6.0 PLANTS

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Phytoplankton, sea-ice microalgae, benthic algae, and macrophytes provide sustenance either directly or indirectly for animals in the Hudson Bay marine ecosystem. Two floral habitats, the eelgrass beds along the east coast of James Bay and salt marshes along the James Bay coast and southwestern coast of Hudson Bay, are particularly important to migratory waterfowl.

6.1 Phytoplankton

To our knowledge, phytoplankters have only been collected in the Hudson Bay marine region during the open water season, mostly from surface waters. Davidson (1931) collected surface samples from 13 stations in Hudson Bay during the Loubyrne Expedition; Bursa (1961) from northern Hudson Bay and along the west coast at the surface and depths of 10, 25, and 50 m during the Calanus Expeditions; and Brooks (1979) and Roff and Legendre (1986) from Chesterfield Inlet and northwestern Hudson Bay. Researchers aboard the C.G.S. Narwhal conducted a wide-ranging synoptic survey of phytoplankton in surface waters of the marine region during the summer of 1975--Gerrath et al. (1980) studied the phytoplankton of fresh water origins and Anderson et al. (1981) the marine diatoms and dinoflagellates. The Nelson River estuary was sampled during August and September of

1988 (Baker 1989) and 1992 (Baker et al. 1993), and the Churchill River estuary in September of 1993 (Baker et al. 1994) and July 1994 (Lawrence and Baker 1995). In August and September 1993, researchers aboard the MV Fogo Isle collected phytoplankton from the upper 50 m of the water column, and at discrete depths to 100 m at selected stations, along a north-south transect from the mouth of James Bay to Hudson Strait and an east-west transect across the mouth of Hudson Bay (Simard et al. 1996; Harvey et al. 1997).

Most studies of phytoplankters in the James Bay marine region have been conducted between mid-February and early October in the general areas of southeastern Hudson Bay (Anderson 1979; Legendre and Simard 1979; Anderson and Roff 1980a,b; Gerrath et al. 1980; Simard et al. 1980, 1996; Grainger 1982; Harvey et al. 1997); Manitounuk Sound and offshore Kuujjuarapik (Legendre and Simard 1979; Legendre et al. 1981, 1982, 1986); the Eastmain and La Grande estuaries in eastern James Bay (Foy and Hsiao 1976; Ingram et al. 1985); and Rupert Bay (Legendre and Simard 1978; De Sève 1993). Little is known of phytoplankton in central or western James Bay or in Richmond Gulf. Seasonal and depth-related changes in offshore phytoplankton species composition have not been documented.

Despite its northerly latitude, Arctic character, and low productivity, the Hudson-James Bay system has a remarkably diverse microalgal community, consisting of over 495 taxa (Roff and Legendre 1986; Harvey et al. 1997). The high diversity of the Arctic water phytoplankton is well known but not understood. It is a reversal of the general trend. Papers by Bursa (1961), Foy and Hsiao (1976), Legendre and Simard (1978, 1979), Anderson (1979), Gerrath et al. (1980), De Sève (1993), Simard et al. (1996), and Harvey et al. (1997) include extensive lists of phytoplanktonic species identified from the marine ecosystem.

The marine diatom and dinoflagellate assemblages in the southeastern Hudson Bay and James Bay do not differ significantly in species composition from those reported in Arctic and North Atlantic waters and are a mixture of arctic, boreal, and temperate forms (Davidson 1931; Bursa 1961, 1968; Anderson et al. 1981; Roff and Legendre 1986; Harvey et al. 1997). This mixture of flora is probably due in part to the presence of warm water relict species, as in the case of the fauna. Species distributions and assemblages appear to be related to the mixing of fresh and saline waters, with changes in temperature, nutrients, and light level all playing a part (Legendre and Simard 1979; Gerrath et al. 1980; Anderson et al. 1981; De Sève 1993). The surface waters are dominated by marine species that have restricted distributions in coastal areas where the effect of fresh water is strongest. Dilute nearshore estuarine waters are dominated by freshwater taxa that originate in the river and either accumulate or continue to grow in the estuary (Schnneider-Vieira et al. 1993). Some typical summer surface species assemblages that occur in Hudson Bay are listed in Table 6-1.

In their survey of Hudson Bay during the summer of 1975, Anderson et al. (1981) found that marine diatoms were most abundant (= 105 cells·L^{-1}) in samples taken northwest of the Belcher Islands. The moderating influence of relatively warm waters flowing from James Bay early in the spring and late in the fall may cause production in this area to begin earlier and continue later than elsewhere in Hudson Bay. Diatom cell numbers generally were lower and more variable adjacent to major river outflows, while dinoflagellates (Anderson et al. 1981) and freshwater forms (Gerrath et al. 1980) tended to have higher concentrations in these areas, with a definite exclusion of marine forms that were otherwise found throughout Hudson Bay. Dinoflagellates were most abundant in samples taken from the plume of Chesterfield Inlet and from immediately south of Mansel Island (Anderson 1979; Anderson et al. 1981). Samples with the greatest diversity of marine diatoms and dinoflagellates were taken between Coats and Mansel islands, and probably reflect the mixing of species from Hudson Bay with those from Hudson Strait (Bursa 1961; Anderson et al. 1981). Species diversity varied in the offshore waters following no discernable pattern, while inshore it was generally higher except along the lower west and southwest coast (Anderson et al. 1981). The area along the southwest coast appears to be less hospitable to marine diatoms and dinoflagellates than the rest of Hudson Bay, and has large populations of a small number of freshwater algal species (Gerrath et al. 1980).

Table 6-1. **Distributional groupings of diatoms and dinoflagellates in the surface waters of Hudson Bay, including the area south and west of the Belcher Islands, during August and September 1975 (after Anderson et al. 1981).**

Species grouped by distribution		**Distribution**
Div. Bacillariophyta (diatoms)		
Group A	*Chaetoceros compressus* Lauder	More common, widespread species. Present in from 53 to 90 of the 130 samples. Found throughout Hudson Bay except in the southwest coast area--particularly in waters adjacent to the Churchill and Nelson rivers.
	Chaetoceros septrionalis Ostrup	
	Leptocylindrus danicus Cleve	
	Leptocylindrus minimus Gran	
	Pseudonitzschia delicatissima (Cleve) Heiden	
	Nitzschia longissima (Brebisson *in* Kutzing) Grunow	
	Nitzschia seriata Cleve	
	Thalassionema nitzschioides (Grunow) Van Heurck	
Group B	*Chaetoceros atlanticus* Cleve	Common, widespread species. Present in from 12 to 32 of the 130 samples. Distribution similar to Group A.
	Chaetoceros neogracile VanLandingham	
	Rhizosolenia alata Brightwell	
	Rhizosolenia hebetata var. *semispina* (Hensen) Gran	
	Thalassiosira gravida (Cleve)	
	Thalassiosira nordenskioeldii Cleve	
	Thalassiothrix frauenfeldii (Grunow) Cleve et Grunow	
	Coscinodiscus sp. Ehrenberg	
Group C	*Chaetoceros decipiens* Cleve	Common, inshore species. Present in from 11 to 30 of the 130 samples. Common in most inshore areas including the southwest coast. Not usually found in the offshore; noticeably rare north of the Ottawa Islands and in the Coats and Mansel islands area. Other commmonly occurring species were found locally, inshore.
	Chaetoceros diadema (Ehrenberg) Gran	
	Chaetoceros convolutus Castracane	
	Chaetoceros laciniosus Schutt	
	Rhizosolenia setigera Brightwell	
Group D	*Asteromphalus* ? *heptactis* (Brebisson) Ralfs in Pritchard	Uncommon species. Present in from 1 to 5 of the 130 samples. Most occurred in the Coats and Mansel islands and (or) along the east coast of Hudson Bay.
	Chaetoceros lorenzianus Grunow	
	Chaetoceros fragilis Meunier	
	Chaetoceros wighami Brightwell	
	Coscinodiscus curvatulus Grunow in Schindt et al.	
	Coscinosira polychorda (Gran) Gran	
	Eucampia groenlandicus Cleve	
	Rhizosolenia ? *delicatula* Cleve	
	Rhizosolenia fragilissima Bergon	
	Rhizosolenia pungens Cleve - Euler	
	Rhizosolenia styliformis Brightwell	
	Thalassiosira decipiens Grunow	
	Thalassiosira ? *hyalina* (Grunow) Gran	
Group E	*Astrionella formosa* Hassall	Freshwater species. Usually present in from 1 to 3 of the 130 samples. Most occurred close to shore adjacent to areas of major freshwater discharge. *F. crotonensis* and *A. gracillima* were more common and widely distributed in coastal waters, and the former was also found offshore.
	Astrionella gracillima (Hantzsch) Heiberg	
	Caloneis bacillum (Grunow) Cleve	
	Cocconeis sp. Ehrenberg	
	Cyclotella comta (Ehrenberg) Kuntzing	
	Fragilaria ? *capucina* Desmazieres	
	Fragilaria crotonensis Kitton	
	Melosira ? *granulata* (Ehrenberg) Ralfs in Pritchard	
	Melosira islandica O. Muller	
	Melosira ? *italica* (Ehrenberg) Kutzing	
	Stephanodiscus ? *hatzschii* Grunow	
	Tabellaria flocculosa (Roth) Kutzing	

Table 6-1. continued.

