

Late-glacial marine invertebrate macrofossils from Point Lepreau, New Brunswick

Randall F. Miller et Jeffrey H. McGovern

Volume 33, numéro 3, fall 1997

URI : https://id.erudit.org/iderudit/ageo33_3art02

[Aller au sommaire du numéro](#)

Éditeur(s)

Atlantic Geoscience Society

ISSN

0843-5561 (imprimé)

1718-7885 (numérique)

[Découvrir la revue](#)

Citer cet article

Miller, R. F. & McGovern, J. H. (1997). Late-glacial marine invertebrate macrofossils from Point Lepreau, New Brunswick. *Atlantic Geology*, 33(3), 217-221.

Résumé de l'article

La datation par le radiocarbone a situ A 13 500 ans BP une faune invertebrée tardiglaciaire de la pointe Lepreau, ou Nouveau-Brunswick. L'assemblage renferme des mollusques et des bernacles subarctiques à bordeaux bien conservés caractéristiques des dépôts marins du Pleistocène tardif de la région. Les spécimens rares d'oursins, de crabes et d'ophiures pourraient constituer les manifestations les plus anciennes de la présence de ces animaux récents dans la région tardiglaciaire de la baie de Fundy. L'assemblage se situe à l'intérieur de l'assemblage d'invertébrés marins tardiglaciaires de la zone 3 antérieurement défini dans la région de la baie de Fundy et du golfe du Maine, caractérisé en tant qu'assemblage arctique hétérogène.

[Traduit par la rédaction]

Late-glacial marine invertebrate macrofossils from Point Lepreau, New Brunswick

Randall F. Miller and Jeffrey H. McGovern

*Steinhammer Palaeontology Laboratory, New Brunswick Museum,
277 Douglas Avenue, Saint John, New Brunswick E2K 1E5, Canada*

Date Received April 14, 1997

Date Accepted July 14, 1997

A late-glacial shell fauna from Point Lepreau, New Brunswick produced a radiocarbon date of 13,500 years B.P. The assemblage contained well-preserved subarctic to boreal molluscs and barnacles typical of late Pleistocene marine deposits from the region. Rare specimens of sea urchin, crab and brittlestar may be the oldest recorded occurrence of these animals in the late-glacial Bay of Fundy. The assemblage fits into a previously defined Zone 3, late-glacial marine invertebrate assemblage in the Bay of Fundy-Gulf of Maine region, characterized as a Diverse Arctic assemblage.

La datation par le radiocarbone a situé à 13 500 ans BP une faune invertébrée tardiglaciaire de la pointe Lepreau, ou Nouveau-Brunswick. L'assemblage renferme des mollusques et des bernacles subarctiques à boréaux bien conservés caractéristiques des dépôts marins du Pléistocène tardif de la région. Les spécimens rares d'oursins, de crabes et d'ophiures pourraient constituer les manifestations les plus anciennes de la présence de ces animaux relevées dans la région tardiglaciaire de la baie de Fundy. L'assemblage se situe à l'intérieur de l'assemblage d'invertébrés marins tardiglaciaires de la zone 3 antérieurement défini dans la région de la baie de Fundy et du golfe du Maine, caractérisé en tant qu'assemblage arctique hétérogène.

[Traduit par la rédaction]

INTRODUCTION

Late-glacial marine invertebrate fossils occur in marine sediments that fringe the modern shoreline of New Brunswick. The earliest observations of Quaternary marine invertebrate fossils were made by Abraham Gesner during his geological survey of New Brunswick (Gesner, 1840, 1841) in which he noted shells, including *Mya*, *Pecten* and *Mytilus*, from clays found in the Saint John region. The first comprehensive list of Quaternary marine invertebrate fossils was compiled by C.F. Hartt and published in Loring Bailey's *Observations on the Geology of Southern New Brunswick* (Hartt, 1865). One of the best exposures occurs at Sheldon Point in west Saint John (Rampton *et al.*, 1984) where mollusc shell dates range from 13,900 ± 620 (GSC-3354) to 11,620 ± 250 years B.P. (BGS-1223) (Walton *et al.*, 1961; Gadd, 1973; Blake, 1983; Rampton *et al.*, 1984; Nicks, 1991). A rich invertebrate assemblage, recently discovered at the Point Lepreau Generating Station (Fig. 1), includes common mollusc species found in New Brunswick (Nicks, 1991; Seaman *et al.*, 1993), but also specimens of sea urchin, crab and brittlestar, that may be the oldest recorded late-glacial occurrence of these animals in the Bay of Fundy. An excellent overview of marine molluscs in glaciated North America during the last 18,000 years by Dyke *et al.* (1996) provides a framework for characterizing the Point Lepreau assemblage.

