ECOSYSTEM OVERVIEW OF THE RICHIBUCTO WATERSHED IN NEW BRUNSWICK

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ABSTRACT

Turcotte-Lanteigne, A. et Ferguson, E. 2008. Ecosystem Overview of the Richibucto Watershed in New Brunswick. Can. Manus. Rep. Fish. Aquat. Sci. 2847: xiv + 167 p.

The Richibucto Bay watershed, located in the central eastern portion of New Brunswick, flows into the Northumberland Strait, which is part of the greater ecosystem of the Gulf of St Lawrence. This region is influenced by a modified continental climate. Located primarily within the coastal plain, the watershed is characterized by a relatively low terrain on a sandstone substrate, leveling out as it approaches the sea. The freshwater tributaries, the estuary and the bay which is separated from the Strait by barrier dunes, are rich in biodiversity and contain many highly productive habitats. They are used by a number of fish species as spawning grounds and rearing and feeding habitats. The human population regroups people of French, English and First Nations descent. They depend largely on the exploitation of natural resources as their source of income. Fishing, aquaculture, forestry, agriculture and peat harvesting are carried out in the watershed. As elsewhere, human activities influence the health of the ecosystem. The main issues of concern originate from the introduction of nutrients and sediments in the watershed. Many areas are closed to shellfish harvesting because of bacterial contamination and many tributaries are particularly affected by sedimentation, showing high levels of turbidity.

RESUME

Le bassin versant de la baie de Richibucto est situé dans la partie à l'est et au centre du Nouveau-Brunswick. Il se déverse dans le détroit de Northumberland et fait parti du plus grand écosystème du golfe Saint-Laurent. Situé principalement dans une plaine côtière, il est caractérisé par un terrain peu élevé situé principalement sur un substrat de grès peu résistant qui se dénivelle graduellement vers la mer. La baie est séparée du détroit par des flèches littorales. La région est influencée par un climat continental modifié. La baie, l'estuaire et les cours d'eau douce sont riches en biodiversité, comprenant divers habitats de haute productivité. Nombreuses espèces de poissons s'en servent comme zones de frai, aires d'alevinage et aires nourricières. La population de la région regroupe des francophones, des anglophones et des autochtones. Celle-ci dépend principalement des ressources naturelles comme source d'emploi. La pêche, l'aquaculture, la foresterie, l'agriculture et l'exploitation de la tourbe se pratiquent dans le bassin versant. Comme ailleurs, les activités humaines influencent la santé de l'écosystème. La plupart des enjeux du bassin versant découlent de l'introduction de nutriments et de sédiments dans le plan d'eau. Plusieurs secteurs sont fermés à la récolte de mollusques, et ce dû à la contamination bactérienne. De nombreux tributaires sont particulièrement affectés par la sédimentation et démontrent des taux élevés de turbidité.

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PREFACE

Under Canada's Action Plan for Oceans (2005), the Oceans and Habitat Division of the DFO Gulf Region is facilitating the development of ecosystem overview reports (EORs) at the community coastal management area level. Local watershed / community groups are collaborating in the production of their respective ecosystem overview report. Several of these reports have been developed for coastal ecosystems located in the southern Gulf of Saint Lawrence. These overviews will serve as the baseline tools in the integrated management process of these coastal zones. The present document is part of a series of reports produced to this effect.

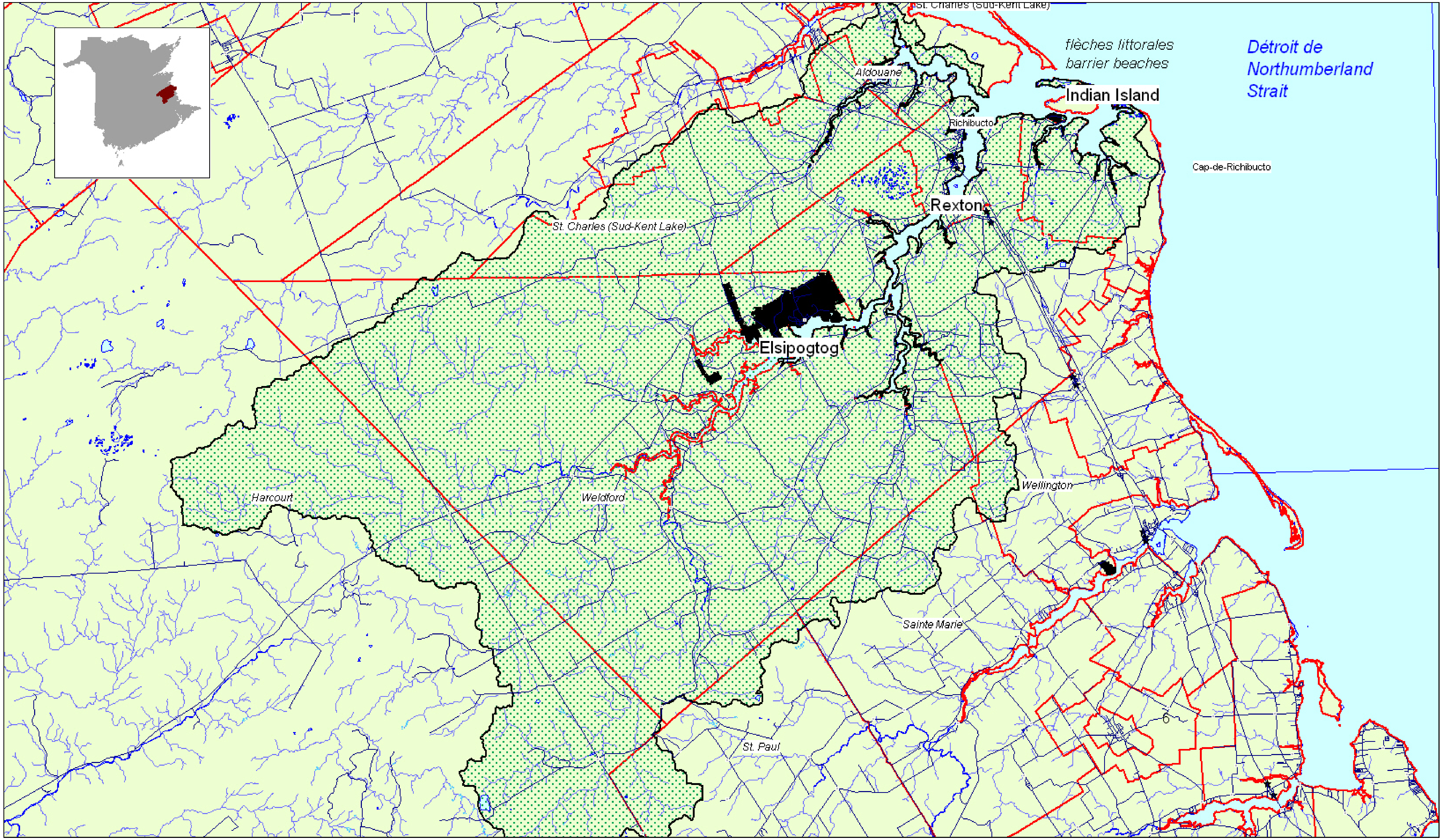

Figure 1:General overview of watershed
Sources: NB Aquatic Data Warehouse, Service NB (2004)

1. GENERAL INTRODUCTION

1.1. PROJECT DESCRIPTION

1.1.1. Purpose of the report

In 1996, Canada became the first country to implement a law on the oceans (Canada. Government of Canada, 2002a). The Oceans Act gives the Department of Fisheries and Oceans (DFO) the responsibility of developing a strategy for the **integrated management**[1] of the estuarine, coastal and marine environments of Canada. The Oceans Strategy introduced in July 2002 meets the requirements of the above-mentioned legislation. It is aimed at increasing public participation in the management of marine activities through the implementation of a planning process for the integrated management of Canada's coastal and marine areas. The first step proposed in this process is to define and assess the territory to be managed so as to be able to take economic, ecological and social components into account in decision-making affecting this territory (Canada. Government of Canada, 2002b).

Accordingly, DFO is in the process of developing comprehensive Ecosystem Overview Reports (EOR) on certain Large Ocean Management Areas (LOMAs) to achieve better management of large marine ecosystems such as the Gulf of St. Lawrence and the Scotian shelf. The DFO Gulf Region, in collaboration with it's Area Offices and in partnership with community organizations is presently developing Ecosystem Overview Reports for smaller community coastal management areas such as the present report for the Richibucto watershed. These reports are aimed at defining and assessing the territory to be managed.

This report provides an overview of the coastal community area of Richibucto Bay,

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[1] The words in bold character are defined in a glossary in chapter 10.

located in eastern New Brunswick. To the extent possible, it contains relevant information needed to understand the functioning of the Richibucto Bay ecosystem as a whole. It also provides a picture of the pressures and threats presented by human activity in the coastal area to be managed and adjacent lands. It is a “living” document in that it can be modified and updated to integrate changes, new discoveries, etc.

This overview report is a compilation of information gleaned from various sources such as scientific, statistical, social and economic study reports, traditional and local information, etc. It will be used by managers, partners and stakeholders involved in the Richibucto Bay integrated management process. It will also be available to the public.

1.1.2. Geographic Area

The Richibucto Bay watershed is the fourth-largest river basin in eastern New Brunswick; it drains into the Northumberland Strait. The watershed, which lies in a coastal plain, is rectangular in shape and covers an area of approximately 1088.5 square kilometres (LeBlanc-Poirier et *al.*, 2004b; Montreal Engineering Company, 1969). The area with which we are here concerned comprises the Richibucto River watershed, the bay known as the Baie-du-Village, and Richibucto Harbour. This is a complex system containing a number of rivers and tributaries, the largest of these being the Richibucto River and the St. Charles River, which drain into the Northwest Branch. Richibucto Harbour extends out to the barrier beaches known as the Richibucto South Dune and the Richibucto North Dune (Fig. 1). However, for the purpose of this report, it ends at the edge of Kouchibouguac National Park of Canada, even though part of the Park is located within this watershed[2] (Fig. 2).

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[2] Because this report is intended to be used as a tool for integrated community coastal management, and in view of the fact that Kouchibouguac National Park has its own management plan, lands of the Park that are within the studied region would be excluded from a proposed management plan for the Richibucto Bay watershed.

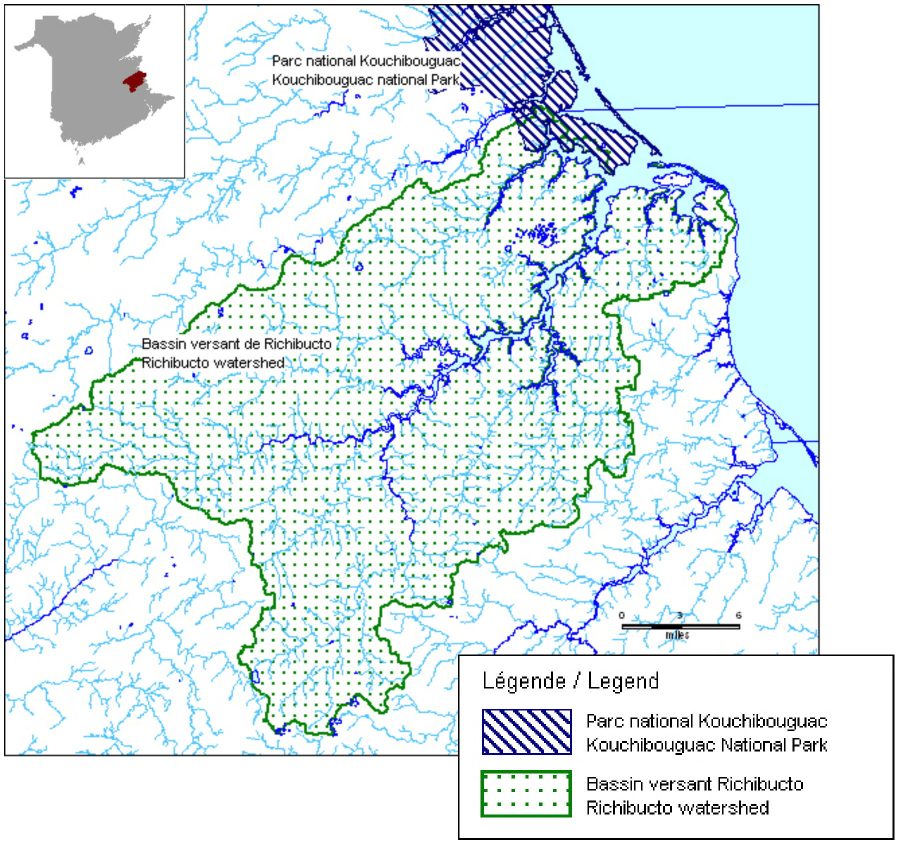


Figure 2: Richibucto watershed and Kouchibouguac Park boundaries

Source: NB Aquatic Data Warehouse, province of New Brunswick

The Indian Island and Elsipogtog First Nations, the Town of Richibucto and the Village of Rexton are located within the area included in this study (Fig. 1), as are various other small communities such as Adamsville, Bass River, Beersville, Bedoc, Cail's Mill, Cap-Lumière, Claireville, Coal Branch, East Branch, Ford's Mill, Ford Bank, Grande-Aldouane, Grangeville, Galloway, Harcourt, Jailletville, Jardineville, Kent Lake, Molus River, Mundelville, Normandie, Peter Mills, Petite-Aldouane, Pine Ridge, Richibouctou Village, Smith's Corner, Saint-Charles, Saint-Norbert, South Branch, Targettville, Upper Rexton, and West Branch (Turcotte-Lanteigne & Ferguson, 2004).

The watershed is noted for its habitat diversity. The marine section is characterized by barrier beaches separating the estuary from Northumberland Strait (Fig. 1). The estuary itself is shallow. The adjacent land is composed of rolling low hills, wooded areas and farmland (Fig. 3), as well as a number of peat bogs, most of which are located in the low-lying area near the coast. The economy of the region relies mainly on the natural resources of the watershed.

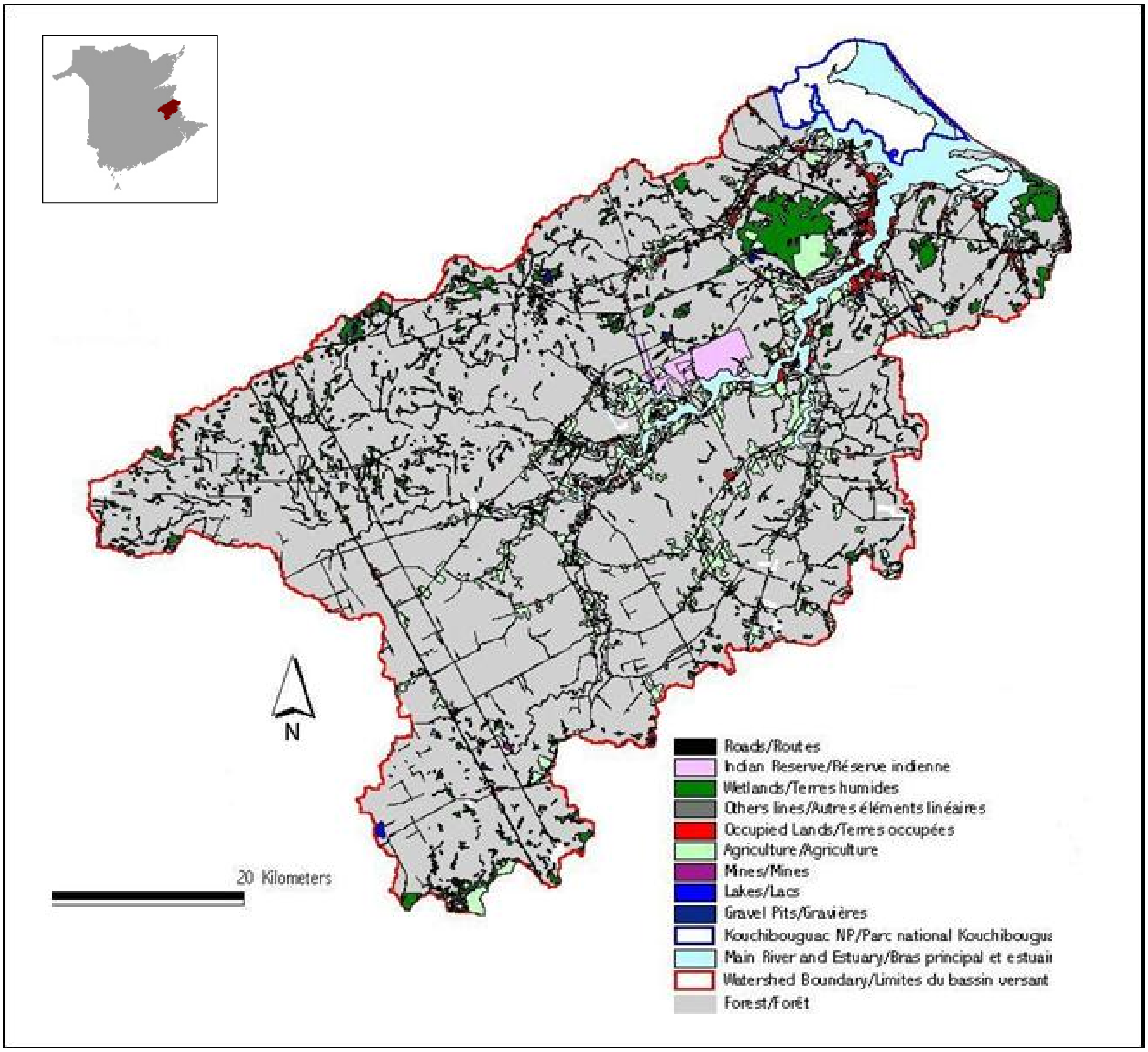


Figure 3: Land use in the watershed

Sources: NB Aquatic Data Warehouse, Service NB.

Map prepared by O. Bédard, Kouchibouguac National Park, for the Richibucto River Association (2004)

1.2. METHODOLOGY

The preparation of this document includes a literature review that brings together pertinent data available from a variety of sources. These include: government primary research publications, government policy and discussion papers, grey literature (unpublished documents), academic journal articles, academic research documents (published and unpublished), proprietary consultant research documents (by permission), non-governmental organization reports, community group reports, personal communications with experts (cited with date of communication) and other sources deemed relevant and reliable (e.g. Traditional Fishers Knowledge Database). No primary research was undertaken specifically in support of this document.

The data collected was integrated into a generalized description of the ecosystem of the Richibucto Bay watershed. The intent is to provide a descriptive overview of how the bay functions as an ecosystem. The document sets the stage for the future development of integrated management plans, protection of the environment, resource conservation or recovery strategies.

2. PHYSICAL SYSTEM

2.1. GEOLOGY AND GEOMORPHOLOGY

2.1.1. Geology

The two most recent events that have affected the characteristics of the region's landforms are the Wisconsin glaciation, which left a covering of unconsolidated sediment overlying the bedrock, and the recent marine transgression, which is contributing to shoreline erosion and the formation of salt marshes (J. Thibault, personal communication, September 12, 2006). The bedrock in the watershed consists exclusively of Pennsylvanian era siltstone and sandstone conglomerates (Montreal Engineering Company, 1969; Rampton et *al*., 1984).

In general, the upper part of the watershed is covered with unconsolidated deposits from 0.5 to 3 m thick, consisting of a mixture of loamy basal till, a little ablation till, silt, sand, gravel and breakstone. Loose, partially disintegrated rock is also found sporadically. Most of the coastal belt is covered with a layer consisting of a mixture of sand, silt and a little gravel and clay, ranging between 0.5 m and 3 m in thickness (Fig. 4). Scattered deposits of organic sediment occur in the region's marshes, peat bogs and **swamp**s (New Brunswick. Department of Natural Resources and Energy, 2002).

Test boring conducted in the course of an environmental assessment of Richibucto Harbour in 1977 indicated that the seabed consists of fine- to medium-grained sand with 10 to 30 per cent silt and 0 to 25 per cent gravel. It is unconsolidated at the surface, and becomes progressively denser with increasing depth (Acres Consulting Services Limited, 1997). Sediment consisting of sand or sand and silt accounts for between 44.2 per cent and 57.6 per cent of the bottom in the Baie-du-Village and Richibucto Harbour (Senpaq Consultants, 1990).

The bottom is hard in theRichibucto Harbour channel and between the channel and the island, whereas the channels of the Northwest Branch and the Richibucto River are somewhat muddy-bottomed. In addition, small areas of the channels of the Baie-du-Village River and the Richibucto River are covered with shells (Senpaq Consultants, 1990).

The bulk of the sediment originating from erosion is carried down by the rivers (Fig. 5) and deposited at the head of the estuary in the form of a delta at the highest point reached by the tides. Finer sediment particles are deposited in the estuary (J.Thibault, pers. comm., Septembre 12, 2006). Sediment amounting to some 37,000 cubic metres per year is constantly being deposited in the estuary and the lagoons, contributing to the formation of salt marshes (The Nature Trust of New Brunswick Inc., 1995, site 452).

Figure 4: Sandy beach with sandstone slabs in Richibucto

Figure 5: Bank erosion

2.1.2. Hydrography, topography and bathymetry

Following the Miramichi, the Richibucto Bay watershed is the second-largest river basin that drains into the Northumberland Strait. The watershed's mean elevation is 45.5 metres above mean sea level (Montreal Engineering Company, 1969). The main rivers in the watershed are the Richibucto, which is approximately 35 kilometres long (St-Hilaire et *al*., 2001a) and the Northwest Branch. Both of these drain into Richibucto Harbour. The St. Charles River and the Petite-Aldouane River drain into the Northwest Branch (St-Hilaire et *al*., 1997b), while the St. Nicholas River drains into the Richibucto (Fig. 6). The watershed also possesses a network of smaller streams which contribute significantly to the total quantity of fresh water that pours into the harbour (Fig. 7). These include the Bass River, the Molus River, the Gaspereau River, Mill Creek and the Coal Branch (LeBlanc-Poirier et *al.*, 2004b). There are no large lakes in the watershed. Lakes and swamps represent less than 1.55 per cent of its area (Montreal Engineering Company, 1969).

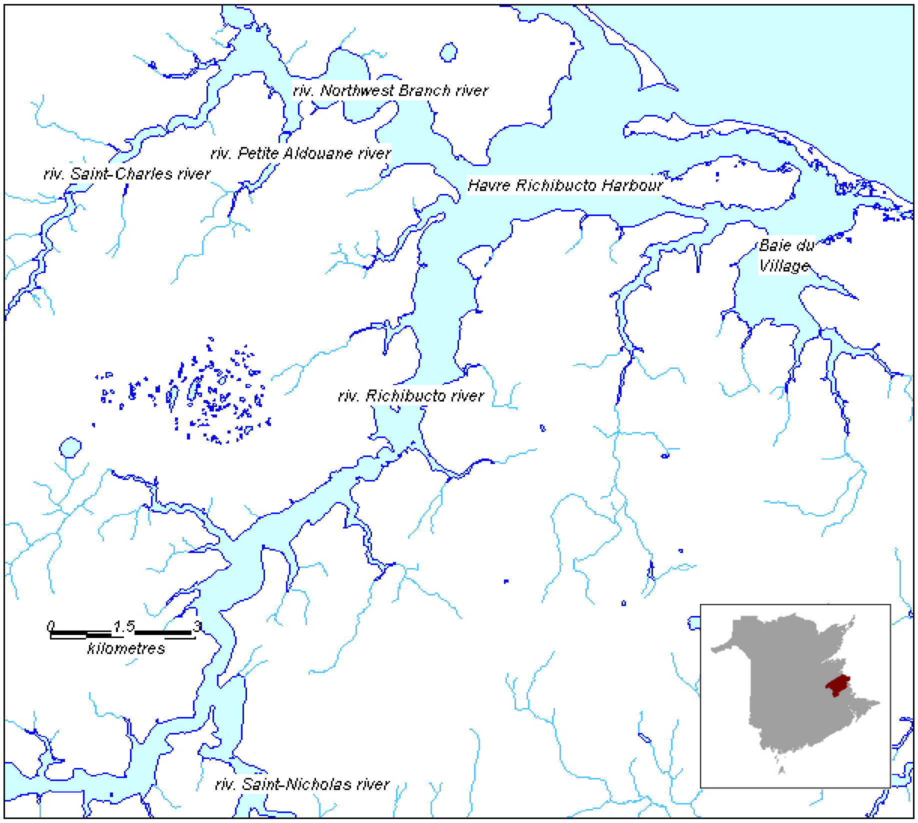


Figure 6: Main watercourses of watershed

Source: DFO

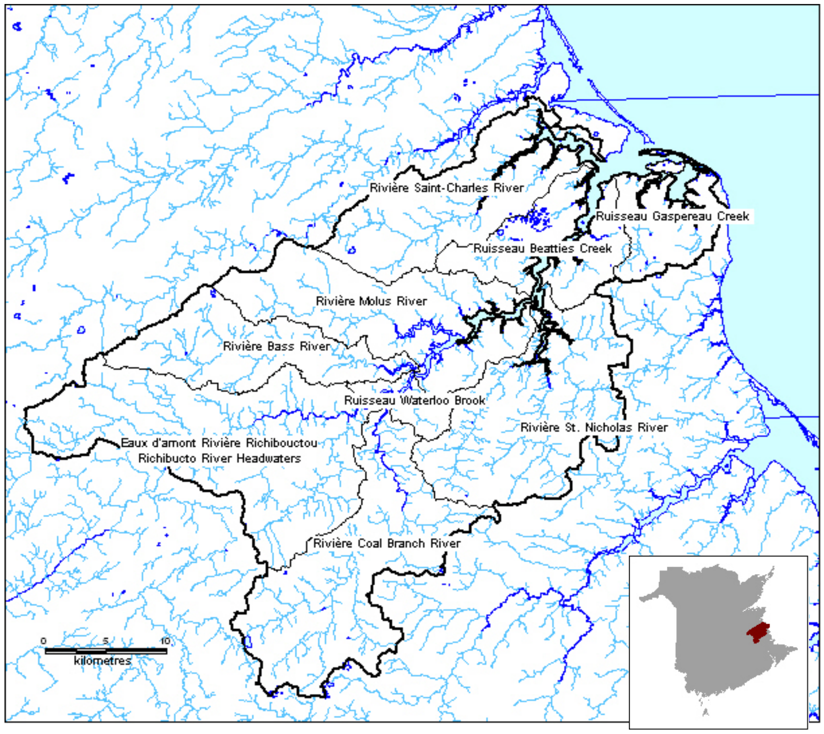


Figure 7: Sub-watersheds

Sources: NB: Aquatic Data Warehouse, Province of New Brunswick; Fraser Papers Inc.:Fundy Model Forest

Richibucto Bay is shallow seldom exceeding one metre in depth except in the channel, which is 150 metres wide and has a maximum depth of 12 metres (St-Hilaire et *al*., 1997b) (Fig. 8). The channel in the Northwest Branch is two to four metres deep. Elsewhere in the estuary, around Indian Island and in the Baie-du-Village, the water depth rarely exceeds three metres (Koutitonsky et *al.*, 2004). The bay is separated from the Northumberland Strait by a string of barrier beaches that are commonly known as the Richibucto North Dune and the Richibucto South Dune. The estuary of the Richibucto River is approximately 300 square kilometres (St-Hilaire et *al*., 2004b). The main opening to the sea is the gap between the North and South Dunes. The Baie-du-Village is part of the Richibucto Bay watershed; it is approximately 7.6 square kilometres (Senpaq consultants, 1990). Indian Island lies within the Baie-du-Village, between the South Dune and the mainland (Fig. 1).

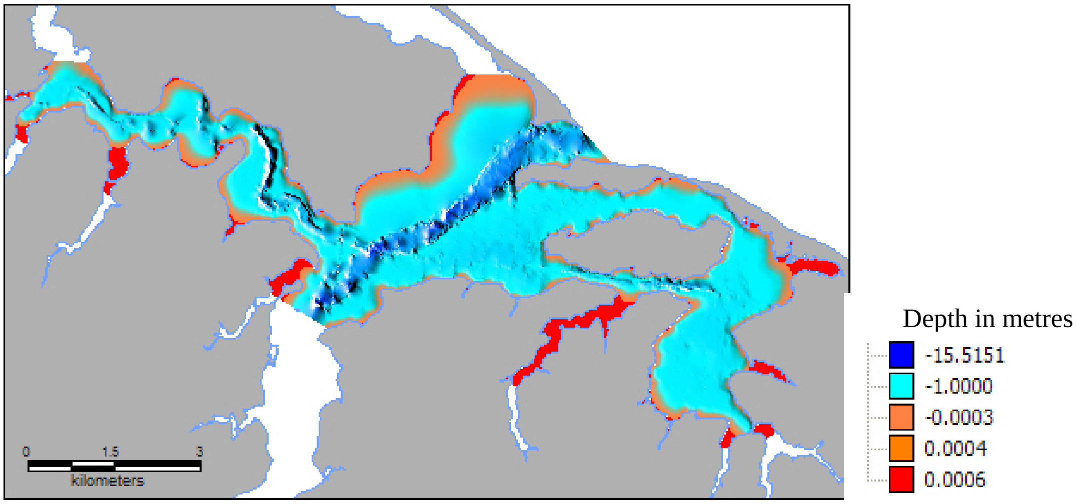


Figure 8: Bathymetry of the estuary

Prepared by: B. Firth & M. Ouellette, DFO, Gulf Fisheries Centre (2005)

These data were collected using QTC View V acoustic seabed classification system. There can be a discrepancy of a metre or so with the existing depth due to the tidal ebb and flow.

The land around the bay is low-lying, never rising to more than 10 metres at any point (The Nature Trust of New Brunswick Inc., 1995). It consists of rolling terrain featuring low hills with moderate slopes (Atlantic Canada Opportunities Agency and New Brunswick Regional Development Corporation (ACOA&NBRDC), 2000). Nearly 60 per cent of the land in the upper part of the watershed is wooded (St-Hilaire et *al*., 2004b). Logging operations and farming are the main economic activities carried on the land adjacent to the watershed. In addition, the St. Charles peat bog is located in the lower part of the watershed. It has an area of 2,265 hectares, and has been harvested since 1983 (LeBlanc-Poirier et *al*., 2004b, Keys and Henderson, 1987).

A study (O'Carroll & Bérubé, 1997) designed to determine the sensitivity of coastal areas to storm waves found that much of the watershed above Highway 11, the Baie-du-Village region and the area including the Northwest Branch as far as the North Dune, was characterized by a moderate sensitivity index (Fig. 9). This means that this region is moderately likely to undergo erosion as a result of storm wave action. The lower part of Richibucto Harbour out to the mouth of Northumberland Strait was found to have a high sensitivity index (*ibid)*. The remainder of the coastline within the watershed was found to be less sensitive to erosion as a result of storm wave action, and was rated low or very low in terms of its sensitivity index (*ibid)*.

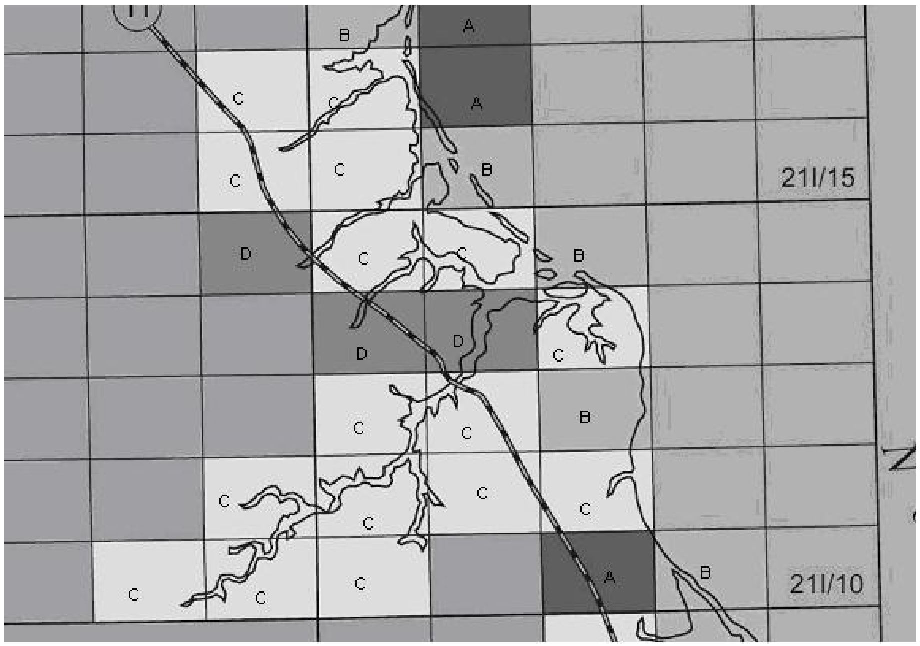


Figure 9: Sensitivity of coast to storm waves
Sensitivity index: A: Very high; B: High; C: Moderate; D: Low
Source: O'Carroll and Bérubé (1997)

2.2. ATMOSPHERIC COMPONENTS

2.2.1. Air quality

In New Brunswick, air quality is regulated by the 1997 Clean Air Act. The Air Quality Regulation is the main management mechanism setting requirements regarding emissions affecting outdoor air quality. The federal government also plays an important role in monitoring air quality. Its efforts are focused mainly on factors that can have an international or cross-border impact, for example, the transport of airborne pollutants that contribute to acid rain or damage the ozone layer. New Brunswick has a network of monitoring stations to ensure that air quality standards and objectives are met.

The only monitoring station within the Richibucto watershed is one that tracks acid rain. It is located in Harcourt, a small village in the upper part of the watershed. In 2003, a mean acid deposition load of 10 kilograms of sulphate per hectare per year was recorded for the region. Acid sulphate deposition loads of between 8 and 11 kilograms per hectare per year are considered critical loads. Critical load values have been calculated with a view to protecting the watershed from acidification. These loads are fairly high for the province as a whole (7.6 to 15.1 kilograms of acid deposition per hectare per year), but it should be noted that they have declined in recent years (New Brunswick, Department of Environment and Local Government (DELG), 2004).

There are no other data that are specific to the Richibucto Bay watershed region. However, it may reasonably be surmised that it is comparable to New Brunswick as a whole in terms of air quality. An evaluation of data from multi year sampling sites reveals that air quality has improved since the 1970s and 1980s, except for the trophospheric ozone, which has not displayed any particular trend (N.B. DELG, 2004).

Airborne pollutants originate from a variety of sources, near and far. Emissions from motor vehicles have a particularly heavy impact on the immediate environment, as they are spewed out near ground level. Emissions from high smokestacks of large industrial plants such as oil refineries and pulp-and-paper mills can travel long distances. However, industrial sources of this kind may also affect the immediate environment as well (N.B. DELG, 2004). At the present time, there are no large industrial facilities located in the vicinity of the Richibucto Bay watershed, although there are a number of pulp-and-paper mills and other industrial plants at various locations in the province, particularly in the north, in regions such as Edmundston, Atholville, Bathurst and Miramichi *(ibid)*.

The weather is another factor that may affect air quality (N.B. DELG, 2005). Under light wind conditions, air masses are slow-moving and airborne pollutants are not dispersed *(ibid)*. A similar phenomenon occurs with rising temperatures: the heat of the sun affects the chemical reactions that produce ozone and ozone smog *(ibid)*. An onshore breeze may also capture airborne pollutants and send them swirling repeatedly near the coast and inland. Furthermore, the province receives via air streams, vast quantities of air pollution that are generated from such regions as the northeastern United States and western Canada *(ibid)*.

2.2.2. Climate and seasonal particularities

The whole of Kent County is characterized by a modified continental climate (Koutitonsky & Bugden, 1991). This climate is governed mainly by air masses originating from central Canada, but moist winds from the Atlantic exert a moderating effect *(ibid)*. The prevailing winds are northwesterly, with occasional southwesterlies *(ibid)*.

The average number of **degree-days** is higher inland than near the coast (Canada. Environment Canada, 2005). Air masses from the ocean tend to create short periods of mild weather in winter and fog in summer. During the period 1971-2000, the mean monthly temperature ranged between -9.5°C and 19.3°C *(ibid)*.

Precipitation rates are typical of a maritime climate. During the period 1971-2000, mean monthly rainfall ranged between 25.4 mm and 107.6 mm (Canada. Environment Canada, 2005). Over that same period, mean monthly snowfall from October to May ranged from 0.4 cm to 64.8 cm *(ibid)*. (For more information see appendix 5, EC Canadian Climate Normals 1971-2000).

As a rule, ice forms in Richibucto Harbour in December and disappears by mid- to late April (Acres Consulting Services Limited, 1997). A study investigating the impact of ice on the substrate around the Richibucto South Dune showed the ice cover ranged in thickness between 24 cm and 200 cm during the winter of 1995-1996 (Boghen & St-Hilaire, 1997).

2.3. AQUATIC COMPONENTS

2.3.1. Physical characteristics

The water in Northumberland Strait is characterized by a northwesterly flow. As a result, water from Miramichi Bay and the Shediac Valley tends to enter via the Strait and disperse into the Kouchibouguac Bay and Richibucto Bay (Beach, 1988). Tides in the Richibucto Bay region are semidiurnal and seldom exceed 0.6 metres in height (St-Hilaire et *al*., 2001b). The mean amplitude of a harmonic tidal component is 0.30 m (Koutitonsky et *al*., 2004). The currents in the main channel may run at a velocity of more than 0.60 metres per second when the tide is falling, and of up to 0.3 metres per second when it is rising *(ibid)*. There is a period of approximately eight hours between tides when current velocity is lower (*ibid*). Strong currents have been observed in the main channel and moderately strong currents in the Northwest Branch and around Indian Island *(ibid).* Currents in the southeastern part of the Baie-du-Village are weaker *(ibid)*. In addition, the breach in the South Dune, which was created in 1996 by heavy weather (Fig. 10, 15 and 16), may be contributing significantly to the currents around Indian Island *(ibid)*. The tidal currents are sufficiently strong to produce a reversing current to a distance of 18 kilometres upstream from the dunes. However, the strength of the tidal currents is different with every tide (St-Hilaire et *al*., 2001b).