Species grouped by distribution		Distribution
Div. Pyrrhophyta (dinoflagellates)		
Group F	*Amphidinium longum* Lohmann *Gymnodinium arcticum* Wulff *Gyrodinium pingue* (Schutt) Kofoid and Swezy *Gyrodinium spirale* (Bergh) Kofoid and Swezy	More common, widespread species. Present in from 59 to 93 of the 130 samples. Found throughout Hudson Bay except for a small area off the Nelson and Severn rivers.
Group G	*Amphidinium* ? *crassum* Lohmann *Amphidinium phaeocysticola* Lebour *Ceratium arcticum* (Ehrenberg) Cleve *Ceratium longipes* (Bailey) Gran *Dinophysis acuminata* Claparede and Lachman *Dinophysis arctica* Mereschkowsky *Dinophysis rotundata* Claparede and Lachman *Peridinium globulus* Stein var. *quarnerense* Schroeder *Peridinium depressum* Bailey	Common to rare species found concentrated in the Coats and Mansel islands area and along the east coast of Hudson Bay--a distribution similar to the diatoms of Group D, and also close to shore along the west coast south to Churchill. Present in from 1 to 6 of the 130 samples with the exception of *P. globulus* var *quarnerense,* which was found in 19 samples.
Group H	*Massartia rotundata* (Lohmann) Schiller *Peridinium pallidum* Ostenfeld *Peridinium pellucidum* (Bergh) Schutt	Common species. Found in 15 to 23 of the 130 samples. Occur mainly along the southwest coast, in the Chesterfield Inlet area and a small area south of Mansel Island. The remaining dinoflagellate species constituted no apparent grouping.

Three distinct species assemblages were identified along a sampling transect from the mouth of James Bay to Hudson Strait in early September 1993 (Harvey et al. 1997; Figure 6-1). The southernmost group (A), was strongly influenced by freshwater runoff entering James Bay and southern Hudson Bay. The most strongly stratified and enriched with particulate organic nitrogen from freshwater runoff, this area was characterized by a relatively high phytoplankton biomass (chlorophyll ***a*** (Chl ***a***) $>1.0\ \mu g \cdot L^{-1}$) in the near surface waters (Figure 6-2) and by a brackish-marine phytoplankton community equally dominated by small flagellates and dinoflagellates; (Figure 6-1). The second group (B) occurred northwest of the Belcher and Sleeper islands. It was less influenced by freshwater runoff and was characterized by relatively well-mixed conditions; small diatoms composed about 50% of this phytoplankton assemblage. The third group (C) occupied northern Hudson Bay and western Hudson Strait, an area characterized by the lowest surface nutrient concentrations and a subsurface chlorophyll maximum. Small flagellates were numerically dominant in this area, comprising over 55% of the species assemblage.

Species typical of fresh water are common in the offshore waters of Hudson Bay, where they occur in apparently good condition up to 400 km offshore and 2 months after the disappearance of ice cover (Bursa 1961; Gerrath et al. 1980; Roff and Legendre 1986). Bursa (1961) referred to this phenomenon as "Arctic neritism". During the summer of 1975 the highest surface cell counts ($= 10^6$ cells$\cdot L^{-1}$) of freshwater taxa occurred in the area of depressed salinity along the southern coast of Hudson Bay (Gerrath et al. 1980). Most were blue green algae (Cl. Cyanophyceae), green algae (Cl. Chlorophyceae), diatoms (Cl. Bacillariophyceae), or golden-brown algae (Cl. Chrysophyceae), and the species diversity tended to be highest inshore. Eight freshwater species were identified at one station northwest of the Belcher Islands, where they comprised 19% of the total cell count—their relative contribution to the biomass was not determined. The origins of these freshwater algae are not known, but they may develop in melt pools on the ice or be distributed under the ice by spring runoff.

In James Bay, Grainger (1976) identified three distributional groups of phytoplankton: arctic, euryhaline, and freshwater. The euryhaline group dominates nearly everywhere, especially in and near the La Grande River estuary, and tolerates a wide range of physical properties of the water. Diatoms dominate, but blue-green and green algae are also plentiful near the mouth of the La Grande River. The same is true of the Churchill River estuary in southern Hudson Bay (Baker et al. 1994; Lawrence and Baker 1995). Ingram et al. (1985) noted the appearance of typically marine phytoplankters in the estuary of the Eastmain River following its diversion, indicating a shift to a more marine environment. In the estuarine environment of Rupert Bay, summer

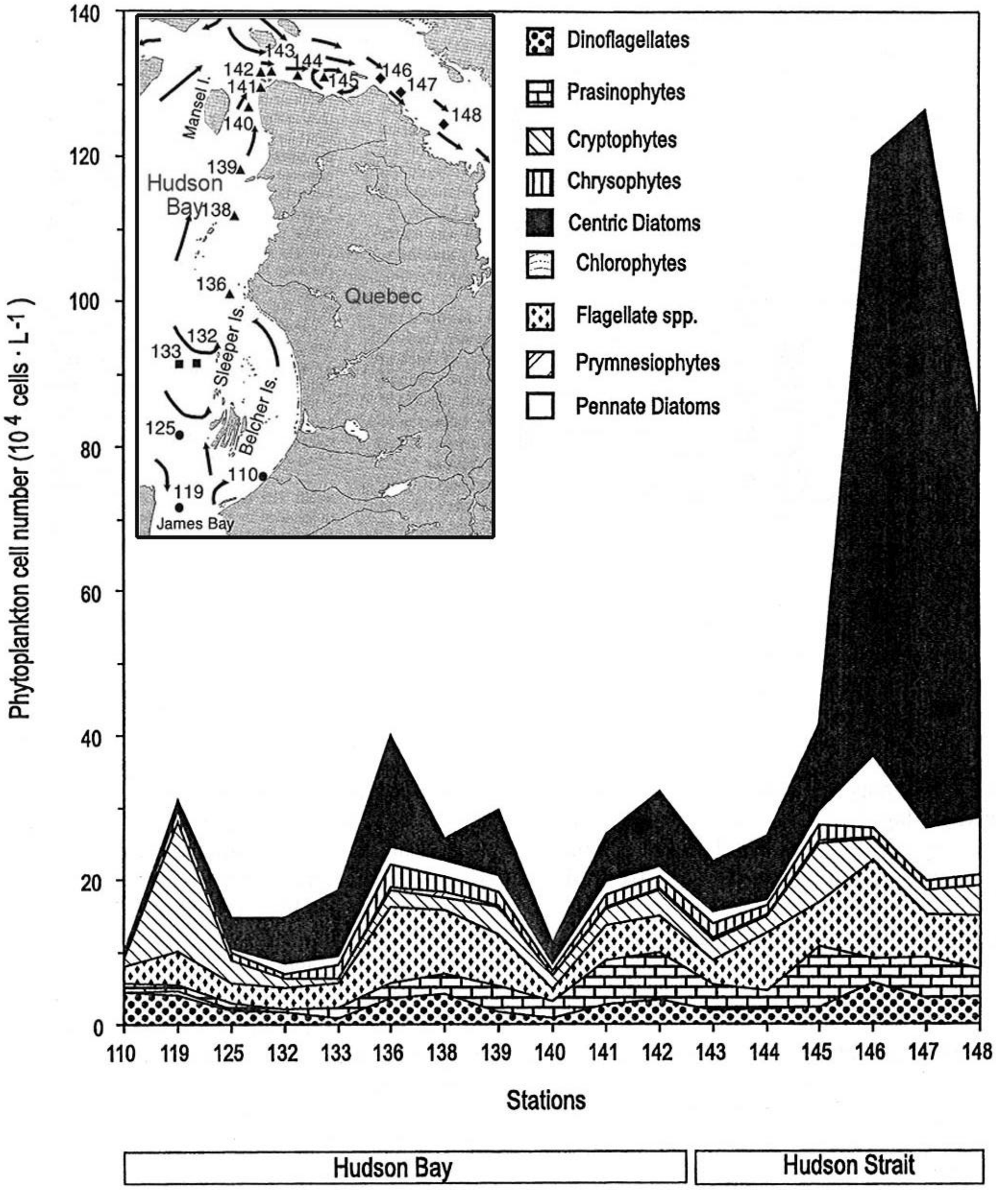

Figure 6-1. **Phytoplankton distribution along a sampling transect (inset) in Hudson Bay and Hudson Strait (adapted from Harvey et al. 1997). The map symbols indicate distinct phytoplankton assemblages that were identified by cluster analysis (● group A; ■ group B, ▲ group C, ◆ group D).**

phytoplankton dynamics are controlled by the tidal and seasonal hydrography, as well as by the high sediment load and the limiting phosphate level of these waters (Legendre and Simard 1978; De Sève 1993).

