Cove, Long Island Bay) are also used as feeding areas or for travelling to and from key feeding areas.

MANAGEMENT CONCERNS:

HARVESTING ACTIVITIES: Harbour porpoises frequently are trapped in herring weirs, in particular those weirs in Whale Cove, Long Island Bay, Great Duck Island and Ledge, Bradford Cove, Dark Harbour, Money Cove, the Wolves, Head Harbour Passage, and Dipper Harbour. Deaths sometimes occur because of these entanglements but most who fish attempt to remove porpoises alive. Porpoises are also entangled, and usually die in ground fish gill nets; one was caught on a groundfish "bug" line and killed; potential exists for...
entrapment in herring purse seines probably leading to deaths. Salmon aquaculture sites may affect porpoise distribution because of boat activity, sound alarms, habitat changes. Aboriginal hunting still occurs.

OUTFALLS: Coastal contamination, pollution

PROTECTED AREAS: none.

INDUSTRY: Low potential of collision from shipping/boating traffic. Most porpoises actively avoid motorized vessels, low potential of harassment from whale watching activities.

APPLICABLE LAWS, REGULATIONS, BEST MANAGEMENT PRACTICES:
In Canada, harbour porpoises are designated "Threatened" by COSEWIC, largely because of the pressure of incidental takes in fisheries; CITES regulations apply for imports and exports; Fisheries Act prevents harassment, hunting, etc. under the Marine Mammals Regulations with the exception of aboriginal hunts.

The Harbour Porpoise Conservation Plan for the Bay of Fundy was developed by the Department of Fisheries and Oceans (DFO) in response to incidental takes of porpoises in groundfish gill nets. It has three goals: (1) to maintain a minimum sustainable porpoise population level which will respond successfully to all population challenges; (2) to determine the level of incidental take which the population can withstand and still allow human use of the BOF/GOM; and (3) to change the classification of harbour porpoises to a non-protected species. A Harbour Porpoise Advisory Team meets annually to work on reducing the incidental take of porpoises below 2% of the population as recommended by the International Whaling Commission. An observer program is in place to assess the actual take of porpoises, effort of fishers, etc. The effectiveness of acoustic alarms on bottom-set gill nets has been undertaken.

In the U.S.A. the harbour porpoise is being reviewed for inclusion under the Endangered Species Act. The National Marine Fisheries Service is actively working with all groups to address the incidental take of porpoises in U.S. fisheries, which has also included observer programs and acoustic alarms on nets. The NMFS has been responsible for current population estimates and supports research into the life history of porpoises in U.S.A. and Canadian waters. The Marine Mammal Protection Act of 1972 legislates human activities which affect marine mammals in the U.S.A., including harassment, hunting, import, export, etc.

Because the incidental take issue is trans-boundary, letters of agreement and co-operation have been initiated which allows exchange of scientific information, and the discussion and implementation of management strategies.
Harbour Porpoise (*Phocoena Phocoena*) Profile

**Temperature:** Wide tolerance; require open water (no ice cover). Temperatures of >7°C preferred, although sometimes seen in Bay of Fundy in winter.

**Salinity:** Wide tolerance from full strength sea water (36ppt) to estuarine conditions of less than 20ppt.

**Depth:** Not a limiting factor and can feed on pelagic organisms in very deep water; probably do not feed on benthic organisms deeper than about 50m but can dive to greater depths. Tend to avoid water less than 10m.

**Substrate:** (Not applicable).

**Prey:** Mostly small fishes (herring, hake, mackerel, capelin, etc.) less than 15 cm long and squid; also some benthic invertebrates. Young feed largely on krill (euphausiids).

**Predators:** May fall prey to large sharks and killer whales; many caught in gill nets and drown. Entrapments in herring weirs sometimes lead to death. Aboriginal hunts still occur in Quoddy Region.

**Reproduction:** Mating occurs in July; young are born in early June (11 month gestation). Probable reproduction in Quoddy Region; births in the wild not recorded. Sperm competition in males. Females have a single calf every year.

**Habitat:** Common in the Bay of Fundy and Gulf of Maine; few in Passamaquoddy Bay but have been recorded well up the St Croix Estuary. Probably separate populations from Gulf of St. Lawrence and Newfoundland.

**Growth:** Young start feeding on krill while still nursing. Growth is direct, maturing at 3+ years of age. Feed throughout year. One calf grew 23cm over 1 year period. Maximum length 170cm. Newborns 70 - 90cm long. Lifespan maximum about 18 years, although most live less than 13 years.
BIBLIOGRAPHY OF BOF LITERATURE RELATED TO MARINE MAMMALS

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**Humpback whale**


**Finback Whales**


**Minke Whales**


**General whale articles, primarily from NW Atlantic**


**Harbour porpoises**


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Humpback whales


Finback whales


Related topic


Harbour Porpoises


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Common Eider - *Somateria mollissima*

**GENERAL CONSIDERATIONS:** At weights of up to 3kg, Common Eiders are easily the largest duck in the northern hemisphere. Abundant just about everywhere in its circumpolar breeding range the Common Eider is a ground-nesting colonial species which typically breeds on coastal islands free of mammalian predators. With the exception of a population in the Bay of Chaleur, Common Eider breed in the province of New Brunswick on coastal islands in the mouth of the Bay of Fundy (Kehoe 1994). The New Brunswick breeding population of the Common Eider has remained relatively constant over the last decade, ranging from 8,000 to 10,000 breeding pairs (Mawhinney and Diamond 1996). Compared to the extensive research and management activities on dabbling ducks conducted by universities, Ducks Unlimited and government agencies over the past 40 years, little attention has been paid to seaducks in Atlantic Canada.

**SOURCES OF DATA:** Regular systematic surveys of the breeding, brood rearing and wintering distribution of Common Eiders have been conducted by the Department of Natural Resources and Energy since 1987. In addition, a banding project was developed in the Bay of Fundy region in 1987 in order to improve knowledge of the migrational patterns, winter distribution and harvest rates of this breeding population (Bowes 1994). Recent research initiatives on seaducks in the Bay of Fundy include: Bioenergetics of breeding and wintering Common Eiders (1984-1988, P.W. Hicklin, Canadian Wildlife Service, Common Eiders as members of the intertidal community (1993-1995, D. Hamilton, University of Guelph); and Factors affecting adult female crèche attendance and survival of Common Eider ducklings in the Gulf of Maine (1995-1998, K. Mawhinney, Atlantic Cooperative Wildlife Ecology Research Network).

**HABITAT CONSIDERATIONS:** The Quoddy region is important to both breeding and wintering Common Eiders. Common Eiders breed on offshore islands in the Quoddy region between late April and mid August; and Passamaquoddy remains important throughout the winter months as it is an important overwintering area.

**Breeding habitat:** Adult Eiders can be seen spread out along the shores of the mainland and around the main breeding islands in the Bay of Fundy beginning in late March. During this time they are feeding predominantly on blue mussels (*Mytilus edulis*). Pairs begin to move onto their nesting islands at the end of April. Nests are shallow depressions in the ground, lined with the down from the adult female's breast. Nest sites are usually built in the undergrowth of the forest canopy but can be found in the open grass. At the onset of incubation, adult males abandon the hens and raft with other males at the head of the Bay of Fundy for approximately 1-2 weeks before they disappear from the area.

At hatch adult females take their broods from the nesting islands to coastal brood rearing areas. During their first days of feeding, Common Eider ducklings are very poor divers and feed almost exclusively in and around rockweed (*Ascophyllum nodosum*) beds picking invertebrates from rockweed floating at the surface (Hamilton 1994). As ducklings mature, they become better divers and begin diving deeper into the rockweed, presumably taking invertebrates from the canopy as well as the substrate below. The importance of amphipods...
(Gammarus sp.) and other crustaceans to young Eider ducklings and hard bodied molluscs like periwinkles (Littorina littorea) later in the rearing period, has been well documented (Pethon 1967, McAloney 1973, Cantin et al. 1974). In addition, Minot (1976) found that rockweed-covered shorelines in the Grand Manan Archipelago were important for both the rearing of Eider broods and the physical recovery of post-nesting females independent of young. Machias Seal Island hosts about 50 breeding pairs annually.

Coastal habitats: Although the majority of Common Eiders that breed in the Bay of Fundy winter in the mid-Atlantic and north-eastern US, the coastal region in Passamaquoddy Bay from St. Andrews to Bocabec Bay remains important throughout the winter months as it is an important overwintering area (Hicklin and Barrow 1995). The winter diet consists almost exclusively of Blue Mussels and Green Sea Urchins (Strongylocentrotus droebachiensis) and they forage in water depths up to 10m (Goudie 1984).

MANAGEMENT CONCERNS: Common Eiders show delayed sexual maturity (Mendall 1968), strong homing (Wakeley and Mendall 1976) and low recruitment rates (Erskine and Smith 1986), suggesting adaptation to a relatively stable environment. Thus, any changes to the environment that affect their survival could have major effects on the status of the population. Coinciding with declining numbers and increasingly restrictive hunting regulation of inland ducks, harvest of Common Eiders in the Atlantic Flyway has increased markedly (Corr et al. 1988, Hicklin 1989) and residential, recreational and industrial development (eg. rockweed harvest) in coastal habitats potentially threaten Eider populations (Krohn et al. 1991). Moreover, increasing populations of Great Black-backed Gulls (Larus marinus) in the Bay of Fundy are a growing concern because these gulls nest on coastal islands and they are more predatory than Herring Gulls (Larus argentatus) on Eider eggs and young (Bourget 1973).

Exceptionally high depredation rates by Great Black-backed Gulls on eider ducklings, precluding a study of brood amalgamation on the Wolves Archipelago in the Bay of Fundy in both 1995 and 1996, suggested that low duckling production was not confined to the Wolves Archipelago; and that duckling production in the Bay of Fundy has declined considerably over the last decade despite stable numbers in breeding pairs. Density-dependent mortality of juveniles and adults, and condition of females during clutch formation in the spring, are considered the major factors regulating Common Eider populations (Milne 1974). Survival of Eider ducklings does not apparently regulate Common Eider population numbers, but it may potentially limit the growth rate of the population (Mendenhall and Milne 1985). Although numbers of Common Eiders breeding in New Brunswick appear stable, we should not be complacent; low annual recruitment over periods of several years has been associated with gradual declines in breeding populations of Common Eiders elsewhere, just as good production years have been reflected in subsequent population increases (Milne 1974).

MAPPING HABITATS: Islands in the Wolves and the Grand Manan Archipelago’s host the largest breeding colonies (750 and 1000-3000 breeding pairs, respectively (Mawhinney 1995 and Minot 1976)). However, Casco Bay Island, Hardwood Island, Hog Island and Dick Island located in Passamaquoddy Bay all support fairly large groups (80-200) of nesting Eider hens (Bowes 1994, Mawhinney 1995). Important coastal brood rearing areas include:
the mainland coastal areas of Grand Manan; the Head Harbour Passage between Deer Island and Campobello Island; the northeast and southwest tips of the Wolves Archipelago; and the mainland coast of New Brunswick from St. Andrews to Bocabec Bay. The coastal region in Passamaquoddy Bay from St. Andrews to Bocabec Bay is important during the winter months.

REFERENCES:


Common Eider Duck (*Somateria mollissima*) Profile

**Temperature:** (Not applicable).

**Salinity:** (Not applicable).

**Depth:** (Not applicable).

**Substrate:** (Not applicable).

**Prey:** Blue mussels, periwinkles, and various crustaceans such as amphipods and decapods when young; blue mussels and green sea urchins when older.

**Predators:** Great black-backed gulls (*Larus marinus*) are principal predators of young birds and eggs.

**Reproduction:** Breed in coastal areas throughout the north as well as down the coasts of Newfoundland and Labrador, Gulf of St Lawrence, western Cape Breton, and the Bay of Fundy. Nests are on the ground (shallow depressions, lined with down feathers).

**Habitat:** Strictly maritime: Breeding in the north (as far south as the Bay of Fundy) and overwintering down the east coast to Maryland, rarely further south.

**Growth:** Young feed primarily on invertebrates associated with beds of rockweed. Initially they are restricted to surface items but dive more deeply as they mature.
Harlequin Duck - *Histrionicus histrionicus*

**GENERAL CONSIDERATIONS:** The Harlequin Duck is a relatively rare seaduck whose low Arctic distribution consists of four distinct populations: Pacific, Icelandic, Greenlandic, and eastern North American. Because of its small population size and apparent decline, the eastern North American population of Harlequin Ducks was designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1990. The breeding distribution of the eastern North American population occurs within the borders of Canada and includes the river systems of eastern Hudson Bay, James Bay, Ungava Bay, northern Labrador, the Gaspé Peninsula and a few of the rivers in the Long Range Mountains of western Newfoundland. Though the majority of Harlequin Ducks in eastern North America winter in the mid-Atlantic and north-eastern US, the Quoddy region also serves as a winter refugia for a small population of 40-60 birds (Hicklin personal communication) wintering on the Wolves Archipelago.

**SOURCES OF DATA:** Following its listing as an "Endangered Species" in 1990, a Harlequin Duck recovery team was established and in 1995 produced a recovery plan which outlined actions needed to assist with the recovery of this species (Montevecchi et al. 1995). The Canadian Wildlife Service monitored the wintering population of the endangered Harlequin Duck from 1987-1994 in the Quoddy region. Monthly winter surveys to monitor the winter population on the Wolves Archipelago have since been conducted through the cooperation of New Brunswick Department of Natural Resources and Atlantic Cooperative Wildlife Ecology Research Network.

**HABITAT CONSIDERATIONS:** Harlequin Ducks do not breed in the Quoddy area. However, the Quoddy region serves as a winter refugia for a small population wintering on the Wolves Archipelago.

**Coastal habitats:** In winter, the Harlequin Duck is strictly marine and occurs in the areas of the outermost headlands and skerries where the surf breaks directly against the rocks. They are rarely seen in sheltered fjords and bays (Gudmundsson 1971). Harlequin Ducks feed close to rocky shorelines, or offshore rock skerries that are often awash or submerged at high tide and during heavy sea swell (Johnsgard 1975). They usually forage in shallow waters of 2 to 3m deep and use deeper waters for resting, preening and roosting (Goudie 1984).

Studies of Harlequin Ducks wintering in southeastern Newfoundland (Goudie 1984) and Quebec (Traverner in Cottam 1939) showed that they spend a large proportion of daylight hours feeding on energy-rich crustaceans. Common food items in the winter diet include crabs, amphipods (*Gammarellus angulosus* and *Calliopsius laeviusculus*), periwinkles (*Littorina littorea*), limpets (*Acmaea testudinalis* and *Crucibulum striatum*), blue mussels (*Mytilus edulis*) and fish eggs (Goudie 1984). The Harlequin Duck is thought to have high food energy requirements (Goudie 1984). These needs are probably due to their relatively small body mass and high metabolic demands. Since fewer body reserves (fat) are stored in the smaller bird, environmental factors are probably quite significant. With fewer energy reserves, environmental factors are probably quite significant and may explain why Harlequin Ducks frequent areas free of pack ice during the winter (Goudie 1984).
MANAGEMENT CONCERNS: Harlequin Ducks have a strong affinity for a few select wintering areas. Disturbance of these areas can affect survival as the best feeding areas may be inaccessible, the birds may not feed effectively and may use much of their energy to avoid humans. Degradation causing changes in food abundance or disturbance in wintering areas may make these areas unsuitable for use by birds. At sea, oil spills are a potential threat to Harlequin Ducks because they spend much time sitting the water (Brown et al. 1975). During the moulting period, the birds are particularly susceptible to human disturbance or oil pollution because of their inability to fly to avoid these stressors. The prevention of oil and chemical spills near areas frequented by Harlequins Ducks is critical to their recovery.

Incidental hunter kill may occur because female and young Harlequin Ducks are difficult to distinguish from more common sea ducks and they may be shot accidentally with other waterfowl. Harlequin Ducks are also relatively tame compared to other sea ducks and they feed close to shore. These two behavioural characteristics result in the species being easily hunted. Even a small number of individuals taken over a hunting season may be significant considering the small population size.

In summary, winter habitat for Harlequins can be defined as the most turbulent and rockiest part of coastal areas, and shoals of small remote islands where human disturbance is minimal; at present only the Wolves Archipelago meets all these criteria in the Quoddy area.

MAPPING OF HABITATS: Coastal areas of the Wolves Archipelago is shown as wintering habitat. Harlequin Ducks on the Wolves Archipelago feed in shallow waters over wave pounded rocks and ledges close to shore. They are found predominately along the east coast of East Wolf and the south east coast of South Wolf on the Wolves Archipelago. High cliffs and high invertebrate prey densities along these coasts (Mawhinney 1996) provide protection from the prevailing southwest winter winds and plentiful prey for their high food energy food requirements (Goudie 1991). Arbitrarily, we suggest a zone of 2km radius around the Wolves Archipelago as a high-priority feeding zone.
REFERENCES:


Harlequin Duck (*Histrionicus histrionicus*) Profile

Temperature: (Not applicable).

Salinity: (Not applicable).

Depth: (Not applicable).

Substrate: (Not applicable).

Prey: Crustaceans (e.g. crabs, amphipods), molluscs (e.g. periwinkles, mussels) and fish eggs during winter; in summer feed largely on freshwater invertebrates (insects, crustaceans, molluscs).

Predators: None indicated specifically but probably susceptible, as young, to predation by larger birds.

Reproduction: Breeding areas generally to the north (Labrador and Canadian north coast, east of Hudson’s Bay).

Habitat: Found only in marine habitat free of pack ice during winter, feeding near rocky shores in 2 - 3m water. East coast of Canadian mainland and west and south coast of Newfoundland.