Fresh water is carried into the estuary of the Richibucto by the Richibucto River itself and the Northwest Branch, of which the St. Charles River and the Petite-Aldouane River are tributaries. On average, 26.0 cubic metres of fresh water are discharged into the estuary every second (Gregory et *al*., 1993). Freshwater discharge reaches a maximum in April, with a mean flow of 91.5 cubic metres per second *(ibid)*. From June onward, this value declines quickly to 22.8 cubic metres per second *(ibid)*. The corresponding figure for October is usually less than the mean monthly flow over the year (18.2 cubic metres per second), while for November it is equal to the mean rate for the year (26.0 cubic metres per second) *(ibid).*

The ratio between tidal water and the fresh water that flows into the estuary is estimated at approximately 86 : 1 (Gregory et *al*., 1993). The average time required for a water exchange in the Richibucto estuary below Rexton is 29.3 hours *(ibid)*. The water mixing process is more rapid at the extremities of the estuary at the river mouths and at the mouth of Northumberland Strait (Koutitonsky et *al*., 2004). The greater the distance from these points, the longer the mixing time (*ibid*).

Water mixing is extensive; there is little **vertical stratification** in the Richibucto estuary (St-Hilaire et *al*., 1997b; St-Hilaire et *al.*, 2001b). Even so, there is some longitudinal migration of salt water, due in part to freshwater discharge *(ibid)*. This vertical stratification is more noticeable in autumn than in summer, when freshwater inflow is lowest (Koutitonsky et *al*., 2004). In the Richibucto River watershed, brackish water is found for a distance of up to 37 kilometres upstream from the barrier beaches (St-Hilaire et *al*., 2001b). Salinity data gathered in the course of several projects executed under the Richibucto Environment and Resource Enhancement Project (REREP) reveal the presence of brackish water as far as five kilometres upstream from Brown's Yard (Fig. 10) (St-Hilaire et *al*., 2004b). In the St. Charles estuary, brackish water occurs as far as 19 kilometres upstream from the dunes (St-Hilaire et *al*., 2001b). Today, the breach in the Richibucto South Dune also contributes to salt water inflow into the Baie-du-Village (Fig. 10, 15 and 16).

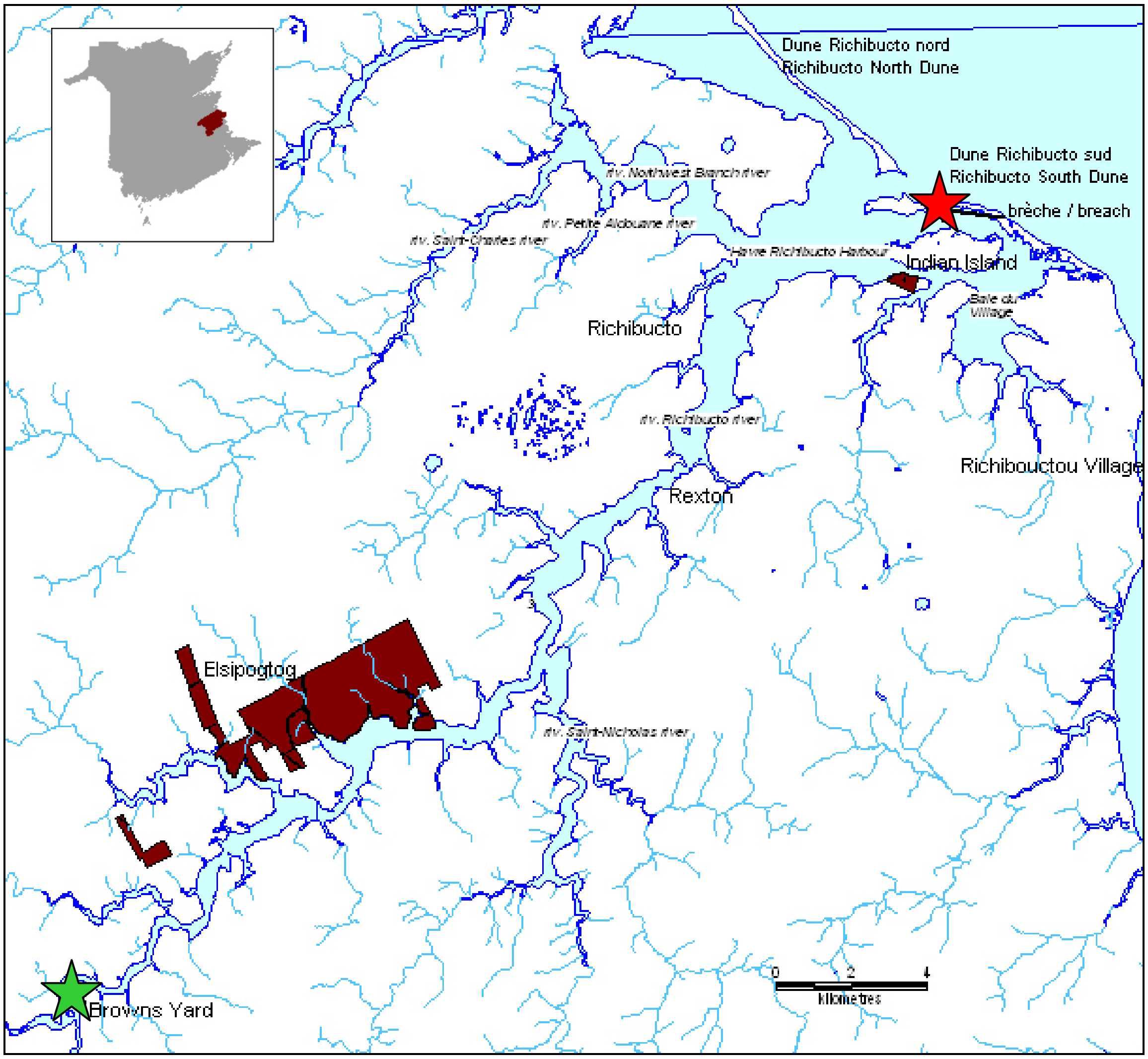


Figure 10: Estuary, Browns Yard and South Dune breach

Sources: Service NB, St Hilaire et *al*. (2001b, 2004b)

2.3.2. Physical-chemical water properties

The physical-chemical properties of the water in the Richibucto watershed are quite well documented. The sources for some of the information presented in this part of the overview, are not indicated. In these cases the information is a summary of the findings of of the following investigators: Menon (1981); Senpaq Consultants (1989, and 1990); St-Hilaire et *al*. (1997b, 2001b, 2004a and 2004b); Bataller et *al*. (1999); Robinson et *al.* (2001); Environmental Sciences Research Centre (2002); Frenette (2004); LeBlanc-Poirier et *al*. (2004a and 2004b).

2.3.2.1. Water quality

A study on the presence of benthic invertebrates in the watershed's rivers has shown that as a rule, freshwater quality is very good, except in the Molus River, the St. Charles River and the West Branch of the St. Nicholas River, where, although it is still good, it is inferior to that of the water in other tributaries (LeBlanc-Poirier et *al*., 2004a). In addition, the mix of invertebrate species in the Coal Branch region is distinctive, probably due to the different chemical composition of its water, which in turn, is likely due to the coal mining activities that were formerly carried out in that region *(ibid)*.

2.3.2.2. Temperature

The water temperature in the estuary of the watershed may range from -2°C to 24°C. The temperature of the freshwater in the streams of the watershed may range from 4°C to 20°C between June and November. During the coldest months of the year, those streams are covered with ice. Mean weekly water temperatures recorded in the Mill Creek area of the estuary between May and September 2005 are shown in Fig. 11.

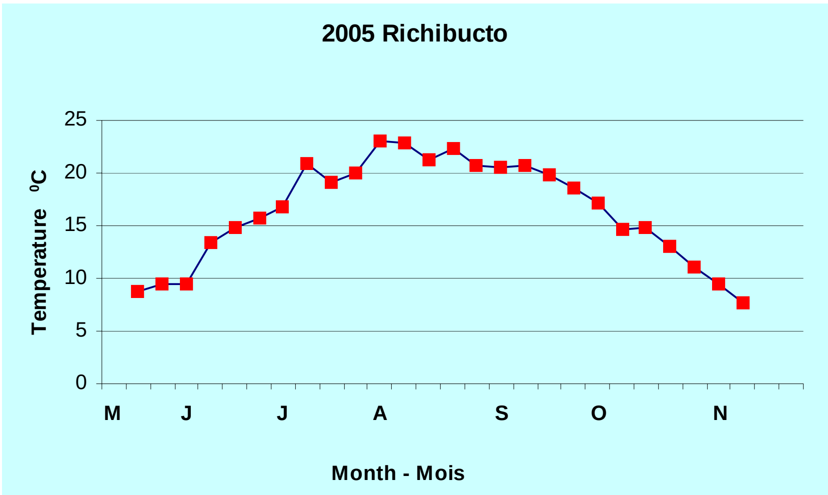


Figure 11: Mean weekly water temperature in the estuary in 2005

Source: J. Weldon, DFO, pers. comm.., (01/09/06), data from the Community Aquatic Monitoring Program, CAMP

2.3.2.3. **Salinity**

Salinity in the marine estuary may range between 21 ppm and 29 ppm. The term "marine estuary" includes Richibucto Harbour, the Baie-du-Village, that part of the Northwest Branch below the Petite-Aldouane River and that part of the Richibucto River below Rexton. A salinity rate of 17 ppm can be observed in the Richibucto River a full 20 kilometres further upstream, in the vicinity of Elsipogtog (Fig. 10).

2.3.2.4. **Oxygen**

Dissolved oxygen (DO) values are within the acceptable range for the protection of aquatic life (5.5 mg/L < DO < 9.5 mg/L) at all sampling stations located in the upper part of the estuary and in all the main streams in the watershed (St-Hilaire et *al*., 2004b; LeBlanc-Poirier et *al*., 2004a). DO content values are between 5.8 and 12.8 for all rivers (LeBlanc-Poirier et *al*., 2004a, & 2004b; St-Hilaire et *al*., 2004b). The lowest DO values (5.8, 6.2 and 6.9 mg/L) were found in ponds in which there was little water circulation, such as those in the St. Charles Plain drainage basin (St-Hilaire et *al*., 2004b).

2.3.2.5. **pH**

In general, the freshwater in this watershed is relatively well buffered and slightly alkaline, with a pH between 7.5 and 8 (Environmental Sciences Research Centre, 2002). However, findings from three sampling stations in the St. Charles Plain drainage basin reveal below-average pH values (<6), including one reading as low as 4.23 in the sedimentation pond at the peat extraction site (St-Hilaire et *al*., 2004b). In addition, pH values that fluctuate between 4.66 and 8.02 have been reported in the Coal Branch (LeBlanc-Poirier et *al*., 2004a).

2.3.2.6. **Nutrients**

Nutrients are elements or compounds that are vital for primary production in an ecosystem. When present in abundance, however, they may be detrimental to the ecosystem by promoting the production of excessive quantities of organic matter.

Nitrogen, phosphorus and nitrates are among the most important nutrients. They occur naturally in the environment, and are also introduced as a result of human activities. (For more information on sources of nutrients see section 7.2.1.2.)

Various studies have shown that nitrogen and nitrate levels are acceptable throughout the watershed. However, rising levels have been reported for locations in the West Branch of the St. Nicholas River, the Coal Branch, the Molus River and the St. Charles River at particular dates (Fig. 12). The highest total nitrogen levels, 0.74 mg/L and 0.61mg/L, were found respectively in the Coal Branch after a period of heavy rain fall (LeBlanc-Poirier et *al.*, 2004a) and the St. Charles Plain sedimentation pond (St-Hilaire et *al.*, 2004b). Normal total nitrogen levels may fall within a range extending between 0.1 mg/L and 0.5 mg/L (LeBlanc-Poirier et al. 2004a). The highest nitrate levels (2.95mg/L) were identified in Mooney's Creek, where the effluent from the Richibucto wastewater treatment plant is discharged (St-Hilaire et *al.*, 2004b). Normal freshwater nitrate content values may range between 1 and 5 mg/L (LeBlanc-Poirier et *al*., 2004a).

High total phosphorus content levels have been reported for streams in the vicinity of the St. Charles Plain, Mooney's Creek, the Molus River, the St. Charles River, and the West Branch of the St. Nicholas River. The highest value (0.66 mg/L) was found in the Bass River following heavy rainfall. The normal freshwater phosphorus content value is approximately 0.03 mg/L (LeBlanc-Poirier et *al.*, 2004a).

2.3.2.7. **Pathogens**

Pathogens may enter a stream or river in wastewater effluent or in runoff from nearby farmland. Wildlife inhabiting streams, marshes, estuaries or riparian areas is another potential source of pathogens. Faecal matter of both human and animal origin contains feacal coliforms and potentially other pathogens.

High faecal coliform (FC) concentrations have been found on a number of occasions in some of the rivers in the Richibucto watershed, including the Molus River, the St. Charles River, the Bass River, and the several branches of the St. Nicholas River.

Acceptable faecal coliform content values for recreational water use are 200 FC/100 ml and 14 FC/100 ml for shellfish harvesting (CCME, 1999). Faecal coliform levels above these limits result in the closure of recreational swimming areas and shellfish zones. Values in excess of 1600 FC/100 ml have been found in all these rivers (Fig. 12) following heavy rainfall conditions (ESRC 2002; LeBlanc-Poirier et *al*. 2004a; St-Hilaire et *al*., 2004a). Several sections of the estuary, including the Northwest Branch and the Baie-du-Village in particular, have also been identified as having high FC levels (Richard & Godin, 2004).

2.3.2.8. **Suspended matter**

Among the rivers in the watershed, those with the highest suspended matter content values are the St. Charles River, the East, West and South Branches of the St. Nicholas River, and the Bass River (Fig. 12), especially following periods of heavy rainfall (LeBlanc-Poirier et *al*., 2004a).

A study on the growth and survival of sea scallops in Cocagne Bay, Shemogue Bay, Bouctouche Bay and Richibucto Bay found that mean seston values were particularly high (32.27 + 18,83 mg/L) in Richibucto Bay, especially in the autumn. At the same time, however, Richibucto Bay was found to be characterized by lower turbidity levels (Frenette, 2004).

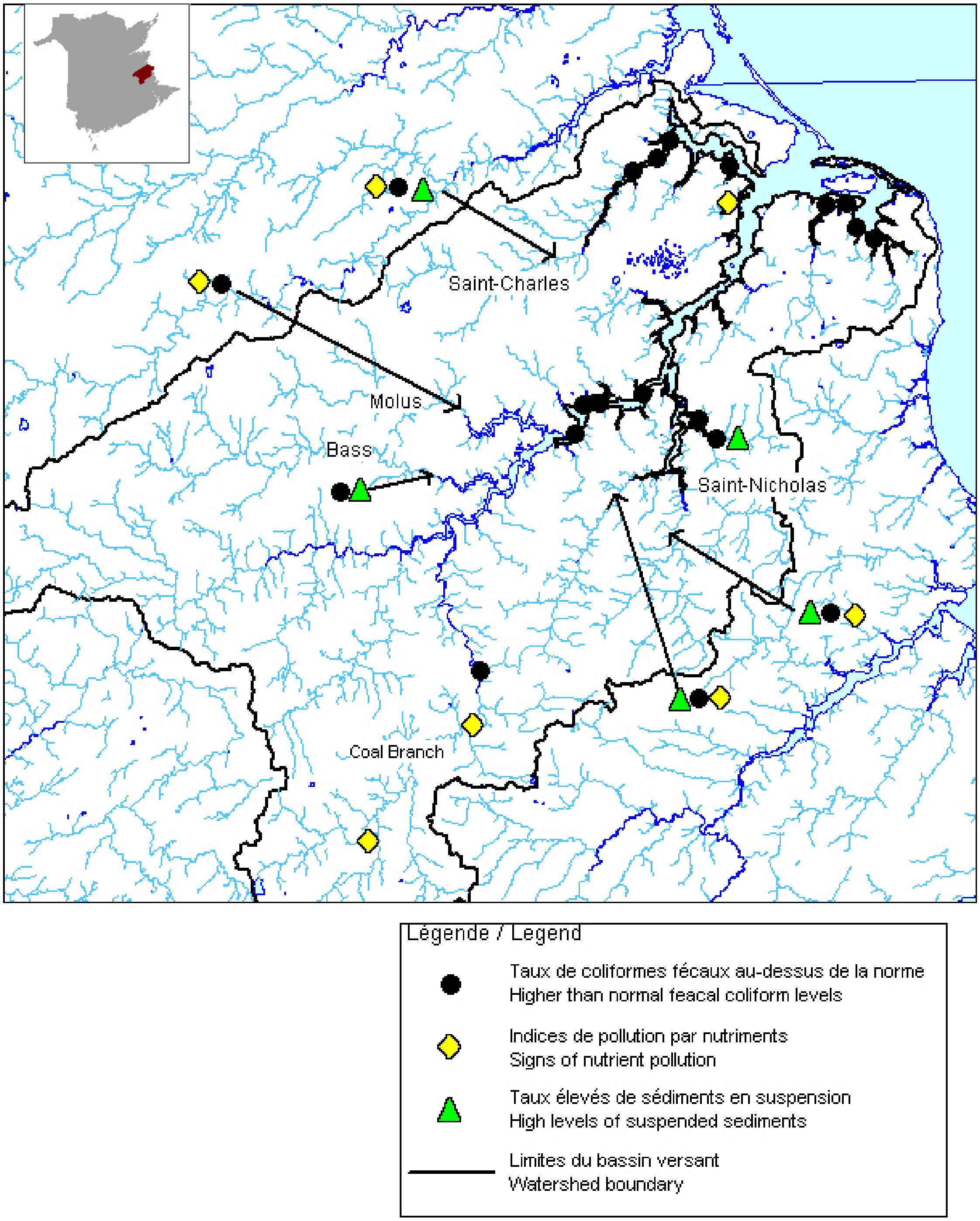


Figure 12: Water quality from a variety of sampling results

Sources: NB Aquatic Data Warehouse, Leblanc-Poirier et *al*. (2004a), (2004b), Environmental Sciences Research Centre (2002), Richard & Godin (2004), St-Hilaire et *al*. (2004a)

2.3.2.9. **Organic carbon**

The main sources of organic carbon are decomposed plants and animals, farm runoff, and municipal and industrial effluent. Sampling activities conducted between July and November 2004 in the rivers of the watershed showed that organic carbon content levels could be anywhere from <2.4 mg/L to 34.8 mg/L, depending on where the samples were taken. Normal values may range between 1 and 30 mg/L. Clearly identifiable sources were observed in the eastern St. Charles River, the South and West Branches of the St. Nicholas River, and the Coal Branch (LeBlanc-Poirier et *al*., 2004a).

2.3.2.10. **Dissolved trace-metals and other elements**

High iron concentrations are frequently observed throughout the watershed. This is attributable to the natural occurrence of iron compounds in the soil, sediments and underlying bedrock. The highest values (1.2 μg/L) have been found in the Coal Branch (LeBlanc-Poirier et *al*., 2004a).

Variable calcium content levels have been observed, and high fluoride, sodium and chloride concentrations have been found in the Coal Branch region. These anomalous findings have been attributed to the former Kent coal-mining operation (LeBlanc-Poirier et *al*., 2004a)

3. BIOLOGICAL SYSTEMS

3.1. NATURAL HABITATS

3.1.1. Terrestrial habitats

The Richibucto Bay watershed lies within the Acadian forest that covers New Brunswick's eastern lowlands (Eaton et *al*., 1994; Rowe, 1992). The typical composition of the Acadian forest is a mixture of deciduous and coniferous species. In the eastern lowlands, however, it consists mainly of softwoods (Eaton et *al*., 1994). This type of forest offers suitable habitat for numerous mammals, birds, amphibians, frogs and invertebrates (Smith, 1980).

Over 60 per cent of the land in the upper part of the watershed is covered with forest (St-Hilaire et *al*., 2004b) (Fig. 3 and 13). There are approximately 625 square kilometres of Crown land in the watershed (G. Watling, DNR, pers. comm., December 12, 2005). Large areas of forested land, especially in the southwestern part of the study area, have been deforested due to logging activities (Graillon et *al.*, 2000).

Figure 13: Forested area

Figure 14: Sandstone cliffs

Approximately 71 square kilometres of the land within the watershed is farmland (LeBlanc-Poirier et *al*., 2004b). Crops include cereals, fruits and vegetables, and there are a number of livestock operations and other types of agricultural activities (Fig. 3). Succession fields constitute one of the seven main habitat types in the Richibucto Bay watershed (ACOA & NBRDC, 2000).

In the upper part of the watershed, some areas along the rivers are lined with cliffs. These cliffs consist mainly of sandstone, and are from approximately 10 to 30 feet in height (Fig. 14).

The dunes and beaches provide habitat for numerous bird species which use them as feeding and nesting areas and also as rest areas during migration. Richibucto Bay is separated from the Northumberland Strait by the barrier beaches of the Richibucto North and South Dunes (Fig. 1 and 10). The Richibucto North Dune is approximately eight kilometres long and 120 metres wide. It is stabilized mainly by beachgrass (*Ammophilia breviligulata*)[3]. The Richibucto South Dune, for its part, is seven kilometres in length. (The Nature Trust of New Brunswick Inc., 1995, sites 451 and 454).

Generally speaking, these dunes are highly dynamic and are subject to constant changes, including the appearance of breaches and infills (Fig. 15 and 16). Longshore drift and the construction of protection walls in the Richibucto gully have an impact on erosion and accretion all around the dunes (Dagneau, 1996): no fewer than six substantial breaches have appeared in the course of the past 60 years (*ibid*). The most recent breach occured in the South Dune in 1996 as a result of ice scouring, and is present to this day. When it first appeared, it was 200 metres wide and 1.5 metres deep (Koutitonsky et *al*., 2004).

[3] Appendix 2 contains a list of species, with the common English name, the common French name and the scientific name of the various species of flora and fauna referred to in this study. The scientific name is indicated in the body of the text only at the first reference to the species in question.

Figure 15: Indian Island and South Dune in 1983

Figure 16: South Dune breach in 2006

Sources: Service NB aerial photo (1983), Google Earth (2006)

The beaches in the region consist mainly of sand with small quantities of gravel (Fig. 17) (E. Tremblay, pers. comm., November 10, 2005). There are also a few beaches that are covered with sandstone rock in some sections (Fig. 4). Some of these are located at the tip of York Point in Richibucto Harbour.

Figure 17: Beach of sand and gravel

3.1.2. Wetlands

Wetlands are features such as peat bogs and marshes where the ground is saturated with water for several consecutive months. These are important productive habitats for various wildlife species, including waterfowl, amphibians, reptiles, and many mammals.

Peat bogs form in cool, wet locations. Organic matter decomposes very slowly in a peat bog, where the prevailing acidity and anaerobic conditions inhibit decomposition. This decomposing matter is what forms peat. The bogs in this region are ombrotrophic; they are dome shaped and are fed primarily by precipitation. Because peat can hold up to 25 times its weight of water, peat bogs affect the ground water table. They may also capture airborne contaminants such as pesticides, mercury and other substances and hold them indefinitely (Rutherford & Matthews, 1998).

There are numerous small peat bogs scattered throughout the watershed. Some of them are located near tributaries and are the point of origin of many streams in the region (Keys & Henderson, 1987). Near the coast, peat may be as much as eight metres deep; however, the nature of the terrain and the proximity of the sea limit harvesting peat from these bogs (Graillon et *al.*, 2000).

The St. Charles Plain is the largest peat bog in the watershed, covering an area of 2,265 hectares (Fig. 18). Three other sizable bogs—the Cape Bog, the peat bog near Richibouctou Village and the one west of Richibouctou Village—cover a total area of 849 hectares (Keys & Henderson, 1987). The Canaan Bog (Fig. 18) is a New Brunswick protected natural area. It lies in the upper part of the watershed, at the point where Kent County, Westmorland County and Queens County meet. It consists of a number of small peat bogs (New Brunswick. Department of Natural Resources, 2004b).

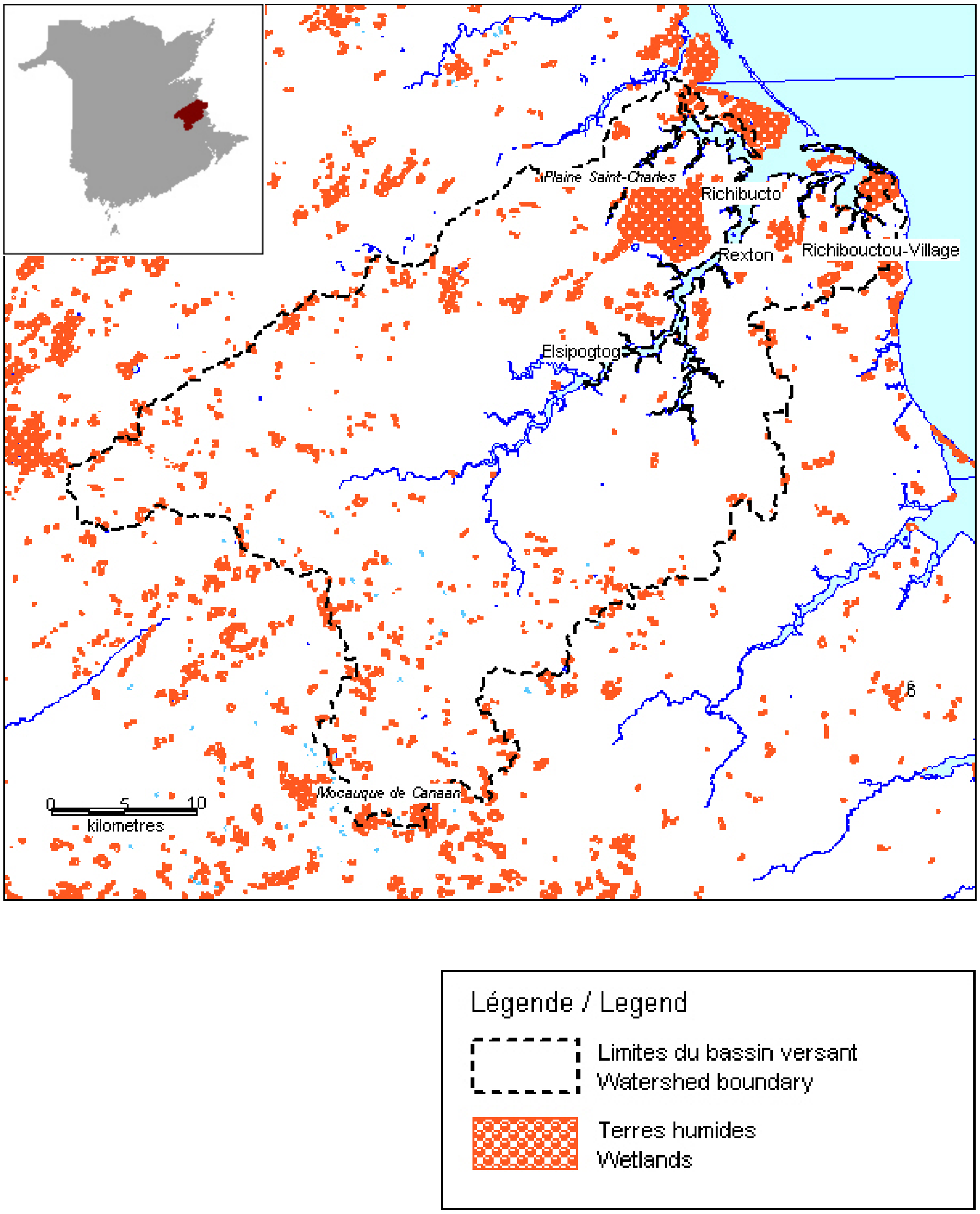


Figure 18: Wetlands located within the Richibucto watershed

Sources: NB Data Warehouse, Service NB (2004); Fraser Papers Inc; Fundy Model Forest, J.D. Irving

Marshes (Fig. 19) are highly productive ecosystems that form in low-lying areas, usually near the seacoast. Typically, they are located in sites which are sheltered from waves and in which sediment accumulates, such as estuaries, lagoons and tidal ponds (Therrien et *al*., 2000). They act to protect lands from erosion, and they also act as filters, absorbing waterborne and airborne pollutants. Organic material of plant origin that is found in marshes provides food for various invertebrates, birds, and other animal species.

Figure 19: Brackish water marsh

The Richibucto Bay watershed includes a number of marshes. Most of these are located in the lower estuary of the bay. Marshes have formed in the lagoon behind the North Dune and on the rear slope of the South Dune, near the point where it joins the mainland or the Cape Bog (The Nature Trust of New Brunswick Inc., 1995; Dagneau 1996). There are a number of large salt marshes in the lower estuary of the bay. In addition, there are numerous small marshes higher up the watershed. Some of these are freshwater marshes, while others are brackish. The plant species found in marshes in the upper part of the watershed, however, are not the same as those that grow in the marshes of the lower section of the estuary.

3.1.3. Aquatic habitats

3.1.3.1. <u>**Freshwater lakes**</u>

Lake water can originate from various sources, including rainfall, runoff from adjacent land and groundwater seepage. Lakes may serve as settling basins for the streams that feed them. Because the current flow through lakes is low, sediment can settle and build up on the bottom (Reid & Wood, 1976).

There are seven small lakes in the Richibucto watershed. All of them are assigned to class "AL" as a result of the Water Classification Program (LeBlanc-Poirier et *al*., 2004b). That status means that, once the province's Water Classification Regulation is implemented, these lakes must be maintained or managed in such a way that the existing condition of the body of water is protected. The seven lakes in the watershed are Adamsville Lake, Camille Lake, Coal Branch Lake, Geddes Lake, Jardine Lake, Kent Lake and St. Joseph Lake *(ibid)* (Fig. 20). Jardine Lake is protected because it is within the boundary of the Kouchibouguac National Park.

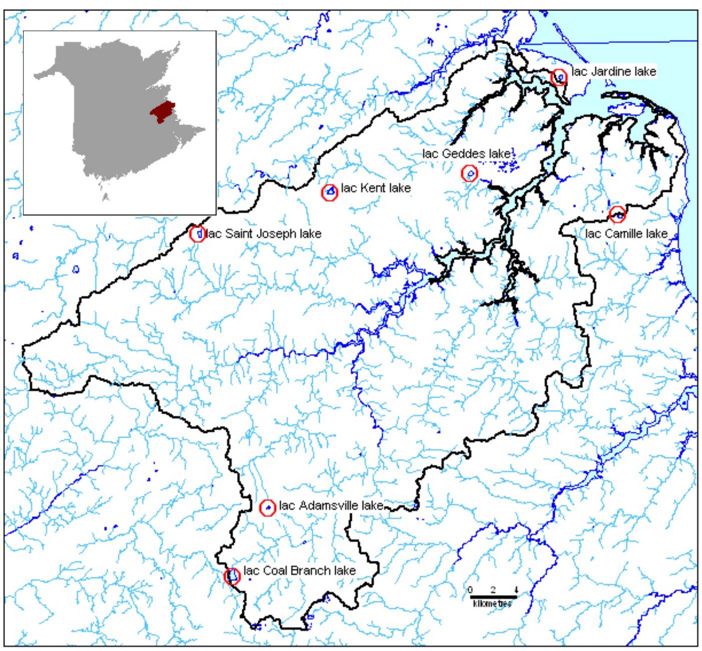


Figure 20 : Freshwater lakes in watershed

Source: NB Aquatic Data Warehouse

3.1.3.2. **Rivers**

The hydrography of the watershed comprises a network of rivers, each of them fed by its own sources. Together they form a continuum of physical environments linking aquatic plant and animal communities to their terrestrial counterparts. For the most part, the watershed's rivers are fed from the same sources as its freshwater lakes. Rainfall, runoff from the adjacent land and groundwater seepage feed the streams that empty into the rivers (Maser & Sedell, 1994).

The Richibucto Bay watershed contains numerous streams and rivers. The main ones are the Richibucto River (Fig. 21), the Bass River, the Molus River, the St. Charles River, the St. Nicholas River and the Coal Branch (Fig. 7). The nature and composition of these streams and rivers vary with the terrain through which they flow. Table 1 presents a summary of field observations of each of these rivers that were made in the course of river classification activities conducted in 2004 (LeBLanc-Poirier et *al*., 2004b).

Table 1: Characteristics of rivers collected during 2004 river classification activities.

River	**Substrate**	**Hydrography**	**Shoreline vegetation**	**Adjacent land use**
Richibucto River (Fig. 6, 7 and 21)	Boulders and rock	Bars, pools and runs	Alder, bushes and a few trees	Region mostly forested, a few residences, cottages and farmland
Bass River (Fig. 7)	Rock, gravel and sediment	Deep pool above the bridge	Alder and 95% conifers on a steep bank	Region mostly forested, a few residences
Molus River (Fig. 7)	Gravel and sand	Riffles and runs; beaver dam	Trees and bushes	Region forested
St. Charles River (Fig. 7)	Rock, gravel and sediment	Riffles and runs, signs of beaver habitat	Alder	Region forested with a few residences and a little farmland
St. Nicholas River, East Branch (Fig. 7)	Sediment build up	Runs	Alder	Region forested with a little farmland
St. Nicholas River, South Branch (Fig. 7)	Sediment build up	Runs, signs of beaver habitat	Grasses and alder	Region forested with a few residences and some farmland

St. Nicholas River, West Branch (Fig. 7)	Rock, gravel and sediment build up	Riffles and runs Signs of beaver habitat	Alder and other tree species along bank	Region forested with a few residences, farmland and a sawmill
Coal Branch (Fig. 7)	Boulders, rock and gravel	Riffles, pools and runs	Grasses, alder and other tree species	Region forested with a few residences, farmland and an abandoned mine

Source: LeBlanc-Poirier et *al.* (2004b)

A total of 318,579.8 square metres of salmonid rearing habitat was identified in the course of an evaluation of 29.4 kilometres of the Richibucto River. Beaver (*Castor canadensis*) ponds account for nearly 90 per cent of the pools in that river (Maillet, 1996).

The St. Charles River contains approximately 88,283 square metres of salmonid rearing habitat, while the West Branch of the St. Nicholas contains an average of 94,505 square metres of salmonid rearing habitat, 14 per cent of it consisting of riffles in the river and 67 per cent beaver ponds. It has been suggested that beavers may be detrimental to trout production in this hydrographic system (Maillet, 1996).

According to a study conducted by Melanson et *al*. (1998), there are very few brook trout (*Salvelinus fontinalis*) or Atlantic salmon (*Salmo salar*) in the Richibucto River and its tributaries, despite stocking efforts from 1995 to 1997. The temperature of the water, which may rise above 20 ^{o}C on occasion, appears to be a limiting factor in the Coal Branch, and sedimentation is a problem that may affect the survival of salmonid eggs and fry (Scott & Crossman, 1998; Maillet, 1996). A study has shown that salmonids do not occupy the entire habitat available to them in the watershed. The study in question, however, did not take fish habitat quality into account (Melanson et *al*., 1998).

Figure 21: View of the Richibucto River

3.1.3.3. Estuary and bay

An estuary is a transition zone that harbours a wide range of plant and animal species. As a rule, all sorts of biological activities take place in these ecosystems. Nutrients from inland and coastal water sources enhance their productivity. An estuary provides spawning beds, rearing areas and feeding grounds for numerous species of fish and other animals.

A bay is “an indentation of indeterminate size in a coastline, in some cases with a narrow entrance” (Parent 1990, p. 64). A bay may also be an estuary if it is characterized by an inflow of fresh water from inland, as is the case with a number of bays, including Richibucto Bay. Marine waters, including estuaries, may be divided into two zones: the benthic zone and the pelagic zone. The term “benthic zone” denotes the sea bed, whereas the “pelagic zone” is the space within the water column.

The estuary of the Richibucto watershed begins at the barrier beaches and extends for over 19 kilometres up the Richibucto River (St-Hilaire et *al*., 2001b). The whole of the Northwest Branch, including the barachois, the body of water surrounding Indian Island and the Baie-du-Village are all considered as parts of the estuary (Fig. 10). The estuary is shallow, and the surrounding land is low-lying, never exceeding a height of 10 metres at any point. The underlying bedrock consists of sandstone, which is loosely consolidated.

Large quantities (some 37,000 cubic metres per year) of sediment are carried down into the estuary contributing to the formation of constantly changing barrier beaches (The Nature Trust of New Brunswick Inc., 1995).

In Richibucto Bay, 55 per cent of the bottom consists of soft or hard mud. Sand and mud cover 57.6 per cent of the bottom area of the Baie-du-Village and Richibucto Harbour. The bottom of the channels in the estuarine part of the Richibucto River and the Northwest Branch consists mainly of silt sediment (Senpaq Consultants, 1990).