The summer phytoplankton cycle in the Belcher Islands area showed the normal cold-water sequence of dinoflagellates succeeding diatoms (Grainger 1982). Diatoms dominated numerically, reaching maximum numbers of 4.5 x 10^5 cells·L^{-1} in June with a second maximum in early August, followed by a drastic decline in numbers later in the month (Figure 5-28). The diatom decline may be attributable to predation by ciliates, which became exceptionally abundant at the Belcher Islands in August. Ciliates may play a significant role in the food chain, serving as important consumers of the nanoplankton and microphytoplankton, and as prey for the larger omnivorous zooplankton.

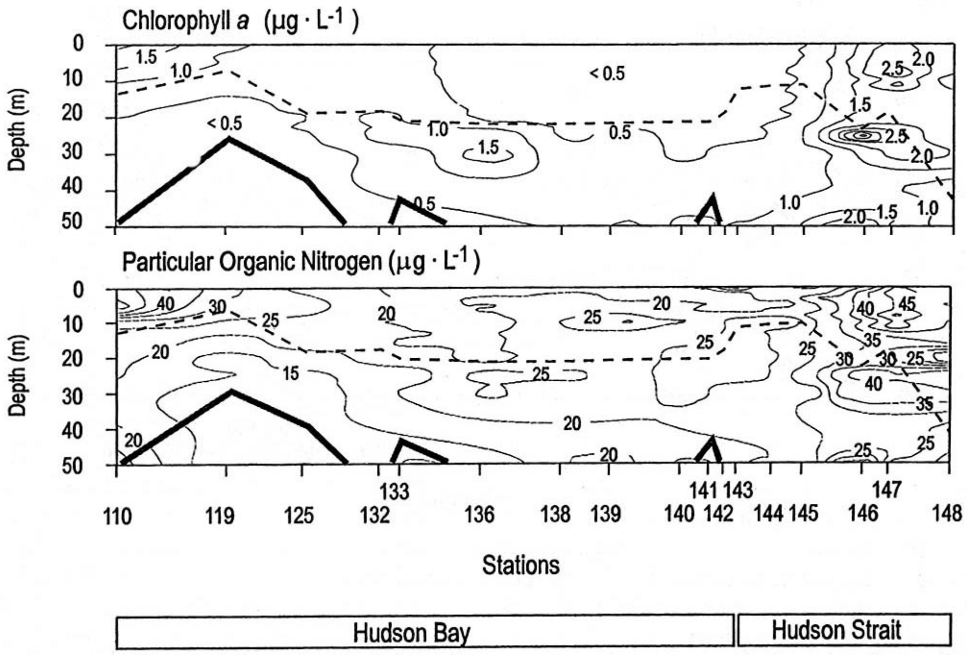

Figure 6-2. Horizontal and vertical distribution of chlorophyll *a* and particulate organic nitrogen in the upper 50 m of the water column along a sampling transect in Hudson Bay and Hudson Strait in September 1993 (adapted from Harvey et al. 1997). Also shown are: the depth of the mixed layer (----), which was defined as the depth where the temperature was 1°C less than at the surface; the lower depth limit of the pycnocline (—); and an index of vertical stratification (●—●), which was defined as the difference in density between the bottom and surface layers (∆σt). See Figure 6-1 for station map and Figure 5-22 for STD and dissolved nutrient distributions.

Phytoplankton blooms typically occur when the upper water column is relatively stable and nutrient rich (Legendre et al. 1982). In exposed areas, these conditions may only occur under the ice in late April and May, as the light increases and the upper water column is stabilized by low-salinity melt water (Legendre et al. 1981). The resultant under-ice bloom is augmented by the release of ice algae. In sheltered embayments such as Manitounuk Sound, where local winds and fortnightly tides combine to cause cycles of relative instability and stability of the water column, phytoplankton blooms can also occur intermittently during the summer (Legendre et al. 1982). These blooms occur once the upper water column has stabilized following a period of nutrient regeneration through mixing. A strong phytoplankton bloom also occurred in the Eastmain River estuary when the water column stabilized following the diversion of flow into the La Grande River and the incursion of marine water into the estuary (Ingram et al. 1985).

In southeastern Hudson Bay, the mid-summer chlorophyll ***a*** maximum generally occurs in the upper 20-25 m (Grainger 1982) at or above the pycnocline (Anderson and Roff 1980b). The strong subpycnocline chlorophyll ***a*** maxima observed by Anderson and Roff (1980a,b) in the offshore waters of Hudson Bay (Figure 5-27) have not been observed inshore or in the James Bay marine region, where their formation may be precluded by higher surface chlorophyll levels and concentrations of total seston, and lower light penetration.

Seasonal and depth-related changes in phytoplankton species composition have not been documented. They may be significant since phytoplankters float more or less passively, following the currents, and species composition changes with the changing properties of the mixing waters (Bursa 1968).

Primary production reaches rates of over 3 mg $C \cdot m^{-3} \cdot h^{-1}$ (Grainger 1982) near the Belchers and about 2.5 mg $C \cdot m^{-3} \cdot h^{-1}$ in Manitounuk Sound (Legendre and Simard 1979). This translates to an annual primary productivity rate of about 35 g C·m^{-2}·a^{-1}, not including ice algal production or the main spring diatom bloom (Roff and Legendre 1986). This annual primary productivity is similar to that for phytoplankton in other seasonally ice-free Arctic marine waters (Subba Rao and Platt 1984). Dilute estuarine waters tend to be nutrient poor and appear to have lower primary production than areas outside their influence (Schneider-Vieira et al. 1993). Organic debris appears to be an important base for the estuarine food chain.

No evidence was found for the existence of red tides in Hudson Bay or James Bay. This phenomenon, which is a threat to public health in some marine areas, is caused by dinoflagellates of the genus *Gonyaulax*—in particular *G. excavata* on the east coast and *G. catenella* and *G. acatenella*, which produce the toxins causing paralytic shellfish poisoning (PSP) (White 1980). Bivalve molluscs that consume these dinoflagellates accumulate the neurotoxins in their soft tissues, which may then be eaten by people. Dinoflagellates of the genus *Gonyaulax* have not been recorded from the region (Bursa 1961; Anderson 1979; Roff and Legendre 1986), nor has PSP been found in the testing of mussels (Jamieson 1986; Giroux 1989; M. Hentzel, DFO Winnipeg, pers. comm. 1993).

6.2 Ice microalgae

In springtime, the bottom 1 to 5 cm of Arctic and Antarctic sea ice is generally colonized by dense populations of microalgae, and there are often high concentrations of free-floating microalgae at the ice-water interface (e.g., Demers et al. 1986; Horner et al. 1992; Legendre et al. 1992a). The structure and dynamics of these ice algal communities has been studied intensively in southeastern Hudson Bay and Manitounuk Sound (e.g., Poulin and Cardinal 1982a, 1982b, 1983; Poulin et al. 1983; Gosselin et al. 1985, 1986, 1990; Rochet et al. 1985, 1986; Maestrini et al. 1986; Legendre et al. 1987, 1996; Barlow et al. 1988; Michel et al. 1988, 1989; Demers et al. 1989; Tremblay et al. 1989; Robineau et al. 1994; Monti et al. 1996). Most of the research has been conducted between late-March and mid-May. Little is known of the communities at other times or elsewhere in Hudson Bay or James Bay, except near Saqvaqjuac in northwestern Hudson Bay (63°39'N, 90°39'W; Bergman et al. 1991; Welch et al. 1991).

The ice algal community of southeastern Hudson Bay is diverse. At least 151 taxa have been identified, including 142 diatoms (Bacillariophyceae), 3 dinoflagellates (Dinophyceae), 2 green algae (Chlorophyceae), 1 golden brown alga (Chrysophyceae), 1 blue-green alga (Cyanophyceae), 1 Eugleniod and a number of microflagellates (Poulin and Cardinal 1982a+b, 1983; Poulin et al. 1983). *Nitzschia* and *Navicula* species usually dominate the community during the April and May ice-algal blooms (Figure 6-3 and Figure 6-4) (Rochet et al. 1985; Barlow et al. 1988; Michel et al. 1988). The species composition changes seasonally with *Nitzschia frigida,* the dominant species, decreasing noticeably in mid-May, possibly due to the detrimental effects of lower salinity and/or photoinhibition (Barlow et al. 1988). *Navicula* spp. may be more tolerant of these conditions.

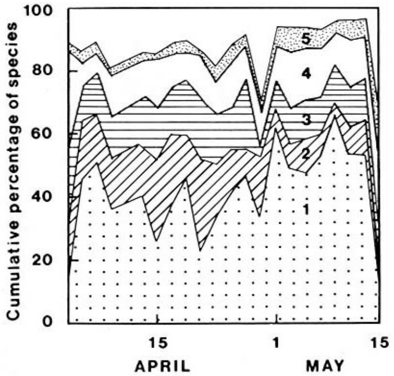

Figure 6-3. Species composition of the sea-ice microalgal community at the ice-water interface 22 km offshore Kuujjuarapik (55°30.1'N, 77°44.9'W): 1) *Nitzschia frigida*, 2) *Nitzschia* spp., 3) *Navicula pelagica*, 4) flagellates, and *Chaetoceros* spp. (from Michel et al. 1988, p. 180).