Growth: Feed and grow during winter at various exposed sites down the eastern seaboard.
Arctic Tern - Sterna paradisaea

GENERAL CONSIDERATIONS: Arctic terns are recognised as the most spectacular long-distance migrants among all birds. The extremes of their summer and winter ranges are over 17,000km apart (Lincoln 1979), and birds banded in the Quoddy region have been recovered as far away as South Africa, Brazil, and Scotland (Brewer et al. In press). Their diet of young forage fish gives them considerable potential as indicators of recruitment to commercial fisheries (Monaghan et al. 1989). The breeding colony in the Quoddy region is probably the largest in eastern North America (Lock et al. 1994).

SOURCES OF DATA: The only known breeding site in the Quoddy region is Machias Seal Island (see Atlantic Puffin). The same general sources apply to Arctic Terns as to puffins, with the addition of papers arising from studies of the terns, notably Pettingill (1939), Hawksley (1957), Newell (1985), Bunin and Boates (1994). As with puffins, there are no systematic surveys of distribution at sea in the region, so estimates of feeding range of breeding birds were derived from the literature and the unpublished study by Amey (in prep.). In addition to the importance of Machias Seal Island as a breeding site, parts of Passamaquoddy Bay are also important to non-breeding and migrating Arctic Terns; information on this aspect is derived from Braune and Gaskin (1982a,b).

HABITAT CONSIDERATIONS: Arctic Terns arrive in the region in late May; breeders leave the colony by mid-August but many remain in the region until late September; during these last two months the regional population probably includes many birds migrating from more northerly breeding grounds.

Breeding habitat: The only known colony in the region is on Machias Seal Island where over 2,000 pairs nest annually (Bunin and Boates 1994). Squires (1976) reported former colonies on White Horse Island, and on Three Islands and Western Green Island near Grand Manan. Nests are placed on the ground, often in quite thick vegetation. Arctic Terns, like puffins, always nest on remote offshore islands, probably for the same reasons.

Coastal habitat: Terns breeding on Machias Seal Island forage mainly very close to the island, on small forage fish (mainly young herring Clupea harengus). Feeding flocks are commonly seen around many of the shoals near the island, especially Southeast Shoal and North Shoal (Amey, in prep.; pers. obs.), which are respectively about 2.5 and 3.5km from the colony. There are no quantitative data on foraging ranges, but studies elsewhere suggest that they are mostly within 3km, and rarely exceed 10-20km (Boecker 1967 in Cramp 1985).

MANAGEMENT CONCERNS: Arctic Terns, like Atlantic Puffins, now breed in the Quoddy Region only on Machias Seal Island which is strictly managed for the protection of all seabirds (CWS 1994). The former existence of colonies on other island (Squires 1976) suggests that appropriate management might be possible for the restoration of other colonies. For CWS management on Machias Seal, see Atlantic Puffin account. Disturbance of breeding terns by tourists, light keepers, and researchers seems not to be a problem (Morrison 1996).
The Quoddy region is important to Arctic Terns not only for breeding birds, but also for birds migrating from other breeding areas; these birds use - or used to use - Head Harbour Passage southeast of Deer Island as a feeding ground. In the 1970s large mixed flocks of Arctic and Common (Sterna hirundo) Terns, and Bonaparte's Gulls (Larus philadelphia) commonly fed on euphausiids, small fish and insects in these waters, especially in August and September (i.e. after the breeding season) (Braune and Gaskin 1982a,b).

For Arctic Terns, as for Atlantic Puffins, breeding habitat can be defined as small remote islands where human disturbance and predation are strictly controlled; at present, only Machias Seal Island meets all these criteria but - unlike puffins - there is historical evidence that other islands in the region also were formerly suitable.

MAPPING OF HABITATS: The whole of Machias Seal Island is shown as breeding habitat. Feeding habitat for breeding birds is shown as a 10km circle centred in Machias Seal Island. L'etete and Head Harbour Passages (shaded zones in accompanying map from Braune and Gaskin 1982a) are shown as critical feeding habitat for post-breeding Arctic Terns in August and September.

REFERENCES:

Amey, K.D. In prep. The use of the breeding and feeding ecology of four species of seabird at Machias Seal Island as indicators of changes in food availability in the Bay of Fundy. M.Sc. thesis, University of New Brunswick, Fredericton, NB.


Arctic Tern (*Sterna paradisaea*) Profile

**Temperature:** Breeds in north (circumpolar); over winters in the sub-Antarctic. Machias Seal Island near the southern limit of breeding populations and probably largest in eastern North America; only one in the Quoddy Region.

**Salinity:** Not restricted to salt water, also found breeding near tundra lakes in the north during summer.

**Depth:** (Not applicable; feeds on surface organisms).

**Substrate:** (Not applicable for underwater substrate).

**Prey:** Small fish, typically herring, as well as euphausiids and insects.

**Predators:** No information available; possible predation on young, unfledged birds by great black-backed gulls (*Larus marinus*) and herring gulls (*Larus argentatus*).

**Reproduction:** Machias Seal Island only known breeding colony in the region (>2,000 pairs nest annually). Nests on ground, often in vegetation.

**Habitat:** Much of the Quoddy Region is used as feeding area for birds prior to their migration to the Antarctic. Migration range can exceed 17,000km. Tundra lakes in the north; open seas, rocky coasts islands.

**Growth:** Feed largely on small fish, especially herring, white hake and butterfish, but also marine invertebrates (e.g. euphausiids), apparently according to availability near the sea surface.
Atlantic Puffin - Fratercula arctica

GENERAL CONSIDERATIONS: Atlantic Puffins are highly regarded seabirds characteristic of remote oceanic islands. In the Quoddy area, they are a significant resource for ecotourism. The Quoddy region is very close to the southern limit of the species in eastern North America; the only colony further south is a small one on Matinicus Rock, ME.

SOURCES OF DATA: The Canadian Wildlife Service manages the only breeding colony in the Quoddy region and hires a seasonal warden who provides annual reports, including counts (CWS 1994). There are no systematic surveys of distribution at sea, so estimates of feeding range derived from the literature were used to define marine habitats.

HABITAT CONSIDERATIONS: Puffins breed in the area between late April and mid August; outside these times they disperse to deeper waters in the NW Atlantic (Harris 1984).

Breeding habitat: The only confirmed colony is on Machias Seal Island, a 6-ha federal Migratory Bird Sanctuary managed by the Canadian Wildlife Service. Nest sites are mostly under large boulders or in rock crevices, but some are in burrows dug by the birds in soft soil under long vegetation just inland from the coastal boulder zone of the island. Puffins always nest on offshore islands, presumably to minimize predation and disturbance (Harris 1984). The breeding population has not been censured accurately; maximum twice-daily counts of adults visible from the top of the lighthouse are 7-800 birds (D.N.Nettleship, pers. comm.) but estimates based on the proportion of banded chicks among fledglings found at the lighthouse at night suggest that as many as 1200-1500 pairs may breed (Diamond and Amey, unpub). Very small numbers may possibly nest elsewhere in the Quoddy region, though there is no documented evidence of this; there are unconfirmed reports by fishermen of adult puffins apparently investigating potential nesting sites at White Horse Island and on the Wolves.

Coastal habitats: The sea within foraging range of Machias Seal Island is critical habitat during the breeding season. Puffins feed on fish and (occasionally) marine invertebrates, which they catch by diving from the surface to depths usually not exceeding 15m (Harris and Hislop 1978); elsewhere they have been recorded diving as deep as 60m (Piatt and Nettleship 1985). Their main prey in these waters are first-year herring and white hake, normally less than 10cm long (Amey and Diamond, unpub).

MANAGEMENT CONCERNS: Puffins have been reduced from pre-historic levels throughout the Gulf of Maine, to a few remnant colonies; some former colonies in Maine, extirpated by human hunting pressure, have been restored in recent years (Kress&Nettleship 1988). The Machias Seal Island colony is protected by the resident light keepers and the CWS warden who is present in June and July. A well-established ecotourist business operates from May through August, focusing on puffins and terns. Tourism, light keeping, and research (the only other activity allowed on the island) are not of management concern so long as they continue to be strictly regulated (CWS 1994).
Predation from gulls - particularly Great Black-backed Gulls *Larus marinus* which have increased greatly in the Bay of Fundy in recent decades (Mawhinney and Diamond, in prep.) - is a constant threat, and is managed by CWS through a policy of gull scaring with occasional killing (CWS 1994).

In summary, nesting habitat for puffins can be defined as small remote islands where human disturbance and gull predation are strictly controlled; at present, only Machias Seal Island meets all these criteria.

At sea, oil spills are a potential threat to puffins, because they spend much time sitting on the water (Brown *et al.* 1975). They are also vulnerable to entanglement in fishing nets, especially close to large breeding colonies such as those in Newfoundland (Piatt and Nettleship 1985).

**MAPPING OF HABITATS:** The coastal zone of Machias Seal Island (i.e. the whole island except for the central rock-free vegetated zone) is shown as breeding habitat. In the absence of data specific to Machias Seal Island, foraging ranges of birds breeding elsewhere have been used to delineate likely waters important for puffin foraging habitat, keeping in mind that foraging ranges can vary greatly between colonies (Harris 1984). At most colonies for which information is available, puffins feed mostly within 8-10km of the colony (Ashcroft 1976, Corkhill 1973) but radio-telemetry at a Maine colony (Matinicus Rock) recorded breeding puffins ranging up to 56km from the colony (National Audubon Society 1989). Arbitrarily, we suggest a zone of 10km radius centred on Machias Seal Island as a high-priority feeding zone for puffins, with a zone of 60km radius as a medium-priority feeding zone.
REFERENCES:

Amey, K.D. *In prep.* The use of the breeding and feeding ecology of four species of seabird at Machias Seal Island as indicators of changes in food availability in the Bay of Fundy. M.Sc. thesis, University of New Brunswick, Fredericton, NB.


Atlantic Puffin (*Fratercula arctica*) Profile

Temperature: 
Prefers cold water; Quoddy Region near southern limit of range.

Salinity:  
Found in the open sea (full salinity of 32 - 36ppt).

Depth:  
(Not applicable).

Substrate:  
(Not applicable for underwater substrate).

Prey:  
Young (first year) herring and small (< 10cm) white hake.

Predators:  
Great black-backed gulls (*Larus marinus*) are increasingly important as predators, especially of young birds, as these gulls become more numerous.

Reproduction:  
Breeds mainly around Newfoundland and Labrador on offshore islands. Nests may be among rocks or in burrows where soft soil occurs.

Habitat:  
Machias Seal Island is the only confirmed breeding colony within the Quoddy Region; with a reduction of great black-backed gulls, breeding may also be possible on The Wolves Islands and White Horse Island.

Growth:  
Once fully fledged, puffins feed and grow at sea where they overwinter.
FISHES
Atlantic Salmon - *Salmo salar*

**GENERAL CONSIDERATIONS:** The Atlantic salmon has been prized and respected as a game and commercial fish for centuries. Widely distributed throughout the North Atlantic basin in both Europe and northern North America, it has always been highly regarded for sporting qualities and as a superb food fish.

Unlike most marine species, the Atlantic salmon is anadromous, that is, it spawns in freshwater rivers, spends at least the first three years of its life there before going to sea. When at sea it may or may not travel widely. Although salmon tend to return to their native river, some mixing or wandering does occur. Generally the populations of particular rivers exhibit features characteristic of the river of origin resulting from both genetic and environmental influences (Saunders, 1981).

The two major groups interested in Atlantic salmon are anglers and commercial fishermen. Anglers seek their quarry in rivers while commercial fishing is usually carried on by netting at sea. Recently, aquaculture of Atlantic salmon has become an established industry supplying Atlantic salmon for the commercial market (Saunders, 1996). Bay of Fundy farms grow about 24,000mt with a value in excess of $100 million annually. Commercial fishing has largely ceased but salmon stocks are still in difficulty because of their freshwater habitat requirements and competition with other resource interests such as forestry, mining, and estuarial developments.

Wild Atlantic salmon resources are now subject to considerable angling pressure and some illegal fishing. There is increasing interest in habitat improvement and in assessing population levels of adult fish, made more difficult in the absence of commercial fishery statistics (see Gibson and Cutting 1993).

**SOURCES OF DATA:** A rich body of scientific literature exists on Atlantic salmon because of its reputation as a game fish par excellence and as an exceptionally fine food fish. The Canadian Department of Fisheries and Oceans (DFO), other government departments, universities using NSERC (NRC) funding and private agencies such as the Atlantic Salmon Federation (ASF) have all supported numerous aspects of research on Atlantic salmon. Indeed whole journals have been devoted solely to the study of the Atlantic salmon in both western Europe and eastern North America.

The most valuable sources are the publications of Canadian Fisheries and Aquatic Sciences Journal, Bulletins, miscellaneous publications and reports of Canada’s Department of Fisheries and Oceans (DFO).

**HABITAT CONSIDERATIONS:** The Atlantic salmon is an anadromous species and requires clean cool gravel and bottom streams for reproduction. Spawning occurs in the fall and the eggs develop over winter (while buried in the gravel) and hatch in the spring. The young salmon remain in the stream for 2 or 3 years before going to sea. Clearly the species is most vulnerable during the stream life of 3 years or more. Protection during this stage is critical. Protection must also include means of access to the river and the upstream spawning beds, so the stream system including the forest cover and the whole watershed must be
given special protection if salmon are to survive. That special treatment is generally costly and contentious because of so many conflicting interests but the requirements for the survival of Atlantic salmon stocks are well documented. Forest harvesting and maintenance, mining operations, water use, such as hydroelectric development must be controlled such that survival conditions are maintained.

MANAGEMENT CONCERNS: Atlantic salmon stocks declined significantly in recent years (Saunders, 1981). Restrictions in the form of quotas and licensing continued through the 1980s and early 1990s and still the numbers of returning fish declined and finally, in 1992, Canada declared a 5yr moratorium on commercial salmon fishing in Newfoundland, the last province with a commercial fishery (Parsons, 1993). A small commercial fishery was permitted in Labrador, the only commercial Atlantic salmon fishery in Canada.

Many factors contributed to the rapid decline of Atlantic salmon populations. High on the list was the combination of habitat deterioration and heavy fishing. Habitat has been a continuing problem with Atlantic salmon because of mankind's continuing use of rivers (for dams and drainage) forests (lowered water table and erosion) making even more difficult the adult salmon spawning migration to the upstream breeding grounds. Added was the damaging effects of DOT spraying for forest insects (Elson, 1967) and of acid rain (Peterson, 1980) on salmon eggs and embryos on the spawning grounds. The salmon populations were being heavily exploited by Canadian onshore and offshore fishermen, when it became apparent that North American and European Atlantic salmon were migrating to a common feeding grounds off Greenland. The commercial catch off Greenland was 127 metric tons in 1961 but reached 1588 metric tons in 1967 (Scott and Crossman, 1973). Subsequently catches off western Greenland have dropped significantly as a result of international negotiation (establishment of TACs and of offshore limits [no fishing beyond 12 miles off coastal states, with some exceptions]). The welfare of salmon stocks which migrate beyond the jurisdiction of coastal states is now covered by a new international Atlantic salmon convention called "The North Atlantic Salmon Conservation Organization (NASCO) (see Parsons, 1993: 287-291 pp.).

A serious concern at present is the danger of the wild salmon gene pool becoming contaminated by interbreeding with highly selectively bred salmon, escapees from aquaculture facilities. A well regulated sport fishery for Atlantic salmon is maintained in selected rivers in the Bay of Fundy watershed.

MAPPING OF HABITATS: The Atlantic salmon was once widely distributed along the Atlantic coast of North America from Ungava Bay to the Hudson River. Populations have been greatly reduced in this century, especially in the southern part of the range (i.e. in the Gulf of Maine watershed). Because it is anadromous, suitable rivers and their estuaries are critical for the species continued existence. Present distribution must also reflect the current aquaculture facilities (grow-out cages, hatcheries and smolt production) in Passamaquoddy Bay and contiguous waters.
REFERENCES:


Gorham, E. 1976. Acid precipitation and its influence upon aquatic ecosystems - an 
overview. Water, Air and Soil Pollution. 6: 457-481.


Sci. 38: 1612-1625.


Canada Bull. 184: 966p.

Sci. 219: 731p.
Atlantic Salmon (*Salmo salar*) Profile

Temperature: Preferred (sea), 4 - 12°C; lower lethal = -0.7°C; upper lethal = 27.8°C.

Salinity: 0 (freshwater phase) - 36ppt.

Depth: Probably to 10m at sea; pelagic feeder.

Substrate: Any substrate at sea; requires loose gravel in streams for spawning.

Prey: Feeds on smaller fish and invertebrates (esp. pelagic crustaceans e.g. shrimp, euphausiids, "krill") at sea; largely insectivorous as juvenile in freshwater.

Predators: Larger piscivorous fishes and mammals, esp. seals and humans.

Reproduction: Anadromous species (breeds in freshwater); adults return to natal rivers and streams to breed. After one year at sea, return as "grilse"; after two or more years at sea, return as "salmon".

Habitat: Migratory in Passamaquoddy Bay and Bay of Fundy; main feeding grounds in north (Greenland). Mouths of rivers & estuaries represent critical habitat due to extended acclimation time at smoltification (change from freshwater phase to saltwater phase) and a waiting period sometimes upon return to spawn if low water levels prevail in home rivers/streams.

Growth: Eggs hatch in freshwater (110d @ 3.9°C) usually in April; first two to three years spent in river of birth followed by downstream migration at time of smoltification (at about 15+ cm long; about 80+ g). One-sea-year fish weigh 1.7 - 2.7kg upon return to freshwater; two-sea-year fish weigh from 2.7 - 6.8kg upon return to freshwater.

Remarks: Highly prized as a sport fish, Atlantic salmon are good monitors of freshwater quality. They have disappeared from a large number of both European and North American river systems due to various types of pollution. Currently, Atlantic salmon are the main cash crop of the aquaculture industry in the Quoddy Region, their economic value being roughly equal to the sum of all traditional fisheries combined (> $100 mill. per year). Conflicts exist between the aquaculture industry and other users of the same coastal resource due to use of chemotherapeutants to control sea lice (chemicals also capable of killing other crustaceans such as lobsters and crabs) and the build-up of waste matter under the sea cages. Wild stocks continue to decline in all parts of the world.
Atlantic Pollock - *Pollachius virens*

**GENERAL CONSIDERATIONS:** Pollock occur on both sides of the North Atlantic. In Canada, pollock are usually marketed under the name "Boston bluefish". In the British Isles the same species is sold as "saithe, coalfish or coley".