LOCATION AND STRATIGRAPHY

Quaternary marine clays near Saint John form thick red deposits interbedded with sandy layers (Gadd, 1973; Rampton *et al.*, 1984). Molluscs, barnacles, ostracodes, foraminifera, and, less commonly, crabs, sea urchins, and brittlestars are found in red marine clay. In May, 1995, excavations at the Point Lepreau Generating Station (45°04'10"N, 66°27'30"W) exposed a fossiliferous band 20 to 100 cm thick, within marine clay, about 24 m above mean sea level. Collections made by M. Fairweather and M. Mersereau of the Point Lepreau Generating Station were turned over to the New Brunswick Museum for identification. No opportunity was available to examine the site before it was covered. Access to the site may become possible if construction resumes in a few years. Description of the site suggests samples were recovered from a narrow embayment enclosed by bedrock on three sides (M. Mersereau, personal communication, 1997). The samples contained a rich assemblage of invertebrate fossils. Sample blocks preserved intact suggest a death assemblage, although articulated valves of *Hiatella arctica* and *Portlandia arctica* may indicate relatively short transport. About 25 to 30 kg of fossiliferous sediment was soaked in water and washed through a 40 mesh sieve to recover hundreds of macrofossils (Table 1). Some untreated samples were retained. All specimens are in the New Brunswick Museum palaeontology collection. A 40 g sample of the pelecypod *Hiatella arctica*