Temperature, light, salinity, and nutrients have been identified as the main environmental factors regulating the growth of sea-ice microalgae (Demers et al. 1986; Roff and Legendre 1986; Bergmann et al. 1991; Welch et al. 1991; Legendre et al. 1992b, 1996; Monti et al. 1996). Physiological adaptations to temperature and light enable the algae to cope with short-term and seasonal changes in their environment, and may explain seasonal changes in production, patchy horizontal distributions, species successions, and so on (Legendre et al. 1989).

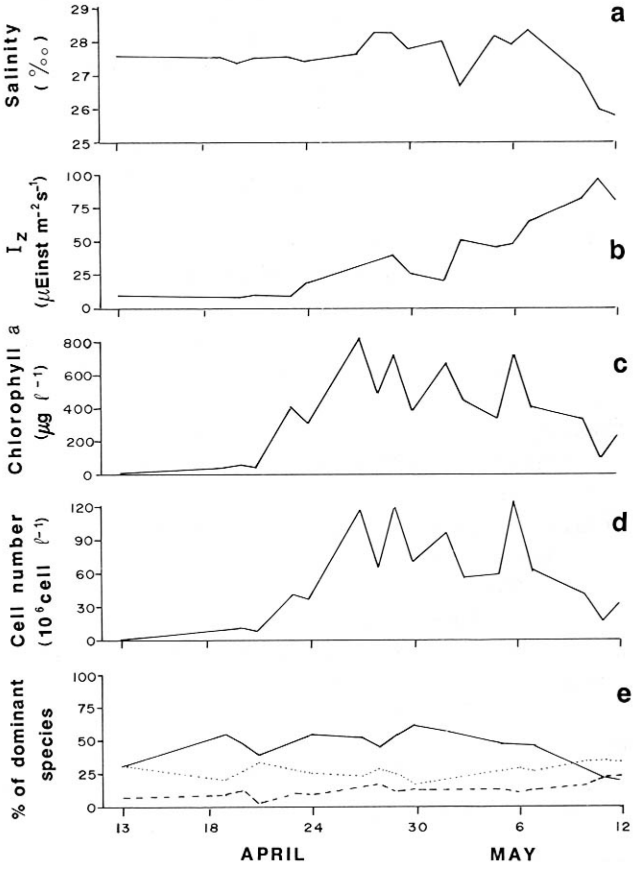

Figure 6-4. Seasonal variation of: a) salinity, b) under-ice photon fluence rate Iz, c) chlorophyll a concentration, d) cell number, and e) the dominant species *Nitzschia frigida* (—), *Navicula* spp. (·····), and *Nitzschia* spp. (-----) at the ice-water interface, 27 km offshore Kuujjuarapik (55°30.1'N, 77°44.5'W) (from Barlow et al. 1988, p. 146).

Ice algae grow under conditions of low and relatively constant temperature (-1.7 to 0°C; e.g., Gosselin et al. 1985; Rochet et al. 1985). They are not obligate shade flora but rather adapt to optimize the use of ambient light energy (Barlow et al. 1988). Photosynthetic activity does not begin until light intensity reaches 7.6 $\mu E \cdot m^{-2} s^{-1}$ (Gosselin et al. 1985). Under the low light conditions of early spring (<9 $\mu E \cdot m^{-2} s^{-1}$) the algae maintain photosynthesis by increasing their light trapping efficiency (shade adaptation) (Barlow et al. 1988). Later in the season, as the light gets stronger, they respond by increasing their rate of photosynthesis (light adaptation). This transition from shade to light adaptation takes place over one generation time (8-17 d; Maestrini et al. 1986) (Michel et al. 1988). It enables the algae to start developing at very low irradiance and may improve their photosynthetic output.

Ice algae respond to changes in the spectral quality of their light environment by rapidly (8 h) rearranging the relative proportions of their photosynthetic pigments (Rochet et al. 1986; Michel et al. 1986). This may be an important ecological adaptation to the under-ice environment, where light is often subjected to rapid variations in spectral quality as a result of shifting snow cover. The ability to adapt chromatically may become a critical factor for species competition, in a context of limiting light and nutrient resources.

The dynamics of ice-algal communities are controlled not only from above by seasonal changes in light intensity, but also from below by shorter-term hydrodynamic events (Maestrini et al. 1986; Demers et al. 1989; Ingram et al. 1989; Gosselin et al. 1990). Following an initial period of light limitation, the ice-algal growth becomes nutrient-limited when in situ irradiance and the accumulated algal biomass are high and the tidally driven nutrient supply is not strong enough to satisfy algal requirements. Vertical mixing, primarily by the fortnightly tides, replenishes nutrients at the ice-water interface, periodically enhancing growth of the ice algae. In spring, higher freshwater inputs result in deepening of the pycnocline, which acts to limit mixing and thereby nutrient input to the ice-water interface (Ingram et al. 1989). The availability of nitrates may limit the growth of inshore ice algae at Saqvaqjuac, where the maximum ice algal biomass was an order of magnitude higher over deep water, about 170 mg Chl ***a***·m^{-2}, than over shallow water (Bergmann et al. 1991; Welch et al. 1991). Nitrogen uptake by kelp may be a factor contributing to the lower nitrate concentration in these shallow waters (Welch et al. 1991).

The distribution of microalgae under the sea ice is patchy (Gosselin et al. 1986; Bergmann et al. 1991). On a large scale (30 km) it is directly related to salinity, which affects the ice surface available for colonization; on a smaller scale (0.3-500 m) by variations in the thickness of snow-ice cover, which affects illumination (Figure 6-5). Early in the season the low irradiance limits photosynthesis so that algal patches tend to develop in lighted areas under thin snow-ice cover, whereas later in the season the maximum growth occurs in areas that offer protection from photoinhibition (Gosselin et al. 1986). In Manitounuk Sound and southeastern Hudson Bay these patches are about 20 to 90 m in diameter. High concentrations of ice flora are often associated with brine channels within the ice, where nutrient concentrations are thought to be much higher than in surrounding water (Demers et al. 1989).

At Manitounuk Sound, Gosselin et al. (1985) observed the maximum concentrations of ice-algal cells and chlorophyll ***a*** on 7 May at the ice-water interface and also in the bottom 20 cm of ice (12 x 10^8 cells·m^{-2} and 0.85 mg Chl ***a***·m^{-2}). Poulin et al. (1983) reported similar values. These chlorophyll ***a*** concentrations vary greatly in Arctic waters. The observed values are low relative to many areas, including Resolute and Saqvaqjuac (Welch et al. 1991), but within the ranges reported by Dunbar and Acreman (1980) from Robeson Channel and Hudson Bay. Offshore Grande rivière de la Baleine, the taxonomic diversity and biomass of ice algae at the ice-water interface are greater at the edge of the freshwater plume than within or beyond it (Monti et al. 1996). This may reflect a greater diversity of habitats for the ice algal taxa at the plume edge.

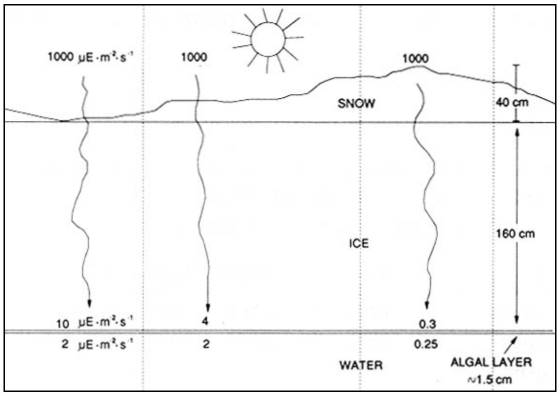

Figure 6-5. Typical light values in April and May, showing attenuation through snow, ice, and the algal layer (from Bergmann et al. 1991, p. 46). Surface reflectance (albedo) is about 60%.

During the spring blooms, a portion of the ice algal production (20%) is exported to the benthos, either as sinking cells or fecal pellets of herbivores, while the remainder may be retained in the pelagic environment (Tremblay et al. 1989). During and immediately after the bloom, ice algae are an important source of food for the marine planktonic copepods *Calanus glacialis* Jaschnov and *Pseudocalanus minutus* (Krøyer) (Runge and Ingram 1991; Tourangeau and Runge 1991).

