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ST. GEORGES BAY ECOSYSTEM PROJECT (GBEP): RESEARCH REPORT I

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By

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Davis A., L. Kellman, G. Ruseski, J. Williams, C. Cameron, S. Mitchell, C. Edwards and D. Spencer. 2000. St. Georges Bay Ecosystem Project (GBEP): Research Report I. Document prepared by the Interdisciplinary Studies in Aquatic Resources, St. Francis Xavier University, Antigonish Nova Scotia for Fisheries and Oceans Canada, Can. Manusc. Rep. Fish Aquat. Sci. 2511, 293pp + Appendix

This report presents the results of preliminary research focused on the St. Georges Bay Ecosystem, located along Nova Scotia's Northumberland Strait, in the Southern Gulf of St. Lawrence. It provides information on the geology, water quality, biology, natural history, human settlement and human use of the Antigonish, Pomquet, Tracadie, Margaree and Mabou estuaries and the coastal zone area between Pleasant Bay and Lismore, Nova Scotia. Coastal, estuarine and river fisheries, contemporary land use practices and patterns associated with the coastal zone are discussed and knowledge gaps are identified. The report serves as an inventory of resources and activities of the study area was prepared, in part, to assist in the development of an integrated approach to coastal zone management.

Résumé:

Davis A., L. Kellman, G. Ruseski, J. Williams, C. Cameron, S. Mitchell, C. Edwards and D. Spencer. 2000. St. Georges Bay Ecosystem Project (GBEP): Research Report I. Document prepared by the Interdisciplinary Studies in Aquatic Resources, St. Francis Xavier University, Antigonish Nova Scotia for Fisheries and Oceans Canada, Can. Manusc. Rep. Fish Aquat. Sci. 2511, 293pp + Appendix

Le rapport présente les résultats de la recherche préliminaire sur l'écosystème de la baie St. Georges situé le long du détroit de Northumberland qui jouxte la Nouvelle-Écosse dans le sud du golfe du Saint-Laurent. Il fournit de l'information sur la géologie, la qualité de l'eau, la biologie, l'histoire naturelle, les établissements humains et l'utilisation faite par les hommes des estuaires Antigonish, Pomquet, Tracadie, Margaree et Mabou ainsi que de la zone côtière entre Pleasant Bay et Lismore, en Nouvelle-Écosse. On y discute de la pêche pratiquée au bord des côtes, dans les estuaires et les rivières ainsi que de l'utilisation des terres et des tendances en ce sens à l'époque contemporaine, le tout en rapport avec la zone côtière, et on cerne les lacunes au niveau de la connaissance. Le rapport sert d'inventaire des ressources et des activités de la zone à l'étude et il a été préparé en partie pour aider à l'élaboration d'une approche intégrée en vue de la gestion de la zone côtière.

Acknowledgements

As with all research projects of this magnitude, achieving goals is essentially realised through the efforts and contributions of many. The diligence and shear work efforts of Senior Researchers, Caroline Cameron and Sean Mitchell, and the Research Assistants, Colin Edwards and David Spencer, have been essential to this project's undertaking and outcomes. Without question, their professionalism and willingness to put in the requisite hours are embodied in the research report. Simply put, this project would not have gotten off the ground without them. Hopefully, their recollections of completing an eight-month project within the "press" of an eight-week period will be positive.

While many have contributed to the project's goal of identifying, accessing and assembling information sources, several have substantially assisted our research processes as well as been patient with our enquiries. Among those that have been especially helpful are J. Dalziel and G. Harding at the Bedford Institute of Oceanography, T. Hurlbut with the Department of Fisheries and Oceans in Moncton, N. Burgess with the Canadian Wildlife Service, the staff in the Antigonish office of the Department of Fisheries and Oceans, S. MacDougall with the St. Francis Xavier University library.

Finally, special mention needs to be made of John A. Legault, A/ Integrated Management Coordinator, Oceans Act Coordination Office, Department of Fisheries and Oceans, Moncton. John took an early interest in the St. Georges Bay Ecosystem Project and its potential linkages with several of his mandates. Indeed, John identified the opportunity for accessing resource essential to accomplishing the work reported here. Further, he requested and received our proposals, representing them within the Department of Fisheries and Oceans. We appreciate the opportunity that this support has provided for furthering the development of the St. Georges Bay Ecosystem Project.

The research reported herein has been supported by a research contract (#F530080009) awarded by the Department of Fisheries and Oceans, Oceans Act Coordination Office.

INTRODUCTION

This report presents the preliminary outcomes of research focused on the St. Georges Bay Ecosystem that has been supported by a contract from the Department of Fisheries and Oceans, Canada Oceans Act Office (#F530080009). The research, as specified in the terms of the supporting contract, has been focused on achieving the following 'Statement of Requirement' objectives.

- Gather and assimilate available secondary information respecting the geology, water quality, biology, human settlement and human use of the Antigonish, Pomquet and Tracadie, Margaree, and Mabou estuaries and the coastal zone area between Pleasant Bay and Lismore, Nova Scotia.
- Gather and assimilate available secondary data respecting coastal, estuarine and river fisheries, e.g., alewive, eel and salmon, including sport recreational fisheries.
- Document contemporary land use practices and patterns associated with the coastal zones, estuaries and the lower reaches of the major rivers, including where possible descriptions and assessments of agricultural, industrial and settlement sourced pollutants.
- Begin the process of documenting and mapping, in collaboration with Mr. John A. Legault and Mr. Lee MacNeill of Habitat Planning and Inventory Section, DFO Moncton, local ecological knowledge and resource distribution/use within the estuaries and major rivers. Preliminary collaboration with DFO Moncton, Habitat Planning and Inventory has been developed under the auspices of St. Georges Bay Ecosystem Project (GBEP). The proposed research will provide the opportunity and resources to further develop this collaboration. More particularly, the proposed work will enable preliminary analysis, employment and mapping of information respecting the estuaries and rivers that has been gathered by Habitat Planning and Inventory, information on local knowledge and use that has yet to be incorporated in understandings of the St. Georges Bay ecosystem.

A central goal of this research has been to begin the work of developing relations with and the participation of First Nations in GBEP. First Nations' on-going use of rivers and estuaries in the GBEP area, e.g., eel and salmon harvesting, will serve as important points of reference for establishing working relationships and partnerships. We intend to document the characteristics of native fishing interactions, to begin the process of documenting First Nation ecological knowledge respecting the rivers, estuaries and St. Georges Bay, and to develop the ways and means whereby First Nations will join GBEP as full partners. Preliminary steps towards building working relations between GBEP and the Mi'kmaq Fish and Wildlife Commission have been initiated.

It is critical to emphasize that the contracted research, as specified above, has been targeted primarily on gathering and assimilating diverse bodies of *existing information* respecting the biotic and abiotic characteristics of the St. Georges Bay Ecosystem. This step is critical to the development of a 'current knowledge' understanding of the St. Georges Bay Ecosystem, as well as to developing a precise understanding of gaps in existing knowledge and the research endeavors necessary to filling in the picture. This focus has shaped the research outcomes and deliverables, as these are specified in the contract's 'Statement of Requirement'.

Outcomes and Deliverables

The contract's 'Statement of Requirement' specifies that the Outcomes and Deliverables will be the following.

"The proposed research will enable information and data respecting estuaries and rivers/watersheds to be integrated into the St. Georges Bay Ecosystem Project data base and model. This will constitute an important contribution to the capacity of GBEP to assist in the development of an integrated approach to coastal zone management. A developed understanding of the St. Georges Bay Ecosystem requires that the biological, physical, and socio-economic place and characteristics of the Bay's coastal zone, estuarine and watershed dynamics be incorporated, particularly given the biological nursery roles associated with these dimensions of the ecosystem. Certainly, a thorough understanding of these systems would be critical to the development and assessment of alternative strategies within an integrated coastal zone management approach. For example, such an understanding would be essential to assessing the practicality, necessity and locations of local *marine reserves and marine protected areas*

Specifically, the immediate outcomes from the research will be:

- A project report which will contain a review of existing knowledge respecting biological, physical, water quality, and human use attributes of the coastal zone, estuaries and major river systems between Lismore, Pictou County and Pleasant Bay, Inverness County, Nova Scotia. .
- Initial results of efforts to map local ecological knowledge of the coastal zone, estuaries and river systems, as well as associated human resource and land use patterns.
- Addition of coastal zone, estuarine and watershed information, data and summary reports to the GBEP website.
- A one day workshop which will consider the project's results, integrate the results into the GBEP conceptual and informational framework, and develop recommendations respecting the areas requiring further inquiry, particularly primary research."

At this juncture, it is necessary to emphasise that the research team has worked within a very restrictive timeframe. In large measure the limitations imposed have arisen directly from the process whereby the contract in support of this research was made available. The research project was conceived to be an eight-month project, but conditions of the contract provided a timeframe of six weeks. Nonetheless, the core goals and deliverables of this research are being achieved. This was fully evident when the material and outcomes were presented in the one-day workshop held in April, 1999.

Background and Context

Interdisciplinary Studies in Aquatic Resources (ISAR) at St. Francis Xavier University has facilitated over the last year the development of a collaborative study of the St. Georges Bay Ecosystem. The collaborators in this study include every Native and commercial marine harvester organization with members fishing in St. Georges Bay and its environs, Department of Fisheries and Oceans, Maritime Regions Fisheries Science Branch, Gulf Region, and various social and natural science research expertise affiliated with ISAR as faculty with St. Francis Xavier University. For several functional purposes, and on the basis of current understandings, the St. Georges Bay Ecosystem has been operationally conceptualized as the physical, biological and socio-economic processes focused within a geographical zone. This zone is defined on its northern perimeter by a line arcing from just below Lismore, Pictou County to a point just above Finlay Point, Inverness County, and encompassing the body of water referred to as St. Georges Bay, including all of the Bay's associated estuaries and watersheds. For the purposes of this research, the catchment area of the unit of study has been expanded to include coastal zones and estuaries between Finlay Point and Pleasant Bay, Inverness County, Nova Scotia.

Titled 'The St. Georges Bay Ecosystem Project (GBEP)', among the goals of this collaborative endeavor are:

- Developing collaborative and inclusive relations between marine harvesters, DFO science, and StFXU/ISAR affiliated researchers focused on developing studies of mutual interest that will contribute directly to a system of integrated coastal zone management.
- Facilitating harvester and scientist interactions whereby resource issues of concern to harvesters are incorporated directly into the design and conduct of research.
- Facilitating harvester access to and knowledge respecting fisheries science.

- Facilitating scientist access to and knowledge of harvester concerns and ecological understandings.
- Developing a case study illustration of the strengths of collaborative approaches to the development of an inclusive and integrated system of coastal zone management.
- Description of Bay focused fisheries, including longitudinal profiles of harvesting targeted on the major species (e.g., lobster, hake, herring, winter flounder, plaice and cod), distribution of fishing capacity and effort by major fishing ports, and fishing technologies associated with targeted resource extraction.
- Assemblage of the major bodies of information, data, published material regarding the geology, oceanography, marine biology, ecology, fisheries, human occupation, and use.
- Employing these materials, construction of a dynamic, though preliminary, ecological model of the St. Georges Bay system.
- Documenting the characteristics and employment of marine harvesters' ecological knowledge.
- Employing mapping techniques to describe the dynamics of fishing effort and technology interactions with targeted species within the Bay ecosystem.

GBEP is ambitious in its scope and goals, an approach the collaborators think essential to developing and implementing realistic and effective alternative approaches to fisheries and coastal zone management. To foster the goals of inclusivity and dynamic participation from the outset, ISAR and StFXU have enabled the development of the St. Georges Bay Ecosystem Project website and listserv (www.stfx.ca/people/gbayesp). The intention is to foster and broaden harvester access to and participation in GBEP through mobilising employment of community-based web access resources such as those developed through the Province of Nova Scotia's Community Access Programme (CAP). CAP sites are situated in a large number of the communities ringing St. Georges Bay and falling with the GBEP study area.

Finally, one of the major end purposes of GBEP is to assemble research results, both existing material as well as the outcomes from new work, that will allow for the development of a working ecosystem model of the St. Georges Bay system. It is anticipated that development of this model will enable marine resource harvesters to participate directly in resource management initiatives and practices through examining 'what if' scenarios. For instance, a working ecosystem model would allow marine harvesters, as well as fisheries managers, to work collegially in examining implications of increasing or decreasing effort in particular fisheries or of implementing alternative management initiatives such as marine protected areas and fishing exclusion zones. ISAR-linked staff and researchers have facilitated GBEP, in large measure, with this outcome in mind. The work support by this research contract is contributing substantially to the achievement of this outcome.

A. ENVIRONMENTAL CONDITIONS

A.1 STUDY AREA

The St. Georges Bay Ecosystem Project study area extends from Lismore, Nova Scotia (Lat. 45° 42.5'N Long., 62° 16.4'W) northeast to Pleasant Bay, Cape Breton (Lat. 46° 49.8'N, Long. 48.00°W) (Figure A.1-1). The study area extends offshore to a line between these two points and inland to the height-of-land between watersheds flowing west (inside of study area) and east (outside of study area). This area encompasses approximately 7,225 km^2 (722,500 ha), of which an estimated 4,600 km^2 (64%) is land mass with the remainder (2,625 km^2) being marine waters. Included within the area are the counties of Inverness, Antigonish and a sliver of the eastern edge of Pictou County.

St. Georges Bay is roughly square in shape with estimated dimensions of 30 km by 30 km, a mean depth of 30 m and maximum depth of 40 m (Petrie and Drinkwater, 1978a). Surface area is estimated at between 940 km^2 (Prouse and Hargrave, 1977) and 1160.5 km^2 (Harding et al., 1979; Kenchington, 1980). Freshwater input to the bay through land drainage is estimated at an annual average of 37 m^3/s with a maximum of 114 m^3/s (Petrie and Drinkwater, 1978a). Spring tidal range for the bay is typically 1.4 m and the tides have a marked diurnal irregularity (Drinkwater, 1979).

In 1954 the Canso causeway was completed linking Nova Scotia and Cape Breton Island. This structure impeded drainage of St. Georges Bay via the Canso Strait and allowed easier access to the island, resulting in changed land use intensity.

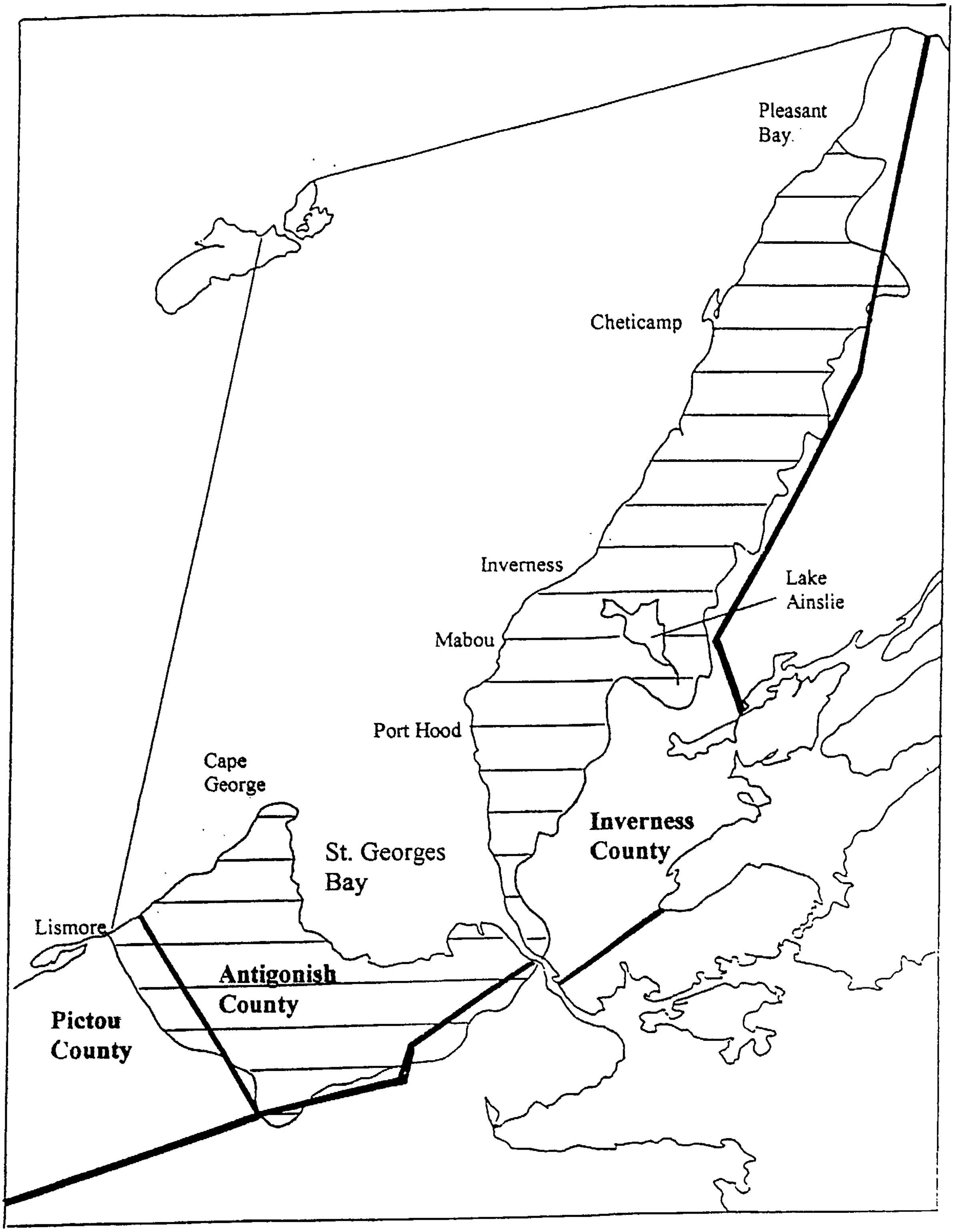


Figure A.1-1: St. Georges Bay Ecosystem project study area (hatched area). Dark lines represent county boundaries.

A.2 CLIMATE

The climate in the study area is representative of two ecoclimatic regions; the Antigonish/Pictou areas are within the Atlantic High Cool Temperate Ecoclimatic Region and the Inverness County area is part of the Transitional Low Boreal Ecoclimatic Region (Anonymous, 1989a). These areas are characterized by warm summers and winters that are typically mild and snowy. Mean summer temperatures range around approximately 18°C and mean winter temperatures –5 to –7°C (Anonymous, 1989a). These generalizations must be tempered, however, as O'Neill (1979) reports historical trends in the Atlantic region including a 0.5°C decrease in mean annual temperature since the mid 1950's and a slight increase in the precipitation index of about 7% between 1944 and 1979. Between 1874 and the present 23 weather stations have been in operation within the study area boundaries (Table A.2-1). Currently there are six in operation.

Thirty year climate Normals are used to describe the local climate. Normals from 1951 to 1980 (number of stations = 11) are used as well as the 1961-1990 data (number of stations = 5) in order to increase the sample size. There is an overlap of twenty years (1961-1980) between the two datasets and so they are not independent. Based on 30 year climate Normals of the area for 1951 to 1980 and 1961-1990 (Anonymous, 1982a, 1993) mean annual daily air temperature within the study area is between 5.2 and 6.3 °C (n=10 stations) with the coldest winter mean monthly temperature occurring in February with values of –6.1 to –7.6 °C between 1951 and 1980, and –5.8 to –10.5 °C between 1961 and 1990. Summer mean monthly temperatures occur in July and range between 17.4 and 18.6°C within this area. Figure A.2-1 illustrates air temperature and precipitation Normals for 1951-1980 at the April Brook station. This station was chosen for illustration due to its central location within the study area; the values associated with it are not intended to be representative of the entire area which will have a diverse array of weather due to local and microclimatic influences.

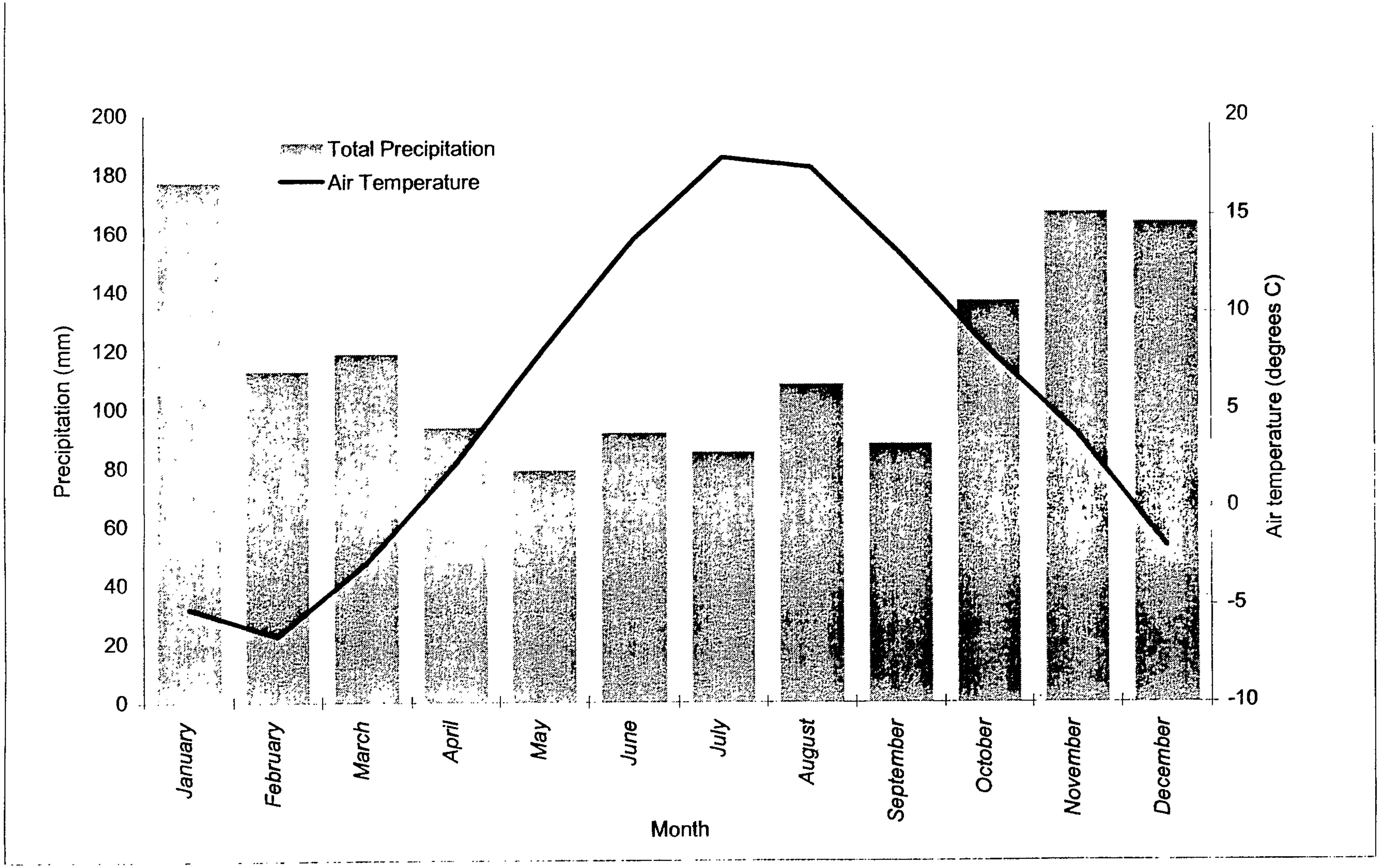


Figure A.2-1: Mean air temperature and precipitation at April Brook (Station No. 8200155), 1951-1980

Table A.2-1: Weather stations within St. Georges Bay Ecosystem Project study area.

Name	Station ID	Lat/Long	Elevation (m)	Years of record
Antigonish	8200150	45°38' / 61°58'	9	1885-1947
Antigonish	8200151	45°37' / 61°59'	31	1979-1982
April Brook	8200155	46°14' / 61°8'	61	1966-1976
Barrie Brook	8200400	45°39' / 61°26'	11	1950-1972
Black River	8200584	46°8' / 61°20'	107	1973-1975
Cheticamp	8200824	46°38' / 61°3'	335	1935-1945
Cheticamp	8200825	46°39' / 60°57'	11	1956-present
Copper Lake	8201100	45°23' / 61°58'	97	1945-1974
Frizzleton	8201900	46°22' / 60°58'	Not provided	1916-1953
Glenora Falls	8201950	46°7' / 61°22'	76	1954-1961
Inverness	8202550	46°14' / 61°18'	39	1971-1991
Mabou	8203249	46°4' / 61°23'	32	1986-present
Margaree Forks	8203422	46°22' / 61°5'	15	1960-1975
Margaree Forks	8203423	46°20' / 61°6'	23	1976-present
Margaree Harbour	8203425	46°26' / 61°6'	6	1958-1971
Northeast Margaree	8204150	46°20' / 60°58'	84	1955-1974
Northeast Margaree	8204151	46°21' / 61°0'	31	1958-1987
Pleasant Bay Grand Anse	8204450	46°49' / 60°46'	30	1955-present
Point Edward	8204455	46°9' / 60°14'	15	1966-1969
Port Hastings	8204480	45°38' / 61°24'	23	1874-1989
Port Hood	8204500	45°59' / 61°32'	52	1950-present
South Highlands	8205180	46°10' / 61°23'	320	1958-1962
Sugar Camp Brook	8205623	45°42' / 61°19'	31	1988-present

Annual rainfall in the study area ranges between 852.9 mm and 1,269.8 mm (n=11 stations) and annual snowfall from 169.7 to 411.9 cm. The number of days with measurable rainfall are between 88 and 135 per year, days with snowfall between 20 and 78 days, and days with some form of precipitation 110 to 200. Wind speed and direction over relatively long time periods (i.e., to construct 30 year climate Normals) are only known for three stations within, or near to, the area of interest. Results indicate that at April Brook the prevailing winds are from the southwest (240°) at a mean velocity of 7 km/hr and a mean monthly range of 5.5 to 8.1 km/hr (Anonymous, 1982b). In the Copper Lake area the prevailing winds are westerly-northwesterly (280 – 300°) at a mean velocity of 11.1-14.0 km/hr and a range of 8.2 to 17.5 km/hr. At Port Hastings winds are westerlies (270^{o}) with a mean velocity of 18.3 km/hr and a range of mean monthly values of 11.2 to 24.8 km/hr.

Ice formation in St. Georges Bay and the surrounding areas for the time between 1963 and 1997 has been summarized as part of a larger data compilation by Drinkwater et al. (1999). On average ice formation in the study area begins between January 1st and 30th, though has been recorded as early as December 15th (1977) and as late as March 16th (1969). The ice remains, on average, 80 to 100 days, ranging from <20 days (1969) to > 140 days (1972) and the timing of removal of last ice is on average around April 15th but has been noted at March 1st (1981) to May 30th (1967). The ice forms eastward out of Northumberland Strait and so forms first in the west of the study area (St. Georges Bay) and proceeds eastward up the coast of Cape Breton. In the spring it then retreats in the opposite direction. This results in the St. Georges Bay area having longer duration of ice cover than Cape Breton each year.

O'Neill (1979) suggested that construction of the Canso Causeway in 1954 may have resulted in a substantial change in the distribution of sea ice along the Nova Scotia coast by eliminating movement of ice through the Strait of Canso from the Gulf of St. Lawrence to the Atlantic. This may be so, with the causeway leading to more frequent ice free conditions in Chedabucto Bay on the eastern coast of Nova Scotia. However, he also states that St. Georges Bay was usually filled with pack ice by mid-January. The timing of this ice formation appears not to have been significantly altered. The causeway does not appear to have significantly affected ice formation on the western side of the Strait.

A.3 GEOLOGY

A.3.1 Bedrock Geology

The bedrock geology of the study area includes large areas of Carboniferous sedimentary rock, approximately 300 million years old, and metamorphic basement rock complex, 400 or more million years old. Igneous bodies are also present in smaller areas associated with the larger metamorphic bodies. These bodies are represented in Figure A.3-1.

Geologists do not agree on the details of events that produced the geological features of the study area, however, Table A.3-1 provides a general outline of events.

Table A.3-1: Geological events significant to study area (m.y. = millions years).

Geological activity	Years before present	Resulting geological features
Formation of metamorphic basement rock	Previous to 900 m.y.	Quartzite, schist, gneiss, gabbro
Volcanic Activity	900-400 m.y.	Formation of igneous bodies
Acadian Orogeny – mountain building event caused by colliding continents	360 m.y.	Uplifting of igneous and metamorphic rock. Erosion and sedimentation creating sedimentary Horton Group - sandstone, shale, conglomerate
Dry climate, successive flooding and evaporation of marine waters, erosion	340 m.y.	Deposition of very erodable Windsor Group. Limestone, gypsum, salts, anhydrite, mudstone, and sandstone
Wet climate, proliferation of plant life	350-310 m.y.	Deposition of organic material. Coals, Riversdale and CansoGroups
Wisconsin Glaciation	75,000-10,000 years	Scouring of highlands and deposition of glacial till in lowlands
Post-glacial sea rise	10,000 to present	Reduced grade at river mouths, increased sedimentation, bar formation and resulting formation of estuaries

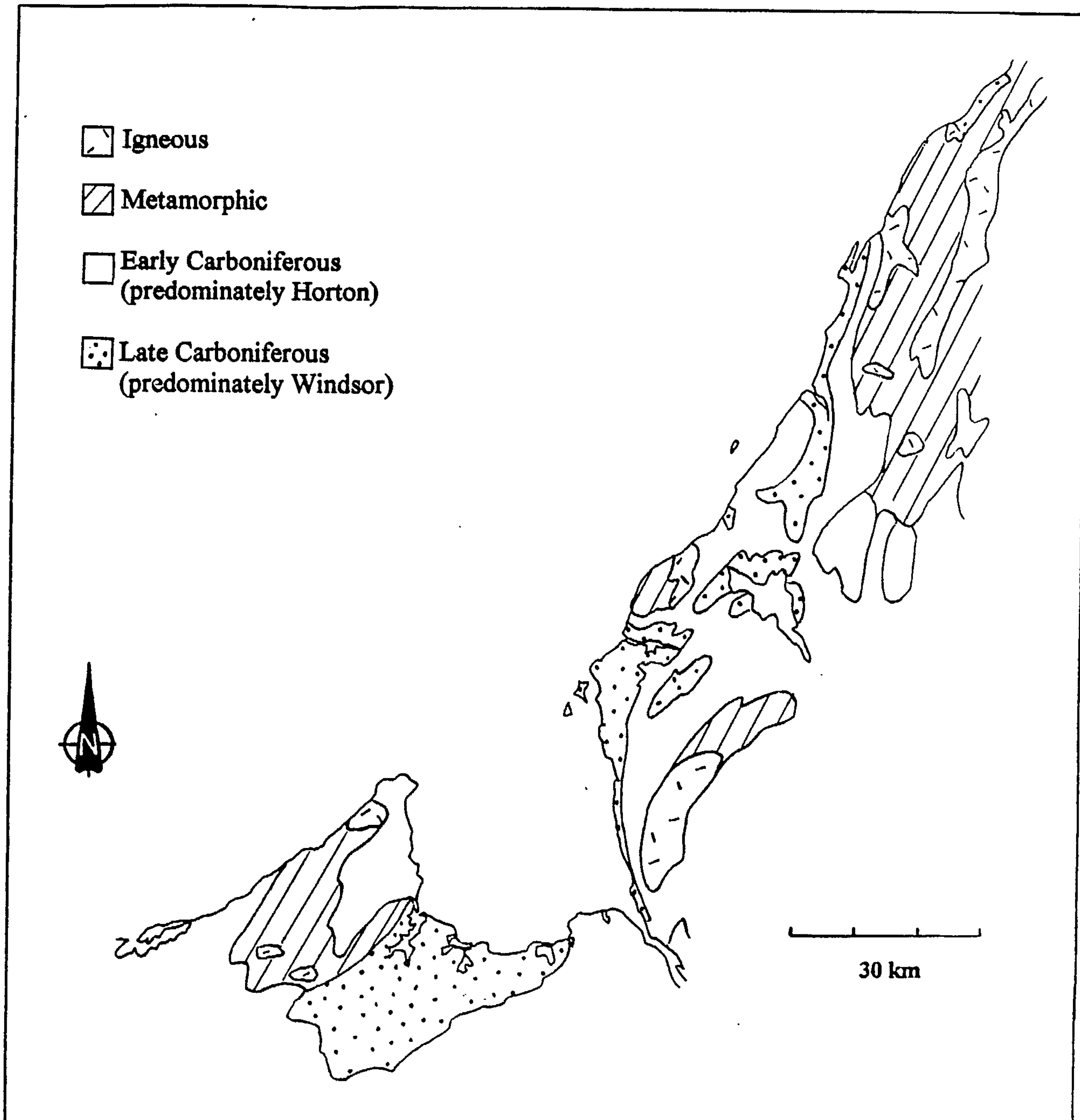


Figure A.3-1: Geological bodies within the study area

A.3.2 Structure/ Topography

The upland regions of the Pictou-Antigonish Highlands and Cape Breton Island are comprised of the older basement rock complex uplifted by the Acadian Orogeny, while the lowland basin between these areas is made up of the younger sedimentary rocks deposited from the erosion of bedrock and precipitated minerals of marine waters. The Pictou-Antigonish Highlands form a rough triangle with side-lengths of about 50 km and with its apex at Arisaig. The larger Cape Breton Highlands formation form most of northern and eastern Cape Breton. Much smaller upland regions of the same older basement rock comprise the tip of Cape George, the Mabou Highlands, and the Creignish Hills within the study area.

Windsor and Canso groups form the lowlands, which are "characterized by an undulating surface and well dissected by streams. Where gypsum and limestone underlie the surface, sink holes, ponds and depressions give the topography a mounded appearance" (Cann and Hilchey, 1954), known as karst topography. Elevation of these lowlands do not reach above 150 m (Anonymous, 1986).

Horton rock, being uplifted with the older rock upon which it was deposited and also less resistant to erosion than Windsor, contributes to higher elevations in the study area. It forms the foothills and slopes of the metamorphic/igneous highlands generally comprising elevations below 200 m. The Pictou-Antigonish Highlands, composed of Precambrian rock of the Georgeville group, (Murphy et al., 1991) have an average elevation of 210 to 245 m with numerous peaks above 300 m. The Cape Breton Highlands reach 530 m. These upland surfaces of the highlands are plains fairly well defined and deeply dissected by numerous streams (Cann and Hilchey, 1954).

A.3.3 Submarine Geology

St. Georges Bay is the central part of the overall basin of the Antigonish/Judique Lowlands, simply carved from the same Carboniferous strata of which the surrounding dry lowlands are comprised (Rolands, 1982). These strata are folded in broad open synclines and narrow, tightly folded or faulted anticlines (Durling et al., 1995). These faults and folds generally run along the southwest-northeast axis that is reflected in the province's axis. The geology of these Carboniferous strata is separated from that of the Magdalen Basin to the north by the Hollow Fault. This feature runs northeasterly from New Glasgow, forming the northwestern perimeter of the Antigonish-Pictou Highlands, below the Northumberland Strait and again onshore south of the Mabou Highlands (Durling et al., 1995). The Magdelan Basin is composed of Carboniferous and Permian rock formed above sea level, forming a broad shallow shelf along the western coast of Cape Breton which is eroded in the north to form the Cape Breton Channel (Roland, 1982).

A.3.4 Surficial Geology

Patterns of surficial geology are generally the result of redistribution of surface materials by the most recent glacial event, Wisconsin Glaciation, beginning 75,000 years ago and ending between 12,000 to 10,000 years ago in Nova Scotia (Davis and Browne, 1996). The result has been the removal of much of the materials from the plateaus of the highlands, leaving only a thin layer of materials upon which soils would subsequently develop. It is thought that some unusually thick soils on the highlands persisted because of protection by overlying glaciers (Davis and Browne, 1996). The surficial geology of the lowlands is predominantly glacial advance deposits of stony to silty till, of 2 to 25 m in thickness. One glacial deposit, a hummocky ridge, pre-empted the drainage of the interior of Inverness County, causing the formation of Lake Ainslie and causing the lake to drain in a circuitous route to the north (Donohoe and Grantham, 1989). Post-glacial alluvial deposits exist along most rivers (Stea et al., 1992).

Glaciofluvial deposits consisting of mixed sand and gravel in the form of kames, eskers and outwash plains, are found on valley floors and particularly along the western foot of the Cape Breton Highlands. The slopes and valleys of the highlands are largely covered with post-glacial colluvial deposits; mixtures of glacial deposits and weathered and frost shattered rock and soil (Stea et al., 1992).

A.3.5 Formation of Commercial Deposits

An excellent general overview of the formation of Nova Scotia's coal and gypsum resources is given by Calder et al. (1993) from which the following is excerpted.

> "The coals of Nova Scotia are not all of the same age. A few thin coals occur in the Late Devonian and Early Carboniferous rocks, termed the Horton Group, that represent some of the earliest sediments to enter the basins of northern Nova Scotia. Conditions for peat accumulation virtually ceased about 330 million years ago during the Early Carboniferous as a sea developed throughout most of the basins. Nova Scotia's salt and gypsum deposits, the Windsor Group, formed as the sea waters evaporated. By the Late Carboniferous Period, the sea had retreated and the climate had become more humid as the continents drifted ever so slowly northward across the equator. The climate, the tropical position of the continents, and the landscape of Northern Nova Scotia combined to set the stage for the development of extensive peat (coal) deposits. The earliest coals to develop in this, the true Coal Age, were those of the Cumberland Basin (Joggins and Springhill coalfields), Port Hood, and St. Rose-Chimney Corner coalfields. Favourable sites for peat accumulation changed as geological forces shaped the basins and the coals of the Debert-Kemptown coalfield and Stellarton Basin (Pictou Coalfield) were deposited later. Widespread peat forming conditions developed near the end of the Late Carboniferous when the coals of the Sydney Basin and Gulf of St. Lawrence basin (Mabou-Inverness coalfield) formed."

A.4 OCEANOGRAPHY

A.4.1 Bathymetry and Seafloor Composition

St. Georges Bay and the coastline along the western edge of Cape Breton are part of the Magdalen Shelf and are bounded to the west by the Cape Breton Trough (Loring and Nota, 1973). Water depths within St. Georges Bay are shallow (less than 40 m) while farther up the coast, near Cheticamp and Pleasant Bay, depths are greater (50-60 m). The Cape Breton Trough deepens from 18 m at the western end of the study area to 140 m at the eastern (Loring and Nota, 1973). The morphology of the Gulf of St. Lawrence, including the study area, results from glacial action during the last glacial advance and retreat. Observed submarine morphologies (i.e., branching patterns and structures of troughs and shelves) are consistent with fluvial and glaciofluvial processes rather than marine action (Krank, 1971; Loring and Nota, 1973). Prior to the last glaciation [Wisconsin] a river flowed southwest through the Strait of Canso, and tributary valleys can be traced from it to the rivers flowing out of the highlands around the bay (Kranck, 1972). During glaciation the sea level was at a considerably lower extent and the areas that presently form the Gulf of St. Lawrence were terrestrial and so morphology was dictated by atmospheric and terrestrial weathering processes. This lower sea level also resulted in an isthmus between Nova Scotia and Prince Edward Island which affected the water flow through the area. The present circulation pattern (see Section A.4.2) was not formed until the isthmus was breached approximately 5,000 years ago (Kranck, 1972). Since the recession of the glaciers, sea level has been a function of rising ocean levels due to melting ice and isostatic rebound of the earth's crust as the weight of the ice was removed. Estimates of sea level rise are approximately 25 cm per century (Farquerson, 1959 cited in Kranck, 1972).

Seafloor sediment composition has been reported in the St. Georges Bay area by Krank (1971) and Loring and Nota (1973). The following description is generalized from these publications. Bottom sediments of the coast from Lismore to St. Georges Bay are mixtures of sands and gravels including pelites (material <5μm), pebbles, cobbles, blocks and boulders. The thickness of sediment varies from less than 1 m to 10-15 m thick. In general, this deposit (termed *Buctouche sand and gravel* in Krank, 1971) is found in areas of strong currents, with an average maximum tidal current greater than 0.5 knots [26 cm/s] (Krank, 1971). This deposit is what has remained after the smaller materials (silts and clays) had been removed as the sea level dropped and the waterline moved down the beach to lower elevations. These finer material, the silts and clays, were deposited further offshore.

Within St. Georges Bay proper, the eastern, southern and western nearshore areas are basically of the same composition as that described for Lismore to St. Georges Bay (i.e., Buctouche sand and gravel). In the central area of the bay there is intrusions of finer sediments from Northumberland Strait. These sediments are largely (>30%) pelite with median particle diameters on the order of 0.01-0.02 mm. These *Pugwash muds* (terminology from Krank, 1971) conform to areas of low tidal current speeds (<0.5 knots [<26 cm/s]). In addition, Krank (1971) recognizes large areas within the bay of mixed bottom, areas that are not dominated by any particular sediment classification. The primary sources of these new fine grained sediments to St. Georges Bay are the river and shoreline erosion of the adjacent landmasses.

Sediment composition along the Cape Breton shores, from St. Georges Bay to Pleasant Bay, is composed of very sandy fines [pelites] along the northern edge of St. Georges Bay and Port Hood and fine sands in the offshore areas from Port Hood to Pleasant Bay. The nearshore areas within this same stretch are gravelly poorly-sorted sands (from Loring and Nota, 1973). Krank (1971) maps the lower half of this section as mixed bottom consisting of small patches of thin discontinuous layers of mud deposited over older coarser sediment.

The sources of these sediments are attributed to erosion of the local landmasses (Krank, 1971; Prouse and Hargrave, 1977) and resuspension of deposited shallow water sediments by advective or turbulent near bottom flow (Hargrave, 1977; Prouse and Hargrave, 1977). Ice rafting of material and deposition is not thought to be an important sediment transport process within this area (Krank, 1971; Loring and Nota, 1973), nor is the sediment ejected by the large but distant St. Lawrence River (Sundby, 1974 cited in Schafer and Mudie, 1980).

A.4.2 Circulation

The oceanographic currents flowing within the St. Georges Bay area are initiated and influenced by discharge of the St. Lawrence River approximately 350 km to the north-northwest. Flow from the south shore of the St. Lawrence turns south to form the Gaspé Current which then flows into the south of the Gulf of St. Lawrence (Figure A.4-1). Flowing along the east coast of the Gaspé Peninsula and the northeast coast of New Brunswick, the current strikes Prince Edward Island where it splits. The larger component of the flow moves along the north shore of P.E.I. while a smaller component flows into Northumberland Strait between P.E.I. and New Brunswick, and eventually between P.E.I and Nova Scotia.

In the area of the east coast of P.E.I., where the narrowest throat of the Northumberland Strait between P.E.I. and the mainland ends, the current is flowing in an east-northeast direction and continues in this general direction following the shape of the province of Nova Scotia and Cape Breton. West of St. Georges Bay this current has been measured at between 2.7 and 5.0 cm/s with a maximum of 6.5 cm/s (Lauzier, 1965). Petrie and Drinkwater (1978b) report the current off of Cape George in the upper 20 m to be flowing northeasterly with a maximum speed of 50 cm/s and rarely dropping to less than 10-20 cm/s. Drinkwater and Taylor (1979) also recorded surface currents of 50 cm/s off of Livingstone Cove and also currents of 8 cm/s along the Cape Breton shore. Petrie and Drinkwater (1978b) also suggest a current speed of 8 cm/s along the Cape Breton shore. In addition, Lauzier (1967) examined bottom currents in the Northumberland Strait area and reports the same northeasterly drift along the Cape Breton shore; but, in general these deep current speeds are only one-tenth to one-third of surface current speeds. He reports 0.1 to 1.0 nautical miles per day [0.21 - 2.14 cm/s] to be the typical speed.

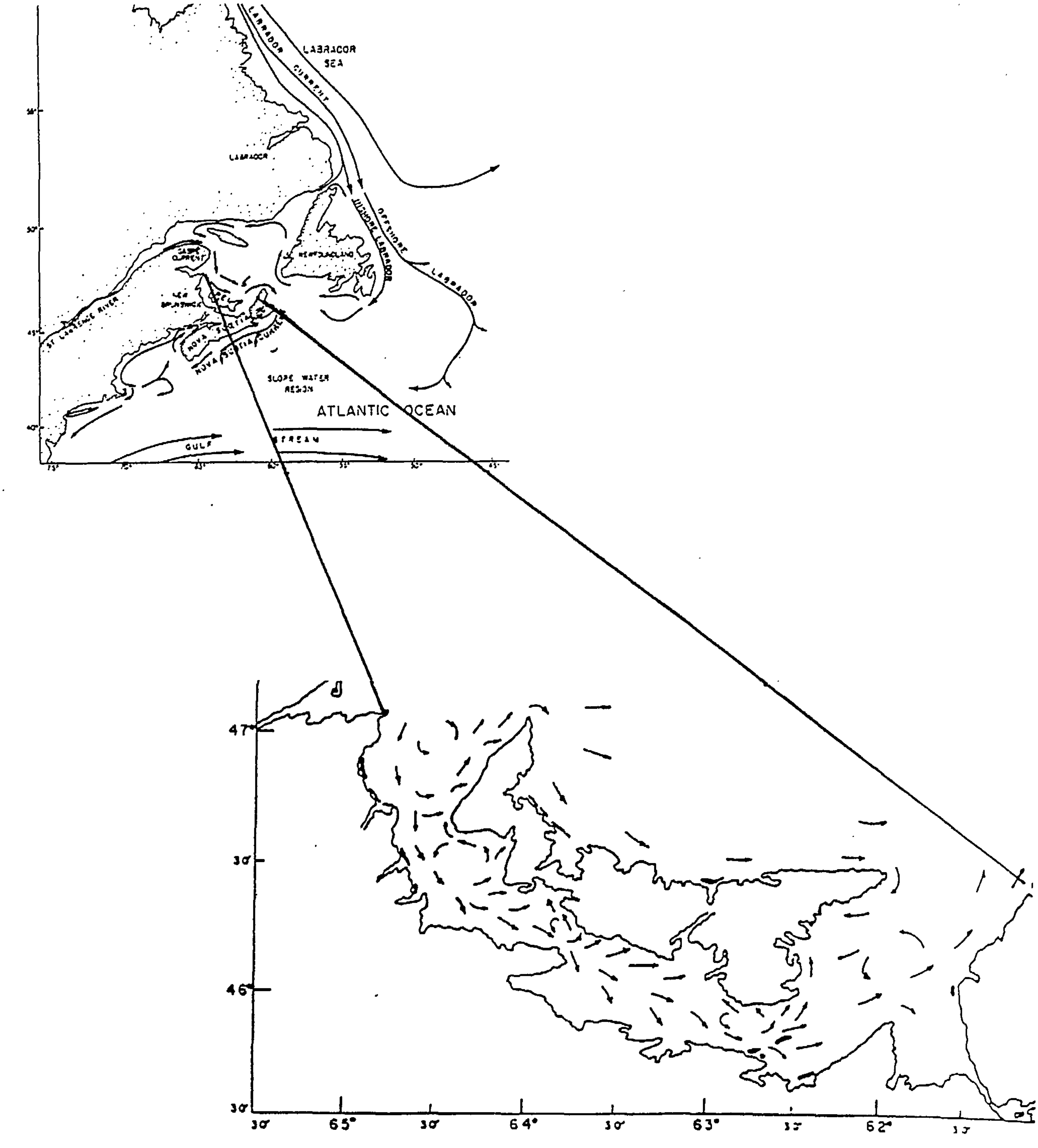


Figure A4-1: Estimated circulation patterns in the Gulf of St. Lawrence and Northumberland Strait (from Lauzier, 1965 and Sutcliffe et al., 1976)

At the mouth of St. Georges Bay the Northumberland Current flowing on to Cape Breton initiates a clockwise gyre within St. Georges Bay (Lauzier, 1965; and Figure A.4-1). Within St. Georges Bay, this clockwise circulation has a surface velocity of approximately 10 cm/s. This velocity decreases with depth – between 5.0 and 13.6 cm/s at 8 m, approximately the same at 20 m, and the gyre is non-existent at 30 m (Petrie and Drinkwater, 1978a). Flow exiting out of the bay at the mouth is estimated at less than 2 cm/s (Petrie and Drinkwater, 1978a). This gyre in St. Georges Bay is suggested to slow the dispersal of passively transported organisms such as plankton, fish eggs and larvae from within the bay to Northumberland Strait, as the organisms may be constrained within the circulation of the bay.

Prior to the construction of the Canso Causeway in 1952 - 1954 a net volume transport of between $4.26*10^3$ and $8.46*10^3$ cubic meters per second was estimated to flow through the Canso Strait (Fothergill, 1954 cited in Trites, 1979) draining out of St. Georges Bay. This is equivalent to approximately 1.4% of the volume of St. Georges Bay and it is estimated that a volume equal to the upper 25 m of the bay would have passed through the Strait in approximately 60 days (Trites, 1979). However, it is important to note that later analysis of Fothergills assessment led to the conclusion that his "[Fothergill's] empirical relationship of velocity proportional to sea level difference is suspect but it does offer first approximations as to flow in Canso Strait prior to completion of the causeway" (Drinkwater, 1979). Estimates for the present flushing time of the bay are on the order of a month when due solely to tides and currents. This schedule may be shortened to a time interval of days with the action of low frequency, high energy events, such as storms (Petrie and Drinkwater, 1978a; Drinkwater, 1979). There is no evidence that flushing time has appreciably changed even though the "drain" through Canso Strait was blocked almost 50 years ago (Trites, 1979; Drinkwater, 1979).

A.4.3 Temperature And Salinity

The following discussion of water temperature and salinity in St. Georges Bay and extending up the Cape Breton shore is based on information contained in references listed in Table A.4-1. There is an extensive body of information reporting temperature and salinity for the area. The sample provided in Table A.4-1 is thought to provide an accurate overview based on the concordance and consistency within these studies, and the time range encompassed by them.

Table A.4-1: Selected sources and sampling times of temperature and salinity data within St. Georges Bay Ecosystem project study area

Source	Sampling Dates	Temperature	Salinity
Lauzier et al., 1957	1914-1950's	X	X
Petrie & Drinkwater, 1978 a	1974-1975	X	X
Drinkwater & Taylor, 1979	1976-1977	X	X
Lambert et al. 1982a	1973-1976	X	
Drinkwater et al. 1983	1981	X	X
Drinkwater et al., 1985	1982	X	X
Swain, 1993	1971-1992	X	
Waite et al. 1997a,b,c; 1998a,b	1991-1996	X	X
Castonguay et al., 1998	1982-1991	X	X

Surface water is cold immediately after the ice leaves the area (April-May), with typical water temperatures of 3-5°C. With solar heating the surface waters warm though the year to commonly reach 18-19°C and occasionally 20°C. Lambert et al. (1982a) report that the thermal regime of St. Georges Bay is quite predictable and a generalized regime is shown in Figure A.4-2. Temperatures of deeper water (i.e., >20 m) range from lows of less than 0°C in the spring to >10°C by September/October (see also Figure A.4-2). Swain (1993) provides bottom temperatures from between 1971 and 1992 for the offshore depths of the study area. From Lismore to approximately Inverness bottom temperatures have averaged 1-10°C with a range of 0-18°C, from Inverness to Pleasant Bay bottom temperatures have averaged 0.5-5°C and ranged from –0.5 to 8°C. Swain (1993) also reports that for the Gulf of St. Lawrence as a whole, bottom temperatures

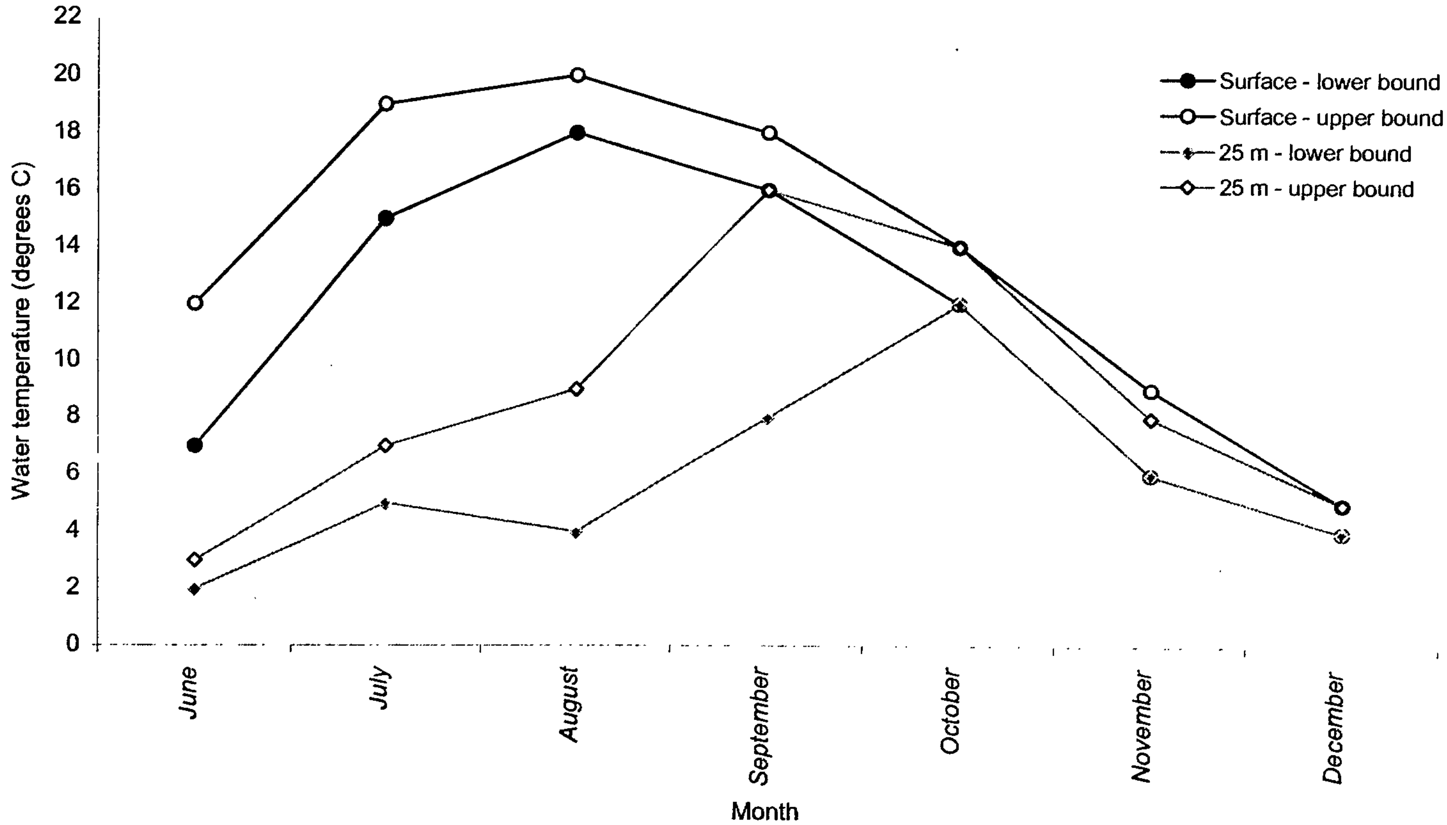


Figure A4-2: generalized thermal regime for St. Georges Bay, Nova Scotia. (Data representing 1973-1976 from Lambert et al. (1982a) and pre-1957 data from Lauzier et al., 1957) between 40-59 m tended to be fairly warm in the 1970's and relatively cold since the mid-1980's.

Due to the warming of the water through the year, some degree of thermal stratification occurs (i.e., a thermocline develops). The depth of this thermocline is generally less than 10 m through May and June, increasing to 20 m through July and August and reaching 30 m by September/October. Through the four years 1973 to 1976, Lambert et al. (1982a) estimated the mixed layer depth to increase at a rate of between 0.134 and 0.235 m/day. Within St. Georges Bay during stratification the thermocline is typically deepest in the middle of the Bay and slopes upward toward the shoreline. This morphology is consistent with the concept of the gyre of circulating water (Lambert et al., 1982a).

The waters of Northumberland Strait and St. Georges Bay are generally warmer than those farther north along the Cape Breton shore (Lauzier et al., 1957). The waters of St. Georges Bay, are, in turn, generally warmer than those of the Northumberland Strait at Livingstone Cove (Drinkwater and Taylor, 1979). Within St. Georges Bay itself, however, temperature fluctuations of up to 6°C over half a day are commonly observed (Drinkwater and Taylor, 1979), and major hydrographic "cold events" locally decreasing the surface water temperature over large areas of the Bay are reported by Lambert et al. (1982a), which they suggest are a result of wind induced upwelling and mixing.

Salinity of the surface water within the study area appears to follow a temporal pattern of high in the spring and fall and low in the summer. Spring salinities are on the order of 29.25 Practical Salinity Units (PSU), decreasing to about 28.25 though August/September then increasing back to 29-30 in the fall months. Drinkwater and Taylor (1979) suggest that this decrease in salinity in summer months may be due to the discharge from the St. Lawrence River. There is some variability between years. Castonguay et al. (1998) report a range from 28.8 to 31.2 parts per thousand (ppt) within the study area through the years 1987 to 1991. Waite et al. (1997c) report a surface salinity of 28.72 PSU (range 28.38-28.87 PSU) for St. Georges Bay in July 1996.

Salinity at depths to 30 m is generally greater than at the surface, though it usually measures as within one unit of the surface (either ppt or PSU). Salinities at depths greater than 30 m are typically equal to or greater than 30 ppt and may be up to two ppt greater than surface salinities (e.g., Waite et al., 1997c). See references from Table A.4-1 for details on salinities at depth.

A.4.4 Nutrients (Ammonia, nitrate, nitrite, phosphate, silicate)

Within the euphotic zone nutrients are reported to be in relatively uniform and low concentrations (Harrison, 1980; Hargrave et al., 1985; Harding et al., 1986). Above the bottom (i.e., below 25 m) there exists a steep concentration gradient of the nutrients ammonia, nitrate, nitrite, phosphate and silicate. The concentration increases rapidly as the bottom is approached (Hargrave and Prouse, 1981). Nutrient concentrations tend to be high from January to April, decrease and remain low until July-August, increase again until October-November, then decrease again prior to the buildup in January (Hargrave and Prouse, 1981). These changes in concentration are reflected in the primary production of the area (see Section A.4.5.1). Maximum ammonia concentrations, in excess of 5 mg/m^3, can occur in the euphotic zone in the summer. These levels are generally not normally observed in unpolluted waters (Hargrave et al., 1985). Ammonia is also thought to exceed utilization though nitrogen is also considered to be the limiting nutrient (Harrison, 1980). Nearshore concentrations of dissolved nutrients do not appear to be significantly different from offshore concentrations (Hargrave et al., 1985).

Table A.4-2 illustrates nutrient concentrations within St. Georges Bay in the 1990's. For other nutrient data see Harrison (1980), Hargrave and Prouse (1981), Hargrave et al. (1985), and Harding et al. (1987).

Table A.4-2: Ranges of nutrient concentrations through depths within St. Georges Bay.

Date	NH_3 µM	NO_2+NO_3 µM	PO_4 µM	SIO_4 µM	Source
June 20-25, 1991	0.05-1.58	0-0.13	0.19-0.39	0.65-2.48	Waite et al., 1998a
Sept. 23-25, 1991	0.16-1.24	0.01-0.49	0.21-0.52	1.76-4.44	Waite et al., 1998a
June 5-8, 1992	0.04-0.69	0.04-0.69	0.35-0.79	0.46-4.47	Waite et al., 1998b
Aug. 3-17, 1994	0.07-3.82	0.07-3.82	0.19-0.8	1.02-8.11	Waite et al., 1997a
July 8, 1995	0.04-0.91	0.04-0.91	0.21-0.66	0.61-5.55	Waite et al., 1997b
Aug. 8-15, 1995	0.21-2.13	0.21-2.13	0.12-0.94	1.01-11.05	Waite et al., 1997b
Sept. 14, 1995	0.1-0.55	0.1-0.55	0.15-0.31	0.33-2.18	Waite et al., 1997b
Oct. 19,1995	0.19-5.85	0.19-5.85	0.28-0.38	1.8-2.61	Waite et al., 1997b
July 24, 1996	0.02-2.57	0.02-2.57	0.3-2.55	0.29-14.92	Waite et al., 1997c

A.4.5 Biological Productivity

A.4.5.1 Primary Production

Chlorophyll *a* concentrations within St. Georges Bay are generally low in May (but see phytoplankton production below) and increase irregularly over the summer to peak in September-October (Prouse and Hargrave, 1980; Hargrave et al., 1985). Prouse and Hargrave (1977) report chlorophyll *a* concentrations of <1 µg/L in late May for Ballantynes Cove, increasing to 8 µg/L by early August. At the Crystal Cliffs site chlorophyll *a* reached a maximum in August of 5 µg/L. These authors also report higher concentrations of chlorophyll *a* at nearshore sites early in the season, with the between site differences declining after mid-August, leading them to suggest the presence of a nearshore chlorophyll rich cold water zone. This only lasted until the first week of August.

Table A.4-3 illustrates chlorophyll *a* concentrations within St. Georges Bay in the 1990's. For other chlorophyll data see Prouse and Hargrave (1977, 1980) and Hargrave et al. (1985).

Table A.4-3: Ranges of chlorophyll *a* concentrations through depths within St. Georges Bay.

Date	Chlor. a (μg/L)	Source
June 20-25, 1991	0.16-1.11	Waite et al., 1998a
Sept. 23-25, 1991	0.99-3.24	Waite et al., 1998a
June 5-8, 1992	0.06-1.06	Waite et al., 1998b
Aug. 3-17, 1994	0.16-1.25	Waite et al., 1997a
July 8, 1995	0.11-0.37	Waite et al., 1997b
Aug. 8-15, 1995	0.11-0.61	Waite et al., 1997b
Sept. 14, 1995	0.61-1.28	Waite et al., 1997b
Oct. 19,1995	0.86-3.02	Waite et al., 1997b
July 24, 1996	0.13-1.78	Waite et al., 1997c

Phytoplankton production is composed of a number of peaks throughout the year. The first one, in late winter (January to February) was estimated in 1977 at around 140 mg C/m^2/day (Hargrave et al., 1985). A second bloom in early Spring (April) was estimated in the same year at 371 mg C/m^2/day. This spring bloom is then thought to decrease the nutrient concentrations in the water column, leading to the observed relatively low summer primary productivity observed in the bay (Hargrave et al., 1985). As nutrients are replenished and recycled they are made available over time. This increase in nutrients by September and October corresponds to a fall phytoplankton bloom (Prouse and Hargrave, 1980). It has been suggested that pulses of phytoplankton production occur on four to five week intervals (MEL 1980). Table A.4-4 presents some results to indicate general levels of primary productivity in St. Georges Bay.

Table A.4-4: Some sample primary productivity results from St. Georges Bay.

Date	Productivity (mg C/m^2/day	Source
mid-June 1977	50-100	Prouse and Hargrave, 1980
Late-Sept. 1977	670-755	Prouse and Hargrave, 1980
Aug 19-20, 1980	455.3	Harding et al. 1987
April 28-29, 1981	411.3	Harding et al. 1987

Phytoplankton production is highest in the upper levels of the water column with estimates of 86% of the total production in the top 15 m (Hargrave et al., 1985) and 90-95% of production in the top 20 m (Hargrave and Prouse, 1981).

A.4.5.2 Secondary Production

There are three recognized peaks of zooplankton biomass in St. Georges Bay 1) early summer composed mainly of fish [mackerel] eggs, 2) mid-summer primarily composed of small copepods, and 3) late Autumn composed of large copepods, chaetognaths and medusae (Lambert, 1980). The bulk of the zooplankton is composed of copepods, with 20 species having been recorded, but the majority of the biomass being composed of six species forming four communities (Lambert, 1980; and Table A.4-5):

Table A.4-5: Zooplankton communities and dominant species through time in St. Georges Bay.