In the NW Atlantic pollock occur from SW Greenland southward to off southern Labrador, Newfoundland, the Scotian Shelf, Bay of Fundy and Gulf of Maine to about Cape Hatteras. Pollock concentrations occur in the outer Bay of Fundy, the area south of western Nova Scotia and the largest one in the southern Gulf of Maine (Steele 1963). The distinctness of these populations is not known but parasite studies by Scott (1955) indicated different levels of infection in pollock from central Scotian Shelf area compared with those from the southwestern Brown Bank region. The major fishing areas are the outer Bay of Fundy to Browns Bank and the Scotian Shelf and the southern Gulf of Maine (Scarratt 1982, Steele, 1963). Pollock are caught by otter trawls, longline, handline, and occasionally, in weirs and traps.

In Passamaquoddy Bay, small pollock, locally called harbour pollock, occur inshore in early summer. During an intensive study of a site 3.2km x 1.6km in Passamaquoddy Bay over a one year period, Tyler (1971a) found pollock in bottom trawl samples only during winter. Pollock entered the area in December and left after March. The early winter arrival corresponds to the sporadic occurrence of a November/December hook and line fishery in the deeper waters of Passamaquoddy Bay.

Both males and females mature at 4-5 to 7 years old and 50-70cms long. Spawning occurs from November to February in southern Gulf of Maine and from September to March off Nova Scotia. There is no evidence to suggest that spawning occurs in the Bay of Fundy. Available evidence suggests that larvae found in the outer bay drifted from spawning grounds in the Gulf of Maine or Scotian Shelf.

Larval pollock eat mainly copepods, and with increasing size, prey upon small crustaceans, especially amphipods. Offshore pollock feed heavily on euphausiids and as they grow larger, other fishes such as herring, sand lance, silver hake and redfish occur more frequently in the diet but shrimps and other crustaceans continue to be important foods.

**SOURCES OF DATA:** A commercial species, the pollock is well documented in the Dept of Fisheries and Oceans landing statistics. The Canadian fishing areas and TAC's were described by Scarratt (1982), the Bay of Fundy population, its movements and biology by Steele (1963) and alimentary tract helminth parasites by Scott (1985). Overall review of pollock in Canadian waters given by Scott & Scott (1988). Canadian landings have ranged from 24,000 to 41,000 mt since 1975.

**HABITAT CONSIDERATIONS:** Adult pollock occur within rather narrow temperature 2° - 12°C and salinity 31 - 34ppt ranges in the Bay of Fundy and Scotian Shelf (Scott 1982), but swim and feed at depths from surface to 364m. Spawning occurs on a falling temperature and begins at 8.3 - 9.4°C (Bigelow and Schroeder 1953). Off Cape Breton Island spawning occurs at depths of 175 - 275m (Steele 1963). The eggs are small, 1.04 -
1.2 mm in diameter, spherical, buoyant, pelagic and without an oil globule and drift in the water column (Markle & Frost, 1985). Eggs hatch in about 9 days at 6°C and 6 days at 9.5°C, the young rising in the surface layers (Bigelow and Schroeder 1953). Although a member of the cod family and thus considered a "groundfish" by the fishing industry, it prefers a pelagic adult life style and spends little time on the bottom. After hatching, young pollock live a pelagic existence for at least 3-4 mo. (Mayo et al 1989). Juvenile pollock, 0+ age group, then move into shallow inshore waters along the coast of Bay of Fundy and New England. Studies in Passamaquoddy Bay, New Brunswick, showed juvenile pollock present in shallow intertidal zone at all tide levels, day and night, throughout the summer, apparently feeding almost continuously. Rangeley and Kramer (1995) note the rockweed algae is used for foraging and also possibly as a shelter from predators. It is suggested that rockweed harvesting may seriously affect the survival of fishes (i.e. pollock) using the rocky intertidal zone (Rangeley 1994).

MANAGEMENT CONCERNS: Canadian landings of pollock have ranged from 21,000 to 44,000 mt since 1975 and have become increasingly important since the decline of groundfish stocks in general. The use of the intertidal zone by juvenile pollock in Passamaquoddy Bay as noted previously by Rangeley and Kramer (1995) suggests a real threat to survival of young pollock by the harvesting of rockweed and may have a serious effect on the landings.

Young pollock moving inshore in summer often enter the salmon cages; feed on salmon pellet food and grow too large to escape through the mesh. Perhaps a candidate for aquaculture.

MAPPING OF HABITATS: The pollock has a wide range on the Atlantic coast but the fishery is concentrated off Cape Breton, the Scotian Shelf and Browns Bank and the Gulf of Maine and mouth of Bay of Fundy. Browns Bank is the centre of the Canadian fishery, although some pollock overwinter in northern part of range most return to southern Gulf of Maine in late fall (Scarratt 1982). Young pollock exhibit a shoreward movement in summer. Distribution patterns have been discussed by Fritz (1968), Leim and Scott (1966), Scarratt (1982), Scott (1982) and Scott and Scott (1988).
REFERENCES:


Atlantic Pollock (*Pollachius virens*) Profile

**Temperature:** Preferred range = 7.2 - 8.6°C; can tolerate temperatures down to 0°C; Not found in temperatures above 15.5°C. Spawn on sea bottom at 8.3 - 9.4°C and lower.

**Salinity:** 21 - 36ppt.

**Depth:** Adults from 37 - 364m; preferred depths = 110 - 181m. Young fish (harbour pollock), up to one+ years, found inshore in shallow waters.

**Substrate:** No preference for any particular substrate; a demersal species.

**Prey:** Larval stage feeds on plankton; juveniles eat small crustaceans (e.g. gammarids); with increased size, euphausiids, and smaller fishes are eaten. In the Bay of Fundy, fish prey include herring, sand lance, silversides.

**Predators:** Few natural predators when large; larval and young fish probably eaten by other, larger fishes.

**Reproduction:** Spawning occurs from September to March off Nova Scotia, from November to February in Massachusetts Bay, Gulf of Maine, and probably no spawning occurs in Bay of Fundy.

**Habitat:** Pollock occur commonly in the Gulf of St Lawrence, around Newfoundland and the Grand Bank, and south along the Scotian Shelf, Bay of Fundy, Gulf of Maine, to Cape Hatteras. Adults found where food is plentiful.

**Growth:** Age determinations made by study of otoliths. Growth rates vary from stock to stock. Males mature at 4-7 years of age and 50 - 65cm in length. In recent years, length at maturity for both males and females has apparently declined. Reported to 84cm FL, 70kg in weight and to 14 years old.

**Remarks:** An important commercial fish, pollock are usually sold as "Boston Bluefish" on Canadian markets. Economic value annually varies around $10 million. Recently, this species has been "accidentally" cultured (grown out) in Atlantic salmon sea cages which young fish can enter, feed on the salmon feed, and get too big to leave. They represent a possible candidate for mariculture.
Atlantic Herring - *Clupea harengus*

**GENERAL CONSIDERATIONS:** There are important commercial fisheries for this species in the Northwest Atlantic including waters in the Gulf of St Lawrence, off Newfoundland and Nova Scotia, and in the Bay of Fundy, this latter being considered as a nursery area (Scarratt, 1982). The fish are caught using different methods including weirs, purse-seining, shut-off seines, and traps. The young fish (one to two years of age) are marketed as sardines. Found in inshore waters, they range from Greenland and Labrador to as far south as Cape Hatteras. There are different and distinct stocks which breed in different areas, making seasonal migrations, which makes management of the species difficult. Spawning of adults, aged five years and older, occurs from April to November in Canadian waters; depending on the stock, in the Quoddy region, spawning is mainly in the summer and early fall (July, August and September) at depths from 2 - 50 fathoms. They represent important energy converters feeding on plankton and small pelagic species such as euphausiids and in turn being eaten by many predators including other fishes, birds, and mammals. Recently, a new market has opened in Japan for the roe ("kazunoko") from Canadian herring due to the decline in Japanese herring stocks (Scott & Scott, 1988).

**SOURCES OF DATA:** As a commercial species, extensive records exist within Fisheries and Oceans, Canada for landings and stock densities. A description of the Canadian stocks or discrete populations can be found in Iles and Sinclair (1982); the various migration patterns for each stock has been suggested by Iles and Sinclair (1982), using morphometric studies, as well as by McGladdery and Burt (1985), using parasites as biological tags. The steady decline of Atlantic herring in Canadian landings from 528,000 t (1968), to 250,000 t (1975), and to 147,000 t (1982) is discussed in Scott and Scott (1988). The assigned total allowable catch (TAC) has not always been met (Scarratt, 1982) indicating reductions in the stocks.

**HABITAT CONSIDERATIONS:** Atlantic herring are found in a wide range of salinities ranging from 21 to 36 ppt. They swim and feed in depths ranging from the surface to 200 m but spawn in relatively shallow water (2-8m), preferring 3-4m with temperatures between 6.8 and 12.3 °C at the surface and between 3.7 and 9.7 °C on the bottom. The preferred substrate for spawning is one of gravel and rocks with seaweeds, to which the eggs can attach. Larvae occur throughout the Bay of Fundy at depths of 0 - 60m from July to December (Colton and St.Onge, 1974).

**MANAGEMENT CONCERNS:** Atlantic herring stocks have declined in most areas and from a TAC of 110,000 t in the 1980s, the 1995 TAC was set at 80,000 t and the 1996 TAC set at 60,000 t (Stephenson et al., 1996). There is some evidence of recovery in Canadian waters but of greatest concern is the fact that spawning occurs in relatively shallow water, the same areas which are most likely to be impacted adversely by other activities. The Canadian "sardine" industry (young herring) is centred in the Bay of Fundy and particularly in Passamaquoddy Bay where the largest "sardine" cannery in the world is situated. Passamaquoddy Bay is also the region in which the East Coast Aquaculture Industry is centred. The herring weir fishermen and the Atlantic salmon aquaculturists make use of the same, common resource. While this resource may be able to support both...
industries at the present time, with further demands on this resource, it becomes increasingly important that all stakeholders have a share in the management of this and other common resources.

**MAPPING OF HABITATS:** Based on the depth and substrate data, potential spawning areas can be determined (depth of 2 - 8 m; benthic temperatures of 3.7 - 9.7°C). Not all of these areas, however, have spawning herring stocks due to other constraints. Both young and adult herring are prey for many other organisms and their eggs are also subject to predation by a variety of other fishes including winter flounder (Tibbo et al., 1963; Pottle et al., 1981); cod, haddock, and red hake (Caddy and Iles, 1973); and sculpins, skates, and smelt (Scott and Scott, 1988). Such predation may restrict spawning areas especially if there is insufficient seaweed cover. Where spawning areas are known, they should be assigned a high priority especially as this once plentiful resource, is trying to recover from a serious decline in recent years.

**REFERENCES:**


Atlantic Herring (*Clupea harengus*) Profile

| **Temperature:** | 6.8 - 12.3°C surface; 3.7 - 9.7°C bottom (spawning). |
| **Salinity:** | 21 - 36 ppt. |
| **Depth:** | Spawns 2 - 8 m; 3 - 4 m preferred. Distribution from surface down to 200 m. |
| **Substrate:** | Gravel or rock bottoms; seaweed cover required for spawning beds. |
| **Prey:** | Plankton, when young; Plankton and larger invertebrates (euphausiids) when larger. |
| **Predators:** | Larger piscivorous fishes (mackerel, tuna, salmon, dogfish, etc.) Piscivorous mammals (seals, porpoises, whales) and many different seabirds; Eggs of herring consumed by a wide variety of epibenthic organisms (e.g. winter flounder, cod, haddock, red hake, scupins etc.). |
| **Reproduction:** | Time of spawning depends on the stock/population (April - November); For Quoddy Region, July-September. |
| **Habitat:** | Each stock/population has its own migratory route, spawning in one area the young moving in a more or less set pattern; Bay of Fundy considered to be an important nursery area. |
| **Growth:** | Age determination made by study of otoliths; Growth rates vary from stock to stock: can mature as early as three years old; more usual at 5 years old. At age 2, length = 18.8 cm; at age 3, length = 24.5 cm; at age 5, length = 28.7 cm; length increase thereafter at about 1 cm/year to 12 years old. |
| **Remarks:** | Herring weir fishermen in some conflict over inshore water use by aquaculture industry; 1997 may have slightly better population sizes than 1996 but a general decline in stocks since the early 1980s. These fish carry many parasites (e.g. *Anisakis simplex* which matures in cetaceans). Large-scale mortalities have been caused by a fungus, *Ichthyosporidium hoferi*, elsewhere, and, in the Bay of Fundy herring mortalities have occurred due to a dinoflagellate, *Gonyaulax excavata*, which had been eaten by plankton. The scales, "pearl essence ", are used in making high quality paints. |
Atlantic Hagfish - *Myxine glutimosa*

**GENERAL CONSIDERATIONS:** There is a modest commercial fishery in the North Pacific Ocean for hagfish (*Eptatretus spp*). The fish are purchased by Korean buyers and the skins processed into a fine soft leather. An experimental fishery commenced by Nova Scotia has met with difficulty in part because of damage to skins by hagfish in crowded containers.

Except for the modest commercial interest noted above, hagfish in the Gulf of Maine region are caught in baited 20 gallon barrels as experimental animals for physiological research. Available evidence suggests local populations can be fished down rather quickly, not surprising for a demersal species that burrows into bottom ooze.

The copious quantities of slime released by hagfishes is of particular interest. The slime glands are arranged in a single row on each side of the hagfish along the abdomen. each gland contains mucous and a coiled continuous protein thread that may be up to 60cm long. The thread can be separated from the mucous and studied independently. It may be one of the longest continuous proteins found in animals.

**SOURCES OF DATA:** Atlantic hagfish have not been fished commercially until very recently and even now it is a low scale fishery. Consequently available information has been gathered mainly from those fishing hagfish for university and biomedical research. Some anecdotal and qualitative information has appeared in the literature via commercial ground fishing operations (i.e. Bigelow & Schroeder, 1953). There is a considerable body of information on the physiology and biochemistry of the hagfish developed by university researchers. Hagfish are attractive to biologists and biochemists because of their unique features.

They are one of the most primitive of living vertebrates. A hagfish has a branchial heart and several accessory hearts that beat independently of each other. The thymus gland is lacking amino acid. Transport is unique and so on. See Hardisty (1979) for these and other characteristics.

**HABITAT CONSIDERATIONS:** Atlantic hagfish occur on soft muddy bottoms in depths of 30 - 958m. High salinity is required, 32 - 34ppt are optimal while 20 - 25ppt are lethal. They burrow in the soft substrate, sometimes with only the head emergent, but sometimes completely buried. The species is thought to be facultatively anaerobic. Probably fairly abundant locally in favourable habitats.

**MANAGEMENT CONCERNS:** No management concerns at present, but should a fishery develop, it would be logical to protect specific areas from commercial fishing because localized populations are vulnerable to being fished out, particularly because baited traps are used and the animals are not known to wander or migrate. They are also vulnerable to perturbations such as underwater explosions.
**MAPING OF HABITATS**: Based on depth, substrate, bottom salinity and temperature, presence or absence of populations can be determined with considerable confidence. Spawning behaviour is not well known. Females carry up to 30 horny-shelled eggs, releasing them when ready to do so but we have no indications of spawning or nursery areas (Scott and Scott 1988).

**REFERENCES:**


### Atlantic Hagfish (Myxine glutinosa) Profile

<table>
<thead>
<tr>
<th><strong>Temperature:</strong></th>
<th>Max. = 12 C; benthic organism at bottom temperature.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salinity:</strong></td>
<td>Optimum = 32 - 34 ppt; low lethal = 20 - 25 ppt.</td>
</tr>
<tr>
<td><strong>Depth:</strong></td>
<td>Normal range = 27 - 457 m; Maximum recorded depth = 958 m. About 40 - 50 m in Passamaquoddy Bay.</td>
</tr>
<tr>
<td><strong>Substrate:</strong></td>
<td>Silt/clay/mud - burrows into soft bottom.</td>
</tr>
<tr>
<td><strong>Prey:</strong></td>
<td>Invertebrates (e.g. shrimp) as well as dead or dying fishes; scavenger.</td>
</tr>
<tr>
<td><strong>Predators:</strong></td>
<td>Few effective predators (other than human collectors); small hagfish recorded from stomach of cod. Because of large amount of slime produced by larger hagfish, the slime would coat the gills of would-be piscivorous predator causing its death, thereby providing food for the would-be prey.</td>
</tr>
<tr>
<td><strong>Reproduction:</strong></td>
<td>Little is known for the Atlantic hagfish which is hermaphroditic. Sexually mature females, with eggs, possess undeveloped male gonadal tissue. Eggs are elongate, few in number (up to about 30) which are large (up to 25 mm long by up to about 10 mm wide. Spawning apparently occurs year-round.</td>
</tr>
<tr>
<td><strong>Habitat:</strong></td>
<td>Benthic organism, burrows into soft mud with head above the mud or completely buried (facultative anaerobic).</td>
</tr>
<tr>
<td><strong>Growth:</strong></td>
<td>Newly-hatched hagfish resemble the adult in appearance; no larval stage. Smallest specimens recorded are about 6 cm long; largest = 79 cm long. Growth rate is not known; typical size of &quot;large&quot; adults in Passamaquoddy Bay = about 35 cm.</td>
</tr>
<tr>
<td><strong>Remarks:</strong></td>
<td>One of the most primitive fishes, without jaws, without eyes, and without scales; more active at night than during the day. Considered as a nuisance species because it eats dead or dying fish caught on line trawls or at the bottom of gill nets. Because of its primitive nature, hagfish are important in scientific and biomedical research.</td>
</tr>
</tbody>
</table>
Winter Flounder - *Pleuronectes americanus*

**GENERAL CONSIDERATIONS:** The winter flounder, although valued as a food fish (sold as sole, lemon sole, flounder) does not support a directed fishery in Canada, although it sometimes does in New England waters. Captures in Canada are a by-catch while trawling for ground fish, or clearing a weir. Regionally winter flounder also support a small sport fishery. Fish caught on offshore banks are usually larger than those taken inshore. There is a marked offshore movement to deeper water in the Bay of Fundy region, which McCracken (1963) related to temperature, but such movement does not occur in Newfoundland. Duman and Devries (1974) showed that winter flounder survive freezing in Newfoundland's coastal waters in winter because of synthesis and accumulation of antifreeze polypeptides in the blood. Ongoing research on the antifreeze mechanism is being conducted by Fletcher (1977, 1981) and co-workers, Fletcher et al (1984). Winter flounder also burrow into the bottom sand or mud, presumably to escape low temperatures.