The quantitative contribution of ultra-algae (<5 μm) to total primary production is remarkable when compared to that of larger cells such as diatoms (Robineau et al. 1994, 1999). These tiny algae occur primarily in the sea-ice bottom but also at the ice-water interface. In April and May 1990, offshore Kuujjuarapik (55°30.1’N, 77°44.5’W), they occurred at concentrations ranging from 36 x 10^3 to 63 x 10^6 cells·L^{-1} and contributed from 9 to 96% of the total chlorophyll ***a***. Availability of a solid substratum was the main factor controlling their abundances, which varied primarily with depth but also with distance from shore and with time. The ice bottom, ice-water interface, and water column formed distinct habitats that were colonized by different taxonomic assemblages. Eucaryotes dominated the high concentrations of ultra-algae in the ice and at the ice-water interface, and this dominance increased with distance from shore; procaryotes (Cyanobacteria) dominated the low concentrations of ultra-algae found in the water column, and were mainly associated with the dilute waters of the river plume and overlying ice cover.

6.3 Benthic algae

Knowledge of benthic algae in the Hudson Bay marine ecosystem is limited largely to the identification of macrobenthic species. At least 94 macro benthic algae have been identified from James Bay and southeastern Hudson Bay including 42 Phaeophyceae, 33 Rhodophyceae, 18 Chlorophyceae, and 1 Xanthophyceaen (Setchell and Collins 1908; Howe 1927; Bell and MacFarlane 1933; Breton-Provencher and Cardinal 1978; Lee 1980--see also Gardner 1937, 1949; Bell and MacFarlane 1938; Whelden 1947; Cardinal 1990). Appendix 1 lists the taxa, together with comments on collection locations, and occurrence. Little is known of either species distributions or species-habitat associations.

The total number of taxa reported is low relative to other seas at similar latitudes, and none of the species is endemic to this region (Breton-Provencher and Cardinal 1978). Ice scour prevents the establishment of a rich bottom flora in shallows and nearshore, and soft mud bottoms may be limiting to species that need a solid substrate for attachment (Bursa 1968). Sunlight, nutrient availability, and water temperature may also affect the establishment of bottom flora. Studies at Rupert Bay, the mouth of the Eastmain River, and Manitounuk Sound found the mean number of taxa per station and the biomass to be relatively low (Breton-Provencher and Cardinal 1978). This may be related to the salinity, which is sometimes much reduced, to soft sediments and high sedimentation rates, and ice cover and scour. Only 7 species of macroalgae were identified from Rupert Bay, each tolerant of a wide range of salinity.

In Hudson Bay, green algae are generally most abundant in the upper littoral zone, brown algae at intermediate depths, and red algae in deep water (Bell and MacFarlane 1933). Two brown algaes, *Pylaiella littoralis* (L.) Kjellm. and *Fucus evanescens* Ag., occur in the intertidal zone, the latter in dwarfed form. *Laminaria*, *Agarum*, *Fucus*, and *Alaria* can be found washed up on beaches (Bursa 1968), where they are sometimes eaten by polar bears in the summer (Russell 1975).

Macroalgae grow on the seafloor of Hudson Bay to a depth of at least 75 m (Barber 1983). A number of underwater photographs were taken by the M.V. Theta at a depth of 55 m in Omarolluk Sound, Belcher Islands (56°10'N, 78°58'W; Barber et al. 1981; Barber 1983). It would be interesting to examine them for the presence of benthic macroalgae. Northern coastal areas and estuaries in the vicinity of Chesterfield Inlet are also characterized by clear waters and a very deep photic zone that permits extensive growth of attached algae (M. Bergman pers. comm. cited in Schneider-Vieira et al. 1993).

6.4 Benthic vascular plants

James Bay is unusual among Canada's Arctic marine regions in having extensive beds of vascular aquatic plants. Subtidal meadows of eelgrass (*Zostera marina* L.), known in Cree as *shiikaapaashkw*, flourish along the eastern coastline of James Bay north of Vieux-Comptoir (Curtis 1973c, 1974/5; SEBJ 1990; Dignard et al. 1991; Lalumière et al. 1994; Ettinger et al. 1995; Julien et al. 1996), and along the coasts of Akimiski Island (Porsild 1932; Smith 1944 cited in Curtis 1973c) (Figure 6-6). Eelgrass also occurs sporadically along the southwestern coast of Hudson Bay north to at least Arviat (Porsild 1932; Bursa 1968). These seed plants colonize areas that are sheltered from wave action and drift ice, have a low tidal range, gentle current =50 $cm{\cdot}s^{-1}$, and fine, gently-sloping bottom sediment that is between 0.5 and 4 m below the average low tide (SEBJ 1990; Dignard et al. 1991; Lalumière et al. 1994). In these areas, the water temperature ranges from -1 to +20^{o}C, and during the growth season the salinity ranges from 10 to 25 ppt (≈psu) and the illumination is at least 1% of that received at the surface. Summer salinities of <10 ppt and possibly substrate instability may explain the absence of eelgrass from the large estuaries.

The eelgrass beds generally are monospecific in deeper waters but in shallow water are often associated with other vascular plants, *Potamogeton pectinatus* and, more rarely, *Ruppia maritima*, and a variety of benthic algae (Dignard et al. 1991; Lalumière et al. 1994). Towards the open sea the eelgrass meadows generally give way to the brown benthic macroalgae *Fucus distichus* and *Ascophyllum nodosum*.

Depending on conditions, *Zostera marina* grows at a density ranging from 50 to 1761 $shoots{\cdot}m^{-2}$ and produces a dry biomass of 30 to 675 $g{\cdot}m^{-2}$ (SEBJ 1990; Lalumière et al. 1994). Reproductive shoots average 5% of the population but can in some places reach 20%. Blades of the most vigorous plants reach 5 mm in width and 2.5 m in length (Dignard et al. 1991; Lalumière et al. 1994). The density and biomass of the beds vary with location and year in response to the effects of waves and currents, ice, turbidity, water temperature, and illumination (SEBJ 1990; Lalumière et al. 1994). While less dense and productive than beds in Alaska, which have densities of 788 to 5033 $plants{\cdot}m^{-2}$ and biomasses of 186 to 1840 g dry $weight{\cdot}m^{-2}$ (McRoy 1970), the eelgrass beds in James Bay still form the base of major food chains (Curtis 1974/5).

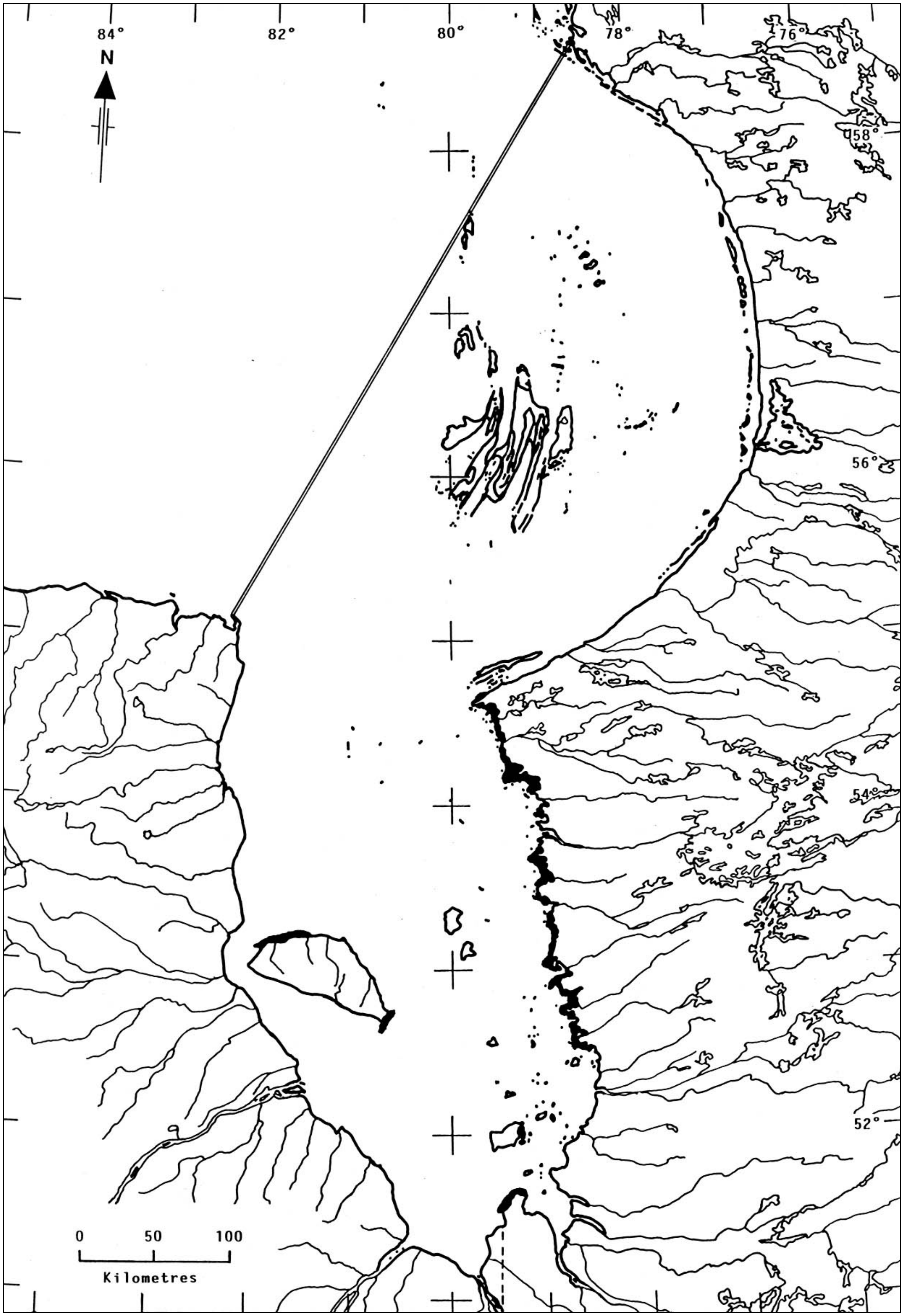

Figure 6-6. Distribution of eelgrass beds in the James Bay marine region (after Curtis 1973c, 1974/5; Dignard et al. 1991).