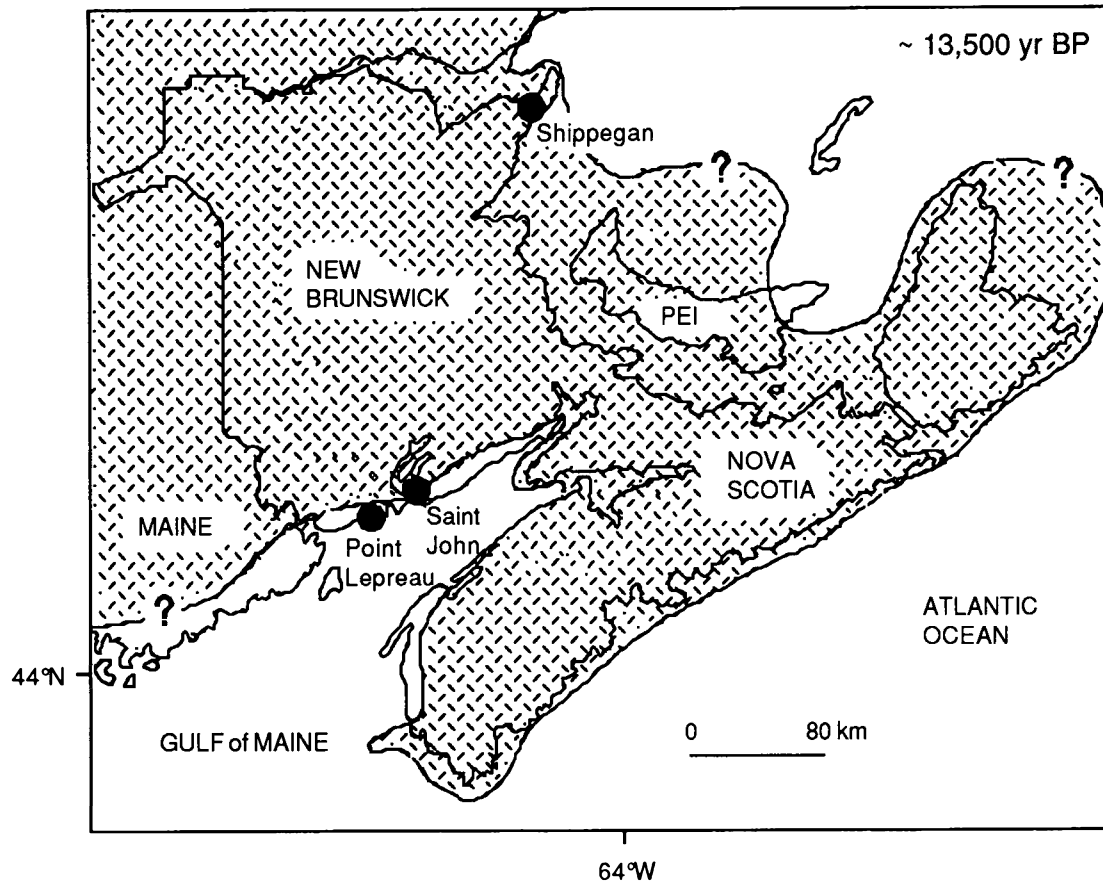


Fig. 1. Location of late-glacial marine invertebrates from Point Lepreau, Saint John and Shippegan, New Brunswick. Approximate glacial ice cover, shown at about 13,500 years B.P., compiled from Rampton *et al.* (1984), Stea *et al.* (1992) and Dyke *et al.* (1996).

produced a corrected radiocarbon date of $13,500 \pm 100$ years B.P. (WAT-2980). To make this comparable to Geological Survey of Canada radiocarbon data, such as those used in Dyke *et al.* (1996), a second marine reservoir correction of -400 years should be applied.

RESULTS

The assemblage of marine invertebrate fossils recovered from Point Lepreau (Table 1) is dominated by molluscs and contains species commonly reported from late-glacial marine assemblages in New Brunswick (Nicks, 1991; Seaman *et al.*, 1993). The pelecypod *Hiatella arctica*, some with valves still articulated, comprised almost 80 percent of the mollusc assemblage, with the clams *Portlandia arctica* and *Macoma calcarea* being fairly common and comprising about 16 percent of the molluscs. A specimen of snail, *Retusa obtusa*, is rarely encountered in late-glacial deposits in New Brunswick. The only other regional late-glacial occurrences of *R. obtusa* found in the literature are from Sheldon Point, Saint John (Welsted, 1976; Nicks, 1991) and Champlain Sea deposits near Rivière des Chutes, Québec (Wagner, 1970).

The barnacle *Balanus crenatus* was also common, although minimum numbers are difficult to assess. Foraminifera, ostracode, snail, brittlestar, sea urchin and crab remains were rare, but their occurrence indicates a relatively

diverse assemblage. Although the sea urchin *Strongylocentrotus droebachiensis* and the brittlestar *Ophiura sarsi* have been described from deposits along the Bay of Fundy (Miller and McAlpine, 1991), they have never been recorded from a dated assemblage. Their appearance at Point Lepreau represents the earliest late-glacial occurrence of these echinoderms in the Bay of Fundy. Likewise, the occurrence of a 'spider' crab, likely *Hyas araneus* or *H. coarctatus*, is the earliest record from the Family Majidae in the Bay of Fundy.

The modern ecology and distribution of the identified species indicates a predominately subarctic to boreal assemblage (Dyke *et al.*, 1996). Some species exhibit wide ranges in distribution from the Arctic to the Caribbean. Southern populations, south of the Gulf of Maine-Bay of Fundy, usually occur in deeper water. The ecology and western Atlantic distribution of species is summarized below.

Buccinum (tenuis) scalariforme, is an arctic to boreal snail found south to Maine (Abbott, 1974; Dyke *et al.*, 1996). It is commonly found in waters from 15 to 180 m deep. Members of this genus of whelk are carnivorous.

Retusa obtusa, the arctic barrel-bubble, is a small snail (3 mm long) that occurs from the Arctic seas to waters off North Carolina. It lives on muddy or sandy bottoms of colder waters from low tide level to 500 m (Bousfield, 1960; Abbott, 1974).

Table 1. List of late-glacial marine invertebrate macrofossils from Point Lepreau, New Brunswick.