Time of spawning varies over the western Atlantic range - earlier in the south and later in the north. Thus off southern New England, spawning begins about November and December, south of Cape Cod at its height in February and March, and in Passamaquoddy Bay. Bay of Fundy spawning occurs usually in May. Spawning takes place over sand or mud bottom and at depths varying from 2-3m to as deep as 75m, possibly depending on bottom temperature. The eggs are demersal and adhesive and average of about 0.8mm in diameter (Fahay 1983). Age - 3, females produce about 435,000 eggs, age - 5, females about 3,329,000 eggs (Topp 1968). Flounders are aged by "reading" or analyzing the growth rings on the otolith, a bone-like structure in the inner ear. They are important energy converters, consuming a variety of benthic invertebrates, including clams (and clam siphons), and may at times prey heavily on eggs of other bottom spawners such as herring (Tibbo et al 1963) and capelin (Frank and Leggett 1984). Flounders in turn are consumed by seals, sea ravens, monkfish, and dogfish, and by birds such as osprey, blue herons and cormorants.

**SOURCES OF DATA:** Seasonal movements or migrations of winter flounder have been demonstrated (McCracken 1963), inshore in summer and offshore in winter. These movements have generally been related to temperature, but there are latitudinal variations in these movements and it is thought that age or state of sexual maturity may also be involved. An extensive study of digenean parasites of winter flounder in Passamaquoddy was conducted by Scott (1985). The studies of cold resistant physiological and genetic (antifreeze gene) characteristics in winter flounder have provided much new biological information (Fletcher 1989). Similarly, the studies of winter flounder as an alternate aquaculture species has also provided much new information on food and growth.

Distributional data was provided by Leim and Scott, (1966) McCracken, (1963) and Scott and Scott (1988).

**HABITAT CONSIDERATIONS:** Winter flounder are demersal fishes, usually found over soft or sandy bottom at depths of 1.8 - 36.6m but reported to depths of 143m by McCracken (1954). Occurs in temperatures of 1.4° - 16°C. An upper incipient lethal temperature of about 27°C was demonstrated by McCracken (1963). Preferred temperature
appears to be 12° - 15°C, and in the field most concentrations of flounders are usually found within this range and avoid temperatures above 15°C. Although flounders are generally regarded as a high salinity species they have a salinity range of 15 - 36% (McCracken 1963 Sumner, 1907). In Passamaquoddy Bay, young fish move shoreward in summer - fish-of-the-year were caught in shore seines by July (McCracken, 1963). Tyler (1971) noted that flounders move inshore with rising tide, presumably to feed on polychaete and soft-shell clams.

MANAGEMENT CONCERNS: Winter flounder are captured commercially in Canada as a by-catch while trawling for other species and are not the object of a directed fishery. When captured they are usually lumped in with other flatfish and listed simply as flounders or flatiish, hence accurate landing statistics are not usually available for Canadian waters.

There are small but regionally important sport fisheries for winter flounders by angling from small boats offshore or from wharves. Winter flounder are also caught in herring weirs and shut-off seines, in which case they may be sold as lobster bait or lumped in with other by-catch species and processed for fish meal. There is much anecdotal evidence of a decline in numbers of winter flounder in recent years but not much hard evidence because of absence of catch statistics.

MAPPING OF HABITATS: Widely distributed in Bay of Fundy and Passamaquoddy Bay and in coastal waters of New Brunswick and Nova Scotia but with few areas of concentration (Scott 1982). It also exhibits seasonal movements to and from deep water (McCracken 1963). In spring and summer young flounder frequent the inshore waters moving in and out with the tide but leave the inshore waters of Passamaquoddy Bay in winter moving into deeper waters of the Bay (McCracken, 1963; Tyler, 1971).

Distributional patterns and movements have been discussed by Fritz (1968), Leim and Scott (1966), McCracken (1963), Scarratt (1982), Mackay et al. (1978), Scott, (1982), Scott, (1985), Scott and Scott (1988) and Tyler (1971).

REFERENCES:


Sumner, F.B. 1907. Further studies of the physical and chemical relations between fishes and their surrounding medium. Amer. J. Physiol. 19: 61-96.


Winter Flounder (*Pleuronectes americanus*) Profile

**Temperature:** Range = 1.4 to 15 C; preferred temperatures = 12 - 15 C. Avoids temperatures > 15 C.

**Salinity:** Highly tolerant species, found in salinity range 16 - 32 ppt.

**Depth:** Range from inshore to 143 m; preferred depth = 1.8 - 36.6 m.

**Substrate:** Soft mud to hard bottom; recorded as buried in 12 - 15 cm in mud in winter (Nfld).

**Prey:** Mainly invertebrates such as polychaetes and crustaceans as well as other fish eggs (e.g. capelin in Newfoundland waters); move inshore with rising tide and feed on clam siphons and small clams.

**Predators:** An important food item for seals, also eaten by other epibenthic fishes such as sea ravens, monk fish, and dogfish. During summer months, they are eaten by ospreys; young fish are also eaten by blue herons and cormorants.

**Reproduction:** Spawning is highly dependent on temperature: earlier in the south of its range and later in the north. South of Cape Cod, spawning occurs in February and March; in the Quoddy Region, spawning occurs in May; in Conception Bay, Nfld, spawning occurs from March to June. Hatching occurs in two to three weeks at 3 C; the larvae metamorphosing after 2.5 to 3.5 months, drifting in surface waters, and assuming the typical flatfish shape.

**Habitat:** Typically, this is an inshore, shallow water species which shows summer/winter, inshore/offshore migrations. Assumed by some to be showing temperature selection; others relate the migration to food availability.

**Growth:** Growth rate is related to temperature, e.g. 2-year fish from St. Mary's Bay, N.S. = 17.8 cm and from Passamaquoddy Bay, N.B. = 11.4 cm. Adults tend to be larger from offshore banks (e.g. a fish from Western Bank measured 63.5 cm and weighed 3.6 kg) than from inshore areas where they seldom exceed 45 cm or 1.4 kg.

**Remarks:** Although there is not a "directed fishery" for this fish, many are taken incidentally while trawling for other species and often sold as fillet of sole or fillet of lemon sole. Under serious consideration as a mariculture candidate, much recent research has developed protocols for hatching eggs, produced and fertilised in captivity as well as maintaining both larvae and young juveniles. Some pilot grow-out trials are in process.
ECHINODERMS
Green Sea Urchin - *Strongylocentrotus droebachiensis*

**GENERAL CONSIDERATIONS:** The green sea urchin is a very common inhabitant of the rocky subtidal waters of the Quoddy region. Long regarded as a nuisance because of its spiny exterior, the sea urchin has become an important fishery in Quoddy waters due to its valuable roe.

**HABITAT CONSIDERATIONS:** Green sea urchins are mobile animals, via their tube feet, though movements are very localized. They occur mostly from the low water mark to 10 - 15 m, preferring protected rocky substrate but also inhabiting mud and sand bottoms. In Passamaquoddy Bay sea urchins are abundant in intertidal waters, including tidepools. They also are found on wharves, pilings, under rocks, and beneath seaweeds. The temperature range for sea urchins is 0 - 16°C. They occupy seawater salinities at all life stages; adults and juveniles are rare in brackish water. Sea urchins prey primarily on the seaweed *Laminaria*, though they are omnivorous and consume a wide variety of food depending on availability. Predators of sea urchins include lobsters and fishes, particularly wolfish. Sea urchins spawn from January to April; larvae can be found from February to May, but are rare in June. The gregarious habit of sea urchins aids fertilization. See References.

**MANAGEMENT CONCERNS:** Green sea urchins are naturally abundant in most Quoddy waters. In recent years a fishery has developed for urchins in both New Brunswick and Maine to market urchin roe. Urchins are fished by dragging, by suction, and by hand picking by divers. Management of the fishery is in an early stage, and overfishing is a definite concern.

**MAPPING OF HABITATS:** Data for mapping known green sea urchin distribution and abundance in the Quoddy region were derived from the Bay of Fundy Resource Inventories of MacKay and Bosein (1979), MacKay et al. (1979a,b), and MacKay et al. (1978a,b,c), and from Neish (1973). Mapping "inferred" sea urchin distribution in unsampled waters, i.e. suitable habitat, was done by identifying those habitats with suitable bottom type, temperature, and salinity.

**REFERENCES:**


## Sea Urchin (*Strongylocentrotus droebacheensis*) Profile

<table>
<thead>
<tr>
<th><strong>Temperature:</strong></th>
<th>0 - 16°C.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salinity:</strong></td>
<td>Inhabit seawater salinities at all life stages; adults and juveniles rare in brackish water.</td>
</tr>
<tr>
<td><strong>Depth:</strong></td>
<td>Usually from low water to 10 - 15m; found to 1200m. Passamaquoddy Bay - abundant in intertidal zone, including tidepools, usually &lt;7.3m.</td>
</tr>
<tr>
<td><strong>Substrate:</strong></td>
<td>Prefers rocky substrate; also found on mud and sand.</td>
</tr>
<tr>
<td><strong>Prey:</strong></td>
<td>Seaweed (kelp) <em>Laminaria</em> primary food. Omnivorous - consumes wide variety of food, depending on availability.</td>
</tr>
<tr>
<td><strong>Predators:</strong></td>
<td>Lobsters, fishes (particularly wolffish).</td>
</tr>
<tr>
<td><strong>Reproduction:</strong></td>
<td>Spawn January to April; larvae present February to May, rare in June. Gregarious habit aids fertilization.</td>
</tr>
<tr>
<td><strong>Habitat:</strong></td>
<td>Protected rocky habitat; wharves, pilings, under rocks, beneath seaweeds.</td>
</tr>
<tr>
<td><strong>Growth:</strong></td>
<td>Larval period lasts several weeks.</td>
</tr>
<tr>
<td><strong>Remarks:</strong></td>
<td>Abundant in study area.</td>
</tr>
</tbody>
</table>
Common or Northern Sand Dollar - *Echinarachnius parma*

**GENERAL CONSIDERATIONS:** This sand dollar presently has no commercial value (although other sand dollars are harvested in subtropical and tropical waters and sold as decorative items to tourists) but it is characteristic of relatively unimpacted areas with mixed sandy substrates.

**HABITAT CONSIDERATIONS:** The Northern sand dollar lives on or just below the sediment surface, often half-buried within soft substrates of sheltered bays and open coasts from low water to over 1,600 m. It is a deposit feeder, selecting fine particles from sandy bottoms as a source of organic matter (e.g. bacteria) and diatoms are also actively selected from the substrate. This sand dollar is probably a good indicator of well oxygenated fine sandy substrates that contain some, but are not overloaded with, organic matter. Thus it will not be found in stagnant waters or sediments that are poorly oxygenated, such as from organic enrichment that produces high bacterial biomass. Predators include bottom feeding fishes such as cod, haddock and flounder.

**MANAGEMENT CONCERNS:** The sand dollar is useful in habitat management from two perspectives. Firstly, the habitat suitable for sand dollars is limited within the study area compared to other target species and thus worthy of habitat conservation efforts. Secondly, the presence of sand dollars probably indicates relatively unimpacted areas and it can thus be used as an indicator of the health of soft sandy environments.

**MAPPING OF HABITATS:** The Northern sand dollar is not used commercially and its distribution is not well understood. Data were principally obtained from the Bay of Fundy resource inventory and directly from staff affiliated with HMSC.

**REFERENCES:**


Common Sand Dollar (*Echinarachnius parma*) Profile

Temperature: 0 - 25°C.

Salinity: Inhabits seawater salinities at all life stages; not in brackish water.

Depth: 1 - 1,600m.

Substrate: Prefers small grain-size sandy bottoms.

Food/Feeding: A deposit feeder gathering fine particles of organic matter.

Predators: Flounder, cod, haddock and other bottom-feeding fishes.

Reproduction: Spawns larvae in spring.

Habitat: Top 5cm of sandy substrate.

Growth: Larval period lasts several weeks.

Remarks: Abundant in restricted areas within study area.
MOLLUSCS
Giant, or Sea Scallop - *Placopecten magellanicus*

**GENERAL CONSIDERATIONS:** The giant scallop is a highly regarded seafood that is fished seasonally in the Quoddy region.

**HABITAT CONSIDERATIONS:** Scallops are relatively sedentary in Quoddy waters, with minimal seasonal migration to deeper water in winter. They dwell together in beds at depths of 1 - 100 m. Growth is faster and scallops grow larger in shallower depths where more food is present. Scallops prefer substrate of clean gravel and rock. Rocky substrate provides some refuge from harvesting. A water temperature of less than 20°C and salinity of more than 22 ppt are major factors determining distribution. Spawning and best growth are from 10 - 15°C. For prey, scallops filter-feed on diatoms, protozoans, and detritus and its associated bacteria. Predators of scallops include starfish, crabs, lobsters, and boring sponges, polychaete, and bivalves. Reproduction spans August to early October and peaks in September. See References.

**MANAGEMENT CONCERNS:** Scallops are fished in the Quoddy region, both commercially by dragging and recreationally by diving. Because scallops are so highly sought, both types of fishing are carefully regulated by the Department of Fisheries and Oceans. In addition, there may be negative impact on scallop beds from activities such as salmon aquaculture and sea urchin and seaweed harvesting. Scallops are abundant only near the mouth of the Waweig River and in upper Oak Bay. However, they are common in most Quoddy waters with rocky or gravelly substrate.

**MAPPING OF HABITATS:** Data for mapping known scallop distribution and abundance in the Quoddy region were derived from the Bay of Fundy Resource Inventories of MacKay and Bosein (1979), MacKay *et al.* (1979a,b), and MacKay *et al.* (1978a,b,c), and from Lawton (1993). Mapping “inferred” scallop distribution in unsampled waters, i.e. suitable habitat, was done by identifying those habitats with suitable bottom type, temperature, and salinity.

**REFERENCES:**


Lawton, P. 1993. Salmon aquaculture and the traditional invertebrate fisheries of the Fundy Isles region: habitat mapping and impact definition. Report to the NB Dept. of Fisheries and Aquaculture, Cooperation Agreement on Fisheries and Aquaculture Development Contract No. 291.303. 84p.


### Scallop (*Placopecten magellanicus*) Profile

| **Temperature:** | < 20°C (major factor determining range)  
|                  | growth best from 10 - 15°C.  
|                  | Spawn 10 - 15°C with larval development 12 - 18°C. |
| **Salinity:**    | 26 - 30ppt preferred; 22ppt suboptimal  
|                  | larvae >10ppt. |
| **Depth:**       | Usually 10 - 100m; Gulf of Maine - up to 1m below Mean Low Water (MLW). |
| **Substrate:**   | Prefers clean gravel and rock. |
| **Prey:**        | Filter feeder  
|                  | diatoms, protozoans, detritus, associated bacteria. |
| **Predators:**   | Starfish, crabs, lobsters; boring sponges, polychaetes, bivalves. |
| **Reproduction:**| Spawn late August to early October, peak in September. |
| **Habitat:**     | Subtidal. |
| **Growth:**      | Faster (and larger) in shallower depths due to more food; rapid growth in Maine inshore waters. |
| **Remarks:**     | Rocky substrate refuge from harvesting; fishing causes mortality, injury, and consequent predation by fishes and crabs. |
Soft-Shell Clam - *Mya arenaria*

**GENERAL CONSIDERATIONS:** The soft-shell clam is a popular seafood inhabiting mainly intertidal mudflats in the Quoddy region.

**HABITAT CONSIDERATIONS:** Soft-shell clams, though mobile via the “foot”, are largely sedentary in Quoddy waters, burrowing mostly into intertidal mudflats but also into subtidal substrates. These clams inhabit estuaries, bays, and coves sheltered from waves, particularly gently sloping beaches of 200 - 400 m or more in breadth. Greatest abundance occurs in a band approximately 60 m wide at the half-tide level. Growth is best at the lowest tidal levels; growth rate declines in proportion to height above lowest tidal level. These clams prefer fine sand mixed with large quantities of black mud and organic matter. Acceptable substrates include mud, muddy sand, sand, and fine sand mixed with clay. Currents are necessary since clams are filter feeders, preying primarily on diatoms, also flagellates and a wide spectrum of microorganisms and debris of larger ones. Predators include starfish, oyster drills, whelks, crabs (green, rock, horseshoe), moon snails, fishes, and birds. Storm mortality also can be important. Soft-shell clams prefer temperatures of 6 - 14°C, though higher temperatures improve growth. Salinity must be greater than 5 ppt; clams do poorly in very brackish waters. Optimum salinity is 25 - 35 ppt. Soft-shell clams spawn chiefly in summer, though in Maine waters larvae may be found in all months of the year. Clams in Passamaquoddy Bay are characterized by low growth rates and small average size. Those in Cobscook Bay are distributed in a narrow strip along the shore. See References.