Eelgrass beds of varying density and size are found along the entire James Bay coastline of the Wemindji Cree territory (Ettinger et al. 1995). These beds vary from dense, nearly continuous fields to thin patches. Cree hunters who use the area extensively have observed increases in the size, density, and number of beds over much of this coastline in recent years. This change has made coastal navigation more difficult but is viewed positively overall, as it provides important food for brant and other waterfowl during their fall migrations. Plants in deeper areas are a dark, rich green and can be up to 9 m long, while those in shallower areas, where they are exposed at low tide, or in low salinity are shorter and a pale or dull green. When the ice breaks up early in the spring the plants grow better and hunters expect to have difficulty travelling in some areas in the late summer and early fall. Travel must be timed to avoid getting stuck in a grass-filled bay at low tide.

The effects of ice on the eelgrass beds are complex and vary with location and year (Ettinger et al. 1995). Ice can be very damaging if the plant's roots are frozen or pulled out or scoured off the bottom. Water depth, ice thickness, local currents, the amount of runoff, spring tides or storm surges, and the timing and speed of breakup can all interact to affect the eelgrass beds. Whether ice promotes eelgrass growth by removing old growth or inhibits it by damaging the beds may depend largely on the depth to which it freezes.

The leaves, seeds, and rhizomes of eelgrass are very important foods for several species of waterfowl (Curtis 1974/5; Curtis and Allen 1976; Dignard et al. 1991; Lalumière et al. 1994; Ettinger et al. 1995). In spring, brant stop on their northward migration to graze on the eelgrass beds through cracks in the sea ice. Canada geese and American widgeons may also exploit this food source. In autumn, the eelgrass is eaten by large numbers of brants and Canada geese, American widgeons, American black ducks, and northern pintails. Diving ducks also frequent the eelgrass beds during their summer moult and in the autumn to feed on epiphytic organisms and other biota (Curtis 1974/5; Dignard et al. 1991). The large concentrations of brants observed in the Pisquamish and North Point areas of the Ontario coast apparently feed on eelgrass that has drifted there from the beds on Akimiski Island (Curtis 1973c). Damage to the eelgrass beds could have serious ecological consequences, particularly for waterfowl (Curtis 1974/5).

Large eelgrass beds have a calming effect on wave action, and stabilize sediments thereby providing shelter and feeding areas for a variety of marine biota (Curtis 1974/5). A variety of molluscs, annelids, cnidarians, and bryozoans grow on the plants; oligochaetes are common in the fine sediment; and the beds provide habitat for juvenile sculpins, Greenland cod, coregonids, and lake trout (SEBJ 1990; Lalumière et al. 1994). The calming effect also enables Cree fishermen to set nets during fairly rough weather in areas protected by eelgrass beds.

6.5 Salt marshes

Salt marshes, as discussed earlier in Section 3.3.1, are widely distributed along the coasts of Canada but are a particularly important and characteristic feature of western James Bay (Figure 6-7). They are also present along the southwestern coast of Hudson Bay, where they tend to be confined to large estuaries and areas protected by barrier islands (Kershaw 1976; D. Punter, Univ. of Manitoba, Winnipeg, pers. comm. 2005). Indeed, the presence of a physical feature that provides protection from wave action is a prerequisite for their occurrence (Long and Mason 1983). Five types of salt marsh have been distinguished on the basis of the form this protection takes: 1) lagoonal marshes (partially enclosed); 2) beach plain marshes (fairly open to wave action); 3) barrier island marshes (partially protected by a chain of offshore islands); 4) estuarine marshes (protected by the estuarine morphology itself); and 5) artificial marshes (made by human activity). At least three of these types (numbers 2, 3 and 4) are found in the Hudson Bay marine ecosystem (Stewart et al. 1993).

Salt marshes are very important to the marine ecosystem for their biological productivity and the habitat they provide other biota (Stewart et al. 1993). They support a large invertebrate population, which in turn supports a large vertebrate fauna including fish, small mammals, and birds. Beds of eelgrass (*Zostera*) are frequently associated with the salt marshes, and occupy the lowest level in the shore slope above the low-tide range (Figure 6-7; Clarke et al. 1982).

Figure 6-7. Distribution of salt marshes in Canada (from Canada 1988, Canadian Wetlands Working Group). Stippling indicates the approximate range of occurrence of salt marsh, not its continuous presence

The importance of salt marsh habitat to migratory birds that visit the shores of western James Bay is well described by Martini et al. (1980b), from which Figure 6-8 is taken. The same paper has an excellent treatment of marsh birds of the whole region, and is quoted at length here. Figure 6-9, also from that paper, shows the localities mentioned in text and the distribution of marshlands and concentrations of bird species. Martini et al. (1980b) write as follows:

> *"**Shorebirds**. The Hudson Bay Lowland supports an extensive avifauna, nearly all of which is migratory. The two most important groups utilizing the coastal flats and marshes are shorebirds and waterfowl.*
>
> *"In general, shorebirds found in James Bay breed in arctic or subarctic areas and undertake long migrations to wintering grounds ranging from the Atlantic and Gulf coasts of the United States of America to the southern parts of South America. Although some of the species breed along coastal and inland areas of James Bay, the coast is most important to shorebirds on migration, and contains areas of outstanding international importance for several species. The most prominent species are the Hudsonian Godwit (*Limosa haemastica*), Red Knot (*Calidris canutus*), and Semipalmated sandpipers (*Calidris pusilla*) which occur along coasts characterized by wide, well developed marshes with extensive short grass (*Pucinellia phryganodes*) zone[s] such as at North Point (NP), Big Piskwanish East (BPE), Chickney Point (CT), Swan River area (SRS) and Nowashe Creek to Lakutsaki River (PNC, and LRS)* [Figure 6-9]. *Recent observation indicates that the Hudsonian Godwit uses staging areas of James Bay to build up fat reserves for a non-stop flight to South America, a distance of at least 5000 kilometres (Morrison and Harrington, 1979).*
>
> *"Both Greater Yellowlegs (*Tringa melanoleucus*) and Lesser Yellowlegs (*Tringa favipes*) occur in large numbers on the James Bay coast, particularly in the stretch of coast between Chickney Point (CT) and the Attawapiskat area, where marshes characterized by long vegetation, especially* Hippurus vulgaris *and* Carex mackenzei *and extensive ponds occur* [Figure 6-9].