The estuary of the Richibucto watershed can represent a substantial economic value, as it is inhabited by various fish and shellfish species that are harvested commercially, for sport, for subsistence and ritual purposes, and for aquaculture. For more information on the various species fished, refer to section 6.4.1.3 Activities based on the aquatic resources.

3.2. TERRESTRIAL BIOTIC COMPONENTS

3.2.1. Terrestrial flora and fauna

3.2.1.1. Terrestrial flora

In New Brunswick’s eastern lowlands, the Acadian forest consists mainly of coniferous species. According to Dryade (1979), the species listed in Table 2 are the dominating species in this type of forest.

Table 2 : Example of trees of the eastern lowlands Acadian Forest

Common name	Scientific name
Red Spruce	*Picea rubens*
Black Spruce	*Picea mariana*
Balsam Fir	*Abies balsamea*
Eastern White Cedar	*Thuya occidentalis*
Eastern Hemlock	*Tsuga candensis*
Eastern White Pine	*Pinus nivea*
Red Maple	*Acer rubrum*
Tremblin Aspen	*Populus tremuloides*

Source: Crossland (1997)

In that part of the province, the vegetation that grows on the domes of peat bogs consists mainly of dwarf trees, bushes and mosses,such as the species listed in Table 3.

Table 3: Examples of plants found on the domes of bogs

Common name	**Scientific name**
Sphagnum moss (dominating species)	*Spagnum sp.*
Black Spruce	*Picea Mariana*
Pale Laurel and Sheep Laurel	*Kalmia sp.*
Leatherleaf	*Chamaedaphne calyculata*
Labrador Tea (Fig. 26)	*Ledum groenlandicum*
Hare's Tail (Fig. 24)	*Eriophorum spissum*

Source: Keys &Henderson (1987)

The plants that become established in succession fields are adapted to poor, disturbed soils. They cover the ground, enriching it while simultaneously protecting it from erosion and evaporation. The plants identified in Table 4 are among the most common for this habitat.

Table 4: Examples of plants in succession fields

Common name	**Scientific name**
Wild Rose (Fig. 25)	*Rosa sp.*
Blueberry	*Vaccinium sp.*
American Strawberry	*Fragaria americana*
Canada Fleabane	*Erigeron Canadensis*
Goldenrod	*Solidago sp.*
Sweet Fern	*Myrica sp.*
Alder	*Alnus sp.*
Orchids	*Orchicaceae sp.*

Source: Smith (1980)

Salt-loving species such as salt-meadow grass and salt-water cord-grass (*Spartina sp*.) are commonly found in the marshes of this region. Rushes (*Juncus sp.*) (Fig. 22) and red fescue *(Festuca rubra*) are other common plants that grow in the marshes of the lower estuary (L. Légère, pers. comm., received from E. Tremblay, November 10, 2005).

Figure 22: Juncus sp.

Figure 23: Beachgrass

Figure 24: Hare's tail

Figure 25: Wildrose

Figure 26: Labrador Tea.

Source: Campagne (1997), "By the sea" modules

Beachgrass (Fig. 23) is the dominant plant on the sand dunes. Its proliferating rhizomes serve to stabilize the dunes.

3.2.1.2. **Terrestrial fauna**

The Richibucto watershed comprises various habitats that are home to many animal species. The peat bogs, marshes and forests, to name only a few, meet the basic needs of a diversified fauna and flora living in and around the watershed.

Ruel et *al.* (1999) reported that animal species found inside the Kouchibouguac National Park also inhabited the Richibucto watershed. Nearly 50 mammal species and over 200 species of birds have been identified in the park (Beach, 1988). Tables 5 and 6 present a summary of the most common species found in New Brunswick as a whole. The scientific names of these species can be found in the list in appendix 2.

Table 5: Common species of mammals, amphibians and reptiles in New Brunswick

Large mammals	Fur-bearing mammals	Small mammals
White-tailed deer Moose Black bear	Long-tailed weasel Beaver Coyote Squirrels Short-tailed weasel Snowshoe hare River otter Bobcat Woodchuck Striped skunk Porcupine Muskrat Common raccoon Red fox American mink	Voles and lemmings Bats Shrews Mice

Amphibians	Reptiles
American toad Green frog, pickerel frog, northern leopard frog, mink frog and wood frog Bullfrog Spring peeper Redback salamander, yellow-spotted salamander and northern two-lined salamander Eastern or red-spotted newt	Common snapping turtle Maritime garter snake Red-bellied snake Smooth green snake

Sources: Atlantic Canada Conservation Data Centre (ACCDC) (2005), G. Godin, DNR, pers. comm.., (November 28, 2005)

Table 6: Bird species common to eastern New Brunswick

Inland and field birds		Coastal and shore birds	Waterfowl and others
Northern harrier Sparrows American goldfinch Ruby-throated hummingbird Raven American crow American kestrel Merlin Great horned owl Ruffed grouse	Thrushes Swallows Waxwings Chickadees American robin Warblers Woodpeckers Mourning dove Vireos	Osprey (Fig. 27) Hudsonian godwit Sandpipers Yellowlegs and willets Gulls Great blue heron Kingfisher Plovers Common tern Ruddy turnstone	Canada goose (Fig. 29) Mallard American black duck Double-crested cormorant Eiders Ring-necked duck Common goldeneye Grebes Mergansers Scoters Teal

Sources: ACCDC (2005), Campagne (1997), Amirault (1997), Canadian Wildlife Service (CWS)(2004) and R. Chiasson, pers. comm.., (December 2, 2005).

The Richibucto estuary and its barrier beaches have long been identified as good habitat for several species of migratory birds. Numerous colonies of birds use the region as nesting, feeding and staging areas (Amirault, 1997). Piping plovers (*Charadrius melodus*), an endangered species (Fig. 28), have been observed on the Richibucto North and South Dunes during their spring nesting period (The Nature Trust of New Brunswick Inc., 1995).

Figure 27: Osprey.

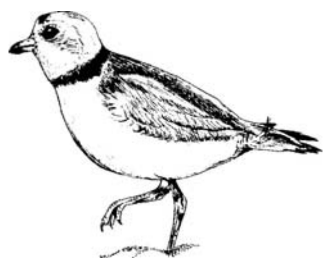


Figure 28: Piping plover

Figure 29: Canada goose

Source: Campagne (1997), "By the Sea" modules

3.3. AQUATIC BIOTIC COMPONENTS

3.3.1. Planktonic communities

Plankton consists of microscopic or near-microscopic organisms that inhabit fresh, brackish or salt water. It comprises three main groups: phytoplankton (Fig. 30), zooplankton (Fig. 31) and ichthyoplankton (Fig. 32). Phytoplankton consists mainly of microscopic algae equipped with tiny flotation devices. Zooplankton consists of micro- and macroscopic animal species, while ichthyoplankton consists exclusively of the larvae of various fish species (Campagne, 1997; R. Bernier, DFO, pers. comm., December 15, 2005).

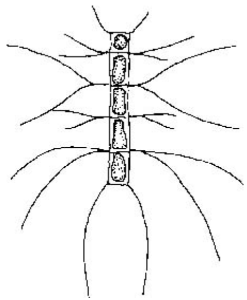


Figure 30: Phytoplankton

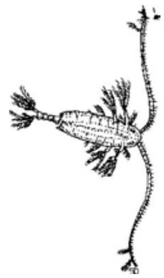


Figure 31: Zooplankton

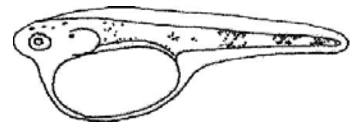


Figure 32: Ichtyoplankton

Source: Campagne (1997), “By the sea” modules

Planktonic organisms are highly important in the aquatic food chain. They themselves are primary and/or secondary producers (Fig. 33), and as such, they serve as food for many types of organism higher up the chain (Campagne, 1997; R. Bernier, DFO, pers. comm., December 15, 2005).

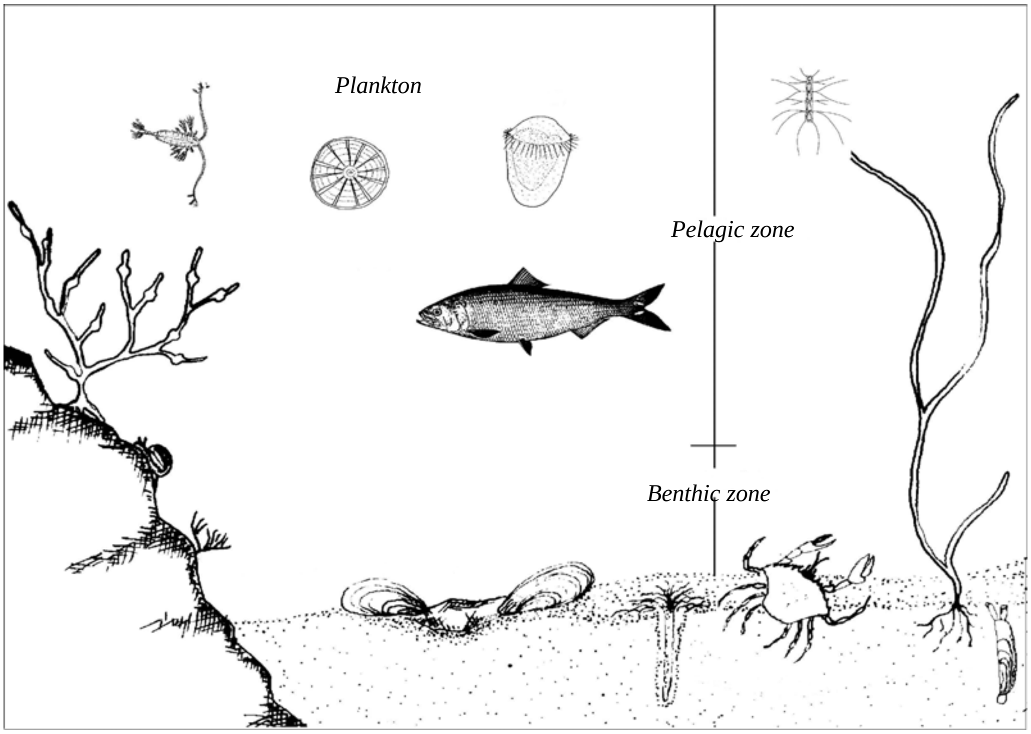


Figure 33: Aquatic community assemblage

Source: Campagne (1997) module 1, p.36 “By the sea“

An inventory of the planktonic community was conducted in the estuaries of the Kouchibouguac National Park in 1997 and 1998. It is to be presumed that the plankton species found in those estuaries are similar to the plankton species that inhabit the Richibucto estuary, as the two watersheds are adjacent to one another and their estuaries are similar (A. Locke, pers. comm., April 14, 2005). Table 7 presents the most common species.

Table 7: Plankton found in the Kouchibouguac National Park

Phytoplankton	**Zooplankton**	**Ichthyoplankton**	**Remarks**
Diatoms: *Thalasiosira nordenskioeldii,* *Th. rotula* *Chaetoceros debilis* *Ch. diadema* *Melosira arctica* Flagellates: *Cryptomonas appendiculata,* *Eutreptiella marina*	Rotifers, worms and jellyfish: Ascomorpha Notholca Oligochaeta Jellyfish (species of *Obelia* and *Sarsia*) Cladocerans such as: *Evadne nordmann* *E. tergestina* *Podon leuckart* Adult copepods: *Acartia spp.* *Calanus finmarchicus* *Centropages hamatus* *Eurytemora spp.* *Labidocera aestiva* *Pseudocalanus minutus* *Temora longicornis* *Tortanus discaudatus* Larval decapods: *Crangon septemspinosa*.	Gaspereau (*Alosa pseudo-harengus*) Smelt (*Osmerus sp*.) Atlantic tomcod (*Microgadus tomcod*) American sand lance (*Ammodytes americanus*) Flounder (*Pleuronectes sp.)*	Found during late winter and spring 88 species of zooplankton identified for the first time in the estuary of the Park Ichthyoplankton was more abundant in June and July
Others: Euglenophytes Dinoflagellates Phytoflagellates			Found later in the season
Chaetoceros salsugineus			Exotic species, native to the Sea of Japan
	Cymbasoma rigidum *Evadne tergestina*		Identified for the first time on the eastern New Brunswick coast

Source: Bernier et *al*. (1998), Bernier (2001)

Chlorophyll is a plant pigment produced by phytoplankton, among other sources. It is an indicator of ecosystem productivity. In the course of a study on the growth and survival of juvenile sea scallops (Frenette, 2004), chlorophyll a levels were determined at three locations in Richibucto Bay and in Cocagne Bay, Shemogue Bay and Bouctouche Bay. The lowest concentrations were found in Richibucto Bay, with an average value of $2.8 \pm 1.1 \mu g/L$ *(ibid)*. Chlorophyll concentrations were higher during the summer months (July to September) than in autumn (October and November) *(ibid)*.

A study on shellfish ecology conducted from 1986-1988 (Senpaq Consultants, 1989) found that chlorophyll concentrations in Richibucto Bay were highest in the Northwest Branch, near the Aldouane marina, and north of Indian Island in Richibucto Harbour.

3.3.2. Benthic communities

The sea floor harbours a wide variety of communities (Fig. 33). Temperature, light conditions, type of substrate, and length of intertidal exposure time are all factors that play a role in species distribution. A number of the species that inhabit this zone are sedentary; some burrow into the substrate, while still others move about but spend their entire lives in the benthic environment (White & Johns, 1997). Table 8 presents a summary of the most common species observed in the course of various inventories. Although some species are assigned to a particular area, they may well inhabit other parts of the watershed, as few of the inventories in question covered the entire basin.

Table 8: Common species of the benthic community

Species	**Location where observed**	**Remarks**
Shore flora		
Eelgrass (1, 2, 3) (*Zostera marina*) (Fig. 34)	Widespread throughout the estuary	Captures sediment Reduces currents Provides food and shelter for various species Contributes to nutrient production in the estuary Roots help stabilize the sea bed Dense growth everywhere except in channels Very dense growth in Richibucto Harbour
Macrophytes		Main productive organisms in the intertidal zone Provide shelter and food for a wide variety of animal and plant species (1)
Sea lettuce (2, 3) (*Ulva lactuca*) (Fig. 35)	Widespread in the Baie-du-Village	Found in areas of shallow water Low density Nutrient indicator
Hollow green weed (2, 3) (*Enteromorpha sp*)		Presence observed in the estuary, density and precise location unknown
Rockweed (2, 3) (*Fucus sp.*) (Fig. 36)	Widespread along the shoreline, especially in the Baie-du-Village	The most widespread species in the Baie-du-Village Grows in areas of shallow water Dense growth along the shore Low-density growth in the Baie-du-Village and the Northwest Branch

Smooth cord weed (2, 3) (*Chorda filum*) (Fig. 37)	Widespread in Richibucto Harbour and the Northwest Branch	Appears to prefer deep water Hardly occurs in the Baie-du-Village
Irish moss (5) (*Chondrus crispus*)	Off the South Dune	Commercially valuable species Harvested off the South Dune
Benthic invertebrates (4)		Used as water quality indicators Some species cannot tolerate degraded habitat Annelid worms like poor conditions
Plecoptera Coleoptera Chironomidae Ephemeroptera Trichoptera Annelid worms (4)	Found in the streams and rivers of the watershed	Intolerant species identified in the Bass River and Richibucto River Tolerant species identified in the Molus River, the St. Charles River, and the West Branch of the St. Nicholas River
Starfish (2) (Fig. 38)	Richibucto Harbour Mouth of Northwest Branch	Mollusc predators Large low-density areas
Sponges (2)	Harbour entrance Entrance to Northwest Branch Entrance to the Richibucto River Near port of Richibucto	
Sea anemones (2)	Throughout the harbour channel up to the wharf	
Molluscs		(Wild populations)
American oyster (2, 11) (*Crassostrea virginica*) (Fig. 40)	Population spread over approximately 22% of the bottom in the bay	Enhance water quality Filter up to 34 litres of water per hour Density low except in Richibucto Harbour and the Baie-du-Village near aquaculture operations Small high-density bed in channels of the Richibucto and the Northwest Branch
Blue mussel (2) (*Mytulis edulis*)	Population spread over approximately 57% of the area in the bay	Dominant species in the bay as a whole A majority of the population covered by the inventory is under legal size (50 mm) Larger-sized mussels do not appear to be able to withstand the high water temperature in the bay Larger beds in the Baie-du-Village and the estuary of the Richibucto River Greater density at the mouth of the Northwest Branch
Ribbed mussel (2) (*Modiolus demissus*)	Found in the Northwest Branch, Richibucto River, Mooney's Creek and the Baie-du-Village	Mainly in water with low salinity Seem to prefer a sandy/muddy bottom
Soft-shell clam (2, 6, 7) (*Mya arenaria*)	Along the north shore of the bay. Especially abundant in the Baie-du-Village and the Northwest Branch	In 1987, the average size of clams covered in the inventory was 31.9 mm (2) In 2004, 95 % of clams covered in the inventory were < legal harvesting size (50 mm) (6) 53% of clams covered in the 2004 inventory were < 20 mm (6) Project aimed at restoration of the soft-shell clam population was initiated in 2005 in the tidal pond

		(6) The ice that forms around the South Dune may have an impact on soft-shell clam beds in some open areas (7) Mean density was 47 individuals/square metre (6) High-density beds had 260 individuals/square metre (6)
Surf clam (2) (*Spisula solidissima*) Quahaug (2) (*Mercenaria mercenaria*) (Fig. 41) Razor clam (2) (*Ensis directus*)	Dispersed	The high water temperature that sometimes occurs in the bay may adversely affect the survival of surf clams Very few beds of surf clams or quahogs, and most of them were low-density A high-density bed of razor clams in Richibucto Harbour
Gastropods		
Sea snail (2) (*Lunatia heros*) (Fig. 39)	Channels in Richibucto Harbour and the Northwest Branch	Mollusc predators Seem to prefer a hard bottom
Common periwinkle (2) (*Littorina littorea*)	Found throughout the bay	Progressively scarcer in rivers with increasing distance upstream High-density beds
Smooth periwinkle (2) (*Littorina obtusata*)	In shallow water throughout the bay, where eelgrass grows	Lives on rocks and vegetation Abundant in eelgrass flats
Eastern mud whelk (2) (*Nassarius obsoleta*	In shallow water in the Baie-du-Village and the Richibucto River	Most beds were low-density
Crustaceans		
American lobster (2) (*Homarus americanus*)	In deep water in the channels	High-density concentration in the island area
Rock crab (2) (*Cancer irroratus*)	Widespread occurrence in the channels in the harbour	High-density concentration in the mouth of the Richibucto River Low density observed in the Baie- du-Village
Mud crab (3) (*Rhithropanopeus harrissii*)	Mill Creek	
Sand shrimp (3, 8) (*Crangon septempspinosa*) (Fig. 42)	Baie-du-Village	Serves as food for fish species, e.g. white perch
Grass shrimp (3) (*Palaemonetes vulgaris*)	Baie-du-Village	
Groundfish		
Winter flounder (2, 3) (*Pleuronectes americanus*)	Throughout the estuary	
Smooth flounder (2, 3, 10) (*Pleuronectes putnami*)	Baie-du-Village, Mill Creek region	
White hake (9) (*Urophysis tenuis*)		Harvested by local fishers

The numbers in parentheses in tables 8 and 9 refer to the following authors:

(1) Campagne (1997)

(2) Senpaq Consultants (1990)

(3) Thériault, M.-H., (2005, unpublished work)

(4) LeBlanc-Poirier et *al*. (2004a)

(5) Therrien et *al*. (2000)

(6) Ouellette, M., (2005, unpublished work)

(7) Boghen & St-Hilaire (1997)

(8) St-Hilaire et *al*. (2002)

(9) DFO Fisheries Landings Statistics

(10) Ouellette et *al*. (1997)

(11) Milewski & Chapman (2002)

(12) Melanson et *al.* (1998)

(13) Atkinson (2004).

(14) Tremblay et *al.* (2005)

(15) Robinson et *al.* (2004)

(16) Robinson et *al.* (1998)

(17) Maillet (1996)

(18) (Robinson et *al*. 2001)


Figure 34: Eel grass

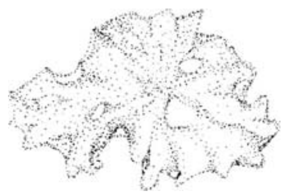


Figure 35: Ulva


Figure 36: *Fucus sp*


Figure 37: Chorda


Figure 38: Starfish

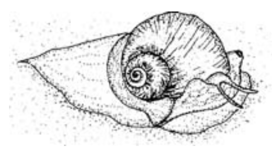


Figure 39: Sea snail.


Figure 40: American oyster


Figure 41: Quahog

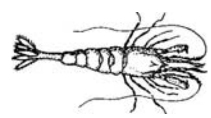


Figure 42: Sand shrimp

Source: Campagne (1997), "By the sea" modules

3.3.3. Pelagic communities

3.3.3.1. Pelagic fish

Pelagic fish are species that live in the water column. They include diadromous species, which live in fresh water at some stages of their lives and in salt water at others. The presence of various fish species is well documented. Table 9 presents a number of common species that have been identified in the course of various studies. For the scientific names of these species, see appendix 2.

Table 9: Recorded species of pelagic fish

Species	Locations	Remarks
Atlantic salmon (Fig. 43) Brook trout Dace Minnows Lamprey Chub Slimy sculpins Atlantic silversides Banded killifish Four-spined stickleback Three-spined stickleback Nine-spined stickleback Black-spotted stickleback (Fig. 44) American shad Striped bass (Fig. 45) White perch Rainbow smelt Atlantic tomcod Gaspereau Flounder Common shiner Mummichog Cunner (10, 12, 13, 14, 17,18)	Richibucto River above Rexton and various streams in the watershed	The Richibucto River and a number of its tributaries were stocked with brook trout around the period 1994-1997. (12) Between 1974 and 2002, the Richibucto River and the Coal Branch were the only rivers found to be harbouring stable populations of juvenile Atlantic salmon. (13) Between 1974 and 2002, there were more slimy sculpins and trout in the St. Nicholas River than in other streams, probably owing to the cold water in that river. (13) An Atlantic salmon stocking project began with the collection of broodstock in 2004. In 2005, the Coal Branch, the Richibucto, the West Branch of the St. Nicholas, the Bass, the Molus and the St. Charles were stocked with parr (E. Tremblay, pers. comm., November 10, 2005)
Striped bass White perch American eel (Fig. 46) Gaspereau Flounder (*Pleuronectes sp*.) Atlantic cod Atlantic tomcod American shad Rainbow smelt Lamprey Sculpin Skate (*Raja sp*.) Three-spined stickleback Four-spined stickleback Nine-spined stickleback Black-spotted stickleback Mummichog Banded killifish Atlantic silversides (3, 8, 15, 16, 17,18)	Estuary of the Richibucto below Rexton, in the harbour, the Northwest Branch, and the Baie-du-Village	White perch is found to be abundant in the estuary of the Richibucto (8). The striped bass population has been on COSEWIC'S list of species at risk since November 2004 Striped bass inhabit the Richibucto River and have been observed in this watershed during the winter season (15)

Figure 43: Atlantic salmon.

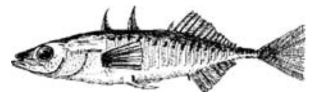


Figure 44: Stickleback

Figure 45: Striped bass

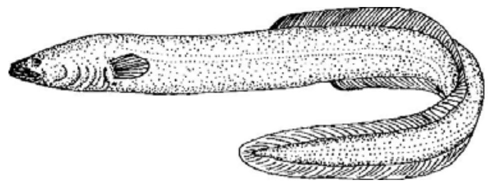


Figure 46: American eel

3.3.3.2. **Marine mammals**

The marine mammals that are frequently observed along the New Brunswick coastline are the harbour porpoise (*Phocoena phocoena*), the Atlantic white-sided dolphin (*Leucopleurus acutus*) and the minke whale (*Balaenoptera acutorostrata*) (Atlantic Canada Conservation Data Centre, 2005). The presence of these species in the Richibucto Bay region or Northumberland Strait has not been confirmed. The local people report that grey seals (*Halichoerus grypus*) (Fig. 47) can be seen in the vicinity of the Richibucto dunes during certain times of the year (M. Daigle, pers. comm., April 27, 2005).

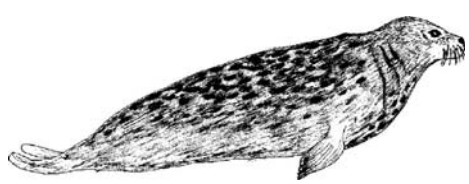


Figure 47: Grey seal

4. TRADITIONAL AND LOCAL KNOWLEDGE

4.1. TRADITIONAL KNOWLEDGE OF LOCAL FIRST NATIONS

Although there are two First Nations communities in the Richibucto Bay watershed (Elsipogtog and Indian Island), very little information about their traditional knowledge was available. Accordingly, this item is included in the section on information gaps in chapter 8 of this report.

The elders of the Indian Island First Nation recall that there were formerly large beds of Atlantic surf clams (*Spisula solidissima*) on both sides of the South Dune (Boghen & St-Hilaire, 1997). There is no indication that these beds still exist, although accumulations of shells are occasionally observed along the shore (*ibid)*.

4.2. TRADITIONAL KNOWLEDGE OF COMMERCIAL FISHERIES

In 1996-97, DFO's Gulf Region attempted to identify the main habitats of commercially harvested species throughout the southern Gulf of St. Lawrence, using traditional knowledge of fishers, fisheries officers, biologists and others. The information gathered was used to prepare an atlas of thematic maps. Table 10 provides details of significant habitats that were identified in the Richibucto Bay region for some of these commercially harvested species (Canada. Department of Fisheries and Oceans, 1998).

Table 10: Significant habitats of certain commercial fish species

Species	Distribution area	Remarks
Rock crab	Both sides of the Richibucto North and South Dunes, in Richibucto Harbour, and in the Northwest Branch to a point below the point at which the Petite-Aldouane River flows into it	High population density throughout this area Heavy concentration of females along the dunes on the Strait side Small crabs in the harbour
Lobster	Both sides of the Richibucto North and South Dunes, in Richibucto Harbour, and in the Northwest Branch to a point below the point at which the Petite-Aldouane River flows into it	Spawn in Richibucto Harbour and in the Northwest Branch below the point at which the Petite-Aldouane River flows into it.
Smooth flounder	In Richibucto Harbour and along the dunes in the Strait	
Scallop	Occurs sporadically off the North and South Dunes in the Strait	
Herring	In the harbour and all along the coastline in the Strait	Spring spawning area
Atlantic mackerel	Off the North Dune	
Mussel	Both sides of Richibucto Harbour, with a section in the Northwest Branch near the mouth of the Petite-Aldouane River	(Fig. 48)
American oyster	Throughout the Richibucto estuary as far as the inner side of the barrier dunes, with a large bed in the Baie-du-Village and part of the tidal pond, on both shores at the mouth of the Richibucto River,	(Fig. 48)
Soft-shelled clam	Nearly everywhere along the coast throughout the estuary	The entire tidal pool appears to be suitable habitat for this species (Fig.48)
Surf clam	Heavy concentrations off the Richibucto North and South Dunes.	

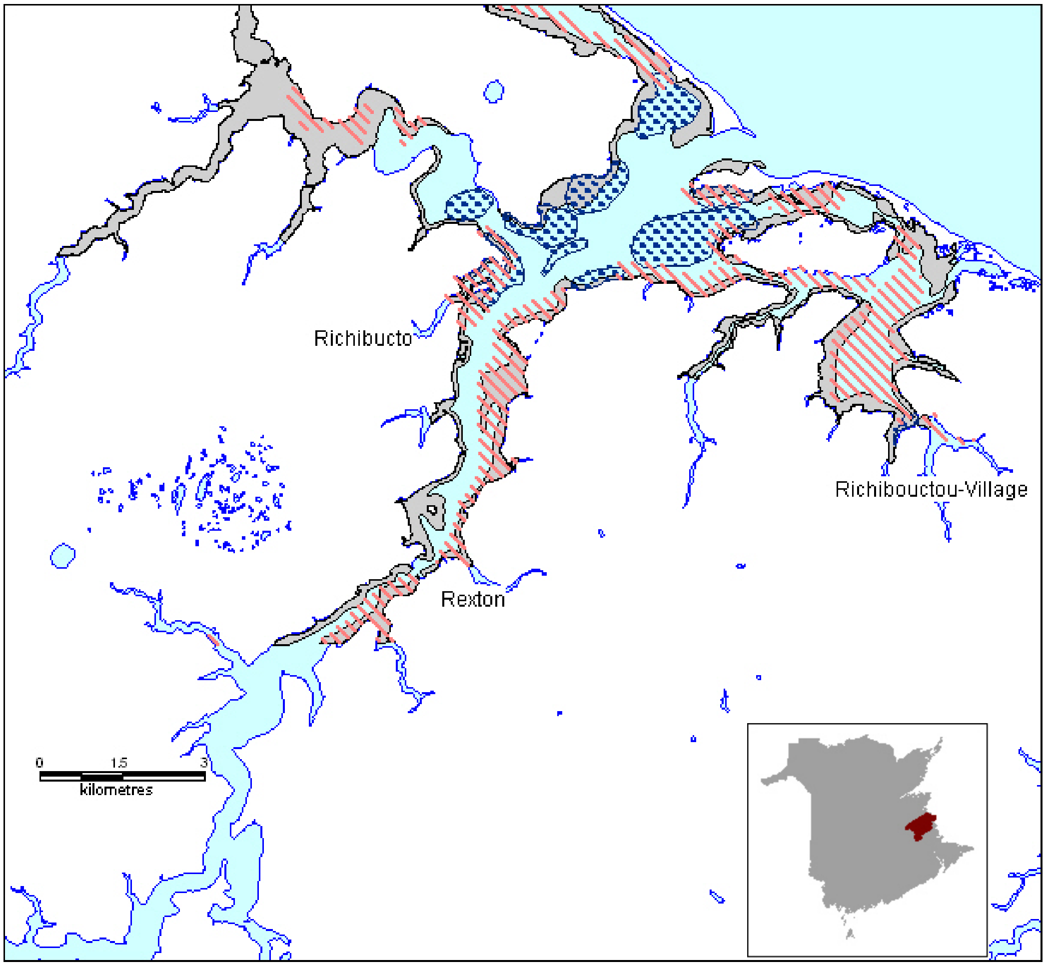
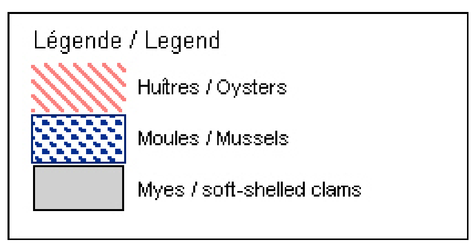


Figure 48: Population distribution of oysters, mussels and soft-shelled clams

Source :
Canada. Dept. of Fisheries and Oceans (1998)



5. ECOSYSTEM DESCRIPTION

This chapter presents a summary of the physical and biological components of the watershed and explains, in simple terms, how this ecosystem functions.

Geology, geomorphology and the seasonal climate are physical factors that form the characteristics of the ecosystem. The entire Richibucto watershed, located in the coastal plain with a mean elevation of 45.5 metres above sea level (Montreal Engineering Company, 1969), is fairly flat, sloping gently down to the sea. The underlying bedrock consists of soft sandstone and siltstone. Sediment erodes from exposed areas and is gradually carried toward the estuary by runoff and wind and wave action. This sediment build-up is part of the reason why the bay is perpetually changing, thus influencing the form of barrier beaches, the depth of water in the bay, and the circulation of water within it (The Nature Trust of New Brunswick Inc., 1995).

The bay is fed by two major sources of water. Fresh water from rivers pours into it at an average rate of approximately 26.0 cubic metres per second (Gregory et *al*., 1993). The Richibucto River, with its various tributaries, and the Northwest Branch, which is fed by the St. Charles and the Petite-Aldouane, are the main sources of fresh water. Salt water comes in from Northumberland Strait. For the most part, it enters the bay through an opening between the Richibucto North Dune and the Richibucto South Dune (Fig. 1 and 10).

Ordinarily, the water becomes thoroughly mixed in the bay, with a retention time of approximately 29 hours (Gregory et *al*., 1993). However, the mixing process is also affected by such factors as increased fresh water inflow from melting snow and ice, heavy rainfall, and unusually high tides. All these factors are associated with the climate and its seasonal fluctuations.

Richibucto Bay forms an estuary that extends upstream above the mouths of the main rivers, where the water ceases to be brackish. The limits of the estuary vary according to the salinity and the flow of water from inland and the tides. In the Richibucto watershed, brackish water has been detected as far upstream as 37 kilometres inland from the barrier dunes (St-Hilaire et *al*., 2001b). The circulation of water in this drainage area, with its shallow bay, normally presents a well mixed non-stratified estuary.

The estuary is a transition zone that harbours a wide range of plants and animals. As a rule, these ecosystems support important biological activity. Water from the inflowing rivers, runoff from the adjacent land areas, and the tides all carry nutrients into the estuary (Campagne, 1997). This habitat provides spawning grounds, rearing grounds and feeding grounds for many species of fish and other creatures (Elliott & McLusky, 2002). It is also used as a nesting and staging area for a number of migratory bird species (Campagne, 1997).

The various marshes in the watershed produce organic matter and nutrients that ultimately precipitate into the water. The turbulence created by the currents that traverse the estuary takes nutrients from the bottom and puts them into suspension in the water column, where they can be used by certain organisms (Fig. 49). The warm water temperatures and the ability of light to penetrate through the water to the substrate contribute to the development of phytoplankton, macrophytes and other plants such as eelgrass (Campagne, 1997).

Phytoplanktons are known as primary producers and constitute the base of the food chain. The sun provides the energy required to produce these organisms, which are subsequently ingested by secondary consumers such as zooplankton (Fig. 49). These primary producers, along with macrophytes and aquatic plant communities, produce organic matter high in energy recycled by the ecosystem (Levasseur, 1996). Chlorophyll is an indicator of the presence of phytoplankton. The levels of chlorophyll are at their peak between July and September in Richibucto Bay (Frenette, 2004).

This mix of phytoplankton, zooplankton and organic matter in the water column provides food for other species, such as fish, molluscs, crustaceans and birds. The energy cycle is transferred from level to level up the food chain (Fig. 49). Various species fished for commercial or recreational purposes use Richibucto Bay during part or all of their life cycle.

The watershed’s hydrological system, determined by the physical characteristics of the bay, contributes to the formation of various habitats that, in turn, define the ecosystem’s characteristics. Human activities of various kinds are known to introduce surplus nutrients and other harmful substances into the rivers of the Richibucto Bay watershed. Nitrogen and nitrate levels, for example, are increasing in a number of sub-watersheds, such as the St. Charles, the St. Nicholas, the Molus and the Coal Branch (Fig. 12). In addition, high faecal coliform counts have been observed at a number of points in the bay, leading to the closure of shellfish harvesting areas.

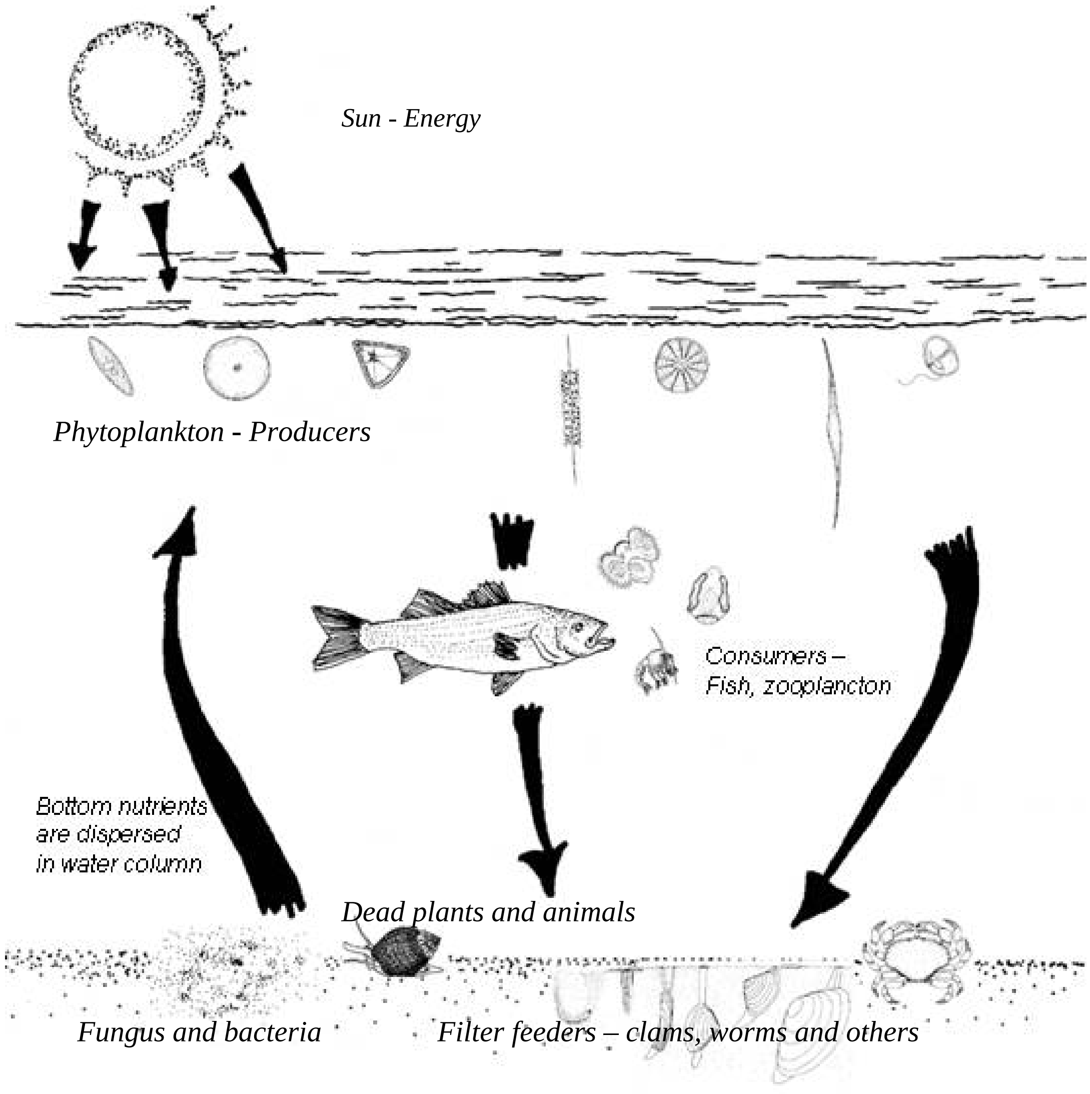


Figure 49: Cycle of nutrients in the coastal zone

Source: Campagne (1997) p. 47 “By the sea” modules

6. HUMAN SYSTEM

6.1. Human Colonization

The Aboriginal people of the watershed are from the Mi'Kmaqs ("Migmag") Nation. In the 1620s or thereabouts, Richibucto was known as the largest Aboriginal village on the entire east coast of North America (MacDonald, 1989). The Mi'Kmaqs of Richibucto were renowned as the most powerful tribe of the Mi'Kmaq Nation *(ibid)*. Early writers tell us that the region was named Richibucto before the arrival of the European settlers, and that this word means "river of fire" or "Elsipogtog" in Mi'Kmaq *(ibid)*.