**MANAGEMENT CONCERNS:** Soft-shell clams are hand dug commercially and recreationally in the Quoddy region. Clam flats are highly impacted by human sewage pollution. Clams are monitored for bacteria levels regularly by the Department of Fisheries and Oceans so that they may be harvested when pollution levels are acceptable. However, flats in the Quoddy region generally are closed for most or all of the year, and little harvesting is currently done. Soft-shell clams are abundant in few areas, though they are common in most mud flats in the region.

**MAPPING OF HABITATS:** Data for mapping known soft-shell clam distribution and abundance in the Quoddy region were derived from the Bay of Fundy Resource Inventories of MacKay and Bosein (1979), MacKay *et al.* (1979a,b), and MacKay *et al.* (1978a,b,c), and from Spencer (1973). Mapping “inferred” soft-shell clam distribution in unsampled waters, i.e. suitable habitat, was done by identifying those habitats with suitable bottom type, temperature, and salinity.
REFERENCES:


Soft-Shell Clam (*Mya arenaria*) Profile

Temperature: Prefers 6 - 14°C; 21°C favours growth.

Salinity: Prefers 25 - 35ppt; requires minimum 5ppt will not thrive in very brackish salinities.

Depth: Largely intertidal, but also subtidal.

Substrate: Found in mud, muddy sand, and fine sand mixed with clay prefers mud flats of fine sand mixed with large quantities of black mud and organic matter.

Prey: Filter feeder - diatoms most important, also flagellates wide spectrum of microorganisms and debris of larger ones.

Predators: Starfish, oyster drill, whelks, crabs (green, rock, horseshoe), moon snails, fishes, birds; often damaged by storms.

Reproduction: Spawn in summer (larvae are found in all months in Maine waters).

Habitat: Coast sheltered from waves (estuaries, bays, coves) gently sloping beaches, especially 200 - 400+m; mud flats most abundant in a ca 60m band at half-tide level; currents required.

Growth: Larval period 2 weeks or less; larvae which settle/burrow at lowest tidal level grow the most. Growth rate declines in proportion to height above lowest tidal level.

Competitors: Blue mussels.

Remarks: Passamaquoddy Bay - low growth rates and small average size Cobscook Bay - populations are distributed in a narrow strip along the shore.
Blue Mussel - *Mytilus edulis*

**GENERAL CONSIDERATIONS:** Locally, blue mussels are the dominant occupier of space in the intertidal zones of rocky shores, where they are a source of food for a variety of animals. While harvest of wild populations is minimal, this species is a primary target of the aquaculture industry, with an annual production of about 5,000 tonnes on the East coast of Canada.

**HABITAT CONSIDERATIONS:** This edible mussel is attached by secreted threads to rocks, pilings or most other solid objects generally between high- and low-tide lines. It usually occurs in dense masses near the low water line, and in lower abundance in shallow subtidal waters. It is a primary source of food for shore birds and ducks and they are also consumed by gulls. Fishes, including flounder and eel pouts, also use them as a source of food. Major invertebrate predators include sea stars, the green sea urchin and different species of whelks (e.g. *Nucella lapillus* and *Buccinum undatum*).

**MANAGEMENT CONCERNS:** Mussels are very abundant in the study area, being an indicator of rocky intertidal habitat. As large-volume filter feeders they are environmental indicators of water quality, such as for Paralytic Shellfish Poisoning (PSP) and other pathogens. Rapid settling and growth rates make them fouling organisms of boats, wharfs, pilings, etc..

**MAPPING OF HABITATS:** Sources used include Mossop (1921) and the Bay of Fundy resource inventory.

**REFERENCES:**


Blue Mussel (*Mytilus edulis*) Profile

Temperature: 0 - 27°C, optimum 15 - 19°C.

Salinity: Inhabits seawater salinities at all life stages but juveniles and adults also occur in brackish waters of estuaries.

Depth: Usually from intertidal to 10 - 15m; most common between high- and low-tide lines.

Substrate: Prefers rocky substrate but also other solid objects such as pilings.

Prey: Phyto- and zooplankton and organic matter (via filter feeding).

Predators: Lobsters, crabs, birds (especially ducks & gulls), fishes, sea star, dog whelks.

Reproduction: Larvae occur spring, summer, and fall.

Habitat: Rocky habitat; sensitive to accumulations of sand.

Growth: Larval period lasts several weeks.

Remarks: In dense masses within study area; a commercial species that is also being cultured elsewhere.
Common Periwinkle - *Littorina littorea*

**GENERAL CONSIDERATIONS:** The periwinkle is a valuable commercial species of local importance. Within the lower Bay of Fundy and Gulf of Maine the species supports a minor fishery throughout the year. The majority of the harvest is sold to Europe and the Far East.

**HABITAT:** Periwinkles are an intertidal species which prefer rocky and boulder-based coastal areas. Rockweed (*Ascophyllum*) and periwinkles are often found in close association. Eggs are spindle-shaped and are laid (attached to substrate by adhesive stalks) in bunches throughout the year. Periwinkle are substrate grazers feeding predominately on algal film. They are in turn preyed upon by sea birds and ducks, predatory gastropods and some larger fishes.

**MANAGEMENT CONCERNS:** Periwinkles are presently harvested by hand-picking from the substrate. Effort is high in selected areas and over-harvesting is a concern. Growth rate is relatively slow for an animal which is this easily accessed and harvested. Since the fishery is relatively recent there is little historical information on impacts of the fishery on population size and structure.

**HABITAT MAPPING:** Periwinkles occur in abundance in all of the intertidal areas within the study area. Distributed records were derived from the Passamaquoddy Bay, Bay of Fundy Resource Inventory (Marine Research Associate).

**REFERENCES:**


Common Periwinkle (*Littorina littorea*) Profile

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<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature:</strong></td>
<td>0 - 14°C (can be killed by long exposure to freezing conditions).</td>
</tr>
<tr>
<td><strong>Salinity:</strong></td>
<td>Frequently found in estuarine areas with salinity values as low as 5 - 10ppt; prefers 20 - 32ppt.</td>
</tr>
<tr>
<td><strong>Depth:</strong></td>
<td>Intertidal; frequently exposed during periods of low tide. Rarely found below 5m depth in any area of the lower Bay of Fundy.</td>
</tr>
<tr>
<td><strong>Substrate:</strong></td>
<td>Rocky shores, ledge areas, boulder and gravel areas preferred; Infrequently found on mud-clay bottoms.</td>
</tr>
<tr>
<td><strong>Prey:</strong></td>
<td>Plant and algal grazers on substrate surfaces.</td>
</tr>
<tr>
<td><strong>Predators:</strong></td>
<td>Sea stars, predatory gastropods, and sea ducks.</td>
</tr>
<tr>
<td><strong>Reproduction:</strong></td>
<td>Adhesive egg capsules are attached to the substrate in groups of 10 - 50; spawning occurs in all seasons, but is infrequent in winter and during periods of cold water temperatures.</td>
</tr>
<tr>
<td><strong>Growth:</strong></td>
<td>Temperature-related; most rapid in warmer summer.</td>
</tr>
<tr>
<td><strong>Remarks:</strong></td>
<td>A substantial fishery for this species exists throughout the lower Bay of Fundy; the fishery is of recent origin and the harvest increases annually.</td>
</tr>
</tbody>
</table>
ARTHROPODS
Pink Shrimp - *Pandalus borealis*

**GENERAL CONSIDERATIONS:** The shrimp supports valuable commercial fisheries within its wide North Atlantic range. Within the study area it is not an abundant species as compared to other parts of its range (such as the Gulf of St. Lawrence). It constitutes a valuable part of the marine ecosystem where it serves as prey of several species of commercially important fishes.

**HABITAT:** Pelagic over oceanic depths, *Pandalus borealis* is a highly mobile and migratory species, usually found in schools at variable depths. Schools of shrimp are usually composed of similar sized individuals. *Pandalus borealis* is an opportunistic predator feeding on smaller planktonic crustaceans and occasionally on benthic invertebrates. It is, in turn, preyed upon by sea birds, marine mammals (cetaceans) and many species of commercially valuable marine fish.

**MANAGEMENT CONSIDERATIONS:** Within the study area, *Pandalus* is of only minor, local importance. The existing fishery is non-organized and levels of effort and catch data is unreliable. The catch is composed predominately of adults and the majority of shrimp are landed in late summer and early fall. Some small catches are reported during the winter months in offshore areas just outside the study area.

**MAPPING OF HABITATS:** Distributions were derived from conversations with local scientists and fishermen in the area and from the Bay of Fundy Resource Inventory (Marine Research Associates).

**REFERENCES:**


Pink Shrimp (*Pandalus borealis*) Profile

**Temperature:** 1 - 14°C (can grow and reproduce within this temperature range wherever they occur) majority of spawning at 3 - 5°C.

**Salinity:** Above 25ppt.

**Depth:** Pelagic over inshore and offshore areas (*P. borealis* is frequently epibenthic in inshore areas).

**Substrate:** Pelagic over all types.

**Prey:** Predatory on small crustaceans and fishes.

**Predators:** Larger fishes and sea birds.

**Reproduction:** Can occur during any season given adequate water temperatures; in the lower Bay of Fundy spawning takes place generally in late spring and early summer.

**Habitat:** Pelagic, mid-depth to surface.

**Growth:** Temperature dependent; shallow inshore habitats with high water temperatures produce fast-growing populations.

**Remarks:** A small annual directed fishery for "shrimp" (this species and *P. montagui*) is reported in the lower Bay of Fundy; landings are not reported.
Copepod - *Calanus finmarchicus*

**GENERAL CONSIDERATIONS:** *Calanus* is a planktonic copepod and a dominant member of the pelagic plankton community. It forms the basis of the majority of food-chains within the marine system. It is likely one of the most abundant animals in the ocean environment.

**HABITAT:** Pelagic over oceanic depths, *Calanus* predominates in the upper 3m of surface ocean waters. Diurnal migrations by *Calanus* are reported and all life-history stages are positively phototaxic. *Calanus* is a true open-ocean species and is seldom found in near-shore coastal areas. *Calanus* is a planktonic herbivore. It is preyed upon by almost every larger predatory organism in its habitat.

**MANAGEMENT CONCERNS:** *Calanus finmarchicus* is not the subject of any commercial fishery and has no individual economic value. However, because it is the basis of marine food webs, it is extremely important as a food item of other predators which are of commercial importance.

**MAPPING OF HABITATS:** Distribution was determined from habitat preference and from local records collected by the Dept of Fisheries and Oceans and the Atlantic Reference Centre. Basically the entire study area (with the exception of intertidal and in-shore areas) has the potential for transient habitation by *C. finmarchicus*.

**REFERENCES:**


### Copepod (*Calanus finmarchicus*) Profile

<table>
<thead>
<tr>
<th><strong>Temperature:</strong></th>
<th>0 - 20°C (no preferred temperature recorded, spawning generally occurs above 8°C).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salinity:</strong></td>
<td>Ambient salinity in area of occurrence; essentially a marine species not tolerant of salinities below 25ppt.</td>
</tr>
<tr>
<td><strong>Depth:</strong></td>
<td>Pelagic; in mid-depth and surface waters.</td>
</tr>
<tr>
<td><strong>Substrate:</strong></td>
<td>Not applicable, occurs over all substrates.</td>
</tr>
<tr>
<td><strong>Prey:</strong></td>
<td>Planktonic predator on small invertebrates and diatoms.</td>
</tr>
<tr>
<td><strong>Predators:</strong></td>
<td>Larger fishes, whales, invertebrates, and sea birds.</td>
</tr>
<tr>
<td><strong>Reproduction:</strong></td>
<td>Planktonic, multiseriate eggs released from paired egg sacs (occurs in spring-summer in the lower Bay of Fundy).</td>
</tr>
<tr>
<td><strong>Habitat:</strong></td>
<td>Pelagic offshore marine waters.</td>
</tr>
<tr>
<td><strong>Growth:</strong></td>
<td>Temperature dependent; greatest at higher temperatures within its range and season.</td>
</tr>
<tr>
<td><strong>Remarks:</strong></td>
<td>Occurs rarely in inshore waters of the lower Bay of Fundy; a common copepod of plankton in offshore, oceanic habitats.</td>
</tr>
</tbody>
</table>
American Lobster - *Homarus americanus*

**GENERAL CONSIDERATIONS:** The American lobster is a long established commercial species that is regarded as a highly prized food item throughout the world. The value of Canadian landings in 1992 was US $228 million.

**HABITAT CONSIDERATIONS:** Locally, planktonic larvae hatch between July and September, after about a 9-12 month incubation period. The planktonic phase lasts 3-10 weeks, when settling to a benthic mode occurs. Juveniles and adults usually live on rocky bottoms, both in bays and open ocean from near shoreline to the continental shelf. Lobsters generally occupy shelters under rocks or hollowed out depressions in soft bottom. They are primarily sedentary and form discrete populations but may migrate to deeper waters in winter. Commercial quantities tend to be found at depths less than 35m in the study area.

Lobsters are opportunistic feeders consuming both living and dead animals. They feed on various invertebrates including bivalve (e.g. blue mussel) and gastropod (whelks and periwinkles) molluscs, various echinoderms, including brittle stars, sea stars and sea cucumbers, polychaete worms, other crustaceans (e.g. *Cancer* crabs), and fish carrion.

Lobsters are preyed upon by groundfish and occasionally seals.

**MANAGEMENT CONCERNS:** Lobsters take longer to reach harvestable size compared to commercial fish species, such as salmon. On average a lobster undergoes 15-20 molts, representing an age of about 6-9 years, before reaching commercial size. Habitat preservation and fishing pressures are principal concerns. The fishery represents a primary local industry, with major lobster grounds in the area. In the St. Croix estuary alone landings are about 100 tons ($800,000) annually. “Long term monitoring of lobster populations ... must be undertaken if we are to understand the regulatory mechanisms controlling these populations” (M. Fogarty in Factor 1995).

**MAPPING OF HABITATS:** The three principal sources for mapping the distribution of the benthic post-planktonic life-history stages of lobster were Lawton (1993), the Charlotte County - Passamaquoddy Coastal Resources Atlas, and the Bay of Fundy Resource Inventory. In addition, data were obtained from Dr. Peter Lawton and David Robicheau at the Department of Fisheries and Oceans, St. Andrews Biological Station.
REFERENCES:


American Lobster (*Homarus americanus*) Profile

**Temperature:** 0 - 20°C (major factor determining range), 5 - 20°C preferred; growth best from 10 - 15°C; spawn at 10 - 15°C with larval development 12 - 18°C.

**Salinity:** Inhabit seawater salinities at all life stages; 21 - 32ppt preferred; larvae and juveniles rare in estuaries.

**Depth:** Occurs subtidally from low water to depths in excess of 200m (to continental shelf). Passamaquoddy Bay - abundant subtidally 5 - 25m; off Grand Manan: 5 - 75m.

**Substrate:** On a variety of substrates, but preferably on rocky bottoms (also on clay in deep water)

**Prey:** Adults: sea urchins, rock crab, hermit crabs, gastropods, bivalves, polychaetes, brittle stars, sea stars, sea cucumbers, seaweeds (primarily kelp) and some fish. Larvae: wide variety of phyto- and zooplankton (mostly copepods).

**Predators:** Predatory groundfish, sharks, rays; plankton feeders consume larvae.

**Reproduction:** Spawning is biennial; larvae present throughout summer (May-September); hatching at about 12.5°C.

**Habitat:** Usually observed in burrows, crevices or shelters under rocks or holes in ledges but also in eel-grass beds, among large seaweeds and in excavated sandy bowl-shaped depressions.

**Growth:** Embryonic development 9 - 12 months; larval period lasts 6 - 8 weeks.

**Remarks:** Abundant in study area; a primary local commercial species.
ANGIOSPERM
INTRODUCTION
Mapping of intertidal wetlands is a challenging task. In the last few decades there have been at least four different attempts to map area of salt marshes in New Brunswick and Maine, three have been based upon aerial photography. The two major challenges in such a mapping exercise are to first identify habitat as salt marsh then to accurately locate inland/terrestrial and seaward boundaries. The rugged coastline and extreme tidal ranges of the region increase the difficulty of both tasks. Even for an experienced interpreter of aerial photographs it may be difficult to discern between macrophytic algal communities or grass-dominated marsh at the base of a cliff or bluff. Accurate delineation of the seaward boundary requires that all photos be obtained at low tide and this has not always been financially possible given the primary objective of many photographic contracts (e.g., forestry in New Brunswick). Delineation of the inland border is difficult if salt marsh is part of a contiguous estuarine marsh which gradually decreases in salinity, or if the terrestrial border is lawn or pasture. Although delineation of the terrestrial boundary is simplified if the marsh is bordered by a habitat of distinctly different physiography these situations may also present problems, for example the terrestrial marsh edge may be masked by forest canopy. Mapping errors can be reduced by field reconnaissance, but the costs of field visits to check designated map units is high and funding for this effort seems not to have been given enough priority to avoid some critical errors.

Most mapping programs noted low and high marsh habitat. Within New Brunswick and regions south we can be certain that Spartina alterniflora (salt marsh cordgrass) is the only dominant flowering macrophyte of low marshes. Spartina patens (salt hay, or salt meadow hay) which has a distribution generally restricted to the high marsh, is often a dominant, but never exclusively so. In fact, along the Fundy coast of New Brunswick it may be absent in habitats designated as high marsh, particularly small, back barrier marshes. (The model used for this habitat is usually that described for the southern New England region of the US; Nixon 1982). Unless field visits are timed to coincide with blooming of S. patens (late July to August) this fine-stemmed grass may be confused with Juncus gerardi, J. balticus, Festuca rubra, and a number of other species.