Time	**Community**	**Dominant species**
May-July	*Temora-Calanus-Tortanus*	*Temora longicornis* *Calanus finmarchius* *Tortanus discaudatus*
Aug.-Sept.	*Temora-Centropages-Tortanus*	*Temora longicornis* *Centropages hamatus* *Tortanus discaudatus*
Oct.-Nov.	*Tortanus-Centropages-Temora*	*Tortanus discaudatus* *Centropages hamatus* *Temora longicornis*
December	*Tortanus-Calanus*	*Tortanus discaudatus* *Calanus finmarchius*

Harding et al. (1980) report eight species at densities > 1 individual/m^3 (also see Table 14 in Harding et al., (1980) for breakdown of plankton by size and abundance).

These species are: *Pseudocalanus minutus, Calanus hyperboreus, Calanus finmarchius, Labidocera aestiva, Temora longicornis, Tortanus discaudatus, Centropages hamatus,* and *Acartia hudsonica.* In addition to these, Harding et al. (1986) report common species as *Evadne nordmanni, Tautogolabrus adsperus, Palaemonetes (pugio?), Podon intermedius, Sagitta elegans, Cancer irroratus* and bivalve larvae.

The trends of zooplankton biomass appears to be quite variable over the season. Lambert et al. (1982a) report the biomass peaking in June and August, with the larger peak occurring in August, between 1973 and 1976. Hargrave et al. (1985) report a decline in plankton biomass starting in mid July, coinciding with the faunal change from a cold water (and so larger bodied) community of *Calanus-Temora-Pseudocalanus* to a *Centropages-Tortanus-Acartia* community. Harding et al. (1980) report a biomass peak (over the entire size range of 25 to >2035 mm size interval) in April and a decrease through to and including August and September for 1977. Larger-bodied species appear to comprise the zooplankton during the colder months of the year and smaller species are more prevalent during the warmer periods (Lambert, 1980: Lambert et al., 1982a).

Values for biomass are reported with a range of mean values with depth from 11.3 to 47.9 mg dry wt./m^3 (April 1981) and 45 to 198 mg dry wt./m^3 (Harding et al., 1987). Sampling between 1973 and 1976 resulted in mean zooplankton values in the top 10 m of the water column of 55.9 to 99.1 mg/m^3 (range 8.0 to 294.4 mg/m^3) (Lambert et al. 1982a). Table A.4-6 presents ranges of zooplankton densities in St. Georges Bay and along the coast of Cape Breton from 1982-1991 (data from Castonguay et al., 1998).

Table A.4-6: Zooplankton densities in St. Georges Bay and along the western Cape Breton coast from 1982-1991.

Year	Zooplankton (g dry wt. m^{-2})
1982	0.19-16.06
1983	0.21-1.62
1984	0.28-2.58
1985	0.4-2.22
1986	0.65-1.92
1987	0.19-1.03
1988	0.46-2.43
1989	0.46-2.46
1990	0.26-2.04
1991	0.21-2.13

A.4.5.3 Sedimentation

Maximum sedimentation rates occur in late May and from September to late fall/early winter when the water column is nearly homogenous, and rates are least in the summer during periods of stratification (Hargrave and Prouse, 1980; Hargrave et al., 1985). Resuspension and horizontal transport contributes a great deal to the rate of sediment deposition, and it is estimated that this resuspension affects the water column to a distance 8 or 9 meters above the bed (Hargrave and Prouse, 1980; Hargrave et. al, 1985). This effect is felt more strongly in nearshore areas where storms and atmospheric events affect the water column stability and circulation to the depth of the bottom (Hargrave and Prouse, 1980). Prouse and Hargrave (1977) report maximum sedimentation rates along the western shore of St. Georges Bay in June 1976 of 2.5 mg/day (dry weight) at 20 m to 12.5 mg/day at 30 m. Other sedimentation data is provided in Table A.4-7.

In summer, when production and consumption of phytoplankton is high, the rate of organic carbon and nitrogen transferred vertically represented by the swimming zooplankton exceeds that of gravitational sedimentation (i.e., there is a net flux upward). Under isothermal conditions in the spring, organic material is sedimented out to a much greater degree than what is transferred vertically upward by the zooplankton (Harding et al., 1987). This is a consequence largely of the increased sediment due to the resuspension of bottom sediments at that time. It has been suggested that changes in the current system and possibly tidal amplitude due to causeway construction has increased sedimentation in many parts of St. Georges Bay (Moseley and MacFarlane, undated). In addition, Schafer and Mudie (1980) report on the fine sediments of two nearshore sites and suggest an increase in the influx of fine grained sediment to the bay due to deforestation and other land use practices.

Table A.4-7: Sedimentation, carbon, nitrogen, and chlorophyll *a* data for St. Georges Bay, 1976-1981.

Date	Depth (m)	Dry weight $g/m^2/d$	Carbon $mg/m^2/d$	Nitrogen $mg/m^2/d$	Chl a $mg/m^2/d$	Source
1976	8	$6.95*10^{-3}$	180.9	25.1	1.64	1
1976	11	$9.11*10^{-3}$	228.9	27.0	3.24	1
1976	13	$11.55*10^{-3}$	268.9	32.1	5.18	1
1976	20	$1.74*10^{-3}$	60.9	8.1	0.62	1
1976	25	$1.89*10^{-3}$	60.6	8.2	0.69	1
1976	30	$6.01*10^{-3}$	125.7	15.7	2.24	1
1977	14	6.26	135	19	0.55	2
1977	18	8.78	194	26.8	0.43	2
1977	20	4.46				2
1977	21	20.19	391.2	53.4	0.99	2
1977	25	4.28	99.6	13.1	0.39	2
1977	30	7.7	164.7	21.1	0.64	2
1977	32	19.1	194.6	41.6	1.11	2
1980	7	2.36	126	19		3
1980	14	3.5	173	26		3
1980	21	5.4	224	33		3
1980	28	10.6	324	49		3
1981	7	2.7	154	18		3
1981	14	5.6	279	38		3
1981	21	6.5	233	34		3
1981	28	7.1	264	40		3

Sources 1: Prouse and Hargrave (1977) samples taken June-Sept. 1976
2: Hargrave et al. (1985) samples taken April-November, 1977
3: Harding et al. (1987) samples taken August 19-20, 1980 and April 28-29, 1981

Within St Georges Bay there is tight coupling between nutrients, phytoplankton, zooplankton and fish. Hargrave et al. (1985) summarize it as:

> "Phytoplankton populations in St. Georges Bay, therefore, are partially controlled by zooplankton grazing during spring and fall but with a sufficient developmental lag on the part of their predators to enable chlorophyll and production peaks to occur. Between July and September, predators [fish and scyphomedusae] appear to contain herbivore populations such that phytoplankton production increases, resulting in the 'fall bloom'".

A.4.5.4 Algae and Macrophytes

Within the St. Georges Bay study area, Pomquet Harbour has been intensively studied with respect to algae while the rest of the area is less well known. In Pomquet Harbour Bird et al. (1976) reported 121 species of algae (39 Chlorophyceae, 32 Rhodophyceae, 44 Phaeophyceae, 5 Xanthophyceae and one Chrysophyceae). Other studies, concentrated within St. Georges Bay, report a total of 132 individual species (Table A.4-8). The sublittoral population of algae in this area is similar to Northumberland Strait (Moseley and MacFarlane, undated), in which Caddy et al. (1977) report 74 species in the Strait (43 Rhodophyceae, 27 Phaeophycea, and two each of Chlorophyceae and Cyanophyceae). The area to the north, along the Cape Breton coast, is notably under-represented in the algal literature.

One of the principal influences on shallow-water algae is the action of ice. During the spring thaw, lateral ice erosion denudes much of the littoral zone of algae but has little effect on the sublittoral (Bell and MacFarlane, 1933). Beyond the sphere of this ice action growth is luxuriant on ledges and boulders, at least to 10 m depth (MacFarlane, 1966). The vertical distribution of algae within St. Georges Bay shows a maximum density of seaweeds immediately below the lowest influence of ice, with density decreasing with depth (Moseley and MacFarlane, undated). The lower limit of algae is imposed either by absence of suitable substrate or bands of sea-urchins and mussels. Decrease in illumination is rarely a limiting factor in the vertical distribution (Moseley and MacFarlane, undated).

Table A.4-8. Reported numbers of species by Class from selected studies for the St. Georges Bay area.

Class							**Total**
Chlorophyceae	13	-	-	6	3	-	22
Phaeophyceae	28	-	8	-	6	-	42
Rhodophyceae	34	9	-	-	-	-	43
Cyanophyceae	-	-	-	-	-	25	25
Locations	1	2, 3	2, 3, 4, 5	2, 4, 5, 6, 7	2	2, 4, 5	
Source	(a)	(b)	(c)	(d)	(e)	(f)	

1= Northumberland Strait
2=Pomquet Harbour
3=Monk Head
4=Town Point
5=Crystal Cliffs
6=Monk Pond
7=Tracadie Harbour

a=Bell & MacFarlane, 1993
b=Edelstein et al., 1967
c=Edelstein & McLachlan, 1967a
d=Edelstein & McLachlan, 1967b
e=Edelstein & McLachlan, 1968
f=Bird & McLachlan, 1977

Algal species associations within St. Georges Bay are dominated by *Chondrus crispus*, *Furcellaria* and *Fucus serratus* (Moseley and MacFarlane, undated; MacFarlane, 1966) while in Northumberland Strait abundant species in the algal communities include *Phyllophora, Polysiphonia*, *Laminaria longicruris*, *Ectocarpus siliculosis*, *Desmarestia aculeata*, *Cystoclonium purpureum*, *Rhodomela confervoides*, *Fucus*, and *Rhodymenia palmata* (Caddy et al., 1977)

In addition to algae, another significant component of the marine ecology in the study area is eelgrass (*Zostera marina*). Eelgrass beds are important habitat for fish and invertebrates and an important microhabitat for epiphytic algae (Thayer et al., 1984; Harlin, 1980), and the abundance and diversity of many groups (e.g., fish, clams, amphipods) are much higher in these areas than in adjacent unvegetated areas (Schneider and Mann 1991a). In Pomquet Harbour, the eelgrass beds have been reported to contain large quantities of macroalgae (*C. crispus, Gracilaria tikvahiae, Polysiphonia urceolata, Sphaerotrichia divaricata*; Schneider and Mann, 1991b), epiphytic algae (38 species; Novaczeck, 1987) and invertebrate herbivores (Novaczeck, 1987). Through its growth and "erosion" the plant makes an important contribution to the flux of nutrients in temperate shallow-water areas (Thayer et. al, 1975). Within St. Georges Bay 'ice-rafting', the freezing of the eelgrass to the ice and being transported subsequently to ice break-up, has been documented (Schneider and Mann, 1991a), dispersing the plant, nutrients and associated floral and faunal assemblages.

A.4.5.5 Benthos

Though no detailed benthic invertebrate work is known from St. Georges Bay and the Cape Breton area, Kenchington (1980) suggests that, at least for St. Georges Bay, the macrobenthos is likely to be closely similar to that described by Caddy et al. (1977) which included 74 species of algae, 91 species of polychaetes, 73 species of amphipods, 26 species each of bivalves and arthropods, 6 species of echinoderms, and 31 species of fish. At seven stations near Cape George and immediately west of the Cape they found 89 invertebrates species, including 30 polychaete, 19 mollusc, 12 amphipod and 8 arthropod species. The remaining taxa at these sites, each represented by ≤ 5 species, were echinoderms, gastropods, porifera, cnidarians, and annelids. Hargrave and Phillips (1986) report that in sampling in St. Georges Bay polychaetes were numerically the most abundant group and accounted for more than 50% of the biomass [Caddy et. al (1977) estimated polycheates formed 58-93% of the biomass at 5 of 7 stations near Cape George]. Clearly polychaetes are a significant member of the benthic community in St. Georges Bay. See the companion report GBEP III (Mitchell, 2000) for a more complete assessment of benthic organism and communities from surrounding areas.

A.4.5.6 Fish

The St. Georges Bay area is rich in diversity of fish species. Kenchington (1980) lists 47 species found during intensive bottom trawl surveys in 1978 and list a further 20 which are expected though were not found by his surveys. Appendix 1 lists the fish species found within the study area as compiled from Caddy et al. (1977), Kenchington, (1980), Koeller and LeGresley, (1981); and Clay, (1991). The results are an estimated 65 species comprising 31 families. The families containing the largest number of species are the sculpins (Cottidae, 7 sp.), codfishes (Gadidae, 6 sp.), righteye flounders (Pleuronectidae, 5 sp.), and herring (Clupeidae), sticklebacks (Gasterostidae), skates (Rajidae) and pricklebacks (Stichaeidae) each represented by four species.

In terms of biomass, estimates from three sources are presented in Table A.4-9. These species appear to represent the greatest component of the biomass but it must also be realized that the majority of the species presented are migratory to varying extents and so the biomass values presented only represent seasonal maxima for these species. For much of the year, the biomass may be expected to be considerably lower, and therefore contributions in biomass from the other species in the community will become increasingly greater.

Of the estimated 65 fish species present, 23 (35%) are harvested commercially.

A.4.5.7 Marine Mammals

Five species of whales, long-finned pilot whales (*Globicephala melas*), fin (*Balaenoptera physalus*), sperm (*Physeter macrocephalus*), minke (*Balaenoptera acutostrata*) and white-beaked dolphins (*Lagenorhynchus albirostris*), are known to be found in the study area based on stranding records (Table A.4-10). In addition to these species, the Atlantic white-sided dolphin (*Lagenorhynchus acutus*), and harbour porpoise (*Phocoena phocoena*) have been observed in the area, and beluga (*Delphinapterus*

Table A.4-9: Estimates of major biomass components. Kenchington (1980) is an estimate of absolute biomass, the other two are biomass per tow during trawl surveys

Species	Kenchington (1980) (kg)	Koeller & LeGresley, (1981) (kg/tow)	Clay (1991) (kg/tow)
American plaice	5,579	0-500	10-500
Winter flounder	3,010	-	10-100
Witch flounder	241	<20	-
Atlantic cod	225	0-100	10-1000
White hake	399	-	10-1000
Herring	Few-100's	0-50	-
American smelt	100	100-1000	-
Little skate	148	-	-
Thorny skate	32	0-50	10-100
Winter skate	148	-	<10
Longhorn sculpin	90+	<10	<10
Ocean pout	279	-	-

Table A.4-10: Stranding records of whales within St. Georges Bay study area, 1991-1998. (Source: Hooker et al., 1997 and S. Hooker, pers. comm.)

Species (number of individuals)	Stranding location	Date
Long-finned pilot whale (1)	Dunvegan, Inverness Co.	Oct. 1, 1992
Dolphin/porpoise (1)	Malignant Cove, Antigonish Co.	July 6, 1994
Long-finned pilot whale (5)	Cheticamp, Inverness Co.	Sept. 5, 1994
Fin whale (1)	Braeshore, Pictou Co.	Sept. 27, 1994
Sperm whale (1)	River John, Pictou Co.	Dec. 12, 1994
Minke whale (1)	Tracadie Harbour, Antigonish Co.	July 20, 1996
White beaked dolphin (1)	Cheticamp, Inverness Co.	May 6, 1997

leucas) and blue whales (*Balaenoptera musculus*) are suspected due to their use of the Gulf of St. Lawrence (S. Hooker, pers. comm.).

Three seal species are known to use the area contained within the St. Georges Bay Ecosystem Project – the grey seal (*Halichoerus grypus*), hooded seal (*Cystophora cristata*) and harbour seal (*Phoca vitulina*). St. Georges Bay is an important grey seal breeding area, occurring on the ice in late December through to February (Stobo et al., 1990). After the breeding season adults and pups either find open water or drift on the ice out to the Scotian Shelf, often being found on Sable Island (Stobo et al., 1990). In 1983/84 aerial surveys of grey seals resulted in estimated numbers of seals using Northumberland Strait of 0 in May, 38 individuals in August, 111 in November, and 396 in January (Clay and Nielsen, 1985). Pup production in 1989 was estimated at 6,607 pups for the St. Georges Bay area (Hammill et al., 1992a). Benoit and Bowen (1990) report that of 194 grey seal stomachs examined from the lower Gulf of St. Lawrence, 105 (54%) were empty. The remaining 89 stomachs contained primarily skate (30.3% of stomachs examined), flatfishes (27%), unidentified fish (25.8%), herring (21.5%), cod (13.5 %) and invertebrates (14.1%). These authors also suggest that there appears to be a seasonal shift from groundfishes (flatfishes and skates) in the spring to pelagic fish (herring) in the summer.

There is very little information on hooded seals within the study area, with two reports on pup production being the extent of available information. Historically hooded seals were very abundant in the Gulf of St. Lawrence (Stenson and Wakeham, 1986). In 1986 a whelping area was identified off of Cape Breton, near Cheticamp, and at that time was estimated to consist of approximately 200 families and pup production was estimated at 161-211 pups (Stenson and Wakeham, 1986). In 1991, this same whelping patch was estimated at 1,875 individuals and a pup production of 1,638 pups (Hammill et al., 1992b). However, this increase is not necessarily a direct reflection of abundance as the 1986 sampling was minimal, instead concentrating on other areas, while the 1990 sampling concentrated on this whelping patch. Differences in sampling effort may account for some of the observed increase in individuals and pup production.

There is no available information on local harbour seal populations, pup production, or feeding habits.

A.4.5.8 Seabirds

Seabirds in St. Georges Bay include great and double-crested cormorants (*Phalacrocorax carbo* and *P. auritus*), black-back, herring and Iceland *gulls (Larus marinus, L. argentatus,* and *L. glaucoides*, respectively), common and arctic terns (*Sterna hirundo* and *S. paradisaea*), gannets (*Morus bassanus*), black legged kittiwakes (*Rissa tridactyla*), and black guillemots (*Cepphus gryle*) (Kenchington, 1980; Cairns et al., 1991). Within Statistical Area 4Tg (see Section B.1.1 for location) there are an estimated 10,000 breeding pairs of birds comprised approximately 50% of gulls, 40% of cormorants, and 10% as terns (Cairns et al., 1991). These birds are estimated to feed on approximately 1,500 tonnes of fish of which approximately 60% are benthic and estuarine fish, 16% are small pelagics (mainly sand lance and capelin), 18% is unclassified fish, and <5% is invertebrates (Cairns et al., 1991). Compared with fisheries landings in 4Tg for 1987 (29,616 tonnes), the consumption by seabirds amounts to approximately 5% of the landings (Cairns et al., 1991).

A.4.6 Contaminants

Sampling for contaminants in St. Georges Bay sediments indicates that the area is quite clean, indeed, some Department of Fisheries and Oceans (DFO) programs use it as a baseline reference site. In the summer of 1976, Leonard (1977) found polychlorinated biphenyl (PCB) concentration in the sediments at less than 5 μg/kg and DDT concentrations around 1 μg/kg. Travers and Wilson (1977), report on sampling in Northumberland Strait, with PCB sediment concentrations <5 μg/kg in six of nine samples; one of the remaining three samples contained 7 μg/kg PCB, the other two each contained 11 μg/kg. This same sampling revealed DDT at less than 1 μg/kg at six of the nine sites and 1 and 2 μg/kg in the remaining three sites. In 1978 a sampling program in Atlantic Harbors examined the presence of 'petroleum residues'; "the ill-defined mixture which remains after petroleum-derived oils are subject to varying amounts of weathering in the marine environment" (Levy et al., 1988). At Lismore, Arisaig and Malignant Cove mean residue concentrations were 9.95, 10.42, and 1.71 μg/g respectively, with a range of 0.34-71.8 μg/g (Levy et al., 1988). Ten micrograms/gram is the regulated limit for these residues under the Ocean Dumping Act, above which material may not be disposed of in the marine environment. The high levels in Lismore and Arisaig, relative to Malignant Cove, are thought to due to such sources as accidental loss of fuel oil, deliberate discharge of fuel oil while pumping bilges, and disposing of spent lubricating oils (Levy et al., 1988). Between 1987 and 1989, sediment polycyclic aromatic hydrocarbon (PAH) concentrations in St. Georges Bay sediments were comparatively low (0.27 μg/g dry weight; Vignier et al. 1994).

Concentrations of heavy metals in these sediments are low. Mercury is less than 0.1 mg/kg (Loring 1975: 1988), total zinc < 50 mg/kg, total copper <15 mg/kg, total lead <15 mg/kg (Loring 1978; 1988), total cobalt <10 mg/kg, total nickel <20 mg/kg, and total vanadium < 60 mg/kg (Loring 1979; 1988). Total chromium is the one exception. It is generally between 30 and 50 mg/kg but in isolated pockets off of the west coast of Cape Breton is found at concentrations of 70-84 mg/kg (Loring 1979). Of the total metals in the sediments, Loring (1979) estimates 76-98% of the metal is not available to biota as it is bound up in various sulphide, oxide and silicate minerals. Two studies are known which document metals levels in biota in the area of interest, Young (1973), and Freeman and Uthe (1974). Young, reporting on a 1972 study which included the Mabou Harbour area reports the following metals concentrations in the blue mussel (*Mytilus edulis*) – aluminum (28 μg/g), cadmium (0.54 μ/g), chromium (0.02 μg/g), copper (4.2 μg/g), lead (2.5 μg/g), and zinc (25 μg/g). Freeman and Uthe (1974) estimate a mean cadmium level in lobster hepatopancreas near Cheticamp of 9.14 μg/g wet weight, and calculate a mean concentration of approximately 1.74 μg/g of cadmium within the edible portion of the lobster. They also suggest that the cadmium is of geologic, as opposed to anthropogenic, origin.

An examination of organochlorine (Lindane, Dieldrin, α-HCH, B-HCH, δ-HCH) levels in seawater in 1976 and 1977 indicated concentrations of 0.45 to 5.7 ng/L, DDT concentrations of 0.05-0.09 ng/L, and PCB concentrations of 3.1 to 26.7 ng/L (Harding et al., 1997). These authors also report that these levels are similar to levels found in other coastal waters studied around the world in the 1970's. PCB concentrations within plankton in St. Georges Bay ranged between 50 and 250 ng/g dry weight in 1976 and 1977 with no indication of food chain biomagnification over the size ranges of plankton studied (Harding et al., 1997). Average PCB concentration within zooplankton (as Aroclar 1254 equivalents) appear to have dropped from highs of >5,000 ng/g wet weight in the early 1970s to between 1 and 10 ng/g between 1975 and 1995 (Figure 4.9 White and Johns, 1997). PCBs within the zooplankton are thought to come from atmospheric deposition (Harding et al., 1996).

Phillips and Hargrave (1992), in an interlaboratory calibration study analyzed organochlorines in zooplankton and benthic amphipod tissues collected from St. Georges Bay in 1987. The results from one of the participating labs (Seakem Oceanography Limited; one of three labs in close agreement with each other) indicates organochlorine (hexachlorocyclohexanes, hexachlorobenzene, and cyclodiense) concentrations of (wet weight) <0.1-41.32 ng/g, DDT concentrations of <0.03-42.24 ng/g and PCB of 0.7-107.95 ng/g. In 1995 snow crab from the area around Cheticamp were used as reference samples in evaluating PCB contamination during the *Irving Whale* recovery. Crab digestive gland samples averaged 0.109-0.111 μg/g wet weight (Anonymous, 1996a).

In 1976-1977 fish were sampled in St. Georges Bay to test for PCB concentrations in tissue. Concentrations were highest in gaspereau (mean concentration 75-418 ng/g as Aroclor 1254 equivalent) and the least in white hake (mean concentration 7 ng/g) (Harding et al., 1997). Herring, mackerel, capelin, and rainbow smelt tissue concentrations fell between these two ranges. Harding et al. (1996) indicate that PCB tissue levels have decreased from approximately 9,000 ng/g to ~4,000 ng/g between 1977 and 1987 in gaspereau, and from 8,000 to approximately 1,000 ng/g between 1977 and 1995 for herring, suggesting a downward trend in fish tissue concentrations of PCBs within this area. Between 1987 and 1989 winter flounder from St. Georges Bay were sampled as a reference source for Mixed Function Oxidase (MFO) activity as part of a larger study. EROD activity averaged 0.38 and 0.289 nmol/min/mg protein for males and females respectively, cyt-b_5 was 0.039 (males) and 0.065 (females) nmol/mg protein, cyt-P450 was 0.302 (males) and 0.344 (females) nmol/mg protein, and BaPH was 0.449 (males) and 0.474 (females) nmol/min/mg protein (Vignier et al., 1994). These results indicate that the flounder may have been recently exposed to some degree of organic contamination. Further experiments are required to verify/confirm these results.

Contaminants have also been sampled in birds eggs. Egg samples of common terns collected from Margaree Island between 1970 and 1976 showed concentrations of DDE (mean = 0.95 ppm, range 0.44-1.44), PCBs (mean 1.86 ppm, range 1.15-2.59), dieldrin (mean=0.04 ppm, range 0.03-0.06), and mercury (mean 0.09 ppm, range 0.07-0.15) (Pearce et al., 1979).

Summary

The St. Georges Bay area is largely shallow water dominated by mud and sand substrates. The currents of the Gulf of St. Lawrence create a northeast current which flows across the mouth of St. Georges Bay and up the Cape Breton shore. This in turn initiates a clockwise gyre in St. Georges Bay itself. The bay has relatively long retention time (30-60 days) under normal conditions but this may be significantly shortened by high-energy events. The waters undergo a temperature range of up to 20°C over the period of a year. This results in the formation of a thermocline and stratification which affects chemical and biological productivity. Salinity of the waters in this region are generally between 28-31 ppt.

Nutrients are generally in relatively uniform and low concentrations, the exception being ammonia which has been reported in very high concentrations in this area. Primary production peaks in late winter, early spring and early fall. Copepods are the primary component of the zooplankton with the majority of the biomass being composed of six species forming four communities. There is a successional series in zooplankton communities as the year progresses.

Sediment deposition is greatest under isothermal water conditions of spring and fall and least during summer stratification. There are well over 100 different algal species in St. Georges Bay of at least four Classes. Macroalgal communities are dominated by *Chondrus crispus, Furcellaria,* and *Fucus*. Eelgrass also form an important vegetative component of the St. Georges Bay ecosystem. Very little is known on the benthic communities though it is obviously diverse from the limited sampling conducted. Polychaetes are the dominant community member both numerically and in biomass. There are an estimated minimum 65 fish species representing 31 families, of which 35% are commercially exploited.

Seven species of whales and three seal species are known to use this area. Another two whale species are suspected of occasional presence. Grey and hooded seal populations have been increasing over time, though determining by how much is difficult. Within the larger area of 4Tg there are an estimated 10,000 breeding pairs of seabirds, composed principally of cormorants, gulls, terns, gannets, kittiwakes and guillemots.

The water, sediment and biota of St. Georges Bay have been sampled for various contaminants. Heavy metals, PCBs, and organochlorines have been analyzed and are generally at relatively low levels. St. Georges Bay is often considered "clean" and used as a reference site, however sensitive tests using MFO induction indicate there may be some contamination of the environment.

A.5 SOILS

Agriculture Canada provides the majority of documentation of soil types of the study area. These are presented in the Soil Survey of Antigonish County, Nova Scotia (1954) and the Soil Survey of Cape Breton Island, Nova Scotia (1963). The Natural History of Nova Scotia (1996) also provides general information. The following is a summary of material presented in these publications.

Glacial till is the predominant material contributing to Nova Scotian soils. Generally this material is not transported more than a 1-2 of kilometers before deposition, thus soils are usually derived from directly underlying bedrock. Other soils of the study area are developed from deposition by water runoff from melting glaciers or more recent deposition of stream sediments.

The majority of soils in the study area belong to the Podzolic Order. Podzols are soils derived from glacial till; iron, aluminum and organic matter is leached from the surface and deposited in an underlying layer, or B horizon, which will be visibly darker as a result. This process is well developed in soils of good drainage, and would be classed as belonging to the Humo-ferric Great Group. These tend to form under softwood forests, which provide them with low annual litter fall. These soils are usually acidic, having a pH of 3.5 to 4.0 in the surface horizon and 4.0 to 5.5 in the underlying horizon. Those with poor drainage will have slow decomposition and accumulate large amounts of organic matter on the surface and would belong to the Ferro-humic Great Group

The study area soils can be broadly divided by bedrock source between those derived from erosion-resistant igneous and metamorphic rocks and less resistant sedimentary rock. Figure A.5-1 presents the distribution of the soils in terms of geological source.

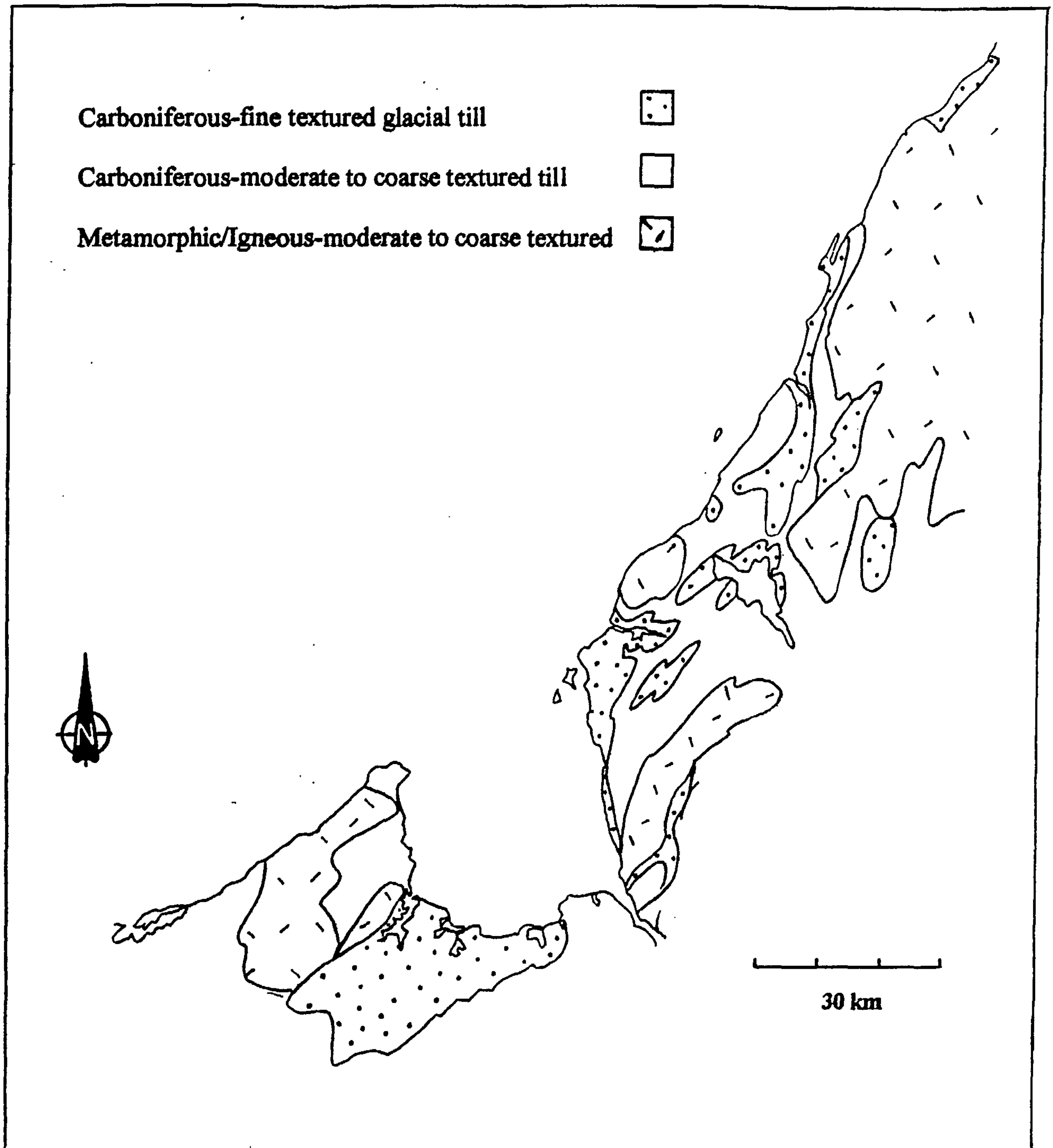


Figure A.5-1. Soil types of the study area

The harder bedrock of the highlands is generally covered with Humo-ferric Podzols. These are formed in thin layers of coarse stony, sandy loam till, which tend to be well drained and reasonably fertile if derived from basic igneous rock. Soils of this type in the study area are Thom soils, located in the four highland bodies of the study area, the Pictou-Antigonish Highlands, the Creignish Hills, the Mabou Highlands and the Cape Breton Highlands. The hard bedrock, forming Ferro-humic Podzols result in poorly drained soils on the plateaus of the highlands. The slopes of these highlands are well drained and prone to erosion. More finely eroded igneous and metamorphic materials are deposited in sufficient depths for agricultural use (e.g. Hebert and Canning soils).

Much of the lowlands of the study area are underlain by Carboniferous sedimentary rock. As with the igneous/metamorphic-derived soils, they are predominantly Podzolic, but the products of erosion of this softer rock are much finer, resulting in limited internal drainage.

Early Carboniferous rock of the Horton Series, a more erosion-resistant rock than the younger Windsor group persists as upland areas. The erosion product of this rock material is of intermediate coarseness and can form moderate textured, fertile soils (such as Westbrook and Shulie), but a portion of these Horton-derived soils are too stony to cultivate.

The Windsor group, comprised of soft sandstone and shale, with some gypsum and limestone parent material, yields a soil of finer texture. Woodburne and Barney soils occur on gently rolling topography, providing more fertile, well-drained shaly loams, well utilized for agriculture. The best of these soils for agriculture are Woodburne, Falmouth and Merigomish, the latter two being among the most fertile in the province but covering small areas. These are produced from fine parent material with good internal drainage. They are found on coastal and interior lands in the Antigonish basin and the Hills and Valleys of southern Inverness County.

Queens, Millbrook and Diligence soils are derived from fine materials. These are limited by poor internal drainage and are classified as Gleyed Podzols. These predominate in the lowlands of the study area where their productivity is greatly dependent on topography to facilitate drainage.

Other soil Orders of the area include Gleysols, in which clay minerals are leached to the subsurface, rather than the iron and aluminum of Podzols. This accumulation causes very poor internal drainage. Kingsville and Joggins soils are Gleysols found in the lowlands of the Judique area and the eastern end of Antigonish County, respectively.

Organic Order soils are created in conditions of near-year-round water saturation and result in surface layers of organic material of over 40 cm, rather than horizons of mineral soils. These are limited in distribution to small areas in eastern Antigonish County and larger areas in the Cape Breton Highlands.

Recent soil deposits that have not yet developed differentiated horizons belong to the Regosol Order. These have been deposited throughout the study area by rivers on flood plains. Table A.5-1 presents significant soils of the study area.

Table A.5-1 Significant soil types in the St. Georges Bay Ecosystem Project study area.

Geological Source	Parent Material	Podzols		Gleysols	Organics
		Orthic Podzols	Gleyed Podzol	-	-
					Peat
Carboniferous	Fine textured glacial till	Falmouth Woodburne	Queens Millbrook Dilligence	Kingsville Joggins	-
Carboniferous	Moderate textured	Westbrook Shulie	-	-	-
	Coarse textured	Canning			
Metamorphic Igneous	Moderate textured	Thom	-	-	-
	Coarse textured	Hebert			

A.6 ECOSYSTEMS

Within the St. Georges Bay Ecosystem study area, native vegetation has been modified considerably by European settlement within some areas. Historically, clearing of forests for agriculture and settlement produced fielded areas, much of which has since reverted to forest. Because the species of trees that have reclaimed the fields are predominantly softwoods, differing from the hardwoods of the original forests, the amount and composition of these forests have been changed. There are large areas, however, that have not been significantly altered by humans.

The geological formations within the study area define the elevation, topography, soil, and to an extent, specific climate conditions on a local level. The resulting conditions, in turn, define the vegetation and wildlife distribution. These ecosystems as described by Davis and Browne (1996) are presented briefly. The distribution of ecosystems in the study area are presented in Figure A.6-1. Species names are presented in Appendix 2.

A.6.1 Taiga

The northernmost highland plateaus are also the highest elevations of Nova Scotia and are unique in the province for their extreme weather conditions and the plants associated with these alpine environments. The vegetation is exposed to high winds and a short growing season; as a result, barrens and stunted conifers predominate. The high precipitation and the impermeability of the bedrock have created extensive peat bogs in places.

The soils are thick despite the hard metamorphic and igneous bedrock. This is believed to indicate protection by the glacial ice cap itself from glacial scouring experienced by adjacent areas (Davis and Browne, 1996). The soils are Ferro-humic Podzols, Gleysols and Organics. Barrens vegetation is comprised of stunted spruce and

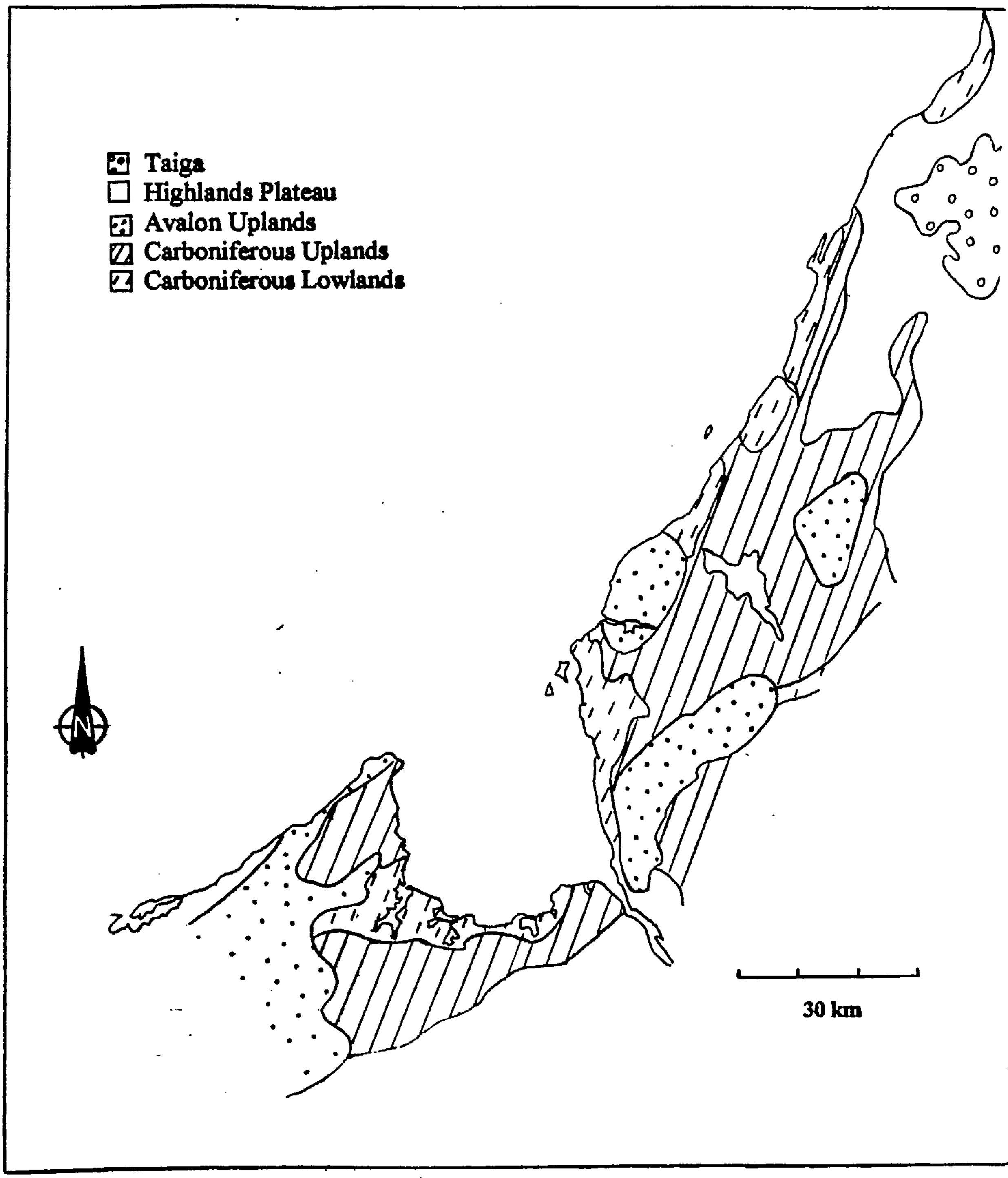


Figure A.6-1. Distribution of ecosystem types of the study area.

fir, lichens, blueberry and sheep laurel. Relict arctic-alpine plants include dwarf birch and alpine whortleberry.

Peat bogs are dominated by sphagnum mosses, bullrush, peak rush, cranberry, mosses and liverworts. Areas with greater protection from the wind harbour black and white spruce, balsam fir, white birch and mountain ash.

The fauna is not diverse in these conditions. Moose and caribou populations have been extirpated by hunting, but moose were reintroduced from Alberta in 1936. Moose, bear and lynx are present during the summer. Small mammals include the red-backed vole and the common shrew. The prevalence of wet areas contributes to an abundance of aquatic insects as well as frogs and salamanders. The greater yellow legs and the grey-cheeked thrush are found here in an area otherwise relatively low in bird numbers.

A.6.2 Highlands Plateau

The plateaus of the Cape Breton Highlands, to the south of the Taiga region, is underlain by the same bedrock as the Taiga, but is exposed to less severe climatic conditions. It is vegetated with true Boreal Forest, consisting almost completely of balsam fir in its climax state, but often including white birch and white spruce. Common to these forests are periodic infestations by spruce budworm, the most recent being in the 1970's. At that time, complete stands of mature fir forest were devastated on the highlands drained by the Northeast Margaree River. At the peak of the infestation, much of the wood was harvested, and replanted with fir and black spruce. Land not replanted is currently regenerating through stages of raspberry and elderberry, followed by a succession of white birch, mountain ash and pin cherry.

Under the mature canopy a ground cover of mosses and liverworts is found, but the various stages of succession allow a variety of plant associations, including wood fern, wood sorrel and mosses. Wildlife includes snowshoe hare, lynx, bear, pine marten and sightings of cougar have been reported. Moose are common, and deer are restricted by deep snow in the winter.

The vegetation of the slopes within the region is distinctly different from that of the plateau. The soils are rich, deep and well drained. The forest cover of the slopes is more characteristic of the Avalon Uplands (Section A.6.3). Shade tolerant deciduous and mixed woodlands, categorized as Acadian Forest, comprise the natural forest here, consisting of eastern hemlock, white pine, yellow birch, white birch and sugar maple. This is the northeastern limit of this forest type in the Atlantic provinces. Toward the lower reaches and in unstable soils, the forest composition varies, giving way to more softwoods. Mosses, young hardwoods, and mountain maple provide a rich understorey. Talus slopes of frost-splintered bedrock are an uncommon feature found here. This particular ecosystem is the most diverse in the province in terms of small mammals. Fourteen of the 17 insectivore and rodent species of Cape Breton occur here, including provincially rare species.

A.6.3 Avalon Uplands

The Mabou Highlands, Creignish Hills and Pictou-Antigonish Highlands have a more moderate climate than the Cape Breton Highlands, characterized by cool summers and winters. The bedrock of the highest portions is igneous/metamorphic, surrounded by early Carboniferous slopes. Soils are Ferro-humic Podzols. The plateaus and ridges are predominantly climax or near-climax Acadian Forest. The understorey associated with these forests consists of mountain and striped maple, rose twisted stalk, starflower, mosses, Christmas fern, baneberry, hazelnut and wild sarsasparilla. Red spruce, white spruce and balsam fir are scattered throughout and form stands in the valleys. White and black spruce stands occupy poorly drained portions of the plateaus and valleys.

This is high quality moose and fisher habitat. The heavy deciduous canopy provides a protected, moist environment that favours slugs, and snails, and a variety of insects in rotting debris. Wood frogs and salamanders are common as well as small mammals and warblers and woodpeckers.

A.6.4 Carboniferous Uplands

The greatest elevations within the Carboniferous formation are largely composed of Horton strata. The soils are heavily podzolized, found in thicknesses of greater than 200 m in portions of western and eastern Antigonish County, and the Ainslie uplands to the west of Lake Ainslie. These areas are characterized by foothills, producing a rolling topography and well to poorly drained soils which have been largely used for farmland. Hardwoods predominate, particularly sugar maple, yellow birch and beech on the slopes, with some agricultural land growing in with white spruce. Lower slopes and valleys are vegetated with softwoods of white spruce and fir.

The Margaree plateau to the south of the Cape Breton Highlands is a faulted block that was sunken relative to its surroundings, and as a result has retained the Windsor strata that has been eroded from other landforms of that elevation. The Mulgrave Plateau is formed from the Canso group. The soil is a heavy soil, predominantly Halifax. The topography is undulating, with ridges of hardwood alternating with bands of bog, as the drainage conditions vary. Elevations reach above 200 m.

A.6.5 Carboniferous Lowlands

The Windsor strata form the lowlands of the Northumberland Plains, which encompass a large portion of southern Antigonish County, and the Coastal Plains of Judique and Inverness. These areas have deep soils with few stones, but are easily compacted. The soils are Podzols, Gleyed Podzols and Organic. Because of their poor drainage, there is great variation in the vegetation depending on the topography. The native forest is red spruce, hemlock and pine in the Northumberland Plains. There are also cleared fields regenerating in alders, followed by white spruce. Larch and black spruce occur on poorly drained soils. Other poorly drained areas exist as bogs.

The fertility and variety of habitats provided by past and present human settlement have allowed for a diverse small mammal population. Beaver, muskrat, mink, raccoon, river otter, fox and coyote are present. Most of Nova Scotia's floodplains and mature rivers are associated with this geology, a large portion of them being in the study area. These surface waters are productive in terms of aquatic life, thus diadromous fish species have historically thrived in these areas.

A.6.6 Estuaries

The series of estuaries that have formed at river mouths along the coast of the study area are significant ecosystems, which are very productive and diverse.

Long term sea level rise (25 cm/century – see Section A.4.1) has flooded the older river valleys, creating long broad water bodies at the river mouths (Davis and Browne, 1996). Sedimentation from the rivers and ocean wave action have both worked to deposit sediment at the openings of the river mouths, leaving only narrow openings. Seymour (1992) describes Antigonish, a representative estuary, as a brackish tidal area separated from the ocean by barrier beaches.

An estuary is strongly influenced by the fresh water of the river, but also receives tidal waters, it varies in salinity throughout the day, seasonally, and along its length. Salinity values throughout Pomquet Harbour are reported from 5.5 ppt to 26. 5 ppt (Bird et al., 1976). During spring, runoff totally displaces the water of the Margaree estuary which by definition, at that time, is no longer an estuary but a river emptying into the ocean (Kraul, 1969). Although salinity varies throughout the estuary, there is also a stratification of less dense freshwater over marine waters. Thus there are distinct 'isohalines' identified as sharp changes in salinity that have been observed to act as partial barriers to drainage at the mouth of the Margaree (Kraul, 1969).

A great deal of work was carried out on the Margaree system from 1934 to 1937 with respect to its role in salmon life history (Kraul, 1969). The physical oceanography of the Margaree and Cheticamp estuaries was studied extensively in 1969 by Kraul. Temperature readings in the estuary have been recorded during DFO salmon capture/recapture studies (L. Forsythe, pers. comm.).

The Antigonish harbour is a rich, relatively undisturbed feeding ground for resident and migrating waterfowl (Seymour, 1997), as well as having a diversity of marine and estuarine fauna. Extensive areas of cordgrass *(Spartina)* grow in the salt marshes of the harbour, and on the shallow flats eelgrass *(Zostera)* is abundant (Erskine, 1997). Bird et al. (1976) investigated algae populations in Pomquet Harbour. This is discussed in detail in Section 4.5.4.

Bird et al. (1976) describes Pomquet Harbour as representative of estuaries of the lower Gulf of St. Lawrence in their investigation of algal populations. Other than these isolated studies, there is not a great deal of documentation of estuarine conditions within the study area. There are plans to investigate several related aspects of the Antigonish estuary in the coming field season by local academics.

The productivity of estuaries allows for a concentration of breeding and foraging terrestrial and marine species, thus they are significant to a large proportion of these populations. In addition they are critical migration routes for seabirds and anadromous fish (see Section 1.1.2.2). The impact of the concentration of people living adjacent to these habitats, and the nature of effluent throughout watersheds feeding them, must be well understood.

There are initiatives to gain a better understanding of Maritime estuaries. Acadia University has established an Esturaine Institute, and a conference was recently held on the subject of New Brunswick Gulf of St. Lawrence estuaries.

A.7 WATERSHEDS

The geological features of the study area define the landform, and therefore the patterns of surface run-off. The watersheds of the area thus can be discussed as groups with similar characteristics, but with distinctions based on local conditions and land use. Figure A.7-1 presents the regions within the study area which will be discussed.

A.7.1 Cape George

The prominent geographical feature is the Antigonish-Pictou Highlands, which produces a series of small streams flowing northward into the Northumberland Strait and eastward into St. Georges Bay. The vegetation and wildlife of this area is representative of the Avalon Uplands. Much of the land is steeply sloped, so this area has historically remained forested rather than being cleared for human settlement.

The individual drainage basins within the region comprise small areas, beginning at high elevations but rapidly coming to sea level because of the topography. The drainage areas of these watersheds range from 2,400 to 4,200 hectares (Maritime Resource Management Services, 1982). Information on the discharge volumes of these streams was not found.

Stream water quality studies have not been found, but would be expected to be similar to other waters originating in the hard rocks of the Avalon Uplands; that is, to be somewhat low in dissolved minerals. The eastward flowing streams travel over Carboniferous bedrock and richer soils surrounding the bay, so the water quality would be expected to differ, having higher concentrations of dissolved minerals.

A portion of the coastal land to the west is underlain by sedimentary rock, thus the landscape is more typical of Carboniferous lowlands; Merigomish, Woodburne and Barney soils are deposited on gently rolling topography, providing more fertile, well drained shaly loams used for agriculture.

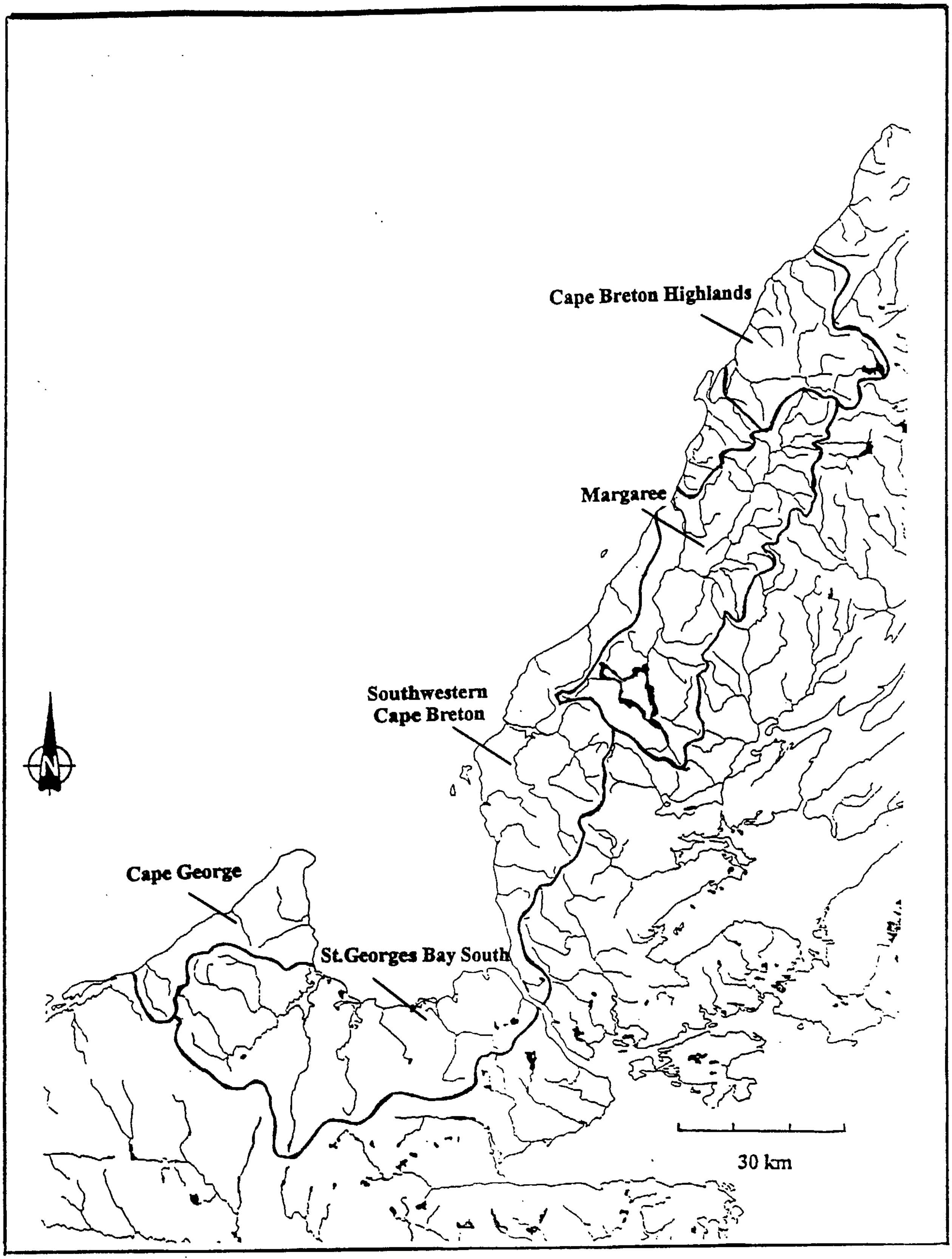


Figure A.7-1 Watershed regions of the St. Georges Bay Ecosystem study area

The extent of forestry activity in this region is unknown, but based on inspection of digital images, and known age classes of forests of Antigonish county, this large resource area has been well utilized. A great deal of the clearing of trees during initial settlement has grown back as forest. Agriculture persists at a limited level, confined to the eastern and western coastal areas.

Human residence is concentrated in coastal fishing communities. Fisheries are significant to the economy. There are active commercial ports at Bailey's Brook, Arisaig, Malignant Cove, Livingstones Cove, Ballantyne's Cove and Cribben's Point. There is also a lobster pound in Arisaig. Tourism is a feature of the local area insomuch as the scenic value is considerable and there are notable features along the coast which include exposed fossiliferous rocks, and cultural and community attractions.

A.7.2 St. Georges Bay South

The mainland watersheds of the study area emptying into St. Georges Bay drain a large basin within the Carboniferous Lowlands. Queens and Woodburne soils support a great deal of settlement and agriculture. Much of the length of the rivers in the basin have depositions of gravel and silt on the river flood plain, providing the base for a very good agricultural soil.

Antigonish Harbour receives water from the relatively large combined watersheds of the Right's, West, and South Rivers, covering 685 km^2. The patterns of watershed usage are similar along each of these rivers. They all originate in forested areas, and are therefore affected by a certain amount of forestry activity. The rivers then pass through agricultural land receiving some runoff and disturbance associated with these activities, converging at the Harbour. There are deposits of conglomerate and salt in the upper reaches of the Rights and West River. The combined watersheds of the basin contain 14 small lakes.

The Rights River originates along the south-eastern face of the Antigonish-Pictou Highlands and travels south and eastwards through farmland, emptying into Antigonish Harbour. The drainage area of the watershed is 12,960 hectares including the North and South branches (Maritime Resource Management Services, 1982). The watershed area was actually increased by 100 hectares in 1973 by diverting Vincent Lake drainage into the South Rights River (MacLellan and Associates Inc., 1995).

The Rights River enters the harbour at the east end of the community of Antigonish and has caused serious property damage for residents in that area due to flooding during spring ice break-up. A hydrotechnical study was carried out in 1983 by MacLaren Plansearch to identify flood hazard zones. MacLellan and Associates (1995) prepared a report for development of plans to control ice jams. This document states that the flood problems occur in areas where the river historically flowed, and that the stream path has been modified in the past. Some jam control measures have included further modification of the river path.

The West River watershed covers an area of 35,560 ha. This watershed provides the water source for the town, and also includes the former Antigonish County landfill site. The headwaters of the various tributaries originate on Carboniferous rocks, extending into Pictou and Guysborough Counties. The Brierly Brook tributary of the river runs directly through Antigonish town, and therefore receives some street and wastewater run off. A considerable amount of habitat restoration work has been carried out on this stream. No background surface water studies have been found for this area, but a Nova Scotia Ground Water survey in 1972 –1973 included a site near the mouth of the West River.

The South River watershed covers an area of 19,940 hectares to the south of Antigonish town. The area has extensive agricultural activity and a sewage treatment plant is located at Lower South River. The province operates a fish hatchery at Fraser's Mills, utilizing the river water, and collecting water quality data. Young (1971) published water quality data for three sites along the South River. Lakes within the watershed include Cameron's, Gillis, Kimballs and Copper Lake.

Stream discharge rates at St. Andrews are available from 1969 to 1974 and the National Water Quality Monitoring Program covered the same site (see Section A.8.2).

A.7.2.1 Antigonish Harbour

The harbour is a brackish tidal area, separated from the ocean by barrier beaches (Seymour, 1997). It is used extensively for recreational activities, including recreational fishing, ice fishing, boating, and hunting.

The harbour is not active in the commercial fishery, but the town , the largest urban centre in the study area, has various businesses. A regional hospital and university are major employers.

The waters are a rich, relatively undisturbed feeding ground for resident and migrating waterfowl, and support a diversity of marine and estuarine fauna. Extensive areas of cordgrass *(Spartina),* grow in the salt marshes of the harbour, and on the shallow flats, eelgrass (*Zostera)* is abundant (Erskine, 1992). Water quality data for the harbour has not been identified.

A.7.2.2 Pomquet River

The Pomquet River has two major tributaries, the West Pomquet River and the Black Avon River. The drainage area of these total 16,995 ha. Studies of water quality have not been found. River surveys of Pomquet and West Pomquet as trout habitat have been published by Miles (1983).

The community of Heatherton lies within the watershed on the Black Avon River. Pomquet Beach has a well developed sandy beach and extensive harbour. There has been a great deal of study of the resident algae in this harbour. The distribution of ecosystem types in the Pomquet watershed system are presented in Figure A.7-2.

Afton, Monastery, Tracadie, Little Tracadie and Wrights Rivers are a series of small rivers whose watersheds range from 1,820 to 11,030 ha in area (Maritime Resource Management Services, 1982). They are located to the east of Pomquet, draining the Mulgrave Plateau. There seems to be a general lack of documentation of this region. The bedrock geology of most of the watersheds is metamorphic bedrock of the Canso Group. The Halifax soils which predominant here are gritty sandy loam, which are very stony, often with a thick surface peat layer. The soils alternate from well to poorly drained resulting from an undulating topography. The resulting vegetation patterns are characterized by bands of bog in the lowland areas, and stands of hardwood along the ridges (Davis and Browne, 1996).

The coastal area is underlain by Carboniferous rock; the elevation is lower, and the land more fertile approaching the coast. Agriculture is restricted to this small area. The communities here have active fishing ports, Bayfied, Havre Boucher, Tracadie, Bayfield and Auld's Cove. Human settlement is primarily along the coast. This region of watersheds extends to the Canso Causeway.

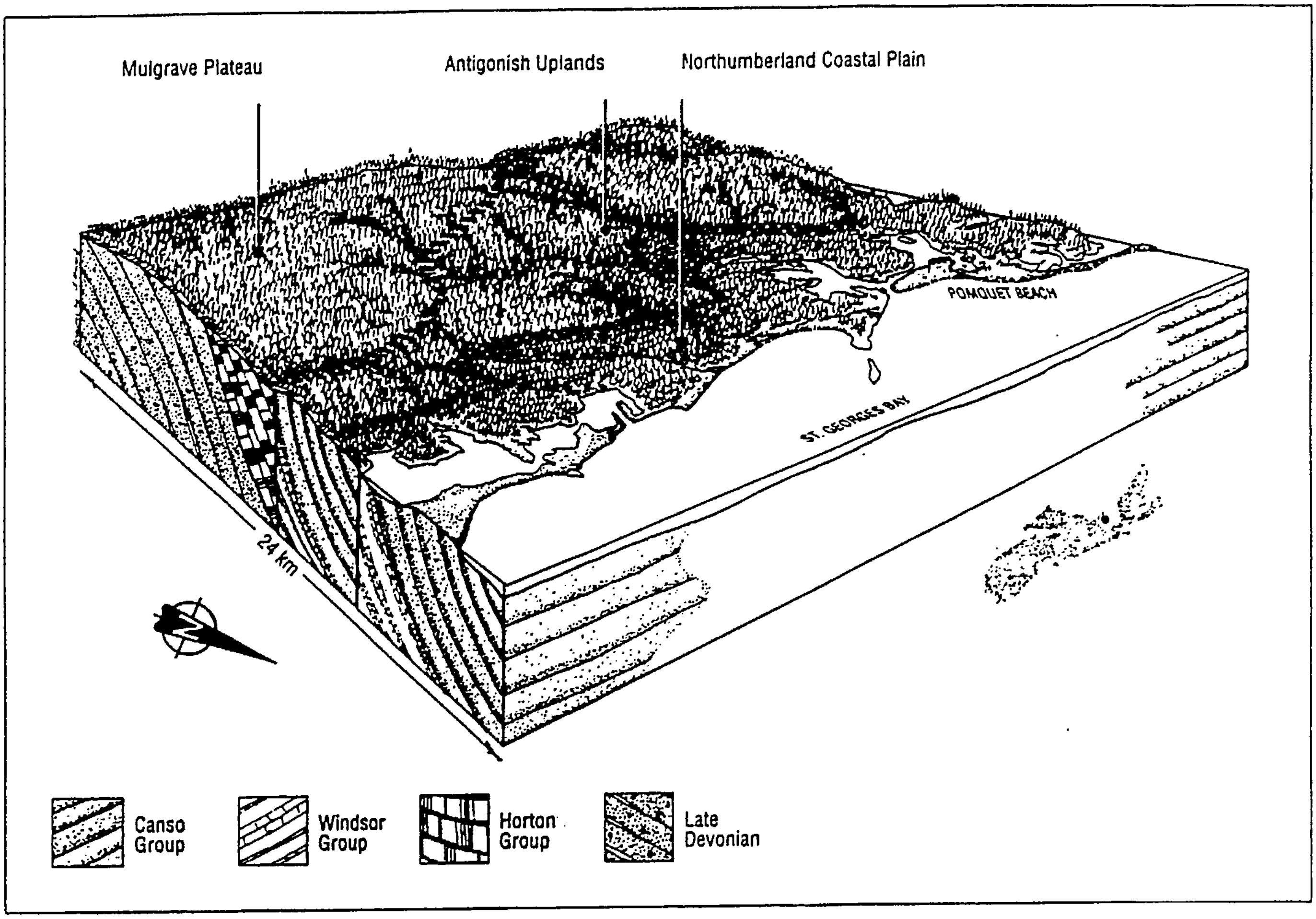


Figure A.7-2. The Landforms and Ecosystems of the Northumberland Coast
Natural History of Nova Scotia

A.7.3 Southwest Cape Breton Watersheds

The land flanking the eastern side of St. George's Bay is underlain by a continuation of the body of sedimentary rocks that form the Antigonish basin. The Creignish Hills lie just inland of this, thus restricting the coastal lowlands to a narrow strip.

This coastal formation is known as the Judique Coastal Plain. As in the Antigonish area, the soils are moderately to poorly drained, moderately fine-grained red brown Carboniferous parent material and have a clay loam texture. The surface drainage patterns reflect those of the Pictou Antigonish Highlands, producing small watersheds draining into the St. Georges Bay from Port Hastings to Judique.

To the north, adjacent highlands begin to recede inland, forming progressively larger drainage basins. The Graham River originates deeper inland in the Creignish Hills and travels through foothills before entering the ocean in Judique.

The total coastal drainage area is approximately 16,000 hectares (Maritime Resource Management Services, 1982). No surface water quality has been found for the area. Settlement is greatest along the coast. There are three active fishing harbours in the Judique area and one each at Port Hood and Port Hood Island. Port Hood is the site of surfacing for the Carboniferous Riversdale group, which is a coal producing body. A coalmine was active there until the 1960's.