Taxa	Relative abundance (minimum # individuals)	Modern Distribution
MOLLUSCA		
Gastropoda		
<i>Buccinum scalariforme</i> Möller	rare (6)	arctic-boreal
cf. <i>Retusa obtusa</i> (Montagu)	rare (2)	arctic-boreal
Pelecypoda		
<i>Hiatella arctica</i> (Linné)	common (466)	arctic-subarctic
<i>Macoma calcarea</i> (Gmelin)	common (47)	arctic-subarctic
<i>Mya truncata</i> Linné	rare (4)	arctic-subarctic
<i>Nucula tenuis</i> (Montagu)	rare (17)	subarctic-boreal
<i>Portlandia arctica</i> (Gray)	common (48)	arctic
ARTHROPODA		
Cirripedia		
<i>Balanus crenatus</i> Bruguière	common (>>1)	widespread
Decapoda		
cf. <i>Hyas araneus</i> (Linnaeus) or <i>H. coarctatus</i> Leach *	rare (5)	subarctic-boreal
ECHINODERMATA		
Ophiuroidea		
cf. <i>Ophiura sarsi</i> Lutken	rare (1)	subarctic-boreal?
Echinoidea		
<i>Strongylocentrotus droebachiensis</i> Muller	rare (1)	widespread

*Specimens probably belong to the Family Majidae, Subfamily Oregoniinae which includes three species *Chionoecetes opilio*, *Hyas coarctatus* and *Hyas araneus*.

Hiatella arctica is a common cold water clam that occurs from the Arctic to deeper water in the West Indies. It nests in kelp holdfasts and rock crevices from low tide to 180 m (Gosner, 1979). It is largest, up to about 5 cm long, in the coldest seas (Rogers, 1936). The maximum valve length recorded from Point Lepreau was 3.8 cm.

Mya truncata is found from the Arctic to Cape Cod. It occurs in the lower intertidal zone in the north. South of the Bay of Fundy it occurs from the subtidal zone to depths of 30 m (Gosner, 1979).

Nucula tenuis occurs from Labrador south to Maryland. Nut shells are common on muddy bottoms of bays and sounds where they are preyed upon by fish (Gosner, 1979).

Portlandia arctica is an arctic species of clam found in the Arctic Ocean and near Greenland, south to Hamilton Inlet, Labrador. It is found in deeper waters only in the subarctic (Dyke *et al.*, 1996).

Macoma calcarea is a cold water clam that occurs from Greenland to Long Island. It is found from the subtidal to 75 m (Bousfield, 1960).

Balanus crenatus is a widespread barnacle found from the Arctic to New Jersey. It is a common subtidal species found from low tide level to more than 90 m (Bousfield, 1960).

Hyas araneus and *H. coarctatus* are 'spider' crabs that have a subarctic to boreal distribution in the western Atlantic south to the Gulf of Maine. *H. coarctatus* is found in Hudson Bay while *H. araneus* occurs in waters off Greenland (Squires, 1990). They are found in waters from depths of 0 to 1,650 m and 0 to 360 m, respectively, on hard, stony, sandy and soft bottom sediments, although *H. araneus* is more common on soft sediment. These crabs are known to have a varied diet that includes many of the kinds of organisms recovered from the Point Lepreau site. Stomach contents from modern *Hyas* have included phytobenthos, crustacean fragments (amphipods and ostracodes), small crabs, hermit crabs,

polychaetes, foraminiferans, brittle stars, bivalves, gastropods, chitons and sea urchins. *Chionoecetes opilio*, the third member of the Subfamily Oregoniinae, has a similar distribution and habit to species of *Hyas* (Williams, 1984; Squires, 1990).

Strongylocentrotus droebachiensis is a widespread, euryhaline echinoid extending to the high Arctic. It is a common subtidal benthic animal found from intertidal pools to depths of almost 1,000 m (Miller and Bishop, 1973). It feeds on a variety of non-calcareous algae such as *Laminaria*, and is preyed upon by lobsters, crabs, starfish, birds and fish (Himmelman and Steele, 1971). Laboratory studies have determined that 10°C is the upper limit for larval growth and that its distribution correlates well with this experimental value. It is found in seas where temperature during the spring rarely exceed 6 to 8°C.