Historians tell us that French pioneers arrived in the Richibucto region before the seventeenth century (MacDonald, 1989). Basques are said to have occupied the watershed's coastline in 1523, remaining there for some 50 years *(ibid)*. They were followed by Spaniards, and in 1534 Jacques Cartier arrived. *(ibid)*.

In 1653, Nicholas Denys founded the first European settlement in the Richibucto region. The local Aboriginal people depended on the watershed for their subsistence, and also for travel and trade. Barter became a major activity when the first pioneers arrived. Canoe routes in the Richibucto were highly important in those days. It was possible to reach the Bay of Fundy by passing through the Salmon River portage. Because of the deep natural channel of the Richibucto River, large numbers of boats arrived from distant places, and the area now known as Rexton became a sizable port where large vessels were built (Boghen et *al*., 1997). In the nineteenth century, New Brunswick's third-largest port was located in the Richibucto-Rexton area (Macdonald, 1989).

The region's first public school was built in 1815 *(ibid)*. The timber trade, notably exports of oak and white pine mainly used for building European ships, became an important economic activity for the region. Farming and large-scale fishing activities also got under way around the beginning of the 19^{th} century *(ibid)*. Rapid economic development and immigration contributed to the growth of local communities and exerted pressure on the Aboriginal population. Around the 1780s, The Mi'Kmaqs were sequestered into the reserves known today as Elsipogtog and Indian Island (ACOA & NBRDC, 2000).

Historically, the Richibucto watershed has played an economically important role in the lives of the Aboriginal, English and French communities because of its diverse natural resources and geographic characteristics.

6.2. HISTORICAL SITES

There is an old cemetery on the river known as the Northwest Branch, which flows into Richibucto Harbour (Fig. 50). It is located in the Kouchibouguac National Park, a kilometre north of Richibouctou Village (Turnbull, 1984). It extends for a distance of approximately 70 metres in a northerly direction along the shoreline, and was 25 metres wide early in the 1980s *(ibid*). Although it may be somewhat narrower now due to coastal erosion, it measured approximately 1,750 square metres at that time. The cemetery was in use for approximately 200 years. The oldest burial sites may go back to the sixteenth century *(ibid)*. The cemetery was reportedly used until the early years of the eighteenth century (*ibid*).

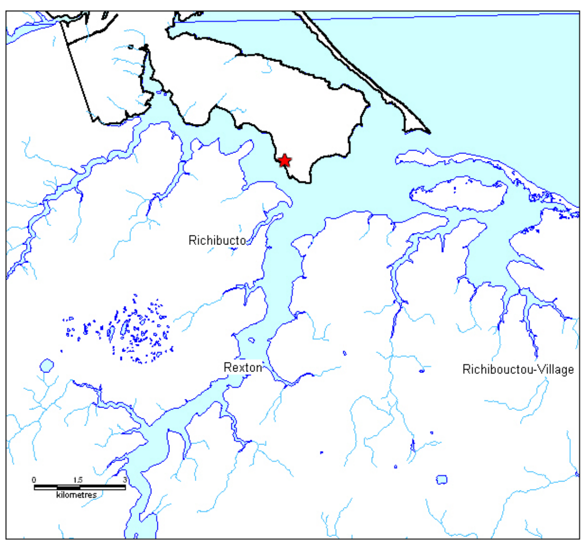


Figure 50: Location of historic cemetery

The site is indicated by a star

Sources: Service NB (2004); Turnbull (1984)

The village of Rexton is known for its wealth of historic places. Over twenty have been identified and placed on the Canada's Historic Places Internet site.These places are identified in Table 11 below.

Table 11: Historic places of Rexton

Name	**Location (Rexton)**	**Historic function**	**Current function**	**Construction date**
The Yard	45, 47, 49 River St.	Industry/Engineering facility	Environment/nature element	Not dated (n/d)
Post Office of 1897	Intersection of Main St. and Bonar Law Ave.	Residence	Residence	(n/d)
Church of the Immaculate Conception Cemetery	16 School St.	Cemetery or enclosure	Cemetery or enclosure	(n/d)
St. Andrew's United Church Cemetery	22 North St.	Cemetery or enclosure	Cemetery or enclosure	(n/d)
St. John the Evangelist Anglican Church	2 Queen St.	Religious facility	Religious facility	(n/d)
Church of the Immaculate Conception	8 School St.	Religious facility	Religious facility	1853
Kent Northern Hotel	125 Main St	Hotel	Commerce/shop	(n/d)
Jardine's Inn	104 Main St.	Residence	Commerce/inn	1860
St. Andrew's United Church	21 Water St.	Religious facility	Religious facility	1859
Richibucto Marine Hospital	36 Indian Rock Lane	Hospital	Residence/single dwelling	1853 to 1854
Lanigan and Bowser Mill Site	At the end of North St.	Industry/wood manufacturing facility	Public art or furnishings	1879
H.O. Stewart General Store	127 Main St.	Commerce/shop	Commerce/shop	1863
Palmer's Store	125 Main St.	Commerce/shop	Commerce/shop	(n/d)
Brait House	1 School St.	Commerce/shop	Commerce/shop	1850
de Olloqui House	12 Sunset Drive	Residence/single dwelling	Residence/single dwelling	(n/d)
John Jardine House	39 King St.	Residence/single dwelling	Residence/single dwelling	1825
Old Kingston Hall	79 Main St.	Residence/single dwelling	Town Hall	1880
Burns Mill Site	44 Sunset Drive	Industry/wood manufacturing facility	Environment/nature element	(n/d)
The Cedars	78 Main St.	Residence/single dwelling	Residence/single dwelling	1859
The Lilacs	33 Sunset Drive	Residence/single dwelling	Residence/single dwelling	c. 1880

Further information can be found at the Internet site http://www.historicplaces.ca

6.3. GOVERNANCE STRUCTURE

This section introduces the roles of the main stakeholders in the management of the territory and the various management mechanisms developed to this effect.

6.3.1. Role of federal and provincial governments

Government agencies have a very important role to play as stakeholders in the integrated management of a coastal zone. They are the primary managers and decision-makers for the territory, since they develop and apply the acts and regulations used to manage it. The Policy and Operational Framework of Canada’s Oceans Strategy (2002) promotes the involvement of all government levels in the integrated management of estuarine, coastal and marine environments in Canada. The concept of integrated management does present some challenges. There are various levels of governments with a multiplicity of jurisdictions and the responsibility of enforcing many acts and regulations. This can lead to overlapping mandates and conflicts in legislation. Government organisations will need to coordinate their activities and work together at all levels to harmonize their regulations so as to ensure the sound management of our oceans.

Since the list of management mechanisms used by various government stakeholders involved in the management of coastal areas can be very long and complicated, only the main management mechanisms are presented in Table 12.

Table 12: Federal and Provincial Governance Mechanisms

Management mechanisms	Agency responsible	Application
Federal mechanisms		
Fisheries Act	Fisheries and Oceans Canada Environment Canada	Targets the protection of fish and the habitats they use at different stages of their lives. Section 36(3) Polluting of fish habitats by the discharging of harmful substances into fish-bearing waters is applied by EC
Aboriginal Communal Fishing Licences Regulations	Fisheries and Oceans Canada	Regulations for issuing a communal licence to aboriginal organisations for fishing related

		activities
Navigable Waters Protection Act	Transport Canada	Designed to protect the public right of navigation of Canadian waters for transportation, trade or recreational purposes.
Oceans Act	Fisheries and Oceans Canada	Management mechanism based on the sustainable development of natural resources, the integrated management of activities carried out in coastal and marine areas and a precautionary approach in decision-making
Species at Risk Act	Responsibility shared by government agencies, the main ones being: Environment Canada Fisheries and Oceans Canada Parks Canada Natural Resources Canada Transport Canada	Designed for the conservation of wildlife species, to prevent their disappearance from this country and the planet as a whole. This act prohibits the slaughter or harassment of wildlife species identified on the List of Wildlife Species at Risk by COSEWIC. It also protects the living habitats of these species.
Migratory Birds Convention Act of 1994	Environment Canada	Management mechanism for the protection of migratory birds and their nests. It calls for the establishment, monitoring and management of protection zones for these birds, among other measures.
Canada Water Act	Environment Canada	Mechanism to manage the implementation and use of Canada's water resources.
Canadian Environmental Protection Act	Environment Canada	Targets the prevention of pollution, the protection of the environment and human health and the sustainable development of natural resources
Canadian Environmental Assessment Act	Canadian Environment Assessment Agency and all other federal departments involved pursuant to federal legislation	Targets protection of the environment, human health and the application of the principle of prudence. It promotes sustainable development conducive to a healthy environment and economy
Canadian Food Inspection Agency Act	Canadian Food Inspection Agency	To ensure the quality of food, the protection of plants and the health of animals
Provincial mechanisms		
Clean Water Act	Department of the Environment (DOE) and Department of Health and Wellness (DHW)	To maintain and improve water quality
Clean Air Act	DOE and DHW	To maintain and improve air quality

Clean Environment Act	DOE	To protect and improve the health of the environment
Aquaculture Act	Department of Agriculture and Aquaculture (DAA)	To regulate aquacultural development
Parks Act	Department of Tourism and Parks (DTP) and Department of Natural Resources (DNR)	To create and manage natural spaces for public use
Fish and Wildlife Act	DNR	To protect and manage fish stocks and wildlife
Community Planning Act	DOE	Used to plan and control the use of the land
Crown Lands and Forests Act	DNR	To manage Crown lands
Marshland Reclamation Act	DAA	To manage the construction and reconditioning of marshland, and to manage work carried out in marshes.
Oil and Natural Gas Act	DNR	To control the exploration and exploitation of oil and gas on freehold or Crown lands
Protected Natural Areas Act	DNR	To establish, maintain and manage unique natural spaces
Quarriable Substances Act	DRN	To control the extraction of substances such as peat, sand, gravel etc. on Crown Lands and all lands within 300 metres of either side of the coastline
Wetlands Conservation Policy	DNR	To preserve wetlands
Coastal Areas Protection Policy	DOE	To regulate coastal development

Sources: Environment Canada (2003), Justice Canada (2005), New Brunswick Department of Justice and Attorney General (2005)

6.3.1.1. **District Planning Commissions**

New Brunswick's District Planning Commissions administer the Community Planning Act under the authority of the Department of the Environment. They work in cooperation with the province and municipalities to produce appropriate land-use planning tools. Those tools may take the form of municipal plans or rural plans and their accompanying by-laws, such as zoning by-laws, construction by-laws and the like. DPCs also issue building permits, inspect buildings, and approve subdivisions. For the past several years, they have assumed the task of developing rural plans for the province's many local services districts (LSDs). These plans focus on the management of lands adjacent to municipalities. They serve to identify or demarcate those lands in zones for residential, recreational, industrial, commercial or agricultural use, logging, or they may be designated protected areas, and so on. Further information about municipal by-laws and rural plans in the Richibucto watershed area may be obtained from the Kent District Planning Commission at kentplan@nb.sympatico.ca (J. Goguen, pers. comm., June 6, 2005; S. Boucher, pers. comm., December 1, 2005).

6.3.1.2. **Other management plans**

Transport Canada has joined forces with Fisheries and Oceans Canada and other federal and provincial stakeholders to develop management plans for sustainable aquaculture activities in most of the bays in the Eastern New Brunswick Area. These plans were produced in the context of a preliminary study aimed at developing a replacement class screening assessment process for the suspended culture of oysters in that part of the province. Richibucto Bay is one of the first bays to have a zoning plan for aquaculture management in the region.

The Department of Natural Resources is responsible for managing Crown lands. Crown lands include not only forested or logged lands and mineral and other resources, but also submerged coastal lands. DNR manages these lands in the best interests of New Brunswickers. Residents of the province may use them for recreational and economic purposes; for extended use of Crown land, however, a formal agreement is required, usually in the form of a lease or permit. Commercial, industrial or communication leases are usually issued for a term of 20 years, while other types of lease, including institutional, municipal service, utility, transportation, campsite, shooting range or maple sugary leases, are usually issued for a term of 10 years (New Brunswick. Dept. of Natural Resources, 2006). Further information on the management of Crown land can be found at the New Brunswick Department of Natural Resources Internet site, http://www.gnb.ca/0263/lease-e.asp.

6.3.2. Local and municipal governance

The main communities in the watershed are Richibucto, Rexton and Elsipogtog. The remaining residents live in small communities that are served by Local Services

Districts, with the exception of the Indian Island Aboriginal community. That community is located on the south shore of Richibucto Harbour, near the Baie-du-Village. At the present time, the population of the watershed and adjacent LSDs totals approximately 13,000 people (Table 13).

Local Services Districts (LSDs) were established by the provincial government as a means of making such services as solid waste collection and fire protection available to residents and other persons living in unincorporated areas (Fig. 51). Under the Municipalities Act, an advisory committee is elected for each LSD. These committees work closely with regional advisors to resolve local issues but haven't any financial or contractual authority. The Minister is responsible for the administration of LSDs, through the advisory committees.

Table 13: Population of Richibucto Bay watershed

Communities, Local Services Districts (LSD) and Parishes	**Population (# of persons)**
* Elsipogtog First Nation (on the reserve)	2100
Richibucto	1341
Rexton	810
**Indian Island First Nation	97
Weldford LSD	1467
Harcourt LSD	458
St. Charles LSD	1197
Aldouane LSD	898
Cap-de-Richibucto LSD	1141
Civil Parish of Richibucto	704
Civil Parish of Sainte-Marie	1762
Civil Parish of Saint-Paul	951
Civil Parish of Wellington	436
Total	13362

Sources: D. Goguen, Kent Planning District, pers. comm., (April 25, 2005)

* Elsipogtog First Nation (2005)

** Statistics Canada 2001 Census

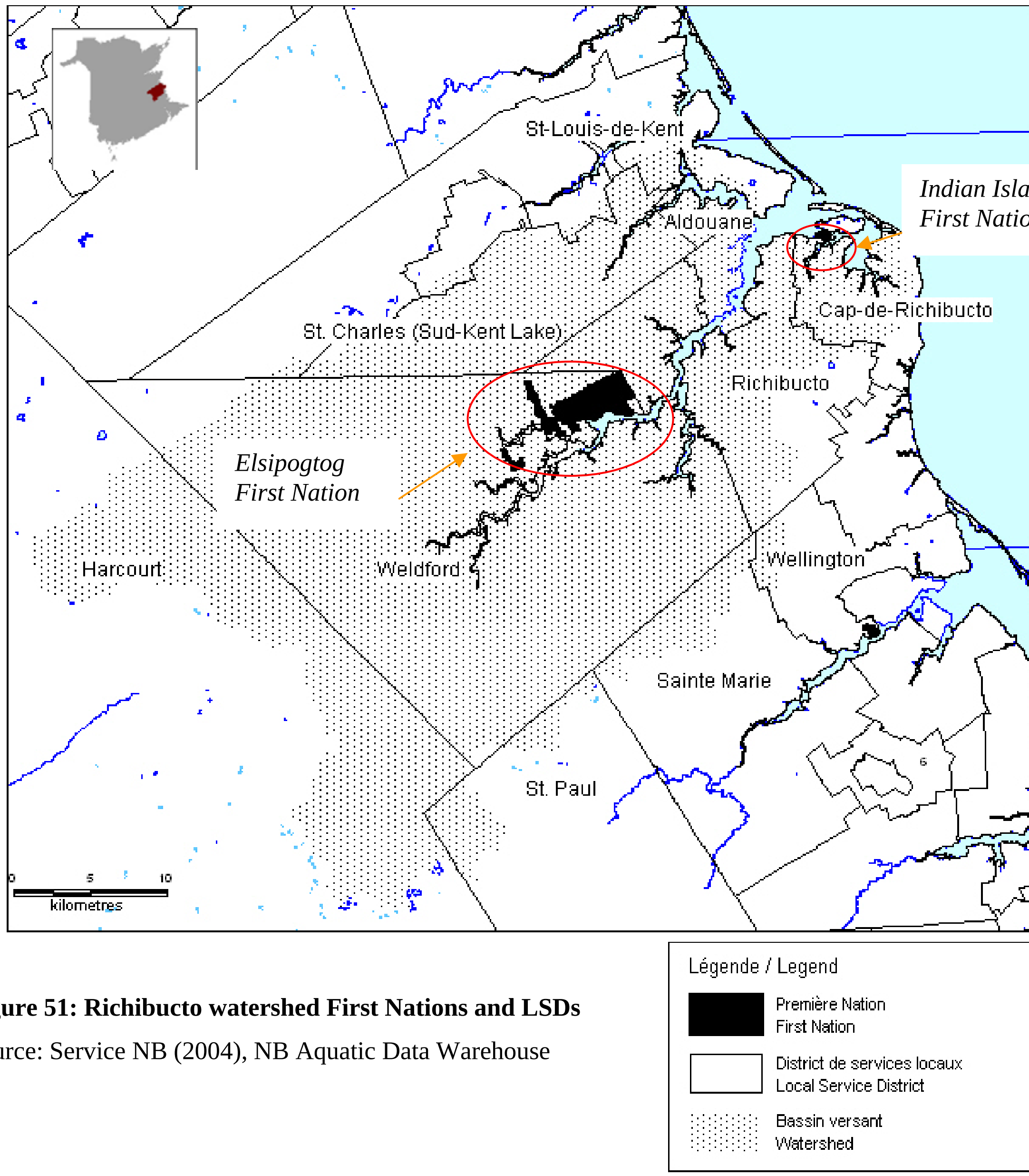


Figure 51: Richibucto watershed First Nations and LSDs

Source: Service NB (2004), NB Aquatic Data Warehouse

6.3.3. First Nations governance

The First Nations have their own system of governance. They may elect their own leaders by holding an election in accordance with the provisions of the Indian Act and its accompanying Indian Band Election Regulations, or they may use their own community electoral system or "custom code" (Canada. Indian and Northern Affairs, 2005). A First Nation band is governed by a band council and a band chief. First Nations are subject to all regulations and laws enacted by the country in which they live, unless exempted under an ancestral treaty. Contrary to those who live on reserves, Aboriginal people who live off-reserve are subject to provincial law (T. Perley-Levi, pers. comm., September 1, 2005).

The Elsipogtog First Nation is the largest Mi'Kmaq reserve in New Brunswick (Fig. 51). It follows a traditional Mi'Kmaq form of governance and is administered by a chief, and 12 councillors. The Indian Island First Nation (Fig. 51) also uses a traditional Mi'Kmaq form of governance. It is administered by a chief and three councillors. Both Elsipogtog and Indian Island First Nation elections are held in accordance with the provisions of the Indian Act and the Indian Band Election Regulations (Elsipogtog First Nation 2005, and T. Perley-Levi, pers. comm., September 1, 2005).

6.4. SOCIO-ECONOMIC COMPONENTS

6.4.1. Economic activities and others

6.4.1.1. Municipal and coastal development

Municipal and coastal development include the construction of highways, bridges, causeways, houses, buildings, corridors for power lines and other structures in order to meet the needs of the people who live in the area.

The province of New Brunswick has not built any new highways anywhere in the Richibucto watershed in the course of the past five years. The region is in a period of stagnation, and its population is declining. Although a decline in private infrastructure construction was observed in 2005, it had been increasing until 2004, (S. Boucher, pers. comm., December 1, 2005).

Approximately 180 building permits for various types of private residences were issued over the period 2000-2004 inclusive. Eighteen such permits were issued in 2000, compared to 83 in 2004. The number of building permits issued for industrial, commercial and institutional facilities ranged from three in 2000 to 10 in 2003. Only four building permits were issued for cottages and three for apartments during those years (Kent District Planning Commission KDPC, December 8, 2005).

All developments of this kind require other infrastructure such as water supply and sewer systems. Three communities in the Richibucto watershed have wastewater treatment plants, namely the Elsipogtog First Nation, Rexton and Richibucto (Fig. 52). The Elsipogtog Aboriginal community's plant has up-to-date infrastructure consisting of a three-cell lagoon and a chlorine disinfection basin (Richard & Godin, 2004). Effluent from the plant is discharged into the Richibucto River.

Richibucto's wastewater treatment plant was rebuilt in 2003-2004 (S. Thériault, pers. comm., February 14, 2005). It now features two basins in series with an aeration system in the first basin and an ultraviolet disinfection system. The plant is at the beginning of its design period and apparently functions properly *(ibid)*. The effluent is discharged into Mooney's Creek. The Department of Transportation has installed new culverts in this region, improving water exchange in the creek *(ibid)*.

The wastewater treatment plant in Rexton has also been upgraded (S. Thériault, pers. comm., February 14, 2005). The control rim has been redesigned. For aeration, the system still relies on natural factors such as sunlight, wind and wave action, and it has only one retention pond. Effluent is discharged into Beattie's Creek *(ibid)*.

The remaining residences and cottages that are not located near these municipal systems must use private septic systems to treat their wastewater.

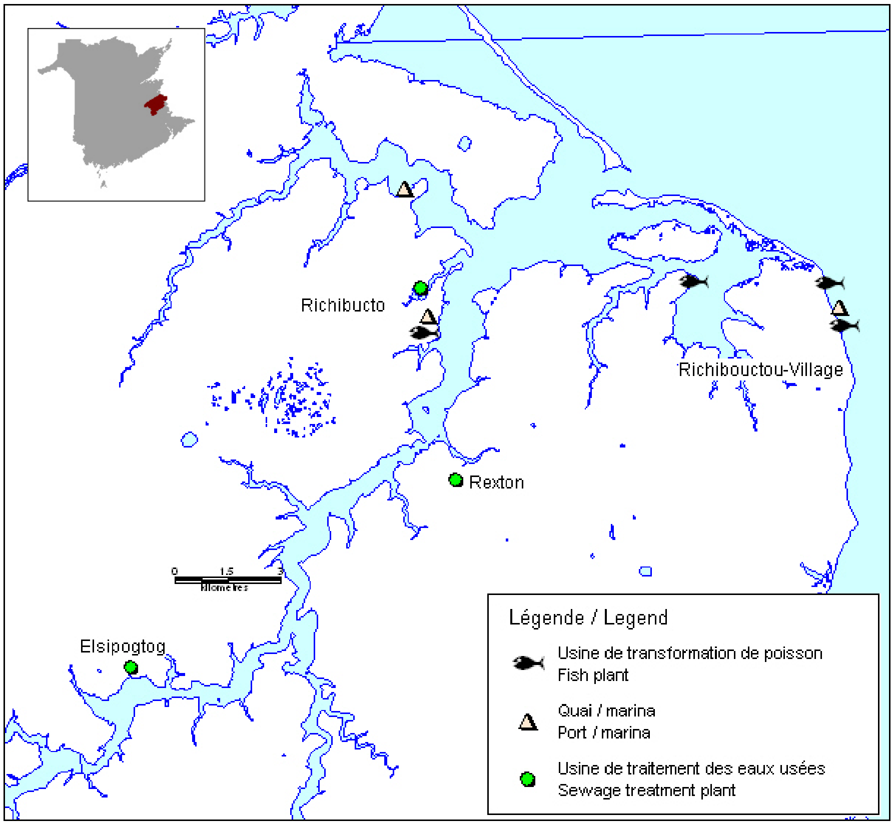


Figure 52: Ports, sewage treatment and fish processing plants.

Sources: Richard & Godin (2004), DFO

6.4.1.2. Activities based on terrestrial resources

Table 14 presents information on the distribution of land in the watershed.

Table 14: Land use in the Richibucto watershed

Type of use	Aggregate area
*Crown lands	624.67 km2* (Fig. 53)
Farming activities	72.14 km2
Wetlands	71.46 km2
Inhabited lands	19.33 km2
Mines	3.40 km2
Other	0.044 km2

Source: LeBlanc-Poirier et *al.* (2004b), *G. Watling, DNR pers. comm., (Dec. 12, 2005)

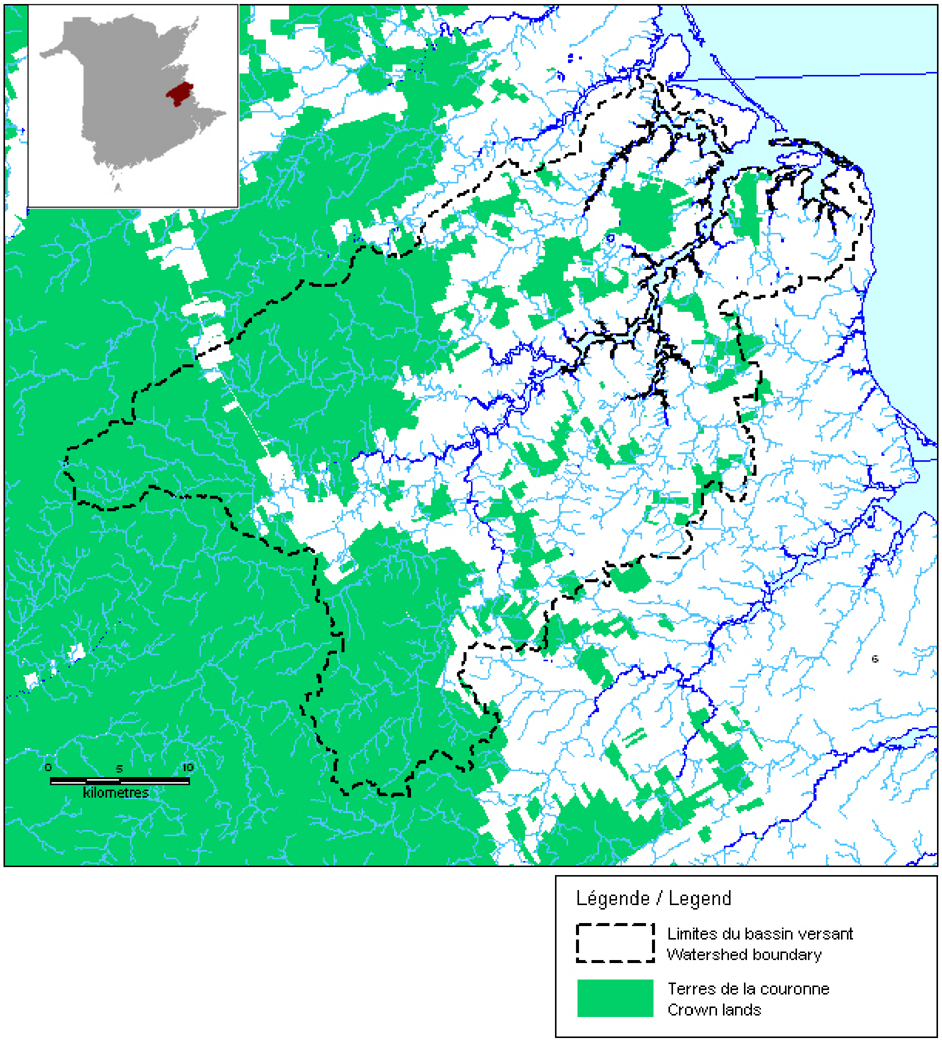


Figure 53: Crown lands in the watershed

Sources: Service New Brunswick (2004), NB Aquatic Data Warehouse

(Note: This map does not include the submerged lands that belong to the province)

Forestry: Logging has been carried out in the watershed since the early nineteenth century. At that time, white pine was in great demand for ship's masts and for export to England (D. Crossland, pers. comm., November 10, 2005). This product destined for foreign markets had to be transported to the port. The most convenient way of doing this, was to float the logs down a river. The usual practice was to fell the trees along tributary streams in order to facilitate the task of moving them to the river. Dynamite and other means were used to break up the log jams that sometimes formed in the course of these operations *(ibid)*.

Logging continues to be an important economic activity in the Richibucto watershed today. Trees are harvested on Crown land (Fig. 53) by industrial logging firms such as Weyerhaeuser and J.D. Irving, and on private woodlots by individuals. In the course of the past five years, approximately 62.34 square kilometres of forest have been cut down on Crown land (G. Watling, DNR, pers. comm., December 12, 2005). Clear-cutting is the most commonly used harvesting method (Ruel et *al.*, 1999). The intensity and repetitiveness of logging activities have brought about changes in the composition of the forest (Beach, 1988). A substantial fraction of the region's buffer zones have been laid bare as a result of logging and human settlements, which tend to be located along rivers and streams.

Since the Supreme Court of Canada's decision in the Bernard case in July 2005, Aboriginal people have been required to possess logging licences in order to market timber commercially. New Brunswick has concluded an agreement with its Aboriginal people that allows them to conduct harvesting operations on 5 per cent of the province's Crown land. The Elsipogtog First Nation has negotiated a draft agreement with the province under which it has the right to harvest 47,500 cubic metres of timber annually for five years. The logging is done on Crown land by members of the community (Simon, 2005).

Logging operations in this region generate income from the processing of forest products, sales of firewood, maple syrup production and sales of pulpwood for paper production (Ruel et *al*., 1999). The Delco Forest Products Ltd. Mill in West Branch is the largest of its kind in all Kent County. In addition, a number of small-scale sawmills operate in various communities in the watershed (LeBlanc-Poirier et *al*., 2004b).

The logging and timber-processing industries support between 140 and 350 jobs. This works out to an average of 240 full-time jobs per year (D. Allain, pers. comm., December 13, 2005).

Peat harvesting: Peat bogs account for nearly 12 per cent of Canada's land area.

Most of them are found in the northern part of the country. New Brunswick's peat bogs, for their part, account for 2 per cent of Canada's land area (Zoltai, 1988). In 2004, the province produced nearly 15,700,000 bales of peat. Thirty-three per cent of that total was sold within Canada, while the remainder was exported to the United States and Japan (New Brunswick. DNR, 2005).

In order to harvest peat, water must be drained from a peat bog. Under provincial law, sedimentation ponds must be used in peat harvesting operations in order to minimize the migration of peat fibres into the aquatic environment. Large quantities of peat settle out in these sedimentation ponds, which are subsequently drained into nearby streams. Some quantities of peat fibres may ultimately be carried into adjacent streams and ocean waters.

There are a number of small peat bogs in the Richibucto watershed, but the St. Charles Plain located north of the municipality of Richibucto (Fig. 54), is the only bog where harvesting is currently taking place (J. Thibault, pers. comm., June 27, 2005). Malpec Peat Moss Ltd, the only peat mining firm within the watershed, is extracting from approximately 19.25 square kilometres at the southern part of the site (St-Hilaire et *al*., 2004a). The peat extraction industry represents a fairly substantial economic activity for the Richibucto region. Annual production is nearly 400,000 bales, which is approximately 5 per cent of New Brunswick's total peat production (Surette, 1999). This industry supports some 40 seasonal jobs in the watershed (D. Allain, pers. comm., December 13, 2005).

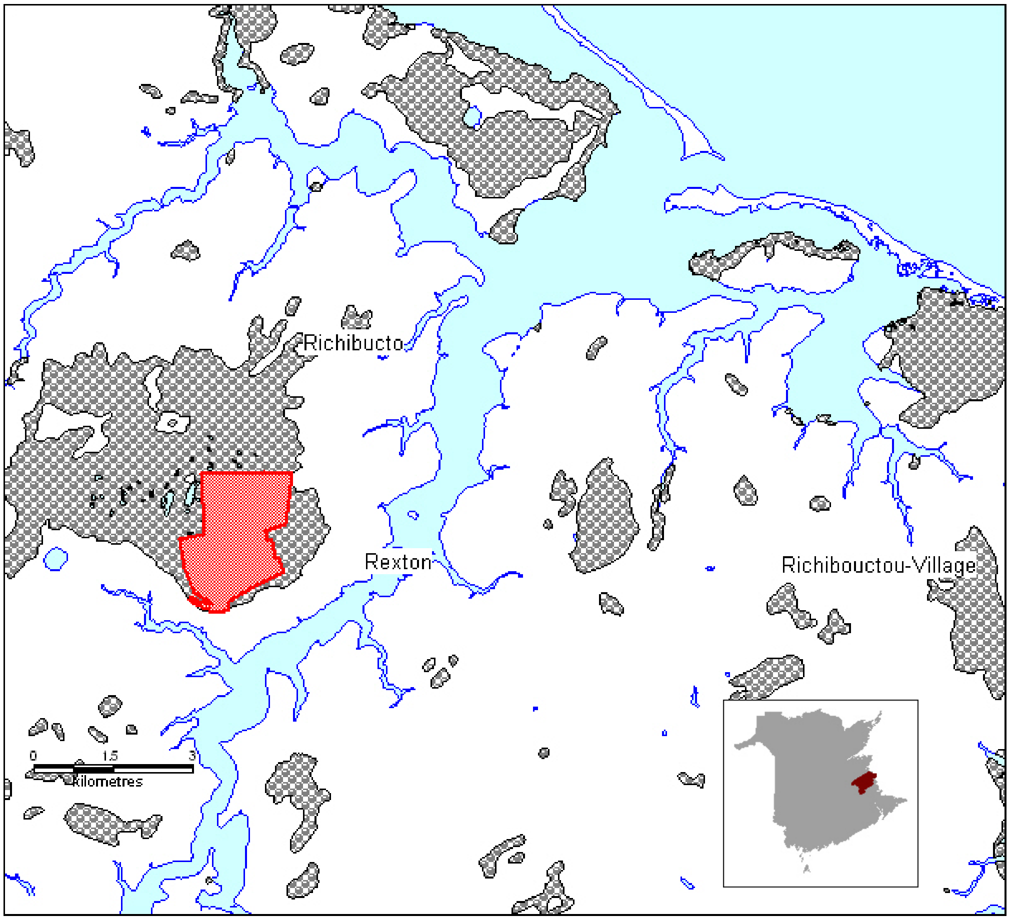


Figure 54: Exploitation of the Saint-Charles peat bog

Sources: Service NB (2004), DFO

Agriculture: Agriculture is a traditional economic activity that is still practiced in the watershed. In 1996, there were 54 working farms along the Richibucto River and its tributaries (St-Hilaire et *al*., 2004b). Together, these farms covered an area of approximately 39 square kilometres (9,575 acres), representing 4 per cent of the total area of the watershed. Of these 54 farms, 38 involved livestock operations *(ibid)*.

In 2005, there are a total of 66 farmers in the watershed (N. Williams, MAPA, pers. comm., Feb. 15, 2005). Table 15 describes the different items produced by farms.

Table 15: Production of the farms in the watershed

# of producers	Items produced
23	Beef
8	Cranberries
6	Hay, grains and vegetables
5	Blueberries
4	Dairy
4	Pork
2	Sheep and small fruit
2	Beef, poultry and vegetables
2	Deer
1	Beef and sheep
1	Pork and beef
1	Specialty in organic vegetables
1	Apples
1	Grapes
1	Rasberries
1	Beef and poultry
1	Honey
1	Pork and bleuberries
1	Greenhouse crops

(N. Williams, MAPA, pers. comm., Feb. 15, 2005)

Ecotourism and tourism: The Richibucto watershed possesses a number of advantages for developing the tourism industry. Its natural landscapes are ideal for outdoor activities, and many of the local people engage in activities such as sport fishing and pleasure boating among others.

Two major tourist attractions are located near the watershed. The Kouchibouguac National Park and the Irving Eco-Centre on Bouctouche Dune attract numerous visitors. The region is fortunate in having picturesque landscapes and being culturally diverse. The New Brunswick Trail passes through the communities of Richibucto and Rexton. With its low-lying plains and relatively flat terrain, the watershed is ideal for cycling. Moreover,the estuary is a network of waterways with little current and as such is ideal for small-craft excursions. The fresh-water and salt marshes are additional assets (ACOA & NBRDC, 2000).