Mabou Harbour is the collection point of larger watersheds that extend inland into the Ainslie Uplands to the north of the Creignish Hills. The underlying rocks are chiefly of the Horton group. The soils of the higher grounds, chiefly Diligence and Woodburne are well drained, but stony. Falmouth and Queens soils are found on lower lands, associated with gypsum deposits.

To the north, St. Georges Bay opens up to the Northumberland Strait. Here, the Mabou Highlands rise directly out of the sea. Stream drainage from these highlands are radial flowing both to the ocean and to inland watersheds. The Highlands are a portion of the Avalon Uplands, of metamorphic and igneous bedrock. It is similar in most respects to the Pictou-Antigonish Highlands, except that the surrounding Horton rocks are eroded away. Thom soils, characterized by stony, sandy loam yielding good drainage, with pockets of peat predominate. The slopes and a portion of the highlands have not been settled, therefore providing good wilderness habitat.

Streams running inland from the Mabou highlands collect in the Broad Cove River. This river drains a watershed of 5,720 ha, northward emptying into the Northumberland Strait north of Inverness. An active fishing harbour and wharf are located in a relatively small inlet to the south of Inverness, and another wharf is located at Broad Cove Marsh.

A municipal sewage treatment plant and a water treatment plant operate here, and a fish processing plant is located near the harbour.

A.7.4 The Margaree River

The Margaree River drains an extensive and diverse watershed totaling 122,255 ha. There are two main branches; the Southwest Margaree which runs northward from Lake Ainslie, a 56 km^2 lake, and the Northeast Margaree River which runs south, originating in the Cape Breton Highlands. The river has been well studied over the last century. The scenery and recreational salmon fishery of the river system distinguish the area. A fish hatchery has been operational there since 1902. Discharge has been monitored on both branches of the watershed, one since 1918. Water quality has also been monitored on both branches. The landforms and associated ecosystems of the northern portion of the Margaree watershed are presented in Figure A.7-3.

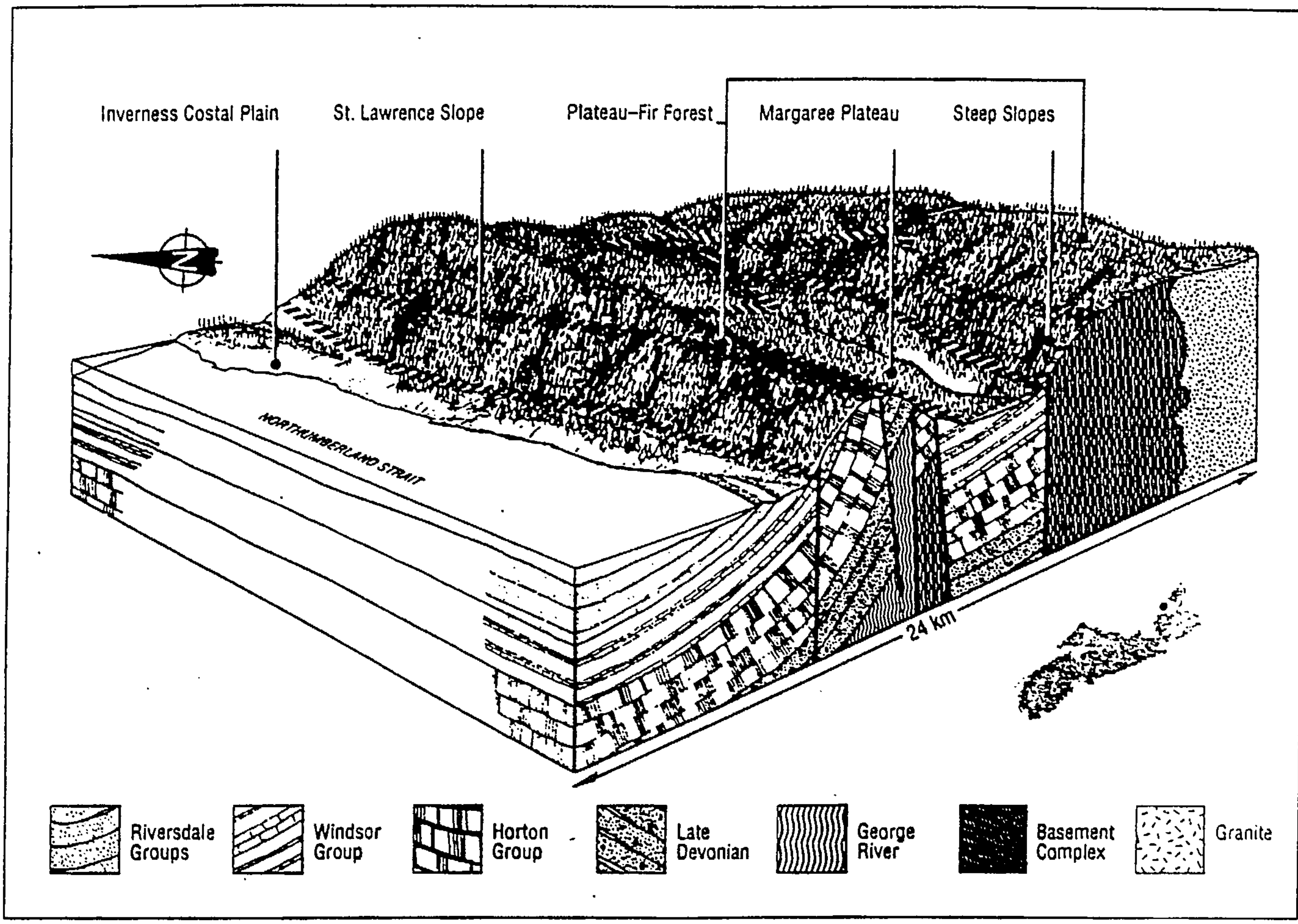


Figure A.7-3. Landforms and Ecosystems of the Margaree Area
Natural History of Nova Scotia

The River has recently been declared a Heritage River. The process leading up to this produced an extensive inventory of the valued features of the area (Rutherford and Assoc., 1988). The watershed includes four designated 'Protected Areas'; a portion of Jim Campbells Barren, the Margaree River, Sugarloaf Mountain and Trout Brook Wilderness Areas. The river has associated with it a large floodplain. The physical oceanography of the Margaree estuary is described by Kraul (1969).

There are no large population centers in this region. Some agriculture is carried out in proximity to the river. The main river and the Southwest branch are the site of the largest commercial gaspereau fishery in the study area. Lake Ainslie is the spawning grounds for the gaspereau, and is used extensively for recreational fishing and boating. The western tip is flanked by a unique alkaline bog which contains a number of uncommon plant species. The Inverness County Landfill site and a currently inactive barite mine, are both located immediately adjacent to Lake Ainslie.

A.7.5 Cape Breton Highlands Watersheds

Watersheds of northern Inverness County, the Cheticamp, MacKenzie and Grand Anse Rivers all originate on the plateaus of the Cape Breton Highlands, draining the Taiga and Highlands habitats. There is little exposure to human activity in this region. The slopes of the river valleys are steep. There are narrow zones of Carboniferous rock along the coast where each of these rivers enter the ocean, upon which the settlements of Cheticamp and Pleasant Bay are located. The settlements here have relied chiefly on fishing; agricultural land is limited to the small Carboniferous bodies along the coast.

The majority of the watershed areas of these rivers are within the boundaries of the Cape Breton Highlands National Park. Because of this, monitoring and management of the rivers and their resources are under park jurisdiction. This includes managing the salmon population in conjunction with the Department of Fisheries and Oceans

Cheticamp is one of the points of entry to the Cape Breton Highlands National Park. The watershed of the Cheticamp River extends into the Cape Breton Highlands, covering 2,705 ha. Approximately 10 % of the outflow of the Cheticamp Lake, has been diverted from the Cheticamp River system to the east, for use in the Wreck Cove hydroelectric project. Water quality and discharge data have been collected for this river. A very active fishing harbour is located at the village located to the south of the mouth of the river. The fishery and fish processing are very important to the local economy.

MacKenzie and Grand Anse Rivers both meet the sea at a small coastal plain upon which the Pleasant Bay community is located. Discharge and water quality data has been collected for the MacKenzie River.

A portion of the Cape Breton Highlands have been maintained as a national park since 1936. The National Park is an uninhabited area of unique physiography and habitat that covers 950 km^2. The unique habitat, as well as its remoteness have prompted interest from the academic community.

Summary

The distribution of conditions that support the terrestrial biological system is primarily influenced by the geological composition of the study area. Metamorphic and igneous rock form the highland area. The conditions predominating at these high altitudes are lower temperatures, rough terrain, and because of the nature the bedrock, soil has formed which is coarse with low fertility and low capacity to hold water. The biological system existing there is less productive and more specialized for these conditions, and is therefore less capable of adapting to changing conditions. Much of this land has been left unsettled, and is utilized as forestry land and wildlife habitat.

The varying degrees of erodibilty in the soft Carboniferous rock produce a continuum of elevation from the highlands to the lowlands. The resulting soils also occur on a continuum from insufficiently eroded for fertile conditions, to so finely textured that drainage of water is obstructed. The chemical composition of late carboniferous depositions (salts and carbonates) are released into the environment more readily and therefore confers a higher level of productivity upon the biological system living upon it. This land has been utilized for settlement and agriculture.

Watersheds within the study area reflect regional geography and geology. Size, productivity and human utilization of the watersheds vary between regions. Watersheds draining highlands are generally small, with a greater concentration of settlement and human activity along the coast. The inland forests are utilized and fisheries are important to coastal communities.

Larger watersheds have formed in the lowlands which empty into productive estuaries and in some cases, active harbours. Agriculture is important in these watersheds, and the distribution of settlement is more uniform.

A.8 WATER RESOURCES

DATA SOURCES

Water is a critical component of the environment and a vector for contaminant transportation; thus studies of environmental quality tend to include water quality information. There have been numerous studies on the water quality of watersheds in the area. Maritime region, federal, provincial, regional and local Departments of Environment, and Fisheries and Oceans have jurisdiction in the area, and therefore are all potential sources of information. Municipal offices also maintain records. Tracking the information among individuals of these offices was difficult because of the large number of possible sources. Also, because of recent reorganization of the departments, particularly within the environment sector, few individuals can be found with continuous knowledge of studies in any particular area. The time constraints of the study allowed for identifying data sources, but not for thorough analysis.

The Nova Scotia Department of the Environment is responsible for environmental monitoring relevant to public health. Thus drinking water sources and high-use swimming areas are monitored regularly by local field offices. Other specific studies are initiated in response to public concern over developments in environmental quality, for example, the increased frequency of algal blooms observed in Lake Ainslie in the early 1990's. The operations of water and sewage treatment plants and landfill sites are executed and monitored by municipalities and results are submitted to local Nova Scotia Department of the Environment offices. Monitoring information is required dependant upon the agreement that each municipality made with the province at the time of facility start-up.

The mandate of Environment Canada goes beyond the protection of human health into the conservation of environmental quality. The Inland Waters Directorate has collected 'Baseline' water quality information. The "Water Quality Branch Activities in Nova Scotia" publication gives details on 15 short and long term studies, 10 of which sample within the study area. Resultant reports present background surface and ground water quality data as well as levels of specific contaminants and assessment of regions for acid rain sensitivity. A review of priority toxin occurrences in the Atlantic provinces is presented by Kieley and O'Neill (1995).

The Inland Waters Directorate (IWD) was disbanded in the early 1990's. Sampling programs of the IWD were continued and data was stored in the database, NAQUADAT (that is currently known as ENVIRODAT), by the regional federal office in Moncton. Reports on the findings are generally no longer published. This information is available by request and is expected to be 'on the web' in the foreseeable future (D. Locherbie, pers. comm.).

Fisheries and Oceans Canada are active in marine fisheries (particularly commercial) conservation, which extends inland with the diadromous fish populations. The Nova Scotia Fisheries and Aquaculture office assesses water quality with respect to freshwater fish habitat.

A.8.1 Water Distribution

The watersheds within the St. Georges Bay region have been previously outlined and described (Section A.7). Streams draining highland areas tend to drain them radially and be relatively small in comparison to those that drain lowland areas. Within this area, an abundance of thick soils and extensive glacial deposits of gravel allow for absorption of a large fraction of precipitation, and the development of large groundwater aquifers (Davis and Browne, 1996). The fractured Carboniferous bedrock prevalent in the study area generally does not allow significant amounts of surface water to accumulate, thus there are few lakes. There are at least 26 smaller lakes within the study region, as well as the largest lake within this province, Lake Ainslie (Alexander et al., 1986).

The characterization to follow of water resources within the region encompasses streamflow and water quality. A section on atmospheric deposition is included due to its direct effects upon water quality in watersheds.

A.8.2 Streamflow

Discharge values for five watersheds within the study area spanning various lengths of time have been collected by the Inland Waters Directorate (for station locations see Figure A.8-1). Plots of this discharge data are presented in Appendix 3. Examples of a yearly stream discharge series based upon monthly averages of the long-term series is presented in Figure A.8-2 for three sites on the Cheticamp River. These series illustrate the typical discharge patterns observed at other sites, with runoff peaking in the spring after snowmelt, reaching the lowest levels in late summer, after which streamflow begins to increase, producing another minor peak. A long-term series of discharge from 1916 to 1991 is illustrated for the Northeast Margaree River at Margaree Valley in Figure A.8-3. Year to year variations in total streamflow as a result of natural variability in climate are commonly observed.

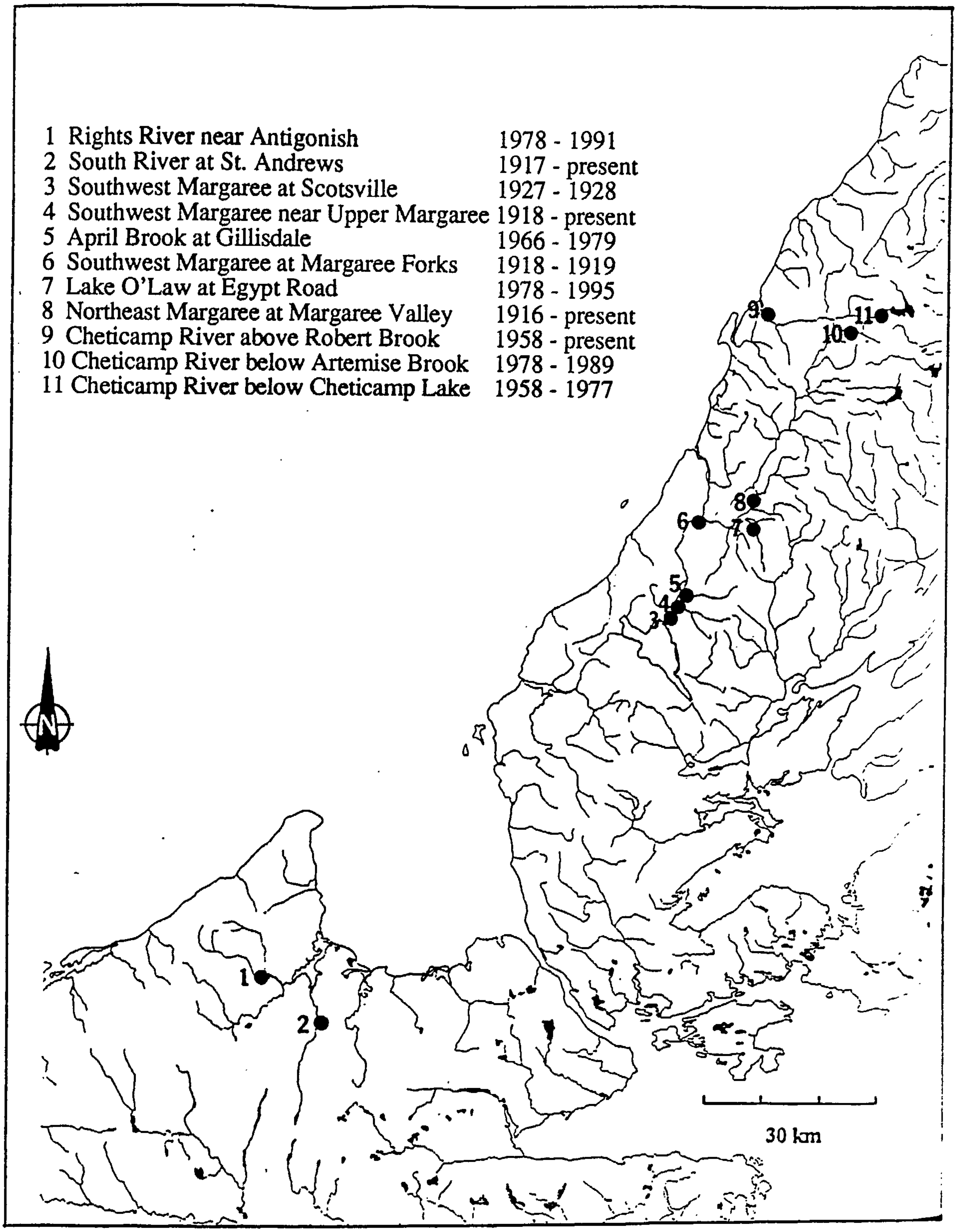
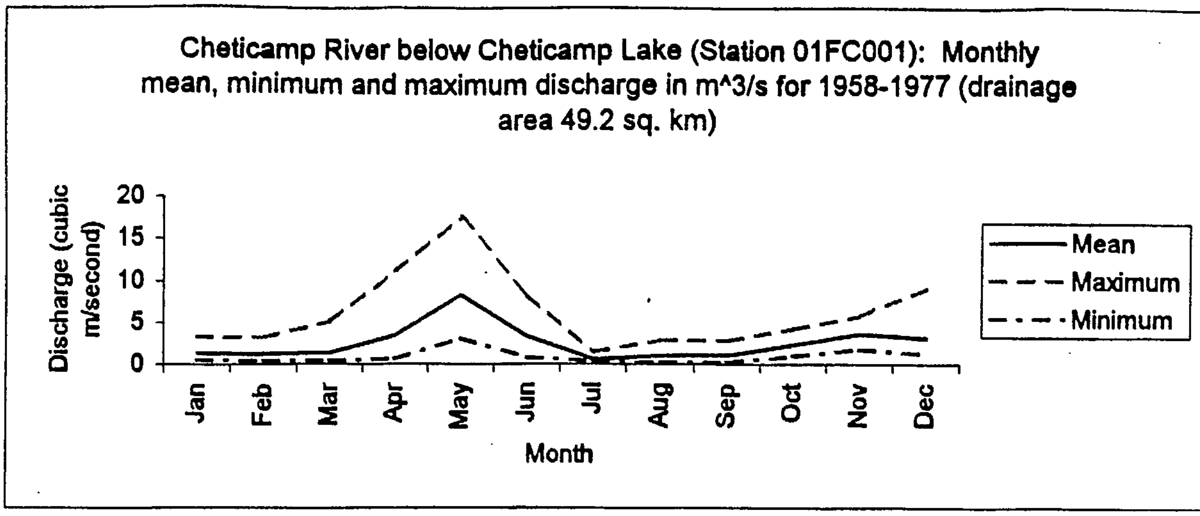
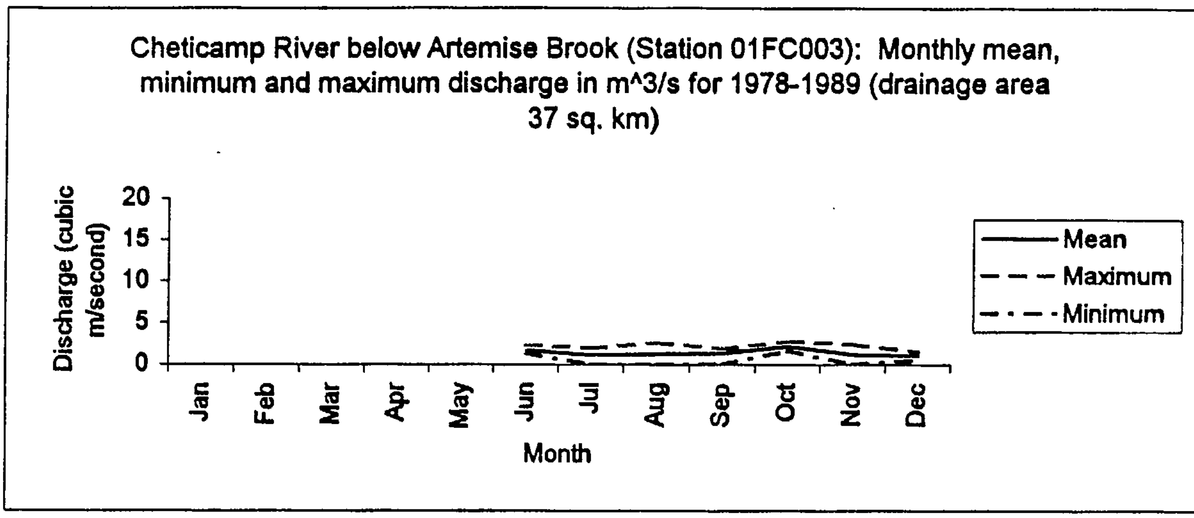


Figure A.8-1. Location of hydrometric stations in study area.





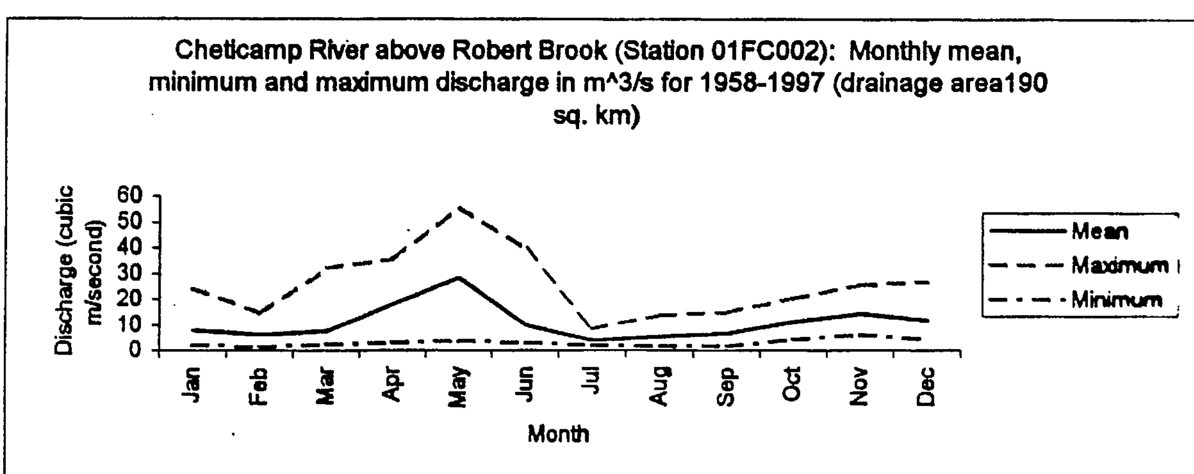


Figure A.8-3. Monthly mean, minimun and maximum stream discharge rates for three sites on the Cheticamp river.

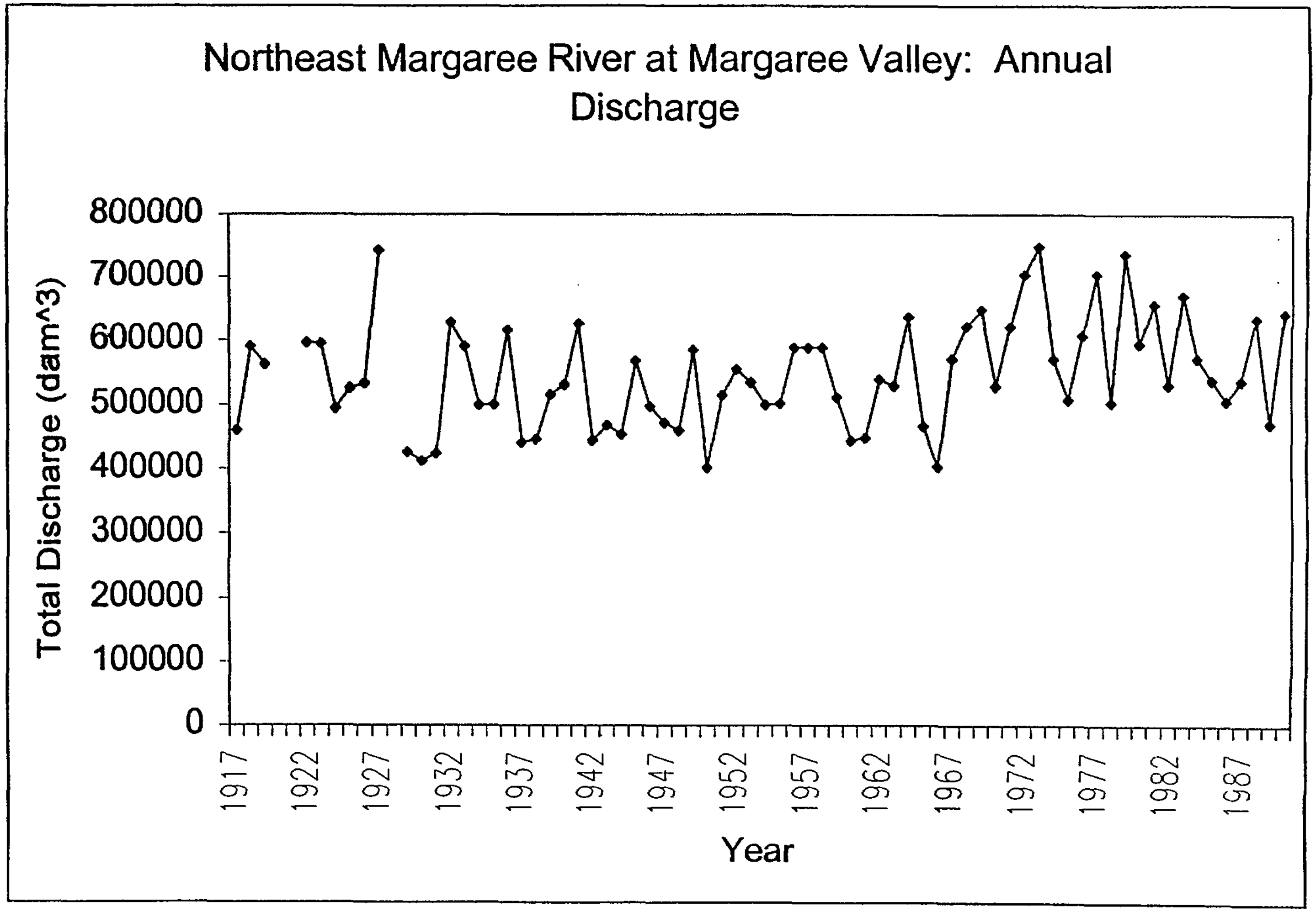


Figure A.8-3: Historic hydrograph of Northeast Margaree River at Margaree Valley, 1917-1991

An analysis of discharge patterns of the northeast Margaree branch was conducted by Peters (1975) for the 1964-1973 period, due to unusually high discharge and a concern that extensive deforestation within the Cape Breton Highlands was having a negative impact on streamflow. It was concluded that the effects of deforestation could not be distinguished from those of climate.

A.8.3 Atmospheric Deposition

It is important to consider contaminant transport into watersheds via the atmosphere. Of widespread concern is the problem of acidic precipitation. Although rainwater is naturally slightly acidic, more pronounced acidification arises from the release of gaseous sulfur and nitrogen compounds which form sulfuric and nitric acids in the atmosphere. The net result is a lowering of the rainwater pH and an increase in sulfate (SO_4^{2-}) and nitrate (NO_3^-) concentrations of rainwater.

Acidification of surface waters as a result of Long Range Transport of Atmospheric Pollutants (LRTAP) has been widely studied. Less information was available about the nature of the precipitation arriving within the study region. Underwood (1979) reported the average pH of precipitation falling on Nova Scotia to be 4.7. Rates of deposition of acid compounds are reported for Port Hood for that time. Underwood et al. (1985) report deposition rates averaging 38 meq/m^2/yr for sulfate and 13 meq/m^2/yr for nitrate (as N) for three sites in Northeastern Nova Scotia. They observed that "40 % of rural deposition occurred when winds accompanied by precipitation events were blowing from the southwest over the 650 km axis of the province". This is consistent with other studies (i.e. Ogden, 1980; Freedman and Ogden, 1981) that identify the area south of the Great Lakes as being an important source of atmospherically-derived pollutants in Nova Scotia. Ogden (1980) found, as did Underwood et al. (1985) that there was a reduction in nitrate and sulfate from west to east within the Province. Sulfate deposition levels have also been reported by Smith-Palmer and Wentzell (1986).

Also of concern is the atmospheric deposition of heavy metals, including mercury. Atmospheric deposition of mercury has been quantified for the study by Rutherford and Matthews (1998). Sites sampled throughout the Maritime provinces included Corney Lake Bog in the Cape Breton Highlands north of Cheticamp. Profiles of sphagnum cores from peat bogs receiving no surface runoff were sampled and revealed a historic trend which was similar to those found in other regions of North America. The pre-industrial deposition rate was estimated at 1.4 $\mu g/m^2/yr$, increasing after industrialization and peaking in the 1960's. Deposition apparently decreased until the early 1980's, and peaked again in the late 1980's the deposition rate for 1992 was estimated at 13 $\mu g/m^2/yr$.

A.8.4 Water Quality

The natural chemical composition of water within the region is controlled by the chemical composition of the incoming precipitation and the nature of the soils and bedrock. Human activities have altered the chemical composition of waters in the region through both atmospheric contamination and land surface contamination. Atmospheric contamination (reviewed in Section A.8.3) occurs in both the form of dry fallout and wet fallout, often altering the chemical signature of the water passing through watersheds. Alterations of land surfaces (through farming or deforestation, for example) alters the rates of weathering and allows for non-point inputs of pollutants such as fertilizers and pesticides. Pumping of wastewaters into natural aquatic environments (as sewage or industrial wastewater, for example) provide point sources of contamination. These activities alter the chemical signature of water in the watersheds, but depending upon the 'natural' signature of the water and the soil and bedrock type, some contaminants may be buffered or removed.

In some areas, the bedrock itself may be responsible for poor water quality. This is particularly evident in areas where sedimentary bedrock such as gypsum dissolves readily producing a 'hard' water, characterized by a high dissolved mineral content. The chemical composition of groundwater has been monitored at various points within the study area by Nolan, Davis and Associates (1987). Groundwater quality data associated with specific geological bodies are presented in Appendix 4.

The surface waters in the study area can be divided according to the three general types of bedrock underlying it. Streams and groundwater in the areas dominated by metamorphic and igneous rock contain low levels of dissolved minerals due to these erosion-resistant rocks. Carboniferous rock tends to contribute more dissolved minerals to surface water and groundwater, whereas those areas abundant in limestone and gypsum (specifically the Windsor Group) contribute greater dissolved minerals (in particular calcium and magnesium). The areas where carbonate rocks are abundant have a high degree of buffering capacities against acid rain.

Conductivity and pH of lakes within the study area which have been surveyed in a longterm initiative by DFO, Nova Scotia Lands and Forests and Canadian Wildlife Service are presented in Appendix 5 (Alexander et al., 1986). Kelly (1976) described Gaspereau Lake as eutrophic in a 1976 study. This report included water quality and chlorophyll levels of the water, and was followed up by another study (Kelly, 1978) of inlet stream quality to identify bacterial and nutrient sources. Miles (1983) provides a general description of an inlet to Gaspereau Lake (MacIsaac's Brook) as it relates to in-stream trout habitat.

Surface water quality data were collected by the IWD for various periods within the 1960's and 1970's for points within five watersheds in the study area. Concentrations of major ions, nutrients, physical parameters and metals and contaminants data are presented in Table A.8-1. Standards for acceptable levels of dissolved materials in water for human consumption and aquatic life are presented in Appendix 6. Other identified sources of water quality data within the study area are fish hatcheries that monitor water quality for facility use, and monitoring programs associated with proposed landfills and sewage and water treatment operations.

Table A.8-1. Concentrations of major ions, nutrients; physical descriptors, metals and contaminants

South River at St. Andrews (Station 00NS01DR0001): Water Quality Data (15/4/69-18/6/74)

Parameter	Symbol	Unit	Mean	Minimum	Maximum
MAJOR IONS					
Calcium	Ca	mg/l	12.94	4.1	34.4
Magnesium	Mg	mg/l	1.8	0.9	3.3
Sodium	Na	mg/l	60	8	160
Potassium	K	mg/l	1.3	0.2	4.1
Chloride	Cl	mg/l	90	12.5	250
Sulphate	SO4	mg/l	23.8	4.8	68.9
Bicarbonate	HCO3	mg/l	18	2	38
Alkalinity (Total)	CaCO3	mg/l	14.9	1.5	31.4
NUTRITIVE SUBSTANCES					
Nitrogen ammonia	N	mg/l	.13*	L .005	0.4
Nitrogen (NO3, NO2)	N	mg/l	.097*	L .005	0.221
Phosphorous (Inorg.)	P	mg/l	.008*	0.001	0.02
Phosphorous (Total)	P	mg/l	.015*	L .005	0.04
Carbon (Total organic)	C	mg/l	3.7	2.8	4.6
PHYSICAL DESCRIPTORS					
Turbidity		JTU	1.2*	L .1	7
Apparent Colour		Rel. units	15*	L 5	40
pH	pH	pH units		5.1	7.7
Conductivity		micro s/cm	401	18	1040
Dissolved Solids (Tot)		mg/l	195	39	494
Hardness (Total)	CaCO3	mg/l	38.5	13.9	99.5
Dissolved Oxygen	DO	mg/l	10.7	9.3	12
METALS & TOXINS					
Cadmium (Extrble.)	Cd	mg/l	.002*	L .001	L .01
Chromium (Extrble.)	Cr	mg/l	0.0033	0.0005	0.006
Copper (Extrble.)	Cu	mg/l	.023*	L .001	0.12
Fluoride (Dissolved)	F	mg/l	.09*	L .05	0.17
Iron (Dissolved)	Fe	mg/l	.026*	L .001	0.11
Lead (Extrble.)	Pb	mg/l	.004*	L .001	0.013
Manganese (Dissolv.)	Mn	mg/l	.01*	L .01	0.01
Mercury (Extrble.)	Hg	micro g/l	.29*	L .05	0.77
Silica (Reactive)	SiO2	mg/l	2.6	1.1	3.6
Zinc (Extrble.)	Zn	mg/l	.017*	L .001	0.05

* statistic includes flagged values (L for low detectable limit, G for high detectable limit)

Table A.8-1 (con't)

South Rights River at Sylvan Valley (Station 00NS01DR0002): Water Quality Data (1/5/71-18/6/74)

Parameter	Symbol	Unit	Mean	Minimum	Maximum
MAJOR IONS					
Calcium	Ca	mg/l	14.45	4.6	35
Magnesium	Mg	mg/l	1.3	0.4	3.2
Sodium	Na	mg/l	5.2	2.2	8.9
Potassium	K	mg/l	0.7	0.3	1.4
Chloride	Cl	mg/l	7.9	2.7	15
Sulphate	SO4	mg/l	26.5	5.9	63
Bicarbonate	HCO3	mg/l	18	9	45
Alkalinity (Total)	CaCO3	mg/l	14.4	7.2	36.7
NUTRITIVE SUBSTANCES					
Nitrogen ammonia	N	mg/l	.09*	L .05	0.1
Nitrogen (NO3, NO2)	N	mg/l	.075*	L .001	0.19
Phosphorous (Inorg.)	P	mg/l	.016*	L .002	0.055
Phosphorous (Total)	P	mg/l	0.015	0.01	0.02
Carbon (Total organic)	C	mg/l	2.3	2.3	2.3
PHYSICAL DESCRIPTORS					
Turbidity		JTU	1.6*	L .1	5.4
Apparent Colour		Rel. units	9*	L 5	30
pH	pH	pH units		5.8	7.8
Conductivity		micro s/cm	113	22	240
Dissolved Solids (Tot)		mg/l	64	24	133
Hardness (Total)	CaCO3	mg/l	41	14.8	94.8
Dissolved Oxygen	DO	mg/l	10.8	9.2	12.4
METALS & TOXINS					
Cadmium (Extrble.)	Cd	mg/l	.002*	L .001	L .01
Chromium (Extrble.)	Cr	mg/l	0.003	0.002	0.004
Copper (Extrble.)	Cu	mg/l	.007*	L .001	0.04
Fluoride (Dissolved)	F	mg/l	.09*	L .05	0.13
Iron (Dissolved)	Fe	mg/l	.021*	L .001	0.04
Lead (Extrble.)	Pb	mg/l	.003*	L .001	0.012
Manganese (Dissolv.)	Mn	mg/l		L .01	L .01
Mercury (Extrble.)	Hg	micro g/l	.09*	L .05	0.12
Silica (Reactive)	SiO2	mg/l	4	2.2	5.5
Zinc (Extrble.)	Zn	mg/l	.013*	L .001	0.03

* statistic includes flagged values (L for low detectable limit, G for high detectable limit)

Table A.8-1 (con't)

Southwest Margaree R.at Upper M. (Station 00NS01FB0011): Water Quality Data (4/4/71-20/6/78)

Parameter	Symbol	Unit	Mean	Minimum	Maximum
MAJOR IONS					
Calcium	Ca	mg/l	9.53	4	14
Magnesium	Mg	mg/l	1.3	0.8	1.9
Sodium	Na	mg/l	10.2	6.2	15
Potassium	K	mg/l	0.8	0.4	2.5
Chloride	Cl	mg/l	16.4	11	23
Sulphate	SO4	mg/l	15.2	5	29
Bicarbonate	HCO3	mg/l	17	5	25
Alkalinity (Total)	CaCO3	mg/l	14.1	4.5	20.3
NUTRITIVE SUBSTANCES					
Nitrogen ammonia	N	mg/l	.048*	L .005	0.1
Nitrogen (NO3, NO2)	N	mg/l	.018*	L .001	0.14
Phosphorous (Inorg.)	P	mg/l	.011*	L .002	0.05
Phosphorous (Total)	P	mg/l	0.017	0.005	0.11
Carbon (Total organic)	C	mg/l	5	1.6	15.5
PHYSICAL DESCRIPTORS					
Turbidity		JTU	1.5*	L .1	7.8
Apparent Colour		Rel. units	8*	L 5	30
pH	pH	pH units		6	7.6
Conductivity		micro s/cm	116	64	166
Dissolved Solids (Tot)		mg/l	61	33	85
Hardness (Total)	CaCO3	mg/l	29	13.5	42
Dissolved Oxygen	DO	mg/l	12.3	9.2	14.7
METALS & TOXINS					
Cadmium (Extrble.)	Cd	mg/l	001*	L .001	0.002
Chromium (Extrble.)	Cr	mg/l	0017*	L .0005	0.003
Copper (Extrble.)	Cu	mg/l	006*	L .001	0.06
Fluoride (Dissolved)	F	mg/l	.1*	L .05	0.17
Iron (Dissolved)	Fe	mg/l	01*	L .001	0.02
Lead (Extrble.)	Pb	mg/l	003*	L .001	0.006
Manganese (Dissolv.)	Mn	mg/l	013*	L .01	0.02
Mercury (Extrble.)	Hg	micro g/l	06*	L .05	0.15
Silica (Reactive)	SiO2	mg/l	3	0.8	5.2
Zinc (Extrble.)	Zn	mg/l	009*	L .002	0.029

* statistic includes flagged values (L for low detectable limit, G for high detectable limit)

Table A.8-1 (con't)

April Brook at Gillisdale (Station 00NS01FB0005): Water Quality Data (21/12/70-20/6/78)

Parameter	Symbol	Unit	Mean	Minimum	Maximum
MAJOR IONS					
Calcium	Ca	mg/l	104.69	28	245
Magnesium	Mg	mg/l	5.4	2	15
Sodium	Na	mg/l	19.3	6.5	44.5
Potassium	K	mg/l	1.2	0.1	3.5
Chloride	Cl	mg/l	26.5	4.3	56
Sulphate	SO4	mg/l	232.7	72.6	640
Bicarbonate	HCO3	mg/l	55	4	122
Alkalinity (Total)	CaCO3	mg/l	45.7	3.5	100
NUTRITIVE SUBSTANCES					
Nitrogen ammonia	N	mg/l	.071*	L .005	0.3
Nitrogen (NO3, NO2)	N	mg/l	.078*	L .005	0.36
Phosphorous (Inorg.)	P	mg/l	.019*	L .001	0.135
Phosphorous (Total)	P	mg/l	.008*	0.001	0.013
Carbon (Total organic)	C	mg/l	2.9*	L .5	7.5
PHYSICAL DESCRIPTORS					
Turbidity		JTU	1.5*	L .1	7
Apparent Colour		Rel. units	7*	L 5	30
pH	pH	pH units		6.3	8.1
Conductivity		micro s/cm	625	225	1242
Dissolved Solids (Tot)		mg/l	404	149	1039
Hardness (Total)	CaCO3	mg/l	276.6	79.8	657.1
Dissolved Oxygen	DO	mg/l	12.4*	G 15	10.1
METALS & TOXINS					
Cadmium (Extrble.)	Cd	mg/l	.001*	L .001	0.01
Chromium (Extrble.)	Cr	mg/l	0.002	0.002	0.002
Copper (Extrble.)	Cu	mg/l	019*	L .001	0.28
Fluoride (Dissolved)	F	mg/l	0.31	0.13	0.62
Iron (Dissolved)	Fe	mg/l	013*	L .001	0.04
Lead (Extrble.)	Pb	mg/l	004*	L .001	0.02
Manganese (Dissolv.)	Mn	mg/l	01*	L .01	0.01
Mercury (Extrble.)	Hg	micro g/l	05*	L .05	0.08
Silica (Reactive)	SiO2	mg/l	4.9	1.9	7
Zinc (Extrble.)	Zn	mg/l	02*	L .001	0.25

* statistic includes flagged values (L for low detectable limit, G for high detectable limit)

Table A.8-1 (con't)

Northeast Margaree R. at M. Valley (Station 00NS01FB0001): Water Quality Data (21/8/65-19/7/78)

Parameter	Symbol	Unit	Mean	Minimum	Maximum
MAJOR IONS					
Calcium	Ca	mg/l	11.84	2.2	25
Magnesium	Mg	mg/l	1.4	0.7	3.3
Sodium	Na	mg/l	16.1	3	41
Potassium	K	mg/l	0.7	0.3	2.3
Chloride	Cl	mg/l	26	3.9	64
Sulphate	SO4	mg/l	21.8	4.5	55
Bicarbonate	HCO3	mg/l	14*	Q 1	30
Alkalinity (Total)	CaCO3	mg/l	11.4*	L 0	24.5
NUTRITIVE SUBSTANCES					
Nitrogen ammonia	N	mg/l	.116*	L .005	0.4
Nitrogen (NO3, NO2)	N	mg/l	.098*	L .005	0.904
Phosphorous (Inorg.)	P	mg/l	.009*	L .002	0.046
Phosphorous (Total)	P	mg/l	.008*	0.001	0.025
Carbon (Total Organic	C	mg/l	3.9	1.5	6.6
PHYSICAL DESCRIPTORS					
Turbidity		JTU	1.3*	L .1	17
Apparent Colour		Rel. units	12*	L 5	60
pH	pH	pH units		5.9	7 7
Conductivity		micro s/cm	159	2	429
Dissolved Solids (Tot)		mg/l	83*	22	185
Hardness (Total)	CaCO3	mg/l	35	12	76
Dissolved Oxygen	DO	mg/l	12.4	10	14 6
METALS & TOXINS					
Cadmium (Extrble.)	Cd	mg/l	.001*	L .001	0.001
Chromium (Extrble.)	Cr	mg/l	0.0055	0.002	0.009
Copper (Extrble.)	Cu	mg/l	.014*	L .001	0.07
Fluoride (Dissolved)	F	mg/l	.13*	L .05	0.75
Iron (Dissolved)	Fe	mg/l	.024*	L .001	0.08
Lead (Extrble.)	Pb	mg/l	.002*	L .001	0.01
Manganese (Dissolv.)	Mn	mg/l		L .01	L .01
Mercury (Extrble.)	Hg	micro g/l	.05*	L .05	0 1
Silica (Reactive)	SiO2	mg/l	5.9	0.9	10 1
Zinc (Extrble.)	Zn	mg/l	.012*	L .001	0.04

* statistic includes flagged values L for low detectable limit, G for high detectable limit,

Table A.8-1 (con't)

Cheticamp River above Robert Brook (Station 00NS01FC0004): Water Quality Data (8/6/72-21/6/78)

Parameter	Symbol	Unit	Mean	Minimum	Maximum
MAJOR IONS					
Calcium	Ca	mg/l	1.87	0.8	4.2
Magnesium	Mg	mg/l	0.9	0.5	1.4
Sodium	Na	mg/l	4.8	2.9	7.1
Potassium	K	mg/l	0.5	0.3	0.8
Chloride	Cl	mg/l	8.2	4.5	13.2
Sulphate	SO4	mg/l	4.4	2	10
Bicarbonate	HCO3	mg/l	5*	Q 1	14
Alkalinity (Total)	CaCO3	mg/l	4.1*	L .5	11.5
NUTRITIVE SUBSTANCES					
Nitrogen ammonia	N	mg/l	.041*	L .005	0.2
Nitrogen (NO3, NO2)	N	mg/l	.06*	L .001	0.23
Phosphorous (Inorg.)	P	mg/l	.01*	0.003	0.025
Phosphorous (Total)	P	mg/l	.01*	0.003	0.05
Carbon (Total organic)	C	mg/l	7.7	3.9	12
PHYSICAL DESCRIPTORS					
Turbidity		JTU	.5*	L .1	2.1
Apparent Colour		Rel. units	48*	10	G 100
pH	pH	pH units		5.2	7.9
Conductivity		micro s/cm	43	24	68
Dissolved Solids (Tot)		mg/l	23*	14	37
Hardness (Total)	CaCO3	mg/l	8.2	4.1	15.8
Dissolved Oxygen	DO	mg/l	12.6	9	14.8
METALS & TOXINS					
Cadmium (Extrble.)	Cd	mg/l	.001*	L .001	0.001
Chromium (Extrble.)	Cr	mg/l	.0005*	L .0005	0.0005
Copper (Extrble.)	Cu	mg/l	.002*	L .001	0.01
Fluoride (Dissolved)	F	mg/l	.08*	L .05	0.1
Iron (Dissolved)	Fe	mg/l	0.033	0.01	0.08
Lead (Extrble.)	Pb	mg/l	.003*	L .001	0.008
Manganese (Dissolv.)	Mn	mg/l		L .01	L .01
Mercury (Extrble.)	Hg	micro g/l	.05*	L .05	0.05
Silica (Reactive)	SiO2	SiO2	5.3	2.4	8.8
Zinc (Extrble.)	Zn	Zn	0.014	0.002	0.038

* statistic includes flagged values L for low detectable limit, G for high detectable limit,

Table A.8-1 (con't)

MacKenzie River at Cabot Trail (Station 00NS01FC0003): Water Quality Data (8/6/72-5/6/74)

Parameter	Symbol	Unit	Mean	Minimum	Maximum
MAJOR IONS					
Calcium	Ca	mg/l	3.24	1.5	6.8
Magnesium	Mg	mg/l	1	0.6	1.5
Sodium	Na	mg/l	6.8	4.3	10
Potassium	K	mg/l	0.6	0.4	0.8
Chloride	Cl	mg/l	11.7	6.4	20
Sulphate	SO4	mg/l	4.8	2.9	8
Bicarbonate	HCO3	mg/l	9	2	24
Alkalinity (Total)	CaCO3	mg/l	7	1.6	19.4
NUTRITIVE SUBSTANCES					
Nitrogen ammonia	N	mg/l	.071*	L .005	0.1
Nitrogen (NO3, NO2)	N	mg/l	0.051	L .001	0.13
Phosphorous (Inorg.)	P	mg/l	0.012	0.002	0.02
Phosphorous (Total)	P	mg/l	0.013	0.01	0.015
Carbon (Total organic)	C	mg/l	5	4.9	5.2
PHYSICAL DESCRIPTORS					
Turbidity		JTU	.2*	L .1	1
Apparent Colour		Rel. units	34	5	100
pH	pH	pH units		5.7	7.1
Conductivity		micro s/cm	63	35	87
Dissolved Solids (Tot)		mg/l	32	20	42
Hardness (Total)	CaCO3	mg/l	12.3	6.2	20.7
Dissolved Oxygen	DO	mg/l	13.3	12.8	13.8
METALS & TOXINS					
Cadmium (Extrble.)	Cd	mg/l	.001*	L .001	0.001
Chromium (Extrble.)	Cr	mg/l	.0007*	L .0005	0.001
Copper (Extrble.)	Cu	mg/l	.006*	L .001	0.017
Fluoride	F	mg/l	.12*	L .05	0.18
Iron (Dissolved)	Fe	mg/l	.024*	L .001	0.06
Lead (Extrble.)	Pb	mg/l	.005*	L .001	0.018
Manganese (Dissolv.)	Mn	mg/l		L .01	L .01
Mercury (Extrble.)	Hg	micro g/l	.13*	L .05	0.21
Silica (Reactive)	SiO2	mg/l	5.4	1.3	9.1
Zinc (Extrble.)	Zn	mg/l	0.022	0.011	0.04

*statistic includes flagged values (L for low detectable limit, G for high detectable limit)

A.8.4.1 Major Ions

The IWD major ion data collected and presented in Table A.8-1 are also presented for individual ions such that comparisons can be made between stations. These plots can be found in Appendix 7. Calcium, magnesium and sulphate concentrations are very elevated at April Brook relative to other stations. This likely reflects the presence of soluble sedimentary rocks. Sodium and chloride concentrations were most elevated at the South River site, whereas potassium varied little amongst sites. Bicarbonate and alkalinity measurements are most elevated at the April Brook site, indicating that it has a high capacity to buffer acid rain. Concentrations of major ions were lowest at the Cheticamp and MacKenzie Rivers, pointing to drainage over less soluble bedrock. These rivers also have the lowest acid-buffering capacity in the region, as indicated by the low bicarbonate and alkalinity readings.

Data from extensive studies conducted on Lake Ainslie (Taylor, 1994; Geen, 1965) and Gaspereau Lake (Kelly, 1976; 1978) have been published.

A.8.4.2 Nutrients

Measures of dissolved nitrogen, phosphorus and carbon concentrations can be important indicators of pollution inputs. However, the data presented in Table A.8-1 was collected several decades ago and may not reflect current concentrations. These data are presented for each chemical form measured for all sites to allow for comparison (Appendix 8). It is important to be aware of the range (particularly the maximum) of measured concentrations. At the time the monitoring was conducted, dissolved inorganic nitrogen (mainly nitrate) was found in relatively low concentrations, well below the drinking water standards. Maximum concentrations were observed at the Northeast Margaree River, but never exceeded 1 mg/l N. Phosphorus concentrations tended to remain low at all sites. The most recent information is available for the Margaree and Cheticamp Rivers from a study by Dalziel et al. (1998). No information was found relating directly to agricultural runoff within the study area.

A.8.4.3 Physical Descriptors

The physical characteristics of the surface waters in the study region are listed in Table A.8-1. The entire set of measurements for all stations are presented for each measurement type in the figures in Appendix 9.

The Atlantic Region Federal-Provincial Toxic Chemical Survey of Municipal Drinking Water Sources for 1985-1988 (Anonymous, undated 1) included Antigonish, Judique, Mabou and Inverness. Inorganic and organic parameters were found to meet drinking water standards. However, aesthetic objectives relating to water colour were not met in Antigonish and Judique. Colour is a result of organic acids which may contribute to the formation of trihalomethanes during chlorination (Anonymous, undated). In January, 2000, Atlantic Television News broadcasted findings of elevated levels of organochlorines in the Antigonish town drinking water.

The average pH was in the range of 7-8. Minimum measurements, which fell below the water quality standard of 6.5, were observed at all stations. The lowest pH readings, which fell below 5.5, were observed at South and Cheticamp Rivers. Clair et al. (1982) has identified northern Cape Breton as being among the most sensitive areas in the Atlantic Provinces to acid precipitation. This is consistent with the low pH measurements and the low alkalinity. On average, it is estimated that 80% of the alkalinity has been lost, largely due to the incapacity of the bedrock to buffer the effects of long range transport of atmospheric pollutants (Anonymous, 1987a). According to this source, the trend of decreasing pH in the 1960's and 1970's has since been reversed.

Studies of the sensitivities of lakes to acid rain have also been widespread within the region. Machell et al. (1985) found a high sensitivity of Copper Lake (Antigonish County), as well as a marked seasonal variability which would likely render the lake much more sensitive to acid rain during the winter months. An unnamed lake in the vicinity of Cheticamp was also included in the study of lake acidification by Underwood et al. (1985). Data specific to the lake was not included in the report.

Conductivity measurements again reflect the general pattern of low solubility of igneous and metamorphic bedrock versus soluble sedimentary bedrock within rivers of the region. April Brook had the most elevated conductivity measurements at 625 μS/cm, with South River as the next highest. Cheticamp and MacKenzie Rivers had by far the lowest conductivity. These data are consistent with the major ion concentrations discussed in Section A.8.4.1, as are the total dissolved solids (TDS) measurements. The highest TDS were observed at April Brook (on average, 404 mg/l), while the Cheticamp and MacKenzie Rivers had extremely low TDS (on average, 23 and 32 mg/l, respectively).

Dissolved oxygen, which can be an important indicator of excessive nutrient loading, had elevated values, always in excess of 10 mg/l during the period of the sampling. Low dissolved oxygen measures never fell below 8 mg/l.

A.8.4.4 Heavy Metals and Contaminants

Heavy metal and contaminant levels for the IWD sample sites in the study area are listed in Table A.8-1, and are shown for each species for all sites in Appendix 10. There is no evidence of unusually elevated concentrations of any of these dissolved species at the time of sampling. A number of detailed studies have been conducted at sites within the study region, and are reviewed below.

Belliveau and Bailey (1983) investigated concentrations of inorganic contaminants in surface water and aquatic sediment. Arsenic, cadmium, lead and mercury were measured in at least one sampling site within the study area. In Lake Ainslie, only cadmium levels in sediment was found at high levels (0.6 – 1.0 mg/kg) relative to guidelines set at 0.6 mg/kg for ocean dumping of dredged sediment. Baker and Matheson (1980) examined stream sediments at Cape George, Antigonish, Margaree, and Lake Ainslie and found each site gave low values of 1 μg/g to high values ranging from 8 to 27 μg/g, and all averaged between 1.1 and 1.5 μg/g. Cadmium is normally found at trace levels in waters.

Cadmium in American eel tissue was found at levels from 0.019 to 0.028 ppm in Lake Ainslie and Margaree River (Hutchinson and Taylor, 1979).

Mercury levels are reported in surface waters at St. Andrews on South River, at 0.045 ppb and on the South Rights River at 0.12 maximum with a mean of 0.073 ppb. Margaree, MacKenzie and Cheticamp river samples produced mean values of 0.05 to 0.097 ppb, with maximums of 0.10 to 0.21 ppb (Sherbin, 1979). Another study by Wilson and Travers (1976) identified sites at Pleasant Bay and Port Hastings as having mean mercury levels between 0.1 and 0.2 ppb. The acceptable level for mercury in water for the protection of aquatic life is 0.1 μg/L, or 0.1 ppb (Anonymous, 1994a).

Mercury has been found in tissue samples of American eel from Antigonish, Margaree and Pleasant Bay at concentrations less than 0.5 ppm and in trout from Lake Ainslie area at the same concentration (Wilson and Travers, 1976). Sherbin (1979), found similar results for Margaree and Cheticamp. The allowable level of mercury for marketable fish is 0.5 ppm.

Hutchinson and Taylor (1979) found mercury levels from 0.166 to 0.336 ppm in Lake Ainslie and Margaree river. In 1981, Hutchinson included Pomquet Harbour as a sampling site and found an average mercury level of 0.119 ppm in American eel tissue.

A stream near Georgeville was analysed in 1988 for dissolved and particulate metals (Harding, pers.comm.).

Surveys for organic contaminants in the aquatic environment in the region have not revealed areas of concern within the study area. Water from Lake Ainslie and the Northeast Margaree River were examined for chlorinated benzenes, mirex, PCP, phthalatic acid esters, PAH and triaryl phosphates, and sediment from Lake Ainslie were tested for the above, substituting PCB for PCP. PAH levels of 0.081 mg/kg (0.081ppm) were reported in Lake Ainslie sediment, however, this was a relatively low value among the sample sites. Many 'background' sample sites yielded PAH concentrations above samples collected near industrial areas, questioning current knowledge of PAH distribution mechanisms (Baker and Matheson, 1980). World Health Organization guidelines for drinking water are 0.200 μg/L (0.0002 ppm) (Bailey and Howell, 1983).

Summary

Characteristic annual streamflow patterns are clearly present within the study region, with elevated discharges during spring and late fall periods, and minimum discharges during the late summer. Year to year variations are evident and more extensive research is needed to determine whether variations are solely a result of climatic variations, or whether land use changes have altered the distribution of streamflow. Similarly, the limited water-quality data suggests that water chemistry within the study region is largely controlled by the underlying bedrock type. Detailed studies conducted within the St. Georges Bay region point to the effects of long-range transport of atmospheric pollutants as having an impact on water quality, particularly acid rain. Clearly, the underlying bedrock in some parts of the study area provide a good buffering capacity, however in some areas the opposite is true. Evidence of contamination of surface waters by mercury is also documented.

B. HUMAN ACTIVITIES, ECONOMICS AND IMPACTS

The study area, although settled by Europeans for centuries, has not experienced continuous economic growth. Largely external economic factors have depressed the economy and curtailed human industrial activity. This has resulted in an economy that is only capable of maintaining a small population. The external factors, by and large, have revolved around historical regional political-economy trends which saw investment capital directed away from the Atlantic provinces (Inwood, 1993). The impacts of European settlement and population growth in the study area, have not, therefore been as substantial as may be expected for an area settled for such a period by Europeans.

Characterizing the activity of the area initially met with difficulty because the information is collected along political borders that do not correlate with the boundaries and natural physiographic regions of the study area. Thus, information pertaining to the portion of the study area in Pictou County was available within values of subdivision encompassing a large portion of Pictou County (Figure B-1). Information on that subdivision would in no way represent the character of the small portion of the subdivision. In description of human activity other than the fisheries, this portion of the study area was excluded, although in a general sense would be reflected in discussions of the Cape George area.

The rest of the study area was addressed with county-level statistics, which were understood to be inexact, but somewhat representative. Specific problems were encountered and will be discussed as they become relevant. In some cases, information is available at the subdivision level within counties. Additional information may be purchased from Statistics Canada, however, uncertainty in level of detail at which the information will be provided makes it difficult to know if the cost is justified.

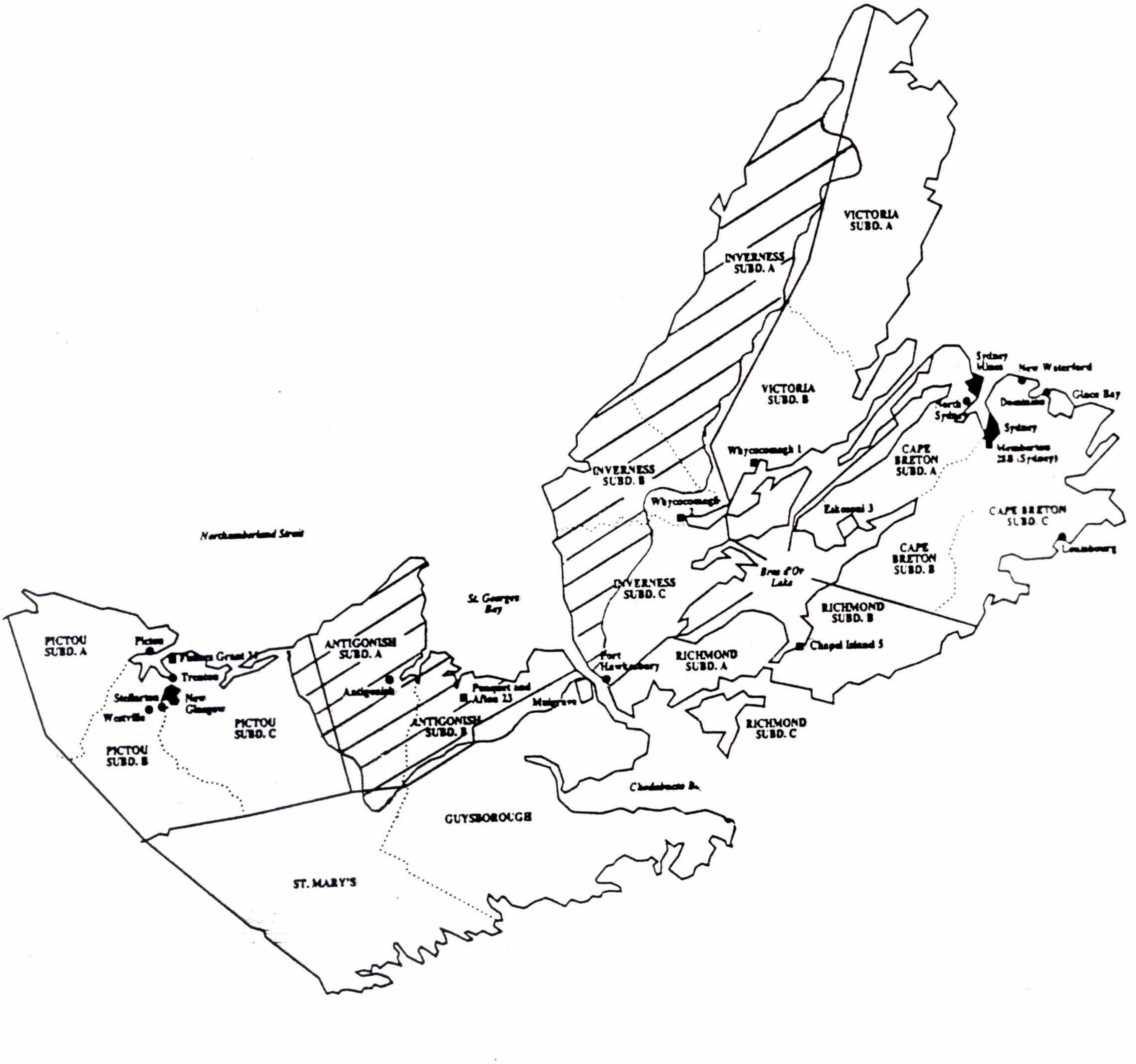


Figure B-1: Study area in relation to statistical subdivisions, Statistics Canada

Annual publications of sector activities by the government departments responsible for them provide detailed information at the provincial level, or broad information at the county level. Generally the trend has been to publish less actual data. In some cases, what data is available is categorized differently over time, so continuous time series up to present are no longer available.

Academic and government research on fisheries and fish biology was extensive and information was accessible. This information concentrated heavily on geographical areas of commercial significance.

A significant problem with publication of financial data is that if general sector values are given, and it is known that only one or two facilities operate in the area described, there is a breach of confidentiality by the government in its use of the statistics collected. Thus any county-level descriptions of fish, forest, agriculture processing, or mining was difficult to quantify other than by numbers of people employed.

Two significant initiatives are underway. The Department of Natural Resources (DNR) is compiling and mapping all land use activities in one database towards the goal of Integrated Resource Management. The draft is expected to be ready by July,1999 (D. Harris, pers. comm.). In addition, the Province of Nova Scotia will begin within the year to organize its land-based information at the watershed level (D. Moerman, pers. comm.).

B.1 INDUSTRY

B.1.1 Fisheries

The commercial fishery has been, and remains, a primary industry of the area. There are 42 ports landing 46 species of shellfish and finfish. The "most significant" species (i.e., large volume landings, landed over a large portion of the study area, or under fishing pressure as emphasis is shifted due to stock closures) are presented in detail below; however, it must be recognized that some of the species not treated in this detail are equally significant in terms of landed values (e.g., bluefin tuna). Rather than analyzing each port individually, the top five or six ports are selected based on the summation of their individual landings from 1990-1998 and these are presented in some detail.