Ophiura sarsi can be found on mud bottoms from the intertidal zone to depths of about 3,000 m. It is commonly reported from depths of 70 to 140 m. In the North Atlantic it occurs from Greenland to as far south as Georgia. Thorson (1971) described typical *O. sarsi* communities in waters near Denmark. In the sublittoral zone it was associated with bivalves, amphipods, acorn worms, sea mice and bristle worms.

DISCUSSION

Beginning about 14,000 years ago glacier ice retreated from New Brunswick leaving most of the province ice-free by 12,000 years B.P. Proposed ice margins from 14,000 to 13,000 vary widely between authors (Rampton *et al.*, 1984; Stea *et al.*, 1992; Dyke *et al.*, 1996), but some place the glacier front near the present New Brunswick, Bay of Fundy coast 13,500 to 13,000 years ago (Fig. 1). Most marine sediments fringing the coastline were likely deposited before 12,300 years B.P. (Rampton *et al.*, 1984). The oldest radiocarbon date establishing the opening of the Bay of Fundy at 14,400 ± 530 years B.P. (GSC-2573) comes from *Hiatella arctica* specimens found near Mispec, Saint John (Lowden and Blake, 1979). Nicks (1991) reported a date of 13,900 ± 620 years B.P. (GSC-3354) on *Hiatella arctica* shells from Sheldon Point in Saint John. *Hiatella arctica* shells from Point Lepreau described here were dated as 13,500 years B.P., one of the oldest dates for the Bay of Fundy.

The marine fossil assemblage described from Sheldon Point, not far from Point Lepreau (Fig. 1), is the best-documented late-glacial shell site in New Brunswick. Gadd (1973) suggested a nearshore intertidal environment for the Sheldon Point deposit. Nicks (1991) described the deposit as a glaciomarine end moraine, a time transgressive sequence (14,000 to 10,000 years B.P.) from a tidewater glacier to subaerial exposure. Molluscs include a number of 'cold' water species like *Hiatella arctica*, *Macoma calcarea*, and *Portlandia arctica* (Gadd, 1973). Most of the marine mollusc species can be described as subarctic to boreal species (Gosner, 1979). Gadd (1973) noted the lack of warmer water species such as

oysters, scallops and sea urchins in the fauna. In the same paper, results presented from ostracode analysis suggested very cold, shallow water.

Eight 'mollusc zones' were recognized by Nicks (1991) for the late glacial deposits of southern New Brunswick and Maine. Zone 2 (14,000 - 13,500 years B.P.) was characterized by *Hiatella arctica* and *Portlandia arctica*. Zones 3 (13,500 - 12,900 years B.P.) and 4 (12,900 - 12,500 years B.P.) were comprised of a more diverse fauna suggesting an amelioration in climatic conditions and possibly a stratification of the water column to produce an upper less saline horizon with salinity as low as 5‰. Zone 3 included both *H. arctica* and *P. arctica*, plus *Clinocardium ciliatum*, *Macoma balthica*, *M. calcarea*, *Mya truncata*, *Retusa obtusa*, the gastropod *Neptunea despecta tornata* and barnacles identified as *Balanus* sp. Zone 4 lacked the species *H. arctica* and *M. truncata*, but included *Mya arenaria*, *Mytilus edulis*, *Nuclula expansa*, *Serripes groenlandicus* and the gastropod *Buccinum tenue*. Zone 5 (12,500 - 12,100 years B.P.) contained molluscs that suggest still warmer conditions and a lack of year round sea-ice cover. Although the assemblage at Point Lepreau straddles the time frames of Zones 2 to 3, the varied fauna suggests it is equivalent to Zone 3. The Point Lepreau assemblage also includes species described in Zone 4, plus crab and sea urchin fossils not recorded by Nicks (1991).