The region's ecotourism industry is expanding (St-Hilaire et *al.*, 2004b). A sustainable tourism development plan was prepared in 2000. It is aimed at building ecotourism based on the region's natural attributes, while having due regard for the conservation and protection of its natural environment. The plan recommends upgrading and development of the infrastructure required to generate tourist activities within the watershed, while simultaneously providing economic opportunities for local entrepreneurs (ACOA & NBRDC, 2000). Some infrastructure development has taken place since the release of the plan: Tourists now have a wider range of cottages and other accommodations available to them.

Some of the watershed's tourist attractions include the Bonar Law Historical Site, the Richibucto River Museum in Rexton, and the Jardine Municipal Park in Richibucto (Fig. 55 and 56). The tourism industry supports over 80 jobs in the watershed, most of them part-time (D. Allain, pers. comm., December 13, 2005).

Figure 55: Bonar Law historical site

Figure 56: Jardine municipal park

Hunting and trapping: To the people who live in the Richibucto watershed, hunting and trapping are fairly important economic activities. Numerous species are hunted or trapped for the fur industry. Table 16 provides examples of species that are trapped or hunted for their fur.

Table 16: Small mammals trapped or hunted in the watershed

Small mammals	
Common name	**Scientific name**
Red fox	*Vulpes vulpes*
Raccoon	*Procyon lotor*
Beaver	*Castor Canadensis*
Snowshoe hare	*Lepus Americana*
Muskrat	*Ondatra zibethicus*
Mustelids	
Otter	*Lutra Canadensis*
Mink	*Mustela vision*
Marten	*Martes americana*
Fisher	*Martes pennanti*
Short-tailed weasel	*Mustela erminéa*
Skunk	*Mephitis mephitis*

Large mammals, such as the moose (*Alces alces*), white-tailed deer (*Odocoileus virginianus*) and black bear (*Ursus americanus*), are hunted in the watershed as well, as are migratory wildfowl and small game such as the ruffed grouse (*Bonasa umbellus*).

The watershed as a whole extends into provincial wildlife management districts 13, 14, 18 and 19 (Fig. 57). The Richibucto River forms the boundary between districts 14 and 19. Hunting, trapping and snaring are prohibited in the Kouchibouguac National Park, which is in district 14 (New Brunswick. DNR 2004a).

Recreational hunting and fishing activities in the watershed contribute to the region’s economic development through related industries such as outfitters, tourist accommodations and retail establishments that sell equipment. There are some half-dozen outfitters in the watershed offering guide services, lodging and the like.

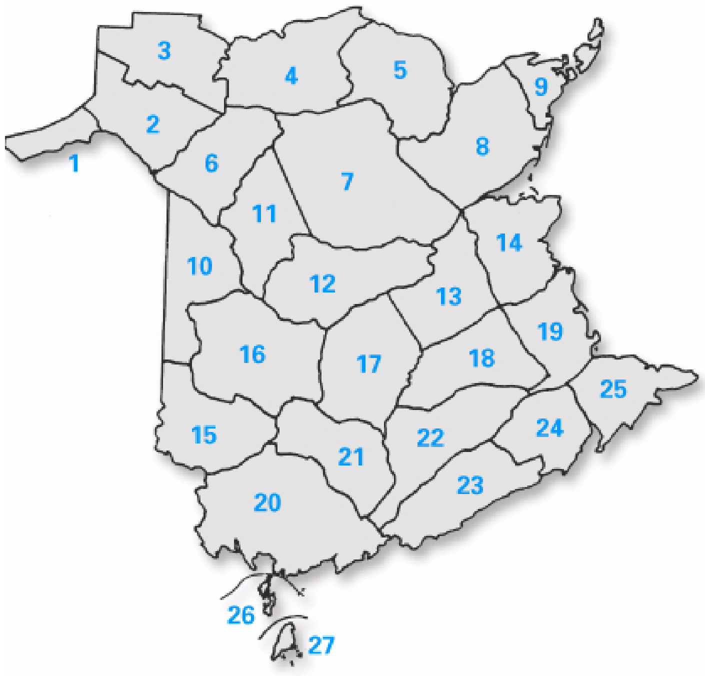


Figure 57: Provincial wildlife management districts

The Richibucto Bay watershed is located within.sections 13, 14, 18 and 19.

Source: New Brunswick Dept. of Natural Resources. (2005). Wildlife management districts [On line]. Available at http://www.gnb.ca/0078/fw/zones/zones_f.asp

6.4.1.3. Activities based on aquatic resources

***Commercial fisheries**:* Commercial fishing is still the main economic activity in the watershed. It is important to note that while a number of species are fished on the other side of the barrier dunes (Fig. 59 and 60), in Northumberland Strait, they are landed in and have an economic impact on the Richibucto watershed, and consequently they are included in the statistics presented in this report. Logging, agriculture and peat extraction are important activities, as we have seen, but in terms of economic value they lag behind fishing. The port of Richibucto (Fig. 58) is one of the leading fishing ports in eastern New Brunswick (Municipality of Richibucto, 2004). Furthermore, commercial fishing helps support other activities, such as selling fishing gear and operating fish-processing plants.

In this region, the fishing industry is concentrated mostly on invertebrates (Fig. 59 and 60), lobster being the main species harvested. Other species are less important in terms of economic value (St-Hilaire et *al*., 1997a). However, fish landings have been steadily declining since the 1980s. Fewer species are now fished, and the species that are still exploited are less abundant *(ibid)*.

Molluscs, such as oysters, soft-shelled clams and quahogs found in the region represent an important source of income for fishers. Back in the mid-1960s, dense oyster beds could be found as far up as Brown's Yard on the Richibucto River. Back then, hand picking was the main harvesting method (St-Hilaire et *al*., 1997a). In 1910, 270 tonnes of oysters were harvested in the Richibucto watershed (Milewski & Chapman, 2002), Now, the oyster fishery is less common and is being replaced by oyster aquaculture which is expanding in the region.

Tables 17 and 18 present a summary of the economic value of the various fisheries in the Richibucto region from the Aldouane to Cap-Lumière between 2000 and 2004, together with the type of fishing gear used to fish each species.

Figure 58: Port of Richibucto

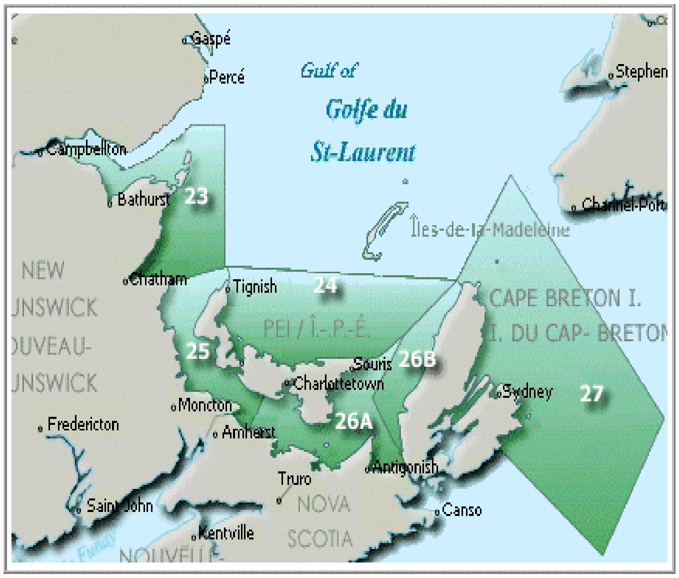


Figure 59: Lobster and rock crab fishing zones

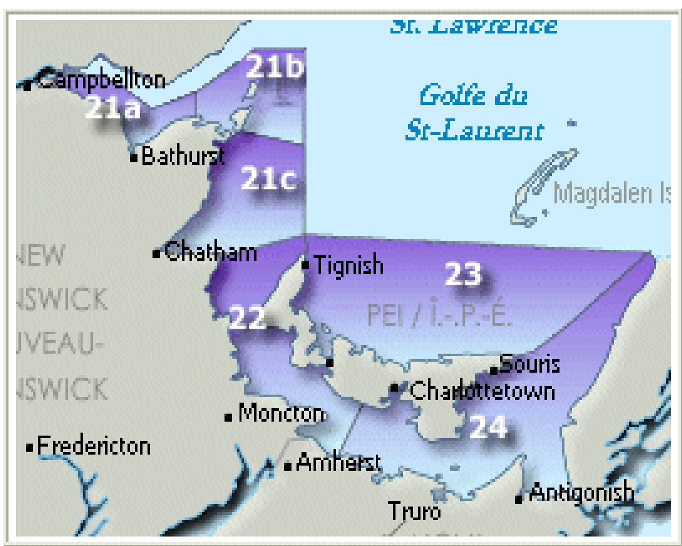


Figure 60: Scallop fishing zones

Source: http://www.glf.dfo-mpo.gc.ca/fm-gp/maps-cartes/index-f.html

Table 17: Landings and economic values of commercial fishing activities from 2000-2004

*Fisheries statistics, from Aldouane to Cap-Lumière (Source: Policy and Economics Branch, DFO, Gulf Region)

Species	**2000 Landings.** (RWKGMS)	**2000 Values**	**2001 Landings** (RWKGMS)	**2001 Values**	**2002 Landings.** (RWKGMS)	**2002 Values**	**2003 Landings.** (RWKGMS)	**2003 Values**	**2004 Landings** (RWKGMS)	**2004 Values**
American Eel	18 896	70 444	13 403	55 250	29 702	86 740	23 270	98 939	10 345	48 523
Clams	66 581	162 643	93 283	173 339	78 836	91 663	55 507	121 860	29 130	55 244
Mussels			379	716			249	302		
American oysters	1 814	5 000	25 856	81 845	21 294	58 962	27 288	90 256	17 016	64 996
White hake	1 816	2 800	1 088	1 400	100	110				
Atlantic herring	15 1842	15 295	598 845	351 437	420 733	176 328	11 000	3 630	2 835	992
Atlantic mackerel	127 030	98 411	128 082	98 148	118 673	80 405	331 562	213 934	127 692	82 544
Smelt	266 425	285 385	76 098	104 924	137 560	205 612	307 476	316 374	20 175	18 552
Quahog			896	2 672						
Scallops	20 379	80 213	27 515	44 971	3 213	4 911				
Lobster	535 463	4 949 083	525 845	5 146 371	493 361	4 908 513	342 078	3 608 613	305 993	3 167 416
Rock crab	153 712	11 1469	210 470	196 375	158 159	124 879	144 258	97 186	127 319	107 991
Tom cod	2 874	585	26 228	4 628			5 320	958		
Gaspereau	534 406	104 585	707 267	155 125	340 841	89 908	620 011	111 896	541 747	130 113
Bar clam			11	25			1 588	1 397		
Alewife			8	5						
Irish moss	95 233	18 896					28 449	8 820		
Spiny dogfish	27	40								
Atlantic cod	93	119			113	156				

RWKGMS: Registered weight in kilograms of meat substances. This table reflects only registered landings. In some cases, catches are not sold, but are used for bait. In addition, direct sales to members of the public or to restaurants are not registered. Those catches are not quantified in the above statistics.

Table 18: Fishing gear

Species	Fishing Gear Used
Gaspereau / blueback herring	Trap net
Bar clam	Manual tools
Cod	Gillnet, Danish seine, trawl, handlines, longlines
Spiny dogfish	Gillnet, Danish seine, trawl
Eel	Fyke net, trap net, hooks, weirs
Herring	Gillnet, purse seine
Lobster	Traps
Mackerel	Gillnet, handline, purse seine
Mussels	Picked manually
Oyster (American)	Long-handled rakes, tongs, manual drag
Quahog	Hand tools, hydraulic gear
Rock crab	Traps
Sea scallop	Drag
Smelt	Gillnet, trap net, spear, bag net
Soft-shelled clam	Hand tools
Tomcod	Trap net
White hake	Gill net, handline, trawl-line, Danish seine, trawl
Irish moss	Drag

Source: M. Albert, pers. comm. (August 4, 2005)

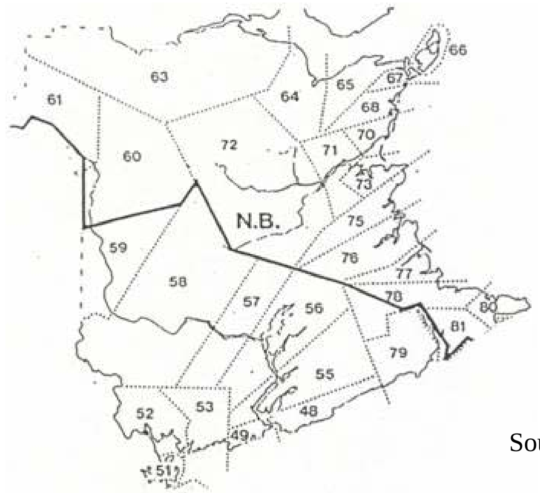
Table 19 presents potential fishing effort for commercial harvesting of eel, gaspereau and smelt in the Richibucto watershed for the year 2000.

Table 19: Fishing efforts for gaspereau, eel and smelt in 2000

Species	# of fishers or # of licences	# and types of fishing gear
Smelt	50 fishers	245 trap nets 2 bag nets 4245 fathoms of gillnet
Gaspereau	24 fishers	58 trap nets 450 fathoms of gillnet
Eel	19 licences	6025 hooks 19 basket traps 7 fyke nets

Source: Canada. Fisheries and Oceans Canada (2001 a, b, c)
*The number of active fishers or licences in the watershed may be less than that shown above.

Table 20 presents the numbers of commercial and recreational fishing licences issued by DFO in 2003-2004 for district 76. District 76 begins south of Saint-Louis and ends north of Bouctouche (Fig. 61), covering the whole of the Richibucto Bay watershed. The statistics also include the Richibucto Cape, Chockpish and Saint-Édouard region.



Source:DFO

Figure 61: Fishing Districts of New Brunswick

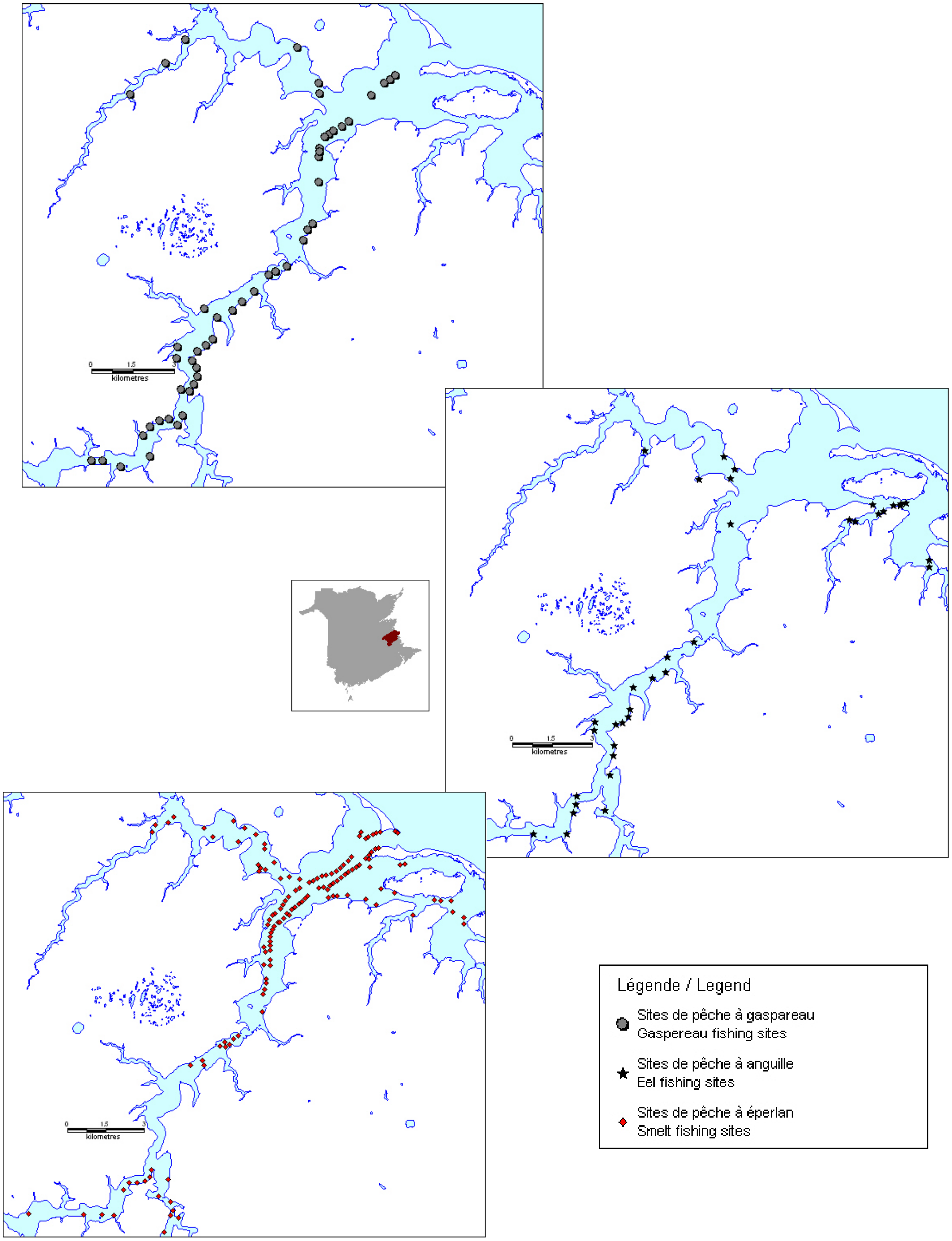
Table 20: Fishing licences-District 76-2003-04

Species	**2003 Number of licences**	**2004 Number of licences**
Commercial fishery		
Shad/Gaspereau	24	24
Surf clam	30	29
Rock crab **	4	3
Eel	15	15
Groundfish **	17	17
Herring **	50	51
Herring and mackerel **	14	14
Lobster **	75	76
Mackerel **	57	58
Irish moss	11	11
Mussel	24	26
Oyster	41	42
Quahog	16	15
Sea scallop	14	14
Shark, unspecified **	2	2
Smelt	47	42
Snow crab **	5	6
Soft-shelled clam	97	94
Bluefin tuna **	1	1
**Species at risk		76
Recreational fishery		
Sea scallop	1	0

Source: G. Moores, pers. comm. (July 26, 2005)

***A species at risk licence is issued to all fishers who hold licenses for fisheries that could result in by-catches of the northern wolffish (Anarhichas denticulatus), spotted wolffish (Anarhichas minor) or other species at risk. The licence provides detailed information on returning the fish to the water and relevant information that must be noted and forwarded to DFO.* (G. Moore, pers. comm. July 26, 2005)

Figures 62a, b and c present an overview of commercial gaspereau, eel and smelt fishing sites.



Figures 62 a, b, c: Locations of fishing gear for gaspereau, eel and smelt

Source: DFO

Recreational fisheries: Recreational fishing is an activity that has always been popular in the watershed. Its economic value is fairly substantial, and it contributes to the development of other related industries such as selling fishing gear and providing outfitter services.

The recreational fishing season extends from mid-April to October, and for some species, ice-fishing in the winter is practised as well. In 2000, for the watershed as a whole, there were a total of 37 smelt fishing shacks (Canada. Fisheries and Oceans Canada, 2001a).

However, declining stocks of salmon and striped bass are having an adverse impact on sport fishing in the region (St-Hilaire et *al*., 2001a). Since the late 1980s, there have been restrictions on catching salmon broodstock in view of promoting the recovery of that species. Restrictive measures have been applied to sport fishing for striped bass as well due to the declining stocks since the early 1990s (Bradford et *al*., 1999).

It is worth noting that white perch (*Morone americana*) are abundant in the Richibucto estuary. Sport fishing for that species could become an alternative for fishers who frequent the region (St-Hilaire et *al*., 2002). The brook trout (*Salvelinus fontinalis*) is another important species for recreational fishing in the region, but its stocks are declining as well.

Aboriginal fisheries for commercial, food, social and ceremonial purposes: The Aboriginal people of the Elsipogtog and Indian Island First Nations rely heavily on the region's natural resources to meet their subsistence and cultural needs and generate income. In former times, soft-shelled clams and oysters were an important food source, and a man could make enough money from the oyster fishery to support his family (Milewski et *al*., 2001). Today, however, fishing for these species is mostly restricted, as most shellfish harvesting zones are closed due to bacteriological contamination (Fig. 63).

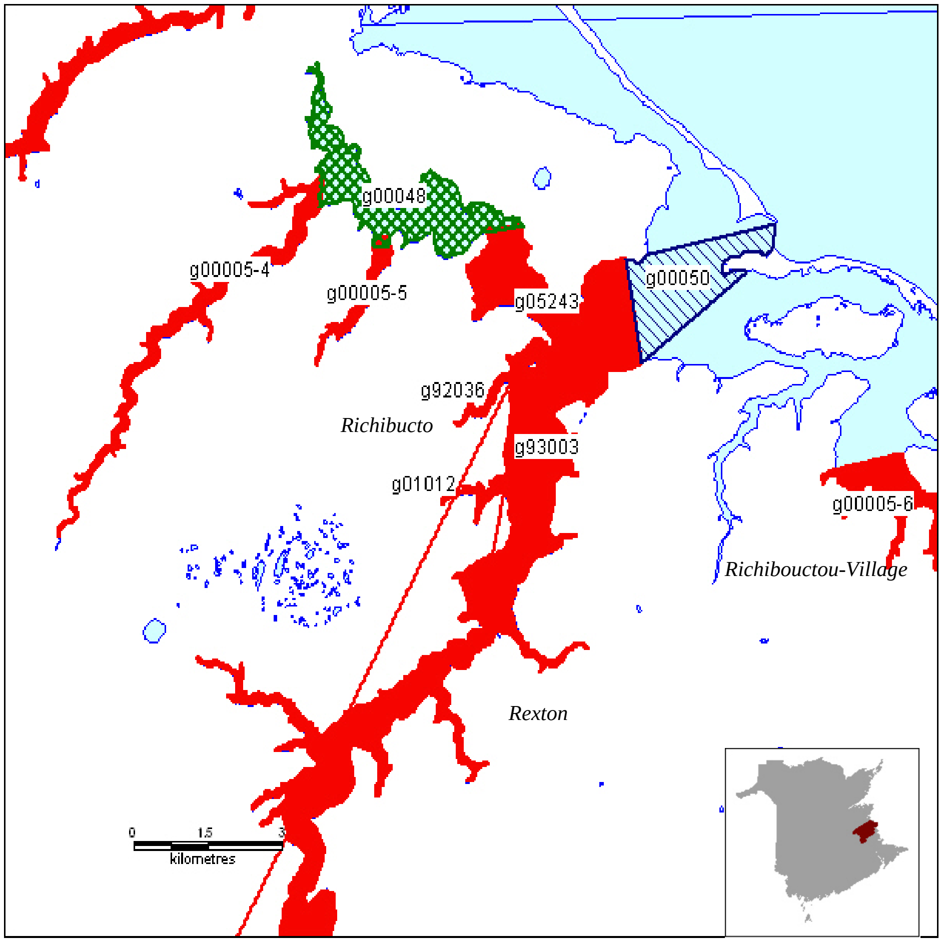


Figure 63: Shellfish closures with prohibition order number

Source: DFO (2005-02-08)

In January 2008, the shellfish closures were the same as identified on this map; however, the prohibition order numbers varied. For an updated version of the shellfish closures visit: http://www.glf.dfo-mpo.gc.ca/shellfish-coquillages/

Table 21 shows access granted for Aboriginal commercial fisheries in equivalent to the number of licences for 2003-2004 in district 76.

Table 21 : First Nations commercial fisheries-District 76, 2003-04

Species	**2003 Access granted in equivalent to the # of licences**	**2004 Access granted in equivalent to the # of licences**
Commercial fishery		
Alewife/gaspereau	4	4
Surf clam	8	8
Rock crab	6	6
Eel	6	6
Groundfish	3	3
Herring	34	34
Herring and mackerel	60	59
Lobster	60	61
Mackerel	40	41
Marine plants	1	1
Mussel	4	4
Oyster	20	20
Quahaug	3	3
Sea scallop	11	11
Smelt	14	15
Snow crab	2	2
Soft-shelled clam	13	13
Species at risk		2
Bluefin tuna	2	12

Source: G. Moores, pers. Comm., (July 26, 2005)

Aquaculture: Shellfish aquaculture is steadily expanding along the east coast of New Brunswick. The region is well suited to the development of this industry. The conditions required for the growth of such species as oysters and soft-shelled clams are evidently present, as those species have been fished in the region for many years (St-Hilaire et *al*., 2001a; Courtenay et *al*., 2000).

Most of the aquaculture sites in the Richibucto estuary are located in the Northwest Branch, Richibucto Harbour, all along the north shore in the vicinity of Indian Island, and in the Baie-du-Village (Fig. 64). Most aquaculture leases are for the bottom culture of oysters, off-bottom culture on submerged trays, or suspended culture using cages or floating bags (Table 22). There are a few blue mussel culture sites in the northern part of Richibucto Harbour, near the Richibucto River; they are currently inactive (Canada. Public Works and Government Services, 2004). Efforts to develop soft-shell clam, quahog and surf clam aquaculture are currently under way; the American oyster however, remains the most commonly cultivated species in the region.

Table 22 presents details of existing aquaculture operations in Richibucto Bay.

Table 22: Aquaculture sites in Richibucto Bay

Location	Hectares	Type of culture	Species cultivated
Richibucto Harbour	68.19	Bottom	American oyster
Richibucto Harbour	1.21	Bottom	American oyster and quahog
Richibucto Harbour	14.17	Bottom, suspended and off-bottom	American oyster
St. Charles River	13.36	Bottom	American oyster
St. Charles River	3.24	Bottom	American oyster and quahog
St. Charles River	5.77	Bottom and suspended	American oyster
St. Charles River	1.62	Bottom and suspended	American oyster
St. Charles River	5.26	Bottom, suspended and off-bottom	American oyster and quahog
St. Charles River	24.56	Bottom, suspended and off-bottom	American oyster
Baie-du-Village	20.24	Bottom	American oyster
Baie-du-Village	4.49	Bottom	American oyster and surf clam
Baie-du-Village	5.26	Bottom, suspended and off-bottom	American oyster, quahog and soft-shelled clam
Baie-du-Village	8.91	Bottom, suspended and off-bottom	American oyster and quahog
Baie-du-Village	6.62	Bottom, suspended and off-bottom	American oyster

Information provided by the NB Dept. of Agriculture and Aquaculture (DAA)
(C. Godin, DAFA data bank, July 9, 2005)

Descriptions of culture methods:

Bottom culture: a form of aquaculture conducted on or in the substrate of an aquaculture site:

- On the substrate: the aquacultural product must be free and in direct contact with the substrate;
- In the substrate: the aquacultural produce may be free or held by or in a structure buried in the substrate, provided that structure does not protrude above the substrate.

Off-bottom culture: a form of aquaculture conducted in the water column, with the rearing structures placed directly on the substrate, or raised off the substrate. In both cases, the structures are fixed in place (do not move with the tides)

Suspended culture: Means a form of aquaculture conducted in the water column or at the surface, where the structures are anchored but float or move with the tides.

Source: H. LaCroix, DAA, pers. comm., April 19, 2006

One of the largest oyster aquaculture operations in the Gulf of St. Lawrence is located in Richibucto Bay. A firm producing oyster spat is located mainly in Richibucto Harbour and at the mouth of the Aldouane River (Courtenay et *al*., 2000).

A number of aquaculture projects have been launched under the Richibucto Environment and Resource Enhancement Project (REREP). One of the main stakeholders in these projects is the Indian Island Aboriginal community (St-Hilaire et *al*., 2001a). The Elsipogtog Aboriginal community also started a shellfish aquaculture operation in 2005.

A study aimed at evaluating the potential for mollusk production in various bays in eastern New Brunswick identified the northern parts of Richibucto Bay and the Baie-du-Village as promising areas for oyster and quahog culture. One question that remains to be answered is whether the spring decline in salinity in the Baie-du-Village might be a constraint in the case of quahogs (Senpaq consultants, 1989). Moreover, a study has suggested that the hydrographic and environmental characteristics of some parts of the bay may be determining factors for site selection or optimal culture method in the case of American oysters (Bataller et *al*., 1999).

It appears that Richibucto Bay is not suitable for sea scallop aquaculture, as the heavy inflows of fresh water in the spring reduce the salinity of the water to levels that the species would be unable to tolerate. These spring inflows also increase turbidity, placing extremely fine benthic sediment particles in suspension, and those particles might clog the gills of the scallops, reducing their oxygen absorption rate (Frenette, 2004).

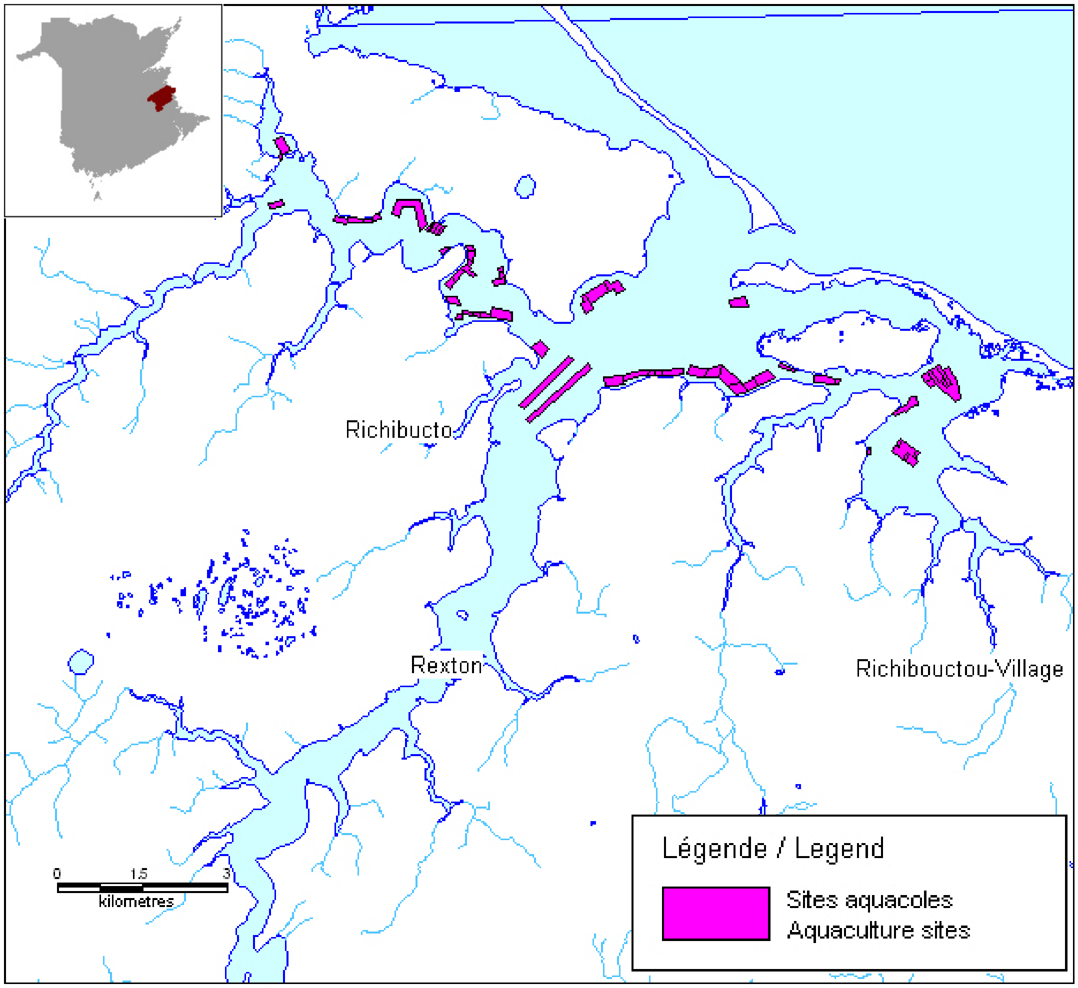


Figure 64: Aquaculture sites in Richibucto Bay

Sources: Dept. of Agriculture, Fisheries and Aquaculture

Fish-processing plants: There are four fish-processing plants in the region, in Cap-Lumière, Richibouctou Village and the town of Richibucto (Fig. 52). Table 23 shows the species that are processed at each of these plants.

Table 23: Fish processing plants

Plant	Species handled
Coopérative des pêcheurs de Richibouctou-Village Ltée	Alewife Lobster Rock crab
Village Bay Sea Products Co. Ltd.	Lobster Rock crab
J. & J. Fisheries Ltd.	Lobster Oyster Cod Quahog Scallop Smelt Clams Eel
Captain Dan's	Rock crab Snow crab Lobster

Source: Business New Brunswick (2003)

The products of these plants are sold to Canadian and American markets. In addition, some of the Cooperative's products are exported to Haiti. This industry supports a minimum of 12 jobs at inactive periods, and a maximum of approximately 480 jobs during the processing season (D. Allain, pers. comm., December 13, 2005).

Maritime transport and harbour facilities: Richibucto was once known as a great international trading port from which forest products, in particular, were exported. Until the mid-1960s, large merchant vessels visited on a regular basis, and cargo handling provided jobs for a number of workers.

Maritime transport in the bay is now limited to fishing and regional tourism activities. It is rare for ships from distant places to navigate into Richibucto these days. The present depth of the channel restricts the size of the ships that the harbour can accommodate (Acres Consulting Services Limited, 1997). Northumberland Strait, too, is now used mainly by fishing boats; virtually none of the traffic that passes through the Strait consists of great cargo vessels plying between international ports.

The nearest international port is in Miramichi Bay, to the north of Northumberland Strait. The infrequent international maritime transport in the region is an advantage for the aquaculture industry in Richibucto Bay and Northumberland Strait, as it reduces the risks of accidental spills or of introducing alien invasive species that could damage the watershed's biodiversity and productivity (Rosenthal et *al.*, 2001).

There are two "registered" ports operating under the Fishing and Recreational Harbours Act in the Richibucto region: Richibucto itself and Cap-Lumière (Fig. 52). Over 100 boats use Richibucto as their home port, while approximately 30 are based at Cap Lumière (D. Thibodeau, pers. comm., September 19, 2005). However, the fleets in these ports may double, depending on the fishing season and the target species, as boats coming from other regions can dock at these wharves on a temporary basis (A. Noël, pers. comm., August 31, 2005).

The port of Richibucto has been undergoing alterations since 2004, and the work is expected to continue for several more years. Its facilities are being upgraded to accommodate pleasure crafts and the boats of Aboriginal fishers from the Elsipogtog region.

At the port of Cap-Lumière, the port basin is dredged every 20 years, while the channel is dredged every year. As a rule, sediment from these channel dredging operations is clean enough that it can be dumped at sea, whereas sediment from dredging in ports has to be dumped on land, as it is contaminated with hydrocarbons and other substances (C. Gaudet, pers. comm., August 30, 2005). Dredging operations are planned for the port of Richibucto as well, but as yet no decision has been made as to where the sediment will be dumped.

In addition, there is a private wharf in the Northwest Branch, in the vicinity of the Petite-Aldouane River (Fig. 52). Approximately 10 boats are based there, and some 30 additional boat-owners use the wharf's ramp to launch their fishing boats or pleasure crafts (M. Daigle, pers. comm., September 20, 2005).

6.5. TOWARD A HEALTHY ENVIRONMENT AND DEVELOPING SUSTAINABLY

There are various organizations that are engaged in activities aimed at sustainable resource management in the watershed. Given the positive impacts these activities may have on the ecosystem, we have decided to acknowledge those endeavors here. This section presents an overview of these organizations and some of the work they have accomplished.

The **Université de Moncton's Environmental Sciences Research Centre** joined forces with various stakeholders in the Richibucto watershed to develop the Richibucto Environment and Resource Enhancement Project (REREP). Under REREP, a series of projects aimed at sustainable development are being executed. The main aim of the project is to contribute to the social, economic and environmental well-being of the Richibucto watershed. The Richibucto region's three cultures are working with government organizations, local industries and research institutes in an effort to restore the ecosystem to health and protect its natural resources (Courtenay et *al*., 2000). The specific objectives of the project are to improve the quality of the river, the estuary and the harbour in view of achieving sustainable development in the fishing and aquaculture industries. REREP provides the watershed's stakeholders with scientific expertise (St-Hilaire et *al*., 2001a). Numerous research projects have been undertaken, including studies on striped bass, the impact of peat extraction, and mollusc cultivation, to name a few.

The **Richibucto River Association** was founded in 1994 by a group of citizens who were concerned about habitat degradation, pollution, declining fish stocks and shellfish bed closures in the watershed. With the help of scientists, they assessed various data and information pertaining to the watershed and entered into discussions with stakeholders to identify priority issues and develop an action plan. The group's mission is to ensure that all members of the community become aware that the only way to achieve sustainable use and development is to become responsible users. The first step must be increased knowledge of and sensitivity to the ecosystem, followed by appropriate action to restore, protect and enhance aquatic habitat (LeBlanc-Poirier et *al*., 2004b). Since its establishment, this group has undertaken a number of activities, alone or in cooperation with other organizations. Most of those activities have been aimed at water quality enhancement and conservation, habitat and fish stock improvement, and public awareness of good environmental practices. The Richibucto River Association works closely with REREP in pursuit of shared objectives.