Fishing management areas are outlined for the different species in Figures B.1-1 to B.1-4.

Data for the following fisheries section were provided by the Statistics Branch of the Department of Fisheries and Oceans (Moncton).

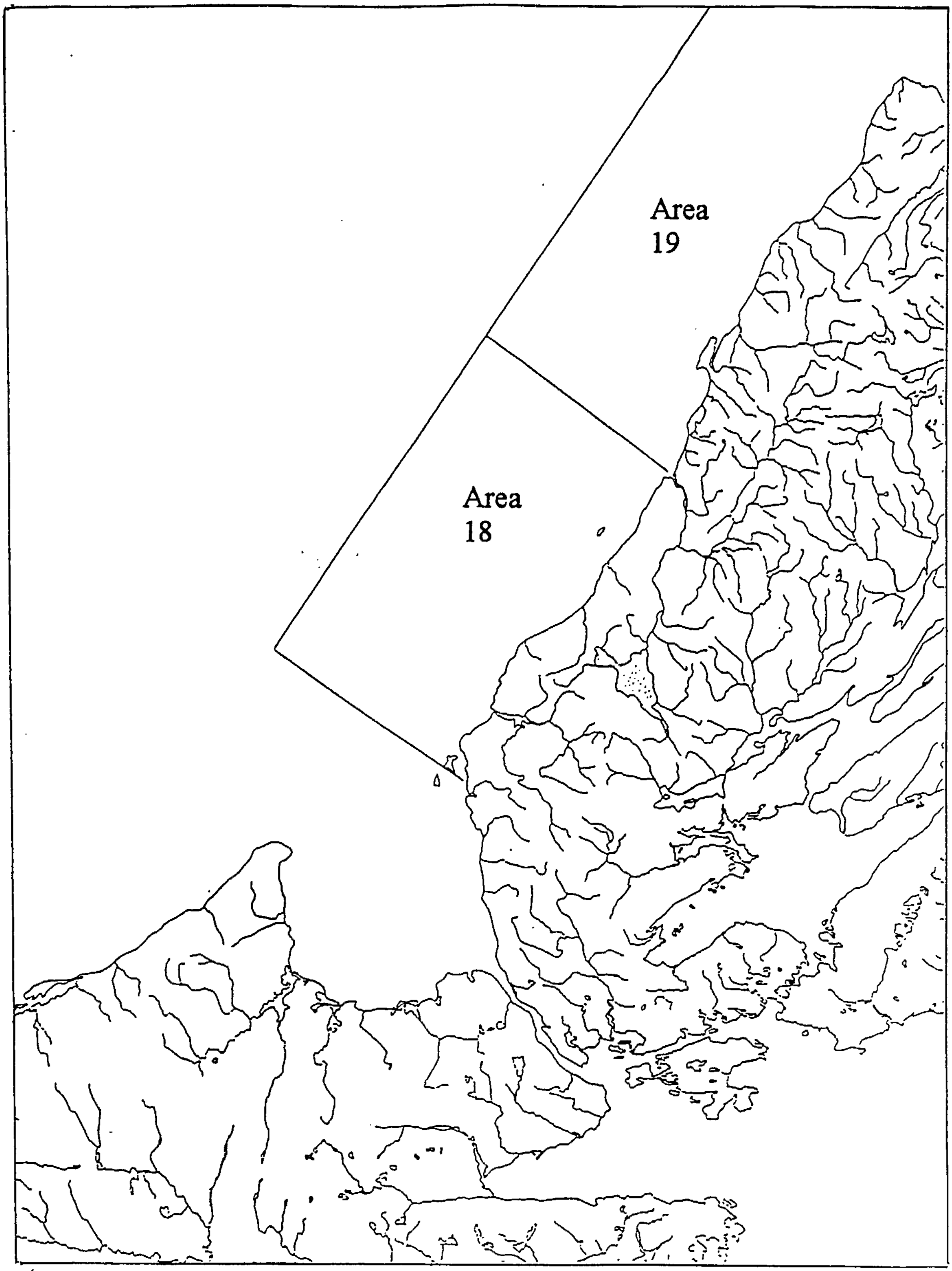


Figure B1-1: Snow crab fishing Areas within the St. Georges Bay Ecosystem Project study area.

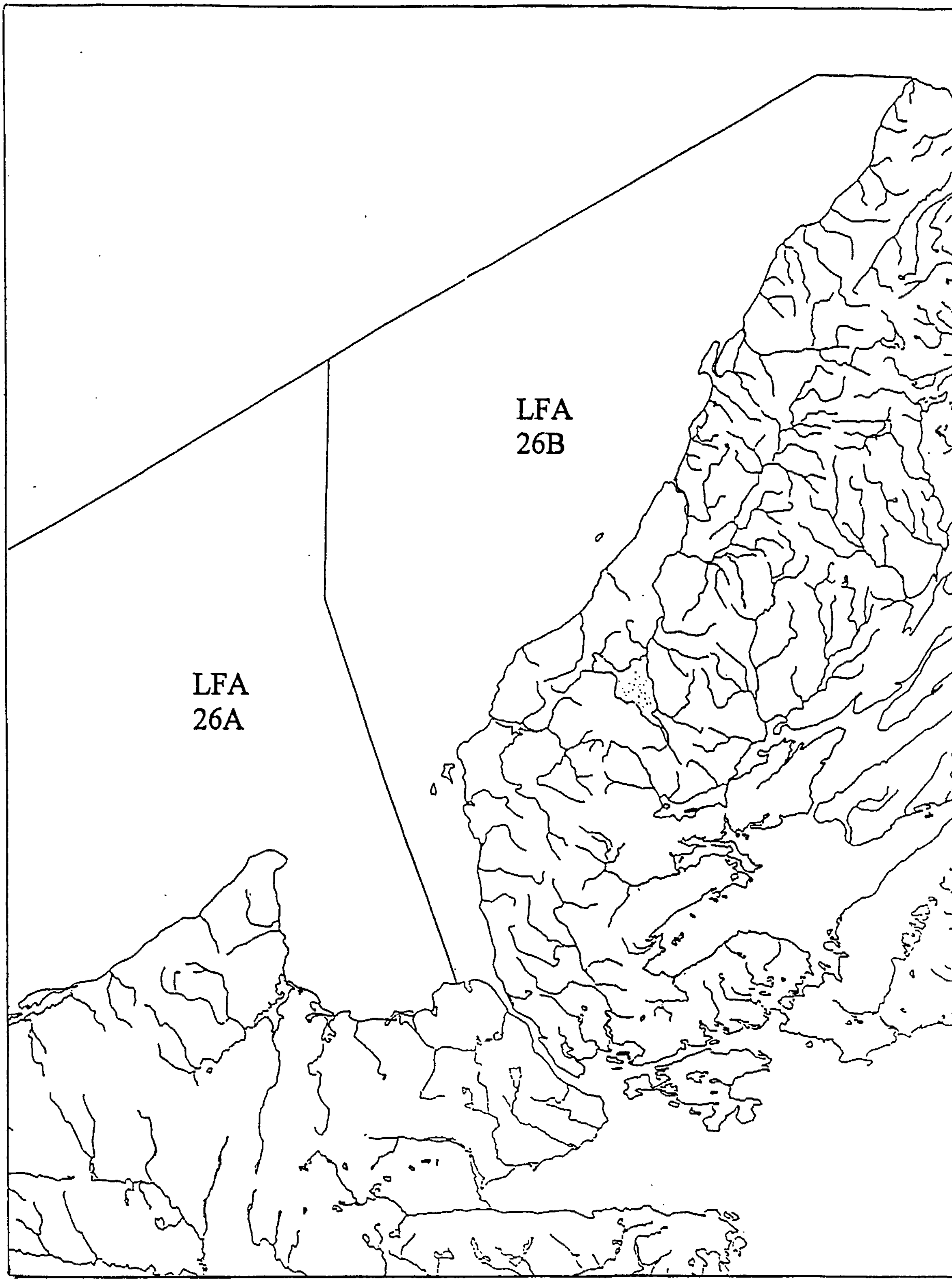


Figure B1-2: Lobster Fishing Areas (LFA's)within the St. Georges Bay Ecosystem project study area.

Figure B1-3: Scallop Fishing Areas (SFA's) within the St. Georges Bay Ecosystem Project study area.

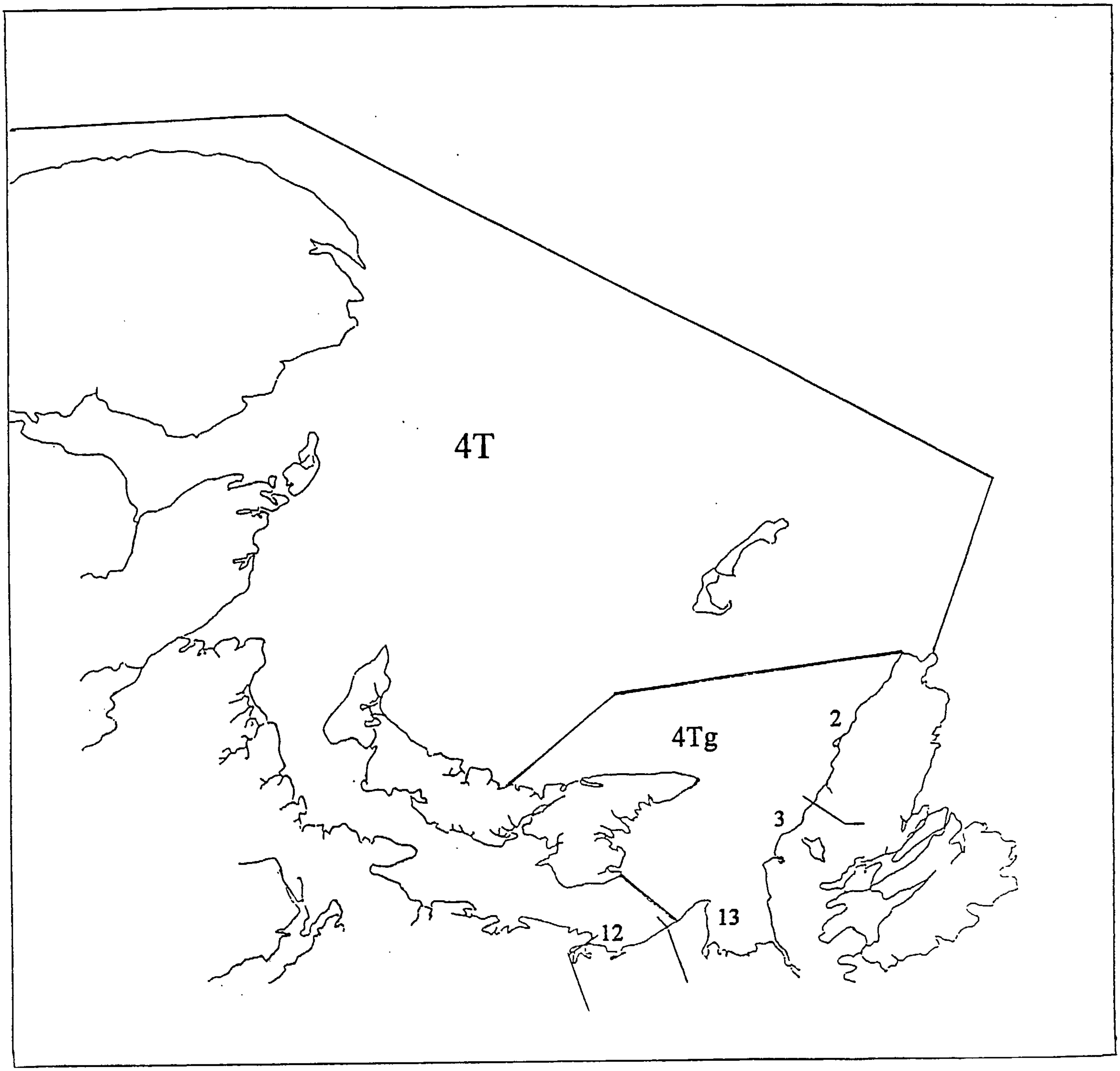


Figure B1-4: Area, Subarea and Statistical Districts of St. Georges Bay study area within the Gulf of St. Lawrence Region.

B.1.1.1 Invertebrates

B.1.1.1.1 Snow Crab *(Chionoecetes opilio)*

BIOLOGY/NATURAL HISTORY

Within the St. Georges Bay Ecosystem Project study area, snow crab are only found at commercial densities along the western edge of Cape Breton (Anonymous, 1990). This area provides the appropriate depth, water temperature and substrates for snow crab ecology (see Section A4.1 –Oceanography). Snow crab live most commonly on muddy or sand-mud bottoms at temperatures ranging from -0.5 to 4.5°C and, off of Cape Breton, they are typically found at depths between 5 and 245 m (Anonymous, 1990). Snow crab do not tend to travel great distances, Dufour (1988) reports that 99% of crabs tagged off of Cape Breton moved <20 km over a five year period. He suggests that bays, gullies and other obstacles may affect the direction and distance of crab movements, thereby restricting them to certain areas. This tendency to not migrate over long distances results in the crabs being susceptible to overexploitation in areas geographically removed from dispersal sources.

As with all crustaceans, growth is accomplished by moulting, the shedding of the exoskeleton and growth of a new one. After the shedding of a shell, the hardening of the successive carapace is a gradual process which requires time. While the shell is soft, the crab has no market value, and since 1976 the retention of these crabs has been prohibited by regulation, and at times has resulted in the early closure to fishing seasons (1997 and 1997 in Area 18) when the number of these animals captured was elevated (Hebert et al. 1998). Growth is slow in the cold waters, by the time an animal has grown to minimum legal size (95 mm carapace width [CW]) they are thought to be at least six years old (Anonymous, 1990). Snow crabs are thought to undergo terminal molt, a final shedding of the exoskeleton after which there is no further growth for the life of the animal (Loch et al. 1995). It is after this moult that the male crabs become sexually mature and competent to breed. The females are thought to remain smaller than 95 mm carapace width throughout their life and so do not enter the fishery at all.

FISHERIES

The snow crab fishery consists of setting baited traps and leaving them for periods of time ('soak-time') up to four days. Fishermen harvest patches of snow crabs averaging 3.5 to 5 km in diameter and move from patch to patch during the fishing season (Hebert et al., 1998). Meat, once removed from the shell, is either quickly frozen or processed in cans (Anonymous, 1990).

There are two management areas for snow crab within the St. Georges Bay project study area, Area 18 extending from approximately Port Hood along the Cape Breton shore to approximately the Margaree River, and Area 19 extending from the Margaree north into Cabot Strait (Hebert et. al, 1998). Both of these areas extend approximately 35 km off the western Cape Breton shore (Figure B1-1). The fishing effort for snow crab within this area is concentrated north of Cheticamp (Anonymous, 1998a).

HISTORY

The snow crab fishery in Atlantic Canada is a recent industry. In 1965 a Danish seine fishery for these crabs was initiated off of Cheticamp (Hare and Dunn, 1993), with the establishment of Management Area 19 in 1978 and Area 18 in 1979 (Loch et al., 1995). These areas are known as the inshore fishery, with the central Gulf being termed the "midshore" fishery. Between 1965 and the present several management actions were taken in attempts to regulate the fishery, including (from Hare and Dunn, 1993; Hebert et al., 1997):

1972 – Issuance of specific crab licenses

1975 – Closed season January 1-January 31

Limited entry (participants clause) into fishery

Restriction on female crabs

1976 – Minimum size of crabs set at 95 mm carapace width (CW)

Restriction of soft shelled crabs

1978 - Establishment of Area 19 (trap limit of 30 traps)

Requirement for tagging gear

Moratorium on issuance of new snow crab licenses

Prohibition of mid-shore fleet from fishing Area 19

1979 – Establishment of Area 18 (trap limit of 30 traps)

1981 – Quota of 835 tonnes instituted for Area 18

1982 – Introduction of minimum mesh size of 130 mm for crab traps

1984 – Establishment of new boundaries for Area 19

Prohibition of mid-shore fleet from fishing Area 18

1986 – Opening date of April 12th established (traps set four days earlier)

10 week season terminating on June 20th (eventually extended to June 29) traps removed by July 1st.

Area 18 quota reduced to 626 tonnes

1988 – Season April 10th to June 18th

Area 18 quota increased to 674 tonnes

1989 – Season April 9th to June 17th

1991 – 200 tonne quota set in Area 18 to promote Spring fishery

674 tonne quota set for Area 18 Fall and Spring fishery combined

1992-93 – Quota in Area 18 raised to 749 tonnes

- Quota in Area 19 1,686 tonnes

1995 – Area 18 Spring fishery abolished

1996 – Total quota for Area 18 set at 340 tonnes

1997 – Area 18 season June 9- Aug 15, Quota 580 tonnes

Area 19 season July 15 – Sept. 2, Quota 1386 tonnes.

Area 19 has been co-managed between DFO and the Area 19 Snow Crab Fishers Association for the last three years. This has involved an Individual Transferable Quota (ITQ) system with a fixed number of licences (111) (S. Beaton, pers. comm.)

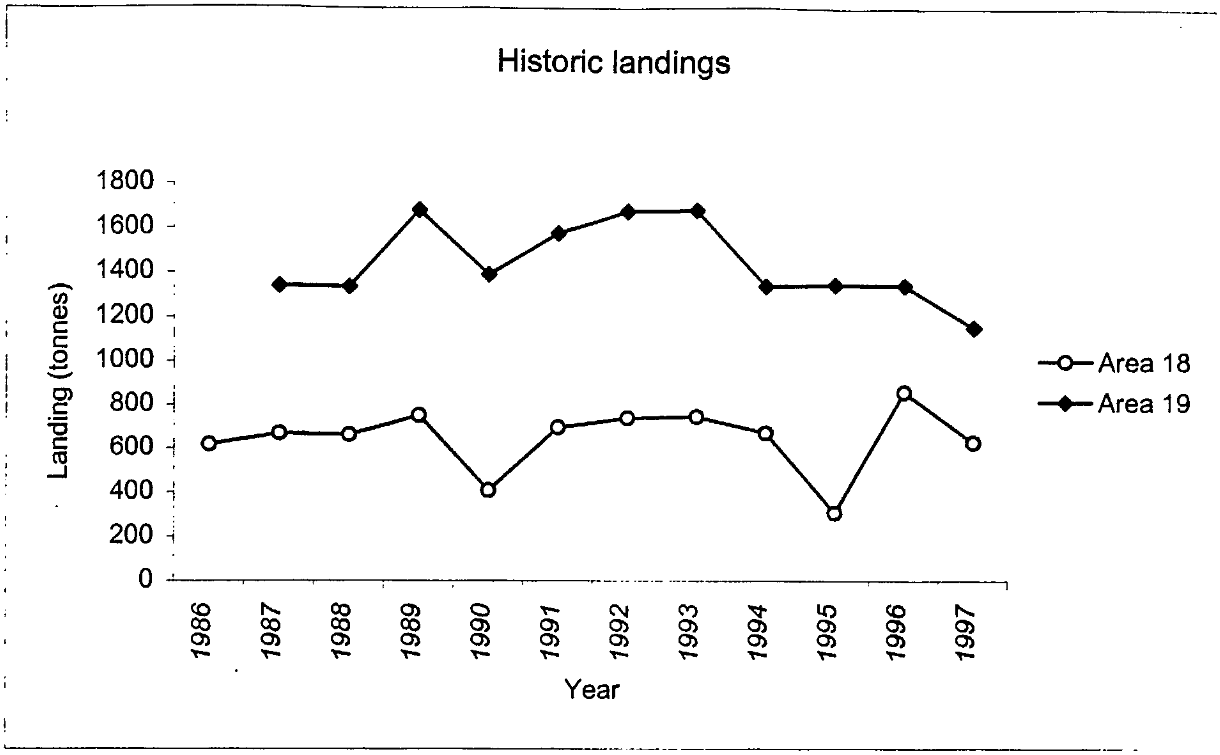
Historically the number of fishers in this crab fishery has remained quite stable, due to the 1978 moratorium on new crab licenses. Table B.1-1 illustrates this stability.

Records on historic landings and Catch Per Unit Effort (CPUE) are available based on management area from 1985-1997 and are presented in Figure B.1-5 (from Hebert et al., 1998). CPUE is a statistic that can be used in many fisheries as a rough indicator of the size/state of the fish stock and can be regularly monitored (G. Ruseski, pers. comm.). As may be seen, landings in Area 18 remained relatively constant from 1985 to 1995 and then decreased between 1995 and 1997. Area 19 showed an increase in landings between 1992 and 1995 and then a decrease from 1995 to 1997, coincident with Area 18. Total landings per year have ranged between 306 and 855 tonnes in Area 18 and 1,151 to 1678 tonnes in Area 19.

Table B.1-1: Number of snow crab licenses issued by Management Area within St. Georges Bay study area. Numbers are licensed fishers, number in brackets for 1998 are number of fishers actively fishing for snow crab.

Year	Area 18	Area 19
1979	14	27
1980	23	-
1984	-	61
1992	30	-
1993	-	74
1998	30 (*13*)	81 (*53*)

Data sources: Hare and Dunn, 1993, Loch et al., 1995, P. George, pers. comm.



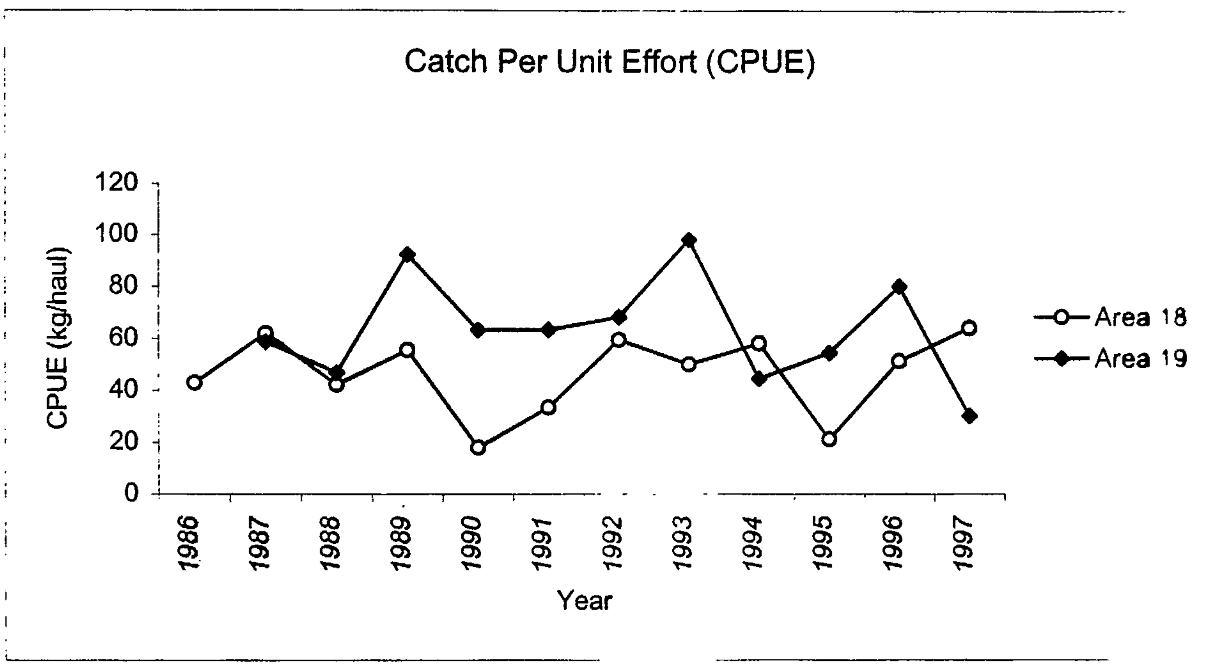


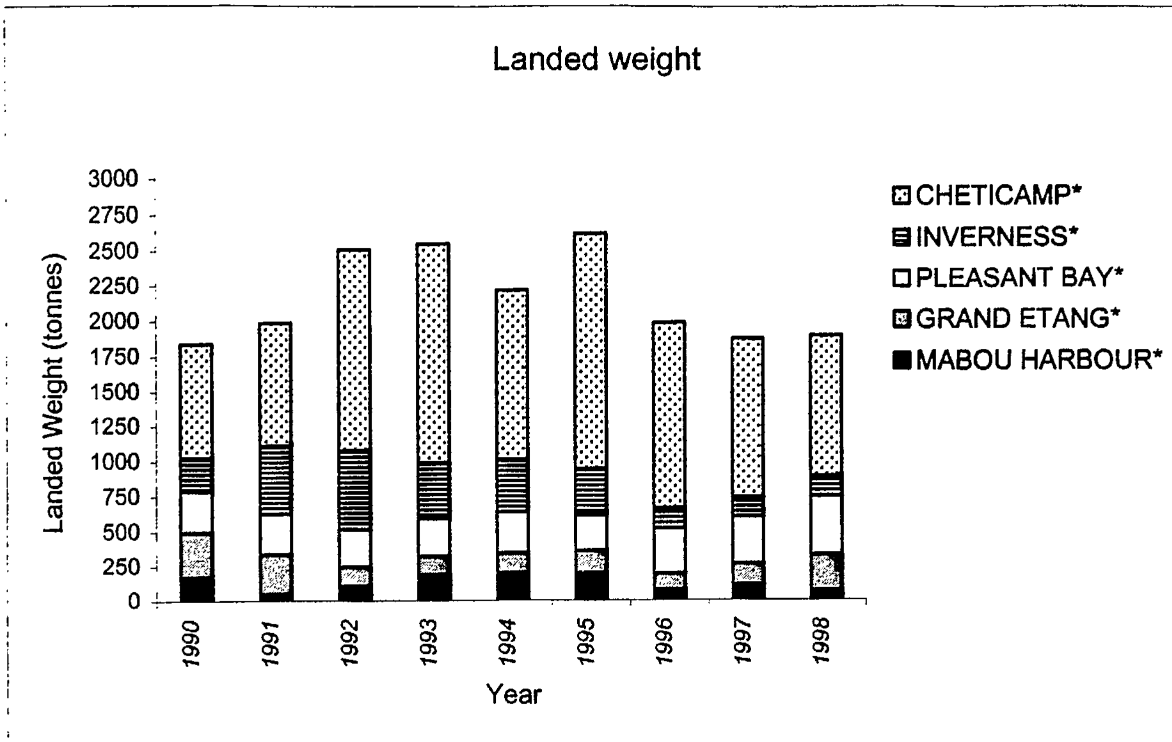
Figure B1-5: Historic snow crab landings and Catch Per Unit Effort for Management Areas 18 and 19, 1985-1997

Snow crab are landed at 12 ports within the St. Georges Bay study area. Five of these ports (Cheticamp, Inverness, Pleasant Bay, Grand Etang and Mabou Harbour) contributed between 90 and 99% of the total annual snow crab catch per year between 1990 and 1998, and landings at these ports peaked between 1992 and 1995 at almost 3,000 tonnes (Figure B.1-6). Prior to these four years, and since, landings have decreased slightly to between 1,872.5 and 2,105.5 tonnes. Cheticamp has been by far the greatest landing port for snow crabs within the study area for the last nine years, accounting for 43% to 63% of the annual landings. Secondarily in importance is Inverness with 7-24% of the landings and thirdly Pleasant Bay with 9-21% of annual landings. These ports reflect the distribution of the snow crab due to the availability of deep water, the crabs are concentrated along the western edge of Cape Breton and are much less common within Northumberland Strait where the other ports are located.

CPUE has fluctuated in both Areas between 1986 and 1997 (Figure B.1-5) with Area 18 remaining within approximately 40-60 kg/haul except for two dips (1990 and 1995). Area 19 has displayed a general upward trend from 20-50 kg/haul, to a peak in the early 1990's (80-100 kg/haul), and then a decline to about 60 kg/haul from 1995-1997.

ECONOMICS

Landed values of snow crab for the five principle ports (accounting for 90-99% of annual snow crab values) rose steadily from 1990 to 1995 and has decreased steadily since then (Figure B.1-6). In 1990-91 total landed value was approximately 4.5-5 million dollars. This rose by almost five times to reach 23.9 million in 1995 and has since dropped off rapidly to 6.9 million in 1998.



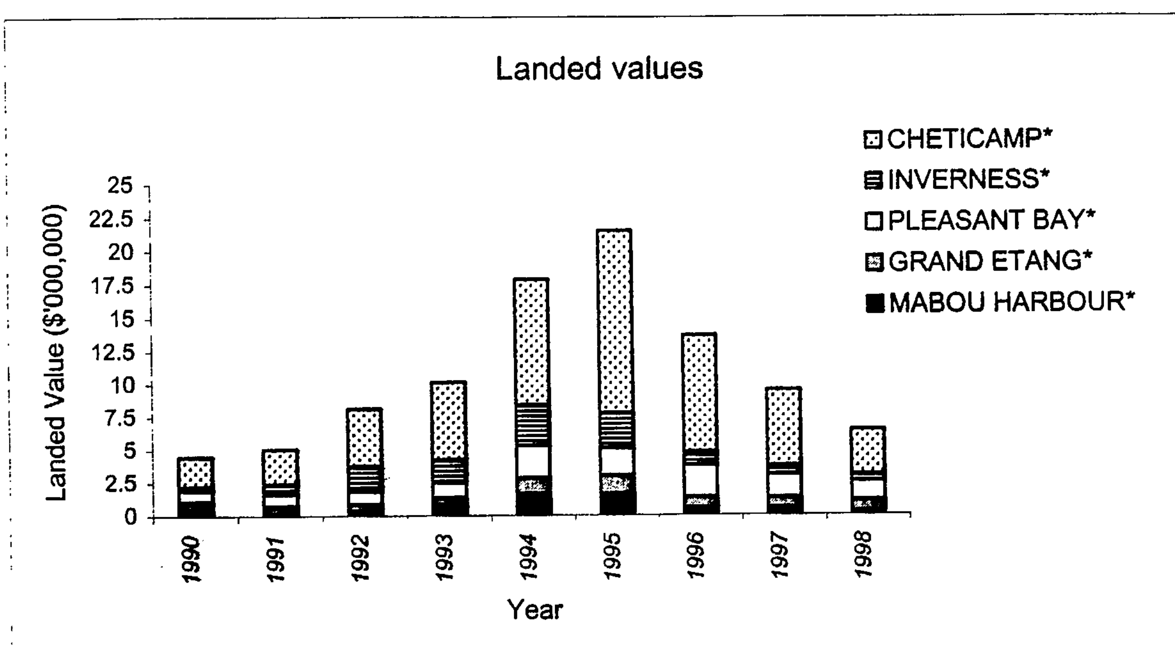


Figure B1-6: Landings and landed values of snow crab for five most significant ports, 1990-1998

Landed values at the three most significant ports between 1990 and 1998 are provided in Table B.1-2.

Table B.1-2: Ranges of annual landed values and proportion of total snow crab catch that the port contributes for three most significant ports, 1990-1998.

Port	**Annual landed values (million dollars)**	**Percentage of total snow crab values for whole area contributed by port**
Cheticamp	2.3-13.7	49-61
Inverness	0.27-3.1	6-22
Pleasant Bay	0.9-2.4	9-21

BIOLOGICAL/ECOLOGICAL CONCERNS

"Ghost Fishing", the ability of fishing gear to continue fishing after all control of that gear is lost by the fisherman (Smolowitz, 1978 quoted in Vienneau and Moriyasu, 1994) affects local snow crab populations as animals enter lost traps and are then confined until they starve to death. Vienneau and Moriyasu (1994) report that in Baie des Chaleurs, New Brunswick, traps lost during the Spring fishery reach saturation levels and the individuals begin to die from cannibalism and predation by sea fleas (amphipods). Although the number of new crabs captured by these ghost traps is negligible immediately after the Spring fishing season, the catch increases again to its saturation level before the following spring which re-initiates the ghost fishing cycle. In attempting to reduces this mortality, in recent years biodegradable panels have been built into traps to allow crabs to escape soon after a trap is lost.

Chiasson et al. (1992) for the southwest portion of the Gulf of St. Lawrence (i.e. New Brunswick) report that a considerable number of traps are lost at sea, ranging from 7-28 traps per boat per year between the years 1966 and 1989. However, in this area there are up to 135 boats with 150 traps per boat (S. Beaton, pers. comm.). In Area 19 there are an estimated total number of traps of 1,480, of which approximately 14 are lost per year (S. Beaton, pers. comm.). Area 18 only has approximately one-third as many licences fishermen so assuming a further five traps are lost each year from this area, this results in an estimated 19 traps lost in total per year within the study area.

Historically, additional fishing related mortality is suggested from the groundfish gillnet fishery, Danish seiners and other groundfish trawl fisheries, as well as rough handling of small crabs by fishermen (Robichaud, 1988).

Fisheries activities have tried to target the post-terminal moult males and leave the smaller, younger ones; but in the late 1980's observations indicated that the terminal molt for some individuals may occur at size smaller than 95 mm and some crabs larger than this minimum legal size may not have reached terminal molt (Hare and Dunn, 1993). Thus some small crabs are probably able to breed, but conversely, some of the males taken by the fishery have not reached terminal moult and so have not reproduced yet. To further complicate the issue, the concept of the terminal moult, while accepted by many, is not proven (Dawe et al., 1991; Hare and Dunn, 1993).

PROSPECTS/FUTURE

Hebert et al. (1998) recommended not increasing the exploitation rate of snow crab in either Area 18 or 19. An increase in recruitment is expected starting in 2000-2001 (Anonymous, 1999a). However, due to a lack of knowledge on growth of the pre-recruits, the forecast of the timing of the next wave of recruitment into the fishery should be interpreted with caution (Anonymous, 1999a). Other sources of error in estimating exploitable biomass are seasonal movement, natural mortality (presently assumed to be negligible), and classification of carapace condition.

Decreasing landings and CPUE, combined with the uncertainty of estimation of some life history parameters, suggest a precautionary approach to future management of this species.

B.1.1.1.2 Lobster *(Homarus americanus)*

BIOLOGY/NATURAL HISTORY

The lobster has two principle phases to its life history, a larval planktonic phase lasting from 3-10 weeks in which it remains part of the plankton community through three growth stages, and a benthic phase in which it spends the rest of it's life (Anonymous, 1995a). Once the lobster larvae has settled on the substrate to begin the benthic phase of its life it requires approximately five to six years to reach a size to recruit into the fishery (Lanteigne et al., 1998). In this benthic phase, the animals do not appear to move over great distances, typically 10-15 km appears to be average for adult lobsters (Lanteigne et al., 1998).

Larval lobster abundance has been estimated in St. Georges Bay through a number of studies. In general, the larvae first appear in the plankton in late June, reach peak number in July and decline through August (Harding et al., 1979; Harding et al., 1982). Estimates of the density of larvae range from 0.1-7.8 * 10^3 larvae/km^2 in 1975 and 1976 (Harding et al., 1979), to 243*10^3 larvae/km^2 in 1978 (Harding et al., 1982). Estimates for total larval production of St. Georges Bay include 90 million larvae in 1975 (Harding et al., 1979) to greater than 500 * 10^6 larvae in 1978 (Harding et al., 1982). As larvae the lobster feed on zooplankton; specifically in St. Georges Bay, they feed on *Podon, Temora, Acartia, Pseudocalanus, Centropages*, large gastropod larvae, and zoea and megalops larvae of *Cancer irroratus* (Harding et al., 1983) [see also Section A4.5.2 Secondary Production for plankton community and dominant species and Cameron and Mitchell, 2000 for lobster diet]. Survival of individual lobster larvae is low, only an estimated 0.2 to 0.4% (Harding et al., 1982) and maximum of 1.1% (Harding et al., 1979) lobster survive from Stage I of the plankton phase to enter the fishery as a five or six year old. Scarrat (1968) calculated a larvae survival from Stage I to Stage IV of 0.11% to 2.5% in Northumberland Strait during the period 1949-1963.

FISHERIES

Lobster are fished by inshore fishermen using traps (pots) set on the ocean floor either individually or in groups on a line (Anonymous, 1982c). Captured lobsters are either returned to the water if they are undersized (current limit of 65.1 and 65.9 minimum carapace size), or sold as "canner" lobster (less than 81 mm carapace length) or "market" lobster (>81 mm carapace length) (Anonymous, 1995a).

Lobster Fishing Areas (LFA's) within the St. Georges Bay project study area are 26A and 26B, with 26A encompassing the eastern end of Northumberland Strait from Pugwash, Nova Scotia to the centre of St. Georges Bay and includes the water between Nova Scotia and Prince Edward Island (Figure B1-2). LFA 26B extends from the centre of St. Georges Bay to the northern tip of Cape Breton and out into the Gulf to approximately a line drawn between the north east point of P.E.I. and the northern-most point of Cape Breton on the western shore. Lobsters are fished in the shallow inshore waters along the entire length of coast within the St. Georges Bay study area (Anonymous, 1998a).

HISTORY

In contrast to the young snow crab fishery, the lobster fishery has a history dating back over 100 years. The following is a chronological summary of important events in the history of the fishery. Information is from DeWolff (1974), Anonymous (1995a), and Lanteigne et al. (1998).

Pre-1870's – Lobster fishing unregulated

1873 – Order In Council prohibited capture of soft shelled lobsters, egg-bearing females and lobsters less than 1.5 lbs [0.68 kg]. This was changed within a year to prohibition of "berried' females, closed season instead of prohibition on soft shell lobsters, and 9 inch [22.8 cm] length limit replacing the weight limit.

1878-1882 – Development of live lobster trade

Circa 1900 – Gasoline powered motorboat allows efficient exploitation of previously untouched lobster grounds

1910 - Lath spacing regulations introduced

1914 – Lath spacing regulation rescinded

1918 – Lobster fishermen required to obtain a license to fish

1934 – Regulation introduced prohibiting fishermen from fishing lobster in more than one district in any one year.

1934-1957 – Variety of changes in size limits

1949 – Lath spacing reintroduced to reduce mortality

1957 – Minimum carapace size in LFA 26A & 26B set at 63.5 mm

1966 – First trap limit introduced

1987 – LFA 26B minimum carapace size increased to 65.1 mm

1988 – LFA 26B minimum carapace size increased to 66.7 mm

1989 – LFA 26B minimum carapace size increased to 68.3 mm

1990 - LFA 26B minimum carapace size increased to 70.0 mm

1991 – LFA 26A minimum carapace size increased to 65.1 mm

1994 – Escape gaps and ghost panels required in many areas

1995 –Development of a conservation framework for Atlantic lobster (FRCC, 1995)

1998 – LFA 26A minimum carapace size increases to 65.9 mm

Where the St. Georges Bay project study area and these LFA's overlap there are presently 187 licensed lobster fishermen in LFA 26A (of these 79 [42%] were active in 1998) and 255 in LFA 26B (of which 127 [50%] were active in 1998) (P. George, pers.

comm.). Fishing season in each of these areas is May-June and the maximum number of traps per fisher is 300 (Lanteigene et al., 1988).

The history of lobster captures in the southern Gulf region is one of great abundance prior to approximately 1910, a decrease and maintenance at a low level of landings from then until the early 1980's then a rapid increase to historic levels or greater, peaking in 1990 and 1991 and decreasing through the 1990's (Anonymous, 1995a; Lanteigne et al., 1998). Records at a finer scale (i.e., LFA 26A and 26B) have only been kept since 1947, Table B.1-3 presents minimum and maximum landings for these LFA's by decade (from Figure 3 Lanteigne et al., 1998)

Table B.1-3: Minimum and maximum landings (metric tonnes) for LFA 26A and 26B by decade. Values are interpreted from histogram in Figure 3 of Lanteigne et al., 1998 so are approximations only.

	LFA 26A		**LFA 26B**	
Decade	**Min.**	**Max.**	**Min.**	**Max.**
1950-1959	2300	3000	440	680
1960-1969	1800	3000	440	610
1970-1979	1500	2600	400	720
1980-1989	2300	6600	690	1200
1990-1997	3500	6200	1050	1550

When the Canso Causeway was constructed (completed in 1954) there was concern that the interruption of the local ocean current would affect the lobster fishery (Dadswell, 1979). Indeed, lobster numbers were depressed at this time and for several years afterward, and Harding et al. (1983) suggest that it may have acted in concert with the start of a general climate cooling to initiate a larval recruitment failure, and so the loss of the lobster. If so, it is uncertain to what to attribute the dramatic rise in numbers in the late 1980's and early 90's.

The combined landings from all the ports in the St. Georges Bay study area (n=30) are illustrated in Figure B.1-7. The distribution of lobster landings between these ports are remarkably similar; no single port accounts for (on average between 1990 and 1998) more than 9% of the total lobster landed. Landings peaked in 1991 at 2550 tonnes and since 1993 have reduced to 1900-2100 tonnes. This estimate is from the combined landings of 30 ports. The six most significant ports, by landing, are: Ballantynes Cove, Cheticamp, Arisaig, Cribbens Head, Margaree Harbour, and Lismore. These six ports accounted for 45-48% of total landings in the area, with the exception of 1998 when the ports of Judique and Bell Cote also contributed significantly, bringing the contribution of eight ports to 54% of the total landings. Minimum landing within a single port in between 1990 and 1998 was 54 kg at Antigonish Harbour (1993) and maximum was at Lismore (1990) of 234 tonnes.

CPUE for lobster is reported to have remained similar between years from 1993 to 1997 for both LFA 26A and 26B (Anonymous, 1998b, Lanteigne et al., 1998).

ECONOMICS

Landed values to the ports within the study area have increased between 1990 and 1998 (Figure B.1-7). A minimum total value of 7.3 million dollars was realized in 1990 and a maximum of 19.76 million in 1996. The maximum landed value by any one port in a year was Lismore in 1997 (215,894 kg landed lobster worth 2.3 million dollars).

BIOLOGICAL/ECOLOGICAL CONCERNS

There is some indication that rake harvesting of Irish moss (*Chondrus crispus*) may contribute to claw loss and wounding of lobsters (Scarrat, 1973). However these wounds are also attributable to other causes such as rough handling by fishermen, moving

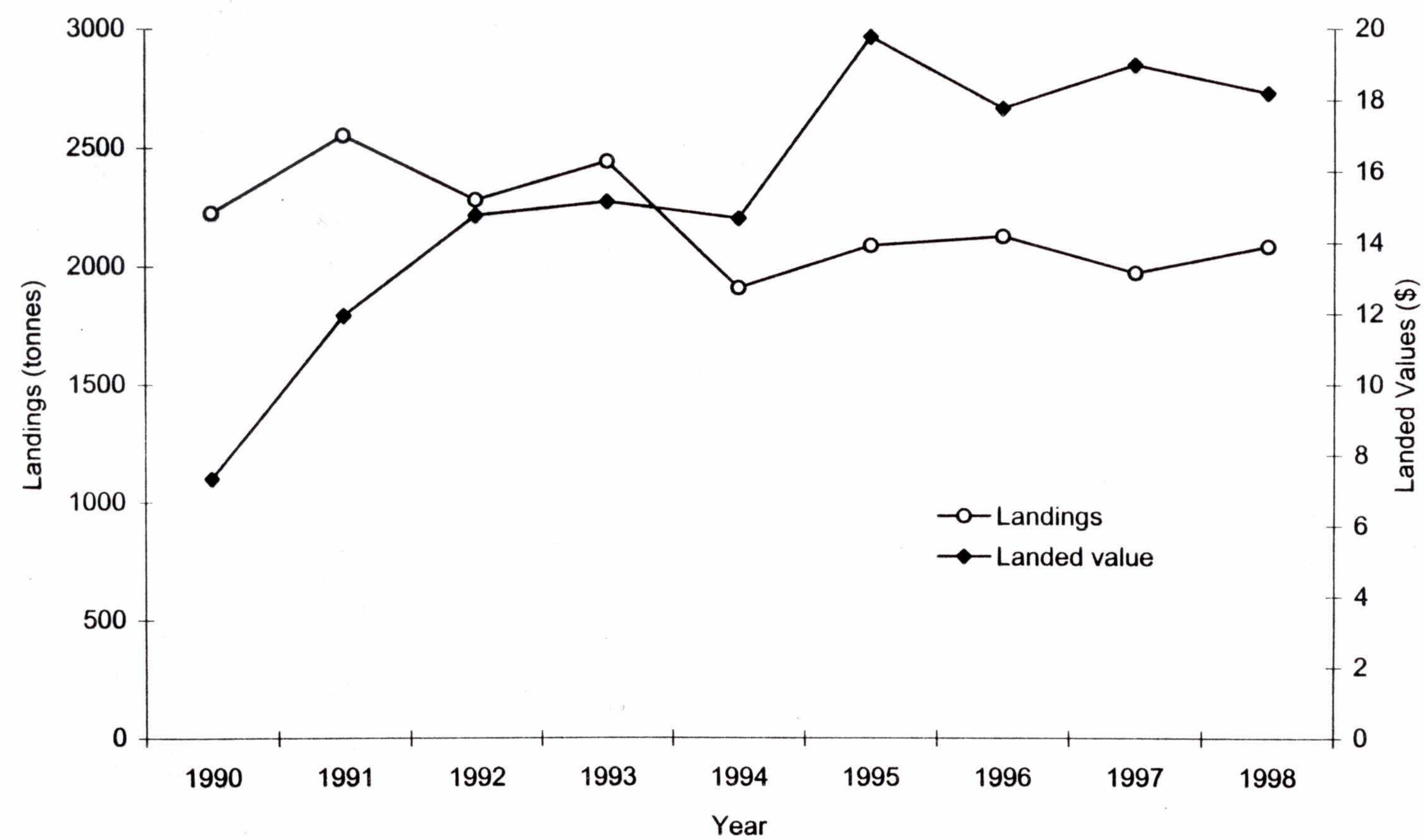


Figure B1-7: Total lobster landings at all ports in St. Georges Bay study area, 1990-1998 fishing gear, and ice in shallow water. In 1971 and 1972, at Prince Edward Island, Scarrat (1973) estimated claw loss at 5-19% and other wounds at 1-11%.

Dredging for sea scallops is also thought to impact upon the lobsters which get caught in the path of the dredge (Campbell, 1980). Other impacts on lobsters are ghost fishing by lost lobster traps, and escaping from traps in injured condition (Campbell, 1980).

PROSPECTS/FUTURE

Though lobster catches have been at record high numbers in the early 1990's they have decreased since then. There remains concern about the high fishing mortality, high fishing effort, increasing fishing power and low egg production (Lanteigne, 1998,; Anonymous, 1998b). It is unrealistic to expect strong recruitment to continue indefinitely, and in the lobster conservation framework developed in 1995 the situation is identified as high risk, despite the high quantity of landings, and it was concluded that the fishery is "taking too much and leaving too little" (Anonymous, 1995a). Thus, the future of the lobster fishery in this area of Nova Scotia is by no means secure.

B.1.1.1.3 Sea Scallops *(Placopecten magellanicus)*

BIOLOGY/NATURAL HISTORY

Scallops are found scattered throughout the study area (see Anonymous, 1997a), with St. Georges Bay itself and the area west of Cape George identified as areas of intensive scallop utilization (Anonymous, 1998a). The area north of St. Georges Bay contains only isolated areas of moderate scallop utilization. Scallops appear to prefer depths greater than 15 m and are not deep water limited within Northumberland Strait, probably due to the shallow water of the Strait (Jamieson, 1979). They are present on a large variety of substrate types, though rare or absent from mud and silt (Anonymous 1997a). Settlement and survival is suggested to be improved by the presence of a well-established epiphytic community and a substrate of hard materials such as gravels (Jamieson, 1979). Sea scallops spawn in late summer, with larvae maintaining a planktonic phase for 4-5 weeks before metamorphosing and settling to the bottom. They may spawn as early as age-2 but do not contribute significantly to egg production until they reach >70 mm shell height (approximately 3 years old) (Anonymous 1997a). Within the Northumberland Strait area scallops do not reach harvestable size until age 4 or 5 years (Anonymous 1997a).

Jamieson (1979) suggests two factors within the Northumberland Strait may be limiting scallop production 1) The temperature extremes in the Strait are considerable which may result in reduced growth rates during cold periods, and heat stress (including mass die-offs such as reported by Dickie and Medcolf (1963) in the warm summer waters). 2) The Strait bottom sediments are generally muddier (see Section A4.1 Oceanography) than the clean gravel sand bottoms found in more productive areas. These two factors interact to produce less-than-optimal conditions for scallop survival and growth in the area.

FISHERIES

Most fishermen in the area use modified Digby dredges for fishing scallops; these are the most efficient gear on rocky/gravel bottoms (Anonymous 1997a). This fishery has always been complementary to the lobster and herring fisheries which are often considered as the major coastal fisheries, with scallop fishermen usually holding more than one license allowing them to harvest different species (Lanteigne and Davidson, 1991).

The Scallop Fishing Area is designated as SFA 24 and the entire area encompasses basically the same area as the Lobster FA 26A and 26B (Figure B1-3)

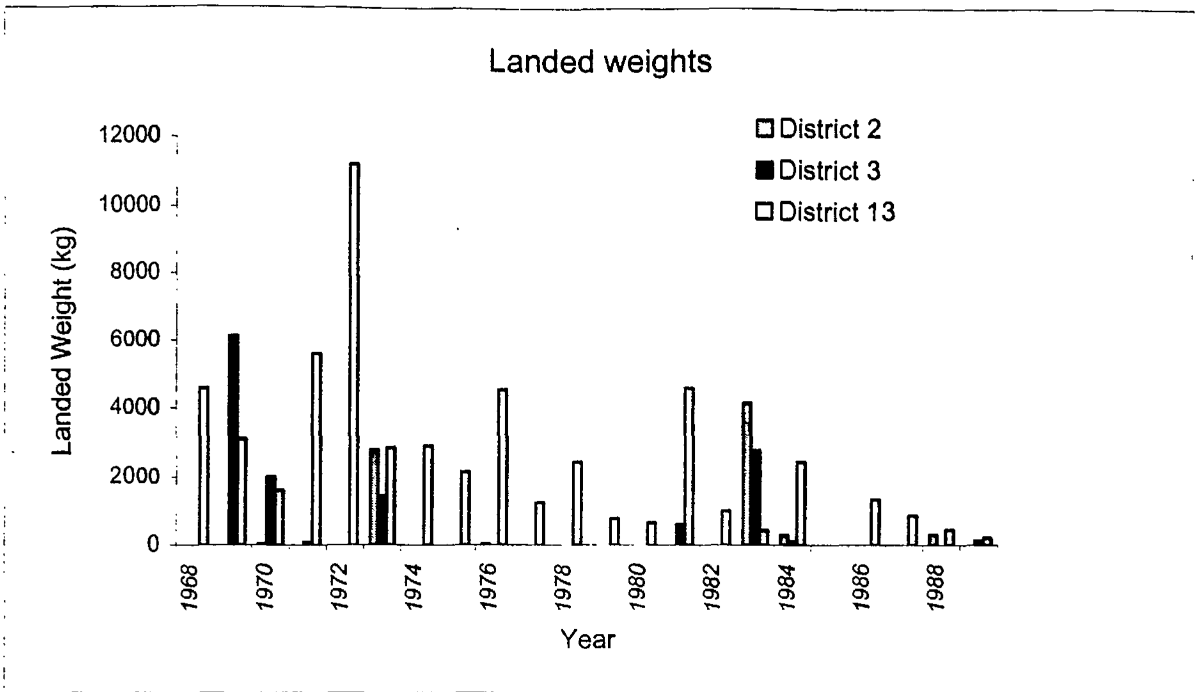
HISTORY

The scallop fishery in Northumberland Strait / St. Georges Bay did not develop until after 1954 (Stasko, 1979), prior to this scallop landings were sporadic (Lanteigne and Davidson, 1991). Between this time and 1978 management consensus could not be reached between fishermen and government and so the fishery remained unregulated. In 1978 the government unilaterally imposed license and season restrictions, freezing the number of licenses and limiting fishing to the periods May-June and September-October (Jamieson, 1979). One of these actions, the freezing of the number of scallop licenses actually resulted in an increase in licensed scallop fishermen. The freeze was delayed while word went out that it was coming, resulting in more licenses being issued in 1978 than in previous years (Jamieson, 1979). There is no documented information on regulations or license numbers between 1978 and 1996. At present there are 40 scallop licenses within the St. Georges Bay Ecosystem Project study area, of which 25 (62.5%) were active in 1998 (P. George, pers. comm.). In 1997, the scallop season was limited to three periods – April 14-18, May 5-June 14, and October 13-December 31 (Anonymous

1998c). A restriction on the fishing of scallops is that the maximum drag width must not exceed 16'8" (5.08 m).

Scallop landings were relatively high (>4000 kg/Statistical District) between 1968 and 1972, then dropped and remained low through until the early 1980's, then further dropped to almost nothing late in the 80's (Figure B.1-8). Peak landings between 1968 and present were in 1972 in Statistical District 13. At a finer scale, examining the landings by port within the study area (number of ports landing scallops = 17) between 1990 and 1998 combined landings peaked in 1992 and 1993 at almost 90,000 kg, with a secondary peak in 1997 (66,700 kg). The five principle ports for scallop landings between 1990 and 1998 have been Lismore, Margaree Harbour, Ballantynes Cove, Tracadie and Arisaig, together contributing between 45-93% of the total annual landings. The port landing the greatest weight of scallops has been Lismore comprising 20-43% of the total catch with the exception of 1997 (15%) and 1998 (5%). The remaining catch is split between the remaining ports, with no other port comprising a consistent annual portion of landings (Figure B.1-9).

A number of caveats must be applied to the landings information, and the corresponding values based on landings. As far back as 1979 it was recognized that not all of the scallop catch is accounted for. Jamieson (1979) suggest that as much as 30-50% of the scallop catch is not sold to registered buyers and thus not accounted for. Further, until the mid 1980's the scallops sold in one particular area did not imply they were caught locally. Fishermen were free to fish the entire Gulf and land their catches where they pleased, thus it was impossible to locate the source of the catch based on landing. In the early 1980's legislation was adopted which confined the fishing areas of each fisherman to a particular location (Lanteigne and Davidson, 1991). In addition Supplementary "B" sales [landing estimations of products not sold to registered buyers and not reported on standard sales slips; used to estimate scallop products sold locally] were estimated to have increased from 14.9% to 46.9% of the total catch between 1982 and 1989 (Lanteigne and Davidson, 1991). This further reduces the accuracy of



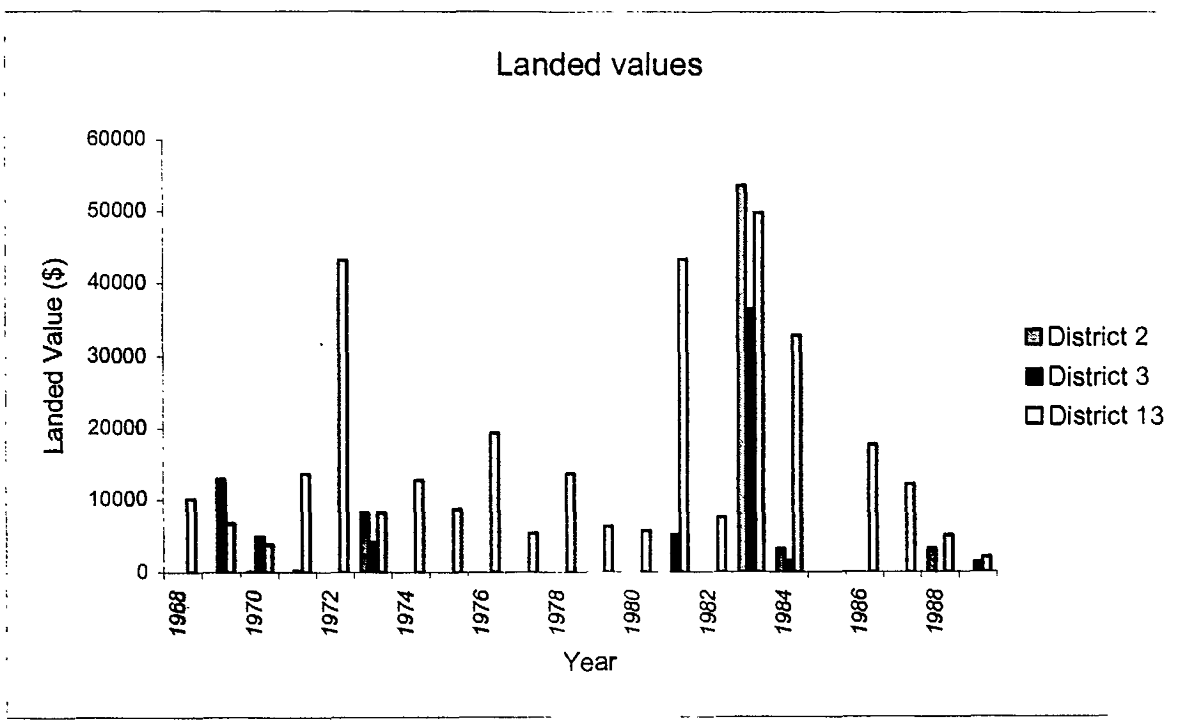
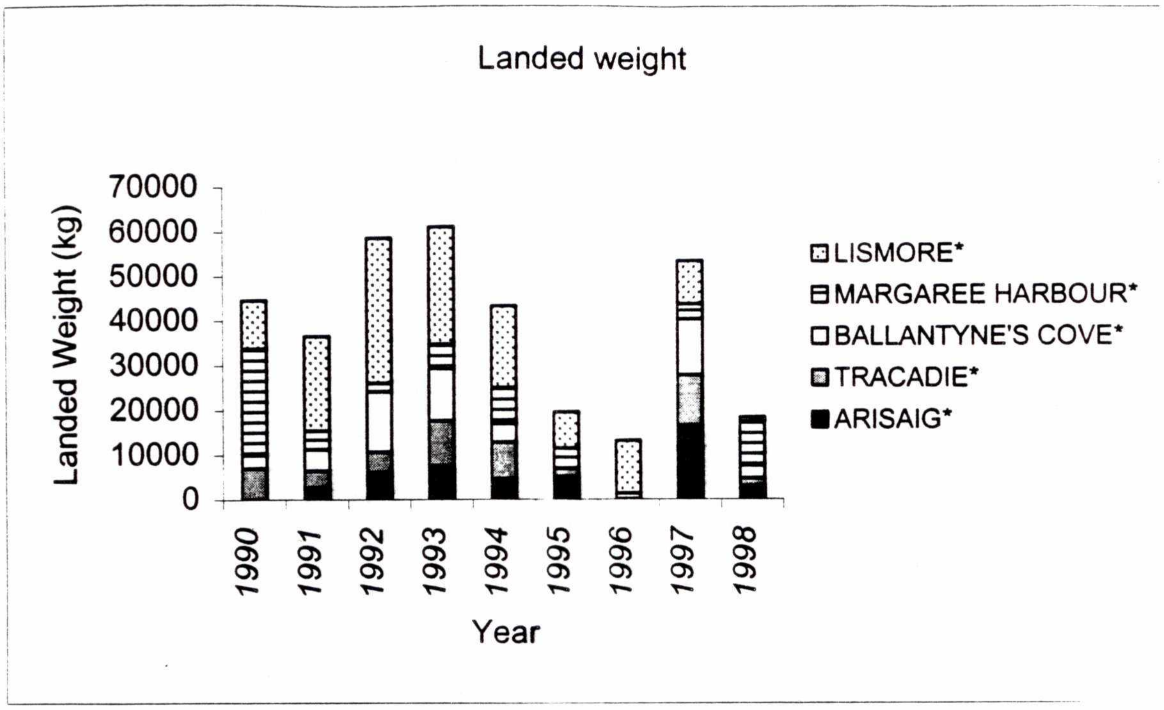


Figure B1-8: Scallop landings and landed values by statistical district within St. Georges Bay study area, 1968-1989. Supplementary "B"s not included. Data from Lanteigne and Davidson (1991).



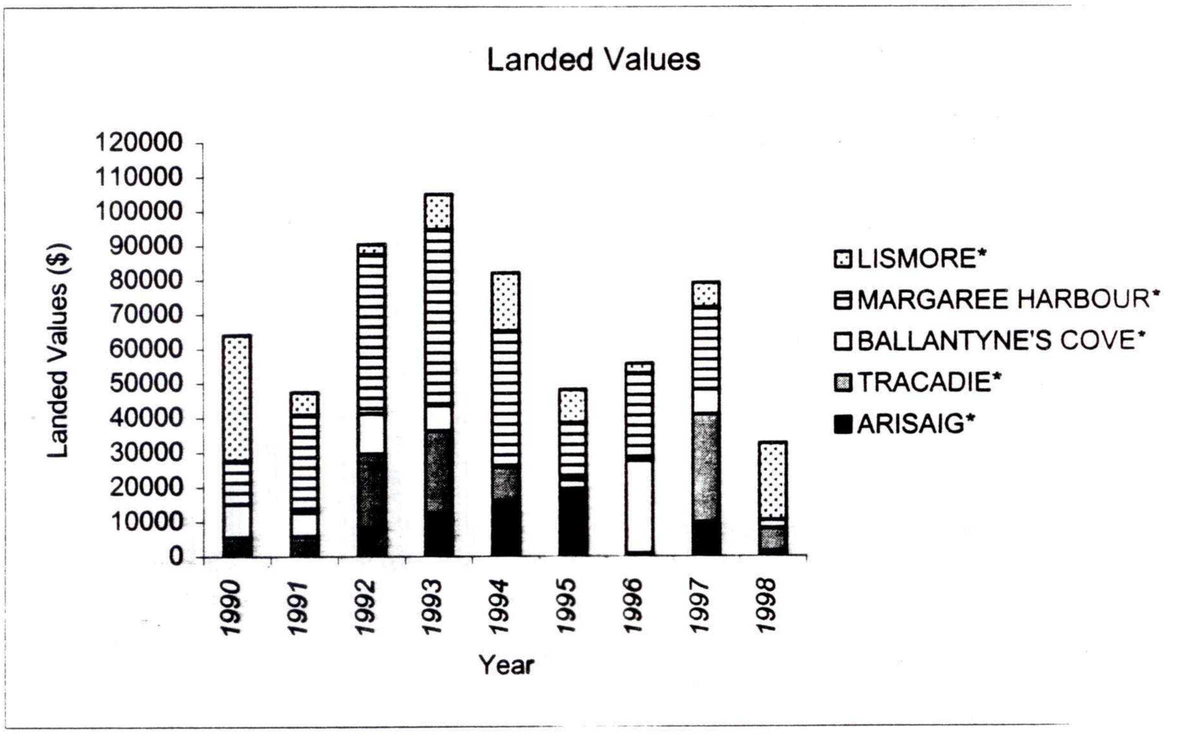


Figure B1-9: Landings and landed values of scallops for five most significant ports, 1990-1998 accounting for landings and values. Unfortunately, there is no published information on the proportion of Supplementary B's in the 1990's.

CPUE estimates for scallops are non-existent. The unreported catches (Supplementary "B"s), lack of sea and port sampling, and no requirement for fishing vessels to keep log books for this species prevent calculation of any CPUE estimate.

ECONOMICS

Landed values of scallops by Statistical District generally reflect the landing of biomass. The values show a small peak in 1972 when the peak of landed shellfish was high, and then a second stronger peak in values occurred in 1981 to 1984 (Figure B.1-8). During this period the number of landed scallops were relatively high. Landed values then dropped off sharply after 1984, in conjunction with the decrease in landings. Between 1990 and 1998 total landed values for all of the ports combined peaked between 1992-1994 (147,000-206,700 kg) and 1997 (163,200 kg). Landed values at the three most significant ports between 1990 and 1998 are provided in Table B.1-4. The remaining landed values each year were split between the remaining ports, with no other port comprising a consistent annual portion of landings (Figure B.1-9). The annual highest value of landings were at Margaree Harbour (1991, 1992, 1993, 1994), Lismore (1990, 1997), Arisaig (1995), Ballantynes Cove (1998), and Havre Boucher (1997).

Table B.1-4: Ranges of annual landed values and proportion of total scallop catch that the port contributes for three most significant ports, 1990-1998.