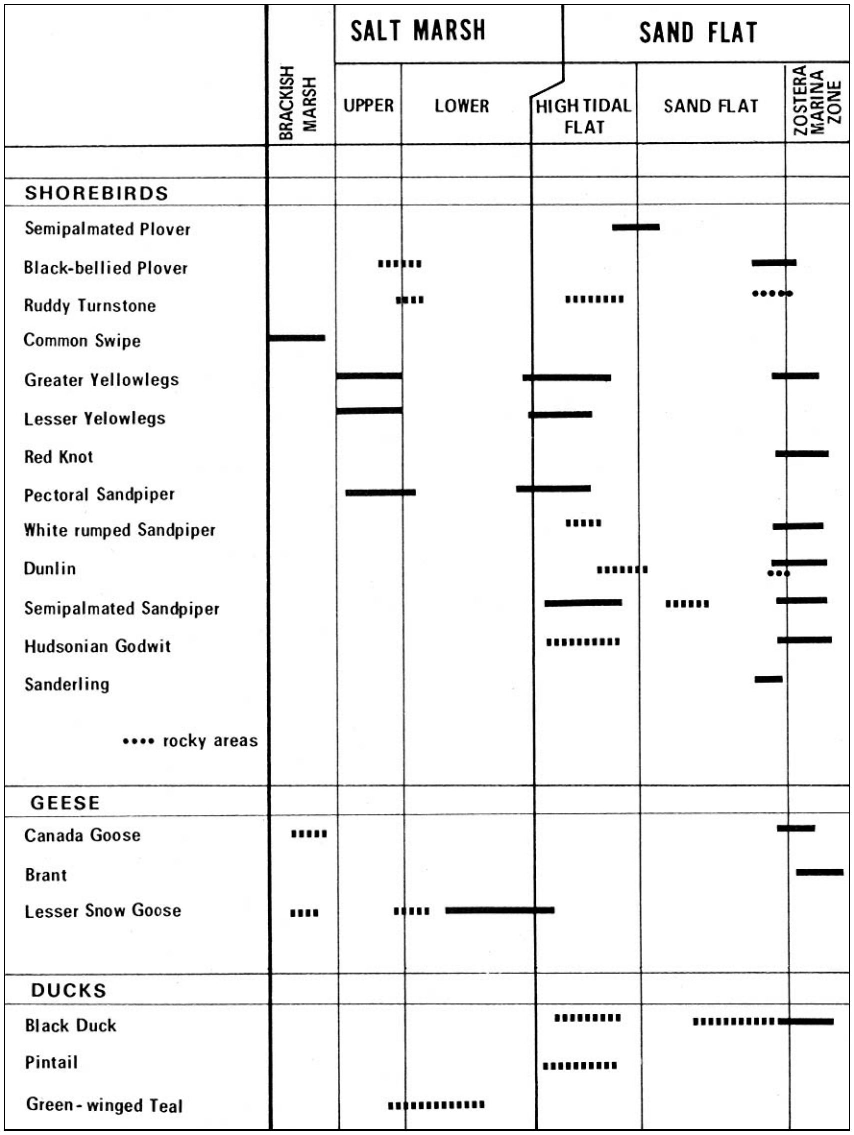

Figure 6-8. Zones of principal habitat use for species of birds on open coastal marshes and tidal flats (from Martini et al. 1980b).

“Other prominent species on the coast include the Black-bellied Plover (Pluvialis squatarola), *Golden Plover* (Pluvialis dominica), *Semipalmated Plover* (Charadrius semipalmatus), *White-rumped Sandpiper* (Calidris fuscicollis), *Least Sandpiper* (Calidris minutilla), *Dunlin* (Calidris alpina), *Sanderling* (Calidris alba), *Pectoral Sandpiper* (Calidris melanotos), *Whimbrel* (Numenius phaeopus), *Marbled Godwit* (Limosa fedoa) *and the Common Snipe* (Gallinago gallinago).

“Most species of shorebirds in James Bay favour well-defined zones of the marsh or flats for feeding and roosting, and resource partitioning on the basis of habitat or food type or size is apparent throughout the shorebird community [Figure 6-8]. *For instance,* Macoma balthica *is a major food resource for several species utilizing the lower intertidal zone, particularly the Hudsonian Godwit and Red Knot, which prey on medium to large size specimens. Smaller size classes of* Macoma balthica *may be taken by Dunlin, Semipalmated Sandpipers and other small Sandpipers when they use this zone. The gastropod* Hydrobia minuta *is also taken regularly by the small Sandpipers and appears to be favoured by the White-rumped Sandpiper, especially when feeding in rocky intertidal zones. Amphipods are also utilized by various species feeding in rocky areas, such as the Dunlin at North Point (NP) and Hudsonian Godwit on northwest Akimiski Island* [Figure 6-9]. *Most Semipalmated Sandpipers feed on the short grass* (Puccinellia

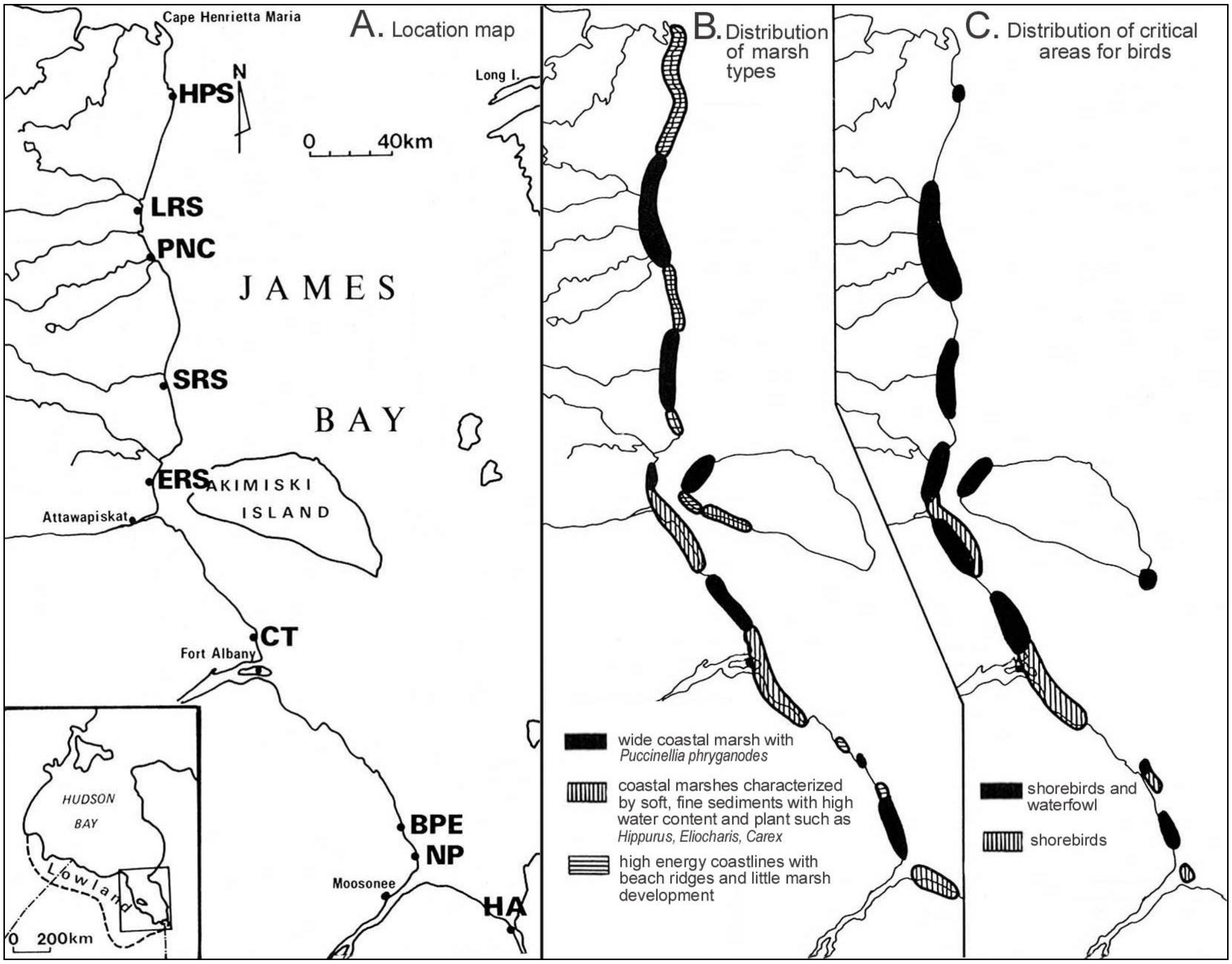

Figure 6-9. **Location map (A), distribution of marsh and coast types (B), and fall concentrations of shorebirds and waterfowl (C) on the west coast of James Bay (adapted from Martini et al. 1980b). Symbols on the location map indicate coastal transects mentioned in text, for example BPE stands for Big Piskwanish East.**

phryganodes*) salt marsh, where they prey on dipteran larvae. Lesser Yellowlegs and Ruddy Turnstones also feed on the swarms of small adult flies inhabiting the short-grass marsh. In central marsh zones, Pectoral Sandpipers and Lesser Yellowlegs are common, the latter feeding on invertebrates of ponds and sometimes on sticklebacks and small fish trapped in pools after tidal inundation.*

"Shorebirds respond sensitively to the distribution of their food resources at several levels: 1) over a wide geographical area: shorebirds numbers observed on aerial surveys are related to food resources as determined at representative transects, 2) over intermediate stretches of coastline (10 to 15 km): distribution of Semipalmated Sandpipers using short-grass saltmarsh habitat is correlated with distribution of food resources (dipteran larvae), and 3) at a local level: distribution of Semipalmated Sandpipers across various zones of the marsh on habitat transects are correlated with distribution of food resources (dipteran larvae). Studies of seasonal abundance of invertebrates indicate that migration of some species is timed to correlate with peak numbers of prey species.