The **Southeastern Anglers Association** operates in all parts of the watershed and has numerous research, conservation and restoration achievements to its credit. It has conducted a number of habitat and fish inventories using the electrofishing technique. In addition, the SAA stocked the Richibucto River with 11,500 brook trout in 1996, 4,000 more in 1997, and 700 in 1998 (Melanson et *al*., 1998). Between 1997 and 1998, the Association did restoration work on over a kilometre of the South Branch tributary of the St. Nicholas River. A number of restoration structures were used, including digger logs, tree deflectors and bank stabilization works (Melanson et *al*., 1998). In 1999, SAA volunteers transplanted 800 trees along the South Branch (Goguen & LeBlanc-Poirier, 1999).

Parks Canada, through the **Kouchibouguac National Park**, is also interested in the Richibucto Bay watershed. The Park's employees have worked closely with various stakeholders, including Fisheries and Oceans Canada (DFO), on a variety of projects, a recent one being an Atlantic salmon enhancement project and a project aimed at re-establishing the soft-shelled clam population in the watershed.

In addition, the **Elsipogtog First Nation** is involved in sustainable natural resource development projects. The First Nation is working with various organizations to restore the Atlantic salmon population (Fig. 65) and to promote the conservation of medicinal plants that are native to the region, among other projects.

Figures 65: Atlantic salmon restoration project in the Richibucto watershed

(trap nets to capture Atlantic salmon broodstock)

7. ECOLOGICAL OVERVIEW

This chapter outlines the distinctive characteristics of the watershed's natural resources and presents a brief description of the impacts of human activities on the ecosystem. It concludes by identifying the main issues of concern in the watershed as identified in the numerous documents that were consulted for the purpose of this study.

7.1. NATURAL ATTRIBUTES OF THE ECOSYSTEM

7.1.1. Species of particular interest

7.1.1.1. Vascular plants

The Gulf of St. Lawrence aster (*Symphyotrichum laurentianum*) (Fig. 66) has "special concern" status under the Species at Risk Act (SARA), and the COSEWIC list (the Committee on the Status of Endangered Wildlife in Canada) (Canadian Wildlife Services CWS, 2004). This plant, which grows in salt-rich environments, has been identified in the region of the Kouchibouguac National Park, and might therefore be found elsewhere in the Richibucto watershed. The Atlantic Canada Conservation Data Centre (ACCDC) designates this plant as an "endangered species" in the province.

The Atlantic listera (*Listera australis*) is identified by the ACCDC as an endangered species for New Brunswick (Fig. 67). This species, which belongs to the orchid family, has been identified in Kent County (ACCDC, 2005). However, it is not referred to in SARA, nor has COSEWIC given it a designation.

The butternut tree (*Juglans cinerea*), which has "endangered" status under SARA and is designated "endangered" by COSEWIC, is found in New Brunswick (Fig. 68) (CWS, 2004). However, it is uncertain whether this tree species occurs in the Richibucto watershed.

Figure 66: Gulf of St Lawrence Aster

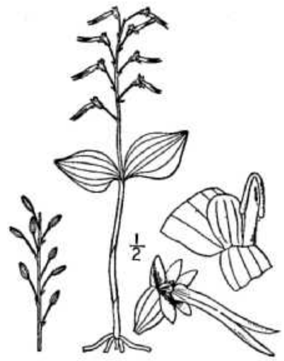


Figure 67: Atlantic listera

Figure 68: Butternut tree

. Source: http://www.plants.usda.gov/java/profile?symbol=JUCI

7.1.1.2. **Non vascular plants**

The boreal felt lichen (*Erioderma pedicellatum*) (Fig. 69) grows on balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), red spruce (*Picea rubens*) and sometimes red maple (*Acer rubrum*). It is not common anywhere in the world, but there is a population in New Brunswick. Both COSEWIC and SARA assign it “endangered” status (CWS, 2004). It is uncertain, however, whether this species occurs within the Richibucto watershed.

Figure 69: Boreal felt lichen

Source: Canadian Wildlife Service (2004)

7.1.1.3. **Birds**

The bald eagle (*Haliaeetus leucocephalus*), which is regarded as endangered in New Bruswick, is observed regularly in Kent County (Fig. 70) (ACCDC, 2005). It is not listed in either SARA, or COSEWIC.

Both COSEWIC and SARA consider the piping plover (*Charadrius melodus*) to be an “endangered” species in Canada (Fig. 71). This species nests along shorelines, on sandy or sand and gravel beaches (Fig. 72). The adult birds arrive on Canada’s east coast in April or May and make their nests by scraping out a shallow hole in the sand (CWS, 2004). They may be seen on the Richibucto North and South Dunes during the nesting season (The Nature Trust of New Brunswick Inc., 1995). On average, approximately a dozen pairs of piping plovers come to nest on the region’s barrier beaches every season (Nature Canada and Bird Studies Canada, 2005).

Figure 70: Bald eagle .

Source: Campagne (1997)

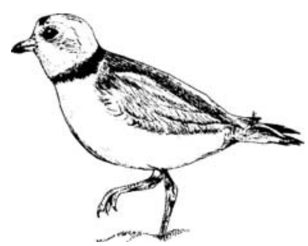
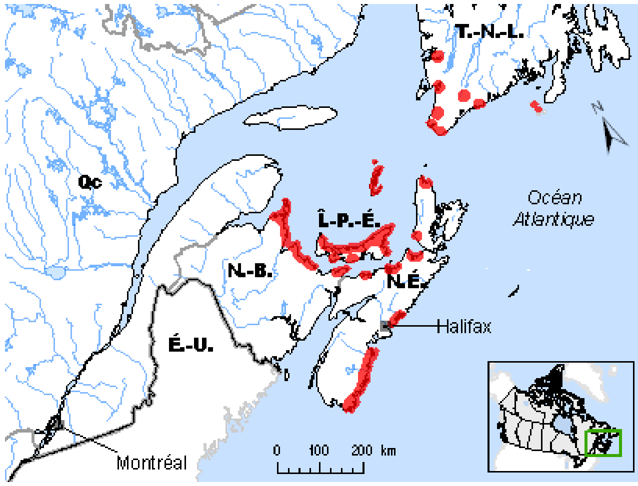


Figure 71: Piping Plover.



Source :
CWF (2004)

Figure 72: Piping plover distribution in Atlantic Canada

Barrow's goldeneye (*Bucephala islandica*) and the short-eared owl (*Asio flammeus*) are given "special concern" status both by COSEWIC and under SARA. Barrow's goldeneye winters and breeds in Canada for the most part, but also breeds in the northern United States (Fig. 73). Logging is a contributing factor in the reduction of its breeding habitat in eastern Canada, where it seems to prefer lakes that do not contain any fish and are surrounded by forest (CWS, 2004). ACCDC considers the species to be rare in Kent County, and it does not breed in this region. The short-eared owl, for its part, appears to prefer open habitat, such as marshlands and deep grass fields. It makes a nest in the form of a slight depression in the ground, concealed, in many cases, under low shrubs near water. Canadian populations usually raise one brood per year. This species seems to be distributed throughout the Maritime Provinces (CWS, 2004).

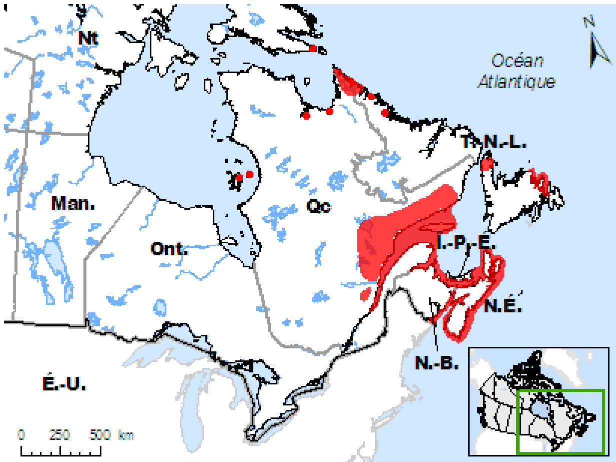


Figure 73: Barrow's Golden eye in eastern Canada

Source: CWS (2004).

7.1.1.4. Arthropodes

Both SARA and COSEWIC regard the Monarch butterfly (*Danaus plexippus*) as a species warranting special concern (Fig. 74). It is widely distributed throughout the province (Fig. 75). Monarchs rely heavily on the leaves of the milkweed plant and other wildflowers as a source of nectar and as egg-laying sites.

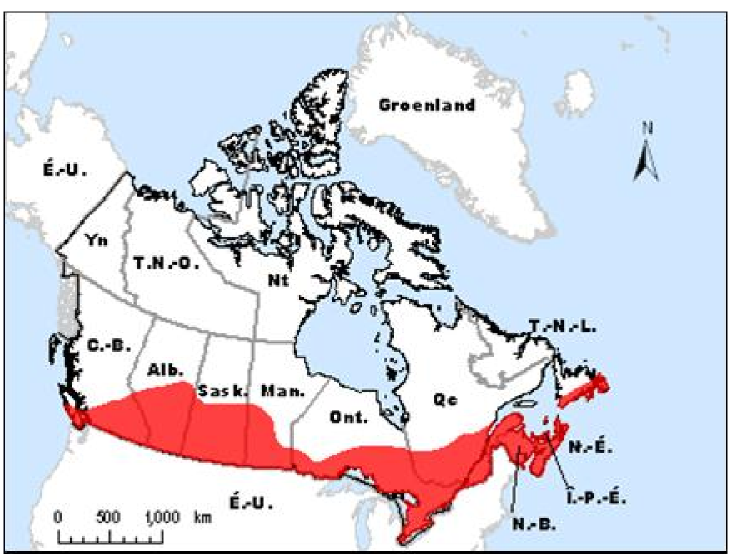


Figure 74: Monarch butterfly

Figure 75: Monarch Butterfly distribution in Canada

Source: CWS (2004)

7.1.1.5. <u>**Fish**</u>

The American eel (*Anguilla rostrata*) has been on COSEWIC's list of species warranting special concern since April 2006 (Fig. 76). At the present time, it has no status under SARA, and consequently does not benefit from protection measures under that Act. The American eel is a species that is fished throughout the Eastern New Brunswick Area, including Richibucto Bay. It lives in rivers, streams and estuaries, and swims to the Sargasso Sea to breed.

Striped bass (*Morone saxatilis*) (Fig. 77) are thought to have appeared in Atlantic Canada during the retreat of the Wisconsin glaciation 10,000 years ago (Brewer, 1988). The rapid decline of this species in Atlantic Canada has given rise to concern for its survival. The southern Gulf of St Lawrence striped bass population has been on COSEWIC's list of "threatened" species since November 2004. It has no status under the Species at Risk Act at present, pending public consultations (CWS, 2004). ACCDC classified this species as rare in Kent County.

Juvenile striped bass from the Miramichi River spawning grounds are thought to disperse to a number of rivers in the southern Gulf of St. Lawrence. Salinity conditions in the Richibucto estuary appear to be suitable for striped bass rearing and wintering habitat (St-Hilaire et *al*., 1997b). According to Robinson et *al*. (2004) the Richibucto serves as rearing grounds and possibly as an overwintering area for that species, but not for its spawning grounds.

Figure 76: American eel

Figure 77: Striped bass

The shortnose sturgeon (*Acipenser brevirostrum*) is considered to be rare in New Brunswick (ACCDC, 2005). It has “special concern”status under SARA, and COSEWIC also designates it as a species warranting special concern (CWS, 2004). The occurrence of this species has not been reported in Kent County.

ACCDC considers the Atlantic salmon (*Salmo salar*) to be an uncommon species in Kent County. Only the Inner Bay of Fundy populations have “endangered species” status under SARA and according to COSEWIC (CWS, 2004). The Atlantic salmon is found in the Richibucto watershed.

ACCDC designates the redbreast sunfish (*Lepomis auritus*) as a common species in New Brunswick. However, both SARA and COSEWIC identify it as warranting “special concern” throughout Canada, as it appears to be present only in New Brunswick (CWS, 2004). This species could possibly be found in the upper reaches of the Richibucto watershed (UNB, Jan. 14, 2008).

7.1.1.6. **Reptiles**

The wood turtle (*Clemmys insculpta*) has been identified at a number of locations in the province. It has “special concern” status under SARA and on the COSEWIC list. The New Brunswick populations are considered to be widespread and stable (CWS, 2004). The presence of this species in the Richibucto watershed has not been documented.

7.1.2. Specially designated areas

The Canaan Bog (Fig. 79) is one of New Brunswick’s Class II protected natural areas. It comprises a number of small discrete peat bogs in the upper part of the watershed, at the point where Kent County, Westmorland County and Queens County meet. Class II areas are reserved for the conservation of biological diversity, and industrial, commercial or agricultural activities are prohibited. However, certain recreational uses having minimal environmental impact, including traditional food-gathering activities, are allowed. Educational and scientific activities require a permit (New Brunswick. DNR, 2004b)

Part of the Kouchibouguac National Park (Fig. 2) is located at the mouth of the Richibucto watershed. This area is also protected, under the National Parks Act. The aim is "the maintenance of ecological integrity through the protection of natural resources" (Canada. Parks Canada, 2005).

7.1.3. Other significant regions

There is a large spring spawning ground for Atlantic herring southeast of the Richibucto South Dune in Northumberland Strait (Fig. 78). These spring spawning grounds are found mainly in water that is less than three metres deep (Therrien et *al*., 2000). Lobster, crab, herring and smelt are fished commercially all along the coast in the strait. This spawning ground is particularly vulnerable to Irish moss dragging, which is carried on in the same area.

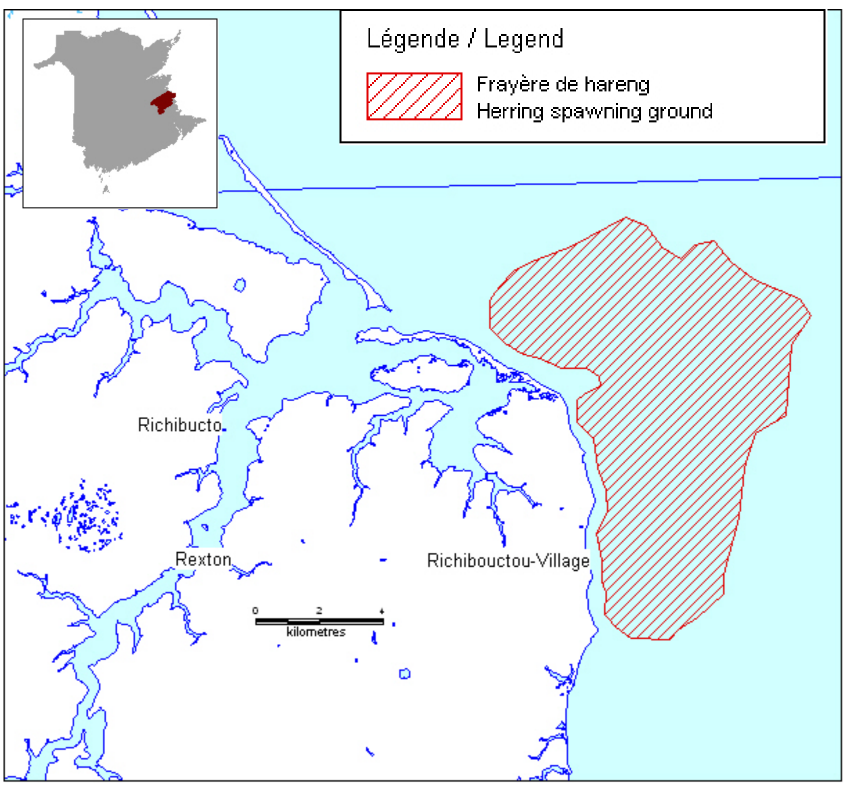


Figure 78: Important spawning ground for herring

Sources: Service New-Brunswick (2004), DFO Atlas (1998) and Therrien et *al*. (2000)

In 1995, the Nature Trust of New Brunswick published a document on environmentally significant areas (ESAs) in New Brunswick (Fig. 79). The sites presented in Table 24 are ESAs that are located in the Richibucto Bay watershed.

Table 24: Environmentally significant areas in the watershed

Site No.	**Name of site**	**Location**	**Description**
445	Bass River	20 km southwest of Richibucto	An important river for striped bass
446	Bass River heronry	2 km west of the community of Bass River	In 1985, this heronry contained 40 great blue heron nests.
451	Richibucto North Dune	Offshore, at the edge of the Kouchibouguac National Park	This dune harbours large colonies of herring gulls and great black-backed gulls, and a few pairs of red-breasted mergansers. A pair of piping plovers once lived on the dune, despite the fact that it does not afford suitable habitat for that species.
452	Richibucto estuary	East coast of N.B. south of the Kouchibouguac National Park, emptying into Northumberland Strait	A shallow estuary with unstable barrier islands, salt marshes and lagoons. Has many mollusc beds, and is an important region for migrating waterfowl.
453	Richibouctou-Village estuary	9 km southeast of Richibucto	The estuaries of the rivers known as la rivière du Cap and la rivière à Étienne support striped bass populations
454	Richibucto South Dune	Extends in an east-west direction, adjacent to Indian Island	Pairs of piping plovers are known to have lived on this dune in the past.
455	York Point Island	Located at the mouth of the Richibucto River	This little island is used by a small colony of common terms. In 1983, 39 pairs were observed there.
486	Coal Branch River	Located in the southwestern part of the watershed	Supports populations of striped bass and Atlantic salmon.

Source: The Nature Trust of New Brunswick Inc. (1995)

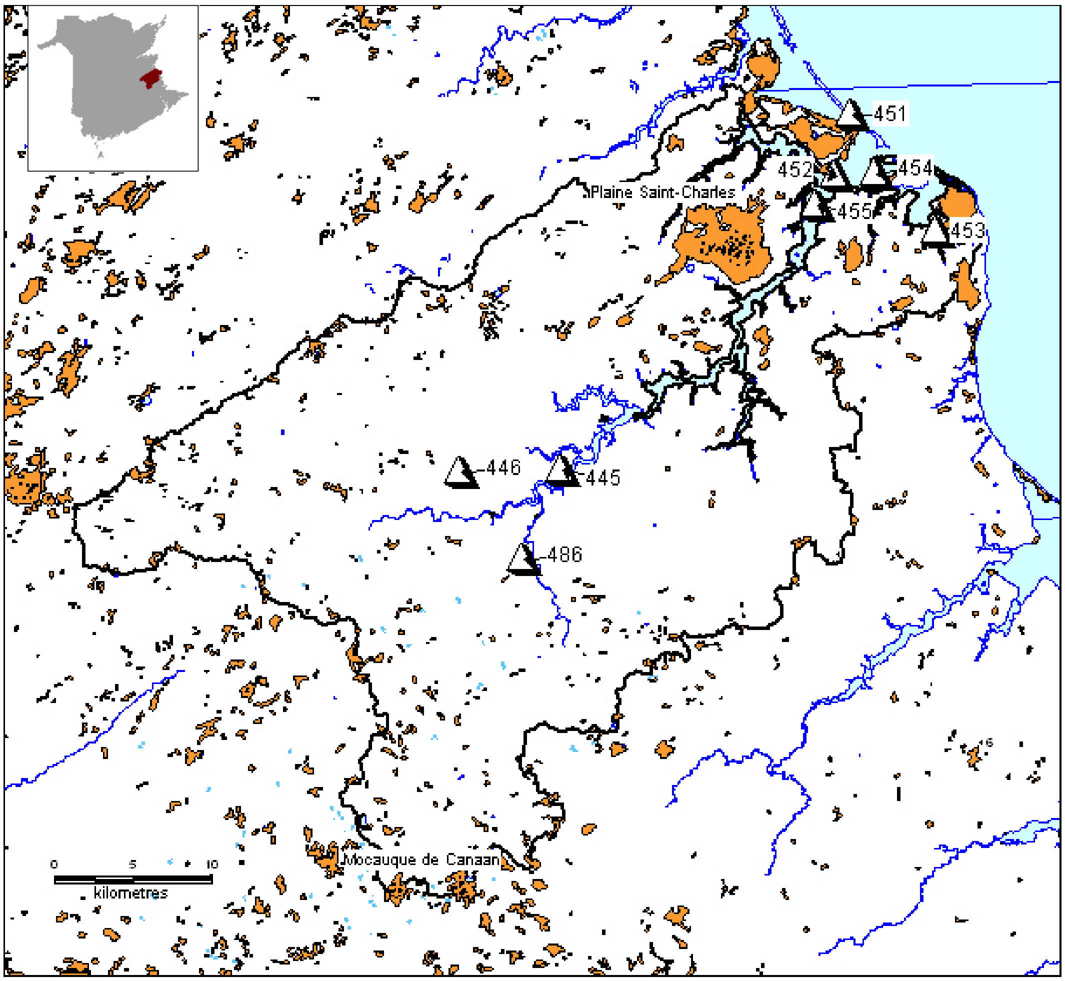
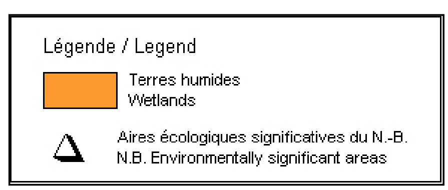


Figure 79: Wetlands and environmentally significant areas

Sources:
Service New Brunswick (2004)
NB Aquatic Data Warehouse
The Nature Trust of NB (1995)



Important bird areas in Canada: Nature Canada and Bird Studies Canada have joined forces to direct a program of important areas for the conservation of birds in Canada. The objective of the program is to identify and protect crucial nesting habitats, migration routes and overwintering areas used by North American birds. Site No. NB003 covers all the barrier beaches extending along St. Louis Bay to the end of the Richibucto North Dune (Fig. 80). This area includes part of Richibucto Harbour but does not include the Richibucto South Dune or Indian Island. It is a nesting site for one of the largest colonies of common terns (*Sterna hirundo*) in the Maritimes: 4,292 tern nests were counted in 1996. This area is also used by piping plovers (*Charadrius melodus*); approximately 12 pairs nest in the area every year (Nature Canada and Bird Studies Canada 2005).

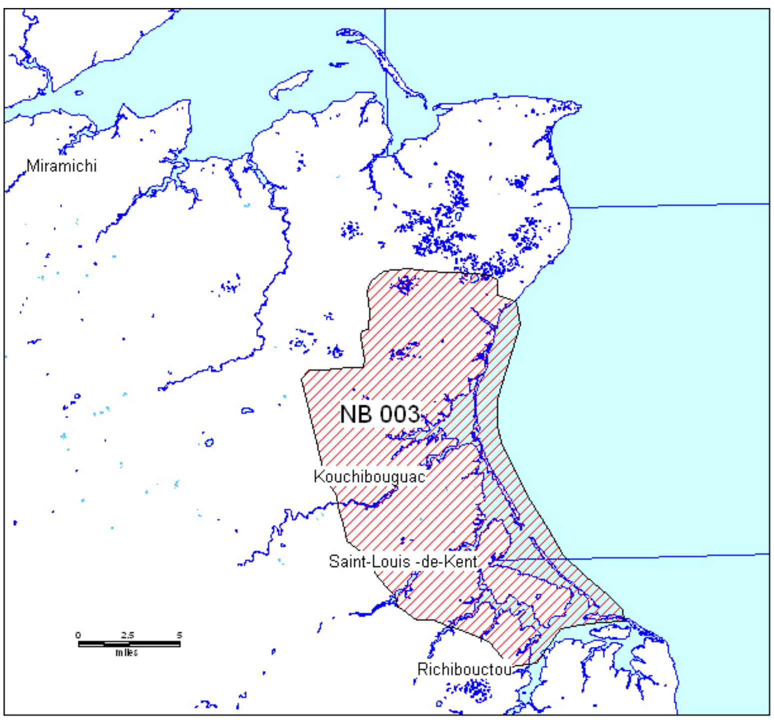


Figure 80 : Important zone for the conservation of birds

Source: Nature Canada and Bird Studies Canada (2005)

7.2. STRESSORS AND IMPACTS FROM HUMAN ACTIVITIES

Tables 25a and 25b below present a summary of the stressors and impacts from human activities that were identified in the various documents consulted in the course of the preparation of this report. It is essential to bear in mind that some subjects have been more extensively researched than others, providing more information to determine the environmental impact of the activities concerned. The stressors and impacts of other human activities identified in these tables may be less detailed, or altogether lacking, either because of inadequate information or because the activities in question are infrequent or not practiced in the area under study. The items identified in the tables are discussed in greater detail in the following pages.

Table 25 a: Stressors and impacts imposed on the environment by human activities

Stressors and impacts	WATER QUALITY STRESSORS						BIOTA STRESSORS							PHYSICAL CHANGES TO THE HABITAT					
Human activities	Introduction of sediment	Introduction of nutrients	Introduction of pathogens	Chemical contamination or changes	Heavy metal contamination	Air point and non-point source pollution	Introduction of exotic or invasive species	Introduction of disease or parasites	Threat to ecosystem biodiversity	Threat to ecosystem productivity	Threat to aquatic fauna	Threat to aquatic flora	Behavioral changes in aquatic species	Changes to the water currents	Obstruction to fish passage	Changes in the bottom composition	Contributing factor to anoxic condition	Disturbance to esthetic appearance	Shoreline changes
Commercial fishing, fixed gear							P				X							P	
Commercial fishing, mobile gear							P		P	P	P					P		P	
Fresh water recreational fishing							P											P	
Salt water recreational fishing							P											P	
In suspension molluscs aquaculture							P											P	
Bottom molluscs aquaculture							P												
Cage or pond rearing salmonid aquaculture																			
Logging activities	X			P					P	P	P	P				P	P	P	P
Silviculture																			
Agriculture of vegetables and small fruits	X	P		P					P	P	P	P				P	P	P	
Agriculture, orchards		P		P							P	P					P	P	
Livestock rearing	X	X	P						P	P	X					P	X	P	
Fish processing plants		X	P						P	P						P	X	P	
Fruit and vegetable processing plants																			
Pulp and paper mill																			
Other industrial plants				X	P	P					P								
Peat mining	X	P		X	X	P			P	X	X		X			X	P	P	
Recreational and tourist activities																		P	P
Hunting																			
Ecotourism activities																			

Table 25b: Stressors and impacts imposed on the environment by human activities

Stressors and impacts	WATER QUALITY STRESSORS						BIOTA STRESSORS							PHYSICAL CHANGES TO THE HABITAT					
	Introduction of sediment	Introduction of nutrients	Introduction of pathogens	Chemical contamination or changes	Heavy metal contamination	Air point and non-point source pollution	Introduction of exotic or invasive species	Introduction of disease or parasites	Threat to ecosystem biodiversity	Threat to ecosystem productivity	Threat to aquatic fauna	Threat to aquatic flora	Behavioral changes in aquatic species	Changes to the water currents	Obstruction to fish passage	Changes in the bottom composition	Contributing factor to anoxic condition	Disturbance to esthetic appearance	Shoreline changes
Human activities																			
Property maintenance		P		P							P	P					P	P	
Household activities		P		P		X					P	P					P	P	
Domestic waste water treatment		X	P						P	X						P	X	P	
Mineral				X							P								
Oil and gas																			
Sand and gravel																			
Water resources																			
Harbour infrastructure activities		P	P	P					P	P	P					P	P	P	
Channel dredging	P			P	P						P	P				P	P		
Marine transport				P			P	P			P								
Illegal boat ramp to a watercourse																			
Dams													P	P					
Beach infilling																			
Breakwaters														P					P
Hydro electric plant																			
Nuclear energy plant																			
Thermal energy plant					P	P					P								
Sea level rise																			P
Temperatures																			
Commercial shipping by land						X													
Domestic transportation						X													
Coastal and urban development																			P
Roads, bridges and causeways	X										X			P	X	P			P
Municipal waste water treatment		X	P	P					P	P						P	X	P	

X= Stressors and impacts supported by existing data for the watershed.
P= Activities that may potentially exert stress or an impact on the ecosystem, but are not supported by data pertinent to this specific ecosystem.

The information presented in Tables 25a and 25b is detailed below. It is categorized for easy reference using the titles and sub-titles from the table. This section is to allow the reader to reference a particular issue and better understand the impacts and threats to the environment imposed by human activities. For this reason, a lot of information is repeated from one issue to another.

7.2.1. Water quality stressors

7.2.1.1. **Introduction of sediment**

Numerous assessments conducted by the Richibucto River Association and other partners have shown that sedimentation is a widespread problem throughout the watershed. The main sources of sediment are the area's maze of logging and secondary roads, runoff from farmland, livestock operations and deforested land (LeBlanc-Poirier et *al*., 2004a).

Farming operations are scattered throughout the watershed. However, they are more heavily concentrated in the vicinity of the St. Charles River and the St. Nicholas River (Ruel et *al*., 1999). According to the National Program of Action (FPTACCNPA, 2000), in New Brunswick, activities that expose bare soil and farming on sloping terrain can contribute to the sedimentation of neighboring water courses.

Livestock that trample the soil along stream banks also contribute to the sedimentation of water courses. Richard et *al*. (2001) note that there are places in the watershed where livestock have access to streams.

An assessment of the Richibucto watershed performed over the period 1996-1998 showed that Hudson Creek and the South Branch (a tributary of the St. Nicholas) were particularly affected by sedimentation (Melanson et *al*., 1998). A water quality analysis performed as part of a water classification program for the watershed indicates that total suspended solid counts tend to be higher in the Bass, Molus and St. Charles Rivers and the West Branch of the St. Nicholas following periods of heavy rainfall. The highest count (72 mg/L) was found on September 29, 2003, in the Bass River at the point where Highway 116 crosses it. Furthermore, a count of 48 mg of suspended solids per litre was found in the

Molus River on that same date. Significantly, heavy rain had fallen that day and the previous day. The remaining samples showed acceptable counts of under 15 mg/L for the whole of the sampling period (LeBlanc-Poirier et *al*., 2004b).

Various types of bridges, culverts and causeways have been built within the watershed. In the course of an assessment, 29 culverts were identified as having erosion problems that were classified as "unacceptable", while 18 more were classified as being potential sources of erosion (Richibucto River Association, 1998). Erosion originating from a culvert can introduce sediment in the stream flowing through it. Since the above-mentioned assessment was performed, however, the Department of Transportation has replaced some of these problem culverts.

A study on the impact of peat harvesting revealed that bottom sediment in Mill Creek at the mouth of a small stream (nameless) flowing near the St. Charles Plain contained up to 90 per cent peat fibres. The extent of this peat deposition area was approximately one hectare, extending 40 metres upstream and 50 metres downstream from the mouth of the stream and covering half the width of Mill Creek (Surette et *al*., 2002). The results of a study on the levels of suspended sediment downstream from a peat bog suggest that the sedimentation ponds are not always designed to accommodate high flow situations, such as in the spring, with its high precipitation rates and heavy runoff from melting snow. Samples taken in the spring of 2001 and in the spring of 2002 showed that suspended sediment levels exceeded the suggested limits 50 per cent of the time in the former year and 80 per cent of the time in the latter (St Hilaire et *al*., 2006).

Dredging in ports and channels is another potential source of sedimentation that can result in habitat degradation. In the port of Cap-Lumière, the basin is dredged every 20 years, while the channel is dredged every year (C. Gaudet, pers. comm., August 30, 2005). Dredging operations are scheduled for the port of Richibucto as well, as part of the upgrading, but the dumping site for that excavation has not yet been identified (G. Robichaud, pers. comm., September 13, 2005). In many instances, dredging projects are subject to environmental assessment to ensure that they comply with the requirements of the Canadian Environmental Assessment Act (CEAA). Any dumping of sediment at sea requires a permit from a federal authority (NPA, 2000).

7.2.1.2. <u>**Introduction of nutrients**</u>

Nitrogen, nitrites, ammonia and various organic substances are all nutrients that can promote biological activity. There are various kinds of human activities that can introduce these nutrients into a body of water. Nutrient loading in a body of water can be harmful to the environment and cause eutrophication.

The three wastewater treatment plants located within the watershed (serving Richibucto, Rexton and Elsipogtog) are potential sources of organic matter (Richard & Godin, 2004). There are also a number of homes and summer cottages with inadequate septic systems, or even with no septic tank at all *(ibid).* Organic matter originating from these facilities may flow into nearby streams or make their way into the ground water table.

The Richibucto wharf and the St. Charles marina are also potential sources of organic matter (Richard & Godin, 2004). Neither of these two infrastructures have washroom facilities, nor a pumping station. Richibucto wharf serves over 100 boats, most of which have on-board sanitary facilities that are dumped at sea. The few boats using St. Charles marina must also empty their sanitary facilities at sea *(ibid).*

Food-processing plants are also known sources of organic matter (FPTACCNPA, 2000). Effluent from fish-processing plants might contain oil, blood and flesh fragments. Solids can accumulate on the bottom of the water course and gradually turn into anoxic sediment (Eaton et *al*., 1994). There are four fish-processing plants, located in Cap-Lumière, Richibouctou Village and the town of Richibucto. One fish processing plant, standing due south of the Richibucto wharf, has five effluent outflow pipes that on occasion discharge substantial quantities of liquid into the harbour (Richard & Godin, 2004).

There is a good deal of farming along the watershed's rivers and streams. In a number of cases, livestock are known to have direct access to, or are kept near a stream or river. These situations contribute to the introduction of organic matter, especially at times of year when there is substantial runoff from the surrounding land (Richard & Godin, 2004).

The use of fertilizers is a common agricultural and domestic practice. Fertilizers are products that get into a lake or other body of water by watercourse or by land runoff. They are a source of nitrogen. The presence of fertilizer in a body of water stimulates the growth of algae. Proliferating algae can contribute to an overload of decomposing organic matter and promote eutrophication (NPA, 2000). A eutrofied body of water is depleated in oxygen. This can result in the asphyxiation of the fish and other aquatic insects inhabiting it. The results of a water quality analysis have shown clearly that there is a threat of eutrophication in the estuarine part of the watershed because of the accumulation of nutrients there. This is particularly the case for the small streams that empty into the Richibucto River: Mooney's, Child's, Beattie's and Weldon Creeks (St-Hilaire et *al*., 2004b).

Draining a peat bog for harvesting purposes induces the decomposition of organic matter and hence may also increase the nutrient load in the drainage water, which flows into nearby streams (St-Hilaire et *al*., 2004b)

7.2.1.3. <u>**Introduction of pathogens**</u>

Potential sources of faecal coliforms include municipal and domestic wastewater treatment systems, boats with onboard toilets, and manure piles near streams. All of these can introduce pathogens into water.

Fish-processing plants are also potential sources of pathogens. Effluent from these plants may contain bacteria and other contaminants (Eaton et *al*., 1994).

E. coli is a faecal coliform. Concentrations of *E. coli* in excess of 200 MPN/100ml were found in the Molus and St. Charles Rivers and in the East and West Branches of the St. Nicholas following a period of heavy rainfall in September 2003. The Canadian Water Quality Guidelines set acceptable levels at <200 MPN/100ml for recreational purposes and

< 14 MPN/100ml for the consumption of shellfish.

In 2003 (St-Hilaire et *al*., 2004a), a study was conducted in a number of the Richibucto River's tributaries to determine the faecal coliform contamination level in the watershed. In July, seven out of nine sampling stations showed coliform counts in excess of acceptable standards for shellfish harvesting. In August, higher levels were found at most sites, with eight sampling stations out of nine reporting counts above the acceptable level for shellfish harvesting.

Environment Canada (Richard & Godin 2004) classify two segments of the Richibucto River above McGuire's Point as conditional, and other segments as closed outright (Fig. 81). However, in the absence of a memorandum of understanding for harvesting in these conditional areas, they remain closed by DFO prohibition order. The St. Charles River, the Petite-Aldouane River and an area at the head of the Baie-du-Village are all closed to shellfish harvesting. In all these cases, the closures are due to probable contamination by faecal coliforms (Richard et *al*., 2001).

DFO prohibition orders supersede Environment Canada designations. Figure 63 shows shellfish area closures ordered by DFO for the Richibucto Region. Updated information on these orders can be found at the Internet site http://www.glf.dfo-mpo.gc.ca/shellfish-coquillages/.