Port	**Annual landed values ($)**	**Percentage of total scallop values for whole area contributed by port**
Lismore	2,800-115,157	2-50
Margaree Harbour	2,295-245,225	5-41
Ballantynes Cove	0-72,564	0-43

BIOLOGICAL/ECOLOGICAL CONCERNS

The principle biological ecological concern is the attempted management of this species without the required information on stock abundance and dynamics. Stock assessment surveys have not been undertaken since 1986, sea and port sampling was terminated in 1988, and license holders are not required to submit logbooks (Anonymous 1997a). This creates great difficulties in assessing stocks of scallops, and hence determining their future, in the Northumberland Strait area.

The activity of scallop dredging impacts on other fisheries. Dredging for sea scallops is thought to impact upon the lobsters which get caught in the path of the dredge (Campbell, 1980). It has been likened to terrestrial forest clear-cutting and documented impacts upon the benthos due to dredging include decrease in abundance and biomass of organisms, and burying and/or resuspension of organic matter (Watling and Norse, 1998).

PROSPECTS/FUTURE

"Catches have remained at about the same level since the early 1970s. Effort, however, has increased in recent years. This resource is likely overexploited, which suggests that fishing effort should be reduced" (Anonymous 1997a).

This suggested over-exploitation, combined with the lack of sampling and knowledge of stock dynamics, create difficulties in successfully managing a fishery to the benefit of the fishers and the resources.

B.1.1.2 Finfish

Commercially important fish species harvested in the St. Georges Bay study area are presented in Table B.1-5. Other species, such as bluefin tuna and squid have not formed a consistent and sizable proportion of the fishery in the past and so will not be discussed in detail here.

Table B.1-5: Commercially important species harvested within the St. Georges Bay Ecosystem project study area.

Intensive Fishing		**Not Intensively Fished or Bycatch**	
Invertebrates	***Finfish***	***Invertebrates***	***Finfish***
American lobster	Alewives (Gaspereau)	American oysters	Blue shark
Sea scallop	American eel	Bar clams	Bluefin tuna
Snow crab	American plaice	Mussels	Dogfish
	Atlantic cod	Quahaugs	Eelpout
	Atlantic herring	Rock crab	Mako shark
	Atlantic mackerel	Soft shell clams	Monkfish
	Haddock	Squid	Porbeagle shark
	Halibut	Stone crab	Redfish
	Pollack	Toad crab	Silversides
	Shad		Skate
	Smelt		Striped bass
	White hake		
	Winter flounder		
	Witch flounder		
	Yellowtail flounder		

B.1.1.2.1 Marine Finfish

History: Due to the interconnectedness of the finfish fisheries (i.e., groundfish, herring, mackerel etc.) the history of these fisheries is treated together in the following (Compiled from, Anonymous 1985; 1997b,c ; 1998d,e,f,g; Jean, 1963; Halliday et al., 1989; Hurlbut et al., 1998; Morin et al., 1996; 1998; Morin and Forest-Gallant, 1997; Powles 1965).

Chronology of finfish fishery in St. Georges Bay and surroundings.

Pre 1947 – Mackerel and cod harvested since 16th Century

Early 20th Century vessels converted from sail to motor increasing efficiency and developing fresh fish market

American plaice landed as incidental catch to cod from hook and line fishery for cod (plaice by-catch rate was low)

1947 – Otter trawling introduced to the southern Gulf of St. Lawrence and rapid expansion of this technology

1957- Minimum cod end mesh size (4.5" [11.43 cm]) first introduced to southern Gulf groundfish fishery

1971 – Annual September DFO trawl surveys initiated in southern Gulf of St. Lawrence

1972 – Herring Total Allowable Catch (TAC) management introduced

1974 – Cod TAC's first introduced

1977 - Witch flounder in northern Gulf (Area 4RS) placed under TAC (3,500 tonnes)

American plaice TAC set at 10,000 tonnes

1982 – First white hake TAC – 12,000 tonnes

1987 – White hake TAC reduced to 9,400 tonnes

1988 – White hake TAC reduced to 5,500 tonnes

1991 – Logbooks become a condition for all mobile gear permits

1993 – White hake TAC reduced to 3,600 tonnes

American plaice TAC reduced to 5,000 tonnes

Cod fishery closed due to low abundance

1994 – First stock assessment of winter flounder

White hake TAC reduced to 2,000 tonnes

1995 – Witch flounder from area 4T combined with area 4RS to make 4RST and come under TAC of 1,000 tonnes

Closure of white hake fishery for Area 4T

1996 – First quota for winter flounder (1,000 tonnes) established due to concerns about fishing pressure on this species due to recent closures of cod and hake fisheries.

American plaice TAC reduced to 2,000 tonnes

1997 – First assessment of yellowtail flounder stock status

"By-catch" quota of 500 tonnes of white hake announced

American plaice TAC increased to 2,500 tonnes

Allocation of 2,000 tonnes of cod to by-catch, sentinel surveys, and experimental fisheries.

1998 – Mackerel TAC continues at 100,000 tonnes

B.1.1.2.1.1 Atlantic Herring *(Clupea harengus harengus)*

BIOLOGY/NATURAL HISTORY

Herring within the Gulf of St. Lawrence have been recognized as separate stocks for a long time. Day (1957) confirmed earlier suggestions that the Northumberland herring were a different stock from the Magdalen Islands stock. The Northumberland stock has been further divided by timing of spawning with two to three spawning stocks identified for spring, autumn, and late summer (Messieh, 1975; Lambert et al., 1982b). Spawning grounds were historically identified along the east shore of St. Georges Bay and near Port Hood for the spring spawners, and west of Cape George and between Port Hood and the Margaree River for the autumn spawners (Messieh, 1975). Lambert et al (1982b) report that historically the largest spawning sites for both spring and fall spawners were Malignant Cove and Havre Boucher. More recently, they report, spawning has been seen in small amounts at Ballantynes Cove and Port Hood.

After hatching the larval herring are retained in the local area. One area identified as a nursery for herring is to the east off of Cape George (Messieh, 1975). There is also evidence that herring larvae drift into St. Georges Bay on the Northumberland current from near Pictou and Caribou (Lambert et al., 1982b). Lambert (1984) reports mean densities of larval herring in the bay from 0-116.1 larvae/1000 m^3 between 1973 and 1976, and mean growth rates of 0.19-0.21 mm/d for 1973 and 1974.

FISHERIES

Traditionally herring were caught by gillnets and traps (Messieh and Moore, 1979) though presently the herring are harvested on the spawning grounds by an inshore gillnet fleet (Anonymous, 1998e). There is a spring and fall fishery prosecuted separately for each of the spawning stocks. North of St. Georges Bay there are only three identified areas of herring fishing (spring stock), while within the bay, spring fishing occurs along the east side and fall fishing along the west. As well, the coast west of Cape George to Lismore has an active fall herring fishery (Anonymous, 1998a). Presently the TAC is 50,000 tonnes for Fall spawners and 16,500 tonnes for Spring. The primary markets for herring are roe (Fall) and bait (Spring) (Anonymous, 1998e).

In 1998 there was a total of 627 herring fishing licenses within the study area, of which only 253 (40%) were active in that year.

Historically herring landings were relatively stable until 1968 when large purse seines began to operate (Messieh and Moore, 1976), and the herring began to decline to all time lows by the mid-1970's (Lambert, 1984). Within the St. Georges Bay area herring landings between 1933 and 1972 were consistently low (mean 301.4 tonnes/year, range 48.2-762.3 tonnes/year; Figure B.1-10). In the early 1970's there was tremendous increase in the landings. Unfortunately, there is a lack of local data for 1975 to 1990, but through the 1990's herring landings in the St. Georges Bay area have remained high, relative to pre-'70s (Figure B.1-10).

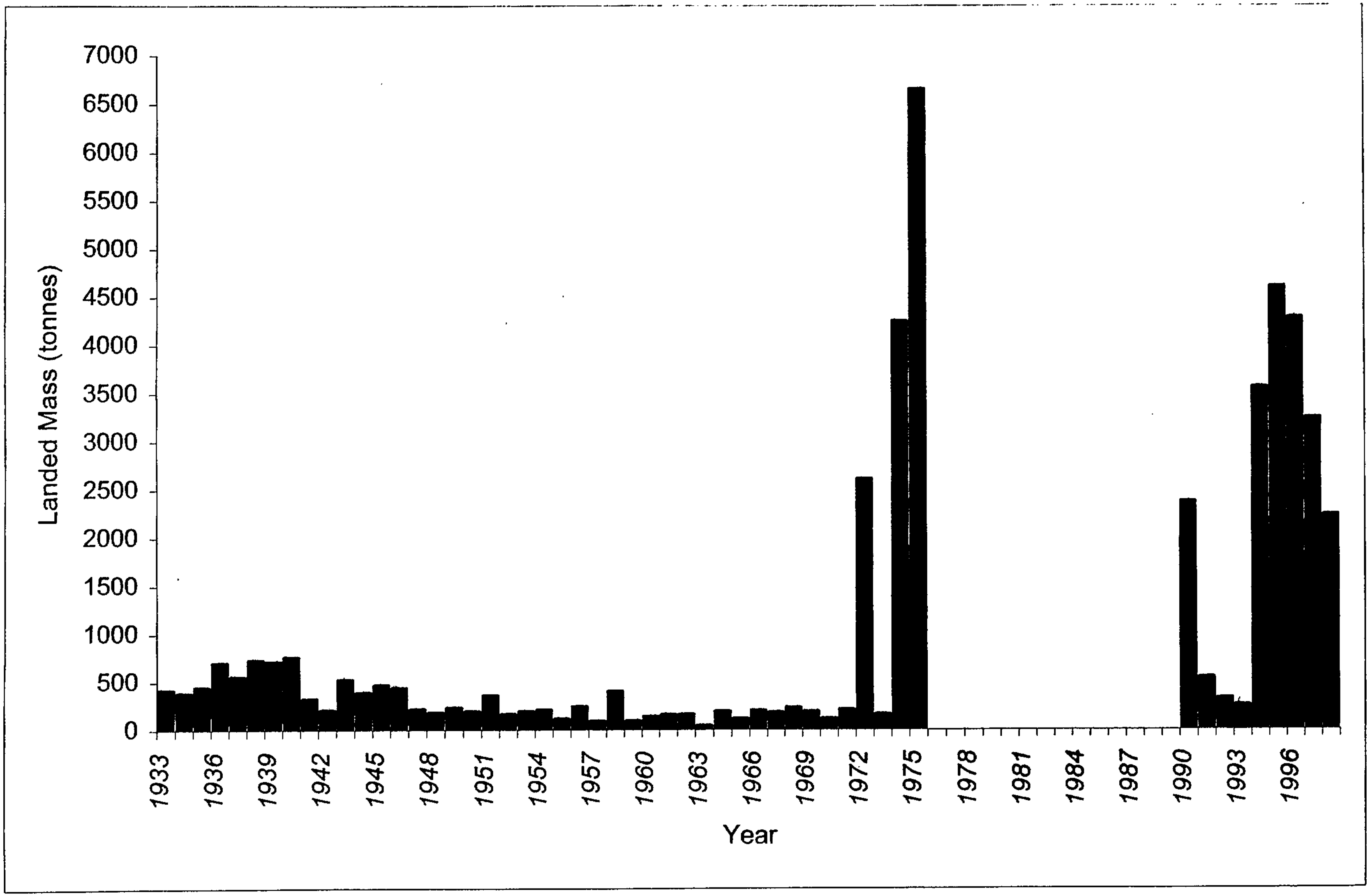


Figure B1-10: Historic (1933-1975 from Messieh and Moore, 1979) and present (1990-1998) herring landings in St. Georges Bay area

Twenty-four ports in the study area report herring landings. The five principle ports for landings between 1990 and 1998 have been Lismore, Cheticamp, Arisaig, Ballantynes Cove, and Cribbens Head, together contributing between 60-99% of the total annual landings. The combined landings of these five ports has ranged from 153 to 4,560 tonnes (Figure B.1-11). The port landing the greatest weight of herring has been Lismore comprising up to 95% of the total catch in a year. Cheticamp has contributed from <1 to 49% of the total annual catch, and Arisaig from <1 to 22%.

ECONOMICS

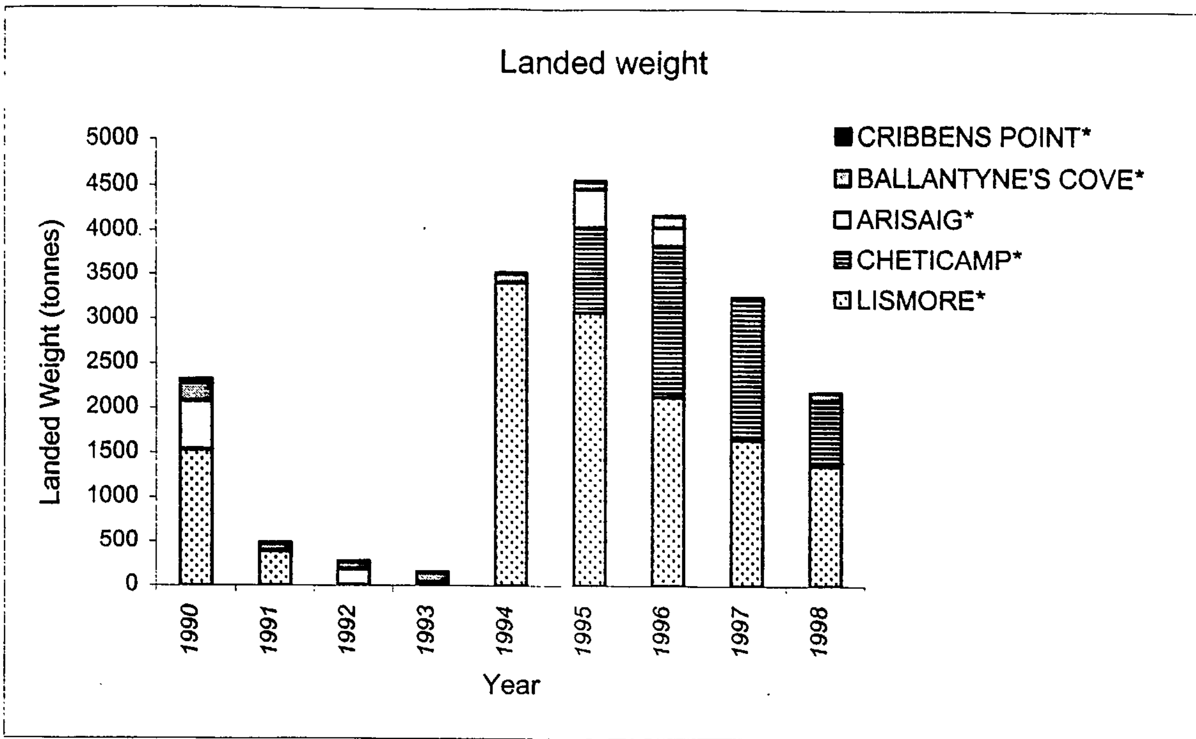
Between 1990 and 1998 total landed values for all of the ports combined peaked in 1996 ($1.38 million) and was least in 1992 ($63,936). The five principle ports listed above accounted for between 60 and 99% of the landed values in each year and by themselves contributed between $44,337 and $1.34 million. Landed values at the three most significant ports between 1990 and 1998 are provided in Table B.1-6. The annual highest value of landings was at Lismore (1996; $935,219).

Table B.1-6: Ranges of annual landed values and proportion of total herring catch that the port contributes for three most significant ports, 1990-1998.

Port	**Annual landed values ($)**	**Percentage of total herring values for Whole area contributed by port**
Lismore	1,260-935,219	2-91
Margaree Harbour	480-267,920	<1-52
Ballantynes Cove	0-94,325	<1-29

BIOLOGICAL/ECOLOGICAL CONCERNS

The herring fishery appears to be quite efficient at capturing herring with limited impact to other species. There is little information on by-catch from this fishery or incidental damage to other fisheries or marine species.



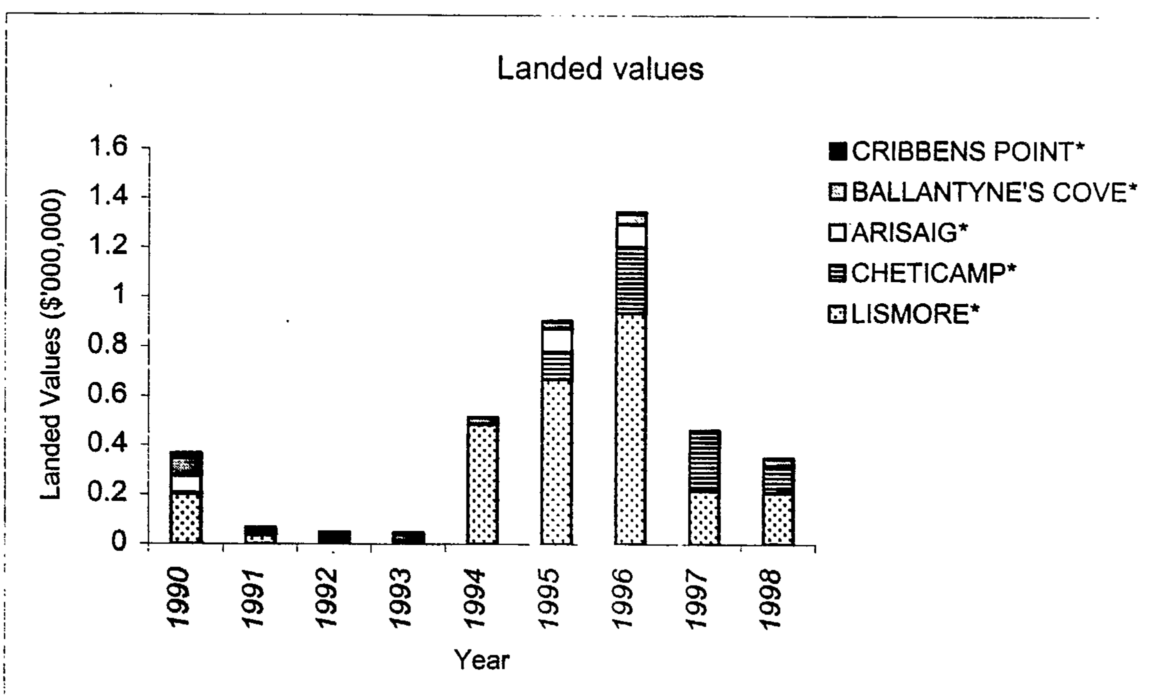


Figure B1-11: Landings and landed values of herring for five most significant ports, 1990-1998

PROSPECTS/FUTURE

"The herring fishery in the southern Gulf shows no sign of depletion" (Day, 1957)

"Twenty years ago herring were caught in great number from Arisaig around Cape George to Cribben Head; from Tracadie around Cape Jack to the Strait of Canso, and from Port Hood northeast along the Cape Breton shore. Today both stocks have declined drastically and only areas adjacent to Ballantynes Cove, Havre Boucher and Port Hood yield herring in any quantity" (Lambert et al., 1982b).

These two statements were made within 25 years of each other. Currently the herring fishery in St. Georges Bay appears healthy (based on historic and present landings), and providing the exploitation rate remains below the target of 26% (Anonymous, 1998e), as it has since 1984, there may be room for cautious optimism on the future of this fishery.

B.1.1.2.1.2 Atlantic Mackerel *(Scomber scombrus)*

BIOLOGY/NATURAL HISTORY

Adult mackerel migrate into the southern Gulf of St. Lawrence from the Atlantic Ocean in spring and first appear in the St. Georges Bay area when the water temperature reaches between 7-8 °C (Ware and Lambert, 1985). These fish spawn in June or early July (Ware, 1977; Anonymous, 1998f), releasing up to 200,000-500,000 eggs per female. Egg incubation is approximately six days (Ware and Lambert, 1985) and during this time the eggs undergo an estimated mortality of 50% per day (Anonymous, 1985). The adults themselves are estimated to suffer a mortality rate of approximately 20% per year due to causes other than fishing (predation, sudden drops in temperature, etc; Anonymous, 1985). Mackerel mature by four years of age, though some are mature at two, and have been observed to live up to 18 years (Anonymous, 1985). These fish leave the Gulf of St. Lawrence for the Atlantic in September-November (Anonymous, 1998f). There is a close link between the major life history events for mackerel (i.e., migration, spawning, development) and water temperature and it is suggested that the ability of this fish to discern small temperature differences guides its major activities (Ware and Lambert, 1985).

FISHERIES

Mackerel has a long history as a fishery; it has been harvested since the 17th Century by hook and line with the final product being salted mackerel (Anonymous, 1985). During the early years of this century the conversion from sail to motor power for fishing boats allowed the development of a fresh fish industry (Anonymous, 1985). Presently, the fishery is primarily an inshore fishery and the gear used (in order of importance) is gillnet, line, trapnet, and purse seine (Anonymous, 1998f), though along Cape Breton shores traps and weirs are also employed (Anonymous, 1985). Identified mackerel fishing areas extend along the coast from Pleasant Bay to, and within the central area of, St. Georges Bay (Anonymous, 1998a). There are only two isolated areas identified as mackerel areas between Cape George and Lismore.

The TAC for mackerel is presently 100,000 tonnes; 60,000 for inshore fisheries and 40,000 for exploratory mobile gear fisheries (Anonymous, 1998f). In 1998 there were 651 mackerel licences in the St. Georges Bay Ecosystem study area, of which 424 (65%) were active. Most fishermen fish other species such as lobster, herring and groundfish in addition to mackerel (Anonymous, 1985). There is also a recreational fishery for this species, with no requirement for registration or licensing so the importance of this fishery remains undocumented (Anonymous, 1998f). As a product mackerel is sold whole, canned, cured or as frozen fillets (Anonymous, 1985).

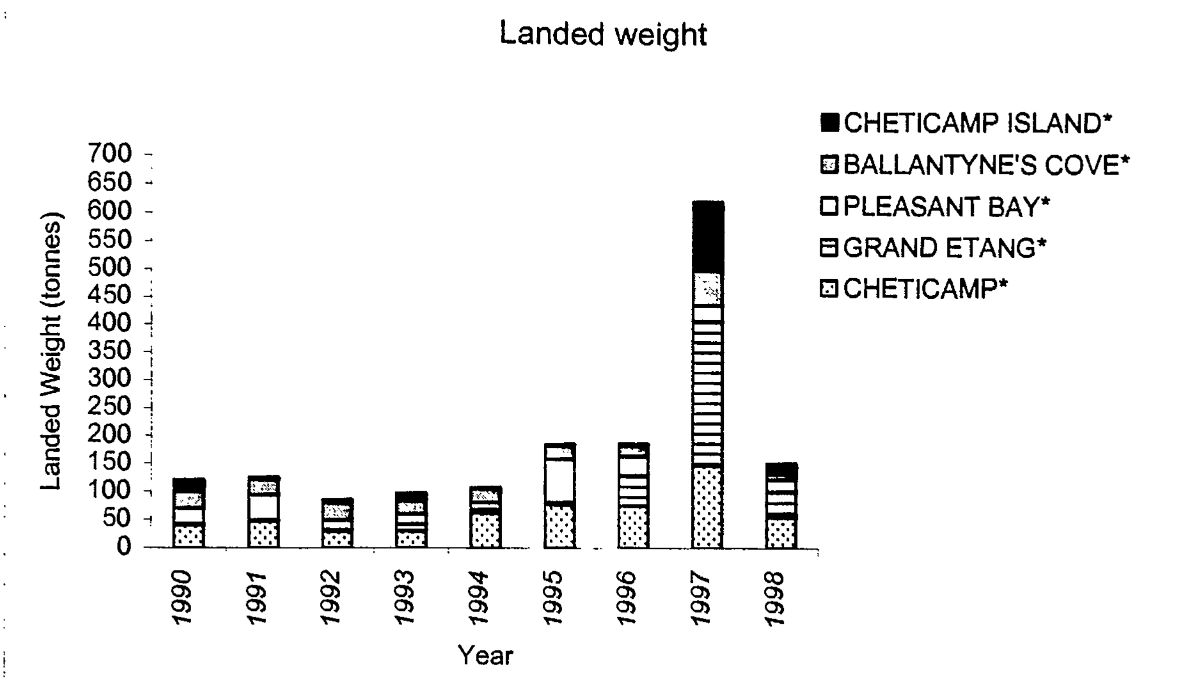
Thirty ports in the study area report landing mackerel. From 1990 to 1993 all of these ports combined landed less than 250 tonnes of mackerel per year. This increased after 1994 to a peak in 1997 of 874 tonnes, and then declined in 1998 to 238 tonnes. Four of the five principle ports for landings between 1990 and 1998 are located in the north, Cheticamp, Grand Etang, Pleasant Bay, and Cheticamp Island. Ballantynes Cove is the fifth principle port. Together these ports have contributed between 40-73% of the total annual landings. The combined landings of these five ports has ranged from 85.2 to 619.9 tonnes (Figure B.1-12). The port landing the greatest weight of mackerel has been Cheticamp, comprising between 16 and 28% of the total catch in a year. Grand Etang has contributed from <1 to 30% of the total annual catch, and Pleasant Bay from 4 to 21%.

These reported landings may underestimate the catch of mackerel as some fish is sold as bait between fishermen and so is not included in the official landings (Anonymous, 1998f). CPUE estimates are not available for this species as the majority of the fishing is done from small boats which don't require log books (Anonymous, 1985).

Gregoire and Baker (1996) report mackerel landings between 1985 and 1994 by statistical districts. The relevant districts are presented in Table B.1-7:

Table B.1-7: Mackerel landings (tonnes), 1985-1994, by statistical district (from Gregoire and Baker, 1996)

District	Mean	Minimum	Maximum
2	91.19	45.1	175.44
3	11.02	2.33	31.25
12	1.63	0	3.86
13	57.81	16.34	92.38



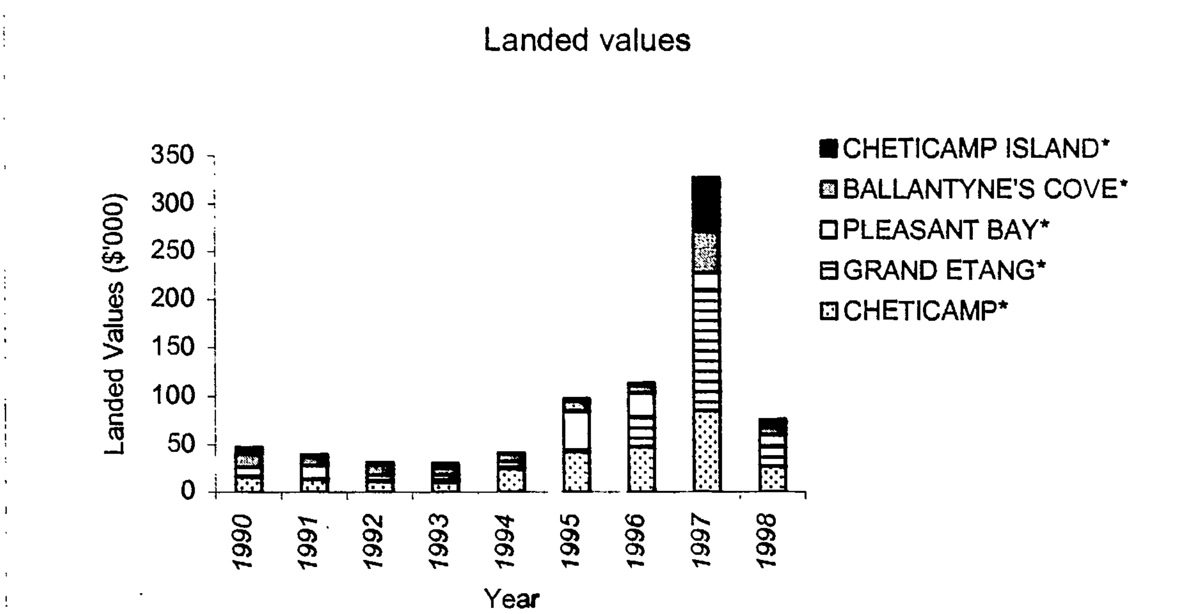


Figure B1-12: Landings and landed values of mackerel for five most significant ports, 1990-1998

ECONOMICS

Between 1990 and 1998 total landed values for all of the ports combined peaked in 1997 ($474,455). The five principle ports listed above accounted for between 40 and 71% of the landed values in each year and by themselves contributed between $30,437 and $328,388 in each year. Landed values at the three most significant ports between 1990 and 1998 are provided in Table B.1-8. The annual highest value of landings was at Grand Etang (1997; $125,543).

Table B.1-8: Ranges of annual landed values and proportion of total mackerel catch that the port contributes for three most significant ports, 1990-1998.

Port	**Annual landed values ($)**	**Percentage of total mackerel values for Whole area contributed by port**
Cheticamp	10,149-85,343	18-30
Grand Etang	582-125,543	<1-16
Pleasant Bay	5,206-40,175	3-28

BIOLOGICAL/ECOLOGICAL CONCERNS

Mackerel are caught as bycatch in the herring purse seine and gillnet fisheries, and in cod trap nets (Anonymous, 1998f). The mackerel fishery is in turn responsible for capturing other species, of which the only species allowed to be retained due to accidental catch is herring, and then only up to 10% by weight of the mackerel catch (Anonymous, 1998f).

PROSPECTS/FUTURE

The TAC for mackerel is set at 100,000 tonnes for the Atlantic fishery, between 1988 and 1996 the maximum reported landing was 26,170 tonnes (Anonymous, 1998f). Because existing mackerel markets do not offer a sufficient price to permit profitable fishing and processing (Anonymous, 1985), there has been relatively light pressure to date on this species. However, the close association between the mackerel life history and water temperatures implies that non-fishing related activities (e.g., global warming, temporary cooling trends, climatic fluctuations, etc.) may affect the abundance of this fish and must be borne in mind when assessing the status and future of this species.

B.1.1.2.1.3 Atlantic Cod *(Gadus morhua)*

BIOLOGY/NATURAL HISTORY

Southern Gulf of St. Lawrence cod are relatively long-lived and may reach ages of 20 years or more when mortality is low (Anonymous, 1998g). During the summer months cod are widely dispersed throughout the southern Gulf, feeding heavily on krill, shrimp and small fish, primarily herring, American plaice and capelin (Anonymous, 1998g). By December the cod move from nearly all areas less than 60 m deep to depths below 100 m, both along the southern slope of the Laurentian Channel and in the Cape Breton Trough (Clay, 1991). Through the winter months cod are thought to leave the Gulf entirely, and winter out in the Atlantic (Clay, 1991). Cod in the southern Gulf reach sexual maturity a slightly less than 41 cm (approximately 4-7 years of age), after which they quickly enter the commercial fishery minimum limit of 41 cm (Anonymous, 1998g).

A parasitological study by Boily and Marcogliese (1995) indicates high infection rates of cod by the sealworm *Pseudoterranova decipiens* within St. Georges Bay. They found 56.9-81.7% of the cod sampled carried this parasite, with a mean abundance of 1.57-2.94 worms/fish. Other parasites included the whaleworm *Anisaki simplex* (infection rate 18.3-29.9% of cod, mean abundance 0.5-0.74 worms/fish) and Contracaecinae [nematode] (9.5-13.0 % of cod infected, mean abundance 0.26-0.52 worms per fish).

FISHERIES

The cod fishery was prosecuted primarily by hook and line for the majority of its existence. This remained the major technique until the late 1940s when a ban on otter trawling in the Gulf of St. Lawrence was lifted. The fixed gear fishery declined most rapidly in the 1980's as mobile gear became more intensively used (Anonymous, 1998g). This remained so until 1993 when the fishery was closed due to low abundance. Cod fishing in the area was largely concentrated along the coast of Cape Breton south of Cheticamp and within St. Georges Bay (Anonymous, 1998a).

Within the southern Gulf of St. Lawrence historic cod landings have varied between 20,000 and 40,000 tonnes per year between 1917 and 1940, then increased to a peak of over 100,000 tonnes in 1958 (Anonymous, 1998g). From about 1960 to 1988 southern Gulf landings generally fluctuated between 45,000 and 70,000 tonnes per year, except for 1974-1978 when they dipped as low as 25,000 tonnes per year (Figure 2, Anonymous, 1998g). In the early 1990s cod landings dropped precipitously and a moratorium on cod fishing in the southern Gulf was imposed in 1993. In 1997 a 2,000 tonne TAC was allowed for cod due to the sentinel fishery, by-catch, and experimental fisheries; landings in this year were 1,591 tonnes, approximately one-half of which was due to the sentinel fishery (Anonymous, 1998g).

On a smaller scale, as reported by Scott (1979), prior to 1975 District 3 (Inverness) landings decreased from 220,000 lbs [100 tonnes] in 1949 to 50,000 lbs [22.7 tonnes] in 1954 then increased to about 240,000 lbs [109 tonnes] in 1956 followed by a general decline to 1975. Within District 13 (Antigonish) landings decreased to a low in 1955 then increased to a peak of over 700,000 lbs [318 tonnes] in 1959 and then showed a general decrease to 1975.

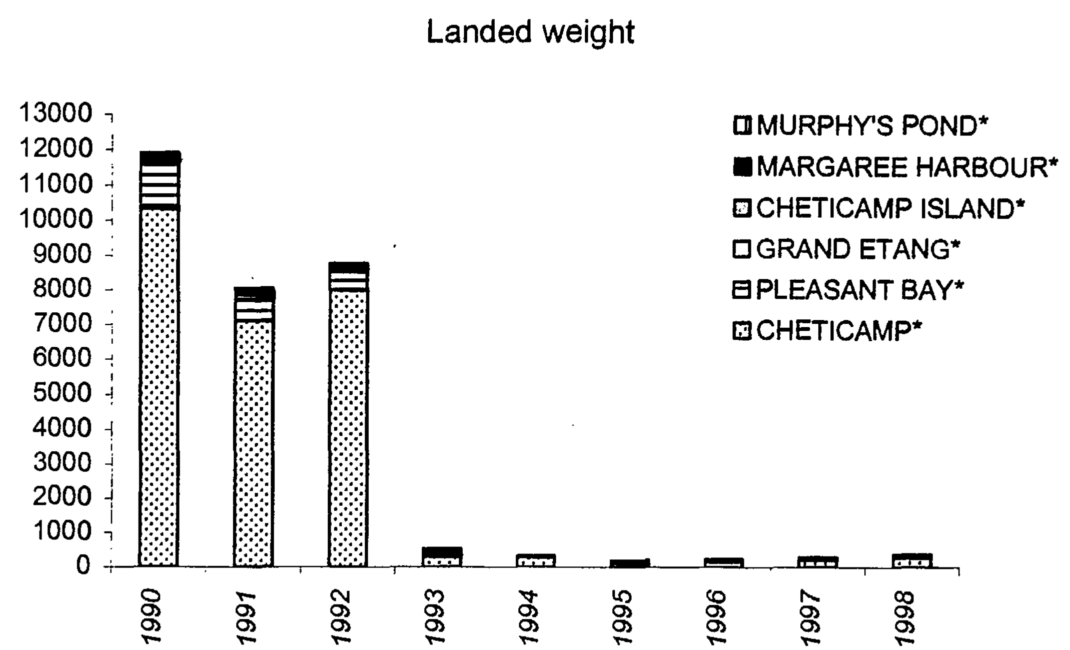
Twenty three ports in the study area report landing cod between 1990 and 1998. Combined these ports landed between 8,075 and 11,980 tonnes of cod per year prior to the moratorium, and 199 to 378 tonnes after 1993. The peak landings occurred in 1990 with a total of 12,000 tonnes and the poorest landing was in 1995 with only 199 tonnes between the 23 ports. The six principle ports for landings between 1990 and 1998 are, Cheticamp, Pleasant Bay, Grand Etang, Cheticamp Island, Margaree Harbour and Murphys Pond, and together these ports have contributed between 94-99% of the total annual landings. The combined landings of these six ports has ranged from 117 to 10,327 tonnes (Figure B.1-13). The port landing the greatest weight of cod has been Cheticamp comprising between 55 and 91% of the total catch in a year. Pleasant Bay has contributed from 6 to 24%, and Grand Etang has contributed from 0 to 12% of the total annual catch.

ECONOMICS

Between 1990 and 1998 total landed values for all of the ports combined peaked in 1992 ($7.38 million). The six principle ports listed above accounted for between 94 and 99% of the landed values in each year and as a whole contributed between $130,209 and $7.33 million in each year (Figure B.1-13). Landed values at the three most significant ports between 1990 and 1998 are provided in Table B.1-9. The annual highest value of landings was at Cheticamp (1992; $6,639,366).

Table B.1-9: Ranges of annual landed values and proportion of total cod catch that the port contributes for three most significant ports, 1990-1998.

Port	**Annual landed values ($)**	**Percentage of total cod values for whole area contributed by port**
Cheticamp	68,189-6,639,366	50-90
Pleasant Bay	19,104-736,213	6-30
Grand Etang	0-120,069	0-11



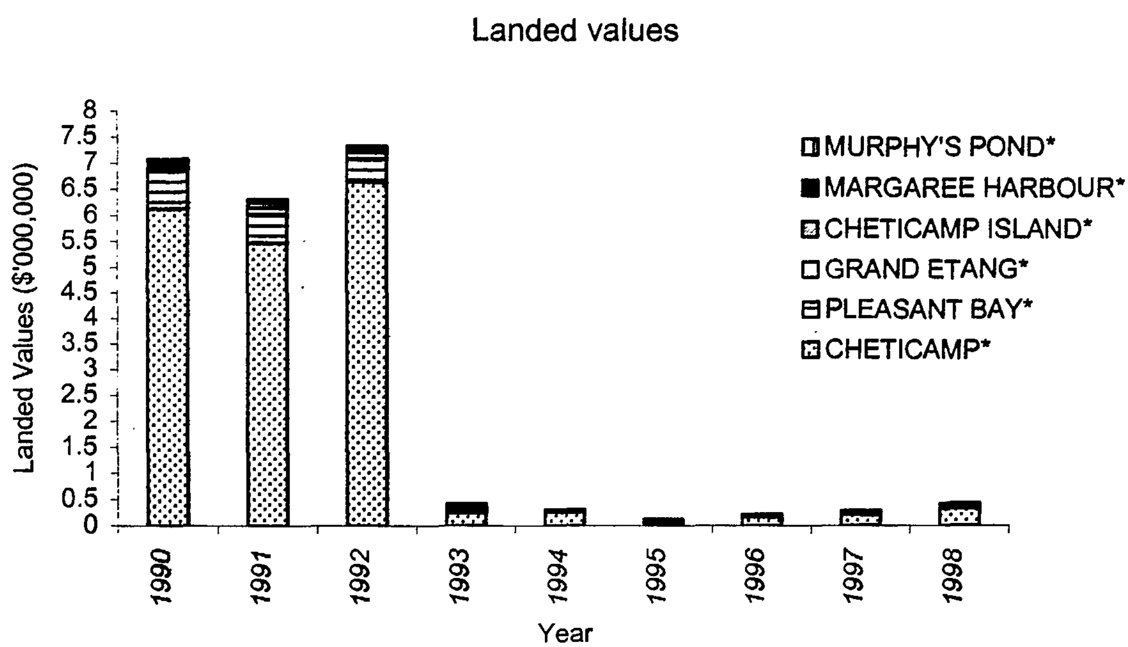


Figure B1-13: Landings and landed values of Atlantic cod for six most significant ports, 1990-1998

BIOLOGICAL/ECOLOGICAL CONCERNS

The widespread dumping and discarding of fish at sea by the domestic fishing fleets in the Gulf of St. Lawrence has been a long-standing problem (Anonymous, 1998h). Discarding may be defined as selective removal of undersized individuals from the catch, and occurs when the fishery does not avoid catching undesirable components of a species (Kulka, 1985 cited in Chouinard and Metuzals, 1985). Table B.1-10 presents some cod discard rates from the literature.

Table B.1-10: Some cod discard rates within the southern Gulf of St. Lawrence.

	Discard (%)			
Date	**By Number**	**By Weight**	**Area**	**Source**
1956-1961	6-25	2-9	Northern New Brunswick	Jean, 1963
1980	7	4	Magdalen islands	Clicke 1981
1984	5.45-37.7	1.7-14.3	Area 4Tg	Chouinard & Metuzals, 1985

Powles (1965) indicates that almost all of discarded cod and American plaice are dead by the time they are shovelled off the deck and back into the water. Though it may be assumed that the 1993 moratorium greatly reduced the number of discarded fish, the effects of this practice, on the scale that it was conducted, likely had profound influences on population dynamics and stock biomass.

In contrast to discarding, a more recent concern regarding the cod fishery is just the opposite of discarding – it is by-catch by other directed fisheries. In prosecuting other fisheries (e.g., winter and witch flounder, American plaice) cod may be captured. Prior to 1997, 10% (by weight) of a total catch was allowed to consist of cod. Fishers had great difficulty fishing other species without exceeding the permitted level of cod by-catch (Anonymous, 1998h) and so in 1997 the by-catch was increased to 25% by weight in the flatfish industry.

A third concern is the effect of the cod fishery, when it was in operation, on other fish species. Jean (1963) estimated that in 1959 in northern New Brunswick, draggers discarded approximately 10% by weight of incidental commercial species caught, and approximately 3,000 fish/boat of incidental non-commercial species. Such large scale disruptions to species population dynamics, occurring continually since 1947 when trawls were introduced, has likely played a large role in the observed fluctuations in, and losses of, fish stocks.

PROSPECTS/FUTURE

Cod population biomass remains at a level close to the lowest observed since 1950. The natural mortality (estimated since the moratorium) is 33-40% per year – this is more than twice that traditionally assumed (Anonymous, 1998g). Unfortunately, it is not documented whether this apparent increased mortality is due to underestimating the mortality in the past or real increased predation pressure on the stock. Recruitment has been well below the historical average and there is no sign of improvement. These factors result in low productivity of the stock (Anonymous, 1998g) and prospects for a significant recovery of this stock in the short term are poor (Chouinard et al., 1998).

B.1.1.2.1.4 White Hake *(Urophycis tenuis)*

BIOLOGY/NATURAL HISTORY

The following discussion of white hake is drawn from Anonymous (1998i) and Hurlbut et al. (1998) unless otherwise indicated. White hake within management area 4T are composed of two different stocks – the 'Strait' component (Northumberland Strait including St. Georges Bay) and the 'Channel' component which are present in the deeper waters such as the Laurentian Channel. The Strait fish are an inshore stock, but are thought to migrate into the deeper waters of the Laurentian Channel as Autumn proceeds and the shallower waters cool. In the southern Gulf, females reach sexual maturity at about 41 cm and the males at about 44 cm. For each sex these sizes correspond to ages of 2-5 years. Spawning occurs in June. The diet of white hake is dominated by other fish species (such as cod, herring and flatfish).

FISHERIES

Historically, white hake have been the third or fourth most important groundfish resource in the southern Gulf of St. Lawrence. The fishery is prosecuted mainly by small inshore vessels, and is strongly affected by outside influences such as weather and market conditions. Since 1960 the fisheries have been dominated by gillnets and bottom trawls (~30 and 26 % of landings, respectively) with longlines (17%) and seiners (11%) also contributing. Hake fishing in the area was concentrated along the coast of Cape Breton south of Cheticamp and within St. Georges Bay (Anonymous, 1998a).

Over the large area of management unit 4T, white hake landings were relatively stable from 1961-1978 (3,600-7,200 tonnes/year), then rose sharply to a peak of 14,039 tonnes in 1981. This increase was due to increased effort, not an abundance of hake. Within area 4Tg, between 1985 and 1992, the landings have generally fluctuated between 1,500 and 2,000 tonnes, with a peak landing in 1987 of more than 3,000 tonnes. A substantial drop in landings occurred in 1993, concurrent with the cod fishery closure, and landings in 4Tg from 1993 to the hake closure in 1995 remained less than 1,000 tonnes per year. Since 1985, the majority (90%) of the white hake landings in the southern Gulf have been of the 'Strait' component.

Twenty six ports in the study area report landing white hake. From 1990 to 1992 all of these ports combined landed more than 1,000 tonnes of hake per year, from 1993 to present this has dropped to between 33 and 710 tonnes. The five principle ports for landings between 1990 and 1998 are Cheticamp, Ballantyne's Cove, Murphys Pond, Bayfield, and Pleasant Bay. Together these ports have contributed between 49-92% of the total annual landings. The combined landings of these five ports has ranged from 18 to 1,400 tonnes (Figure B.1-14). The port landing the greatest weight of white hake has been Cheticamp comprising between 4 and 30% of the total catch in a year. Ballantynes Cove has contributed from 8 to 34% of the total annual catch, and Murphys Pond from 7 to 23%.

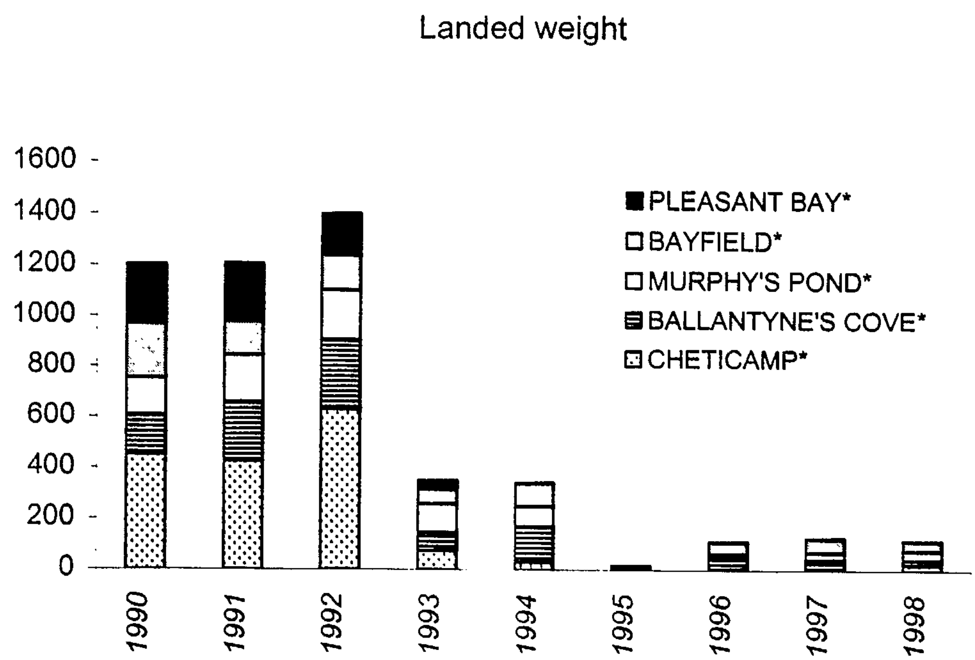
At the present time, St. Georges Bay appears to be the preferred area for hake in the southern Gulf. It is one of the few areas with concentrations of this species. This is acknowledged by both DFO and local fishers.

ECONOMICS

Between 1990 and 1998 total landed values for all of the ports combined peaked in 1992 ($1,381,000). The five principle ports listed above accounted for between 48 and 93% of the landed values in each year and by themselves contributed between $13,260 and $841,940 in each year. Landed values at the three most significant ports between 1990 and 1998 are provided in Table B.1-11. The annual highest value of landings was at Cheticamp (1992; $270,156).

Table B.1-11: Ranges of annual landed values and proportion of total white hake catch that the port contributes for three most significant ports, 1990-1998.

Port	**Annual landed values ($)**	**Percentage of total white hake values for whole area contributed by port**
Cheticamp	1,209-270,156	3-20
Ballantynes Cove	4,935-211,211	8-36
Murphys Pond	2.950-159,142	8-20



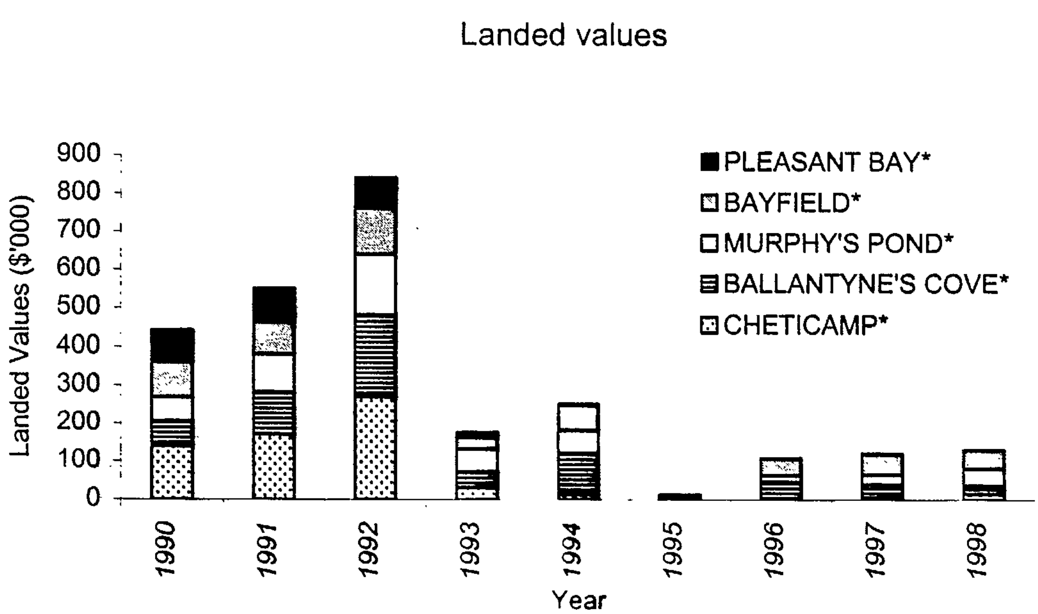


Figure B1-14: Landings and landed values of white hake for five most significant ports, 1990-1998

BIOLOGICAL/ECOLOGICAL CONCERNS

In the past discards of hake as an incidental catch had an impact. Jean (1963) estimates 6,000 lbs [2,725 kgs]/boat of hake were discarded in 1959. Presently the smelt fishery catches hake as bycatch – in the Miramichi Estuary (New Brunswick), 275,000 one and two year old hake are estimated to be taken as bycatch each year. A similar by-catch rate for the considerably smaller smelt fishery in the St. Georges Bay area may be a reasonable assumption. In addition, the present directed fisheries (i.e., winter flounder, American plaice, witch flounder, etc.) are allocated an annual 500 tonnes by-catch of white hake.

PROSPECTS/FUTURE

The white hake resource remains near its lowest level since 1982 (when the first quota was established) and is estimated to be near its lowest historical levels (Chouinard et al., 1998). Recent research surveys also suggest that there has been a contraction of the geographic range as well as a reduction in the abundance of hake.

"*The recent abrupt decline in hake abundance and continuing high mortality despite limited fishing raise grave concerns for the state of this resource*" (Anonymous, 1998i).

B.1.1.2.1.5 American Plaice *(Hippoglossoides platessoides)*

BIOLOGY/NATURAL HISTORY

American plaice dominate the benthic communities in the southern Gulf of St. Lawrence. Clay (1991) reports this as the most abundant species in research surveys. Within the southern Gulf, two discrete stocks of plaice are recognized – a northern ('Miscou-Magdalen') group concentrated to the west of the Magdalen Islands, and a southern ('Cape Breton') group distributed from Cape North to St. Georges Bay (Powles, 1965; Koeller and LeGresley, 1981). Koeller and LeGresley (1981) found plaice generally most abundant in waters less than 90 m deep in September surveys, though these fish are also reported as being most abundant at intermediate depths (80-250 m) and cold waters (0-1.5°C) (Anonymous, 1998j). Plaice are thought to move from these shallower waters to deeper warmer waters in winter (Clay, 1991). These fish are relatively sedentary though they may move surprisingly long distances. Studies have indicated that most fish moved less than 30 miles [48 km] (Anonymous 1989b) to 60 miles [96 km] (Powles, 1965), though several old fish were found 100 miles [160 km] from the tagging site and one wanderer was recaptured 150 miles [240 km] from its point of release (Powles, 1965).

Through most of their distribution female plaice begin to spawn at 8 or 9 years of age (~30 cm), but most females do not reach the spawning stage until at least 11 years old (40-45 cm). Sexual maturity in males may be as early as 3 years of age (15-20 cm) with the majority being mature by 6 years (25-30 cm) (Powles, 1965; Anonymous, 1989b) Maximum spawning occurs from mid-April to mid-May. Young plaice feed mainly on mysids, amphipods, small echinoderms and annelids, and are in turn preyed upon largely by cod. Adults eat mainly echinoderms and pelicypods, and to a lesser extent amphipods and polychaetes (Powles, 1965).

A parasitological study by Boily and Marcogliese (1995) indicates moderate infection rates of plaice by the sealworm *Pseudoterranova decipiens* within St. Georges Bay. They found 40.3% of the plaice sampled carried this parasite, with a mean abundance of 0.89 worms/fish. Other parasites were present in very low abundance and included the whaleworm *Anisaki simplex* (infection rate 2.4% of plaice, mean abundance 0.02 worms/fish) and Contracaecinae (0.8 % of plaice infected, mean abundance 0.01 worms per fish).

FISHERIES

American plaice were the second most important fish in groundfish landings after Atlantic cod until the cod fishery was closed in 1993 (Morin et al., 1998). Seines have been the dominant gear in the southern Gulf, surpassing otter trawls in most years since 1981; in 1996 and 1997 seines accounted for approximately 75% of annual landings. However, the number of trawling vessels directing for plaice has increased greatly since the cod closure of 1993, with most of this increase in area 4Tg (Morin et al., 1998). Fishing effort is concentrated in the area north of Cheticamp, and the western half of St. Georges Bay out into Northumberland Strait north to Cape Mabou. There are only a couple of relatively small, isolated plaice grounds between Mabou and Cheticamp (Anonymous, 1998a). In 1998 there were 275 groundfish licences within the study area, of which 139 (50.5%) were active (P. George, pers. comm.).

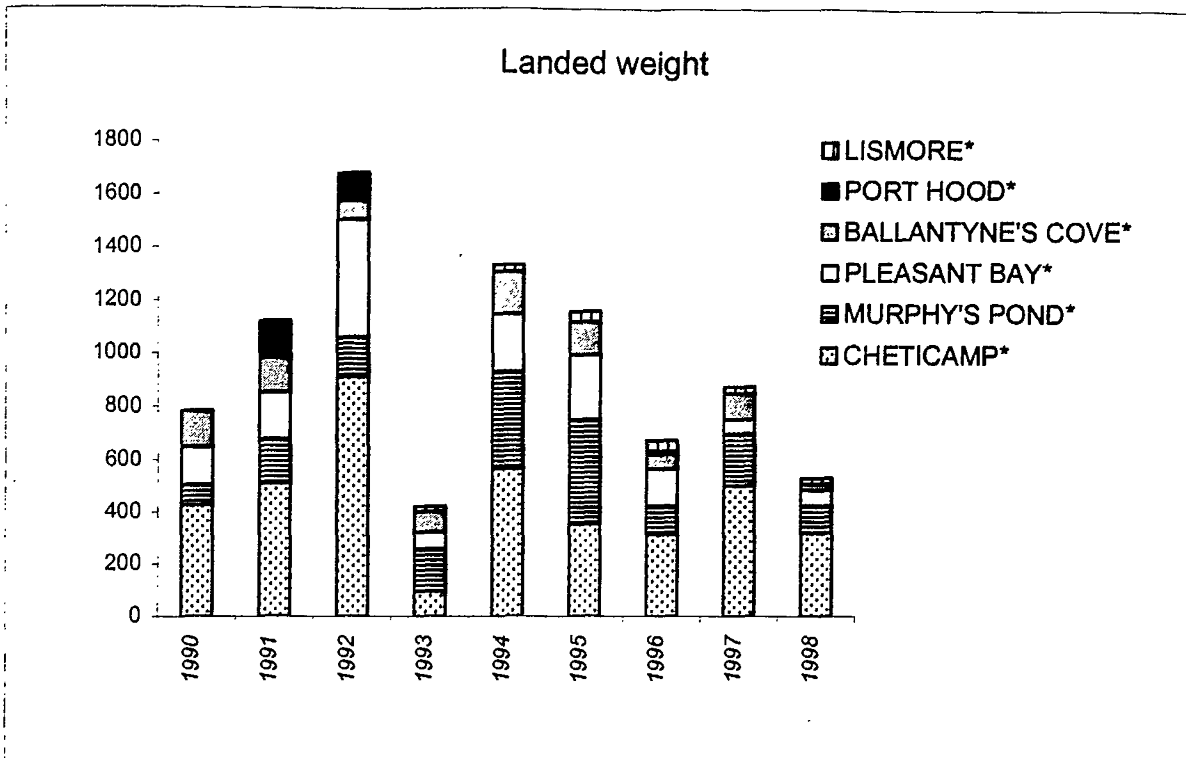
Interestingly, American plaice appear to be relatively new to the St. Georges Bay area. Scott (1979) reports that plaice in this area were not recorded until 1964 when a small quantity appeared in the statistics for District 3 (Inverness). In addition, there appears to be a shift in the distribution of American plaice within the southern Gulf in recent years. Swain and Poirier (1997) and Anonymous (1998j) report a sharp shift in plaice distribution to the eastern regions of the Gulf when comparing the mid-1990s with the 1970s and '80s. Captured plaice are filleted and almost all that are produced in Canada are sold frozen (Anonymous, 1989b).

Within government documents (e.g., Anonymous 1998j; Morin et al., 1998) historic American plaice landings are only provided for the entire statistical area of 4T, a vast area from which it is not reasonable to proportionately estimate local landings in the St. Georges Bay area. There does not appear to be any relatively readily available information on historic landings of plaice at a smaller scale (i.e., summarized by area 4Tg or by Statistical District).

Twenty seven ports in the study area report landing American plaice. From 1990 to 1998 all of these ports combined landed between 427 tonnes (1993) and 1,339 tonnes (1994) of plaice per year. The six principle ports for landings between 1990 and 1998 were Cheticamp, Murphys Pond, Pleasant Bay, Ballantyne's Cove, Port Hood, and Lismore. Together these ports have contributed between 96 and 100% of the total annual landings. The combined landings of these six ports has ranged from 422 to 1,679 tonnes (Figure B.1-15). The port landing the greatest weight of American plaice has been Cheticamp comprising between 22 and 59% of the total catch in a year. Murphys Pond has contributed from 9 to38% of the total annual catch, and Pleasant Bay from 6 to 26%.

ECONOMICS

Between 1990 and 1998 total landed values for all of the ports combined peaked in 1994 ($1,275,000). The six principle ports listed above accounted for between 97 and 100% of the landed values in each year and by themselves contributed between $283,964 and $1,269,094 in each year. Landed values at the three most significant ports between 1990 and 1998 are provided in Table B.1-12. The annual highest value of landings was at Cheticamp (1992; $594,696).



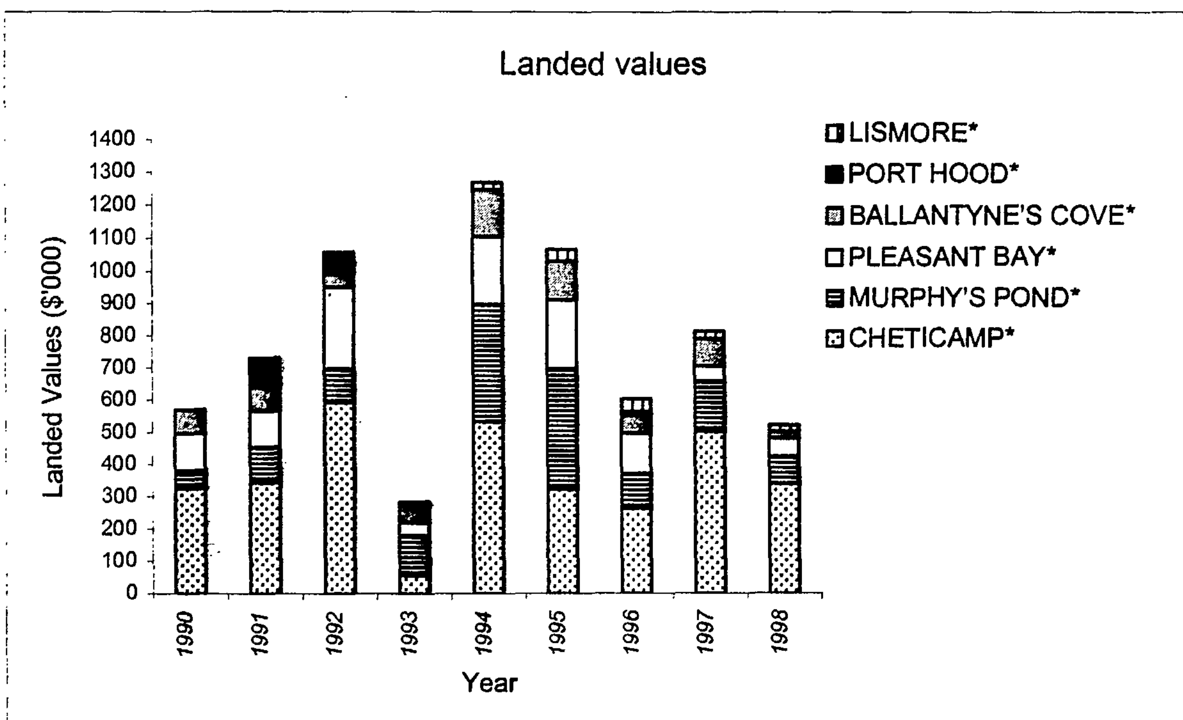


Figure B1-15: Landings and landed value Figure B1-15
1990-1998

Table B.1-12: Ranges of annual landed values and proportion of American plaice catch that the port contributes for three most significant ports, 1990-1998.

Port	Annual landed values ($)	Percentage of total American plaice values for whole area contributed by port
Cheticamp	56,486-594,696	20-64
Murphys Pond	56,122-373,360	10-42
Pleasant Bay	40,620-254,556	6-21

BIOLOGICAL/ECOLOGICAL CONCERNS

Similar to Atlantic cod, the principle ecological impact on the American plaice, aside from the actual capture by fisheries and removal from the population, is discarding at sea. Table B.1-13 presents some estimated discard rates of American Plaice within the Gulf of St. Lawrence.

Table B.1-13: Some plaice discard rates within the southern Gulf of St. Lawrence.

Date	Discard (%)		Area	Source
	By Number	By Weight		
1957-1959		40-60	Northern New Brunswick	Jean, 1963*
1961		50	Northern New Brunswick	Jean, 1963*
mid 1970's	70			DFO unpub.*
1976		15-51	Area 4Tg	Halliday et al., 1989
1980	50	25	Magdalen Islands	Clicke, 1981*
1984	35-80	23.5-60.6	Area 4Tg	Chouinard & Metuzals, 1985
mid 1990's		40-80	Cape Breton & Shediac Valley	Morin et al. 1998

* Cited in Chouinard and Metuzals, 1985.

Powles (1965) indicates that almost all of discarded cod and American plaice are dead by the time they are shoveled off the deck and back into the water. Choiunard and Metuzals (1985) report that the discarded male plaice are 6-10 years old and the females are 7-10 year olds. The mean age of discarded plaice was 8 years, which is younger than the sexual maturation for the female fish. Therefore, these fish are being killed before they have the opportunity to reproduce. Halliday et. al. (1989) report the male plaice being preferentially discarded – the sex ratio in the catch is approximately 1:1, but about 90% of the males and 50% of the females are discarded.

Choiunard and Metuzals (1985) also examined whether the increasing cod-end mesh sizes between 1976 and 1981 had reduced the amount of discarding occurring. Their conclusion was that it had not.

PROSPECTS/FUTURE

The mean catch of all age classes of females and males is presently at a low level, particularly in comparison to the levels obtained in the mid-1970s (Morin et al., 1998)

Declining stock abundance, the changing distribution of the resource, poor recruitment and high mortalities suggest that landings during the latest period of decline (1994-1997) which averaged about 2,000 tonnes, were too high (Anonymous, 1998j).

The abundance of this resource attained its lowest level of abundance in 1997 and remains low compared to values in the time series of the survey (Chouinard et al., 1998).

It appears that the future of the American plaice stocks within the southern Gulf is uncertain. However, many fishermen suggest that the species is at its average abundance and that the 1996 and 1997 fisheries were better than previous years (Morin et al.., 1998). Thus, prediction of the future for this stock is fraught with uncertainty.