Some would assume that a local herbarium collection would provide verification of the presence of S. patens, but the objectives of collectors are most often to study variation in morphology or establish the range of species. Neither requires that taxonomists visit every
habitat. For example, the herbarium of the University of New Brunswick at Fredericton (the base of H. Hinds who produced a flora of New Brunswick) holds only three specimens of *S. patens* collected from the province. Notes on one of these specimens is illuminating. Hinds collected *S. patens* in Katy’s Cove, a well-known marsh often visited by Huntsman Marine Science Centre classes, and noted on the specimen sheet, "One plant in a clump about 0.5m high, very robust in edge of high water zone". In southern New England, and even southern Maine this species would be consistently present as an extensive turf, but its abundance is considerably reduced in marshes from New Brunswick north. It may not be present in every marsh noted as salt marsh. I, however, do assume that its presence increases with size of the marsh. Nearly all the high salt marsh habitat mapped to date should be considered "potential" habitat until verified by field visits. I can personally confirm the presence of *S. patens* at Bocabec marsh, the NW shore of Pendelton Island, and in St. Andrews's (west of the blockhouse, but too small to be mappable at this scale). I would consider both Katy’s Cove and Upper Duck Pond as verified by Hinds and Thomas (1983), respectively.

I could locate only one other paper (in addition to my own) on salt marshes in the target region of New Brunswick, that published by Thomas (1983) for a volume on Passamaquoddy Bay. Thomas' chapter includes a map in figure 1, "showing location and extent of present salt marshes". Both map and figure caption are seriously misleading. As the scale of the map (which is mislabeled on the figure) is on the order of 1:1,500,000 (1 to 1.5 million) it would be impossible to delineate individual marshes, and Thomas apparently attempted to note only locations of those mentioned in his manuscript and regions in the Bay of Fundy where salt marshes are more common. There has been more study along the coast of Maine, but none have focussed on Cobscook Bay. The research conducted in Maine is cited in table 1.

To determine locations of *Spartina patens* habitat I have utilized the map sources described below. Although I have recognized some irregularities and errors I could not attempt to check all designations or more importantly, omissions; this would have required an extensive period of time (weeks to months) to examine aerial photos and make field visits. (Plus, there is a new mapping effort underway in New Brunswick, see below.) I have made only minor deletions and additions; most notably the addition of marshes along Bocabec River. The map sources and NOAA bathymetric maps treat shoreline differently thus it was impossible to accurately delineate seaward or terrestrial marsh boundaries on the NOAA maps, an attempt to do so would compound existing errors. {For this reason I have forwarded my personal copies of maps from the New Brunswick/Canadian Wildlife Service Wetlands Atlas and will have my personal copies of the Maine series sent from McGill.} Salt marsh habitats have been coloured on the source maps. On the Atlas series I included sites shown in other mapping programs, but missing in this Atlas. The location of all marshes is indicated in red on the NOAA maps, but I could find no reasonable way to accurately indicate marsh boundaries. It would be more advisable to digitize the original sources, or obtain digital files from the St. Croix Estuary program, and the Bigelow Lab or Maine Geological Survey.
MAP SOURCES FOR PASSAMAQUODDY BAY

Wetlands Atlas - Wetland Protection Mapping Program
Contact Al Hanson for computerized data on file at Canadian Wildlife Service, Environmental Conservation Branch; P.O. Box 1590; Sackville, NB E0A 3C0 (phone 506-364-5044; fax 506-2).

A set of maps, accompanying text and production of hard copies are available at New Brunswick Department of Natural Resources and Energy, Fredericton. Ms. Lorrie Roberts, DNRE, Division of Fish and Wildlife, who is familiar with this data base, is about to begin revisions of marsh maps utilizing interpretation of recent colour aerial photographs. I am told that there are plans to make a digital data base from the aerial photo base.

Data are presented on a 1:50,000 scale using base maps of the National Topographic Series maps, available in spatially coded and sortable list form stored in electronic format. (A hard copy of the list of marshes in the target region is attached). Locations of marshes are also recorded in electronic format, but this is limited to point locations, as opposed to marsh boundaries.

Salt marsh areas were determined by interpretation of 1:10,000 (and some 1:15,840) colour air photos, but the date of photography is not specified on the text accompanying the maps. The smallest size unit mapped is not clear, from the introduction of the accompanying map text one would assume that the smallest mapped unit is 0.25 ha.

In this series the proportion of low to high salt marsh is designated as one of six categories, each representing a 20% change in relative area of low and high marsh; from 0 (0% low marsh, 100% high marsh) to 5 (100% low marsh, 0% high marsh). The text accompanying the map series defines high marsh as "that portion of the salt marsh above Mean High Water which is flooded only infrequently by the highest tides. The dominant vegetation is Spartina patens and Puccinellia americana. Other species that may be present are Juncus gerardii, Scirpus maritimus (paludosus), Glaux maritima, Atriplex patula, Carex paleacea, Solidage sempervirens, Distichlis spicata, Triglochin elata, Scirpus paludosus, Limonium nashii, Plantago juncoideae. High marsh is further categorized with respect to the number of ponds per hectare.

The area of each salt marsh map unit is meant to be designated below the classification, but this information is missing at a number of sites. There are also some map units with no label, which are likely salt marsh. For instance, there are boundaries delineating the area around Sam Orr Pond, but there is no label for this unit. This area is designated as tidal marsh in the Fundy Coastal Zone Study Atlas.

Based upon this source, the minimum area of high salt marsh is 28.56 ha. Five maps from this series were used to compile data:
NB 160 St. Stephen and Vicinity (marsh designated, no area noted)
NB 161 St. Andrews and Vicinity (2.76 ha high marsh)
NB 162 St. George - Pennfield - Utopia (1.92 ha high marsh)
NB 166 Campobello and Deer Island (7.48 ha high marsh)
NB 167 Grand Manan Island (16.4 ha high marsh)

Charlotte County - Passamaquoddy Bay Coastal Resources Mapping Project
available from St. Croix Estuary Project, contact Robert Rainer, 165.5 Water Street; St. Andrews; New Brunswick phone (506)529-4868. A copy is also at the DFO Biological Station Library, St. Andrews.

Outside of the legends there is no text to accompany these maps and charts, which display the location of greater that 37 habitats and coastal uses. Critical details on the source information was made available by contacting the past project manager, Mr. Terry Kennedy (Strait North Solutions, 6729 Tyndal Road: Northort, NS B0L 1E0; phone (902)661-4105). Salt marsh areas are designated on maps at 1:10,000 with digital topographic maps as the base. Salt marsh mapping was conducted by re-evaluating the Fundy Coastal Zone maps, making deletions and additions through extensive field surveys guided by local ecological knowledge, and concentrated in the Canadian portion of the study area. Salt marshes are noted on 14 of the 56 maps (nos. 4, 10, 12, 13, 14, 16, 17, 20, 33, 36, 39, 46, 56). A set of charts based upon bathymetric charts, and including parts of the adjacent Maine coast are also included in this series, but this component does not denote salt marsh habitat. Habitat data is also available in digital format, presently in Map Info format, at the St. Croix Estuary Project. In its digital form salt marshes areas are shown as open polygons, thus complete marsh areas cannot be determined by this single file. It is assumed that combining the salt marsh habitat "lines" with the digital topographic map base will provide complete boundaries. Thus, the computerized spatial data, as presently available, cannot be used to display the salt marsh habitats mapped, nor to calculate the area of marsh. Further information on the creation of the digital data set may be available from DFO who arranged the digitizing contract; project coordinator for DFO was Denise McCollough (office phone (902)426-4274; home (902)455-7356).

Fundy coastal Zone Study Map Atlas (vol 3)

Description of mapping program is provided in accompanying Technical Report, Coastal Zone Management Study, Bay of Fundy, vol 1. Salt marsh areas were mapped through interpretation and analysis of recent (1976/77) and selected historical (1935, 45, 53, 62, 71) aerial photographs. Salt marshes are designated on three of the four map layers: vegetation (class Ct), surficial geology (class Tm), and land-use (denoted by the marsh symbol). Designation of salt marsh on these three layers is not consistent, the surficial geology layer appears to be more conclusive. On page 155 of the technical report, under the category of terrestrial vegetation, tidal marshes are described as "small and scattered along the coast, except along the shores of Chignecto Bay. Many of these have been dyked, drained and cultivated, but under disturbed situations, there are natural zones with the cord grasses, sedges and a number of marsh halophytes common." The citation for this description is Acadia: the geography of early Nova Scotia to 1760, written by A.H. Clark in 1968, published by the University of Wisconsin Press.
On page 55 of the technical report salt marshes are described as "low areas at the high water mark, often surrounding a brackish pond, estuary, bay or inlet. They are distinguished by profuse growths of salt-tolerant grasses, herbs and bushes. Marshes are generally spotty in occurrence and of limited extent in the Outer Bay".

MAP SOURCES FOR COBSCOOK BAY

Coastal Marine Geologic Environments available from Maine Geological Survey
Department of Conservation
State House Station #22
Augusta, ME 04333-0022
phone (207)287-2801
http://www.state.me.us/doc/nrimc/nrimc.htm

Data is presented on a scale of 1:24,000, based upon interpretation of black and white aerial photographs at a scale of 1:20,000. Less than 2% of shoreline was field-checked for this exercise. Four sub-environments are designated within intertidal marshes: high salt marsh, low salt marsh, marsh levee, and salt pannes and salt ponds. The map legend defines high salt marsh as "organic-rich sediments densely vegetated primarily with the salt marsh grass Spartina patens (salt-meadow grass)" and are considered to be at the same level as mean high water.

Five maps from this series (all date 1976), all Maine quadrangels, were used to compile data:
Pembroke, Open-File No. 76-118
Eastport, Open-File No. 76-88
Lubec, Open-File No. 76-104
Whiting, Open-File No. 76-141
West Lubec, Open-File No. 76-139

Cobscook Bay Marine Ecosystem Research Project
Principal coordinator, Barbara Vickery; The Nature Conservancy; Fort Andross, Suite 401; Brunswick, ME 04011 (I personally spoke to Jim Dow, Downeast Field Rep. at P.O. Box 974; Blue Hill, ME 04614; jimdow@acadia.net.)

A primary objective of this project is to examine productivity and carbon flow within Cobscook Bay ecosystems. The original intention of this project was to relate productivity estimates to areas of coastal environments mapped from recent 1:12,000 scale colour aerial photographs. (Seth Barker, the GIS specialist of the Maine Department of Marine Resources has the collection of photographs, which he is presently using to map location of eelgrass beds in coastal Maine). Staff at the Bigelow Lab digitized the colour photographs and mapped habitats using an "unsupervised" classification (contact Peter Larsen, phone 207-633-9600). Field reconnaissance was performed by Gail Whippelhauser of the Maine Department of Marine Resources. The size of the electronic files created were prohibitively
extensive and this approach was given up. For the purposes of the project data on salt marsh locations and areas has been retrieved from the Coastal Marine Geologic Environments Maps (often referred to as the Timson maps) described above. It is not certain how complete their digitized file is.

**HABITAT PROFILE FOR SPARTINA PATENS (SALT MEADOW HAY)**

Value and Loss of *Spartina patens* habitat

There has been extensive loss of high salt marsh in the Gulf of Maine/Fundy area during historical times. In the Bay of Fundy most of the marsh area lost was due to diking of high marsh. The small bit of high marsh remaining is now endangered by deposition of fill for purposes of residential expansion and road development or trash (large appliance, demolition material). Such activities are common along the New Brunswick coast. In contrast low marsh, characterized predominantly by *Spartina alterniflora*, is less endangered and has remained along the seaward sides of dikes and in narrow fringes along coastal bluffs and minor embayments. In the US the research focus has been on the low marsh species, *S. alterniflora*, but here as well the greatest habitat loss probably has been in terms of *S. patens* habitat. When comparing changes in salt marshes of Long Island, New York over the period of 1938-1971, O'Connor and Terry (1972) noted that human destruction had caused loss of proportionately more high marsh than low marsh area.

Tidal salt marshes are regionally significant for a number of reasons. First, they are important to humans for they serve as a buffer to coastal storms and erosion, and are self-maintaining as they increase in thickness and elevation (towards upland areas) in response to sea level rise. We can assume that at the present time this is equal to or slightly greater than 1mm/yr in the region, based upon studies in Maine (Wood et al. 1989) and New Brunswick (Helmer and Chmura 1995). The high marsh also serves as a buffer between coastal forest and sea.

Salt marshes play a critical physical role as their substrates define and protect creeks and embayments important to avifauna, finfish, and invertebrates. Both these waters and the marsh interior are used by a number of waterfowl species. Reed and Moisan (1971) have noted the importance of *Spartina* salt marshes of the St. Lawrence estuary to breeding populations of black ducks, common eiders, gulls and herons, as well as migrating waterfowl, particularly geese. Van Zoost (1970) observed that seeds of salt marsh plants were a major fall food of black ducks, green-winged teal and blue-winged teal in the upper Bay, at Amherst Point, Nova Scotia. During field trips to marshes on Point Lepreau, just northwest of the Passamaquoddy Bay area, I have observed use of the high marsh by deer and rabbit.

**Distribution of *S. patens***

Distribution of *S. patens* is controlled on two spatial scales. The larger scale is the set of physical properties which make possible the existence of its general habitat, the salt marsh (Table 1). It is common knowledge that salt marshes occur only on sheltered coastlines and
in brackish to saline waters. With increasing latitude in the Gulf of Maine salt marshes become progressively less abundant, and the proportion of *S. patens* decreases (Jacobson et al. 1987). In the Cobscook Bay area this decrease is attributed to reduced sediment supply (Jacobson et al. 1987).

There appears to have been little attempt to parameterize the conditions which control salt marsh distribution along coastlines. This is probably because even on the most exposed coastal reaches there may be geological barriers (e.g., spits, barrier beaches) or tidal streams which could provide the required shelter. The only attempt which I have been able to locate, fortuitously, was for the coast of Maine. Kelley (1987) conducted a detailed examination of the variation in physiographic parameters and geological environments, including salt marshes. The relevant parameters examined by Kelley were relief, slope, and exposure, but only an average was reported for exposure and boundary conditions were not recorded (Kelley, personal communication). These parameters were examined in four different regions of the Maine coast, and limitations of each parameter appear to vary from southwest to northeast. For purposes of the regional profile I have used Kelley's results for the northeast compartment.

On a smaller spatial scale are the set of properties which limit the distribution of *S. patens* within a salt marsh (Table 2). On this scale many of the critical parameters, such as substrate salinity and redox potential, vary over a distance of metres to centimetres. These latter parameters relate to physiological limitations of the species and dynamic relations of the species present (i.e., competition and facilitation). There has been some research on physiological limitations of *S. alterniflora*, but little on *S. patens* and the research on *S. alterniflora* cannot be applied to *S. patens*. The most applicable published research can be found in the field studies of salt marsh plant dynamics by Bertness and his colleagues at Rumstick Cove, Rhode Island (e.g., Bertness and Ellison 1987; Bertness 1992). The detail of their investigations and proximity of the Rhode Island site to the Gulf of Maine make their study an obvious choice for development of the habitat profile. In applying the work of Bertness one must be aware of the species replacements with increasing latitude. Such replacements along the Gulf of Maine coast may be *Plantago maritima* for *Distichlis spicata* (Chmura et al. in press) and *Juncus balticus* for *Juncus gerardi* (Jacobson and Jacobson 1987), as well as addition of other elements in the high marsh flora such as *Puccinellia maritima* (Ganong 1903; Jacobson and Jacobson 1987).

**NOTE:** The detailed information provided by Dr. Chmura related only to **spot locations** of salt marshes and not to the actual areas they occupy. Accordingly, the relative area shown in Table 2 has but little meaning *per se*. However, it is not likely to be so different (if the actual areas were calculated from finer scale maps) that the final product (Table 2) would be significantly different. **For the stated objectives of this study,** the confirmed information used is considered to be sufficiently accurate. For any ecologica studies of particular or specific areas, workers should refer to Dr. Chmura's text above for appropriate references.

M.D.B. Burt
REFERENCES


Helmer, L.L. and Chmura, G.L. 1995. Two hundred years at Dipper Harbour, New Brunswick: a paleoenvironmental study of salt marsh dynamics. CANQUA-CGRG Joint Meeting, St. John’s, NF.


Table 1. Large scale parameters which limit *Spartina patens* habitat along a coastal reach

<table>
<thead>
<tr>
<th>Parameter</th>
<th>definition/qualification</th>
<th>limits</th>
<th>explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure</td>
<td>the number of degrees surrounding the mean high-water mark with more than 0.8 km of unrestricted fetch</td>
<td>~20°</td>
<td>0°</td>
</tr>
<tr>
<td>Relief</td>
<td>difference in elevation across the coastline</td>
<td>24.4 m</td>
<td>0</td>
</tr>
<tr>
<td>Slope</td>
<td>relief divided by width of intertidal zone</td>
<td>7%</td>
<td>0</td>
</tr>
<tr>
<td>Salinity</td>
<td>of surface water / tidal flood waters</td>
<td>34 ppt</td>
<td>variable</td>
</tr>
<tr>
<td>Elevation</td>
<td>with respect to Canadian Hydrographic Service chart datum</td>
<td>variable</td>
<td>6.1 m - point reached by ~95% of flood tides</td>
</tr>
</tbody>
</table>
Table 2. Small scale parameters which limit *Spartina patens* distribution within the high marsh habitat

<table>
<thead>
<tr>
<th>Parameter</th>
<th>definition/qualification</th>
<th>limits</th>
<th>explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>max</td>
<td>min</td>
</tr>
<tr>
<td>Redox potential of soil</td>
<td>2 cm depth</td>
<td>none</td>
<td>18±13 mv</td>
</tr>
<tr>
<td></td>
<td>10 cm depth</td>
<td>none</td>
<td>27±23 mv</td>
</tr>
<tr>
<td>Interstitial soil salinity</td>
<td>2 cm depth</td>
<td>17.0±0.7 ppt</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10 cm depth</td>
<td>19.0±0.4 ppt</td>
<td>0</td>
</tr>
<tr>
<td>Disturbance</td>
<td>covering by wrack for more than a few weeks</td>
<td>~3 weeks</td>
<td>0</td>
</tr>
</tbody>
</table>
Rockweed - *Ascophyllum nodosum*

GENERAL CONSIDERATIONS: *Ascophyllum nodosum* is a dominant intertidal alga on the North Atlantic shores of Europe, North America, and adjoining areas, where it occurs in both open, coastal and sheltered estuarine habitats (Baardseth, 1970; Keser *et al.*, 1981; Topinka *et al.*, 1981). It is ubiquitous in the intertidal zone in the western North Atlantic between 40° and 65° N latitude and in the eastern North Atlantic between 42° and 72° N latitude (Sharp, 1981). Commonly known as knotted wrack, it is one of the most abundant intertidal algae found in the Quoddy Region (Vadas *et al.*, 1976, Keser *et al.*, 1981, Topinka *et al.*, 1981, Vadas & Wright, 1986) where it dominates the mid to lower littoral zone in most estuaries and bays (Vadas & Ring, 1968; Vadas *et al.*, 1976). Growth in the Gulf of Maine and Bay of Fundy is impressive and rivals some of the most productive intertidal systems in the world (Mathieson *et al.*, 1991). In many areas *A. nodosum* is so abundant that it completely covers the exposed rocks at low tide and forms a monoculture (*sensu* Paine, 1984).