Dyke *et al.* (1996) described a subarctic molluscan faunistic zone in the Gulf of Maine-Bay of Fundy region from 14,000 to 13,000 years B.P. They believed that during this interval the boreal zone expanded northward, possibly due to decreased meltwater flux through the Gulf of Maine by 13,000 years B.P., but that the more ice-proximal Bay of Fundy retained an arctic aspect. Interpretation of the Point Lepreau assemblage is consistent with this model. Molluscs from Point Lepreau are arctic, arctic-subarctic and arctic-boreal in distribution. Arthropods and echinoderms from this site have widespread to arctic-subarctic distributions (Table 1). The assemblage from Point Lepreau is similar to the Diverse Arctic assemblage described by Dyke *et al.* (1996), dominated by *Hiatella arctica* and *Mya truncata*, but including, among other species, *Macoma calcarea* and *Portlandia arctica*.

Bousfield and Thomas (1975) speculated on late-glacial and postglacial changes in near-surface ocean temperatures based on the distribution of modern littoral marine invertebrates in the Maritimes. Their data demonstrated that between 13,000 and 12,000 years B.P., as ice retreated from most of New Brunswick, water temperatures adjusted to changing currents and sea levels. During this time the Strait of Belle Isle opened to allow cold subarctic (< 12°C summer) waters to penetrate along the St. Lawrence River valley and into the Champlain Sea. They estimated that temperatures in the Bay of Fundy by about 12,500 years B.P. were less than 12°C in summer.

Invertebrate fossils are reasonably common in late-glacial marine sediments along the New Brunswick coastline (Rampton *et al.*, 1984). Pelecypods dominate most assemblages and barnacles are often common. Although few brittlestar and sea urchin remains are known (Miller and McAlpine, 1991),

both were noted from Saint John as early as 1865 (Hartt, 1865). The Sheldon Point-Duck Cove-Sand Cove locality in west Saint John has been the principal source of brittlestars. Specimens in the New Brunswick Museum record crab occurrences at Sheldon Point, Duck Cove, and Red Head in Saint John, although some may be modern contaminants. The only late-glacial occurrence of crab (*Cancer irroratus*) and sea urchin (*Strongylocentrotus droebachiensis*) fossils in New Brunswick that have been dated, other than at Point Lepreau, are from a deposit near Shippegan (Thomas *et al.*, 1973). In addition to sea urchins and crabs, this site contained a diverse assemblage of clams and snails. Radiocarbon dating of *Mytilus edulis* shells produced a date of 12,600 ± 400 years B.P., making the assemblage time equivalent to Zone 4 (Nicks, 1991). At 13,000 years B.P., Dyke *et al.* (1996) show the Bay of Chaleur-Gulf of St. Lawrence region part of the same subarctic faunistic zone as the Bay of Fundy. By 12,000 years B.P., when the Bay of Fundy was well within the boreal faunistic zone, the Shippegan site was still near the subarctic-boreal boundary. It would be reasonable to suspect a more diverse fauna to appear earlier in the Gulf of Maine-Bay of Fundy region. *Cancer irroratus* has a modern distribution described as boreal, extending from just south of the Gulf of Maine to the Strait of Belle Isle. Species of *Hyas coarctatus*, *Hyas araneus* and *Chionoecetes opilio* are considered subarctic-boreal and are found from the Gulf of Maine north to waters off Greenland or in Hudson Bay. Based on their modern ecology and distribution one might expect these would be among the first species of crab to populate the Bay of Fundy following deglaciation.

ACKNOWLEDGEMENTS

Thanks are extended to the staff of N.B. Power Lepreau Generating Station for their help. M. Fairweather and M. Mersereau recognized the importance of the material and collected the samples during the construction work. K. Duguay arranged for financial support of radiocarbon dating through N.B. Power Lepreau Generating Station. A.S. Dyke and S.K. Donovan provided helpful reviews of the manuscript.

ABBOTT, R.T. 1974. American Seashells, 2nd edition. Van Nostrand Reinhold, New York, 663 p.
 BLAKE, W., JR. 1983. Geological Survey of Canada radiocarbon dates XXIII. Geological Survey of Canada, Paper 83-7, 34 p.
 BOUSFIELD, E.L. 1960. Canadian Atlantic Sea Shells. National Museum of Canada, Ottawa, 72 p.
 BOUSFIELD, E.L. and THOMAS, M.L.H. 1975. Postglacial changes in distribution of littoral marine invertebrates in the Canadian Atlantic Region. Proceedings of the Nova Scotia Institute of Science, 27, Supplement 3, pp. 47-60.
 DYKE, A.S., DALE, J.E., and MCNEELY, R.N. 1996. Marine molluscs as indicators of environmental change in glaciated North America and Greenland during the last 18,000 years. Géographie physique et Quaternaire, 50, pp. 125-184.
 GADD, N.R. 1973. Quaternary geology of southwest New Brunswick with particular reference to Fredericton area. Geological Survey of Canada, Paper 71-34, 31 p.