B.1.1.2.1.6 Flounder Species

In addition to American plaice other flatfish species are also harvested in the St. Georges Bay area. These include the winter flounder (*Pleuronectes americanus*), witch flounder (*Glyptocephalus cynoglossus*) and yellowtail flounder (*Limanda ferruginea*) which will be discussed as a group in the following section.

BIOLOGY/NATURAL HISTORY

Winter flounder are associated with soft or moderately hard substrate and prefer relatively shallow depths of less than 40 m (Anonymous, 1997b). In the winter, most of the winter flounder appear to disperse to deeper (>60 m) waters, but some overwinter in the shallower water (Clay, 1991) and some are known to use estuaries to overwinter (Hanson and Coutenay, 1996). Spawning occurs in late winter or early spring. Growth rates vary widely between regions, female winter flounder are estimated to reach sexual maturity by about 25 cm and males mature at approximately 20 cm (Anonymous, 1997b). Winter flounder feed principally on benthic organisms such as molluscs and small crustaceans, as well as eggs and larvae/juveniles of small fish such as herring and capelin. The first stock status assessment for winter flounder was not conducted until 1994.

There is very little published information on witch flounder within the present study area, the following discussion of winter flounder is drawn from Morin et al. (1996) and Anonymous (1998d) unless otherwise indicated. Relative to other flounders, witch are slow growing and long lived. Spawners aggregate in the Laurentian Channel in January-February, with spawning thought to occur in these deep waters in late spring or early summer. In the winter these fish move into deeper waters and cease feeding. In the late 1970s and early 1980s, 50% of females reached maturity at lengths of 40-45 cm (9-14 years of age) and 50% of males matured at 30-34 cm (5-8 years of age).

Yellowtail flounder within the St. Georges Bay study area has never been under TAC, therefore it has never been studied and very little is known of the biology or population dynamics of this fish (Poirier et al., 1997) The following discussion of yellowtail flounder is drawn from Poireier et al. (1997) and Anonymous (1997c) unless otherwise indicated.

Yellowtail are associated with sand or sand and mud bottoms, usually at depths of 37-91 m, and are known to migrate seasonally into shallower waters in the spring and back to deeper waters in the winter. Clay (1991) reports in September that he found yellowtail restricted to waters less than 60 m deep and in two geographic locations within the southern Gulf of St. Lawrence – one north of the Magdalene islands and the other between P.E.I. and Cape Breton. By December he had noted a size shift in these fish with depth, with the largest fish within the Cape Breton Trough, intermediate sized fish in the 60-80 m depth range and the smaller individuals in 40-60 m of water. Due to their small mouth size, yellowtail feed on polychaetes, amphipods and other small crustaceans, and to a lesser extent on fish such as sand lance (*Ammodytes* sp.).

FISHERIES

Winter flounder have been an important bait fishery (Anonymous 1997b) with the fishery occuring during the open water periods of May-October. Trawls have contributed the greatest to yearly landings since 1960 (Morin and Forest-Gallant, 1997). Seine landings have declined since 1992, and gill net landings have declined since about 1994; but, the gill net contribution to the total landings has increased to 34-39% (Morin and Forest-Gallant, 1997). In addition to these gear types, localized fisheries use modified gillnets (tangle nets) set on the spring and fall spawning ground of herring (Anonymous, 1997b). Winter flounder fishing grounds are located slightly offshore of Pleasant Bay, in isolated pockets between Finlay Point and the Margaree River and within St. Georges Bay (Anonymous, 1998a). The closure of the cod fishery in 1993 and hake fishery in 1995 raised concerns for the future of secondary groundfish, and so in 1996 a precautionary quota of 1,000 tonnes was established (Morin and Forest-Gallant, 1997).

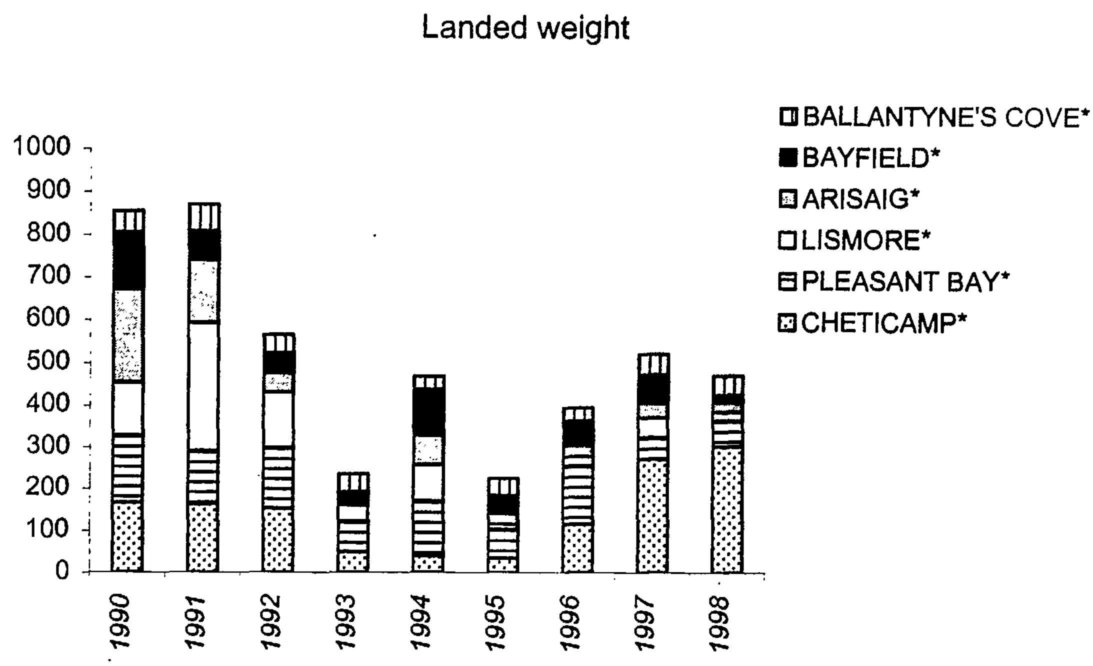
There were an estimated 139 active groundfishers in the area from Lismore to Pleasant Bay in 1998 (see American plaice).

Until 1995 witch flounder in area 4Tg (which includes the St. Georges Bay Ecosystem Project study area) were not managed. In that year the witch in area 4T were combined with area 4RS (Northern Gulf) to create a management of witch flounder for the entire Gulf of St. Lawrence as one unit (Area 4RST). The dominant gear taking witch flounder are Danish Seines, accounting for more than 85% of witch landings.

Yellowtail flounder in the southern Gulf of St. Lawrence are fished primarily with seine and trawl during the months of May to October. Gill nets account for only a small part of annual yellowtail landings. The market is primarily bait for other fisheries.

Twenty one ports in the study area report landing at least one of the three species of flounder. From 1990 to 1993 all of these ports combined landed between 268 and 1,027 tonnes of flounder per year. The six principle ports for landings between 1990 and 1998 were Cheticamp, Pleasant Bay, Lismore, Arisaig, Bayfield, and Ballantynes Cove. Together these ports have contributed between 83-95% of the total annual landings. The combined landings of these six ports has ranged from 223.4 to 869.8 tonnes (Figure B.1-16). The port landing the greatest weight of combined flounder species has been Cheticamp comprising between 7 and 61% of the total catch in a year. Pleasant Bay has contributed from 9 to31% of the total annual catch, and Lismore from 4 to 30%.

Chouinard et al. (1998) report that the annual September groundfish survey in 1998 was near the third lowest level recorded since 1985. However, research surveys may poorly reflect the abundance of winter flounder as these fish are distributed in shallow water of the inshore edge of the survey (Anonymous, 1997b). The large research vessel cannot adequately sample these nearshore waters.



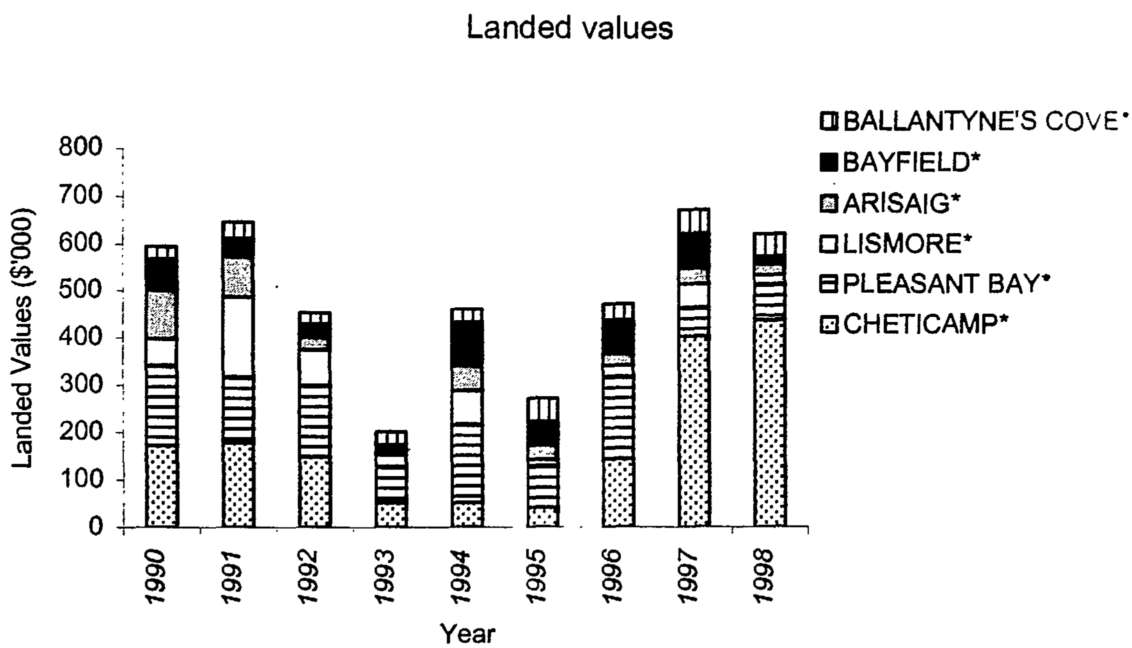


Figure B1-16: Landings and landed values of combined flounders (winter, witch, and yellowtail) for six most important ports, 1990-1998.

The annual September groundfish surveys conducted by DFO indicate that in the early 1980s witch stock abundance was low. Since about 1993, however, the abundance indices are in the upper range of values that have been observed since the survey began in 1971, with the fish being distributed primarily along the Laurentian Channel and Cape Breton Trough in 1998 (Chouinard et al., 1998)

Yellowtail do not appear to have always been a local fish. Based on the annual September DFO trawl surveys (conducted since 1971), yellowtail do not consistently appear in catches in this study area until 1984, and then they are present at low frequency (5-50 kg/tow) until 1991 when 50-100+ kg/tow are consistently encountered (Figure 12 in Poirier et al., 1997). St. Georges Bay is now one of the areas in the southern Gulf which contains a concentration of yellowtail flounder.

ECONOMICS

Between 1990 and 1998 total landed values for all of the ports combined peaked in 1991 ($769,832). The six principle ports listed above accounted for between 82 and 95% of the landed values in each year and by themselves contributed between $201,828 and $674,748 in each year. Landed values at the three most significant ports between 1990 and 1998 are provided in Table B.1-14. The annual highest value of landings was at Cheticamp (1991; $178,095).

Table B.1-14: Ranges of annual landed values and proportion of total flounder catch that the port contributes for three most significant ports, 1990-1998.

Port	**Annual landed values ($)**	**Percentage of total flounder values for Whole area contributed by port**
Cheticamp	42,070-439,177	10-67
Pleasant Bay	60,941-173,896	8-32
Lismore	13,305-169,261	3-22

BIOLOGICAL/ECOLOGICAL CONCERNS

Historically winter flounder has been a bycatch species which has been discarded at sea. Jean (1963) estimated northern New Brunswick trawlers in 1959 discarded ~400 lbs [182 kg] of winter flounder /boat. Yellowtail are a bycatch in fisheries for cod and white hake (historically) and still are bycatch in the American plaice and winter flounder fisheries. There is a dearth of information on yellowtail flounder, from their basic biology, to population dynamics to potential and existing impacts. This lack of knowledge may be more harmful than any existing impacts.

PROSPECTS/FUTURE

It is not presently possible to project the abundance of winter flounder in the area (Anonymous, 1997b). Without the ability to assess what is present (insufficient sampling by trawl surveys), what is captured (unreported and misreported catches) or project abundance, the future of this small fish is indeed uncertain.

The annual DFO groundfish surveys indicate an abundance of witch flounder, while significant landings are now confined to only a few of the management areas. The St. Georges Bay area has not reflected the sharp decline in spawning stock biomass seen throughout the Gulf, but there is concern that unless recruitment to this stock improves substantially, current catch levels are unlikely to permit any rebuilding of the stock and risk further decline.

Information from the annual September DFO trawl surveys indicate that yellowtail in the area of 4T are at a stable abundance level and have been so since 1985. However, the sentinel fisheries in 1994 to 1996 revealed very few yellowtail within the St. Georges Bay Ecosystem Project study area (0-25 kg/tow; Figure 6, Poireir et al., 1997), though as stated above, the trawl survey continues to indicate moderate abundance in the area. At present there is no expectation of increased fishing effort on yellowtail flounder.

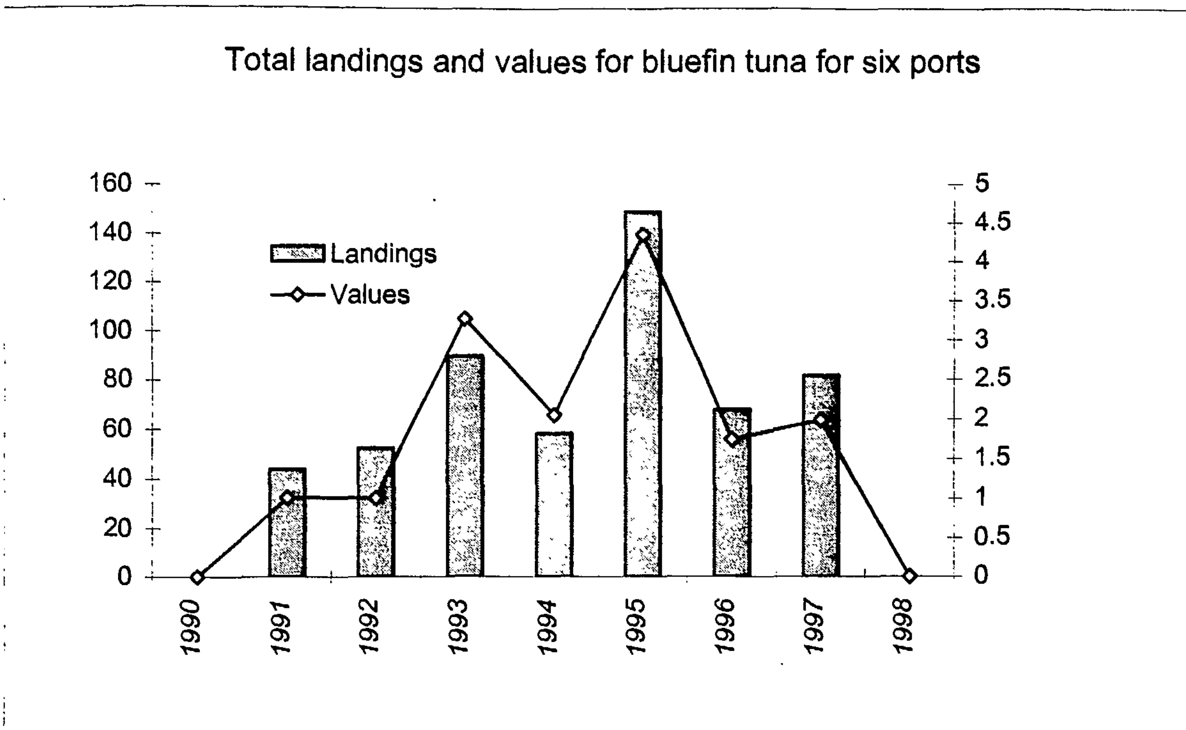
B.1.1.2.1.7 Miscellaneous Fisheries

In addition to the fisheries considered in detail above, there are a number of other fish species commercially exploited within the St. Georges Bay Ecosystem project study area. The species are presented in Table B.1-5. Some brief summary statistics of harvest are provided in Table B.1-15, and Figure B.1-17 to illustrate trends in catch over time for these fisheries.

In addition to the finfish and invertebrate fisheries mentioned above, there is also an industry for algae. Irish moss (*C. crispus*) harvesting in the area was some of the earliest in Nova Scotia, beginning before 1940. It is harvested for use in the food, brewing, packing and textile industries, as well as for pharmaceuticals and cosmetics (MacFarlane, 1956). *Chondrus* is harvested by dragrakes towed behind inshore fishing vessels with the upright fronds binding between the dragrakes tines and either separating from the holdfast or being removed complete with the holdfast (Pringle and Mathieson, 1987). July and August are the best months for harvesting of high quality *Chondrus* (MacFarlane, 1956). Impacts associated with *Chondrus* harvesting include: less algal reproductive structures per unit bed area (Chopin et al., 1988), a reduction in mean frond weight (Pringle and Semple, 1988), a lobster mortality estimated at from 1%-3% (Pringle and Mathieson, 1987), lobster claw loss and wounding from 1%-19% (Scarrat, 1973 and see Section B.1.1.2), and a direct impact on both the target species and closely associated flora and fauna (Sharp and Pringle, 1990). It is recommended that harvesting strategies for dominant kelp species must allow approximately two years to recover from harvesting (Smith, 1985; Sharp, 1987).

Table B.1-15: Landings, values and principle ports of miscellaneous fish species commercially harvested in the St. Georges Bay study area.

Number of ports landing species	Landings (kg) and values ($) of combined ports			Principle five ports
	Minimum	Mean	Maximum	
		Halibut		
13	573 kg ($3,238)	3,494 kg ($10,867)	10,317 kg ($17,872)	Cheticamp Pleasant Bay Grand Etang Cheticamp island Murphys Pond
		Bluefin Tuna		
6	0 kg ($0)	60,157 kg ($1,711,728(	148,591 kg ($4,346,387)	Ballantynes Cove Murphys Pond Port Hood Inverness Margaree Harbour
		Sharks and Skates		
20	4,659 kg ($2,225)	84,135 kg ($26,405)	194,566 kg ($58,896)	Grand Etang Margaree Harbour Murphys Pond Havre Boucher Ballantynes Cove
		Miscellaneous Fish Species		
11	586 kg ($659)	163,766 kg ($71,979)	474,859 kg ($200,933)	Cheticamp Pleasnat Bay Cheticamp Island Grand Etang Margaree Harbour
		Miscellaneous Invertebrate Species		
25	454 kg ($400)	47,780 kg (32,534)	154,944 kg ($120,623)	Lismore Bayfield Cribbeans Point Port Hood Margaree Harbour



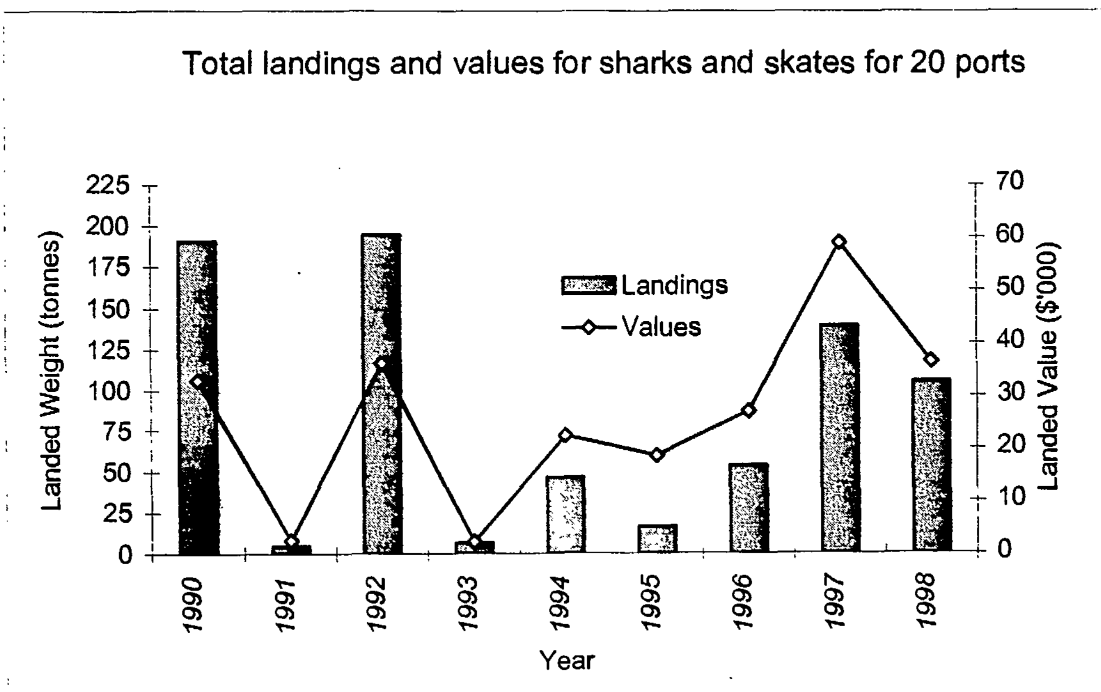
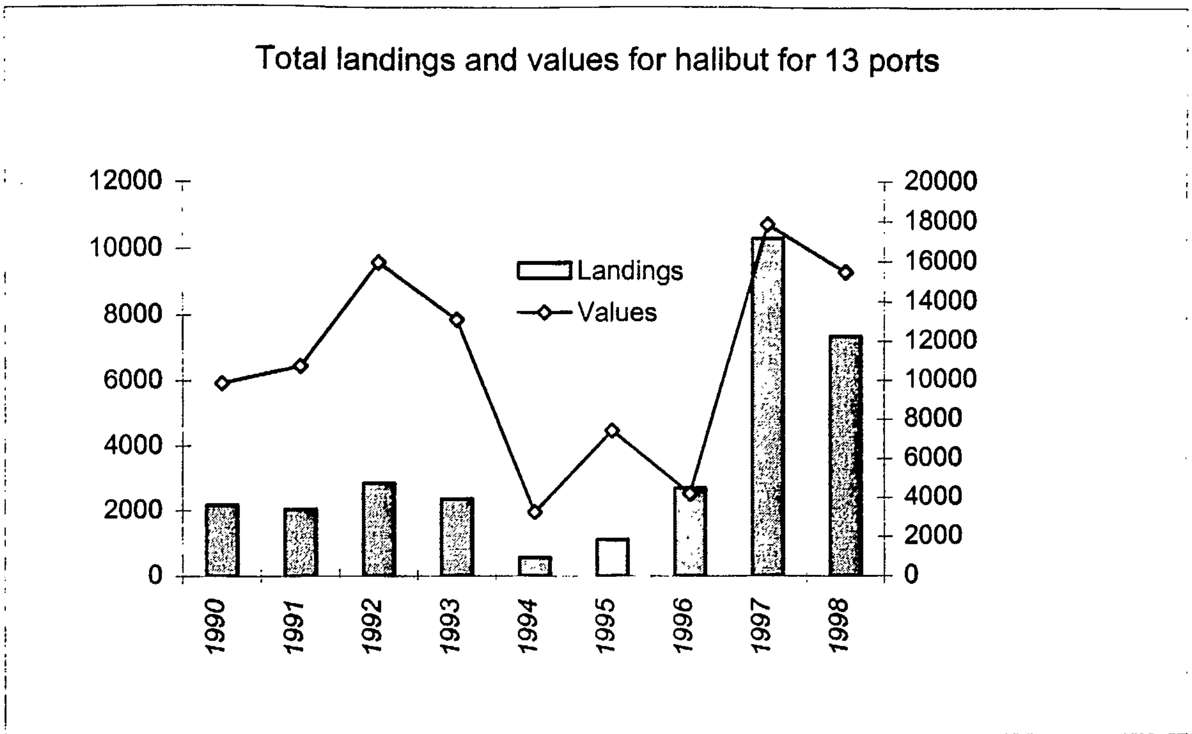


Figure B1-17: Total landings and values for miscellaneous fish species, 1990-1998



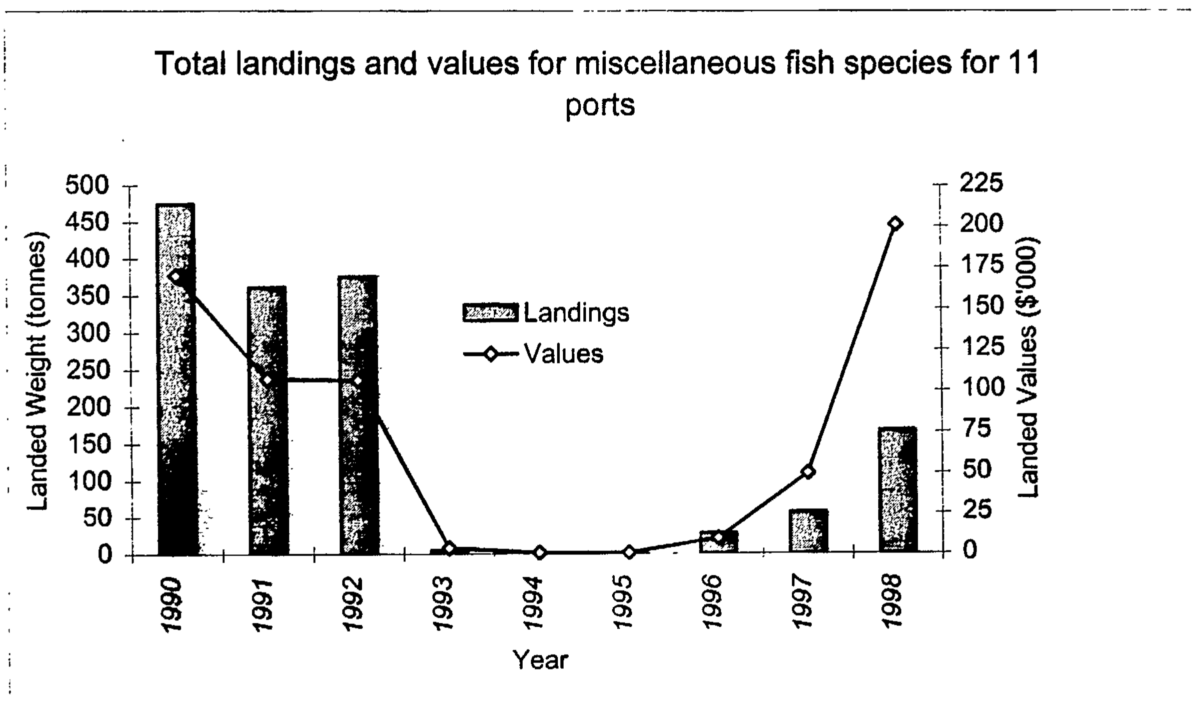


Figure B1-17: Total landings and values for miscellaneous fish species, 1990-1998 (con't)

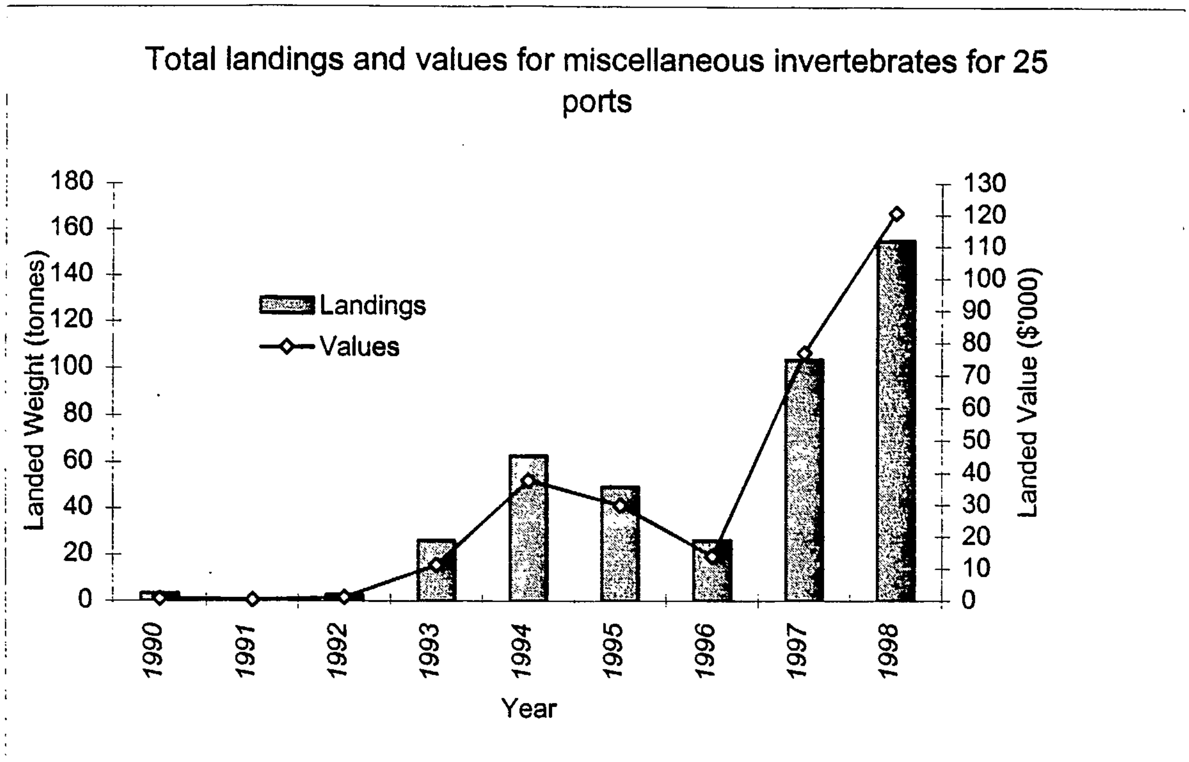


Figure B1-17: Total landings and values for miscellaneous fish species, 1990-1998 (con't)

Summary of the Fisheries

Based on the landings and landed values supplied by DFO it is possible to make some generalizations regarding the extent and economy of the commercial fisheries in the St. Georges Bay area. Of the 46 reported species fished in the area the top 10 in volume and values are presented in Table B.1-16. An estimated total of 126,196 tonnes of fish have been landed in the 42 ports of which the top 6 represent two-thirds (66.8%) of the total catch (Table B.1-17). As far as landings can be used to accurately reflect a fishery, Atlantic cod has been by far the most important single species, followed in order by herring, snow crab, lobster and American plaice. It is significant that even with a moratorium on cod in 1993 a greater weight of this fish was landed between 1990 and 1992 than for any other species over a time period four times longer.

The present status of the species with respect to the fishing pressure placed on them is presented in Table B1-18.

Table B.1-16 Total landed weight and landed values summed across all ports and all years (1990-1998) for the top 10 producing fish species in the St. Georges Bay study area.

Rank	**Species**	**Landed weight (tonnes)**	**Species**	**Landed value ($'000,000)**
1	Atlantic cod	30,911	Lobster	138.60
2	Herring	21,805	Snow crab	104.55
3	Snow crab	20,747	Atlantic cod	22.72
4	Lobster	19,667	Bluefin tuna	15.40
5	American plaice	8,689	American plaice	7.01
6	White hake	7,935	White hake	4.46
7	Gaspereau	4,261	Herring	4.33
8	Winter flounder	2,843	Greysole/witch	2.95
9	Greysole/witch	2,395	Gaspereau	2.07
10	Mackerel	2,630	Winter flounder	2.03
Totals		**121,898**		**304.13**

Table B.1-17: Total landed weight and landed values summed across all fish species and all years (1990-1998) for the top 6 producing ports in the St. Georges Bay study area.

Rank	**Port**	**Landed weight (tonnes)**	*Landed value* **($'000,000)**
1	Cheticamp	53,293	93.12
2	Pleasant Bay	9,847	26.57
3	Margaree Harbour	7,078	19.55
4	Ballantynes Cove	5,327	19.48
5	Murphys Pond	4,670	16.66
6	Grand Etang	4,107	15.02
Totals		**84,323**	**190.41**

Table B.1-18: Status of commercially exploited fish species in St. Georges Bay study area with respect to fishing pressure placed on them.

Species	**Status**
Snow crab	Uncertain, possibly at maximum exploitation
Lobster	Exploited
Scallop	Over-exploited
Atlantic herring	Exploited
Atlantic mackerel	Under-exploited (when compared with TAC)
Atlantic cod	Closed
White hake	Closed
American plaice	Over-exploited
Flounder	
Winter flounder	Uncertain
Witch flounder	Probable over-exploitation
Yellowtail flounder	Unknown

In examining values generated by the fishery lobster ranks first followed by snow crab, cod, bluefin tuna, and American plaice. Lobster and snow crab have generated over 25 million dollars in landed value in the St. Georges Bay area between 1990 and 1998. This represents 62.8% of the total landed values of all fish species at all ports ($309,253,000) during this time interval.

Cheticamp is the most significant fishing port in the area having landed over 53 million kg of fish which generated over 93 million dollars between 1990-1998. The other significant ports were Pleasant Bay, Margaree Harbour, Ballantynes Cove, Murphys Pond and Grand Etang. The landings and landed values of these six ports over the time interval 1990-1998 are illustrated in Figure B.1-18.

Catches, landed values and CPUE have been used extensively in this document to attempt to describe the fishery. However, it is essential that the limitations of these estimates be recognized. Many factors prevent port landings from reflecting actual catch, including:

Discarding at sea – Results in much greater mortality and impact on population dynamics than simple port landings indicate

Ghost fishing – Mortality and lost biomass affecting fishery and dynamics not accounted for by landings

Unrecorded sales – Local sales, bait sales, etc. Generally an unknown quantity in addition to the landed fish. Also sensitive to market conditions so fluctuates over time.

Misreporting and under-reporting of catch – conscious and inadvertent misrepresentation of fishing results, activity, etc.

In a similar fashion landed values do not reflect the true value of the fishery as they do not account for the added value of the processing, transportation to market, and ultimate delivery to the consumer.

Thus, while the landings and values have been quoted extensively throughout, it is emphasized that these are estimates only and their accuracy is unknown until some of the variables mentioned above are controlled or accounted for.

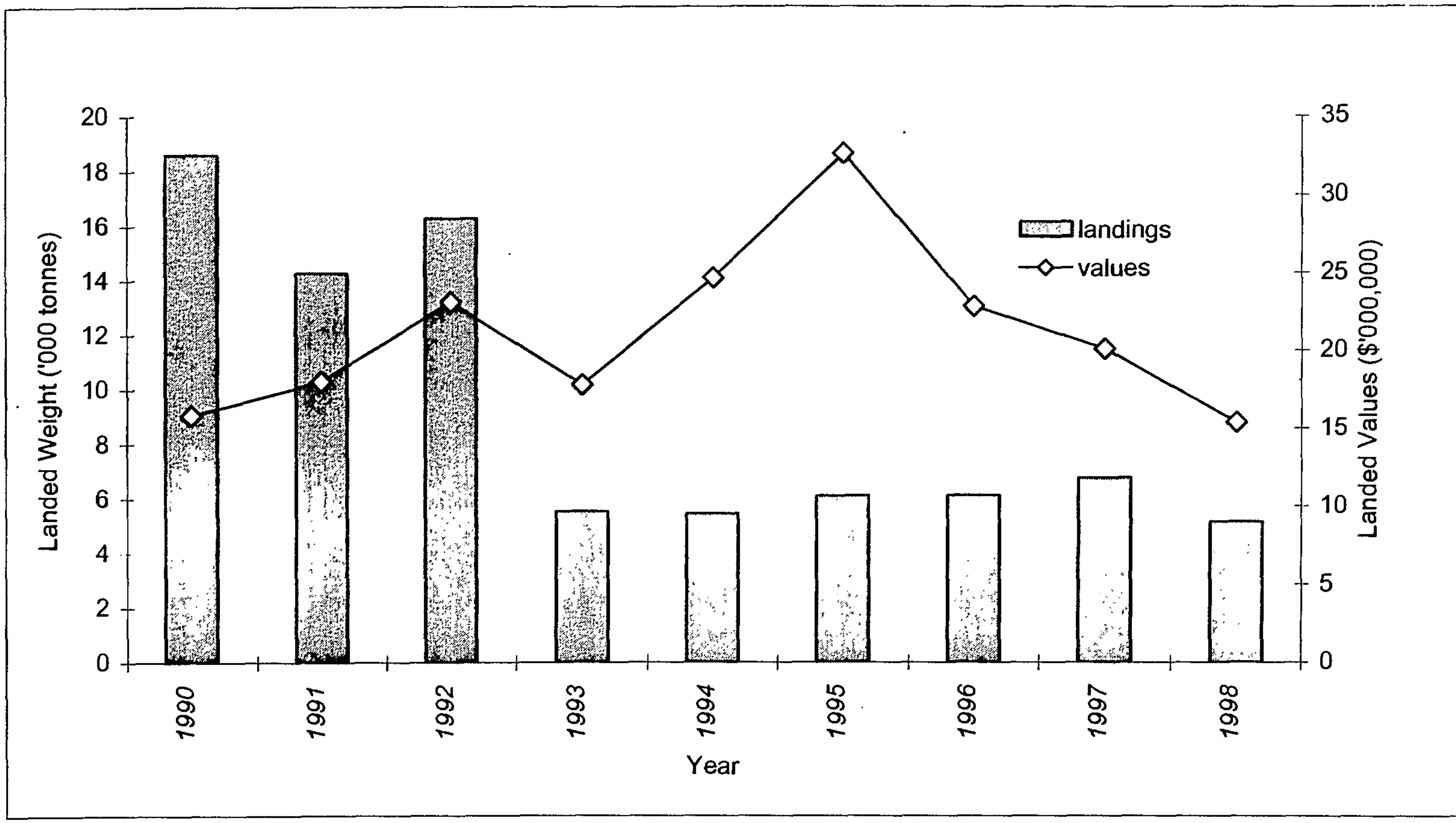


Figure B1-18: Total landed weight and values for six principle ports in the St. Georges Bay study area, 1990-1998.

B.1.1.3 Diadromous fish

Fish of this group typically spend portions of their lives in both the marine and aquatic environment. Most are anadromous, spawned in fresh water, migrating to sea and then returning yearly to spawn. The exception is the American eel which is catadromous, spawning in the ocean. Diadromous fish undertake a spawning migration *en masse*. When aggregated in large numbers, travelling through the restricted passages of rivers, they are easily harvested, and this has generally been the mode of the various fisheries. Various populations of diadromous fish are landlocked and therefore do not make spawning migrations.

B.1.1.3.1 American Eel *(Anguilla rostrata)*

NATURAL HISTORY/BIOLOGY

American eels are found in most estuaries and rivers of the Atlantic coast of North and Central America, as well as the West Indies. American eels are unique among North American fish in that they are catadromous, meaning they mature in fresh water and travel to the sea to spawn. Between August and December, mature eels begin their reproductive migration downstream, mostly travelling by night. By January through to March, they arrive in the western portion of the Sargasso Sea where they spawn and presumably die. Although no adult has actually been caught there, the spawning location is presumed because of the presence of young eels radiating from that location. The eggs hatch into transparent larvae, shaped like willow leaves. These feed on plankton over the next year, and develop into the adult eel form while travelling in the Gulf Stream to the North American coast. They retain their transparency and are known as glass eels. As they approach fresh water in May, they develop pigment and become known as elvers, which are now about 4 to 7 cm in length (Eales, 1968).

Upon entry to the estuary, they must acclimatize to the fresh water, and can be heavily preyed upon. Once in the fresh water, they are called yellow eels and will be yellow to olive in colour for several years. Many remain in the rich foraging ground of the estuaries, or in the ocean nearby, and many travel inland considerably. They are now carnivorous, feeding at night or on dull days on the bottom, on a variety of organisms from snails to small fishes. Those that travel upstream, enter rivers in May and June, often grouped in large numbers. In the fall, the eels will remain in the river or return to the estuary to overwinter, burrowing down in soft sediment. The yellow eel may stay in fresh water from 5 to 10 or more years. At sexual maturity they begin their seaward migration, taking on a bronze to black colour with a silver sheen, thus called silver eels, and return to the sea to spawn.

FISHERIES

Eales (1968) provides a full description of the American eel fishery. American eel was first harvested by aboriginal peoples as a subsistence food fishery. The commercial fishery began with the arrival of the Europeans. The subsistence food fishery certainly persists in native and European-descent communities and is categorized by fisheries managers as recreational.

In Nova Scotia, from the early 1900's to the 1960's, the catch fluctuated fairly regularly between 36 to 75 tonnes. The value per tonne dipped in the 1930's from approximately $260 to $100 but then increased in the 1950's to about $350 were it remained until the late 1960's. For the Gulf of St. Lawrence region, there was an increase in landings in the1960's corresponding to increased fishing effort, and the introduction of fyke nets. Most of the landings were in the northwestern Cape Breton district. These catches peaked and fell quickly in early 1970's and the reduced catches have developed into a long-term decline. General decrease in catch is thought to reflect widespread population decline.

Standard fisheries management approaches have not provided a clear understanding of status of the American eel. Catches in North America are declining (Locke et al, 1995). The area with the most successful fishery, in the St. Lawrence River (Anonymous, 1984) has witnessed a decline of 98% of juvenile eels returning from the ocean in the period from 1985 to1992 (Castonguay et al, 1994). This has been attributed to a combination of four factors; changes in habitat, overfishing, chemical contamination, and a change in ocean climate (Castonguay et al, 1994).

The eel fishery is concentrated in estuaries, reflecting eel distribution given the availability of forage species, sediment for burrowing and passageway for migration present here (Chaput et al, 1997). The Silver eel and yellow eel have traditionally been harvested, which takes place as eels travel downstream in large numbers at night in the fall for overwintering.

The variety of gear used in the fishery, described by Eales (1968), includes baited traps, unbaited traps, weirs, spears, trawl nets and beam trawling. Baited traps, or eel pots, take a variety of shapes and are made of differing materials depending on the fisher. The pot is a rigid frame structure, enclosed in netting, which has a funneled opening into a chamber. The eel enters the chamber freely but has difficulty finding it's way out. These are usually baited in the evening and checked in the morning. Longlines are also used. These are a series of baited hooks on a line which are anchored on the river or estuary bottom and are checked regularly.

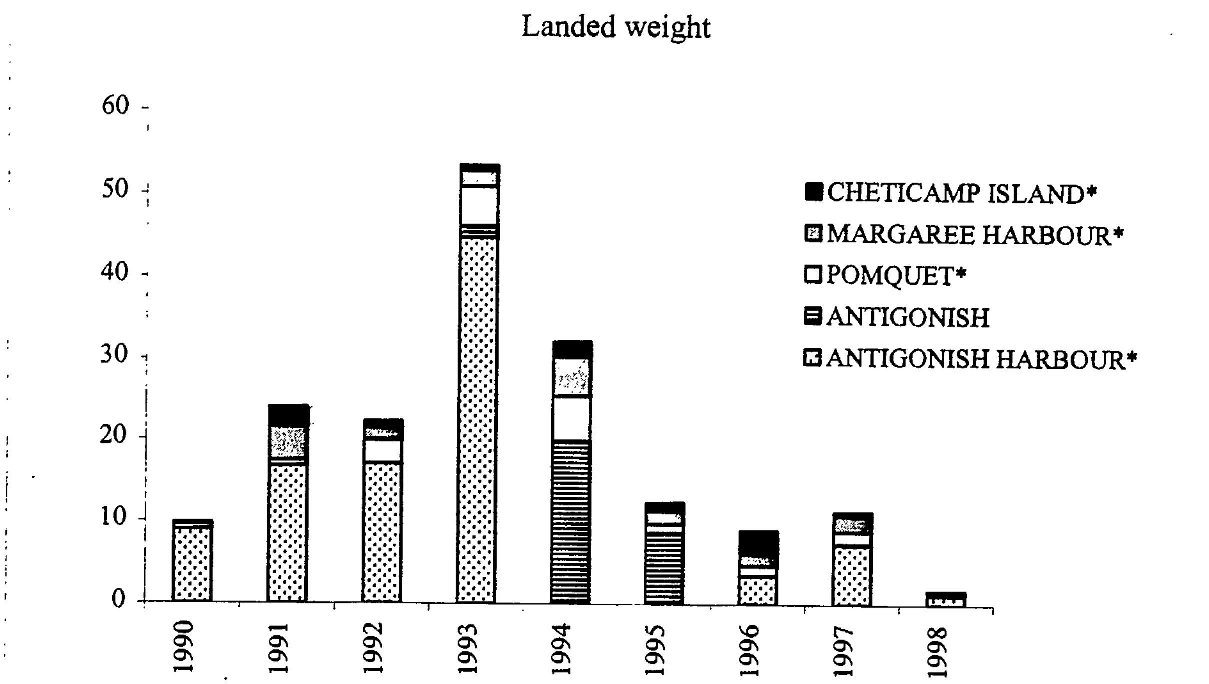
All of the above methods rely on eel activity and are therefore not as effective during the winter when the eels are relatively inactive. In addition, winter ice would make these methods difficult if not impossible. Spearing is an intensive harvest method as the actual capture requires continual effort on the part of the fisher. It can be used during through the winter, through holes in the ice. Spearing effort benefits from the inactivity of the eels at this time. An eel can be spotted as it lies buried in the sediment by its circulation hole. They can also be stirred into activity and thus identified.

The type of gear varies throughout the study area and seasonally. Trap and spear methods are most used in different areas, and during winter, spear fishing replaces other methods (Chaput et al., 1997).

In 1995, Chaput et al. stated that there was not enough data from fishers or science for a stock assessment of Southern Gulf of St. Lawrence eel. Commercial landings have not been reported consistently, there are no records of recreational fisheries, which may be significantly large, and there is no quantitative recording of how fishing effort has changed over the years (Locke et al, 1997). The mode and timing of eel fishery in the study area do not allow the same landings reporting procedures as other fisheries (D. Cairns, pers. comm.). There is currently an initiative to utilize fishers logbooks to assess effort and landings more accurately.

Reported landings can be discussed as an indicator of actual catch, but changes in these values can be a reflection of changes in effort rather than changes in fish availability. Given these limitations, the current trend of reduced catches as recorded by fishers and fisheries science through electrofishing studies has been interpreted by many as reflecting a declining population (Chaput et al, 1997). Many fishers have observed a reduced catch per unit effort recently, suggesting that there are less eels to be caught (Locke et al, 1995). There is a Stock Status Report currently being prepared for the American eel (Jessop, pers. comm.).

Catches of eels for the 5 most productive ports over for the period of 1990 to 1998 are presented in Figure B.1-19. These account for 43 to 85% of the landings obtained over those 8 years. The fishery peaked in 1993, and has rapidly decreased to 1990 levels. The harbours and estuaries of the southern St. Georges Bay have contributed to most of this catch, Antigonish/Antigonish Harbour consistently producing the largest catch. Pomquet, Cheticamp and Margaree Harbour also provide large catches.



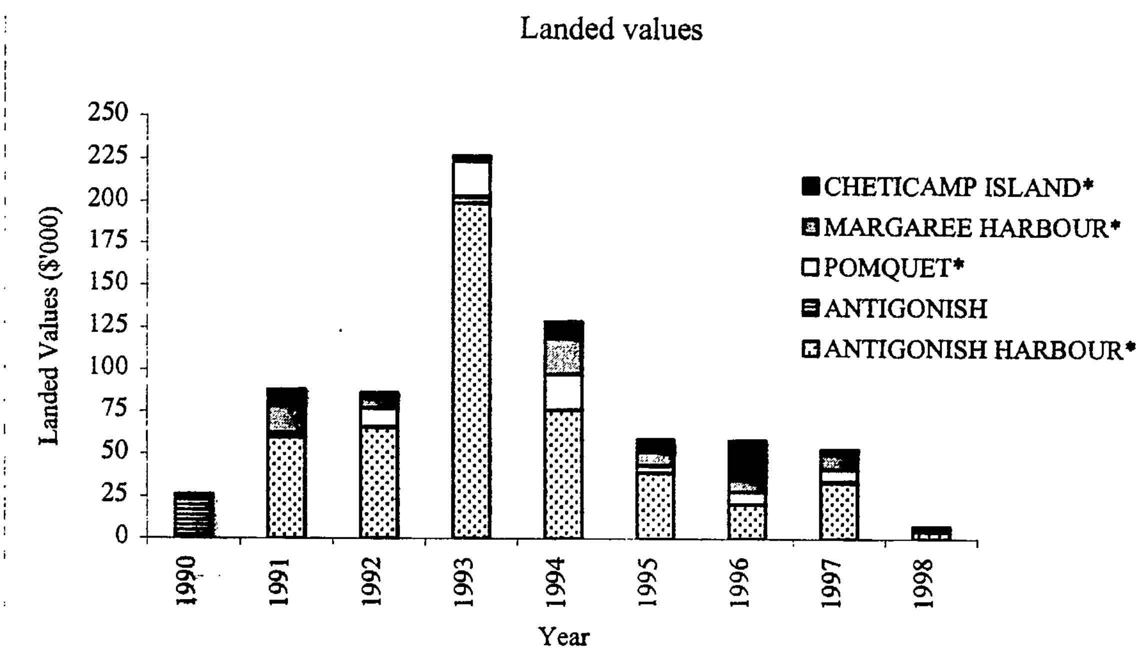


Figure B.1-19. Landed weights and commercial value of American eel from 5 major harvesting locations in study area. Data from Statistics Division, DFO, Moncton harbours and estuaries of the southern St. Georges Bay have contributed to most of this catch, Antigonish/Antigonish Harbour consistently producing the largest catch. Pomquet, Cheticamp and Margaree Harbour also provide significant catches.

Eel catches from 1917 to 1988 in the Gulf of St. Lawrence are summarized by LeBlanc and Chaput (1991). Landings in fishing areas in our study area have not fallen to the same degree as the rest of the southern Gulf over the last decade. The current catches are within the range of catches in previous decades. Landings had been substantially increasing in districts 12 and 13 up until the 1993 reduction.

Catches of eel are high in August, and peak in September for most districts, but the fishery continues through the winter. The winter fishery is about half of the annual catch in St. Georges Bay area (Chaput et al., 1997a).

Lucrative markets have now opened for live elvers for aquaculture stocking in Asia. Elver market value is much greater than that of eels. The level at which elvers can be harvested without depletion of the spawning stock is not known (Jessop, 1995). An experimental elver fishery has opened in the Scotia-Fundy district. It is not known if fluctuations in harvest are reflecting fluctuations in population (Jessop, 1998). Chaput, (1997) discusses eel fishery management given the relative values of eel and elver harvest, and suggests that without knowledge of elver harvest impact on the population, conclusions cannot be drawn.

Paulin (1997), summarizes the American eel fishery to that date:

1970's Season from August 15 to October 30
Licensing available only to bonafide fishers, except in Margaree
Licensing of non-commercial fishers using pots
Spear fishers required no license and no seasonal restrictions
1991 Freeze on all new licenses for all gear types
1993 Implementation of licensing commercial spear fishery
1995-96 Season from April 1 – 30, and August 16 –November 15 for nets, pots
Closure of Pomquet Harbour
Minimum size of 46 cm introduced.
Voluntary bag limit of 10 suggested for recreational fishers.
1997 License required for spear fishery, restriction on intensity of light used, season from January 15 to June 30, minimum length of 50 cm
Season runs from September 1 to October 30 for other eel fisheries.

ECONOMICS

Figure B.1-19 provides financial value of the American eel catch to the major contributors of the study area The price has not fluctuated considerably, thus the pattern of distribution reflects the catch. The 1993 landings were valued at $227,121; $199,443 being at Antigonish. The 1998 value was $7,492, distributed between Cheticamp and Antigonish Harbour.

ECOLOGICAL CONSIDERATIONS

Because the American eel spend a large proportion of their lives in the sediments of the study area's estuaries, they are vulnerable to accumulation of contaminants introduced into this habitat. Watershed, estuary and harbour activities all have demonstrated impacts on study area estuary water quality. Many of these impacts can be lessened. Hutchinson and Taylor (1979) found mercury levels in Nova Scotia eels that exceeded the acceptable level for consumption of 0.5 ppm. Average mercury levels in study area eels have been found to be consistently below this level, ranging from 0.168 - 0.268 ppm. In 1981, Hutchinson found Nova Scotian levels averaging 0.41 ppm, with study area value of 0.119 ppm.

These mercury levels in tissue are a consideration with respect to both eel success as a population and the impact upon humans consuming the meat on a regular basis. Recommended levels of 0.50 ppm assumes infrequent consumption

The issue of the degree to which the American eel preys upon juvenile Salmonids, and therefore adversely affects those populations was addressed by Hutchinson (undated). Her analysis of eel stomach contents within the study area found mummichogs as the predominant food source but also identified a variety of insects, yellow perch and gaspereau eggs.

PROSPECTS

As the estuary and stream habitat available to the American eel in the study area is less impacted by humans than many others in North America, the catches will probably continue to be maintained at higher levels than surrounding areas. North American eels all belong to one oceanic breeding population, thus the relative success of the local population will only continue if the whole population is sustained. The recent decline of both American eel and European eel, which also spawns in the Sargasso Sea, suggests that there is a significant factor at work at sea, perhaps the interference with larval transport by a weakened Gulf Stream in the 1980's (Castonguay et al, 1994).

B.1.1.3.2 Gaspereau *Alosa aestivalis, Alosa pseudoharengus*

BIOLOGY/HISTORY

Gaspereau is a name collectively used for two species of fish harvested in the study area. These species are the blue back herring, *Alosa aestivalis*, and alewives, *Alosa pseudoharengus*. Their distribution, being anadromous, includes fresh streams and marine environments from North Carolina to Newfoundland (Scott and Scott, 1988).

Gaspereau enter rivers in large numbers in the spring in order to spawn in fresh water. The largest numbers enter the Margaree River where there has been historically a substantial fishery. Spawning occurs in Lake Ainslie in this case, and the juveniles remain in fresh water initially. The average age at first spawning is 3 years and lifespan is approximately 9 years (Scott and Scott, 1988).

The two species' migration times vary, the alewives entering first in mid-May and the blue back herring in June.

FISHERIES

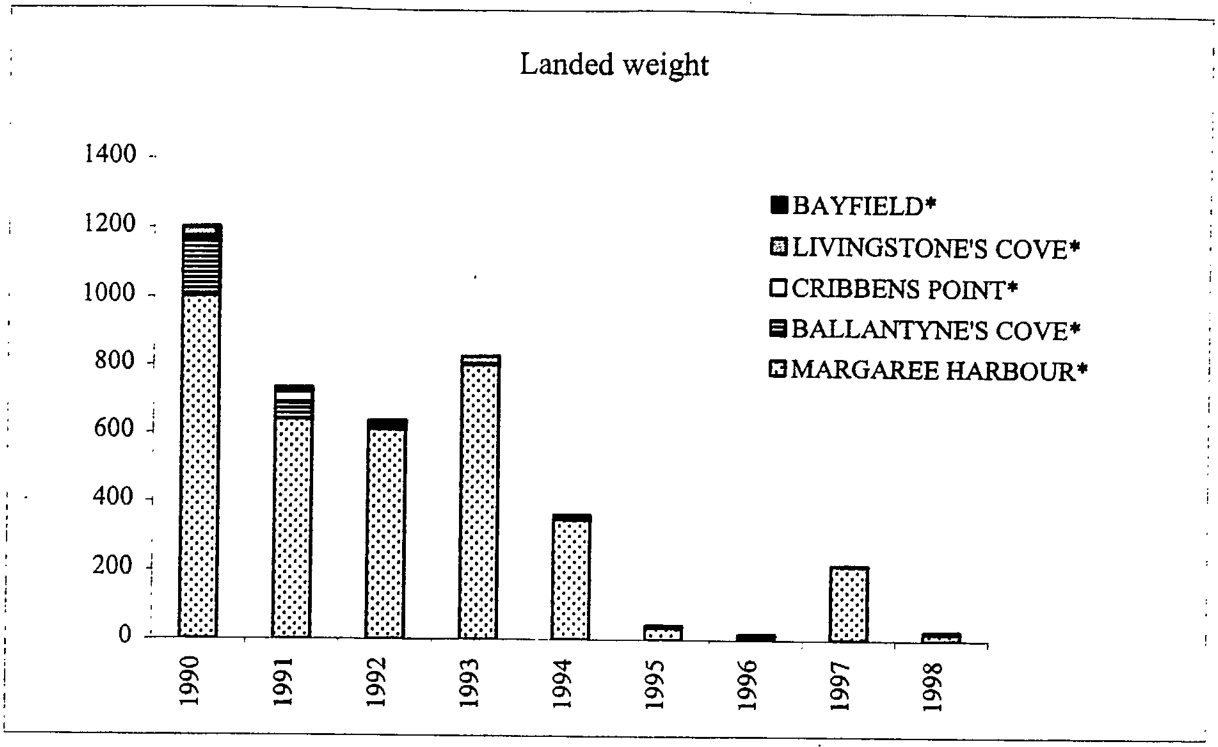
Gaspereau are harvested as they migrate upstream to spawn. The gear used is a tip-trap, effectively a large dip net. They are sold as bait or cured by salting immediately on site and then packaged for export. The catch usually consists of greater than 95% alewives, depending on the timing of runs. If the alewives run is delayed, a greater portion of the catch will be contributed by the blueback herring run (Chaput, 1993). The 1993 and 1994 catches were considered to be mostly 3 and 4 –year olds. The catch is typically dominated by first time spawners (Chaput et al., 1991).

Records of harvests from the Margaree River, in tonnes, have been recorded continuously since 1917 (LeBlanc and Chaput, 1991). The Margaree landings constitute 15 to 40% of the Gulf of St. Lawrence landings, thus fisheries management have focussed on this location for population monitoring. A significant increase in numbers caught occurred in the 1940's and 1950's and then plateaued at a higher level in the 1970's (Figure B.1-20). By the mid 1980's the catches returned to levels of the early 1900's. The gaspereau fisheries have been formally assessed since 1983 (Anonymous, 1996a). The fisheries has experienced an almost continuous decline since 1988 and large oscillations in part due to overfishing (Chaput et al, 1997b).

The catch of gaspereau in the study area over the last ten years are presented in Figure B.1-20. Drastic decline in the fisheries is evident over the study period. The five ports reported here account for 93 –100% of the study area landings. Margaree contributes almost solely to recent years' catches. Historically catches have fluctuated between less than 10 to over 1000 tonnes in Statistical District 2, which would be largely be contributed to by the Margaree catch (LeBlanc and Chaput, 1991). Thus it has been demonstrated that catch levels can recover remarkably. This is not to suggest that the current situation is not worrying.

The key events in terms of the fishery management are as follows:

Prior to 1984 the were no in-season closures
1990 - the number of licenses were frozen at 62
1992 - restrictions were placed on the conditions of fish processing
1984 - weekend closures were introduced.
1993 - fishing was restricted to half days throughout the week.
1996 - fishing was restricted to 3 plus 2 half-days per week



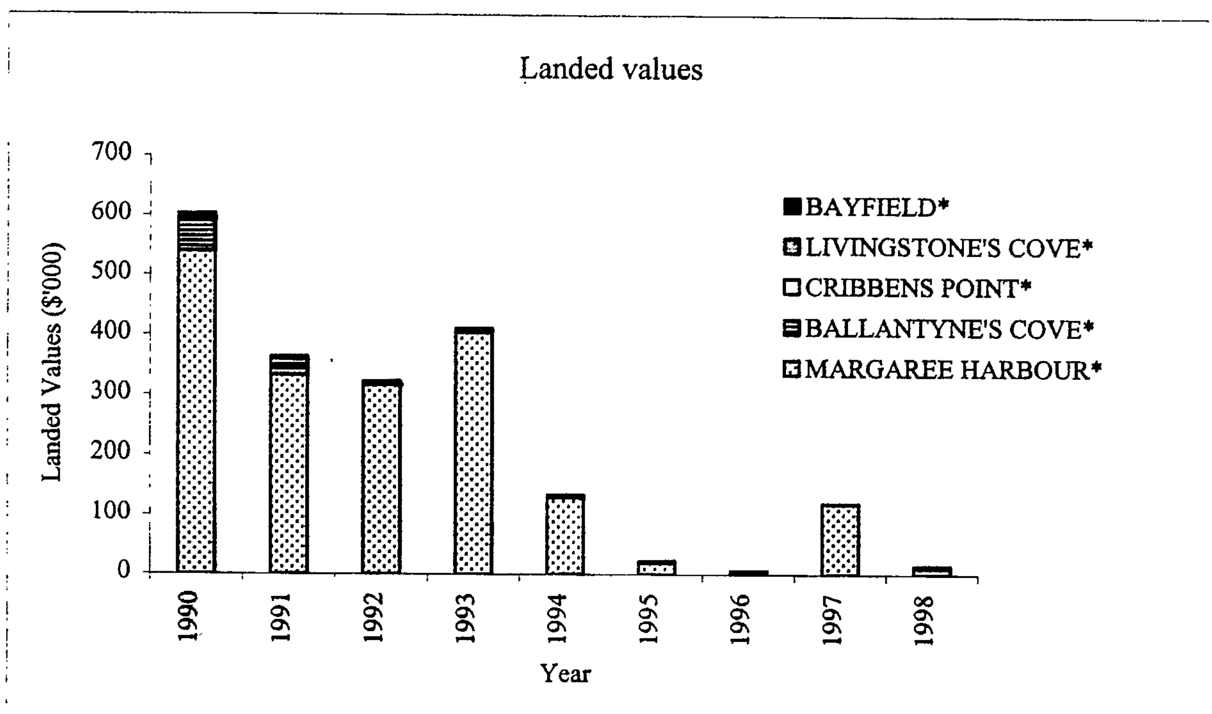


Figure B.1-20. Landed weights and commercial value of 5 major landing sites for gaspereau in the study area. Data from Statistics Division, DFO, Moncton.

The restrictions on fish processing in 1992, applied to fish intended for human consumption. This prevented some participants from the fishery. The actual numbers of participants in 1991 and 1992, were around 40 (Chaput, 1993). The harvest at that time was believed to represent 60% of the spawning population, which was considered high, but not endangering the fishery sustainability. The natural spawning mortality was estimated to be 36% from South River (Chaput and Alexander, 1989), cited in Chaput, 1993). The target fishing mortality was set at 65%. Catches from 1991 onward were above target (Claytor et al., 1995). Resulting management strategies have sought to reduce harvest by restricting the period of fishing, rather than the allowable volume of harvest. The 1993 and 1994 harvests ranged from 73% to 96% of the returning fish, demonstrating that the management strategy did not succeed in reducing pressure on the resource. Some closure mornings were followed by afternoons of double the normal rate of catch.

The 1996 restriction brought the catch to a level calculated to have a 60% probability of exceeding the target harvest (Chaput et al., 1997). Larval abundance in Lake Ainslie was observed to increase in 1996. Previous studies demonstrated that spawning escapement correlated with observed larval abundance (Crawford, 1996, cited in Chaput et al., 1997).

The current size limit is less than 15 cm long, tip traps are not to cover more than half the river width, or be closer than 55m from another.

ECONOMICS

Values of landings for 1990-1998 are presented in Figure B.1-20. The financial returns from the gaspereau fishery in the study area have fallen dramatically with the decrease of landings since 1990. Margaree harbour has been the largest contributor to the fishery peaking at $540,056 in 1990. The current years' landed value dipped to $3818.

BIOLOGICAL/ECOLOGICAL CONSIDERATIONS

The gaspereau fishery has experienced a considerable decrease in recent years. Certain annual catches have been influenced by climate (Chaput, 1993). Fishers do not feel that river level has affect on catch although it is known to affect runs of salmon; the operation of different traps is effected differently, so that changes in catch per trap do not effect the overall average (Claytor et al.1995).

PROSPECTS

Chaput et al. (1997) suggests that a sustainable fishery could be achieved by setting a conservative exploitation rate of 0.3 to 0.4, and adopting a fixed harvest approach. This would be successful only if it were insured that the harvest will be adjusted if returns are poor.