The ecological conditions under which *A. nodosum* thrives vary markedly. It occurs in regions with considerable winter ice cover (Kjellman, 1983) to regions with summer temperatures of 22° to 23°C (Sethell, 1920; Schmidt, 1931; Soneira and Niell, 1975). Similarly, salinity values over the range of its occurrence vary considerably due to location and climatic or seasonal changes, e.g. spring run-off. Values range from 35 ppt in oceanic areas to greatly reduced on variable salinities (0 to 17.3 ppt) in some estuaries (Doty & Newhouse, 1954; Baardseth, 1970). *A. nodosum* is not as tolerant to wave exposure, however, as it is to the above factors. *Ascophyllum* has a marked horizontal distribution being absent or greatly reduced on wave-exposed ledges but forming impressive standing stocks (10-20 kg m⁻² wet wt) on moderately exposed and sheltered shores (Vadas & Elner, 1992). On exposed shores *Ascophyllum* appears stunted and does not attain the size nor density common in estuaries and sheltered locations (MacFarlane, 1952; Vadas & Ring, 1968; Vadas & Wright, 1986). Within a single site, exposure to wave action may result in great variations in growth, morphology and pigmentation over very short distances (Cousens, 1982). Also, attachment strength is dependent on the degree of wave exposure (McEachreon & Thomas, 1987). In addition, wave action is a significant source of mortality to recently settled zygotes (Vadas *et al.*, 1990). Water movement is the primary factor controlling recruitment and distributional patterns of *A. nodosum* and, as such, successful recruitment is highly episodic on all but the most sheltered shores (Vadas *et al.*, 1990).

*Ascophyllum nodosum* has an annual growth cycle which appears to be a general phenomenon throughout its range (Nova Scotia - MacFarlane, 1932; Great Britain - Blackler, 1955; Norway - Printz, 1959a; Maine - Vadas, 1972, Vadas *et al.*, 1976). Although new seasonal growth is actually initiated in mid-October (David, 1943), it is not apparent until March when it becomes evident as an inflation (vesicle or bladder) of the apical tip. Thereafter the growing tip elongates rapidly during late spring and summer, slows down during the fall, and virtually ceases during winter. A new vesicle is produced the following March and can be used to age the shoot but not necessarily the plant (David, 1943).
Reproductive structures are produced in receptacles that develop laterally along the axis. They are initiated in spring or early summer and reach maturity the following spring (MacFarlane, 1932; David, 1943; Printz, 1956). New apical shoots do not develop receptacles until their second year. Older portions of thalli also have fewer receptacles; the net result being a concentration of receptacles in the mid region of the thallus (David, 1943). Following gamete release (April - May) the receptacles exfoliate and decay in sheltered coves, thereby enriching these areas in nitrogen and other nutrients (David, 1943; Josselyn & Mathieson, 1978).

HABITAT CONSIDERATIONS: In marine systems, seagrasses, saltmarsh grasses, kelps, and seaweeds that extend into the water column have a profound influence on coexisting animals; they provide physical structure to an otherwise structurally monotonous environment (Irlandi & Peterson, 1991). Macroalgae add considerably to the structural complexity of the rocky substratum, serving as an extension of the substratum up into the water column (Bodkin, 1988). The emergent structure acts to provide new habitat for epibiota, physical orientation for fish assemblages, alters the behaviour and access of predators, increases shelter, or refugia, and grossly changes fluid dynamics near the seafloor (Neushul, 1972; Bodkin, 1988; Irlandi & Peterson, 1991). Macroalgal canopies reduce water flow, increase sedimentation, reduce light intensities and reduce microalgal cover (Jackson & Winant, 1983; Duggins et al., 1990; Eckman & Duggins, 1991). The effect of these macroalgal characteristics on the associated assemblage of species within the habitat vary considerably based on the complex interactions of these variables.

*Ascophyllum* is unique in that its structure provides not only additional substrate for colonization but also creates habitat for species in the water column. Its profuse growth, large size (5-15 dm), developmental pattern, and perennial nature create a predictable and highly branched forest for phytal assemblages (e.g. Amphipods, Harpacticoids and other invertebrates) during high tide and a moist shelter and habitat for sessile and mobile invertebrates during low tide (Mathieson et al., 1976; Hillson, 1977; Menge, 1978). Larval fish, such as juvenile pollock, also recruit into these beds (Rangeley & Kramer, 1995a,b). At a site in Scotland it was found that species diversity and the abundance of individuals settling on the substrate was greater under an *Ascophyllum* canopy than outside it (Hruby & Norton, 1979). This was attributed to the higher humidity found under the *Ascophyllum* when the tide was out. One might also consider that organisms living under a canopy of *Ascophyllum* would be sheltered from the full force of turbulent water movement induced by wave action, while those outside the canopy would be exposed to it. Those under the canopy would also be protected from predation, intense light and desiccation.

MANAGEMENT CONCERNS: The existence of concentrated *Ascophyllum* stands with their unique colloidal and chemical properties has encouraged harvesting in many countries where it is used for alginates, organic fertilizers and fodder (Baardseth, 1970). The largest quantities of industrially harvestable *Ascophyllum* are found in Western Norway, the British Isles, Northern France, Iceland and Eastern Canada (Baardseth, 1970). The great width of the rocky intertidal zone in the Quoddy Region combined with a high tidal range and partial shelter from the full force of Atlantic storms all result in favourable conditions for the
growth of *Ascophyllum* (MacFarlane, 1952). Biomass values in the Gulf of Maine (Keser *et al.*, 1981) are as high as the most productive Canadian and European shores (Cousens, 1984; Sharp 1987) where the alga is commercially exploited. Although *Ascophyllum* is abundant along the coast of Maine, harvesting remains limited and is predominantly done on a small scale in the western region of the State.

Long-term industrial utilization of fucoids, such as *A. nodosum*, is absolutely dependent on valid information concerning growth and ecology. A few studies have shown that harvesting can be conducted over a number of years or decades, but that sustainability depends on the intensity of harvests (Sharp, 1987; Sharp & Pringle, 1990). Studies in Canada, Maine and Europe strongly indicate that *A. nodosum* is extremely susceptible to stress from uncontrolled harvesting. Long-term effects of repeated harvests include reduced competitive ability with *Fucus vesiculosus* (MacFarlane, 1952), depressed vigor and reduced yields (Printz, 1959b). Continued stress from harvesting completely eliminated *A. nodosum* from several areas in France (devirville, 1953).

Another problem with harvesting this alga, commented on by several workers, is the inability of *A. nodosum* to recolonize overharvested and denuded shores (Boney, 1965; Keser *et al.*, 1981; Vadas & Wright, 1986; Vadas *et al.*, 1990). The lack of recolonization is due to reproductive failure. *Ascophyllum* reproduces prolifically and annually invests 40-50% of its biomass in reproductive structures (Josselyn & Mathieson, 1978; 1980; Aberg 1990). Despite the annual production of large numbers of gametes and zygotes (propagules) the natural rate of recruitment into adult populations appears to be very low at most sites throughout the North Atlantic. In addition, and relevant to the long-term lack of recolonization on European and North American shores (Printz, 1959b; Vadas & Wright, 1986), is the apparent inability of zygotes to attach readily to natural surfaces in the presence of water motion (Vadas *et al.*, 1990). Despite our increased knowledge on the ecology of fucoid algae, especially *A. nodosum*, we still can not predict when successful recruitment will occur. Successful recruitment on exposed and moderately exposed shores probably involves a rare combination of mechanisms or stochastic events.

The effects of the destruction of some Fucoid stands often lasts decades (Boney, 1965) and parallels the over exploitation of harvestable stocks in many commercial fisheries (Beverton, 1982). Seaweed resources are treated as common property (Pringle, 1985) and usually harvested with little resource management and regulation. With greater demands from an increasing population and more efficient methods of exploitation, the fate of many natural stocks may be in jeopardy. Pringle and Sharp (1990) outlined the major ingredients required for a successful seaweed industry. Among these was the need for biological research, both for greater understanding of the natural factors affecting the resource and for developing sustained management strategies.
REFERENCES


If *Ascophyllum nodosum* (rockweed or knotted wrack), then

<table>
<thead>
<tr>
<th>KEYWORD</th>
<th>FEATURE</th>
<th>WHY?</th>
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<tbody>
<tr>
<td>HYDROGRAPHY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vertical patterns</td>
<td>- common in intertidal region, forming patchy distributions with species of <em>Fucus</em> to nearly complete coverage (monocultures) throughout the intertidal zone.</td>
<td></td>
</tr>
<tr>
<td>horizontal patterns</td>
<td>- abundance patterns form a gradient of decreasing biomass within wave exposure, except where disturbance from ice regularly removes plants e.g., protected, low salinity sites. - growth rates greatest in areas of intermediate wave exposure (linked to nutrient availability).</td>
<td></td>
</tr>
<tr>
<td>PHYSICAL FACTORS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>waves and currents</td>
<td>- zygotes require low wave energy or protection for successful attachment and germination.</td>
<td></td>
</tr>
<tr>
<td>desiccation</td>
<td>- zygotes do not survive extended periods of drying.</td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>- integrity of holdfast system weakened under high temperatures.</td>
<td></td>
</tr>
<tr>
<td>salinity</td>
<td>- found in a wide range of salinities including estuaries.</td>
<td></td>
</tr>
<tr>
<td>substrate</td>
<td>- requires firm substrate such as rock and ledge. - not attached to vertical walls.</td>
<td></td>
</tr>
<tr>
<td>BIOLOGICAL FACTORS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>competition</td>
<td>- <em>Fucus vesiculosus</em> outcompetes <em>Ascophyllum</em> in the short-term immediately following a severe disturbance. - outcompetes or outlives <em>F. vesiculosus</em> in long term succession.</td>
<td></td>
</tr>
<tr>
<td>grazing</td>
<td>- effects zygote survival. - removes limited amounts of biomass from adults.</td>
<td></td>
</tr>
<tr>
<td>disturbance (whiplash)</td>
<td>- frond movement reduces survival of newly recruited zygotes.</td>
<td></td>
</tr>
<tr>
<td>HARVESTING/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXPLOITATION</td>
<td>- height of cut effects regrowth and survival. - overharvest (or severe physical disturbance) may require many years for full recovery of <em>Ascophyllum</em>.</td>
<td></td>
</tr>
<tr>
<td>MANAGEMENT/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REGULATIONS</td>
<td>- see regulations (Canadian Department of Fisheries and Oceans).</td>
<td></td>
</tr>
</tbody>
</table>
REFERENCES: *Palmaria* and *Laminaria*

Bell, H.P. 1927. Observations of the seasonal disappearance of certain algae in the tide pools near the biological station, St. Andrews, N.B. Transactions of the Nova Scotian Institute of Science 17: 1-5.


Laminaria longicuris (kelp)

NW Atlantic: Long Island Sound to high Arctic (41°N - 82°N)

Associations: subtidal fringe: Laminaria digitata; in subtidal: Chondrus crispus above and Agarum ciathrum below

Depth: extreme lower littoral and low tidepools, subtidal to 20 m depth (high Arctic), to 9 m depth (Charlotte Co., NB)

Substratum: epilithic; in exposed sites restricted to hard rock; in sheltered sites on gravel, small stones and shells; absent or at best rare on mud or sand

Salinity: absent when <20°/oo; maximum growth of sporophytes at 25-32°/oo

Temperature: sporophytes--optimum ca 10°C, growth at 0°C, ca 23°C lethal; gametophytes--cell damage >20°C

Light: ps saturation (sporophytes) 75-90 µmol m⁻² s⁻¹ (1°-5°C); compensation point: PFD ca 4-5 µmol m⁻² s⁻¹ (2°-5°C)

Productivity: 4.2-17 µg C cm⁻² d⁻¹; maximum: 2 mg C m⁻² d⁻¹ elongation: ca 2.6 m yr⁻¹, maximum length 15 m

Nutrients: maximum uptake of NO₃⁻: 7-15 µmol g⁻¹ (dw) h⁻¹ (15°C), reduced by 2/3 at 0°C; growth limited by NO₃⁻ < 20 µmol L⁻¹

Biomass: on average, 0.2-0.6 kg (fw) m⁻²; in lower Bay of Fundy, average = 0.7-4.9 kg m⁻²; bed 1.7 X 10³ ha contains 12 X 10³ t, yield estimate = 9X 10³ t (fw)

Density: 0.7-14.2 individuals m⁻², maximal at 5 m depth; inversely related to wave action

Herbivores /Predators: Stronglyocentrotus droebachiensis; Lacuna vincta;

Competitors: Phymatolithon, Chondrus, Ceramium, Phyllophora (for substrate)

Utilization: potential use for colloids, condiments and fertilizer

Management: Fisheries and Oceans Canada: permits required for harvest, issued on individual basis; advice on management strategy
**Palmaria palmata** (dulse)

| NW Atlantic: | New Jersey to high Arctic (40°-78°N); perennial |
| Associations: | dense bands; in low littoral: *Corallina, Mastocarpus, Chondrus*; in subtidal: *Laminaria, Chondrus* |
| Depth: | low littoral, including pools, to 20 m deep; in Fundy mainly lower intertidal and upper subtidal to 1-2 m depth below low tide level, considered a shallow species |
| Substratum: | epilithic, epiphytic (*Corallina, Mastocarpus*, stipes and holdfasts of *Alaria* and *Laminaria*) |
| Salinity: | prefers full oceanic salinity; in brackish areas only below halocline |
| Temperature: | growth mainly at 6-14°C; slow at 3°C; poor condition at 18°C; 20°C lethal |
| Light: | ps saturation 210 μmol m⁻² s⁻¹ (when grown at 10°C, saturated at 53 ly d⁻¹); compensation point: PFD 1.3-4.6 μmol m⁻² s⁻¹; growth maximum at 50 μmol m⁻² s⁻¹ |
| Productivity: | maximum relative growth rate 0.08 d⁻¹; maximum yield 18-28 g (dw) m⁻² d⁻¹; maximum length 50 cm |
| Nutrients: | NO₃⁻ and PO₄³⁻ stimulate growth; grows well at high concentration of NO₃⁻; NO₃⁻ supports higher growth rates than NH₄⁺; N content to 7.2% d.w. |
| Biomass: | maximum in low littoral; maximum reproduction in late summer to autumn |
| Density: | maximum ca 3.8 kg (fw) m⁻² (Grand Manan); stocking density of 10 kg m⁻³ yields maximum productivity in culture |
| Herbivores/Predators: | *Gammarus lawrencianus, Idotea baltica*; substrate for *Lacuna vincta* egg masses |
| Utilization: | commercial harvest: condiment, health food preparations, animal fodder |
| Management: | No regulations regarding harvest. Industry is small and harvesters pursue individual strategies for conservation. |
DISCUSSION

The objectives of this study were to identify and delineate the habitats of those species chosen as the "most important" species in the Quoddy Region. By identifying these various habitats, and by showing which habitats overlapped, certain areas could be recognized as being "more valuable" perhaps than other areas. This should provide important information to decision makers with respect to the utilisation of our coastal resources. Areas which served a large number of species, or which were highly sensitive for a single important species would be recognised. Such recognition is essential if the species is going to be protected from any encroachment which might put it at risk.

Without detracting from the objectives indicated above, there was serious concern expressed by several experts that by focusing only on a handful of species, certain ecological systems might be compromised. Time constraints have not allowed any review of the habitat maps by the experts and so it remains to be seen whether the concern expressed at the beginning is justified. In my view, by picking enough species (as I think we did) the potential problem of missing an important part of the whole ecosystem is greatly reduced though perhaps not entirely eliminated.

Although the scientific input is as accurate as it could be in such an endeavour and has been provided by scientists with expert knowledge of the species whose habitats they were delineating, it must be clearly understood that this project is not aimed at managing these species. Such management is clearly the mandate of many existing agencies with detailed information of the organisms and their habitats. What this project is aimed at is providing a source of reference and a tool for people who might be involved in making decisions that could alter the nature of the habitats of these species. It is aimed at illustrating the intrinsic importance of these areas to the very species we recognise as being important.

We have not developed a fine-tuned, mechanical model to predict the potential suitability of areas based purely on the physical parameters of substrate, salinity, temperature, and depth. Even within the Quoddy Region, there is monthly variation of many physical factors such as temperature, and salinity. In addition, the requirements of different species at different times of their life cycles, further compounds the difficulties in developing a mathematical type model. In the present study, the "modelling" has been done, on a subjective basis, by each expert recognising that many other factors such as availability of food and presence of predators are also important factors that might limit the utilisation of a habitat by a species. The breadth of the brush must also be recognised when these habitats were delineated and subsequently digitised. Throughout the whole exercise, generalisations have been made and although it would have been very nice to have fine-scaled, detailed maps at high resolution for each of the species, this was neither realistic nor necessary in view of the
overall objective, namely the provision of a useful and valuable tool for those involved in making decisions about the use of our coastal resources. As indicated in the methodology section, although lines have been drawn on a map, these must be considered as general "guide" lines as it is axiomatic that individuals of any of the species will not be found only within the polygon(s) drawn for it (unless they have this report to refer to!).