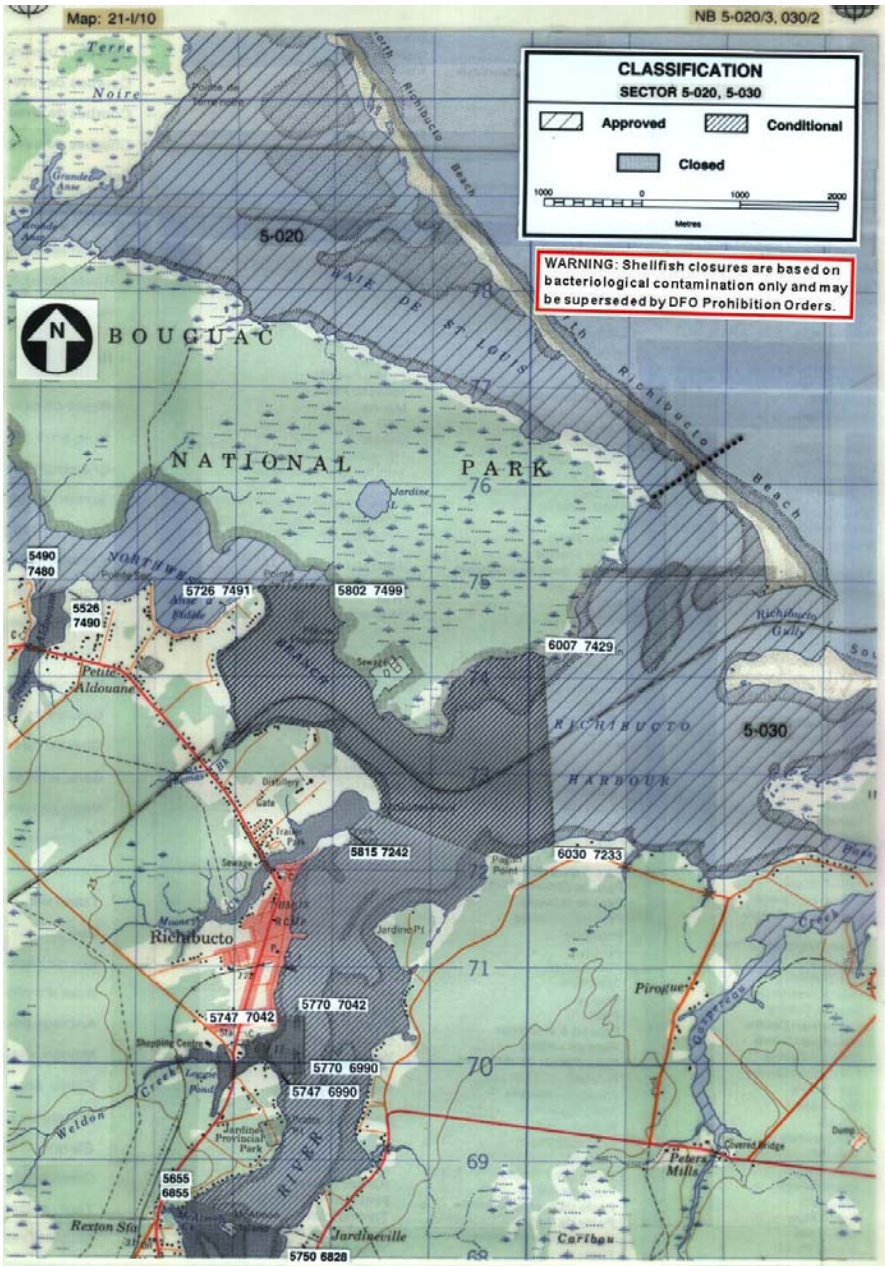


Figure 81: Enviroment Canada shellfish classification map area sector 5020, 5030

Source: Canada. Environment Canada, (December 2007), http://www.atl.ec.gc.ca/epb/sfish/maps/nb/area5.html

7.2.1.4. Chemical contamination or changes

Peat bogs are usually acidic, owing to the presence of humic and fulvic acids. The quality of the water in the sedimentation ponds used in peat harvesting operations is not the same as that of the water in nearby rivers or streams (St-Hilaire et *al*., 2004b). A study on the impact of peat harvesting on water quality has shown that peat bog effluent tends to lower the pH of nearby streams (Surette et *al*., 2002). A pH value of less than 6 was found in the streams receiving the drainage of the St Charles Plain (St-Hilaire et *al*., 2004b).

Surette et *al*. (2002) reported elevated phosphorus and organic carbon levels in Mill Creek at the mouth of the nameless little creek where peat sediment has accumulated in the water. An average concentration of 0.32 mg of phosphorus per litre was found in a small stream that receives the drainage water from the part of the St. Charles Plain where peat moss harvesting operations are conducted. In addition, high total nitrogen levels were found in the St. Charles Plain sedimentation pond (0.36 mg/L, 0.44 mg/L and 0.61 mg/L) (St-Hilaire et *al*., 2004b). Information on heavy metal contamination is presented in the following section.

The mining activities that were formerly carried out near the Coal Branch (a tributary of the Richibucto) appear to have affected the water in this ecosystem permanently. Analyses performed under the New Brunswick water classification program carried out by the Richibucto River Association (2004) indicate that the chemical composition of the water in the Coal Branch is different from that of other rivers and streams in the watershed. Significant calcium (Ca) variance was found, along with substantial fluctuation in pH values, very low alkalinity (ALK_T), and high levels of fluoride (F), conductivity (COND), chloride (Cl) and sodium (Na). These findings are attributed to the operation of the old Kent coal mine (LeBlanc-Poirier et *al*., 2004a).

The use of pesticides is a common activity on farms, on forested land and even in and around homes (FPTACCNPA, 2000). Year in and year out, pesticides are used to control insects and animals that may be harmful to crops, trees or ornamental plants *(ibid*). These pesticides may be carried into watercourses by waste water effluents or through runoff and can alter the water quality and have an adverse impact on the aquatic life (*ibid*).

Tributyltin (TBT) is a chemical used in antifouling paints. There was a time when paints containing TBT were commonly applied to fishing boats as a protective measure.These paints were also routinely used in fishing area 25 to protect lobster traps from woodworm (turbularia) (W. Landsberg, pers. comm., May 29, 2006). Since 1989, the use of paints containing TBT has been restricted to boats over 25 metres in length with aluminium hulls. TBT is toxic to some aquatic species, disrupting their reproduction (FPTACCNPA, 2000). It can find its way into the marine environment during application or removal of antifouling paint, cleaning, as well as through direct transfer from the treated surface *(ibid)*. Sources of TBT are found mainly around marinas, shipyards and major ports (*ibid)*. There are three main fishing ports and/or marinas in Richibucto Bay. None of them is a home port for boats over 25 metres in length (D. Thibodeau, pers. comm., December 20, 2005).

Oil and hydrocarbons from land-based sources can reach the marine environment via rainfall, wastewater and industrial waste (FPTACCNPA, 2000). While the quantity of waste involved may not be very substantial in any individual case, it may have a cumulative impact on some types of aquatic life such as insect larvae and fish eggs. Heavy crude, for example, is toxic and can deprive a habitat of oxygen *(ibid)*.

Sediment from channel-dredging operations is generally clean enough that it can be dumped at sea, whereas sediment from dredging operations in ports has to be dumped on land because it is contaminated with hydrocarbons and other substances (C. Gaudet, pers. comm., August 30, 2005). An analysis of the marine sediment that will be dredged in the course of the prospective upgrading work in the port of Richibucto has shown that the sediment around the wharf contains polycyclic aromatic hydrocarbons (PACs), metals and PCBs (Polychlorinated biphenyls) (Canada. Public Works and Government Services 2004). However, those substances are not present in high concentrations; the levels are deemed acceptable under the standards in force *(ibid)*.

In the town of Richibucto, there are two manufacturing establishments that use chemicals, CON-O-Lab and Peinture Laurentide. These establishments are also potential sources of chemical pollutants (Ruel et *al*., 1999).

Airborne pollutants from industrial and other sources make the rain more acidic, and acid rain, in turn, can contribute to lowering the pH of a watercourse. In 2003, a mean acid deposition load of 10 kilograms of sulphate per hectare per year was recorded in the Richibucto watershed (New Brunswick. DELG, 2004). Acid sulphate deposits of between eight and 11 kg/ha/year are regarded as critical loads *(ibid)*. Pollutants from the effluents of various industries in the Miramichi region may also make their way into Richibucto Bay via the northwesterly currents in Northumberland Strait (Ruel et *al*., 1999).

7.2.1.5. **Heavy metal contamination**

Heavy metals can originate from local mining operations or from more distant sources such as power plants with high smokestacks that enable emissions to travel long distances by air (FPTACCNPA, 2000). They can also be carried in excavated material from dredging operations that has been dumped on land or out at sea *(ibid)*.

Out of 16 marine sediment samples taken near the Richibucto wharf (Canada. Public Works and Government Services 2004), five were found to contain lead (Pb) and copper (Cu) levels in excess of the values specified in the provisional recommendations for the quality of marine sediments (PRQS) adopted by the Canadian Council of Ministers of the Environment (CCME). However, the Pb and Cu levels in the samples in question were below effect-producing concentrations as set by the CCME (1999).

Peat harvesting destroys the structure of the peat and allows particles to get into the air and water. Peat particles from the St. Charles Plain contain high concentrations of mercury (Surette et *al*., 2002). However, samples collected during the Surette et *al*. (2002) study showed relatively low levels of dissolved mercury in the water and no bioaccumulation of mercury in the biota. Mercury is a universal contaminant. It originates from natural sources and is dispersed into the environment by air and water. Recent research attributes between 60 and 80 per cent of the mercury in the environment to sources originating from human activities (Mason et *al*., 1994).

In an aquatic environment, mercury can be transformed into methyl mercury by bacteriological action. It can then be ingested by animals. Mercury can thus accumulate in the human body from food consomption (Surette et *al*., 2002). Mercury levels in the peat sediment in Mill Creek are approximately 10 times greater than in the sediments of other streams containing lower concentrations of peat (Surette, 1999). However, the harvesting operations conducted at the St. Charles Plain peat bog do not appear to present any short-term bioaccumulation hazard. The physical-chemical conditions of the water appear to be responsible for the non-methylation of the mercury *(ibid)*. The quantity of mercury appears to vary inversely with salinity: the more saline the water, the lower its mercury content *(ibid)*.

7.2.1.6. **Air point and non-point source pollution**

Domestic and industrial transport vehicles that burn fossil fuels contribute to air pollution by producing greenhouse gas emissions (Canada. Health Canada, 1999). Cars alone account for 10 per cent of all carbon dioxide emissions (*ibid)*. Some household activities that involve the burning of fossil fuels may also contribute to **greenhouse gas emissions**. Home heating systems, trash incinerators, gas stoves or poorly functioning wood-burning stoves may all produce carbon dioxide and other greenhouse gases *(ibid*).

Airborne contaminants from industrial plants, power plants and other facilities not only endanger human health, but can ultimately settle out into bodies of water, either near or farther away, thereby contributing to their contamination (Canada. Health Canada, 1999).

An acid rain monitoring station located in Harcourt in the Richibucto watershed recorded an acid deposition load of 10 kilograms of sulphate per hectare per year for that region in 2003 (New Brunswick. DELG, 2004). Acid sulphate deposition rates of between eight and 11 kilograms per hectare per year are considered critical loads *(ibid)*.

7.2.2. Biota stressors

7.2.2.1. **Introduction of exotic or invasive species and introduction of disease or parasites**.

Shipping is a potential means by which exotic or invasive species may be introduced into a body of water (Rosenthal et *al*., 2001). Vessels from distant places may dump their ballast water in coastal regions, and that water may contain exotic or invasive species, disease-causing organisms or parasites from other parts of the world (*ibid)*. Some 10 to 12 billion tonnes of ballast water is carried in the ballast tanks of ocean-going ships every year *(ibid)*. An estimated 4,000 species travel this way between continents every day *(ibid*). Those species include microscopic algae that may cause toxic blooms, parasites and disease-causing organisms that may affect an aquaculture industry or endemic wild populations. Another hazard is the possibility of introducing new species that can have an adverse impact on indigenous species and their habitat *(ibid)*.

Exotic and invasive species may also be introduced into a body of water deliberately or accidentally as a result of human activities. They may attach themselves to fishing boats and fishing gear, aquaculture product or pleasure crafts and thus be carried from one bay to another (Canada. Fisheries and Oceans Canada (n/d)). These species may also be introduced through fish transfers for transformation, aquaculture activities or other.

An inventory of the plankton community in the estuaries of the Kouchibouguac National Park (Bernier et *al*., 1998) was conducted in 1997 and 1998. The results showed that an exotic species of phytoplankton native to the Sea of Japan, *Chaetoceros salsugineus*, was present in the Kouchibouguac estuary. Species that inhabit that estuary can presumably inhabit the Richibucto estuary as well, as they are neighbouring watersheds with similar conditions (A. Locke, pers. comm., April 14, 2005). In the course of the inventory, 123 ichthyoplankton (fish eggs, larvae or fry) and zooplankton taxa were identified in all the estuaries of the Kouchibouguac National Park, including 88 previously unidentified taxa. Two species (*Cymbasoma rigidum* and *Evadne tergestina*) had never before been reported on the east coast of New Brunswick (Bernier, 2001). It is however, impossible to determine the origin of these new species.

Except for the Malpec disease which contributed significantly to the reduction of oyster populations in N.B. at the beginning of the fifties (Milewski & Chapman, 2002), there is no information available to support the introduction of diseases or parasites as a result of maritime transport in Richibucto Bay.

7.2.2.2. **Threat to ecosystem biodiversity**

Historically, the Richibucto watershed is a rich ecosystem in terms of its biodiversity. However, declining catches of fish and fish species have been noted and are a source of some concern (St-Hilaire et *al*., 2001a).

A study (Ouellette et *al*., 1997) was conducted in one of the tributaries of the Richibucto River in an effort to determine the effect of peat sediment on biodiversity and the health of the aquatic environment, and also the impact of peat on the substrate and water quality. The results showed that peat deposition could alter benthic invertebrate habitat. High peat density values correlated with lower numbers of individuals in fish and invertebrate populations. Furthermore, laboratory experiments revealed that if given a choice, organisms will avoid a peat substrate (Ouellette et *al*., 1997).

The use of mobile gear, such as drag nets used by trawlers for fishing or for harvesting algae, can alter or destroy the marine habitat to such an extent that it is no longer usable by some aquatic species. Such alterations can make some organisms more vulnerable to predators and thereby increase the numbers of such predators. A species that is found in abundance may be a contributing factor in the stock reduction of a prey species (White & Johns, 1997).

All activities that are likely to introduce nutrients into a body of water may jeopardize ecosystem biodiversity because nutrient loading can cause eutrophication (see 7.2.1., Introduction of nutrients). Lotze et *al*. (2003) reported that a proliferation of sea lettuce could cover eelgrass beds and create anoxic areas. This may be a factor in the degradation or loss of habitat for marine organisms and thereby create a threat to ecosystem biodiversity.

7.2.2.3. **Threat to ecosystem productivity**

Human activities that are likely to introduce organic matter into a watercourse may have an adverse impact on an ecosystem's productivity, as its natural resources can become contaminated and hazardous for human consumption. See section 7.2.1.2, Introduction of nutrients and section 7.2.1.3 Introduction of pathogens for more details.

Eutrophication of the marine ecosystem is suspected of being a contributing factor in the prolific growth of toxic phytoplankton that can contaminate shellfish and make them hazardous for human consumption (Eaton et *al*., 1994). All factors that are likely to promote anoxic conditions can thus represent threats to ecosystem productivity. For more information, see section 7.2.3 below, Physical changes to the habitat.

Richard and Godin (2004) identify the entire section above McGuire's Point on the Richibucto River as being entirely closed for shellfish harvesting. The St. Charles River, the Petite-Aldouane River and an area at the head of the Baie-du-Village are all closed to shellfish harvesting. In all these cases, the closures are due to contamination by faecal coliforms. Figure 82 shows aquaculture sites and shellfish closures as indicated by Environment Canada and DFO prohibition orders.

Activities that promote sedimentation in a body of water can also harm ecosystem productivity. Large amounts of sediment in the water column prevent light penetration which is essential to phytoplankton and macrophyte production which constitutes the base of the food chain (NPA, 2000).

In 1999, samples of dead clams picked in the Mooney's Creek region were assessed. The health report concluded that the clams in question had been affected by a disease that was suspected of being linked to human activities, although it was extremely difficult, to the point of being virtually impossible, to identify a causal relationship in the absence of precise experiments (Report on the health of mollusks, Mollusk health, Gulf Fisheries Centre, dated August 23, 1999). There is no available information indicating that the disease in question has persisted in the clam population of the Richibucto watershed. It's important to note that this disease cannot be transmitted to humans.

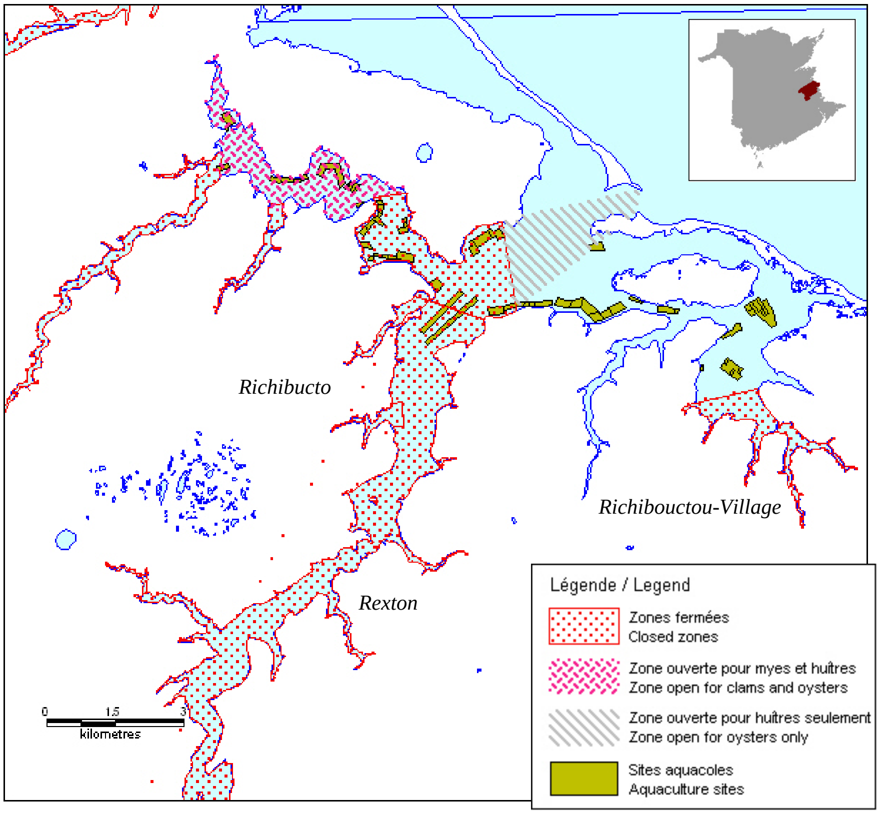


Figure 82: Aquaculture sites and shellfish closures

Sources: NB Dept. of Agriculture, Fisheries and Aquaculture, and DFO (2007) Internet site for shellfish closures: http://www.glf.dfo-mpo.gc.ca/shellfish-coquillages/

7.2.2.4. Threat to aquatic fauna

Sediment accumulation is a serious problem throughout the watershed, especially in Hudson Creek and the South Branch tributary of the St. Nicholas. This problem of sedimentation can have serious repercussions on the survival of salmonid fry (Melanson et *al*., 1998). The Canadian Council of Ministers of the Environment (1999) note that suspended sediments can have an adverse impact on the growth of fish by making it more difficult for them to feed, either because they are unable to see their food or because food is scarcer under conditions of turbidity. In addition, suspended sediments may irritate their gills, causing infections that are hazardous to their health. Sediment that is deposited on the bottom of a stream can asphyxiate fish eggs and fry by inhibiting gas exchange between egg and water. Fish can be adversely affected by even low concentrations of suspended sediment at all stages of their lives (CCME, 1999).

Spring samples taken in a river downstream of a peat harvesting operation showed that levels of suspended sediment exceeded the suggested limits approximately 50 % of the time in 2001 and 80 % of the time in 2002. According to the authors (St Hilaire et *al*., 2006), long periods of high turbidity could increase stress levels in the various aquatic wildlife species, such as molluscs, crustaceans and fish, that inhabited the estuary. The Richibucto Bay estuary contains sizable aquaculture operations where American oysters (*Crassostrea virginica*) are cultivated *(ibid)*. The American oyster can survive under high-turbidity conditions, but prefers concentrations in a range extending between 6 mg/L and 700 mg/L. That maximum was exceeded in a number of instances during the sampling period, especially in 2002 (Fig. 83) *(ibid)*.

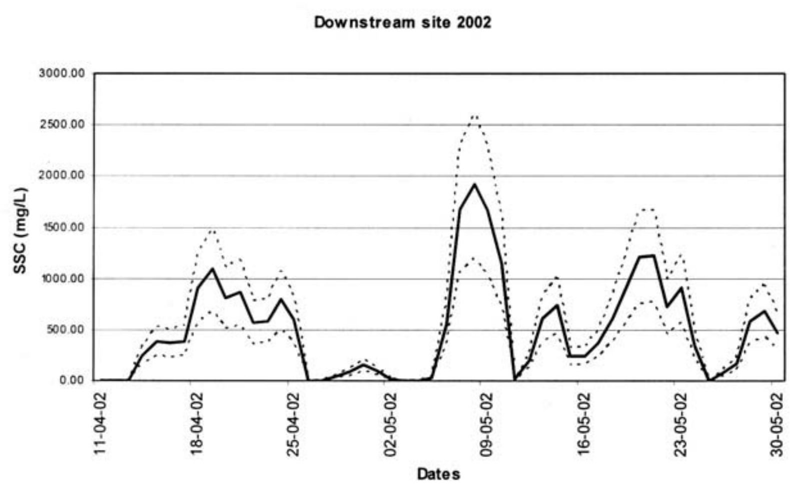


Figure 83: Suspended sediment concentrations downstream of a harvested peat bog

Extracted from St. Hilaire et al. 2006

In the course of an evaluation of culverts in the watershed, 13 culverts were noted as creating an obstruction to fish passage (Richibucto River Association, 1998). This may cause serious problems for the fish that inhabit the river, as they must swim from place to place in order to be able to hide from predators, feed, and reproduce.

Fishing with fixed gear may also be harmful to certain aquatic fauna. Trap nets, gillnets and other types of fixed gear catch fish other than the target species (by-catches). Often enough, the by-catch species die before they are returned to the water. A survey (Maillet, 1996) of eel (*Anguilla rostrata*) and gaspereau *(Alosa pseudoharengus*) fishing operations revealed by-catches of salmon *(Salmo salar)*, Trout *(Salvelinus fontinalis*), flounder species, cod (*Gadus morhua*), tomcod (*Microgadus tomcod*), alewife/gaspereau (*Alosa sp*.), white perch (*Morone americana*), mummichog (*Fundulus heteroclitus*), smelt *(Osmerus mordax*), lampreys (*Petromyson marinus*), striped bass (*Morone saxatilis*), sculpins (*Myoxocephalus aenaeus*) and skate (*Raya sp*.).

The use of mobile gear, such as drag nets used by trawlers for fishing or for harvesting algae, can alter the marine habitat to such an extent that it is no longer usable by some aquatic species. Such alterations can risk making some organisms more vulnerable to predators, while simultaneously increasing the numbers of such predators. A species that is found in abundance may be a contributing factor in the stock reduction of other species (White & Johns, 1997).

Since 1989, the use of paints containing TBT has been restricted to boats over 25 metres in length with aluminium hulls. This chemical is toxic to some aquatic species, disrupting their reproduction (FPTACCNPA, 2000). While point sources have declined in recent years, thanks to strict enforcement of the regulations, TBT is still found in the blue mussels of the southern Gulf of St. Laurence at concentrations (100-500 ng/g) that could be toxic to other marine organisms *(ibid).*

A study (Surette, 1997) was conducted in Richibucto Bay to determine the heavy metal accumulation in four fish species: American eel (*Anguilla rostrata*), Atlantic tomcod (*Microgadus tomcod*), mummichog (*Fondulus heteroclitus*) and sand shrimp (*Crangon septemspinosa*). Heavy metal concentrations in these species were found to be comparable to or lower than the values found in other estuaries of the Gulf of St. Lawrence. Despite the fact that Richibucto Bay does not appear to contain excessively high levels of heavy metals, it is clear that bioaccumulation is occurring in the food chain. More details on human activities that may be a factor in heavy metal dispersion can be found in section 7.2.1, Heavy metal contamination.

The use of pesticides is a common activity on farms, on forested land and even in and around homes (FPTACCNPA, 2000). Pesticides are used to control insects and animals that may be harmful to crops, trees or ornamental plants. These pesticides may be carried into watercourses by waste water effluents or through runoff and can alter the water quality and have an adverse impact on its benthic and pelagic organisms (*ibid*).

7.2.2.5. **Threat to aquatic flora**

The presence of fertilizer in a body of water introduces excessive quantities of nutrients that stimulate the growth of some species of algae at the expense of others. Proliferating algae may contribute to eutrophication (FPTACCNPA, 2000). A eutrophied body of water has depleted oxygen levels, thus having the potential to cause the asphyxiation of the fish, insects, plants or other organisms living there (Lotze et *al*., 2003). The results of a water quality analysis have shown clearly that eutrophication is a possible hazard in the estuarine part of the watershed because of the build-up of nutrients there. This is particularly the case for the small tributaries that empty into the Richibucto River: Mooney’s, Child’s, Beattie’s and Weldon Creeks (St-Hilaire et *al*., 2004b).

The use of mobile gear, such as drag nets used by trawlers for fishing or for harvesting algae, can alter or destroy the marine habitat to such an extent that it is no longer usable by some aquatic species (White & Johns, 1997). Irish moss is harvested with drag nets in the Strait on the outskirts of the South Dune / Cap Lumière region.

Sediment in suspension resulting from dredging and other activities may be harmful to phytoplankton and macrophyte production (FPTACCNPA, 2000). The channel leading to the port of Cap Lumière is dredged every year, while the port basin is dredged every 20 years (C. Gaudet, pers. comm., August 30, 2005).

7.2.2.6. **Behavioral changes in aquatic species**

A study was conducted in one of the tributaries of the Richibucto River in an effort to determine the effect of peat sediment on the biodiversity and the health of the aquatic species and also to study its impact on the substrate and water quality (Ouellette et *al*., 1997). The results showed that high peat density values correlated with lower numbers of individuals in fish and invertebrate populations, and also that peat deposition could alter benthic invertebrate habitat. Furthermore, laboratory experiments have revealed that if given a choice, organisms will avoid a peat substrate (*ibid).*

Another study, this one on the influence of peat on the distribution and behaviour patterns of sand shrimp (*Crangon septemspinosa*) (Ouellette et *al.*, 2003), has shown that these shrimp prefer a sand substrate to a peat substrate. It very difficult for them to burrow into peat, as the peat particles tend to float instead of settling back over the burrowing individual *(ibid).* Furthermore, their body colouring does not afford them camouflage against a background of peat sediment. Peat particles may interfere with their respiration and their ingestion of food *(ibid)*. Particles that are ingested occupy the space that should be occupied by food in the creature's gastric mill. The task of digesting such particles demands a great deal of energy, and the shrimp may actually suffer an energy loss during the process *(ibid)*.

7.2.3. Physical changes to the habitat

7.2.3.1. **Changes to the water current**

The construction of dams, causeways, breakwaters and other infrastructure items can disrupt the hydrology of a body of water and bring about changes to the current in neighbouring rivers and streams (FPTACCNPA, 2000). A few years ago, the provincial Dept. of Transportation made modifications to the causeways on Mooney's Creek and Weldon Creek to improve water circulation.

7.2.3.2. **Obstruction to fish passage**

The construction of dams, culverts and other infrastructure items may create major obstacles to fish passage (FPTACCNPA, 2000). In the course of an evaluation of culverts in the watershed, 13 culverts were identified as obstructing the passage of fish (Richibucto River Association, 1998). This may cause serious problems for the fish that inhabit the river, as they must swim from place to place in order to be able to hide from predators, feed, or even reproduce.

7.2.3.3. **Changes in the bottom composition**

Any activities that are likely to promote sediment build-up in a stream or river may also foster changes to the composition of its bottom, as suspended sediment can eventually settle out and accumulate, thereby altering or degrading fish habitat (FPTACCNPA, 2000). More information about human activities that are likely to promote sediment buildup in a stream or river can be found in section 7.2.1, Introduction of sediment.

All activities that introduce nutrients into a body of water can contribute to an overload of phytoplankton biomass. This excess biomass can eventually create a build up of decomposing matter on the ocean, river or stream bed thus contributing to a change in bottom composition (Lotze, Milewski, Worm, & Koller, 2003). Further information about human activities that may introduce nutrients into a stream or river can be found in section 7.2.1, Introduction of nutrients, and section 7.2.3 below, Contributing factors to anoxic conditions.

A study on the impact of peat harvesting revealed that the bottom sediment in Mill Creek at the mouth of a small stream (with no name) flowing near the St. Charles Plain contained up to 90 per cent of peat fibres. The extent of this peat deposition area was approximately one hectare, extending 40 metres upstream and 50 metres downstream from the mouth of the stream and covering half the width of Mill Creek (Surette et *al*., 2002).

The use of mobile gear, such as drag nets used by trawlers for fishing or for harvesting algae, can degrade or destroy the substrate to such an extent that it is no longer usable by some aquatic species (White & Johns, 1997).

Dredging in harbours and channels may permanently alter the composition of the immediate habitat and have a critical impact on the species that use it (White & Johns, 1997).

7.2.3.4. **Contributing factors to anoxic conditions**

All human activities that introduce nutrients into a stream or river may be contributing factors to anoxic conditions (White & Johns, 1997). Excessively rich nutrient input stimulates the growth of algae, and as these plants die and dead vegetation builds up on the bottom, they provide food for aerobic bacteria, which use up great quantities of oxygen, causing anoxic conditions. More information about human activities that are likely to introduce nutrients or organic matter into a stream or river can be found in section 7.2.1, Introduction of nutrients.

A water quality analysis done in the context of the water classification program for the watershed pointed to evidence of nutrient enrichment in the sub-watersheds of the St. Charles River, the East, West and South Branch tributaries of the St. Nicholas, and at a number of sites on the Coal Branch (LeBlanc-Poirier et *al*., 2004a). High total organic carbon and total nitrogen levels were found in these rivers, while high total phosphorus concentrations were found in the Molus River, the St. Charles River, and the West Branch tributary of the St. Nicholas at specific dates.

A water quality analysis (St-Hilaire et *al*. 2004b) identified a pH value of less than 6 in the streams into which the St. Charles Plain drains. An average concentration of 0.32 mg of phosphorus per litre was found in a small stream that receives the drainage water from the part of the St. Charles Plain where peat moss harvesting operations are conducted. In addition, high total nitrogen levels (0.36 mg/L, 0.44 mg/L and 0.61 mg/L) were found in the St. Charles Plain sedimentation pond *(ibid)*. The results show clearly that eutrophication is a possible hazard in the estuarine part of the watershed because of the build-up of nutrients there. This is particularly the case for the small tributaries that empty into the Richibucto River: Mooney's, Child's, Beattie's and Weldon Creeks *(ibid)*.

Fertilizers used in farming and logging operations and even in residential settings can eventually make there way into a body of water where they can stimulate the growth of algae, increase the nutrient load and promote eutrophication *(ibid)*. No research has been done to date to study the link between the nutrient loading found in a number of the watershed's rivers and the fertilizers used by farmers, loggers and householders in the region.

When the current in a river is slowed as a result of the construction of a causeway or other type of infrastructure, there is a danger of sediment and nutrient build-up that can lead to the eutrophication of that river (FPTACCNPA, 2000).

7.2.3.5. **Disturbance to aesthetic appearance**

**It is essential to note that all the factors identified below as tending to cause a disturbance to aesthetic appearance are subjective. That is to say, the issue is a matter of personal perception or opinion. What one person may see as a disturbance to aesthetic appearance may not necessarily be seen in the same light by someone else.*

A body of water in a condition of eutrophication may be aesthetically unattractive because of the accumulation of dead algae along the shoreline, depleting the oxygen and giving off noxious gases such as ammonia and hydrogen sulphide (FPTACCNPA, 2000). Accordingly, all potential contributing factors to the eutrophication of a body of water may indirectly disturb the aesthetic appearance of the coastal region.

Fishing, tourism and other local activities may also be factors contributing to the disturbance of the region's aesthetic appearance, as they generate all sorts of trash that litters the shoreline (PARTENARIAT, 2004). A garbage-strewn beach is unattractive to the eye and may repel visitors.

Aquaculture sites may also be unattractive from an aesthetic standpoint. Some people may find that the sight of a large number of buoys floating on the water of a bay tends to spoil the picturesque view.

7.2.3.6. **Shoreline changes**

The construction of roads near the coast allows access for human activities and invites development. The utilization of the coastal region and the construction of flood protection structures, breakwaters, wharves and the like may alter the coastline and change the local habitat (FPTACCNPA, 2000). Tourism, residential and commercial infrastructure along the coast may contribute to the degradation of habitats such as marshes, dunes and the like, putting the coastline at greater risk of erosion *(ibid)*. Driving all-terrain vehicles along the shore, for example, may have a destabilizing impact on dunes and make them vulnerable to the elements. Dunes are natural barriers that protect the shoreline from the sea. When they disappear or are altered by waves and wind action, the hydrodynamic characteristics of the region may change, and this may entail risks for the adjacent land areas (White & Johns, 1997; FPTACCNPA, 2000).

According to O’Carroll and Bérubé (1997), much of the watershed above Highway 11, the Baie-du-Village region and the area including the Northwest Branch as far as the North Dune, is characterized by a moderate sensitivity index. This means that that region is moderately likely to undergo erosion as a result of storm wave action (Fig. 9). The lower part of Richibucto Harbour out to the mouth of Northumberland Strait was found to have a high sensitivity index (*ibid)*. The remainder of the coastline within the watershed was found to be less sensitive to erosion as a result of storm wave action, and was rated low or very low in terms of its sensitivity index *(ibid)*.

7.3. SUMMARY OF MAIN ISSUES OF CONCERN

Table 26 presents a summary of the main issues of concern that could be taken into consideration in the preparation of an integrated management plan for this community coastal area. Activities identified as giving cause for concern could be addressed in a plan of action managed at the local or regional level.

Table 26: Summary of main issues of concern

Stressors and impacts	**Issues of concern**	**Details**	**Major consequences**
Water quality stressors			
Introduction of sediment	Peat mining Erosion caused by bad construction of forestry routes or secondary routes	Inadequate sedimentation ponds Poorly constructed culverts	Change in habitat Threatens aquatic life
Introduction of nutrients	Treatment of municipal and domestic sewage Fish processing plant effluents Agricultural and domestic use of fertilizers	Poorly treated or non-treated sewage Fish plant effluent to rich in nutrients Run-off of treated lands enter neighboring watercourse	Closure of shellfish growing areas Eutrophication of water body (anoxic conditions)
Biota stressors			
Threat to ecosystem biodiversity	Main activities that introduce nutrients in a watercourse (mentioned above)	Rapid growth of algae Increase in sediment and turbidity	Decrease in oxygen levels Light cannot penetrate through water
Threat to ecosystem productivity	Activities that can introduce pathogens	Shellfish contamination	Closure of shellfish growing areas
Threat to aquatic fauna	Main activities that introduce sediments in a watercourse Construction of infrastructures such as culverts and causeways	Renders waters turbid and cause stress to fish populations Several culverts poorly constructed are an obstruction to fish passage	Fish have difficulty feeding Asphyxiates fish eggs and larvae Prevents fish migration
Physical changes to the habitat			
Factors contributing to anoxic conditions	Main activities that introduce sediment and nutrients in watercourse	Accumulation of organic matter and sediments on the bottom	Production of toxic gases Habitat becomes unsuitable or even harmful to aquatic species
Factors contributing to shoreline changes	Coastal and urban development Use of motorized vehicles in the coastal zone	Contributes to coastal erosion Destruction of dunes and marshes	Exposes neighboring lands to winds and storm waves Productivity of coastal zone is threatened

8. CONCLUSION

DFO promotes an integrated management approach to achieve the sustainable development of the aquatic resources of coastal and marine ecosystems. All human activities, whether pursued inland or in the coastal region itself, may have direct or indirect consequences for the natural environment. The use of integrated management is a means of managing our activities in such a way as to achieve a preventive (rather than a curative) approach not only to environmental issues as such but also to conflicts between users.

Awareness and stewardship programs will be developed in an integrated management framework. These programs will serve to inform and to educate people, will set a feeling of responsibility in communities, thereby engage citizens in the management of their watershed, and consequently reducing the level of activities that threaten or adversely impact upon the natural environment.

The preparation of an ecosystem overview report is a first step toward integrated management. It is a tool that will be useful, not only as a means of informing the main stakeholders, but throughout the entire process, as a means of enabling them to reach sound decisions. Regular updates will be necessary and research projects should be undertaken in order to fill in any information gaps, thereby ensuring that the tool will retain its utility and effectiveness.

8.1. Information gaps

Some types of human activities in the Richibucto Bay watershed have been extensively documented, but others have not, and it would be desirable for the latter to be studied in greater depth. Moreover, it is important to note that some of the available information is no longer current and needs to be brought up to date. The paragraphs below outline a number of subjects for which information is outdated or not available.

- Some potential sources of nutrients have been identified in a few reports, but this topic has not been researched in depth for the watershed as a whole. A comprehensive assessment of potential sources of nutrients might be a practical means of determining the main causes of eutrophication in the watershed.

- Very little information is available on the problem of eutrophication in the watershed. It would be valuable to know at what locations nutrient matter appears to be accumulating and where seasonal proliferations of sea lettuce and hollow green weed have been observed.

- The impact of logging operations on the watershed is not well documented. It would be useful to know more about the condition of buffer zones along rivers and the pressures exerted by that economic activity on the watershed.

- Very little information is available on the condition of the buffer zones surrounding privately owned land in the watershed. There exists very little data on the main sources of erosion and contamination associated to runoff from privately owned land.

- The inventory on mollusc populations mentioned frequently in this report (Senpaq Consultants, 1990) is some fifteen years old. Given that aquaculture operations are expanding and that water quality issues and shellfish area closures are ongoing, a new inventory might be in order. This could allow for a more accurate assessment of the bay’s economic potential.

- Suspended aquaculture operations are expanding in the watershed. It would be important to continue the research and document the effects this method of culture may have on the environment.

- Better knowledge of the distribution and extent of marshes in the watershed would be valuable. Marshes are highly productive habitats, and it would be usefull to have a more thorough review of their location, their span and the plant species growing in them.