GESNER, A. 1840. Second Report on the Geological Survey of the Province of New Brunswick. Henry Chubb, Saint John, 76 p.
 ----- 1841. Third Report on the Geological Survey of the Province of New Brunswick. Henry Chubb, Saint John, 88 p.
 GOSNER, K.L. 1979. A Field Guide to the Atlantic Seashore. The Peterson Field Guide Series. Houghton Mifflin, Boston, 329 p.
 HARTT, C.F. 1865. List of New Brunswick fossils. In Observations on the Geology of Southern New Brunswick, Appendix B. Edited by L.W. Bailey. G.E. Fenety, Fredericton, pp. 143-147.
 HIMMELMAN, J.H. and STEELE, D.H. 1971. Foods and predators of the green sea urchin *Strongylocentrotus droebachiensis* in Newfoundland waters. Marine Biology, 9, pp. 315-322.
 LOWDEN, J.A. and BLAKE, W., JR. 1979. Geological Survey of Canada radiocarbon dates XIX. Geological Survey of Canada, Paper 79-7, 58 p.
 MILLER, R.F. and McALPINE, D.F. 1991. A review of echinoderms from Pleistocene marine deposits near Saint John, New Brunswick. Atlantic Geology, 27, pp. 111-117.
 MILLER, R.J. and BISHOP, C.A. 1973. A Sea Urchin Fishery for Eastern Canada. Fisheries and Marine Service, Biological Station, St. John's, Newfoundland, Circular 19.
 NICKS, L.P. 1991. The study of the glacial stratigraphy and sedimentation of the Sheldon Point Moraine, Saint John, New Brunswick. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Open File Report 91-12, 171 p.
 RAMPTON, V.N., GAUTHIER, R.C., THIBAUT, J., and SEAMAN, A.A. 1984. Quaternary Geology of New Brunswick. Geological Survey of Canada, Memoir 416, 77 p.
 ROGERS, J.E. 1936. The Shell Book. Charles T. Branford, Boston, 503 p.
 SEAMAN, A.A., BROSTER, B.E., Cwynar, L., LAMOTHE, M., MILLER, R.F., and THIBAUT, J.J. 1993. Field Guide to the Quaternary Geology of Southwestern New Brunswick. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Open File Report 93-1, 102 p.
 SQUIRES, H.J. 1990. Decapod Crustacea of the Atlantic coast of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences, 221, 532 p.
 STEA, R.R., CONLEY, H., and BROWN, Y. 1992. Surficial Geology of the province of Nova Scotia. Nova Scotia Department of Natural Resources, Map 92-3, Scale 1: 500 000.
 THOMAS, L.H., GRANT, D.R., and DE GRACE, M. 1973. A late Pleistocene marine shell deposit at Shippegan, New Brunswick. Canadian Journal of Earth Sciences, 10, pp. 1329-1332.
 THORSON, G. 1971. Life in the Sea. McGraw-Hill, Toronto, 256 p.
 WAGNER, F.J.E. 1970. Faunas of the Pleistocene Champlain Sea. Geological Survey of Canada Bulletin, 181, 104 p.
 WALTON, A., TRAUTMAN, M.A., and FRIEND, J.P. 1961. Isotopes Inc., radiocarbon measurements I. American Journal of Science, Radiocarbon Supplement, 3, pp. 47-59.
 WELSTED, J. 1976. Post-glacial emergence of the Fundy Coast: An analysis of the evidence. Canadian Geographer, 20, pp. 367-383.
 WILLIAMS, A.B. 1984. Shrimps, lobsters, and crabs of the Atlantic coast of the eastern United States, Maine to Florida. Smithsonian Institution Press, Washington, 550 p.