"The significance of the food resources to shorebirds in James Bay lies in their use as materials which the birds convert to fat stores, essential as a food supply to enable long, non-stop flights over inhospitable "ecological barriers" such as boreal forest to the next migration stopover area. Many shorebirds make a direct flight to the Atlantic seaboard from James Bay, the Hudsonian Godwit probably to South America. While in James Bay, the birds feed intensively, distributing themselves across marsh and

> *intertidal areas at low tide, and gathering to rest together, often in large numbers (a few hundred to several thousand) when feeding areas are unavailable at high tide. The availability of suitable resting areas and the type of vegetation of marshes influence shorebird distribution. Areas in central or inner parts of the marsh used extensively in spring by short-legged species become unsuitable for use later in the autumn through growth of vegetation, though changing relative abundance of food resources also affects the pattern of habitat use.*
>
> *"**Waterfowl**. Geese and ducks make heavy use of the James Bay coastal marshes. Canada Geese (*Branta canadensis*) breed in large numbers, though at low densities, in inland marshy areas and are numerous on the coast on migration. Lesser Snow geese (*Chen caerulescens*) are very abundant on migration and there is an extensive colony of some 50-60,000 pairs west of Cape Henrietta Maria* [Figure 6-8 and Figure 6-9]. *This colony is thought to have developed over the past 20-30 years. Brant (*Branta bernicla*) concentrate in areas of the coast where eelgrass (*Zostera marina*) is abundant in the low intertidal zone.*
>
> *"Many species of ducks breed in inland areas and occur in large numbers on the coast on migration. Prominent species include Pintail (*Anas acuta*), Black Ducks (*Anas rubripes*), Green-winged Teal (*Anas carolinensis*), Mallard (*Anas platyrhynchos*), Widgeon (*Mareca americana*), and Scaup (*Aythya *sp.). Large rafts of Scoters (mostly Black Scoters* Melanitta nigra*) in flocks of several hundred to several thousand totalling up to about 40,000 birds are found in the northern part of James Bay from around the Swan River (SRS) to Hook Point (HPS)* [Figure 6-8 and Figure 6-9]. *Mergansers (*Mergus *sp.) and loons (*Gavia *sp.) utilize coastal waters for feeding and inland lakes and ponds for breeding.*
>
> *"Geese and ducks prefer those areas in James Bay characterized by wide coastal marshes with an emergent zone of* Puccinellia phryganodes *and a variety of vegetational associations leading to fresh water inland fens* [Figure 6-8]. *Fall foods of Lesser Snow Geese in James Bay includes 40 species, of which 9 made up 90 per cent of the food items identified (Prevett* et al. *1979).* Triglochin palustris *is the most preferred and consistently selected plant. Other important foods are comprised of sedges (Cyperaceae), arrow grasses (Juncaginaceae), horsetails (Equisetaceae) and grasses (Graminae) (Prevett* et al. *1979).*
>
> *"The impact of the birds on vegetation and sediments is considerable. Geese feeding on plant shoots in the spring may leave areas of marsh uprooted and churned, and marshes in the Cape Henrietta Maria area are closely cropped to the ground after use by flocks of flightless, moulting geese and their young in the autumn. Feeding behaviour and movements of waterfowl in and out of marsh ponds influence the development of pools, the path and shape of drainage creeks, associated vegetational structure, and the thickness and character of marsh sediments."*

In the James Bay region, salt marshes are developed to the greatest extent along the western shore of James Bay and at the head of the bay. Rupert Bay, and the estuary of the Hurricana River, form the eastern and southeast boundary of this salt marsh shore; to the north along the eastern James Bay coast the Shield rock is frequently exposed at the surface (in contrast to the west coast) and the coast itself is bolder and the water somewhat deeper inshore. It is also a skerry coast (see Section 3.3.3; see also chart No. 5800, Canadian Hydrographic Service 1961, updated to 1990. Dignard et al. (1991) have provided a detailed map of salt marsh distribution along the east coast of James Bay north of Rivière du Castor. While salt marshes extend along the southern coast of Hudson Bay west and north to at least Arviat, their distribution has not been documented in detail. Given the ecological importance of this habitat to geese, and the risk of its degradation by geese, salt marsh habitats along the Hudson Bay coast should be mapped in detail.

One area that has been given special attention, apart from western James Bay as a whole, is North Point (Glooschenko 1978; Clarke et al. 1982). These authors raise a point that is extremely important in northern ecology as a whole, marine and terrestrial, namely the phenomenon of seasonality in high latitudes. With respect to salt marshes, Clarke et al. (1982) write:

> *"The physicochemical properties of the intertidal and salt marsh sediments are strongly influenced by tides, and many exhibit lateral gradients associated with the frequency and duration of tidal inundation. Negative correlations between sand and silt content ($r = -0.846$, $P<0.001$), and positive correlations between clay content and elevation ($r = 0.7097$, $P<0.01$) reflect the well developed sequence of landward fining in grain size which is directly related to tidal deposition. In the salt marsh the sediments are also affected by vegetation, topography and drainage pattern. Strong seasonal changes occur in chemical properties of the sediments, but there are nonetheless well-defined trends. Elevation of the marsh is positively correlated with organic carbon content ($r = 0.613$, $P<0.01$), and negatively correlated with pH ($r = -0.780$, $P<0.001$) and electrical conductivity, although this last variable varies greatly depending on tidal inundation, precipitation and evaporation. There exist strong lateral differences in average Eh [oxidation-reduction potential] which are associated with drainage patterns. Reducing conditions are consistently recorded in marsh zones which retain standing water, have high electrical conductivities and are subject to frequent tidal inundation."*

Interactions between grazing geese and salt marsh vegetation and soils have been the subject of intensive research at La Pérouse Bay, on the southwestern coast of Hudson Bay (e.g., Jones and Hanson 1983; Jones et al. 1985; Williams et al. 1993; Jefferies et al. 1995, 2002, 2003, 2004; Abraham et al. 1996; Ganter et al. 1996; Johnson 1996a+b; Jefferies 1997, 1998, 2000; Kotanen and Jefferies 1997; Jano et al. 1998; Forbes and Jefferies 1999; Wilson et al. 1999; Chang et al. 2000, 2001; Handa and Jefferies 2000; Handa et al. 2002; Henry and Jefferies 2002; Jefferies and Rockwell 2002; Kotanen 2002; Srivistava and Jefferies 2002), in Polar Bear Provincial Park (Abraham et al. 1998), and near the McConnell River (MacInnes and Kerbes 1987; Kerbes et al. 1990; Abraham and Jefferies 1997). The primary purpose of this work has been to assess the effect of goose foraging on the salt marsh and its ability to sustain burgeoning goose populations.

At low population densities goose foraging acts to increase the primary production of intertidal salt marshes, whereas at high population densities it decreases production (Jefferies et al. 2004). The mid-continent lesser snow goose population increased sharply between 1971 and 1999, and remains large, although the implementation of spring hunts in the United States and southern Canada in 1999, and possibly declining reproductive success, appear to be limiting further growth. The high goose populations continue to damage salt marsh nesting habitats in southwestern Hudson Bay (Ganter et al. 1996; Kotanen and Jefferies 1997; Jano et al. 1998; Jefferies et al. 2002, 2003, 2004). Continued foraging has led to loss of vegetation cover and changes in species composition and soil condition in these marshes (Kerbes et al. 1990; Chang et al. 2001; Handa et al. 2002). Foraging geese remove the graminoids and short grasses by grubbing, and lyme grass (*Elymus mollis)* by shoot pulling (Ganter et al. 1996). This exposes the sediments and adversely affects reproductive success among the geese by reducing food availability (Williams et al. 1993; Jefferies et al. 1995; Ganter et al. 1996). If continued it leads to habitat abandonment. Large salt marsh swards have been converted to hypersaline (3x saltwater) mudflats that are very slow to revegetate, even in the absence of grazing, except in moist intertidal areas (Forbes and Jefferies 1999; Handa and Jefferies 2000; Jefferies and Rockwell 2002). Low soil temperatures, hypersaline conditions at the soil surface, limited nitrogen availability, and other factors interact to limit the rate of revegetation (Wilson et al. 1999). The extent of the salt marsh damage is considerable, and its progress has been followed using satellite imagery (Jano et al. 1998). This degradation also appears to decrease the species richness of aquatic invertebrate assemblages in the associated supratidal, vernal ponds (Milakovic et al. 2001). Despite damage to their nesting habitat, there is little or no evidence that a sharp decline (crash) in the goose population is imminent (Jefferies et al. 2002).

6.6 Summary

While the marine flora of the Hudson Bay marine ecosystem has been subject to detailed study in areas subject to environmental changes from hydroelectric developments or habitat degradation, it is still poorly known overall. This is particularly so for the area north and west of the Belchers, western James Bay, and Richmond Gulf; for the winter season; and for biological productivity and species distribution. Little is known of the species composition of the water column, seafloor, or sea ice; or how species distribution, abundance, or productivity change with the seasons—particularly offshore.

Hudson Bay and James Bay are remarkable in having a diverse phytoplankton, impoverished bottom flora with few seed plants, and freshwater taxa offshore in the summer--most of which are related to the presence of annual ice cover. A subpycnocline chlorophyll ***a*** maximum occurs in the offshore waters of Hudson Bay in the summer. James Bay is unusual among Canada's Arctic marine regions in having rich eelgrass beds and extensive salt marshes that provide critical habitat for migratory birds and other species. Significant degradation of salt marsh habitats has occurred along the southwestern coast of Hudson Bay as the result of foraging by the burgeoning population of nesting lesser snow geese.