- Municipal, industrial and residential wastewater treatment systems appear to be a major source of organic matter and pathogens. Non-point sources such as fishing and recreational vessels are also potential sources of organic matter and pathogens.

Understanding the effectiveness and maintenance of these systems and identifying the non-point sources is critical to filling information gaps and enhancing water quality in the bay.

- Very little information is available about populations of fauna and flora in the watershed. It would be desirable to possess a summary of the various population densities.
- A great deal of information about the watershed is available in text form. It would be very useful to have that information presented in the form of thematic maps, as the result would be a comprehensive picture of the watershed. The items listed below are particularly noteworthy:
    - Span of animal populations
    - The various forest types
    - Farmland and land used for livestock production
    - Residential density along the main rivers
    - The condition of buffer zones along the main rivers
    - All obstacles to fish migration
    - All point sources of sedimentation
- Few reports or other documents about the watershed’s historic sites and traditional and local knowledge are available. Information of that kind could be obtained from the First Nations, fishermen, historical societies and the like and could be presented in the form of a report on traditional ecological knowledge.
- There is insufficient of data on the number of fishers fishing commercially. The numbers of licences issued for the various species do not necessarily provide a valid picture of the economic importance of these fisheries. It might be of interest to conduct a survey targeting the various fishing organizations to gather more accurate data.
- Commercial fisheries statistics do not necessarily reflect the actual situation with respect

to fishing efforts, because in some cases catches are sold directly to customers and hence are not included in the statistics, while in other cases catches are not sold, but are used for other purposes. Better ways of registering catches should be developed in order to obtain a valid picture of the actual catches taken in the watershed.

- Very little information is available on the watershed's groundwater. It would be of interest to present an overview of groundwater use and quality, inasmuch as groundwater is directly related to the watershed's surface water and in all likelihood is a major resource for the people who live in the region.

8.2. Moving toward risk management

The objective of integrated management is to practise an approach featuring preventive measures instead of taking corrective action. The list below presents some suggested initiatives aimed at bringing about a shift from corrective measures taken after the fact to potential risk management.

Identify the various fish species that inhabit the watershed and the factors that are essential to their survival;

- Identify all fish habitats in the watershed that are in good condition;
- Ensure sustainable development of rivers and riparian lands by means of buffer zone maintenance and the adoption of sound environmental practices;
- Identify in order of priority, obstacles to fish passage;
- Take corrective measures to remove obstacles to fish passage;
- Identify sources of sedimentation in streams;
- Take corrective measures to eliminate sources of sedimentation;
- Identify stretches of rivers and streams with sediment buildup;
- Install structures designed to capture sediment already in rivers and streams;
- Encourage sound environmental practices through public awareness and education.

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10. APPENDICES

10.1. APPENDIX 1 : GLOSSARY

Anaerobic condition: a condition in which dissolved oxygen, nitrate and nitrite are absent. [Definition standardized by ISO.] (Source: Termium / Water quality : vocabulary. International Organization for Standardization. [Geneva] : ISO, 1980. 1st ed. = 1ère éd.)

Anadromous: Migrating from sea-water to freshwater to spawn, e.g. salmon (Source: "By the Sea" Glossary)

Anoxic: [Said of a] condition in which the concentration of dissolved oxygen is so low that certain groups of micro-organisms prefer oxidized forms of nitrogen, sulfur, or carbon as an electron acceptor. [Definition standardized by ISO.] (Source: Termium / Water quality : vocabulary. Part 5 International Organization for Standardization. Geneva : ISO, 1986.) 1st ed. = 1ère éd.)

Ballast: Unnecessary stock used for stabilizing an ocean carrier operating below its stowage capacity (Source: Termium / Dictionary of international trade / Jerry M. Rosenberg, Jerry Martin. New York : J. Wiley, ©1994.)

Barrier beach: A strip of cobbles or sand joining two headlands (Source: "By the sea" glossary)

Bathymetry: The study of the ocean depth. (Source: "By the Sea" glossary)

Benthic: Bottom-dwelling. (Source: "By the Sea" glossary)

Chlorophyll: Generic name for the green, fat-soluble pigments of plants. They have a complex structure (similar to hemoglobin's) and are essential photoreceptors for the synthesis of glucides (i.e. photosynthesis). (Source: Termium / Dept. of the Secretary of State of Canada, Translation Bureau, Terminology)

Coliform: A group of aerobic and facultatively anaerobic Gram-negative, non-spore-forming, lactose-fermenting bacteria which typically inhabit the large intestine of man and animals. Generally, apart form E. coli, many of them are able to survive and multiply in the natural environment (Source: Termium / Water quality : vocabulary. Part 7. International Organization for Standardization. Geneva : ISO, 1990. 1st ed. = 1ère éd.)

Community: An association of lifeforms living within a specific environment, linked through a food chain and other interactions. A salt marsh is composed of a community of living beings. (Source: "By the Sea" glossary)

Diadromous: [Said of] Truly migratory fishes which migrate between the sea and freshwater. (Source: Termium / Fish migration / F. R. Harden Jones; illustrated by H. E. Jenner. Harden Jones, F. R. London : Edward Arnold, 1968)

Degree days: Algebraic difference, expressed in degrees, between the mean temperature of a particular day and a reference temperature (Source: Termium / International meteorological vocabulary / World Meteorological Organization. Geneva : Secretariat of World Meterological Organization, 1966.)

Ecology: The scientific study of how lifeforms interact with the living and nonliving components of the environment. (Source: "By the Sea" glossary)

Ecosystem: Comprises all living things in a community together with physical factors of sunlight, temperature, salt, currents, etc., as well as the flow of energy from one organism to the next. (Source: “By the Sea” glossary)

Estuary: A partially enclosed body of water in the lower reaches of a river, which is freely connected with the sea and which receives fresh water supplies from upland drainage areas. (Source: Termium / Definition standardized by ISO.)

Eutrofication: The enrichment of water, both fresh and saline, by nutrients, especially compounds of nitrogen and phosphorus, that will accelerate the growth of algae and higher forms of plant life. (Source: Termium / Definition standardized by ISO.)

Greenhouse gas emissions: A gaseous component of the atmosphere contributing to the greenhouse effect. Greenhouse gases include carbon dioxide, methane, nitrous oxide, chloroflurocarbons, and water vapor. Carbon dioxide, methane, and nitrous oxide have significant natural and human sources while only industries produce chloroflurocarbons. (Source: Termium / Internet. [http://www.windows.ucar.edu])

Integrated management: is a continuous planning process in which interested parties, stakeholders and regulators reach general agreement on the best mix of conservation, sustainable resource use and economic development for coastal and marine areas. (Source: Termium / Internet. [http://www.oceansconservation.com/iczm/imhome.htm]. Fisheries and Oceans Canada. \"Integrated Management Web Site\)

Intertidal zone: The area covered by water at high tide and exposed to the air at low tide (Source: “By the Sea “ glossary)

Longitudinal migration: That migrates in the direction of the length contrarily to migrating in the direction of depth

Marine transgression: The spread of the sea over land areas (Source: Termium / Dictionary of geological terms / Robert L. Bates and Julia A. Jackson, editors; prepared under the direction of the American Geological Institute. Garden City, N.Y. Anchor Press, 1984. 3rd ed.)

Pathogen: An agent (virus, micro-organism or other substance) capable of producing disease in a susceptible plant or animal, including man (Source: Termium / Lainé, Claude, TB - Scientific and Technical Division – Montréal)

Productivity: The amount of organic matter formed in an ecosystem and its rate of formation. In other words, a measure of how rich or fertile an ecosystem is. (Source: “By the Sea” glossary)

Seston: The aggregate of substances and organisms that float or swim in water, including the bioseston (living organisms) and the abioseston (non-living). (Source: Termium / Dictionary of ecology / by Herbert C. Hanson. 1891- New York : Philosophical Library, [1962])

Stratification: The existence or formation of distinct layers in a body of water identified by thermal or salinity characteristics or by differences in oxygen or nutrient content. (Source: Termium / Definition standardized by ISO. 1980)

Swamp: Low-lying land, permanently saturated with standing water or water gently flowing through pools of channels at the surface and usually having trees and shrubs. (Source: Termium / Glossary of generic terms in Canada's geographical names. Ottawa : Dept. of the Secretary of State of Canada, 1987.xxi, 311 p.;Text in English and French.;Co-published by Energy, Mines and Resources Canada and Canadian Permanent Committee on Geographical Names.;Cover title : Génériques en usage dans les noms géographiques du Canada = Generic terms in Canada's geographical names.;Bibliography : p. 307-311.;ISBN 0660537648.

Tropospheric ozone: That small part of the total atmospheric ozone which is contained in the atmospheric boundary layer (Source: International meteorological vocabulary. World Meteorological Organization.Geneva : Secretariat of World Meterological Organization, 1966)

Wisconsin glaciation: A period of glaciation covering most of the northern half of North America from about 85,000 years ago until about 7,000 years ago. It was the most recent continental glaciation. (Source: Termium / Internet. [http://www-nais.ccrs.nrcan.gc.ca/Schoolnet/issues/borealnet/glos.htm] Natural Resources Canada, National Atlas on Schoolnet, Boreal Forest, Glossary, July 1997)

10.2. Appendix 2 : List of species

Aquatic fauna and flora / Faune et flore aquatique

Crustaceans / Crustacés

English	Français	Latin
Acadian Hermit Crab	Bernard-l'hermite	*Pagarus acadianus*
American Lobster	Homard	*Homarus americanus*
Mud Crab	Crabe de vase	*Rhithropanopeus harrissii*
Rock Crab	Crabe commun	*Cancer irroratus*
Sand Shrimp	Crevette de sable	*Crangon septemspinosa*
Grass shrimp	Crevette d'herbe	*Palaemonetes vulgaris*

Echinoderms / Échinodermes

English	Français	Latin
Arctic Cushion Star	Étoile coussin	*Pteraster militaris*
asterias sea star	Astéries, étoiles de mer	*Asterias sp.*
asteriid sea star	Étoile de mer pourpre	*Asterias vulgaris*
Basket Star	Tête de méduse arctique	*Gorgonocephalus arcticus*
blood star	Petite-étoile rouge-sang	*Henricia sp.*
Dwarf Brittle Star	Ophiure	*Axiognathus squamatus*
Forbes' Asterias	Étoile de mer	*Asterias forbesii*
Polar Sea Star	Étoile de mer polaire	*Leptasterias polaris*

Sponges / Éponges

English	Français	Latin
Crumb of Bread Sponge	Éponge en croute de pain	*Halichondria panicea*
Encrusting sponge	Éponge encroûtante	*Halichondria sp.*
Finger Sponge	Éponge digitée	*Haliclona oculata*
organ-pipe sponge	Éponge calcaire de l'Ordre des Homocèles	*Leucosolenia sp.*
palmate sponge	Éponge palmée	*Isodictya sp.*

Fish / Poissons

English	Français	Latin
American Eel	Anguille	*Anguilla rostrata*
American Plaice	Plie canadienne	*Hippoglossoides platessoides*
American Sand Lance	Lançon d'Amérique	*Ammodytes americanus*
American Shad	Alose savoureuse	*Alosa sapidissima*
Atlantic Cod	Morue	*Gadus morhua*
Atlantic Herring	Hareng	*Clupea harengus harengus*
Atlantic Mackerel	Maquereau	*Scomber scombrus*

Atlantic Salmon	Saumon de l'Atlantique	*Salmo salar*
Atlantic Silverside	Capucette d'Atlantique	*Menidia menidia*
Atlantic Tomcod	Poulamon	*Microgadus tomcod*
Atlantic Wolfish	Loup Atlantique	*Anarhichas lupus*
Banded Killifish	Fondule barrée	*Fundulus diaphanus*
Blackspotted stickleback	Épinoche tachetée	*Gasterosteus wheatlandi*
Blueback Herring	Alose d'été	*Alosa aestivalis*
Bluefin Tuna	Thon rouge	*Thunnus Thynnus*
Brook Trout	Truite mouchetée	*Salvelinus fontinalis*
Capelin	Capelan	*Mallotus villosus*
Catfish	Poisson chat	*Ictalurus punctatus*
Cunner	Tanche-tautogue	*Tautogolabrus adspersus*
Fourspine Stickeback	Épinoche à quatre épingles	*Apeltes quadracus*
Gaspereau/Gaspereau	Gaspareau	*Alosa pseudoharengus*
Grey Sole/Witch Flounder	Plie grise	*Glyptocephalus cynoglossus*
Grubby	Chaboisseau bronzé	*Myoxocephalus aenaeus*
Lamprey	Lamproie	*Petromyzon marinus*
Longhorn Sculpin	Chaboisseau à dix-huit épines	*Myoxocephalus octodecemspinosus*
Mummichog	Choquemort	*Fundulus heteroclitus*
Ninespine Stickleback	Épinoche à neuf épines	*Pungitius pungitius*
Rainbow Smelt	Éperlan	*Osmerus mordax*
Redbreast sunfish	Crapet rouge	*Lepomis auritus*
Shorthorn Sculpin	Chaboisseau à épines courtes	*Myoxocephalus scorpius*
Slimy sculpin	Chabot visqueux	*Cottus cognatus*
Smooth Flounder	Plie lisse	*Liopsetta putnami*
Spiny Dogfish	Aiguillat commun	*Squalus acanthias*
Striped Bass	Bar rayé	*Morone saxatilis*
Threespine Stickleback	Épinoche à trios épines	*Gasterosteus aculeatus*
White hake	Merluche blanche	*Urophucis tenuis*
White Perch	Baret, bar américain	*Morone americana*
White Sucker	Meunier noir	*Catostomus commersoni*
Winter Flounder	Plie rouge	*Pseudopleuronectes americanus*

Marine mammals / Mammifères marins

English	**Français**	**Latin**
Atlantic white-sided dolphin	Dauphins à flancs blancs	*Leucopleurus acutus*
Grey seal	Phoques gris	*Halichoeus grypus*
Harbour porpoise	Marsouin commun	*Phocoena phocoena*
Mink whale	Petit rorqual	*Balaenoptera acutorostrata*

Marine Reptiles / Reptiles marins

English	**Français**	**Latin**

Leatherback turtle	Tortue luth	*Dermochelys coriacea*

Molluscs / Mollusques

English	**Français**	**Latin**
American Oyster	Huître américaine	*Crassostrea virginica*
Quahaug	Palourde	*Mercenaria mercenaria*
Blue Mussel	Moule bleue	*Mytilus edulis*
Common Northern Moon Shell/Moon Snail	Lunatie sp.	*Lunatia heros*
Common Periwinkle	Bigorneau	*Littorina littorea*
Razor Clam	Couteau	*Ensis directus*
Ribbed Mussel	Moule striée	*Modiolus demissus*
Rough Periwinkle	Littorine rugueuse	*Littorina saxatilus*
Sea scallop	Pétoncle géan	*Placopecten magellanicus*
Smooth Periwinkle	Littorine lisse	*Littorina obtusata*
Soft-shell Clam	Mye	*Mya arenaria*
Spotted Northern Moon Shell	Lunatie sp.	*Lunatia triseriata*
Surf Clam	Mactre d'Amérique	*Spisula solidissima*

Plants / Plantes

English	**Français**	**Latin**
Common southern kelp	Laminaire sp.	*Laminaria agardhii*
Ditch-grass/Widgeon-grass	Ruppie	*Ruppia maritima*
Dulse	Dulse	*Palmaria palmata*
Edible Kelp/Alaria Kelp	Alarie	*Alaria esculenta*
Eelgrass	Zostère	*Zostera marina*
Freshwater Cord-grass/Slough Grass	Spartine pectinée	*Spartina pectinata*
Green fleece	Codium	*Codium fragile*
Hollow green weed	Entéromorphe intestinal	*Enteromorpha intestinalis*
Horsetail Kelp	Laminaire digitée	*Laminaria digitata*
Irish Moss	Mousse irlandaise	*Chondrus crispus*
Long-stemmed Kelp	Laminaire à long stipe	*Laminaria longicruris*
Marsh Cinquefoil	Potentille palustre	*Potentilla palustris*
Marsh Marigold	Bouton d'or	*Caltha palustris*
Red Fescue	Fétuque rouge	*Festuca rubra*
Rockweeds	Fucus	*Fucus sp.*
Rush	Jonc	*Juncus sp.*
Salt-marsh Bulrush	Scirpe maritime	*Scirpus maritimus*
Salt-meadow Grass	Spartine étalée	*Spartina patens*
Salt-water Cord-grass	Spartine alterniflore	*Spartina alterniflora*
Sea Lettuce	Laitue de mer	*Ulva lactuca*

Sedges	Carex sp.	*Carex paleacea + others*
Smooth chord weed	Algue lacet	*Chorda filum*

Terrestrial fauna and flora / Faune et flore terrestre

Mammals / Mammifères

English	**Français**	**Latin**
American Marten	Martre d'Amérique	*Martes americana*
American Mink	Vison d'Amérique	*Mustela vision*
Arctic Shrew	Musaraigne arctique	*Sorex arcticus maritimensis*
Beaver	Castor	*Castor canadensis*
Big Brown Bat	Grande chauve-souris brune	*Eptesicus fuscus*
Black Bear	Ours noir	*Ursus americanus*
Black Rat	Rat noir	*Rattus rattus*
Bobcat	Lynx roux	*Lynx rufus*
Common Masked Shrew	Musaraigne cendrée	*Sorex cinereus*
Common Raccoon	Raton laveur	*Procyon lotor*
Cougar	Couguar	*Puma concolor*
Deer mouse	Souris sylvestre	*Peromyscus maniculatus*
Eastern Chipmunk	Tamia rayée	*Tamias striatus*
Eastern Coyote	Coyote	*Canis latrans*
Eastern Gray Squirrel	Écureuil gris	*Sciurus carolinensis*
Fisher	Pékan	*Martes pennanti*
Gaspé Shrew	Musaraigne de Gaspé	*Sorex gaspensis*
Hoary Bat	Chauve-souris cendrée	*Lasiurus cinereus*
House Mouse	Souris commune	*Mus musculus*
Least Weasel	Belette pygmée	*Mustela nivalis*
Little Brown Bat	Petite chauve-souris brune	*Myotis lucifugus*
Long Tailed Shrew	Musaraigne longicaude	*Sorex dispar*
Long Tailed Weasel	Belette à longue queue	*Mustela frenata*
Lynx	Lynx du Canada	*Lynx canadensis*
Meadow Jumping Mouse	Souris sauteuse des champs	*Zapus hudsonius*
Meadow Vole	Campagnols des champs	*Microtus pennsylvanicus*
Moose	Orignal	*Alces alces*
Muskrat	Rat musqué	*Ondatra zibethicus*
Northern Bog Lemming	Campagnol lemming boréal	*Synaptomys borealis*
Northern Flying Squirrel	Grand Polatouche	*Glaucomys sabrinus*
Northern Long-eared Bat	Chauve-souris à longue oreille	*Myotis septentrionalis*
Porcupine	Porc-épic d'Amérique	*Erethizon dorsatum*
Pygmy Shrew	Musaraigne pygmée	*Sorex hoyi*
Red Bat	Chauve-souris rousse	*Lasiurus borealis*
Red Fox	Renard roux	*Vulpes vulpes*

Red Squirrel	Écureuil roux	*Tamiasciurus hudsonicus*
River Otter	Loutre de rivière	*Lutra canadensis*
Rock Vole	Campagnols des rochers	*Microtus chrotorrhinus*
Short-tailed Shrew	Grande musaraigne	*Blarina brevicauda*
Short-tailed Weasel; Ermine	Hermine	*Mustela erminea*
Silver Haired Bat	Chauve-souris argentée	*Lasionycteris noctivagans*
Smokey Shrew	Musaraigne fuligineuse	*Sorex fumeus*
Snowshoe Hare	Lièvre d'Amérique	*Lepus americanus*
Southern Bog Lemming	Campagnol lemming de Cooper	*Synaptomys cooperi*
Southern Flying Squirrel	Petit polatouche	*Glaucomys volans*
Southern Red-backed Vole	Campagnol à dos roux de Gapper	*Clethrionomys gapperi*
Striped Skunk	Mouffette rayée	*Mephitis mephitis*
Water Shrew	Musaraigne palustre	*Sorex palustris*
White-tailed Deer	Cerf de Virginie	*Odocoileus virginianus*
Woodchuck	Marmotte commune	*Marmota monax*
Woodland Jumping Mouse	Souris sauteuse des bois	*Napaeozapus insignis*

Reptiles / Reptiles

English	**Français**	**Latin**
Common Snapping Turtle	Chélydre serpentine	*Chelydra serpentina*
Eastern Painted Turtle	Tortue peinte	*Chrysemys picta picta*
Maritime Garter Snake	Couleuvre rayée	*Thamnophis sirtalis pallidula*
Redbelly Snake	Couleuvre à ventre rouge	*Storeria occipitomaculata*
Ringneck Snake; Northern Ringneck Snake	Couleuvre à collier	*Diadophis punctatus*
Smooth Green Snake	Couleuvre verte	*Opheodrys vernalis*
Wood Turtle	Tortue des bois	*Clemmys insculpta*

Amphibians / Amphibiens

English	**Français**	**Latin**
American Toad	Crapaud d'Amérique	*Bufo americanus*
Blue-spotted Salamander	Salamandre à points bleus	*Ambystoma laterale*
Bullfrog	Ouaouaron	*Rana catesbeiana*
Dusky Salamander	Salamandre somber du nord	*Desmognathus fuscus*
Eastern Newt; Red-spotted Newt	Triton vert	*Notophthalmus viridescens*
Four-toed Salamander	Salamandre à quatres doigts	*Hemidactylium scutatum*
Green Frog	Grenouille verte	*Rana clamitans*
Mink Frog	Grenouille du nord	*Rana septentrionalis*
Northern Leopard Frog	Grenouille léopard	*Rana pipiens*
Northern Two-lined Salamander	Salamandre à deux lignes	*Eurycea bislineata*
Pickerel Frog	Grenouille des marais	*Rana palustris*

Redback Salamander	Salamandre rayée	*Plethodon cinereus*
Spring Peeper	Rainette crucifière	*Pseudacris crucifer*
Wood Frog	Grenouille des bois	*Rana sylvatica*
Yellow-spotted Salamander	Salamandre maculée	*Ambystoma maculatum*

Birds / Oiseaux

English	**Français**	**Latin**
American Black Duck	Canard noir	*Anas rubripes*
American Crow	Corneille d'Amérique	*Corvus brachyrhynchos*
American Goldfinch	Chardonneret jaune	*Carduelis tristis*
America Kestrel	Crécerelle d'Amérique	*Falco sparverius*
American Redstart	Paruline flamboyante	*Setophaga ruticilla*
American Robin	Merle d'Amérique	*Turdus migratorius*
Bald Eagle	Pygargue à tête blanche	*Haliaeetus leucocephalus*
Bank Swallow	Hirondelle de rivage	*Riparia riparia*
Barn Swallow	Hirondelle rustique	*Hirunda rustica*
Barrow's Goldeneye	Garrot d'islande	*Bucephala islandica*
Belted Kingfisher	Martin-pêcheur d'Amérique	*Ceryle alcyon*
Blackburnian warbler	Paruline à gorge orangée	*Dendroica fusca*
Blackpoll warbler	Paruline rayée	*Dendroica striata*
Black-capped Chickadee	Mésange à tête noire	*Parus atricapillus*
Black Scoter	Macreuse à bec jaune	*Melanitta nigra*
Black-bellied Plover	Pluvier argenté	*Pluvialis squatarola*
Black-crowned Night Heron	Bihoreau à couronne noir	*Nycticorax nycticorax*
Blackpoll Warbler	Paruline rayée	*Dendroica striata*
Black-throated green warbler	Paruline à gorge noire	*Dendroica virens*
Blue-headed Vireo	Viréo à tête bleue	*Vireo solitarius*
Blue Jay	Geai bleu	*Cyanocitta cristata*
Blue-winged Teal	Sarcelle à ailes bleues	*Anas discors*
Bohemian Waxwing	Jaseur boréal	*Bombycilla garrulus*
Bonaparte's Gull	Mouette de Bonaparte	*Larus philadelphia*
Boreal Chickadee	Mésange à tête brune	*Parus hudsonicus*
Canada Goose	Bernache du Canada	*Branta canadensis*
Cedar Waxwing	Jaseur des cèdres	*Bombycilla cedrorum*
Cliff Swallow	Hirondelle à front blanc	*Petrochelidon pyrrhonota*
Common Eider	Eider à duvet	*Somateria mollissima*
Common Flicker	Pic flamboyant	*Colaptes auratus*
Common Golden Eye	Garrot à oeil d'or	*Bucephala clangula*
Common Loon	Huart à collier	*Gava immer*
Common Raven	Grand corbeau	*Corvus corax*
Common Snipe	Bécassine des marais	*Gallinago gallinago*
Common Tern	Sterne pierregarin	*Sterna hirundo*
Common Yellowthroat	Paruline masquée	*Geothlypis trichas*

Double-crested Cormorant	Cormoran à aigrettes	*Phalacrocorax auritus*
Downy Woodpecker	Pic mineur	*Picoides pubescens*
Dunlin	Bécasseau variable	*Calidris alpina*
Fox Sparrow	Bruant fauve	*Passerella iliaca*
Great Black-backed Gull	Larus marinus	*Larus marinus*
Great Blue Heron	Grand héron	*Ardea herodias*
Greater Yellowlegs	Grand chevalier	*Tringa melanoleuca*
Great horned Owl	Grand-duc d'Amérique	*Bubo virginianus*
Green-winged Teal	Sarcelle à ailes vertes	*Anas crecca*
Hairy Woodpecker	Pic chevelu	*Picoides villosus*
Harlequin Duck	Canard arlequin	*Histrionicus histrionicus*
Hermit Thrush	Grive solitaire	*Catharus guttatus*
Herring Gull	Goéland argenté	*Larus argentatus*
Horned Grebe	Grèbe cornu	*Podiceps auritus*
Hudsonian Godwit	Barge hudsonienne	*Limosa haemastica*
Least Sandpiper	Bécasseau minuscule	*Calidris minutilla*
Lesser Yellowlegs	Petit chevalier	*Tringa flavipes*
Mallard	Canard colvert	*Anas platyrhynchos*
Merlin	Faucon émerillon	*Falco columbarius*
Mourning Dove	Tourterelle triste	*Zenaida macroura*
Myrtle Warbler	Paruline à croupion jaune	*Dendroica coranata*
Northern Harrier	Busard Saint Martin	*Circus cyaneus*
Northern Pintail	Canard pilet	*Anas acuta*
Northern Shoveler	Canard souchet	*Anas clypeata*
Osprey	Balbusard	*Pandion haliaetus*
Pectoral Sandpiper	Bécsseau à poitrine cendrée	*Calidris melanotos*
Pied-billed Grebe	Brèbe à bec bigarré	*Podilymbus podiceps*
Pileated woodpecker	Grand pic	*Dryocopus pileatus*
Piping Plover	Pluvier siffleur	*Charadrius melodus*
Purple martin	Hirondelle noire	*Progne subis*
Red Knot	Bécasseau maubèche	*Calidris canutus*
Red-breasted Merganser	Bec-scie à poitrine rousse	*Mergus serrator*
Red-tailed Hawk	Buse à queue rousse	*Buteo jamaicensis*
Red-winged Blackbird	Carouge à épaulettes	*Aeglaius phoeniceus*
Ring-billed Gull	Goéland à bec cerclé	*Larus delawarensis*
Ringed Plover	Grand gravelot	*Charadrius hiaticula*
Ruby-throated Hummingbird	Colibris à gorge rubis	*Archilochus colubris*
Ruddy Turnstone	Tournepierre à collier	*Arenaria interpres*
Ruffed grouse	Gélinotte huppée	*Bonasa umbellus*
Sanderling	Bécasseau sandeling	*Calidris alba*
Savannah Sparrow	Bruant des prés	*Passerculus sandwichensis*
Semipalmated Plover	Pluvier semi-palmé	*Charadrius semiplamatus*
Semipalmated Sandpiper	Bécasseau semi-palmé	*Calidris pusilla*

Short-billed Dowitcher	Bécasseau roux	*Limnodromus griseus*
Short-eared Owl	Hibou des marais	*Asio flammeus*
Snow bunting	Bruant des neiges	*Plectrophenax nivalis*
Song Sparrow	Bruant chanteur	*Melospiza melodia*
Spotted Sandpiper	Chevalier grivelé	*Actitis macularia*
Surf Scoter	Macreuse à front blanc	*Malanitta perspicillata*
Swainson’s Thrush	Grive à dos olive	*Catharus ustulatus*
Swamp Sparrow	Bruant des marais	*Malospiza georgiana*
Tree Swallow	Hirondelle bicolore	*Tachycineta bicolor*
Veery	Grive fauve	*Catharus fuscescens*
White-rumped Sandpiper	Bécasseau à croupion blanc	*Calidris fuscicollis*
White-winged Scoter	Macreuse à ailes blanches	*Malanitta fusca*
Willet	Chevalier semipalmé	*Catoptrophorus semipalmatus*
Wood Thrush	Grive des bois	*Catharus mustelinus*
Yellow-bellied Sapsucker	Pic maculé	*Sphyrapicus varius*
Yellow Warbler	Paruline jaune	*Dendroica petechia*

Plants / Plantes

English	**Français**	**Latin**
Atlantic Listera	Listère australe	*Listera australis*
Alder	Aulne	*Alnus sp.*
American strawberry	Fraisier à vache	*Fragaria americana*
Balsam Fir	Sapin baumier	*Abies balsamea*
Beachgrass	Ammophile à ligule courte	*Ammophilia breviligulata*
Black Spruce	Épinette noire	*Picea mariana*
Boreal Felt Lichen	Érioderme boréal	*Erioderma pedicellatum*
Butternut tree	Noyer cendré	*Juglans cinerea*
Canada Fleabane	Érigéron du Canada	*Erigeron canadensis*
Eastern Hemlock	Pruche du Canada	*Tsuga canadensis*
Eastern White Cedar	Cèdre blanc	*Thuja occidentalis*
Eastern White Pine	Pin blanc	*Pinus strobus*
Golden Rod	Verges d’or	*Solidago sp.*
Gulf of St. Lawrence Aster	Aster du golfe Saint Laurent	*Symphyotrichum laurentianum*
Hare’s Tail	Linaigrette dense	*Eriophorum spissum*
Labrador Tea	Thé du Labrador	*Ledum groenlandicum*
Leatherleaf	Cassandre caliculé	*Chamaedaphne calyculata*
Orchid Family	Ochidacées	*Orchidaceae sp.*
Pale Laurel	Kalmia à feuilles d’Andromèdes	*Kalmia polifolia*
Sweet Fern	Myrice (fougère odorante)	*Myrica aspenifolia*
Red maple	Érable rouge	*Acer rubrum*
Red Spruce	Épinette rouge	*Picea rubens*
Sphagnum	Sphaigne	*Sphagnum sp.*
Sheep Laurel	Kalmia à feuilles étroites	*Kalmia angustifolia*

Tremblin Aspen	Peuplier faux-tremble	*Populus tremuloides*
Blueberry	Bleuet	*Vaccinium sp.*
White spruce	Épinette blanche	*Picea glauca*
Wrinkled Rose	Rosier rugueux	*Rosa rugosa*

Arthropods / Arthropodes

English	**Français**	**Latin**
Monarch Butterfly	Papillon monarque	*Danaus plexippus*

10.3. APPENDIX 3 : ACRONYMS

ACCDC : Atlantic Canada Conservation Data Centre

AAFC : Agriculture and Agri-food Canada

CCME : Canadian Council of Ministers of the Environment

CEAA : Canadian Environmental Assessment Act

CFIA : Canadian Food Inspection Agency

COSEWIC : The Committee on the Status of Endangered Wildlife in Canada

DAA : New Brunswick Department of Agriculture and Aquaculture (Since fall of 2006)

DAFA : New Brunswick Department of Agriculture, Fisheries and Aquaculture

DFO : Department of Fisheries and Oceans Canada

DHW : New Brunswick Department of Health and Wellness

DND : Department of National Defence

DNR : New Brunswick Department of Natural Resources

DO : Disolved oxygen

DOE : NB Department of Environment

EC : Environment Canada

ESA : Environmentally Significant Areas

FC : Feacal coliform

IC : Industry Canada

KDPC : Kent District Planning Commission

LOMA : Large Ocean Management Area

LSD : Local Service District

NRC : Natural Resources Canada

RCMP : Royal Canadian Mounted Police

PRQS : Provisional reccommendations for the quality of marine sediments

PWGSC: Public Works and Government Services Canada

REREP: Richibucto Environment and Resource Enhancement Project

SARA : Species at Risk Act

10.4. Appendix 4 : Units of measure

FC/100 ml: Feacal coliform per 100 millilitres

Km : kilometres

m : metres

m^3/s: Cubic metres per second

Mg/L : milligrams per litre: A measure of concentration equivalent to and replacing "ppm" ("parts per million") in the case of dilute solutions

MPN/100 ml : Most probable number per 100 millilitres

PPT : or ‰, Parts per thousand, used to measure the salinity of water

pH : used as a measure of the degree of acidity or alkalinity of a particular solution. Based on a scale of 0-14, a pH of 7 is neutral.

μg/L : microgram per litre. One millionth of a gram per litre

10.5. APPENDIX 5: TABLE OF METEOROLOGICAL CONDITIONS FROM 1971-2000

The minimum number of years used to calculate these Normals is indicated by a code for each element. A "+" beside an extreme date indicates that this date is the first occurrence of the extreme value. Values and dates in bold indicate all-time extremes for the location.

NOTE!! *Data used in the calculation of these Normals may be subject to further quality assurance checks. This may result in minor changes to some values presented here.*

REXTON *

NEW BRUNSWICK

Latitude: 46° 40' N Longitude: 64° 52' W Elevation: 04.60 m

Climate ID: 8104400 WMO ID: TC ID:

*** This station meets WMO standards WMO standards for temperature and precipitation.**

Temperature: Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Code
Daily Average (°C)	-9.3	-8.4	-3.0	2.9	9.9	15.8	19.3	18.6	13.6	7.6	1.6	-5.6	A
Standard Deviation	1.9	2.2	1.9	1.4	1.6	1.3	1.3	0.9	1.3	1.1	1.6	2.8	A
Daily Maximum (°C)	-3.8	-2.7	2.2	7.5	15.5	21.6	25.1	24.3	19.2	12.6	5.8	-0.9	A
Daily Minimum (°C)	-14.8	-14.1	-8.1	-1.8	4.3	9.9	13.5	12.8	8.0	2.6	-2.5	-10.3	A
Extreme Maximum (°C)	14.0	18.9	18.3	27.8	33.9	36.7	36.7	39.4	35.0	30.0	22.2	17.2	
Date (yyyy/dd)	1996/19	1943/23	1945/29	1942/24	1937/31+	1942/11	1949/30	1935/19	1942/02	1930/14+	1956/01	1966/11	
Extreme Minimum (°C)	-39.4	-36.7	-32.8	-17.2	-8.3	-2.0	1.7	-1.7	-5.6	-13.9	-21.0	-31.1	
Date (yyyy/dd)	1925/19	1934/17+	1950/04	1926/12	1972/02	1990/01	1950/07	1947/31	1947/29	1925/26	1989/30	1933/29	
Precipitation: Precipitation:													
Rainfall (mm)	37.6	25.4	42.3	63.3	95.7	81.1	107.6	85.1	95.9	99.7	86.8	53.1	A
Snowfall (cm)	64.8	54.0	58.4	23.0	0.4	0.0	0.0	0.0	0.0	1.1	14.0	49.1	A
Precipitation (mm)	102.3	79.4	100.7	86.3	96.0	81.1	107.6	85.1	95.9	100.8	100.8	102.2	A
Average Snow Depth	47	48	44	16	0	0	0	0	0	0		15	

(cm)													
Median Snow Depth (cm)	47	48	41	16	0	0	0	0	0	0		13	
Snow Depth at Month-end (cm)	39	56	30	1	0	0	0	0	0	0	4	22	D
Extreme Daily Rainfall (mm)	69.9	76.7	64.3	74.9	69.0	61.7	88.9	99.1	97.8	124.5	72.4	56.6	
Date (yyyy/dd)	1935/10	1947/05	1955/22	1962/01	2001/14	1954/23	1934/29	1924/27	1940/16	1933/25	1959/28	1937/07	
Extreme Daily Snowfall (cm)	61.0	61.0	55.0	34.0	10.2	0.0	0.0	0.0	0.0	17.8	30.5	50.8	
Date (yyyy/dd)	1956/06	1944/24+	1999/07	1997/01	1967/12	1923/01+	1923/01+	1923/01+	1923/01+	1974/20	1938/25	1967/04	
Extreme Daily Precipitation (mm)	90.2	79.2	64.3	74.9	69.0	61.7	88.9	99.1	97.8	124.5	72.4	59.2	
Date (yyyy/dd)	1935/10	1947/05	1955/22	1962/01	2001/14	1954/23	1934/29	1924/27	1940/16	1933/25	1959/28	1937/07	
Extreme Snow Depth (cm)	178.0	183.0	208.0	213.0	76.0	0.0	0.0	0.0	0.0	13.0	47.0	163.0	
Date (yyyy/dd)	1971/24+	1971/08+	1967/31	1961/01+	1961/01+	1961/01+	1961/01+	1961/01+	1961/01+	1974/20+	1989/29	1970/26+	