There have been problems developing a final, single composite map showing the habitat overlaps of all 27 species and up to three different values for some species, a total of 55 layers. We hope that this first draft copy will provide much of the information we set out to compile. A final document will be produced within the next week or two, as soon as the computer can be coerced into cooperating to give us the completed composite map. This work is in progress.

Although each expert has seen and approved the written descriptions contained herein, the individual species maps have neither been seen nor approved by them. These will be sent to them within the next few days so that any necessary modifications can be made for incorporation into the final report.
Appendix I

GULF OF MAINE COUNCIL
AND
HUNTSMAN MARINE SCIENCE CENTRE

Report on workshop held March 7 and 8, 1996

Report on workshop held March 7 and 8, 1996 to identify important species in the Quoddy Region for subsequent habitat delineation and mapping.

Introduction:

The Gulf of Maine Council in collaboration with the Huntsman Marine Science Centre have developed a project aimed at identifying the "most important" species in the Quoddy Region so that their habitats can be identified and delineated. This will provide information that can be used to produce a habitat map for each species identified and by overlaying the habitat maps of all species identified, critical areas in and around Passamaquoddy Bay and the Lower Bay of Fundy can be recognised. This, in turn, should facilitate better management, protection and restoration where needed. In 1993/1994, the Habitat Panel of the Gulf of Maine Council selected and ranked a list of "Priority Species" according to social, commercial, ecological and institutional criteria. This list, of 161 different species, is to be used as the source for identifying the most important species in the Quoddy Region.

Approach followed:

Thirty one scientists (Appendix I), whose combined expertise combined expertise covered all 161 species listed by the Habitat Panel, were invited to attend the Workshop to assist in selecting the 15 most important species from the top-ranked 30 species of the longer list. In addition, representatives were invited from those groups known to have an interest in species and habitat conservation, protection and restoration (Appendix II). From the former group, 25 had indicated they would attend and from the latter group, only one expressed an interest in attending although three others expressed an interest in being kept informed and provided some input as to species they considered to be important. All those invited were provided with the list and ranking of the 161 species identified by the Habitat Panel.

The first day of the Workshop (see program, Appendix III), the afternoon of March 7, was used to introduce participants to the joint project and to explain the goals and objectives. In addition, the process to be used in selecting and identifying the most important species was discusses. Informal discussions of many related topics were held during the evening of March 7. On the morning of March 8, the aim of the Workshop was to identify the most important 15 species from the top 30 of the list of 161 and to identify any other species of great importance to the specific area to be covered in this project.
Results

Largely owing to inclement weather, several intended participants were unable to attend the Workshop, the total number present being reduced to 20 (Appendix IV). Thanks to the excellent presentation of Arnold Banner who introduced participants to the rationale for the project and who shared his experience of looking after the Great Bay project, a similar venture with similar goals, the Workshop got off to a fast start. It was agreed that some time be spent not only identifying species but clearly marking the boundaries of the study area. There was a real consensus that limiting the study to Passamaquoddy Bay, *sensu stricto*, did not make sense from an ecosystem viewpoint and that the Quoddy Region be identified as the study area. This region includes Passamaquoddy Bay, the St. Croix Estuary up to the head of Tide, and part of the Lower Bay of Fundy including that area contained west of a line joining Point Lepreau to the Islands known as the Wolves and from there to Machias Seal Island, south of Grand Manan.

The top 30 species from the Gulf of Maine Council list were considered with respect to their specific importance within the Quoddy Region as described above. Four species were eliminated as being absent or poorly represented which reduced the list to 26 species all of which were considered to be important. Species not included on the list of 26 remaining but which were considered also to be important were nominated by those present and after discussion by the group, either retained on a second list or rejected. This exercise resulted in the eventual nomination of a further 22 species, most of which were on the list of 161 but lower in priority. The species remaining on the top 30 list are shown in Table I; the new nominations that survived initial discussion are shown in Table II.

Both lists were subsequently considered with specific reference to the weighting provided by the Habitat Panel using various criteria. A numerical ranking was obtained for all species on both lists. This resulted in 14 species being retained on the top 30 list (Table III) and 13 species being retained on the other list (Table IV) making a total of 27 species. There was general consensus that we try to develop the habitat boundaries for all of these 27 species especially as some of the species listed were well-known and probably would not need much work. Two other species, recommended by someone who had to cancel at the last minute, were also included as the habitat boundaries appear to be well documented as well. These two are shown at the bottom of Table IV and will be deleted if the habitat boundaries are not already known.

No attempt was made to integrate the two lists at this time.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1.</td>
<td>Irish moss (<em>Chondrus crispus</em>)</td>
</tr>
<tr>
<td>2.</td>
<td>Soft-shelled clam (<em>Mya arenaria</em>)</td>
</tr>
<tr>
<td>3.</td>
<td>Tufted red weed (<em>Mastocarpus</em> [Syn:<em>Gigartina</em>] <em>stellatus</em>)</td>
</tr>
<tr>
<td>4.</td>
<td>Rockweed (<em>Ascophyllum nodosum</em>)</td>
</tr>
<tr>
<td>5.</td>
<td>Atlantic salmon (<em>Salmo salar</em>)</td>
</tr>
<tr>
<td>6.</td>
<td>Harbour porpoise (<em>Phocoena phocoena</em>)</td>
</tr>
<tr>
<td>7.</td>
<td>Winter flounder (<em>Pleuronectes americana</em>)</td>
</tr>
<tr>
<td>8.</td>
<td>Sei whale (<em>Balaenoptera borealis</em>)</td>
</tr>
<tr>
<td>9.</td>
<td>Right whale (<em>Eubalaena glacialis</em>)</td>
</tr>
<tr>
<td>10.</td>
<td>Green sea urchin (<em>Strongylocentrotus droebachiensis</em>)</td>
</tr>
<tr>
<td>11.</td>
<td>Sea scallop (<em>Placopecten magellanicus</em>)</td>
</tr>
<tr>
<td>12.</td>
<td>Eel grass (<em>Zostera marina</em>)</td>
</tr>
<tr>
<td>13.</td>
<td>Atlantic cod (<em>Gadus morhua</em>)</td>
</tr>
<tr>
<td>14.</td>
<td>Blue mussel (<em>Mytilus edulis</em>)</td>
</tr>
<tr>
<td>15.</td>
<td>Atlantic herring (<em>Clupea harengus</em>)</td>
</tr>
<tr>
<td>16.</td>
<td>Common loon (<em>Gavia immer</em>)</td>
</tr>
<tr>
<td>17.</td>
<td>Atlantic whitefish (<em>Coregonus huntsmanii</em>) - DELETED</td>
</tr>
<tr>
<td>18.</td>
<td>Atlantic Ridley turtle (<em>Lepidochelys kempii</em>) - DELETED</td>
</tr>
<tr>
<td>19.</td>
<td>Haddock (<em>Melanogrammus aeglefinus</em>)</td>
</tr>
<tr>
<td>20.</td>
<td>Finback whale (<em>Balaenoptera physalus</em>)</td>
</tr>
<tr>
<td>21.</td>
<td>American shad (<em>Alosa sapidissima</em>)</td>
</tr>
<tr>
<td>22.</td>
<td>Cordgrass (<em>Spartina alterniflora</em>)</td>
</tr>
<tr>
<td>23.</td>
<td>Pollock (<em>Pollachius virens</em>)</td>
</tr>
<tr>
<td>24.</td>
<td>Diamondback terrapin (<em>Malaclemys terrapin</em>) - DELETED</td>
</tr>
<tr>
<td>25.</td>
<td>Atlantic mackerel (<em>Scomber scombrus</em>)</td>
</tr>
<tr>
<td>26.</td>
<td>American lobster (<em>Homarus americanus</em>)</td>
</tr>
<tr>
<td>27.</td>
<td>Bay scallop (<em>Aequipecten irradians</em>) - DELETED</td>
</tr>
<tr>
<td>28.</td>
<td>Quahog (<em>Mercenaria mercenaria</em>)</td>
</tr>
<tr>
<td>29.</td>
<td>Sperm whale (<em>Physeter catodon</em>)</td>
</tr>
<tr>
<td>30.</td>
<td>Humpback whale (<em>Megaptera novaeangliae</em>)</td>
</tr>
<tr>
<td>TABLE II</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td></td>
</tr>
<tr>
<td>Candidate species of local importance</td>
<td></td>
</tr>
</tbody>
</table>

**Mammals:**
- Minke whale (*Balaenoptera acutorostrata*)

**Birds:**
- Common eider (*Somateria mollissima*)
- Arctic tern (*Sterna paradisaea*)
- Puffin (*Fratercula arctica*)
- Harlequin duck (*Histrionicus histrionicus*)
- Bonaparte’s gull (*Larus philadelphia*)

**Fishes:**
- Lumpfish (*Cyclopterus lumpus*)
- Hagfish (*Myxine glutinosa*)
- Tom cod (*Microgadus tomcod*)
- Smooth flounder (*Liopsetta putnami*)

**Invertebrates:**
- Sand dollar (*Echinorachnius parma*)
- Calanoid copepod (*Calanus finmarchicus*)
- Pandalid shrimp (*Pandalus borealis*)
- Periwinkle (*Littorina littorea*)
- Inshore copepod (*Acartia longiramus*)
- Gammarid (*Gammarus oceanicus*)
- Polychaete (*Nepthys incisa*)

**Plants:**
- Cord grass (*Spartina patens*)
- Dulse (*Palmaria palmata*)
- Kelp (*Laminaria longicurris*)
- (*Lomatogonium rotatum*)
- (*Secesio pseudoarnica*)
TABLE III

Top 14 species selected from the Gulf of Maine Council list for identifying regionally significant habitats

(The number on the left is the order of priority assigned by the participants at the workshop; the number on the right is the Gulf of Maine Council order of priority)

<table>
<thead>
<tr>
<th></th>
<th>Species</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Soft shelled clam (<em>Mya arenaria</em>)</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Rockweed (<em>Ascophyllum nodosum</em>)</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Atlantic salmon (<em>Salmo salar</em>)</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>Harbour porpoise (<em>Phocoena phocoena</em>)</td>
<td>6</td>
</tr>
<tr>
<td>14</td>
<td>Winter flounder (<em>Pleuronectes americana</em>)</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Right whale (<em>Eubalaena glacialis</em>)</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>Green sea urchin (<em>Strongylocentrotus droebachiensis</em>)</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Sea scallop (<em>Placopecten magenallicus</em>)</td>
<td>11</td>
</tr>
<tr>
<td>11</td>
<td>Blue mussel (<em>Mytilus edulis</em>)</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>Herring (<em>Clupea harenhus</em>)</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>Finback whale (<em>Balaenoptera physalus</em>)</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>Pollock (<em>Pollachius virens</em>)</td>
<td>23</td>
</tr>
<tr>
<td>13</td>
<td>American lobster (<em>Homarus americanus</em>)</td>
<td>26</td>
</tr>
<tr>
<td>1</td>
<td>Humpback whale (<em>Megaptera novaeangliae</em>)</td>
<td>30</td>
</tr>
</tbody>
</table>
### TABLE IV

Top 13 species considered to be of local importance and not included in the top 30 of the Gulf of Maine Council list

(The number on the left is the ranking accorded by participants at the workshop; the number in brackets on the right is the priority assigned by the Gulf of Maine, if listed)

1. Periwinkle (*Littorina littorea*) [32]
2. Shrimp (*Pandalus borealis*) [not listed]
3. Calanoid copepod (*Calanus finmarchicus*) [129]
4. Arctic tern (*Sterna paradisea*) [42]
5. Common eider (*Somateria mollissima*) [46]
6. Cordgrass (*Spartina patens*) [not listed]
7. Sand dollar (*Echinorachnius parma*) [not listed]
8. Minke whale (*Balaenoptera acutorostrata*) [not listed]
9. Harlequin duck (*Histrionicus histrionicus*) [50]
10. Dulse (*Palmaria palmata*) [54]
11. Kelp (*Laminaria longicruris*) [not listed]
12. Hagfish (*Myxine glutinosa*) [not listed]
13. Puffin (*Fratercula arctica*) [not listed]
Species habitat workshop I
March 7/8, 1996
(Appendix I)

List of experts invited

R. Aiken, Mount Allison University
J. Allen, Huntsman Marine Science Centre
W. Ayer, NB Department of the Environment
A. Banner, U.S. Fish and Wildlife Service
S. Boates N.S. Department of Natural Resources
M. Burt, Huntsman Marine Science Centre
G. Chmura, McGill University
S. Crighton, Washburn and Gillis
G. Daborn, Acadia University
T. Dean, Huntsman Marine Science Centre
A. Diamond, University of New Brunswick
G. Finney, Environment Canada
G. Gillis, Washburn and Gillis
D. Hamilton, University of Guelph
P. Hicklin, Canadian Wildlife Service
H. Hinds, University of New Brunswick
W. Hogans, Huntsman Marine Science Centre
G. Hayes, U.S. Fish and Wildlife Service
B. Jones, N.B. Department of Fish and Aquaculture
I. Kaczmarska, Mount Allison University
P. Kehoe, N.B. Department of Natural Resources and Energy
P. Lawton, Fisheries and Oceans, Canada
A. Logan, University of New Brunswick
C. MacKenzie, Washburn and Gillis
D. McAlpine, New Brunswick Museum
A. McKay, St. Croix Estuary Project
P. Pearce, Environment Canada
G. Pohle, Atlantic Reference Centre
F. Purton, Huntsman Marine Science Centre
R. Rangeley, Fisheries and Oceans, Canada
S. Robinson, Fisheries and Oceans, Canada
B. Scott, Huntsman Marine Science Centre
A. Smith, Environment Canada
R. Stephenson, Fisheries and Oceans, Canada
M. Thomas, Bridgetown, N.S.
E. Trippel, Fisheries and Oceans, Canada
R. Vadas, University of Maine
L. Van Guelpen, Atlantic Reference Centre
D. Wildish, Fisheries and Oceans, Canada
SPECIES HABITAT WORKSHOP
MARCH 7/8, 1996
(Appendix II)

List of special interest groups invited

Eastern Charlotte Waterways, T. Clark
West Isles Clean Environment Association, M. Leeman
Nature Trust of New Brunswick, J. Davies
New Brunswick Clam Diggers’ Association, L. Foster
New Brunswick Conservation Council, J. Harvey
St. Croix Estuary Project, R. Rainer, J. Trifts
Fundy North Fishermen’s Association, J. Kearney
WORKSHOP

Gulf of Maine, Council on the Marine Environment

and

Huntsman Marine Science Centre

Identification of "important" species for habitat delineation in the Quoddy Region

(Appendix III)

PROGRAM

Thursday, March 7, 1996

12:00 - 13:00 Lunch at Anderson House, Huntsman Upper Campus

13:30 - 14:30 Introduction to project and explanation of objectives - Dr. A. Banner

14:30 - 15:00 Break

15:00 - 17:00 Discussion of "Process to be used"

18:00 - 20:30 Dinner at Anderson House

20:30 - Informal mixer; host bar until supplies run out

Friday, March 8, 1996

8:00 - 8:45 Breakfast at Anderson House

9:00 - 10:30 Species selection I (Preliminary)

10:30 - 11:00 Break

11:00 - 12:00 Species selection II (Final); Close of workshop

12:30 - Lunch at Anderson House; Homeward bound.
Participants in
Species habitat workshop
March 7-8, 1996
(Appendix IV)

PARTICIPANTS:

John Allen
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(Tel: (506) 529-1200)

Arnold Banner
United States Fish and Wildlife Service
Gulf of Maine and Estuary Project
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Tracey Dean
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ACWERN
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Diana Hamilton
(University of Guelph)
at Huntsman Marine Science Centre
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(Tel: (207) 781-8364)

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Washburn and Gillis
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Montreal, PQ H3A 2K6
(Tel: (514) 398-4111)

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Fred Purton  
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Brandy Cove Road  
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(Tel: (506) 529-1204)

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(Tel: (506) 529-4868)

Bob Rangeley  
Biological Station  
Fisheries and Oceans Canada  
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Bev Scott  
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Jonathan Trifts  
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St. Andrews, NB E0G 2X0  
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Bob Vadas  
University of Maine  
Orono, ME 04469  
(Tel: (207) 581-2974)

David Wildish  
Biological Station  
Fisheries and Oceans Canada  
St. Andrews, NB E0G 2X0  
(Tel: (506) 529-8854)
Appendix II

Experts invited to attend the Second GOM Council/HMSC Workshop on the Passamaquoddy Bay Restoration Project (July 1996)

John Allen, Huntsman Marine Science Centre
Bill Ayer, NBDOE & Member GOM Council Working Group
Jill Fegley, University of Maine, Orono
Carolyn Bird, Institute for Marine Biosciences, NRC Canada
Mick Burt, Huntsman Marine Science Centre
Gail Chmura, McGill University
Tony Diamond, UNB & ACWERN
David Gaskin, University of Guelph
Bill Hogans, Atlantic Reference Centre, HMSC
Cathy MacKenzie, ICOIN & Washburn & Gillis, Ltd.
Kim Mawhinney, University of New Brunswick
Jack McLachlan, Institute for Marine Biosciences, NRC Canada
Laurie Murison, Marine Mammal Research Centre, Grand Manan
Gerhard Pohle, Atlantic Reference Centre, HMSC
Bev Scott, Huntsman Marine Science Centre
Bob Vadas, University of Maine, Orono
Lou Van Guelpen, Atlantic Reference Centre
Barbara Vickery, Nature Conservancy, Cobscook Bay