B.1.1.3.3 Rainbow Smelt *Osmerus mordax*

BIOLOGY/NATURAL HISTORY

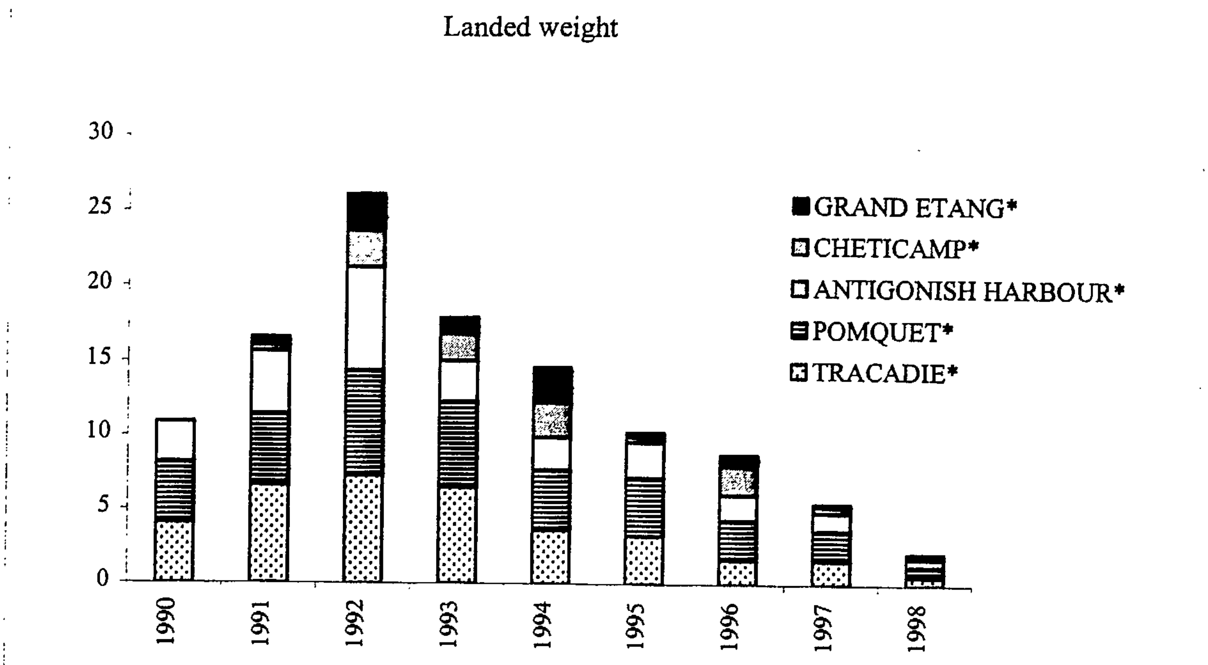
Rainbow smelts are the most abundant anadromous fish of the Gulf of St. Lawrence. They are relatively small, being about 13 to 15 cm at spawning. They are distributed throughout the Atlantic Provinces and are harvested commercially and recreationally. The smelts enter streams in the fall, to late winter and overwinter there. Spawning is in the spring, in fresh water. The eggs hatch and grow rapidly, feeding on zooplankton, and copepods and then small fish. They are heavily preyed upon, because of their schooling habit. Spawning age is generally 2 or 3 years and lifespan is generally less than 7 (Chaput and Leblanc, 1996). During summer smelts tend to be restricted to cooler, deeper marine waters. Their distribution includes most estuaries of the gulf; their northern limit being Newfoundland (Scott and Scott, 1988).

FISHERY

The smelt fishery is carried out with trapnets and is dependant largely on 2 and 3 year-old smelts. There is a fall fishery, but the winter fishery is most significant in the Gulf of St. Lawrence. In the study area, records have been found for commercial landings in all fishing districts (LeBlanc and Chaput, 1991). Landings for the ports with the greatest catch are presented in Figure B.1-21. The southern St. Georges Bay landing sites of Antigonish, Tracadie, and Pomquet has harvested amounts similar to each other for the past 8 years, with Cheticamp and Grand Etang harvesting about proportionally half. The total catch had increased to greater than 26,158 tonnes in 1992 and quickly declined to the most recent catch of 2126 tonnes.

Although 76% of the Gulf of St. Lawrence smelt fishery occurs in New Brunswick, there is a significant catch in the study area. This catch is largely focused on the rivers of southern St. Georges Bay, with three sites, Antigonish Harbour and Pomquet and Tracadie Rivers harvesting the majority. Cheticamp and Grand Etang are included in the five ports that have contributed 64 – 85% of the catch over the last 8 years. The catch peaked in 1992 and has steadily fallen to less than one fifth of the peak volume at present. Scientific discussion of the fishery has been limited to the New Brunswick fishery because of its prominence. Chaput and Leblanc (1996) attribute the decline in the New Brunswick fishery to reduced effort, but estimates of fishing effort have not been found for the study area.

The smelt fishery is regulated by an October 15 to end of February season, (Chaput and LeBlanc, 1996), with occasional extensions to the season. There has not been a target harvest set. In 1996, with the decline of the ground fishery and the



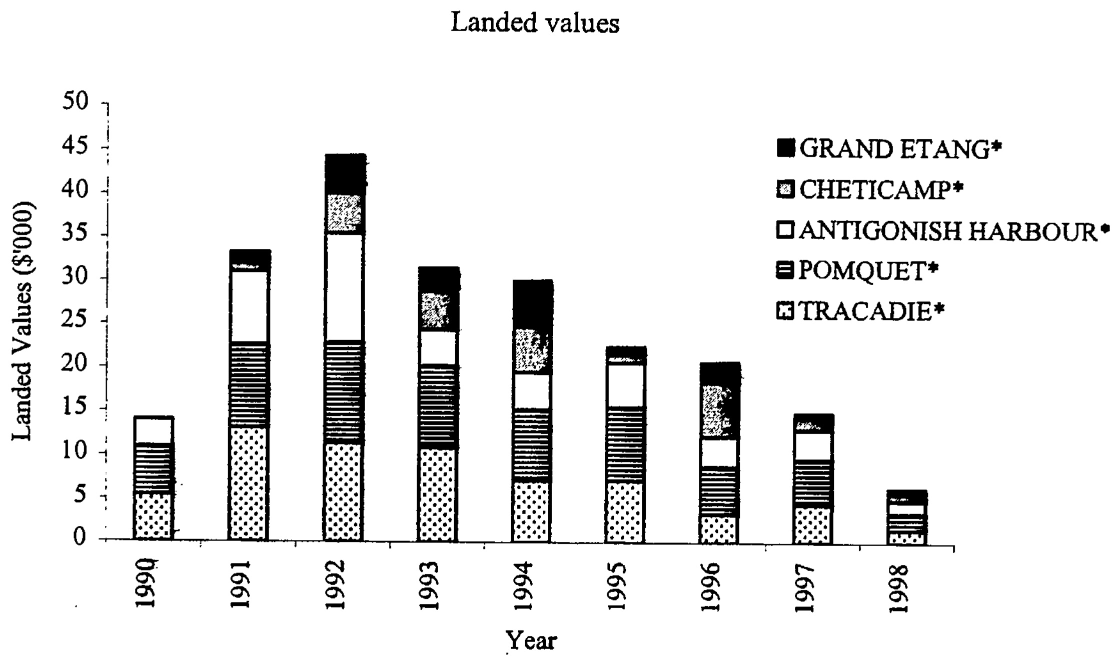


Figure B.1-21. Landed weights and commercial value of rainbow smelts from the 5 largest harvesting sites in study area. Data from Statistics Branch, DFO, Moncton potential for increased pressure upon coastal fisheries, it was believed to be prudent to assess the population. A decline in catches at that time also caused concern about commercial fishery in all districts.

ECONOMICS

Landed values for the major smelt fishing ports for the last 10 years are presented in Figure B.1-21. The current value for five ports combined is just above $5,000 for the top 5 harvesting ports in the study area. Commercial value has been stable for the study period, so that changes in landed value directly reflect changes in landings. This fishery peak was in 1992 at $45,000.

BIOLOGICAL/ECOLOGICAL CONSIDERATIONS

Fishers have expressed a concern over the quality of and access to stream habitat for spawning smelts. Population numbers have been difficult to predict since larvae abundance has not been found to correlate with numbers of return. Without information on fisher effort within the study area, it is impossible to assess the status of the population.

Summary of Diadromous Fisheries

The commercial fishery of gaspereau, American eel and smelt have followed similar historical patterns. These fish have traditionally been harvested in large numbers seasonally during their spawning migration, thus harvesters approach the fishery from this methodology. American eel are also harvested outside of the spawning migration. The populations have each supported prolonged substantial fishery. Gaspereau and eel populations have declined sufficiently to hinder the fishery.

Because all diadromous fish utilize marine and aquatic habitat, there are effectively double the numbers of potential impacts, and it is difficult to account for the effects of one environment at the exclusion of the other. In the case of the study area, the aquatic habitat does not seem to have the capacity to severely impact these species, although it could be argued that harvesting practices do. The interaction of species with the marine habitat is difficult to characterize because of the vastness of the habitat and large potential for unknown local effects. The smelt catch has not been reduced as the others, but there is concern that in the absence of other viable fisheries, they will be over-exploited.

B.1.1.4 Indirect Potential Impacts of the Commercial Fisheries

Commercial fisheries in the study area are a significant economic factor. There are active fishing ports and numerous fish landing locations. The impact of the marine fisheries on watersheds is limited to harbours. Boat traffic introduces engine oil and heavy metals from hull paint pigments into the harbour. Dredging, although disruptive, is also necessary in many ports to maintain passageway.

There are a total of 21 sites that require dredging of the harbour basin or the channel to the harbour on a relatively regular basis. Details of these operations are presented in Appendix 11. Five of these require annual dredging, eleven sites require dredging on a less regular basis, from 2 to 6 years, and five harbours require dredging on a 10 year cycle. Disturbance and removal of habitat, as well as the release of deposited toxic sediment leads to the deterioration of habitat quality. Consideration is given to timing of the activity relative to seasonal sensitivity of species, such as avoiding spawning migrations. There are specific guidelines used governing dredging activities with respect to minimizing disturbance to the environment of the water column. Each dredging project requires an Environmental Assessment.

The levels of contaminants in sediments removed by dredging usually require that they be disposed of on land rather than being deposited at sea, as minimum allowable levels of 0.6 mg/kg are lower than for terrestrial disposal. The sediment toxicity is monitored at four year intervals by the Department of Fisheries and Oceans. Sediments in harbour basins are found to have higher contaminant levels than channel sediments (MacDonald, pers. comm.); this is attributed to the greater traffic in the inner basin as opposed to the less traveled channel. Dredged sediment is deposited nearby, or trucked to private land. Those dredging projects done less frequently tend to involve the removal of larger volumes and these sediments are disposed of at sea. Cadmium levels were measured by Environment Canada in harbour sediment between 1977 and 1979, and found in all cases but two to be below the acceptable level. Much higher levels were found by N.S. Department of Mines and Energy in stream sediment throughout the study area (Baker and Matheson, 1980).

Commercial fisheries within the watershed are restricted to diadromous fisheries. The prosecution of gaspereau and smelt fisheries seem to have little impact on habitat, although above-target harvests in the past are believed to contribute to reduced numbers in gaspereau populations (Chaput et. al., 1997).

A study of impacts of regional fish processing included Cheticamp (Canadian Fishery Consultants Limited, 1981) which states "The Fish Waste Reduction process does not result in the discharge of gaseous or liquid effluents which are toxic or hazardous to humans outside the plant". The main concern for this industry in Nova Scotia at the time was public image as a result of the odour produced. Concerns over the potential problems in receiving waters caused by wastewater from the process were described as justifiable. No information on the potential impacts of riverside gaspereau salting was found.

B1.1.5 Shellfish and Aquaculture

B1.1.5.1 Shellfish Harvesting and Area Closures

Bivalve molluscs (i.e., clams, mussels, oysters and quahaugs) are a popular food item for restaurants as well as recreational beach-goers. However, due to their feeding mechanism of filtering large quantities of water they can accumulate contaminants within their edible portions when growing in unsanitary conditions. This contamination can then affect the organisms that eat the shellfish. Contamination sources to shellfish may be of bacteriological origin (e.g., municipal sewage treatment plants), chemical (e.g., metals, pesticides, chlorinated organics) or natural (e.g., Paralytic and Amnesiac Shellfish Poisonings; PSP and ASP) (Anonymous, 1999b). Due to these concerns Environment Canada regularly inspects the water quality near shellfish growing areas for contaminants. To be approved for safe harvesting of shellfish the waters must be free of pathogenic micro-organisms, radionuclides, and toxic wastes (Anonymous, 1991a). Based on the results of the inspection an area may be Approved for harvesting, Conditionally Approved, or Prohibited from harvesting (Anonymous, 1988).

The St. Georges Bay Ecosystem Project study area contains three of Environment Canada's shellfish growing areas – Area 3 (Northumberland Strait west of Cape George), Area 4 (St. Georges Bay *including Antigonish Harbour, Pomquet, Tracadie, and Havre Boucher*) and Area 5 (Inverness Gulf Shore *including Mabou, Inverness, Margaree and Cheticamp*) (Anonymous, 1999c). Shellfish Area 3 will not be included in the following discussion as the areas of interest (e.g., Pictou Harbour, Merigomish) are outside the study area. Closures to shellfish harvesting within Areas 4 and 5 go back to 1955-1958 (Waller, 1976) and the areas closed to harvesting appear to be increasing over time (Table B1-19 and Figure 7 in Anonymous, 1991a). However, increased surveillance and identification of new area of fecal contamination make direct comparison over the years questionable. Within these areas the reasons for closure are primarily bacteriological (i.e., municipal sewers, shoreline development).

Table B.1-19: Areas of shellfish closures (km^2) by shellfish growing areas

	Area 4	**Area 5**	**Source**
Pre 1975	15.36	4.83	Waller et al., 1976
1988*	~21	~9.3	Anonymous, 1988
1992	29.11	12.8	Anonymous, 1992a

Note: 1988 data was estimated from 1:50,000 scale maps and so are approximations only

As of 1998 all of Antigonish, Pomquet, Mabou, Inverness, Margaree and Grand Etang harbours, the northern and southern one-thirds of Tracadie Harbour, northern three-quarters of Cheticamp Harbour, and the Grand Anse River estuary at Pleasant Bay were closed to shellfish harvesting (Anonymous, 1999c). These closed areas represent approximately 83% of the available shellfish growing areas in the study area. This contamination greatly reduces potential aquaculture possibilities in Antigonish and Inverness Counties as well as preventing recreational and commercial opportunities.

B1.1.5.2 Aquaculture

Aquaculture information was gathered from published material, government agencies, and promotional media. There exists very little information with respect to 'hard numbers' for this industry. The available literature is long on promotion and short on substance. What substantial information is available is presented below.

Within the St. Georges Bay Ecosystem Project study area there are only two licensed aquaculture facilities – one at Tracadie Harbour raising American oyster and the other in the Strait of Canso near the causeway raising American oyster, blue mussel and Sea scallops (C. Reardon, pers. comm.). In 1993, Scarrat reported that current aquaculture production statistics for Nova Scotia are not readily available by county and that many reports are from single enterprises and therefore not publishable due to confidentiality. In the intervening six years little has changed. Representation of the most basic information (e.g., economics, jobs created, landings, export, etc.) at a finer than Provincial level is not readily available.

A survey of marine and estuarine aquaculture potential in the study area was conducted in 1992 (Scarrat, 1993). The relevant highlights are presented in Table B1-20 The author made a number of recommendations for procedures to clean up or mitigate the contamination of the harbours so as to allow aquaculture and shellfish harvesting. However, Human Resources Development Canada (HRDC) states that "Market and environmental conditions do not make this a profitable industry at the current time" (Anonymous, 1999d) and so the amount of time and energy spent on developing these poor locations must be weighed carefully.

Table B.1-20: Summary of marine and estuarine aquaculture survey (from Scarrat, 1993)

Location	Status	Comments
Antigonish Harbour	Closed	Historically had 15 oyster leases – all have been cancelled
Captains Pond	Closed	Vulnerable to overfishing, pollution, vandalism/theft
Monks Head Pond	Open	Recommend as a controlled experimental site for finfish culture
Pomquet	Closed	Historic oyster leases – now cancelled
Laytons Pond	Closed	Subject to fecal contamination from sewage treatment plant
Tracadie Harbour	Closed*	Historic and active oyster leases
Havre Boucher	Closed*	
Archies Pond, Aulds Cove	Closed	Closed due to sewage discharge from cottages, residences and businesses along the shore. Two mussel leases have been cancelled
Port Hood	Closed	Discharge of raw sewage from ineffective treatment plant
Mabou Harbour		Several operational oyster and mussel leases cancelled in 1987 due to fecal coliforms from the town, isolated houses and agriculture.
Inverness Harbour	Closed	Closed in 1992 due to sewage contamination
Margaree Harbour	Closed	Closed due to run-off from farming along the SW branch
Grand Etang	Closed	Seabird fecal contamination and residential sewage
Cheticamp	Closed	Closed due to contamination from raw sewage, filtered treatment plant waste, and agricultural runoff.
Pleasant Bay	Closed	Closed due to sewage discharge from private homes.

- Part of harbour is closed and part Conditionally Approved.

Summary

83% of the available shellfish growing areas in the St. Georges Bay study area are closed to shellfish harvesting due to contamination problems. These areas are closed due to pollution from municipal sewage treatment plants, residential wastes along shorelines and industrial activities in harbours.

Due to the number of closed shellfish areas, and the limited protected locations feasible for aquaculture operations in the area, there is very limited current aquaculture activity. Projected work must first deal with the issue of contaminated sites.

B.1.2 Forestry

Intensive forestry began in Nova Scotia in the 1960's. Over the last forty years there has been a rapid replacement of labour by capital. Management of forests has been the responsibility of government as early as the 1820's when the province declared all pine harvest be reserved for naval masts. Despite its longstanding contribution to the economy, there has been a vocal debate about many aspects of forestry.

In 1985 the government commissioned a report on the state of forestry in the province. This resulted in the publication of "Forestry: A report on the Nova Scotia Royal Commission on Forestry". This report stated that the province's resources were "...diminished as a result of high-grading, the ravages of fire, insects, disease, weeds and wind, and the failure of society to make the best use of the remaining trees and to restore forest losses". In consequence, many forest-related jobs are in jeopardy, and the ecosystem is deteriorating. The commission report predicted that by the year 2005, given current forestry practices, industry needs will not be met in the seven eastern counties of Nova Scotia. At the time of the report, these counties' sawmills experienced a shortage in sawlog-quality wood.

There remain shortages for sawlogs today. Some mills now find themselves using sawlogs out of which only a single 2X4 inch construction stud can be cut (P. MacLean, pers comm).

The recommendations resulting from the 1985 Royal Commission were: 1) the long-term scheduling of harvesting 2) most valued use allocation, and more effort in marketing 3) silviculture and protection. The details of the report address the concerns of the forest industry and the economic implications for the people within the industry.

There are pitfalls, however, in suggesting that practices should comply to serve the industry rather than the resource. A 1992 evaluation of the Canada/Nova Scotia Cooperation Agreement for Forestry Development states that, while,

> "...there appears to be adequate assessment and monitoring of certain environmental considerations for which there are clearly established guidelines... The aggregate environmental impact of forest management programs is unknown" (Gardener et al., 1992).

While considerable effort has been made to improve monitoring standards there remains a real need to evaluate forestry operation impact within ecosystem terms.

B.1.2.1 Economics and Forestry

The purpose of this section is to identify and describe the utilization of forest resources as a determining contributor to the economy of the St.Georges Bay study area. Time constraints on the report did not allow for exhaustive review and summation of all available material. What exists here is a starting point for further research.

It is a well known fact that sawmilling was one of the first industries to develop in Nova Scotia (Runyon et al., 1973). As recently as 1979 it could be said that,

> "Virtually all Nova Scotian sawmills are family owned and have existed within their small rural Nova Scotian communities for generations" (Anonymous, 1983).

Today the Nova Scotia Department of Natural Resources maintains a registry of wood buyers. There are 14 mills and 1 exporter registered in Antigonish County. In Inverness County there are 11 mills, 1 firewood seller and 1 wood exporter registered. All of these operations are small and often seasonal with most having fewer than 10 employees. In addition to the exporters listed, some undetermined volume of milled lumber and stud wood produced by mills in the area goes to export.

Although sawmill operation has historically been important to the study area economy, it is the pulp wood market which has dominated end use trends for forest resources in the last 30 years (Anonymous, 1987b). Table B.1-21 shows an example, on a scale relevant to the study area, of the disparity in the volume cut between sawn lumber and pulp in Antigonish County for 1991.

Table: B.1-21

Antigonish 1991

Forestry:

Sawn lumber (M Fbm)	7,820
Pulpwood (m^3, solidwood)	226,100
Employment	265
Total revenue ($ million)	$4.7

Prepared by: Ian Spencer, St.F.X.U. Business Administration Department

Sources: Northeastern Regional Statistical Profile, N.S. Department of Finance, 1994. The Financial Post Canadian Markets, 1993. Canada Employment Centre, Local Labour Market Review, 1992. Antigonish Town and County Business Directory. Antigonish, Nova Scotia, "A Retail Opportunity", Xanadu Investments, 1993.

Pulp and paper mills in both Port Hawskbury and Pictou, located just outside the study area, have been the principle buyers since their construction in the 1960's. Today, increasingly, an Irving owned company in New Brunswick purchases large quantities of pulpwood from the region.

It is a documented fact that there have been many years of profitable pulpwood harvesting in Nova Scotia (Gardener et al., 1992). This should, however, be qualified by two current divergent observations. These observations are not presented as summative fact, but rather, as indicators for the need for study of the subject

First, without any precipitative reasons cited, it has been said that the market for pulpwood has been depressed (Arseneault et al., 1997). Second, the recent construction of a new "supercalender" mill in Port Hawsbury is,

> "...an investment that wouldn't make sense without continued access to forest resources on a sustainable, long term basis" (Anonymous, 1998k).

Although pulp cutters have seen a decrease in demand for their goods, a private company would not make a $750 million (CDN) investment to build a new mill without a fairly reasonable degree of certainty on return.

This assertion cannot be conclusive without a proper understanding of the political-economy of the pulp and paper industry and the forestry sector as a whole in Nova Scotia. Also on this topic, some understanding of the political influence in the economic activity of wood harvesting could gained from review of the considerable participation by private woodlot owners in collective associations within the St. Georges Bay study area.

In addition to being a buyer of raw material, the Stora mill in Port Hawkesbury employs more than 1,000 people. Many of these workers live within the St. Georges Bay study area (Arsenault et al., 1997). The employment of construction and tradespeople required to build Stora's new "supercalander" mill should also be included when considering the economics of forestry for 1998.

It is difficult to provide concrete published evidence of the forestry sector role in the economy of the study area. The Antigonish Regional Development Authority provides for a characterization of relative importance through its estimates for the year 1993.

> "Forest products (saw lumber and pulpwood) represent a major economic pillar for the Northeastern Region. In 1993, the region produced 51.8% of Nova Scotia's pulpwood and 30.9% of saw logs. Within the region, Antigonish plays a small role in saw lumber (softwood: 2.2% and hardwood: 20.7%) and a larger role in pulpwood (softwood: 12.3% and hardwood: 8.0%)" (Anonymous, 1995b).

1991 estimates for forestry as a primary industry, place employment in Antigonish County at 265 people (Spencer, 1998).

Of the Census Canada statistics compiled pertaining to employment and occupations in forestry and related work (See Section C1) it must be said that a considerable number of people work on a seasonal and or casual basis. Due to the nature of their employment patterns they may not have been included in the Census results. While an individual's casual contribution to the economy may not be significant, the contribution of aggregate effort may be significant.

A considerable amount of material has been written about the relationship between the technology used in production (harvesting, replanting and silviculture treatments) and levels of employment. It is an important subject, which has, for lack of published material, not been discussed case-specific to the study area.

There has been a recent attempt by Natural Resources Canada to develop an analytical model through which an assessment of a given community's " forest reliance" could be made (Williamson et al., 1996).

This work is introduced here because Antigonish is listed as being among the communities in Canada "with over 50% of their economic base in the forest products sector." There are no communities listed in the Inverness County area with a reliance greater than 50%. Casual observation of the volume of pulpwood cut in Inverness County would suggest that this may not be an accurate conclusion.

The 1991 Canada Census, the National Input/Output table and series of geographic overlays for stratifying communities by ecological regions were the primary source of data for this work.

> " An economic base methodology was applied to 6,006 Census Subdivisions (CSD's) in the 1991 Canada Census. The purpose of the analysis was to determine the size of the economic base in each CSD and the percentage of the economic base accounted for by the forest sector." (Williamson, et al., 1996)

Further attention should be given to the ongoing work of this model's developers and to the model itself as it pertains to the study area. This "Economic Base" analysis included the compilation 57 S.I.C. (Standard Industrial Classification) categories which were "reliant" on forestry.

There are many issues facing a researcher attempting to estimate the importance of the forestry sector to a given economy. The Business Administration Department at St. F.X. has considered some of the important issues involved in compiling existing forestry data (Spencer, 1997).

This work raises issues for discussion on such topics as the measurement of "persons employed", classification of employers, value of shipments, government employment, capital expansion expenditures, and data collection. The study goes on to list sectors by both product and activity. They are, in ascending order, Maple Syrup, Christmas-Trees, Logging and Forest Services, Wood Industries and Paper & Allied Products. While the scope of data collection is framed at the province level, a significant number of people do hold jobs within these categories in the study area. The report's summary suggests that further work in data collection and analysis is necessary.

> "This report suggests that the forest sector in Nova Scotia is larger and more important than is often realized or reported. However, to generate the estimates a number of definitional and data collect issues were encountered. These issues are substantial but not insurmountable. If there is widespread interest within the industry and within government in obtaining better estimates these issues can largely be overcome." (Spencer, 1997)

Statistical evaluation of the forestry sector in the St.Georges Bay study area and the relevance of the aforementioned Canadian Forest Service research should be considered in the context of the data collection and definition issues raised.

The subject and outcome of resource management is important to the economics of forestry. Government facilitated forest management has been largely a Provincial responsibility. Both policy development and the fieldwork of the Department of Natural Resources must be included as factors important to the economy of the forestry sector. Also, the Department's role in the promotion of private woodlot management should be considered. The data gathered from this work is a potenial source of valuable information.

There has been a move during the last decade to form partnership between industry, the federal government and the provincial government. An independent evaluation of 1989-91 Federal-Provincial Cooperation Agreement for Forestry Development (CAFD) found that,

> "...the CAFD plus private sector spending generated approximately $25 million in household income and about 1,000 person years of employment in each year (1989-1990)" (Gardener et. al, 1992).

This agreement is an example of the direct financial impact of government facilitated management activity. The longterm goals of such fund-matching programs are aimed at promoting "sustainable" forestry.

The economics of the forestry sector is driven by demand for the wood and wood derived products. Where once the forestry sectors greatest concern had been for the efficiency of harvest there are now statements made of a recognized need to ensure that the resource of forests are renewed if the industry is to remain viable (Anonymous, 1998k). It is difficult to ascertain the extent to which such expression is motivated out of a concern for public relations or out of a concern for the future of forest resources.

B.1.2.2 Potential Impacts

Wood harvesting practices are predominantly carried out as clear cutting in the study area. The impact of this practice is the reduction and removal of wildlife habitat, loss of organic matter from the ecosystem, reduced water and nutrient retention, and reduced temperature moderation (Englert and Grant, 1982). The degree of impact upon adjacent waterways is dependent on compliance by woodcutters with government recommendations. Impacts on waterways include reduction in moderation of water flow, increases in nutrient, silt and temperature and riverbank instability. Green belt maintenance along waterways is voluntary, not mandatory.

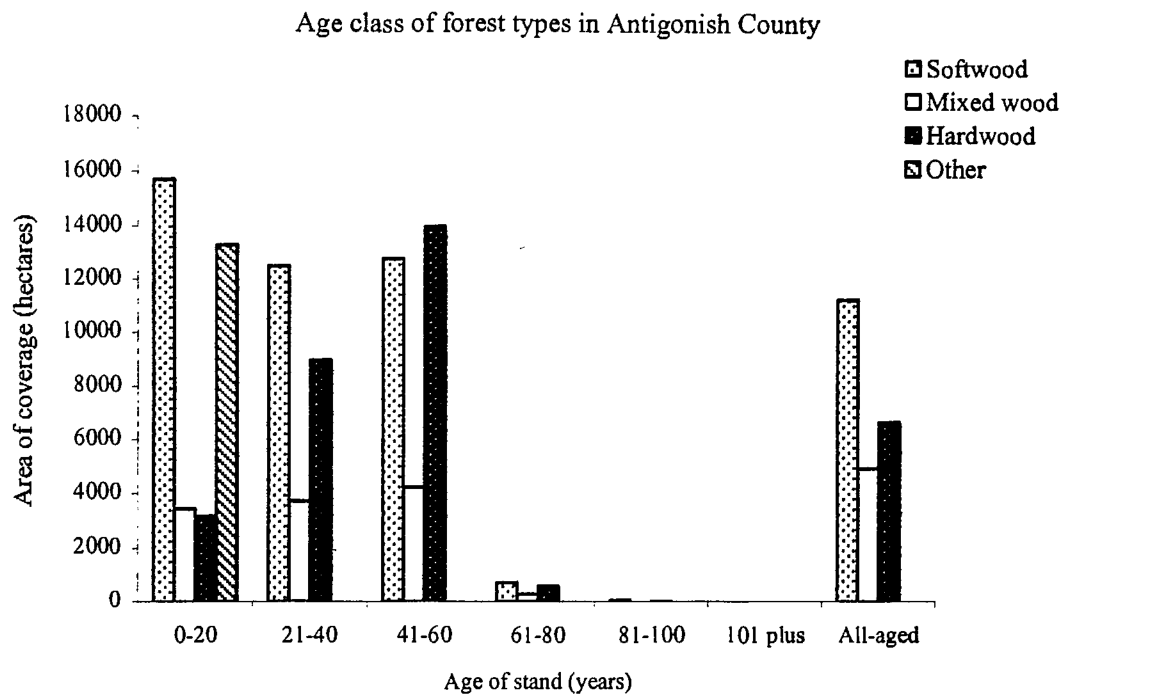
Englert and Grant (1982) examined the impact of logging on Atlantic salmon and trout in streams in Pictou County adjacent to the study area in representative Acadian Forest. They found significantly reduced salmon biomass downstream of disturbed forest, possibly attributed to siltation. They also observed an effect of increased fork length of salmon parr and an increase in biomass of aquatic plants and moss at the site of disturbance. This was believed to be as a result of increase nutrient input and increased light and temperature because of lack of shade. The increase in temperature increases the rate of development of parr and increased primary productivity. These positive effects were not observed in trout as they are 'pool' fish, which do not respond as positively to warm conditions as the 'riffle' fish.

Transportation of machinery in the watershed, although regulated, can still be extremely destructive in certain instances. The result is disruption and removal of habitat, as well as downstream siltation of spawning beds which essentially suffocates developing eggs.

The use of herbicide spray to remove hardwood growth in regenerating softwood stands has declined as funding made available by the Province of Nova Scotia has been recently reduced. Englert and Grant (1982) also examined the effects of logging crossing disturbances and found that for years afterwards, disturbed sites will continue to cause increased turbidity during heavy rain.

Data on actual area cut per year was not found, but a general impression is easily drawn from data of age class of standing forest, Figure B.1-22. Comparable proportions of 0-20 21-40, 41-60 and mixed stands exist for each county. There are effectively no stands over 60 years in age, other than mixed, in Antigonish County, but there are significant 40-80 year old hardwood stands.

Foray, or BTK (*Bacillus thuringiensis* K) has been used as a biological pesticide to control populations of Tussock Moth in the province, but very little has been used in Antigonish County. Five herbicides are used to reduce competition by other plants with harvestable softwood species. These are Pronone, Release, Simazine, Velpar, and Vision. Application of forestry chemicals is heavily regulated and monitored by governmental departments.



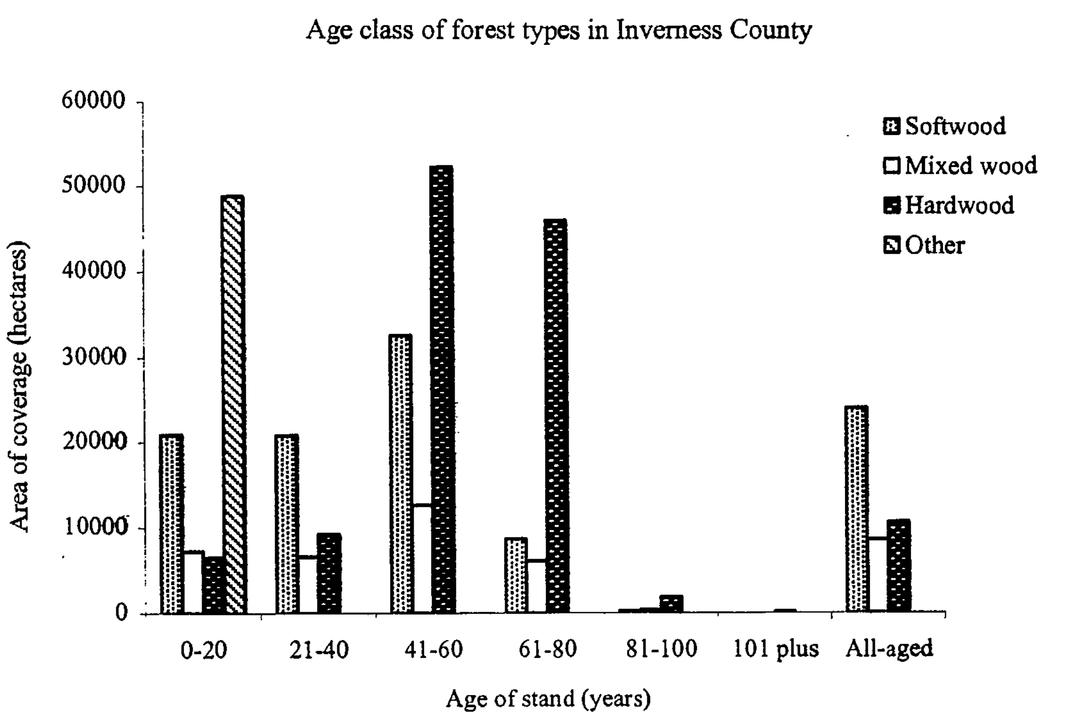


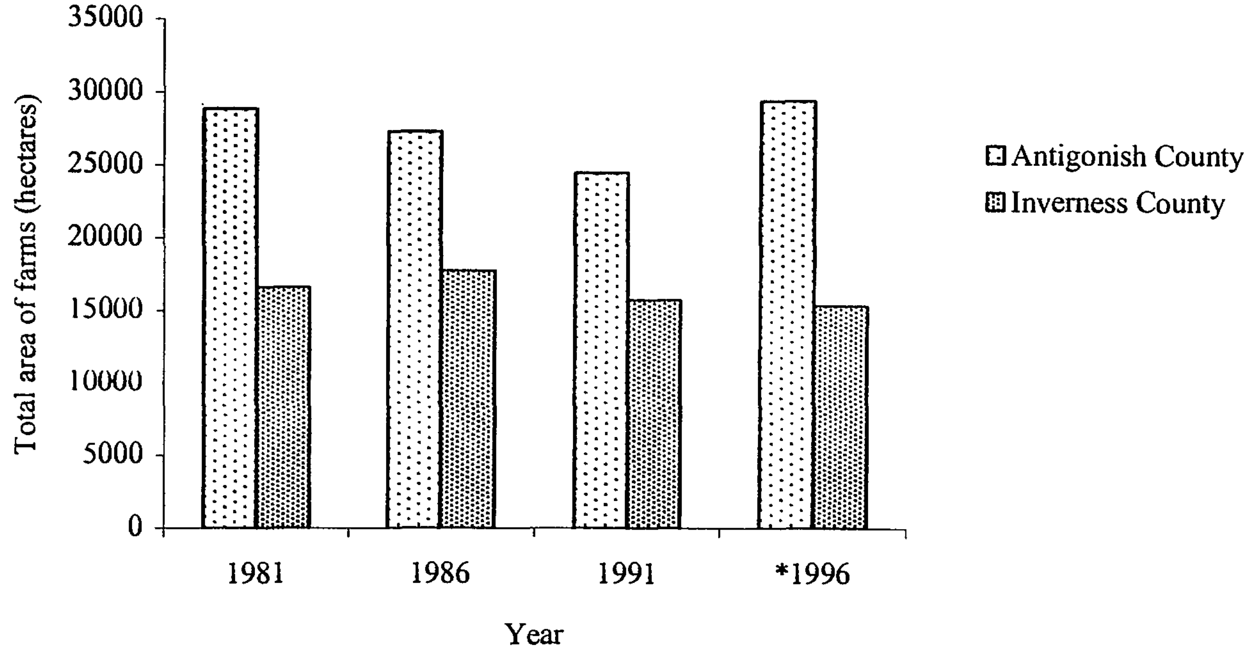
Figure B.1-22. Age class of standing forests in Antigonish and Inverness Counties

Local government representatives are unaware of any studies on the impact of forestry practices performed in the study area. Government fisheries employees have observed considerable habitat damage as a result of noncompliance with regulations concerning physical and chemical interference with fish habitat (R. Bancroft, pers com). Kiely and Ernst (1984) carried out assessments of drift of forestry herbicide on a Pictou County watershed, and Ernst et al. (1994) investigated the persistence and effects of herbicide residue in materials including foliage and litter adjacent to the study area. Glyphoshpate (Roundup) was found to deteriorate rapidly up to 58 days after spray application. Also, rate of leaf litter decomposition was found to be reduced by glyphosphate.

B.1.3 Agriculture

Census information is collected and published every 5 years in great detail. The definition of the commercial farm has been changed, so that 1996 data, onward, are not directly comparable to previous data. The amount of farm area over the period of 1981 to 1996 is presented in Figure B.1-23. There is a general decline, except for the 1996 value. It can not be distinguished if this is a reverse in trend or an artifact of the change in farm definition. It is likely to be the former, as Statistics Canada states that the number of family farms has been over-reported in the past. Thus, commercial farms had been under-reported.

The current distribution of farming capital over Subdivisions of the study area is presented in the Figure B.1-24. Subdivision A in Antigonish County has the greatest holdings. The uneven distribution of capital could be a direct reflection of the distribution of resources as there are significant differences in geographical features among the Subdivisions. Table B.1-22 presents a more detailed characterization of the distribution of farming activity over Subdivision.



B.1-23 Total farm area in study area, 1976-1996. * change in farm definition, 1996, Statistics Canada

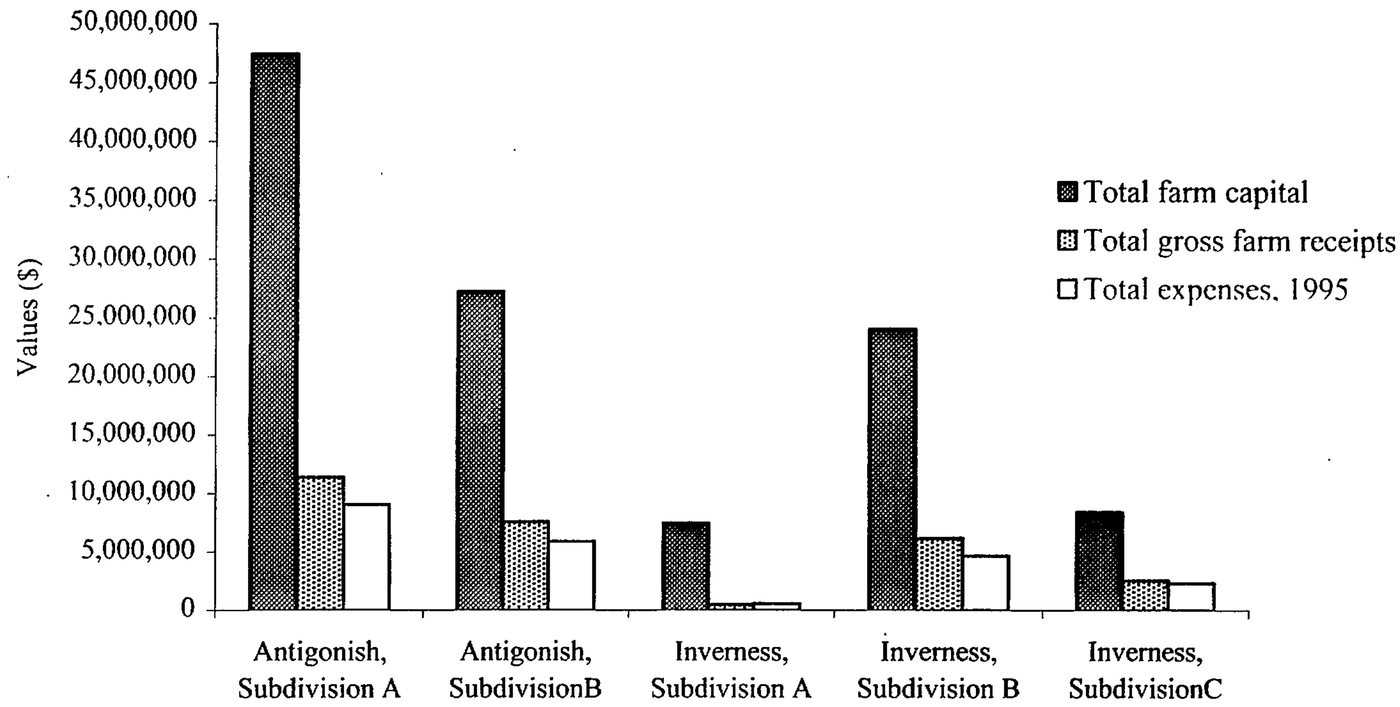


Figure B.1-24 Capital, gross receipts, and total expenses of farms in the study area, 1995, Statistics Canada

Table B.1-22: Distribution of farm activity in Census Subdivision of study area. Statistics Canada

	Antigonish Subdiv. A	Antigonish, Subdiv. B	Inverness, Subdiv. A	Inverness, Subdiv. B	Inverness, Subdiv.C
Number of farms	155	92	36	69	25
Area of farms (hectares)	18,122	11,269	2,770	8,579	4,006
Land in crops	7,356	2,688	433	2,012	747
Farm capital	47,425,813	27,220,806	7,421,973	24,054,557	8,387,122
Gross farm receipts	11,380,386	7,564,127	491,427	6,142,977	2,555,588
Total expenses, 1995	9,042,938	5,907,323	556,718	4,669,887	2,313.165

The numbers of farms, categorized by total capital value per county is presented in Figure B.1-25. There is generally a modal distribution , representing the average farm as having between $100,000 and 350,000.

Employment provided by farming is presented by number of weeks worked for the two counties in Table B.1-23. Calculation to reflect the number of full time employees, for general perspective, yields values of 53 full-time and the equivalent of 47 full-time individuals who worked seasonally in Antigonish County. For Inverness County, the values are 32 full time and an equivalent 36 full time working seasonally, assuming 50 weeks worked per year.

Wages and salaries in 1996 are presented by Census Canada for Antigonish County as totaling $2,200,850, and were not provided for Inverness County.

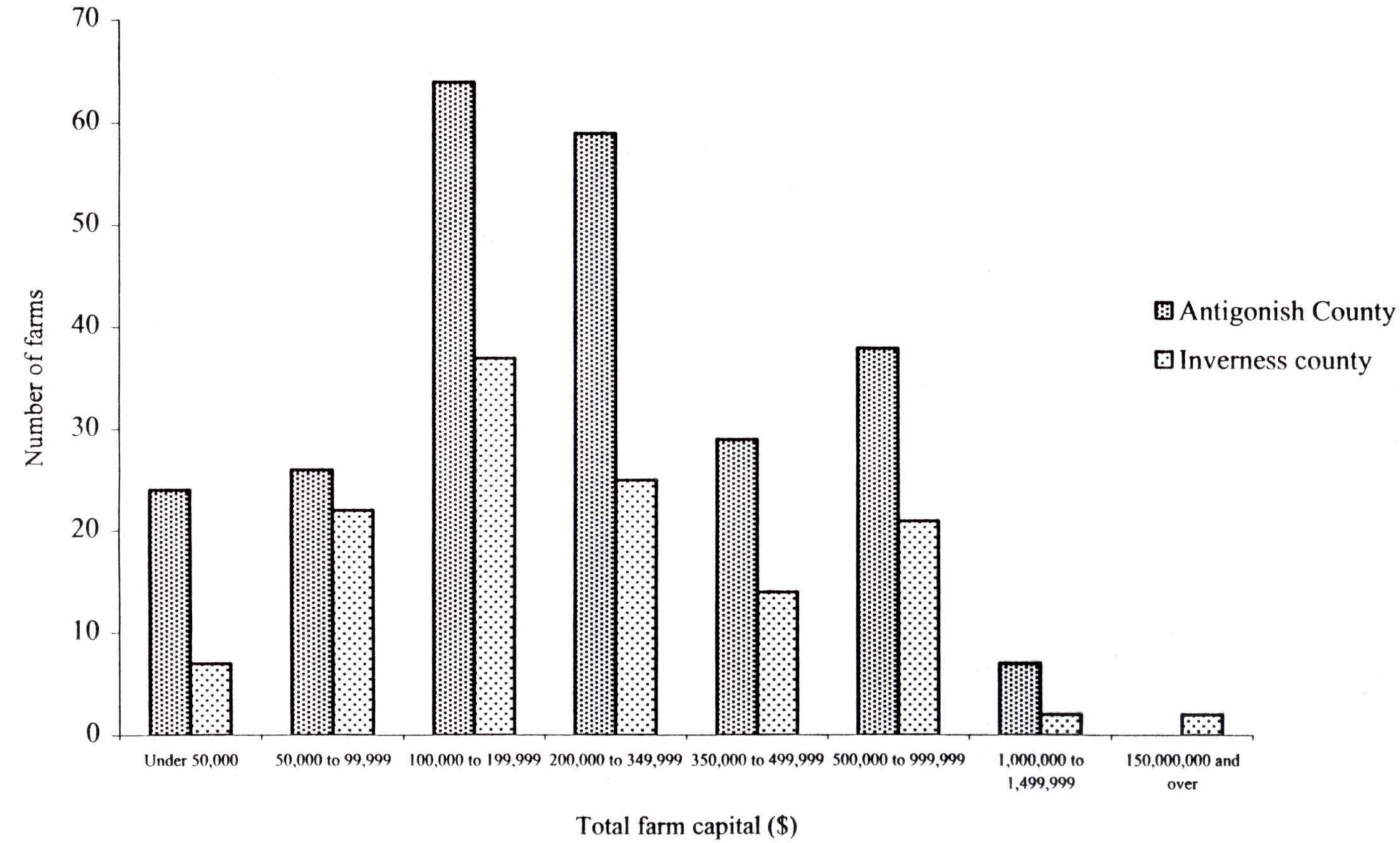


Figure B.1-25 Farms categorized by total farm capital,1996, Statistics Canada

Table B.1-23: Number of weeks worked in agriculture as seasonal and full time labour.

	Antigonish County weeks worked	Inverness County weeks worked
Full time	2697	1,614
Seasonal	2363	1,803
Total	5059	3,417

B.1.3.1 Potential Impacts

The removal of habitat occurs on a smaller scale than forestry, but it is a permanent removal, whereas forestry allows regeneration of habitat. Generally, impacts of agriculture include chemical, nutrient, and fecal contamination of adjacent waterways, and stream disturbance by livestock if their access is not restricted. This will lead to riverbank instability and siltation of habitat. Impact varies considerably depending on type of agricultural activity.

Application of chemicals is regulated through the Department of Environment which issue permits for use over several years. Volumes of treatments are not recorded, but area of land to which these chemicals are applied are reported by Census Canada and are available in Table B.1-24

Table B.1-24: Application of pesticides on agricultural land in Antigonish and Inverness Counties reported by Census Canada

	Farms reporting herbicide use	Number of hectares treated	Farms reporting insecticides or fungicides	Number of hectares treated
Antigonish County 1991	45	590	10	X
Antigonish County 1996	16	200	2	X
Inverness County 1991	58	731	9	X
Inverness County 1996	58	731	4	X

X=data not available

The crops grown will define which chemicals are applied. The details of numbers and types of chemical applications is too great for the scope of this report, although a possible route of investigation is assessing sales of agricultural products locally. Approximately 60% of dairy producers of Antigonish County use Round-up as a pasture treatment for control of tansy ragwort. Beef producers use 2,4-D and Round up. Crop producers use herbicide before crop emergence for weed control and also afterwards in the case of corn. Blueberry production receives herbicide spray every second year, while strawberry production will often use herbicide, fungicides and insecticide (Bekkers, pers. comm.). The application of fertilizers will depend on soil type, and generally will consist mostly of a nitrogen source if phosphorus and potassium are made available by manuring.

The level of agricultural chemical used in the study area is not thought to pose the same level of potential threat to ground water resources as in other areas of the province. No studies on this subject have been found. Gillis and Walker (1986), when examining this potential in the Atlantic Region, did not include this area as a study site, but instead focussed on the Annapolis Valley, Cumberland and Truro areas of Nova Scotia.

B.1.4 Mining

Information on mining activities was gathered from published sources and primarily from Annual Reports (pre-1991 Department of Energy and Mines, post-1991 Department of Natural Resources). In examining annual reports over time the quantity and value of the information lost in recent year became glaringly obvious. In the 1960s and 1970's annual reports had multiple tables of various aspects of information broken down by county or smaller unit. In the 1980s and 1990s the tables are simpler, often providing information only at the provincial level. There is a significant loss of information available to the public by the omission of this information. It also precludes conducting long term time series as data is not consistently presented. Prior to 1991, the Department of Energy and Mines Annual reports were still quite comprehensive, however, their amalgamation with the DNR Annual reports has been to the detriment of information transfer by both departments.

Mining activity within the St. Georges Bay Ecosystem Project area has been focused on three resources – coal, gypsum and barite - though iron, copper and limestone have also been extracted. The following historical outline is based on Nolan, Davis & Associates (1987) and Calder et al. (1993) unless otherwise noted.

B.1.4.1 Coal

There are four identified coalfields within the study area, all in Inverness County (Figure B.1-26). These are Port Hood, Mabou, Inverness and St. Rose/Chimney Corner (Calder, 1985). The coal in this area is high in ash and sulphur and is therefore used in power generation and home heating, it is not of sufficiently high quality for steel-making. The Port Hood coalfield is composed of four seams, only one of which is mineable

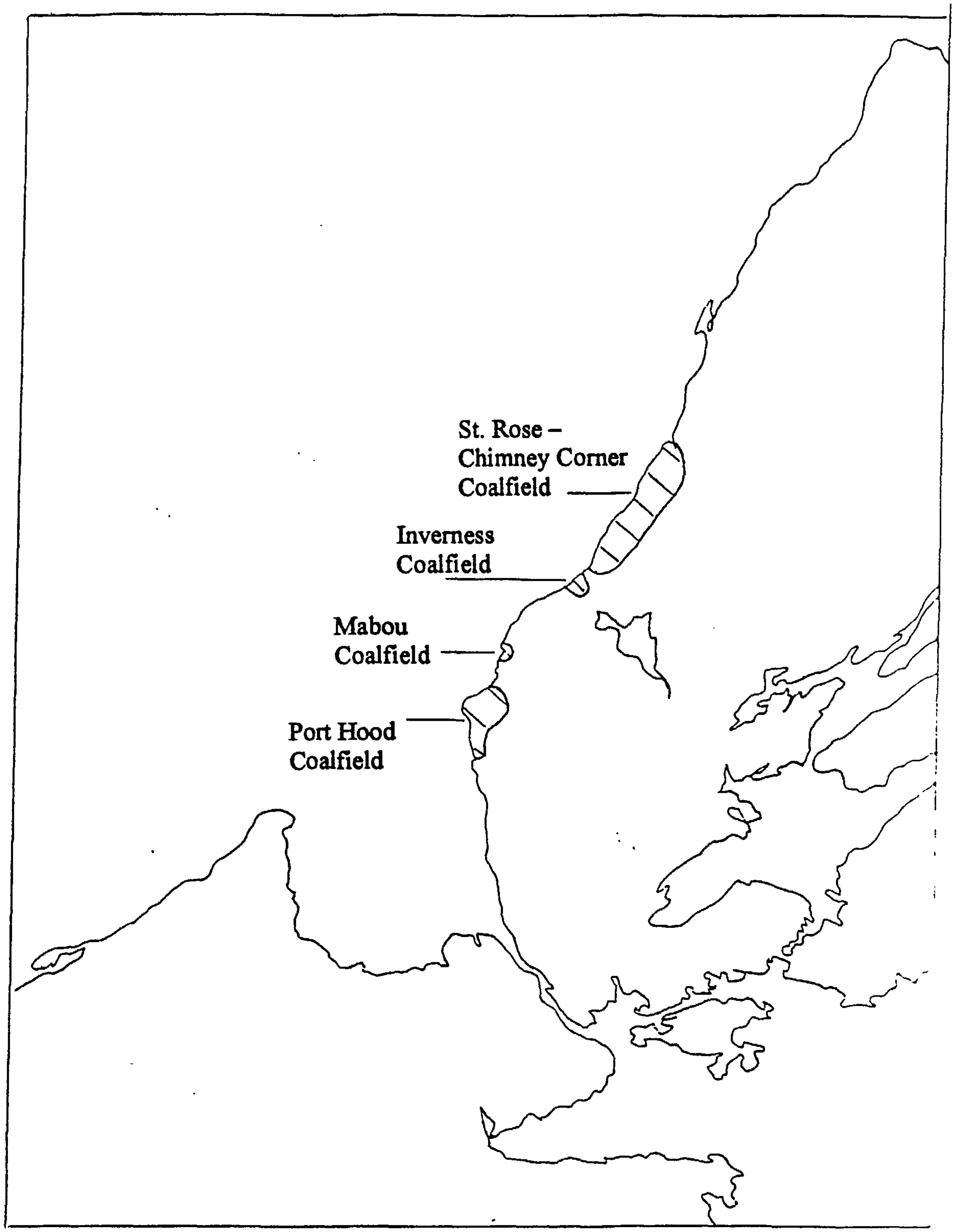


Figure B.1-26: Location of coalfields within study area, Inverness County.

thickness and is now essentially underwater; the more easily accessed land based coal has already been mined. There were two mines in the area working the seam, Port Hood and Chestico; both were closed by 1966.

The Mabou coalfield is composed of eight coal seams of which three are mineable. Similar to Port Hood, the remaining coal available is underwater, composed of offshore extensions of these seams. These seams were worked out by two mines, Mabou and Tijer, by the mid-late 1960's then abandoned.

The Inverness coalfield is made up of four seams, three which have been depleted. These seams supported 17 operations in the area. The last one closed in 1966.

The St. Rose/Chimney Corner coalfield is comprised of five seams with one of them (No. 5) being mined underground until 1992 by Evans Coal Mine Ltd. Production at this facility was between 30,900 and 42,800 tonnes per year between 1985 and 1990, and it employed between 40 and 45 people during this time (Dept. Mines and Energy, Annual Reports, 1985-1990). When this mine closed it was the last operating coal mine in the study area. In addition to Evans, in the past there were also two other mines operating in this area. The coal seams at Chimney Corner are not considered economically viable because they are thin and difficult to mine.

There is currently no active coal mining in the St. Georges Bay Ecosystem Project study area.

B.1.4.2 Gypsum

Gypsum was historically mined at Harbour Centre, Mabou and Belle Marche, all of which are abandoned now. The single remaining gypsum operation, Nova Construction Ltd., was at Brierly Brook (Antigonish Co.), which produced from 15,600 to 73,800 tonnes per year between 1985 and 1990, and employed four people (Dept. Mines and Energy, Annual Reports, 1985-1990). There are presently no gypsum operations listed as operational in the study area (Anonymous, 1999e) and it is unknown if the closure of the Brierly Brook operation is temporary or permanent.

B.1.4.3 Barite

Barite was historically extracted by four operations at Lake Ainslie, Scotsville, and Trout River, three of which are now abandoned; Scotsville is listed as inactive. There are presently no barite operations listed as operational in the study area (Anonymous, 1999e).

B.1.4.4 Iron and Copper

An iron mine in operation at Arisaig and a copper mine at Copper Lake are now abandoned (Nolan, Davis and Associates, 1987).

B.1.4.5 Limestone

Ridge Brokers Ltd at Southside Harbour have been extracting limestone. Between 1985 and 1990 the company produced 8,800 to 15,000 tonnes of limestone per year and employed 6-8 people (Dept. Mines and Energy, Annual Reports, 1985-1990). There are presently no limestone operations listed as operational in the study area (Anonymous, 1999e) and it is unknown if the closure of the Ridge Brokers operation is temporary or permanent.

B.1.4.6 Impacts

A majority of the resources were extracted at a time when concern for environmental impact by industry was not a societal priority. A report on the potential impact on groundwaters by mining activities identified only one area of concern in the study area. Observable leachate from tailings proximal to residences at Inverness had potential to impact a nearby development, and slight potential groundwater contamination was identified at Mabou (Nolan, Davis and Associates, 1987). In 1977, the mine discharge from the St. Rose surface mine operation exceeded acceptable levels for various metals, and when reexamined in 1990 had additional metals in excess. Features attributed to mine effluent, such as an absence of aquatic plants were observed downstream from the mine outflow into an unnamed stream, but were not noted in the 1977 study. These details, as well as the proposal for corrective measures in terms of a brook diversion are provided in a report by Acres International Limited, 1993.

B.1.4.7 Petroleum Resources

There is currently a great deal of activity associated with the development of offshore hydrocarbon resources in the Atlantic region. The Antigonish area will potentially receive a great deal of revenue from the development of natural gas resources from the Scotian Shelf. There is also movement to assess and develop oil and gas resources along the shore of Inverness County. There is some public discussion of the process by which this development is being implemented. This is partly due to the concerns of some about the appropriateness of this type of development within the Gulf, given the significant implications for other industries such as the fisheries and tourism, which are important to the area.

B.1.5 Trapping

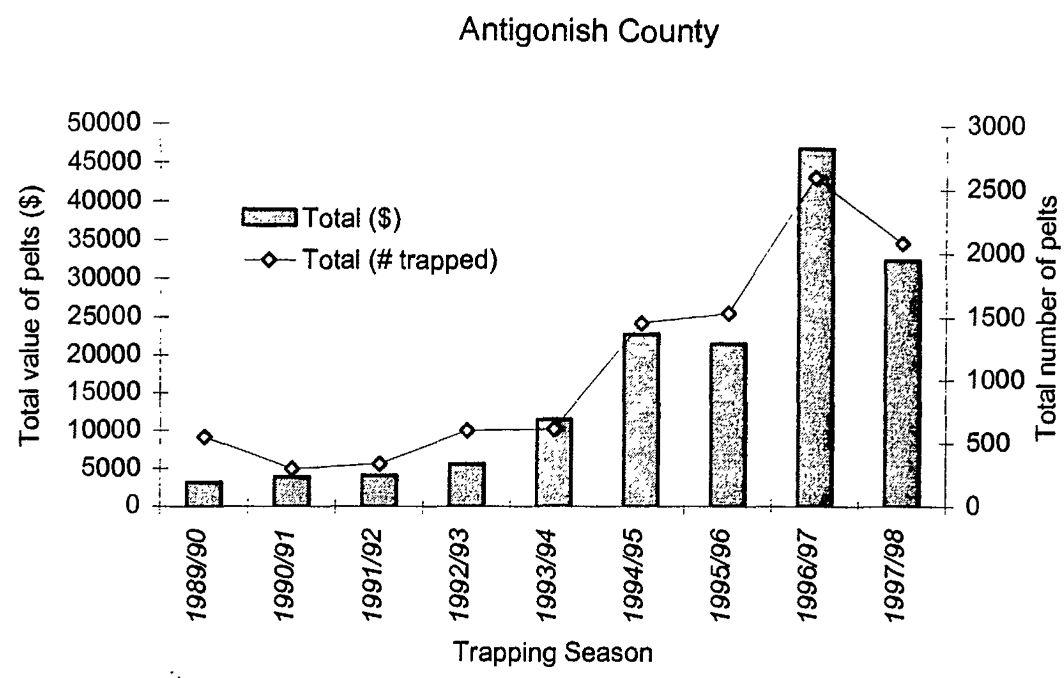
Thirteen species of furbearers are actively trapped within Antigonish and Inverness Counties – beaver (*Castor canadensis*), muskrat (*Onadata zibethicus*), otter

(*Lutra canadensis*), mink (*Mustela vison*), bobcat (*Lynx rufus*), fox (*vulpes vulpes*), raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*), squirrel (*Tamiascirius hudsonicus*), weasel (*Mustela erminea*), coyote (*Canis latrans*), fisher (*Martes pennati*), and black bear (*Ursus americanus*). The ranking in order of number of captures and values generated by each county are given in Table B.1-25. All trapping data presented here are from annual Nova Scotia Trappers Newsletters.

Table B.1-25: Ranking of principle five species taken in each county by number of animals trapped and total annual values of pelts. Data from annual *Nova Scotia Trappers Newsletter* 1989-1998.

Rank	**ANTIGONISH**		**INVERNESS**	
	Species	**Mean # taken/yr.**	**Species**	**Mean # taken/yr**
1	Muskrat	468	Muskrat	959
2	Beaver	197	Squirrel	483
3	Raccoon	182	Beaver	380
4	Squirrel	93	Weasel	131
5	Coyote	51	Coyote	61
	Species	**Mean total value/yr ($).**	**Species**	**Mean total value/yr ($)**
1	Beaver	6,109.43	Beaver	11,588.80
2	Raccoon	3,394.25	Muskrat	4,361.98
3	Muskrat	2,092.80	Otter	2,951.48
4	Otter	1,440.56	Fox	1,966.81
5	Coyote	1,235.44	Coyote	1,542.81
Total		**14,272.48**		**22,411.88**

Total annual values of pelts sold by county have ranged from $3,225 (Antigonish 1989-90) to $70,310 (Inverness 1996-97) (Figure B.1-27).



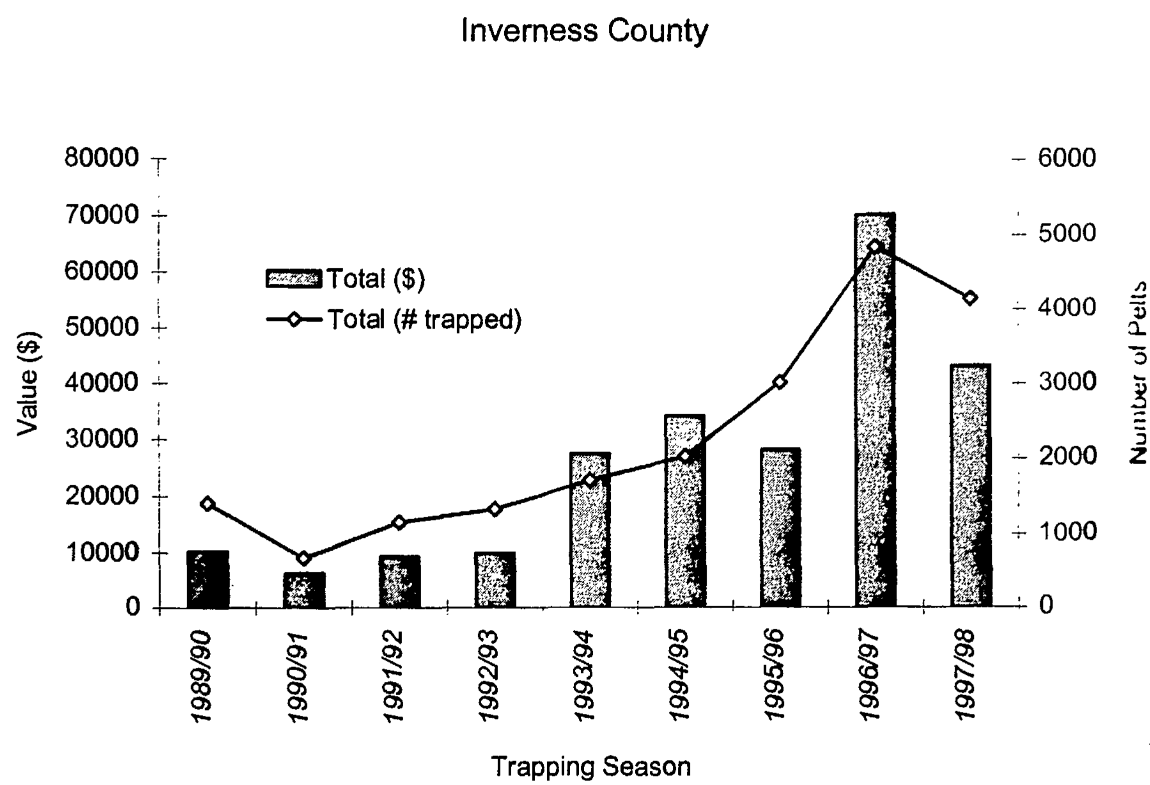


Figure B.1-27: Total number of pelts, and annual values of pelts for Antigonish and Inverness Counties, 1989-1998

Trends from 1989 to 1998 show a gradual increase in both the total number of trapped animals and the money generated for each county (Figure B.1-27). License sales over this same time have remained relatively stable in Inverness County (between 72 and 98 licenses, with the exception of 1989-90). In Antigonish County there has been a gradual increase in number of license sales, and in 1992-93 there was a large increase to 122 licenses which then fell back again to the previous low levels (Figure B.1-28). This jump in license sales is actually an increase to historic levels; from 1984/85 to 1987/88 number of licenses sold in Antigonish County ranged from 137 to 162 (1993 Nova Scotia Trappers newsletter).

Though trapping is treated as an industry in this report it is important to recognize that it is also recreation and a lifestyle to some people. The monetary returns of trapping within the study area are not high and so there must be a non-financial motivation for these people to take part in this activity.

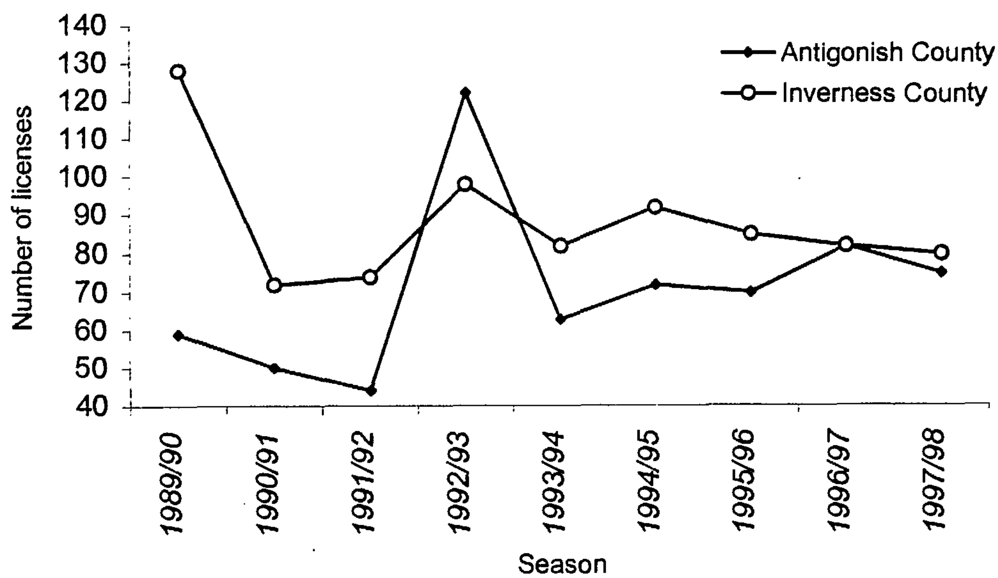


Figure B.1-28: Fur harvest license sales in Antigonish and Inverness Counties, 1989-1998

Summary

Throughout Nova Scotia's history forestry has been a major contributor to the economies of both local communities and the province as whole. It remains an important sector for rural employment in communities such as those in the study area. It is difficult to make an accurate estimation of total economic value that forestry contributes the economy. A few large pulp and paper companies dominate the local and provincial market for harvested wood. For more than twenty years this situation has motivated the industry to maximize the yield of trees harvested through the most efficient means available. In the province this promoted patterns of harvesting which resulted in significant pressure being placed on the resource's capacity for renewal.

After a Royal Commission recognition of the problem in forestry, various levels of government began putting effort into programs aimed at the regeneration of wood supply in areas that had been extensively harvested. This work in itself has produced some degree of economic benefit.

There has been considerable effort put towards the promotion and expression of confidence in current industry practice and government management approaches. Publications from both sources suggest that the industry and the resource have a long and productive future in the province. There is some evidence that is contrary to this optimistic view. Also, while some wood lot specific studies have been carried out, the aggregate impact of past and current forestry practices are unknown.

Verification of the assertion that current forest industry practices are "sustainable" for both the business of production and the health of forests has not been supported by any independent research. This remains true as much for the St.Georges Bay study area as it does for the province.

Coal, gypsum and barite have been the principle mineral resources extracted. Four coalfields have been mined in the study area, none of which are currently active. Gypsum was historically mined at three sites and more recently at Brierly brook; no gypsum operations are currently active. Barite, iron and copper have all been mined in the area, but none of the mines are presently in operation. Limestone has also been extracted in Antigonish County, but this is not occurring at present.

Agriculture is a significant contributor to the economy of the study area. Based on 1995 figures, there is the equivalent of 168 individuals employed full-time although, approximately half of this is carried out as seasonal work. Total farm capital is approximately $115 million for the study area.

Thirteen species of furbearers are trapped in the St. Georges Bay study area with muskrat, beaver, otter and coyote providing the greatest revenue. Total annual value of pelts for all species has ranged from $3,000 to $70,000 per county per year. The number of people participating in trapping appears to be stable in the last few years compared with the early 1990's.

B.2 RESIDENCE

B.2.1 Settlement Patterns

Initial settlement patterns of the study area reflect the preferences and requirements for survival of the indigenous community and European settlers of the 18th and 19th centuries. Agriculture, fishing and trade were necessary for survival of the settlers, thus settlement occurred along the coast where docking harbours were found, often at river mouths, and proceeded inland along rivers. These areas provided water transport, fishing, hunting, water and preferred agricultural land. As these lands were settled, upland areas were cleared and settled, but it is suggested that these, having less fertile soils, were the first to be abandoned in the mid 1900's (Davis and Browne, 1996). Transportation routes of the 20th century have provided a new landscape feature that has modified this pattern, increasing settlement along highway arteries.

Figure B.2.1 illustrates the distribution of populations in unincorporated centres of the study area. Antigonish Town is the only incorporated town of the area, and is also included. Population distribution by Subdivision is presented in Figure B.2-2.

The current status of the population is better understood in context of historical data. The change in populations of the counties, and each county's largest centre is illustrated for in Figure B.2.3. Current attitude about the stability of rural communities would predict decreasing populations, but the opposite is true. Age profiles by county from the 1996 Canada Census do not suggest an unusually small number of youths relative to adults.

As population is only moderately increasing, only a moderate impact upon the environment would be expected. However, general lifestyle and attitude has changed over the last decades towards greater material and resource utilization. Thus there should be attention given to this issue given the increasing population.

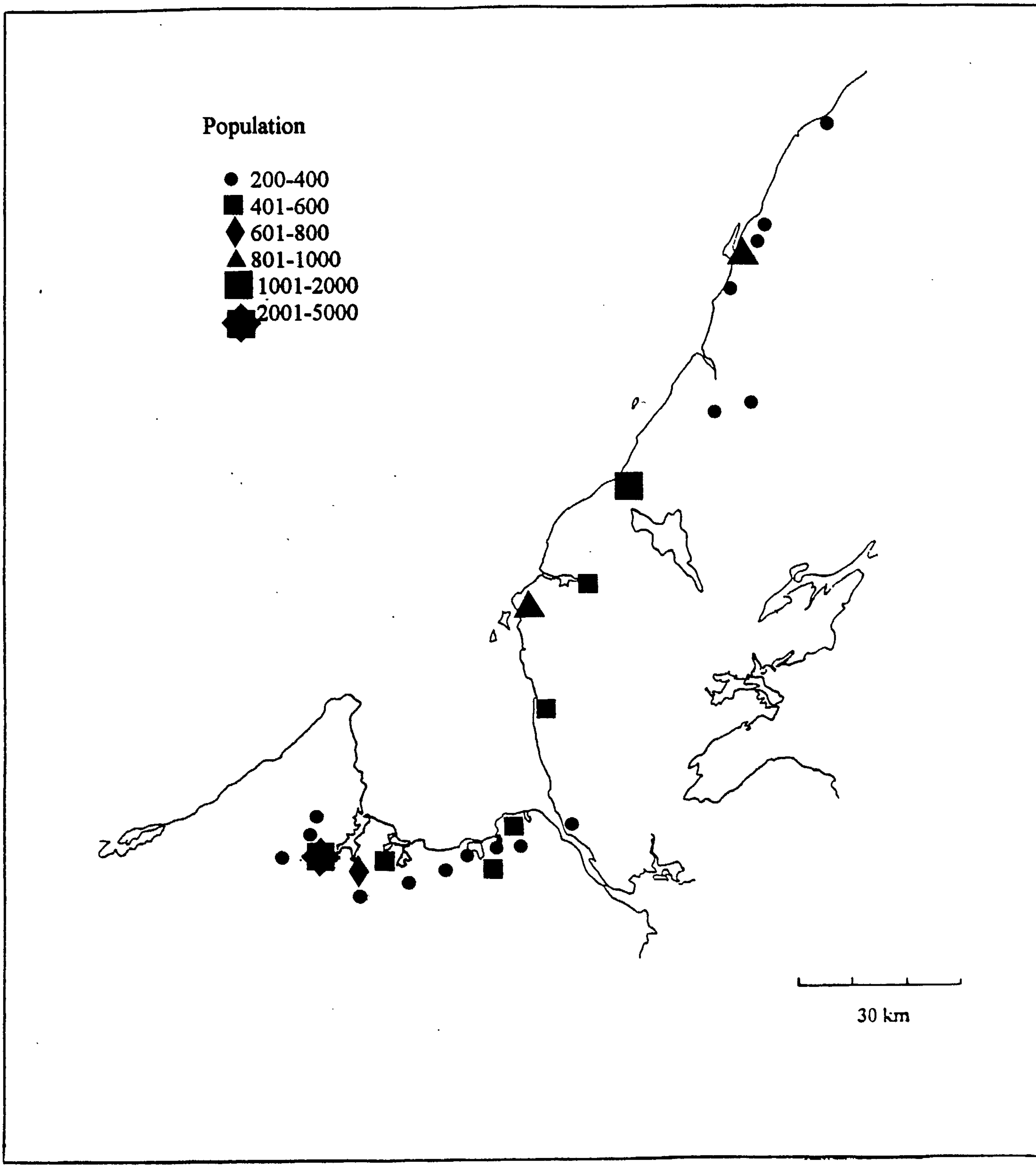


Figure B.2.-1 Population distribution in St. Georges Bay Ecosystem Project study area

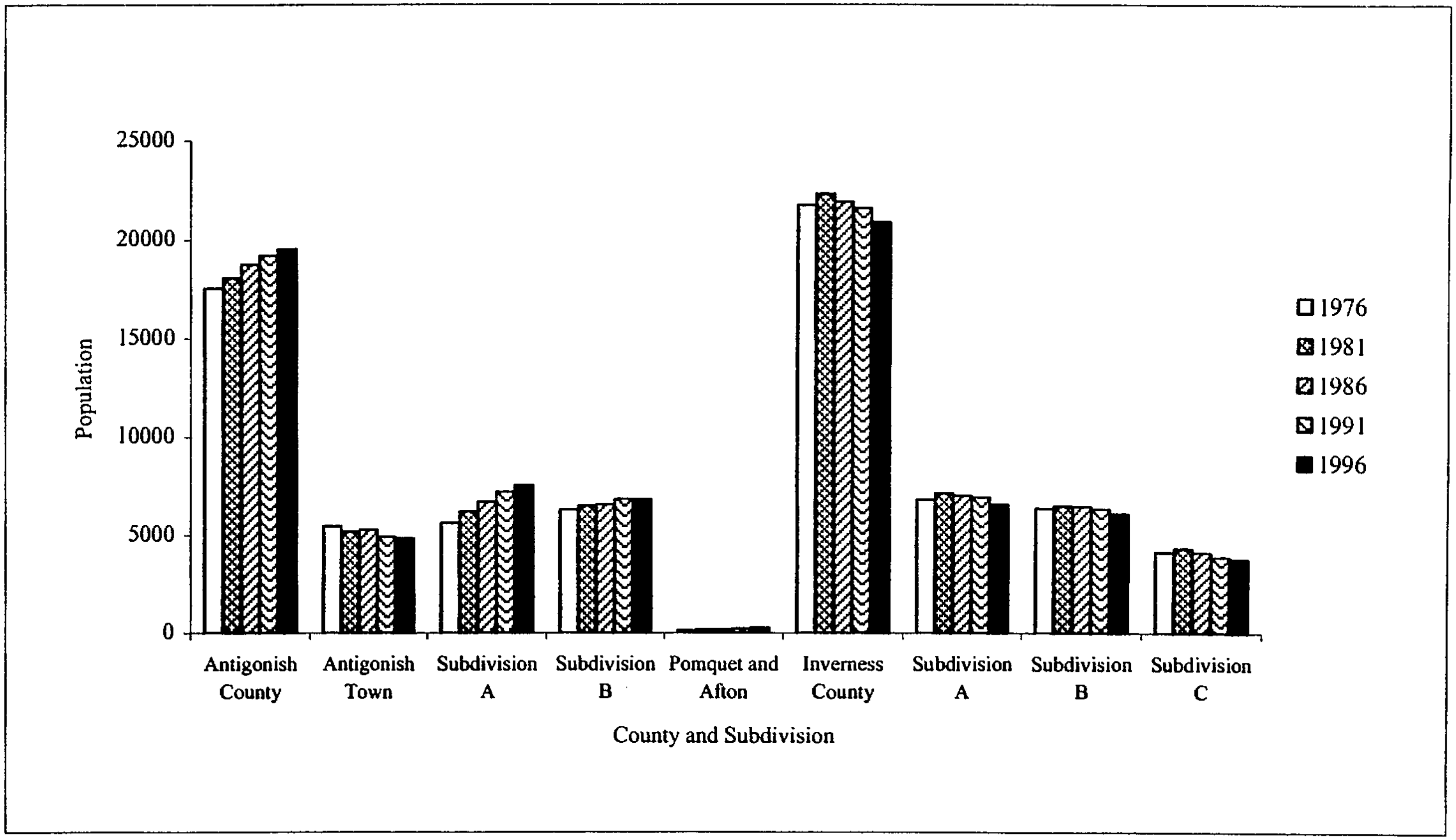


Figure B.2-2 Distribution of population throughout study area, 1976-1996, Statistics Canada

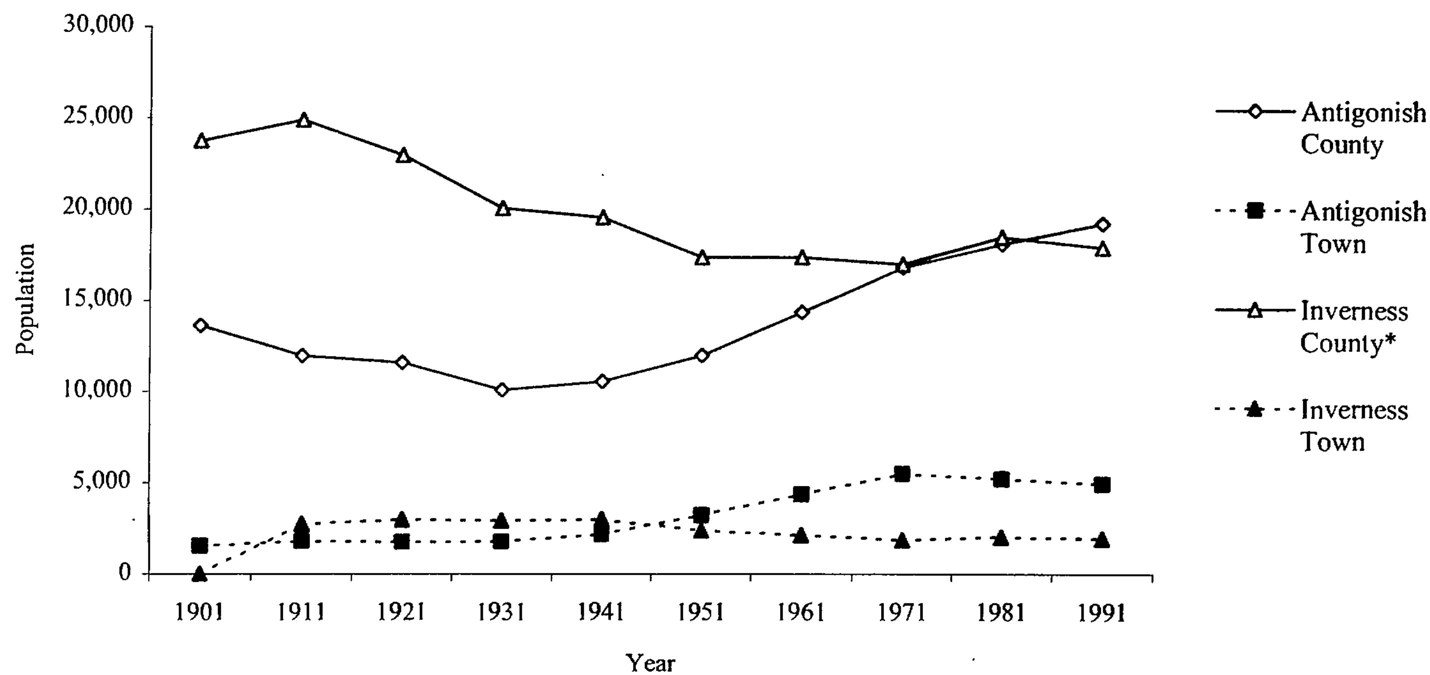


Figure B.2-3 Population trends for counties and selected centres of the study area, 1901-1991, Statistics Canada

* Adjusted to excludePort Hawkesbury, which is not in study area.

The significance of impacts of present-day residence would not be as significant except for the fact that human residence tends to cluster around water bodies. The result is the direct exposure of water resources to human wastes, without the benefit of initial amelioration by the terrestrial environment. Household and yard chemicals, and faecal bacteria and nutrients all have detrimental effects on freshwater habitat and populations, and water quality for human consumption. This water will also carry these materials out of the aquatic into the marine environment.

Within the study area, approximately 20% of the residents live in communities that have sewage treatment plants (STP) and waste water treatment plants (WWTP). The rural population relies on private facilities. There is no information on the relative success of private versus public treatment in the area. In terms of harbour habitat, it is unfortunate that these larger concentrations of people tend to live in proximity.

This is not to say that STP's of the study area are not effective, but that when there are problems with a facility, it is handling such a large quantity of material, that the impacts can be substantial. The alternative is many smaller private facilities that would require more resources than are available to regulate and monitor. This same dilemma also faces landfill sites, and is certainly not unique to the study area.

It is abundantly clear, however, that 83% of the harbours in the study area are closed for shellfish harvesting because of contaminated conditions. The contamination is, in some cases, directly attributed to human fecal waste. The shallow protected harbours are vulnerable to biological contamination problems because of warm summer temperatures and restricted tidal flushing. Additional nutrient input will heighten the potential for problems. It is possible, as well, that actual contamination is not as much a motivator for shellfish closure by Environment Canada as fear of liability if sickness occurs, when the source can be traced to an 'unclosed' harbour.

Vehicle transportation contributes considerably in terms of road and bridge construction and maintenance, surface drainage patterns are disturbed, resulting in siltation of streambeds. Salting, roadside spraying and automobile exhaust are associated contamination sources.

Monitoring of the impacts of these activities are carried out by the NSDOE. Environment Canada has carried out surface water studies to assess levels of natural and human introduced contaminants in drinking water. Studies of household and roadside chemical impacts were not found for the study area.

Appendix 13 presents locations and details of operations of sewage and wastewater treatment plants, and landfill sites. Also included are abandoned disposal sites which were inventoried by MacPherson (1987).

The types of disturbances common to this area result from human habitation and waste disposal, recreational activities, and human industry. Because of the small population base and a low level of industry, there are few significant point-source polluters. However, localized disturbances occur and precipitation and water drainage throughout watersheds distribute the effects of small disturbances over large areas. The impacts of diffuse pollution sources is not well identified within the study area. Another significant impact is the deposition of LRTAP (long range transport of atmospheric pollutants – see Section A.8.3) from industry to the southwest and west.

B.3 Recreation

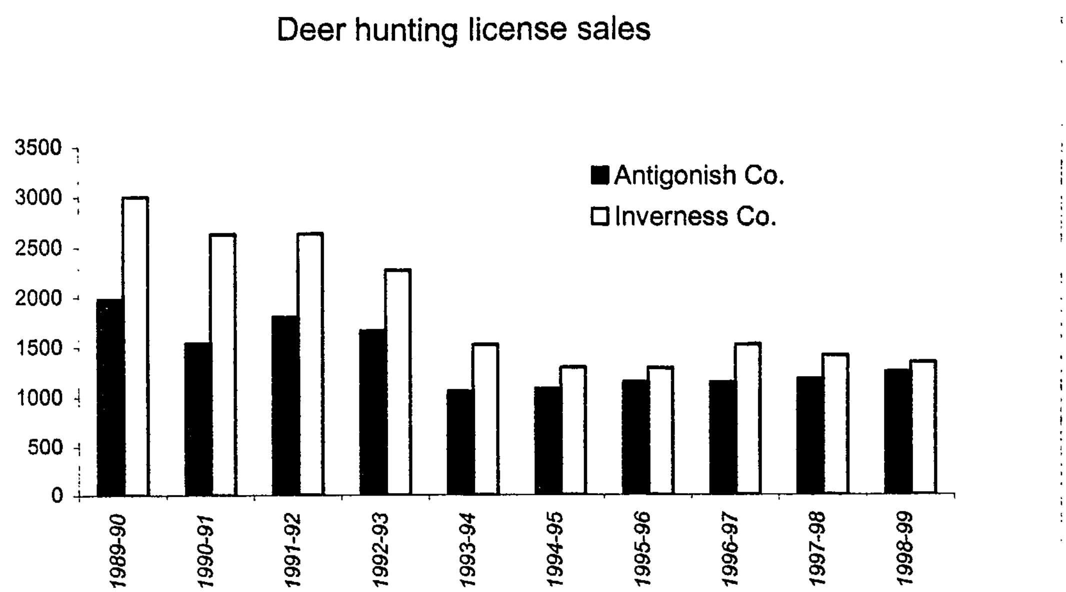
Recreation by residents and tourists is perhaps the one sector with a net positive impact on watershed ecosystems. The use of resources in the study area in some cases have affected the resource detrimentally, but user groups are often most active in lobbying for protection of the resources.

B.3.1 Hunting

Recreation includes harvesting activities such as hunting small and large mammals, waterfowl and gamebirds. These are closely regulated by the Department of Natural Resources in the interest of stock preservation. Routine studies are carried out by DNR to establish populations of key animals. Moose, deer, beaver, hare, and coastal waterfowl surveys are conducted on a regular, if not annual basis by DNR field offices. High profile lobby groups are involved in conservation, and are often partners with government management bodies in studies.

Within the St. Georges Bay study area the main species hunted are white-tailed deer (*Odocoileus virginianus*), and the small game snowshoe hare (*Lepus americanus*) and ruffed grouse (*Bonasa umbellus*). Black bear are also hunted but to a much lesser extent than the previous three species. Results presented below are based on data presented in Sabean (1991), Nette and Stewart (1992), Patton, (1991), Department of Natural Resources Annual Reports (1992-1996) and provided by Department of Natural Resources personnel (Nette, Clattenburg, and Boudreau, pers. comm.).

License sales for deer have remained relatively stable in Antigonish County for the period of 1989-1998, ranging between 1,058 and 1,981 licenses issued per year. Inverness County has more license sales (range of 1,291-3,005 during 1989-1998), but also shows a pronounced decline in number of license sales over time (Figure B.3-1). In the last few years there are only approximately one-half the number of licensed deer hunters in Inverness County that there were in the early 1990's.



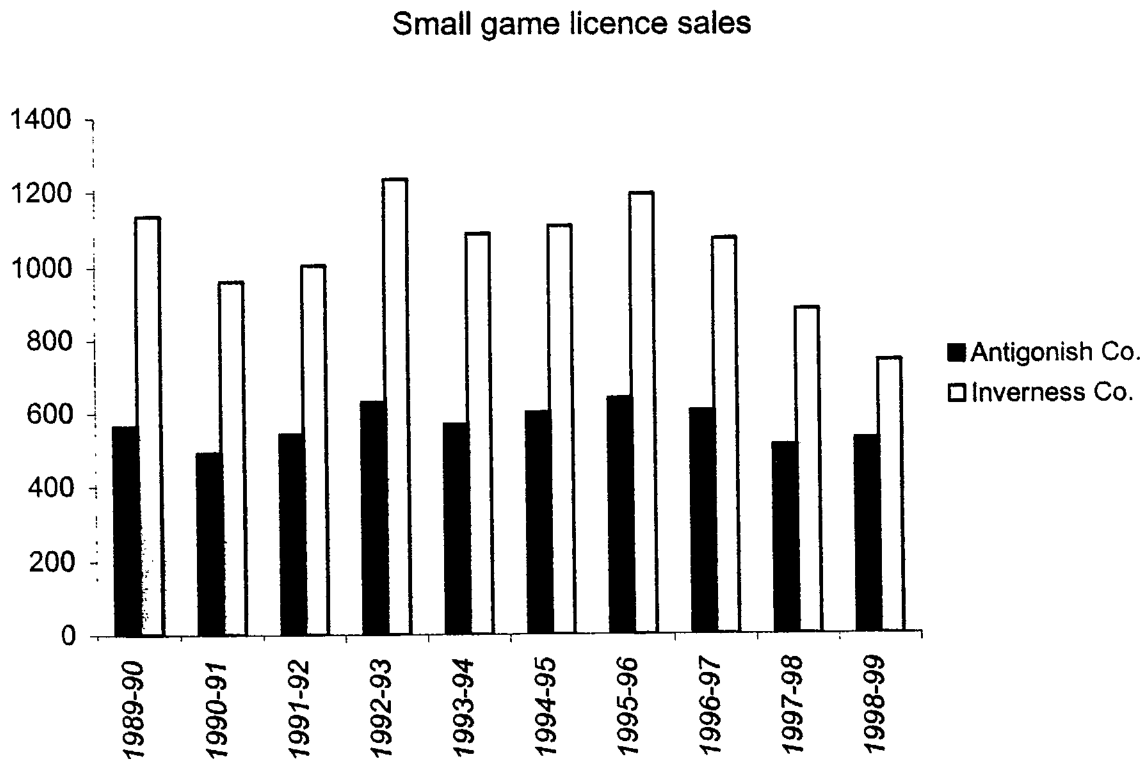


Figure B.3-1: Deer and small game hunting licence sales (resident and non-resident combined) for Antigonish and Inverness Counties 1990-1999

The number of deer harvested by county reflect these license sales (Figure B.3-2). Number of harvested deer in Antigonish County has ranged between 192 and 535 between 1989 and 1998, while in Inverness County during the same period the range has been 298-1,332. Combined, the two counties account for 7.2%-10.9% of the annual provincial harvest of deer. The number of deer killed in Inverness County has decreased substantially over time, presently it is one-quarter to one-third of the level in the early 1990's.

Upland game hunting has remained more consistent over time than deer hunting. License sales have remained stable in both counties over the last ten years; between 492 and 640 in Antigonish County, and 743 and 1,235 in Inverness County (Figure B.3-3). Harvests of snowshoe hare show a similar pattern in each county, an increase over time to a peak in 1996-97 then abrupt decline. In 1998-99 the harvest in Antigonish Co. had rebounded but in Inverness it remained low. Ruffed grouse harvests have remained low and relatively stable in both counties between 1989 and 1998, peaking in 1995-96 then declining since.

B.3 2 Recreational Fishery

The recreational fishery in Nova Scotia is a significant aspect of local cultural identity and economy. There is a considerable tourism industry surrounding the fishery in addition to a food fishery.

The fishery has both marine and freshwater aspects. Marine recreational fish harvests are included in statistics of the commercial marine fisheries. Thus, the issues surrounding recreational fisheries are discussed in the commercial fisheries section. The size of this fishery is unknown, as the numbers are not recorded separately from the commercial fisheries. One of the popular fisheries, mackerel, requires no licensing or registration, and is therefore not well documented.

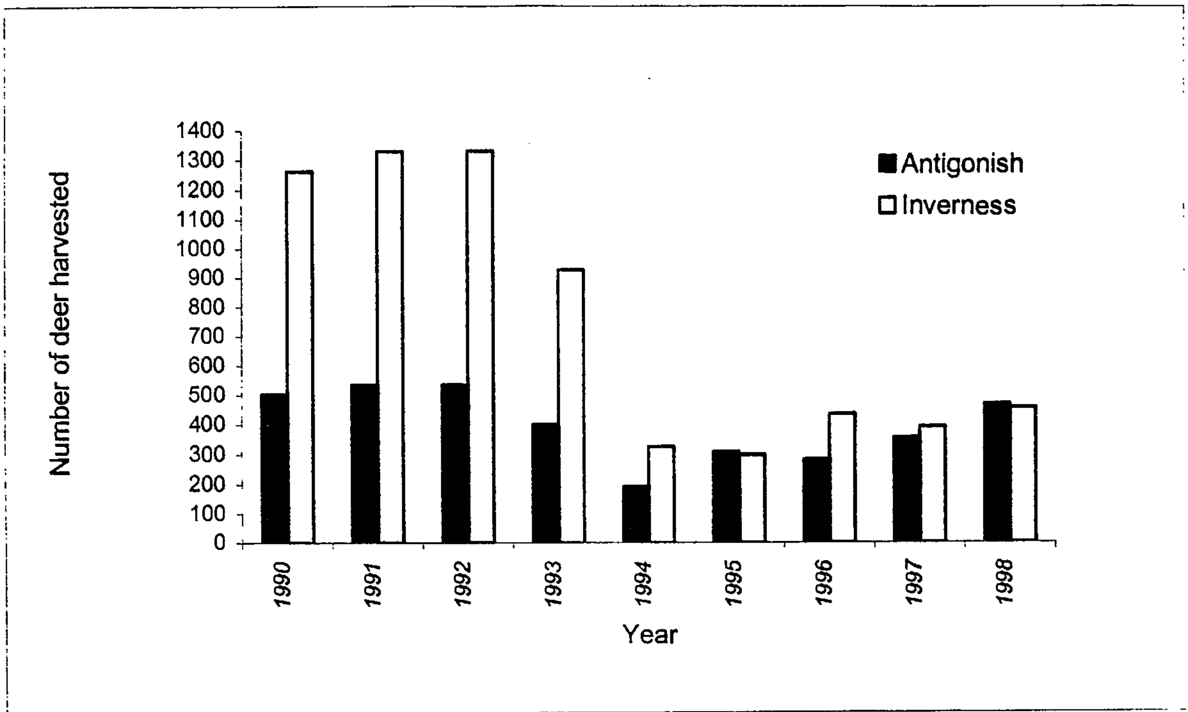


Figure B.3-2: Deer harvest in Antigonish and Inverness Counties, 1990-1998

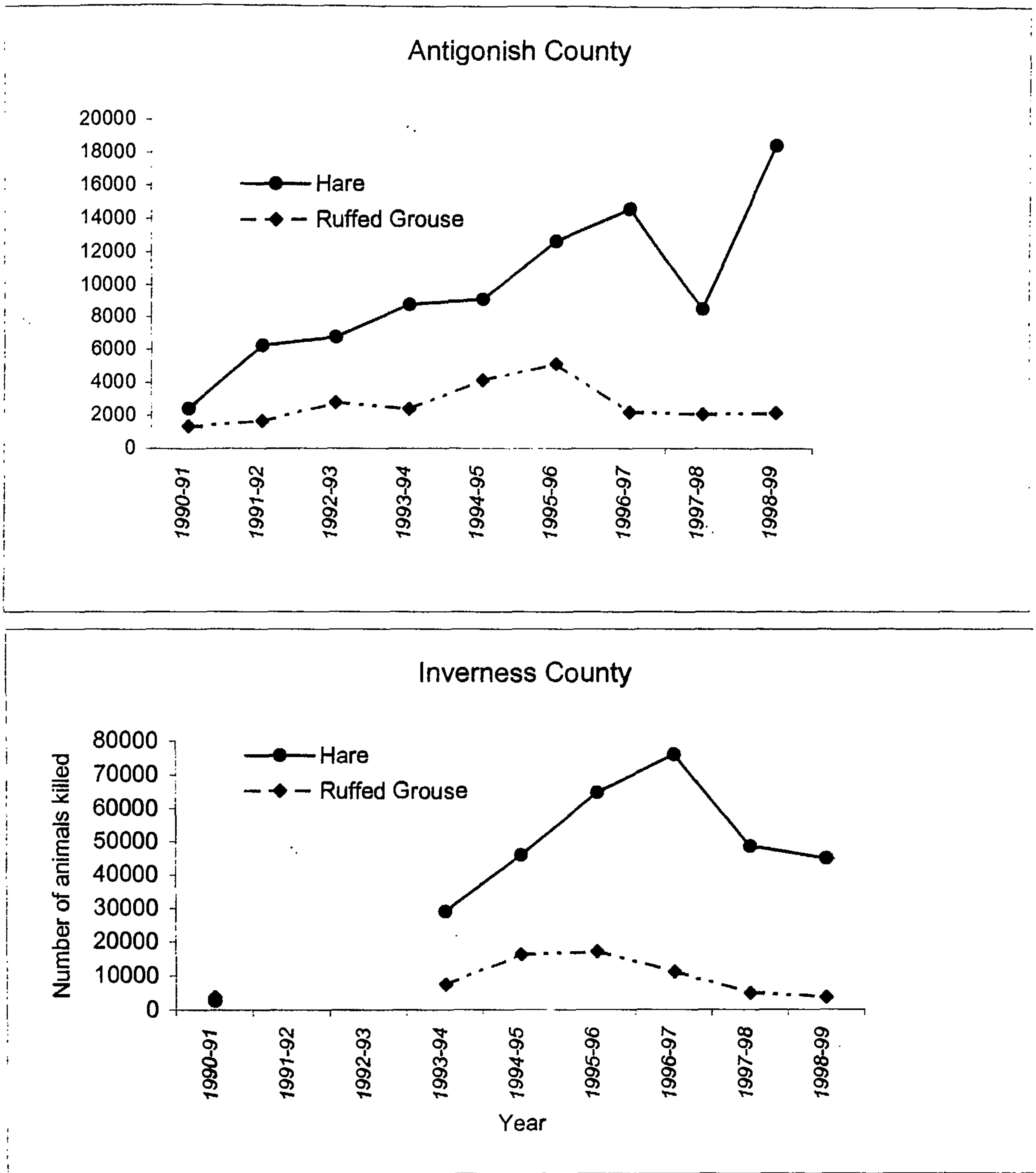


Figure B.3-3: Upland game harvest in Antigonish and Inverness Counties, 1990-1999
Data lacking for Inverness County, 1991-1993.

The provincial Department of Fisheries and Aquaculture manages a portion of the recreational fishery and generally works closely with anglers and the Department of Fisheries and Oceans in order to have an understanding of the effort and catch occurring annually. Indicators of effort and catch include numbers of licenses sold, and information volunteered by anglers through survey programs initiated by the province. The province published an extensive assessment of fishing effort and catch for Nova Scotia Northumberland Rivers for 1991 to 1997 based on angler surveys, which covers the South and West rivers of the study area. Estimation of fish populations as a management tool has been accomplished through Federal and Provincial Electrofishing Programs.

The provincial department also engages in population enhancement by hatchery rearing and introducing young fish to streams and rivers of the study area. A hatchery operates at Fraser Mills on the South River and the community has taken over operation of a hatchery at Margaree. Details of numbers of fish released and sites of release are published yearly. The impact of hatchery releases on population can be estimated by observing the proportions of total population caught that are of hatchery origin. However, behavioral considerations must be taken into account, as the hatchery fish may be caught more easily. DFO sampling in 1996 found that of the Atlantic salmon sampled in the Margaree River, 26% of the small salmon (less than 63 cm) and only 4% of adults caught were hatchery-raised.

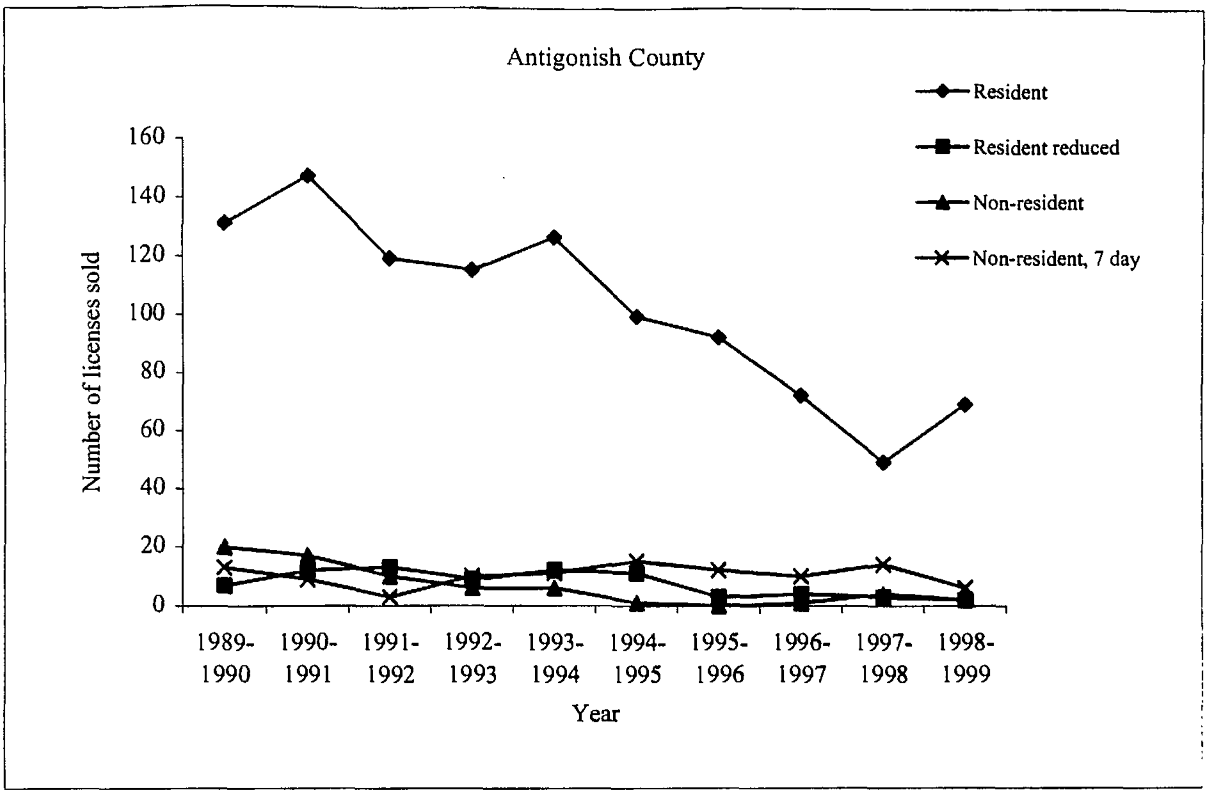
The bulk of inland recreational fisheries harvest anadromous fish. The most favoured of the sport fisheries are the salmon and brook trout (Anonymous, 1995c). Others include brown and rainbow trout, rainbow smelt, white perch and American eel In the study area, there were no reported catches of shad, smallmouth and striped bass, fished elsewhere in the province in the 1997 logbook report, and negligible catches of yellow perch and striped bass from 1997 stub returns.

Angling effort has increased from 24,052 days fished in 1980 to 51,203 in 1995 in Antigonish County and from 49,606 to 69,068 in Inverness County. Days fished is an estimation of effort and is used to describe one fishing excursion to one river, regardless of hours spent or numbers of rivers visited in one day. This is an approximate but reasonable tool in describing effort.

The number of general and salmon licenses sold to residents since 1983 has fallen from 6,702 to 1,689, but has remained relatively constant for non-resident (Figure B.3-4, Nova Scotia Fisheries and Aquaculture statistics). During this period, the prices for both types of licenses have increased more than 300%.

An important aspect of the recreational fishery is the non-resident component. License sales per county reflect a difference in this feature between the counties. The Inverness non-resident license sales are a much larger proportion of the total than in Antigonish County (Figure B.3-4). In addition, the non-resident effort is Antigonish is 1.7 % of the provinces value, whereas Inverness receives 40% of the provinces non-resident fishing effort (Anonymous, 1995c). This is expected to be a result of the Atlantic salmon fishery in the Margaree River. The fishery there is an important contributor to the economy as non-resident fishers need to be supplied with equipment, lodging and food. The numbers of fishers also places pressure on the salmon population, but also presents the impetus to conserve the stocks.

The study area salmon population remains stable when, in the Atlantic region, the salmon of 14 rivers have become extinct and 19 have only remnant populations (Anonymous,1998L). The demise of other populations has been attributed largely to the acidification of rivers as a result of acid precipitation. The study area compares favourably to other regions in terms of egg deposition, juvenile densities and contribution of smolts (young salmon). These indicate adequate habitat which has maintained the populations in face of a 10% marine survival rate (Anonymous, 1998L). Catches in the major salmon rivers of the study area are presented in Table B.3-1. These numbers illustrate the significance of the Margaree River to the salmon fishery. Catches of salmon from 1989 to 1998 are presented in Figure B.3-5.



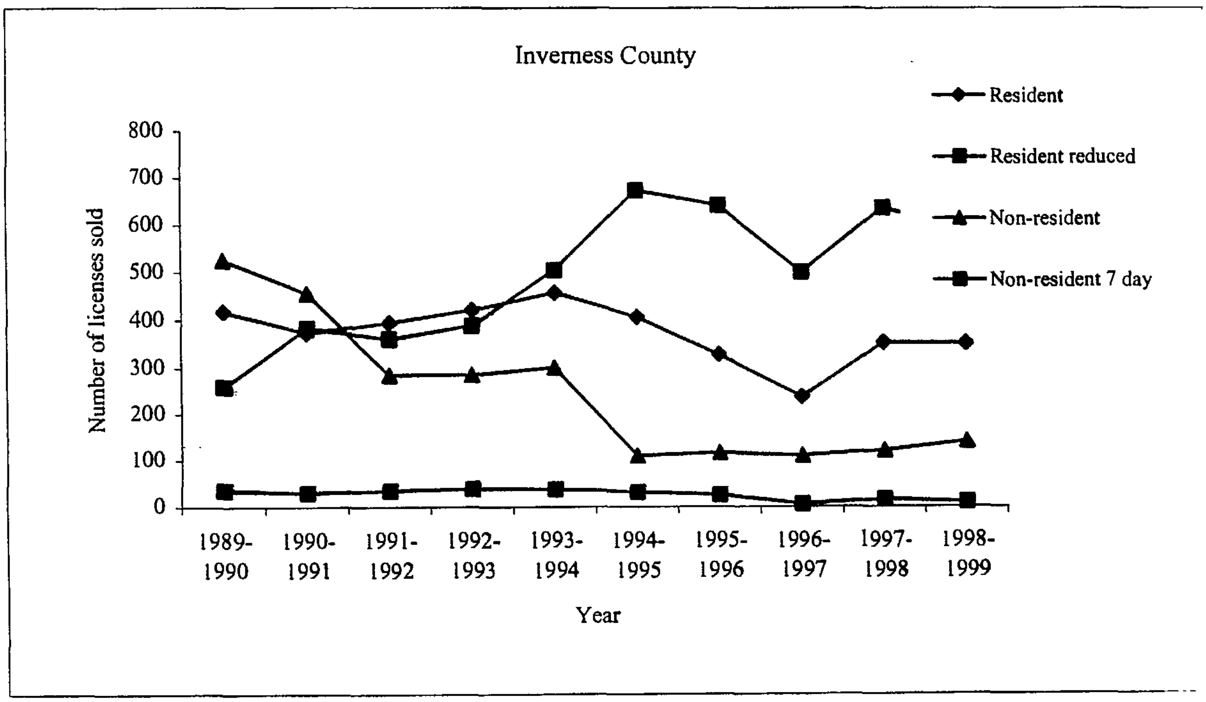


Figure B.3-4. Resident and non-resident salmon angling licenses sold in Antigonish and Inverness Counties, 1989-1999

Table B.3-1 Atlantic salmon catches in study area rivers, 1997, DFO statistics.

River	Small salmon	Large salmon
West	45	100
South	4	0
Mabou	0	2
Margaree	228	1536
Cheticamp	14	19

The Nova Scotia Department of Fisheries and Aquaculture have the mandate for recreational fishery management. The mode of regulation of harvesting is generally the restriction to a specific fishing season. The timing of the seasons is as follows.

All trout	April 15 – September 30 in the study area
Smelt	April 1-June 15 for dip netting, no Friday and weekend fishing
White perch	No closed season in the tidal area
Yellow perch	"
Shad	"
Gaspereau	"
Eel	"

Fly-fishing for salmon is only permitted in designated areas and specific times. On the Margaree River, the season runs from June 1 to the end of all seasons and at Trout Brook, Lake Ainslie from April 15 to end of all seasons. Only salmon smaller than 63 cm may retained, large salmon of spawning size must be returned.

The average direct spending per salmon caught was estimated to be $370 on the Margaree River (ASE Consultants, 1993). The annual average catch over the last ten years for the study area would contribute an economic input of approximately $1 million. The fishery contributes $84.6 million to incomes in Nova Scotia (ASE Consultants, 1993).

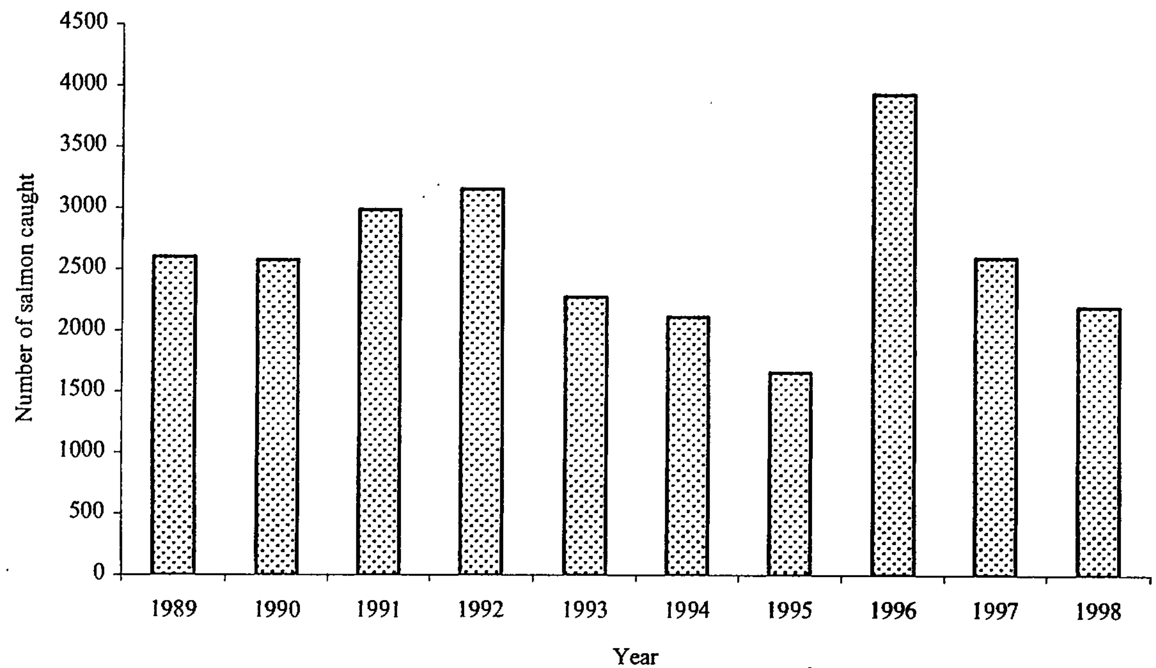


Figure B.3-5 Number of salmon caught in study area rivers, 1989 to 1998, includes grilse retained and salmon released

Because the Atlantic salmon fishery is such a valuable economic asset, it has been monitored very closely. This fishery has experienced significant declines throughout the province in recent years. A commercial fishery was closed in the study area in 1984.

The brook trout fishery has fluctuated considerably from the 1960's to the 1980's and since 1984 has fallen below the 1971 to 1995 mean and has slowly declined since. "The traditional approach to recreational fisheries management in Nova Scotia , with the Atlantic salmon, was to manage species and environmental issues on a 'crisis' or ad hoc basis" (ASE Consultants, 1993). This assessment was made in an analysis of the Nova Scotia fishery that was faced with declining populations, resulting in a great concern for future of the inland fishery. Major problems identified included decline and loss of fish habitat and a range of management issues impacting the resource such as user conflict, inadequate awareness of the issue, inadequate fiscal resources, and fragmentation of management and enforcement.

Brook trout are more adversely affected by increased water temperature than salmon and in the Margaree River are reported to be severely decreased (L. Forsythe, pers. comm). It would seem that, because brook trout are not the favoured fish of non-resident fishers, and therefore do not attract as much money to the area, there has not been as much concern over their status as should be. It is also possible that the provincial department have not had the same kind of resources to manage the fisheries as the Federal government has had for salmon conservation.

A significant aspect of the fisheries surrounds the quality of the fish as food. Contamination levels in fish tissue are discussed in Sections A.4.6 and B.1.1.2. The handbook of regulations for recreational fishers has suggestions as to which fish represent a health risk through regular consumption.

B.3.3 Tourism

Data on tourism activities are collected by the Province on a regional basis, generally through interview of travelers. Antigonish and Inverness Counties are each included within different regions, so specific data can not be extracted. The economic impact on the region is experienced by many businesses that are not specific to travelers; thus the degree of activity attributed to travelers would be difficult to determine. The 'tourist season' has traditionally been in the summer, thus differences in activity between seasons would provide some insight, but promotion of winter attractions is now a priority of the tourist industry

Within the St. Georges Bay Ecosystem Project study area there exists a number of tourist attractions in the form of natural areas, recreation and festivals/cultural events.

B.3.3.1 Natural Areas

The largest natural area within the study area is the Cape Breton Highlands National Park. This protected area encompasses approximately 950 km^2 and provides tourism opportunities via scenic vistas, camping, hiking, cross-country skiing and wildlife viewing (Anonymous, 1998m). Between 1995 and 1998 an estimated 359,550-392,870 visitors entered the park between May and October in each year (National Parks personnel, pers. comm.). This is considerably less than the 550,000 annual visitor estimate between 1985 and 1994 reported by Anonymous (1994b). A 1989 estimate places the monetary value injected into the economy by the park at 26.1 million dollars, of which approximately 14.25 million was generated from non-residents (i.e., tourists; Anonymous, 1994b). However, as park visits appear to have decreased since this time, it may be assumed that the values generated from the tourists are also decreased. The tourist entry to the park appears to be more concentrated on the eastern side (i.e., 1992-1997 average 69.9% of total visitors entered from Ingonish side, 30.1% from Cheticamp area; National Parks personnel, pers. comm.).

In addition to the National Park, the St. Georges Bay study area also contains nine provincial parks (Appendix 11) which also provide tourists with recreation. Time did not permit the gathering of data on park use or the economic values from these parks.

B.3.3.2 Recreational Activities

Within the study area are 31 walking/hiking trails (27 in Cape Breton Highlands National Park), beaches, golf course, downhill and cross-country skiing, horseback riding, hay and sleigh rides, and snowmobile clubs (Anonymous, 1998m: Appendix 11). In addition, Anonymous (1997d) identified one existing marine tourism operation (a dive shop) in Antigonish County, and 14 in Inverness County (6 whale watching operations, 5 boat tours, one each of coastal/hiking tour, kayaking, fishing). This represents 15 of an identified 324 throughout Nova Scotia (4.6%).

B.3.3.3 Festivals/Cultural Events

There are an estimated 30 festivals occurring between February and September each year throughout the study area (Anonymous, 1998m: Appendix 11). They range from small, regularly scheduled events such as Thursday Night Ceilidhs at Inverness to the well-known and well attended Highland Games in Antigonish. These games were estimated in the early 1990's to have an attendance of 8,000-10,000 people with 23% of that from the County and the remainder from outside the County (Anonymous, 1994c). It was estimated in 1994 that 1.22 million dollars was spent by visitors to these games (Anonymous, 1994c). It is unknown whether attendance and spending has increased or decreased since this time.

In addition to the Festival and events there are also nine cultural facilities (i.e., museums, theaters, galleries) for the tourist trade (Anonymous, 1998m).

B.3.3.4 Tourist Visitation by Area

In 1992 a traffic study by the Nova Scotia Department of Tourism and Culture monitored traffic use through several sites of the study area. The findings for pleasure travelling are presented in Table B.3-2. Cheticamp stands out in this analysis as having a relatively high number of parties stopping (34%) and also staying overnight (23%). Though the absolute numbers of parties passing through are less than half that of Antigonish, they have more non-residents stopping in the town and almost as many staying at least one night.

Table B.3-2: Traffic flow through various centres within the study area indicating numbers stopping. Values in parentheses are numbers expressed as percent of total. (Data from Anonymous 1992b)

Community	Party pass-through	Party Stop	Party Overnight	Total
Antigonish	107,500(79)	12,300 (9)	16,100 (12)	135,900
Cape George	11,300 (86)	1,100 (8)	700 (5)	13,100
Cheticamp	26,300 (42)	21,300 (34)	14,400 (23)	62,000
Inverness	26,400 (78)	3,800 (11)	3600 (11)	33,800
Mabou	27,800 (82)	4,700 (14)	1,100 (3)	33,600
Margaree	50,400 (77)	8,900 (14)	5,500 (8)	64,800
Pleasant Bay	51,600 (84)	8,300 (13)	1,400 (2)	61,300

Party pass through = number of non-resident party trips passing through a specific community without stopping
Party stop = Number of non-resident party trips involving a stop, but not overnight, in a specific community
Party overnight = Number of non-resident party trips involving a stop of one or more nights in a specific community.

C.1 Fisheries and Economics

C.1.1 Introduction

This section of the report aims to both review the fisheries related economic material published which is specific to the study area, and to introduce other subjects relevant to the topic. It represents an introductory stage in the process of evaluating existing work on the subject. The notion that economic study should be useful to the people involved in the activity of the fisheries has been used as a general guideline in the collection and compilation of the material.

The subjects introduced here include: placing value on fish and fishing, a review of the statistical estimations of these, government involvement in fisheries economics, a review of one community initiative and a brief discussion of applied research and institutional research on the topic.

The traditional tasks involved in the fisheries have been essentially those of harvesting, processing, and selling fish. The activity of "primary fishing" represents private enterprise, utilizing a natural resource to generate financial profit (Mandale, 1998). It must be said, however obvious it may seem, that economics pertaining to fisheries goes much further then an analysis of this primary activity.

It is important not only to describe the "indicators" of an ongoing relationship between the resource, producer and consumer but also to understand dynamics of a large number of influencing factors.

C.1.1.1 The Economic Value of Fish and of Fishing

What is the value of fish, fishing and the activities associated with the fisheries? This is not an easy question to answer.

The federal Department of Fisheries and Oceans maintains detailed records of the volume of fish landed at each port. This also includes the landed value of the fish at the port (Table C.1-1). Such information is vital to economic analysis.

Collected data represents fact, qualified by collection terms and procedure. The economic significance of these facts lies in their use as indicators in the analysis and evaluation of a larger matrix of economic activity. Also, depending on their purpose and motivation, different people may feel qualified to draw a variety of different conclusions from the same data.

For example, the reader can observe that the volume of lobster landed at Ballantyne's Cove in Antigonish County declined between 1993 and 1994 (Table C.1-2). Also, they can see that this decreased volume saw an increase in the value of the landed lobster. What can be said about this? It would seem, apparently, to be a simple matter of scarcity in supply producing an increase in market value.

The answer to what these changes in landed catch size and value represent may be significantly different depending on who you ask. A fisherman at the wharf, a buyer with an independent purchasing license or large company with provincial market influence may each have a different view of the same facts.

The value of lobster or any other fish does not end at the wharf. The process in "added value" is an important topic. This is essentially any activity or process which adds commercial value to the fish after it leaves the wharf and before it sold to the consumer. This includes transportation, fish processing, product development, distribution, marketing and sales.

Table C.1-1: Fisheries Statistics by County

Fish Landing	**Weight (metric tons)**	**Value ($000)**	**Fishermen 1995**	**Vessels 1995**
Inverness County	6,695	36,984	1,118	374
Antigonish County	1,793	9,034	409	141
Totals	8,488	46,018	1527	515

Source: Compiled by the Nova Scotia Department Finance, Statistics Division 1998
Original source: DFO

Table C.1-2: Example of Lobster Volume and Value Ratio (1993-1994)

Balantines Cove Landings	**1993**	**1994**
Volume	163,866 (metric tons 000)	142, 958 (metric tons 000)
Value	1,111,813.24 ($000)	1,183,954.10 ($000)

Source: DFO Moncton

After carrying out an initial search it appears that there are no published evaluations of the added value and ultimate consumer destination of fish landed at the ports in the study area. This topic should be examined in-depth in the future. At the provincial level a recent report indicates that,

> "Fish and fish processing combined are consistently Nova Scotia's single biggest source of export earnings, exceeding other well-known provincial products like forestry products, Michelin tires, or Volvo motor cars" (Mandale, 1998).

It is not possible, using the data provided by Mandale (1998), to determine how much of the cited export earnings are contributed from within the St. Georges Bay study area. This statement does, however, characterize the importance of the industry.

C1.1.2 Statistical Determination of Employment Levels:

There are problems with the use of published statistical data in the estimation of employment level in the fisheries.

A variety of published sources cite the number of people employed within different but related Statistics Canada occupational classifications which cover the fisheries within the study area. There are some problems associated with drawing accurate conclusions from compilations of such data.

The Census of Canada occupation classification in "Labour Force by Sex" lists "fishing and trapping" combined. The occupation classification in "Experienced Labour Force", lists "fishing, hunting, trapping and related" combined. These grouping of employment type create problem for fisheries analysis.

Furthermore, there seem often to be errors in presentation of calculations for 1981 data, when the males and females for "fishing and trapping" in the "Labour Force by Sex", were added together the results came out to be (200 +15=235) (Table C.1-3). The same addition of sexes for "fishing, hunting, trapping and related", in the "Experienced Labour Force" table, resulted in (220+20=235) (Table C.1-3).

When examining a work force of 7,305 people the cumulative effect of these variations in compiled totals may represent a significant factor. Any attempt to create a profile, over time, becomes problematic. The occupational classification for the 1996 Census of Canada changes to "Occupations Unique to Primary Industry." Combining occupations in broad categories makes assessment of the fisheries difficult though the use of this census data.

Samples of this publicly available Statistics Canada data are shown in Tables C.1-3, C.1-4, C.1-5, C.1-6 and C.1-7.

There are other sources which selectively cite levels of employment without qualification of their data sources. For example, in the estimation the Antigonish Regional Development Authority;

> "The fishery represents a small but vital part of the Antigonish economy. In 1993, there were 374 fisherman in Antigonish County. Of this total, 100 obtained over 75% of their income from the fishery." (Anonymous, 1995b)

This provides a number a fishermen for one year without considering the state of the fishery during that year relative to other years. In order to be able to show trends over time other means of deriving accurate levels of employment in the fishery must be utilized.

Table C.1-3: **Labour Force, 15 Years and Over, By Sex, Showing Industry Divisions** Antigonish County 1981

	Antigonish County			% of Total Labour Force	
	Male	**Female**	**Total**	**Antigonish Co.**	**Nova Scotia**
Agriculture	285	65	350	4.8	2.3
Forestry	225	30	225	3.5	1.3
Fishing and Trapping	200	15	225	3.1	2.0
Mines, Quarries and Oil wells	65	-	70	0.9	1.8
Manufacturing	555	150	705	9.6	15.0
Construction	575	35	615	8.4	6.5
Transportation, Communication & Other Utilities	355	30	380	5.2	8.0
Trade	630	525	1,150	15.7	17.4
Finance, Insurance and Real Estate	75	100	180	2.5	4.4
Community, Business & Personal Services	1,215	1,170	2,980	40.8	29.2
Public Administration	245	155	405	5.5	12.1
Total Labour Force	4,430	2,880	7,305	100.0	100.0

Labour Force: By Place of residence, excludes persons looking for work who last worked prior to January 1, 1980, and who never worked.

This sample is in original format includes their unexplained total. For example see the line for Fishing and Trapping. 200 plus 15 provides a total of 225.

Source: The Nova Scotia Department Finance has compiled data in many different formats. In 1986 they produced County Profiles for both Antigonish and Inverness from Statistics Canada, Census of Canada data.

Table C.1-4: Experienced Labour Force by Occupation Groups
Antigonish County, 1981

Antigonish County Labour Force	**% of Total Experienced**				
	Male	**Female**	**Total**	**Antigonish Co.**	**Nova Scotia**
Managerial, Administrative & Related	405	115	525	7.2	7.3
Natural Sciences, Engineering & Math	160	05	165	2.3	2.8
Occupations in Social Sciences & Related	70	65	135	1.8	1.5
Occupations in Religion	20	30	45	0.6	0.3
Teaching & Related Occupations	275	320	600	8.2	4.7
Occupations in Medicine & Health	105	320	425	5.8	5.2
Artistic, Literary, Recreational & Related	40	55	90	1.2	1.2
Clerical & Related	165	865	1,025	14.0	16.5
Sales Occupations	320	265	585	8.0	9.2
Service Occupations	325	615	940	12.9	14.6
Farming Horticulture & Animal Husbandry	270	65	340	4.7	2.3
Fishing, Hunting, Trapping & Related	220	20	235	3.2	2.4
Forestry & Logging	165	20	185	2.5	1.2
Mining & Quarrying	40	-	40	0.6	1.0
Processing Occupations	180	45	230	3.1	5.0
Machining & Related Occupations	160	-	160	2.2	1.6
Product Fabrication, Assembly & Repairing	290	5	295	4.0	6.1
Construction trades	705	10	715	9.8	7.6
Transport Equipment Operating	275	15	290	4.0	4.4
Materials Handing & Related	65	15	85	1.2	2.2
Other Crafts & Equipment Operating	80	-	80	1.1	1.2
Occupations Not Elsewhere Classified	95	25	115	1.6	1.7
Total Experience Labour Force	4,430	2,880	7,310	100.00	100.00

Labour Force: Excludes persons looking for work, who prior to January 1, 1980 or who never worked.

TABLE C.1-5: EXPERIENCED LABOUR FORCE BY OCCUPATION GROUPS

Antigonish County	**1981**	**1991**
Managerial, Administrative & Related	525	710
Natural Sciences, Engineering & Math	165	105
Occupations in Social Sciences & Related	135	155
Occupations in Religion	45	65
Teaching & Related Occupations	600	570
Occupations in Medicine & Health	425	580
Artistic, Literary, Recreational & Related	90	130
Clerical & Related	1,025	1,265
SALES OCCUPATIONS	585	680
Service Occupations	940	1,365
Farming Horticulture & Animal Husbandry	340	330
Fishing, Hunting, Trapping & Related	235	235
Forestry & Logging	185	265
Mining & Quarrying	40	-
Processing Occupations	230	295
Machining & Related Occupations	160	230
Product Fabrication, Assembly & Repairing	295	420
Construction trades	715	810
Transport Equipment Operating	290	285
Materials Handing & Related	85	35
Other Crafts & Equipment Operating	80	20
Occupations Not Elsewhere Classified	115	165
Total Experience Labour Force	7,310	8, 745

Labour Force: Excludes persons looking for work, who prior to January 1, 1980 and January 1, 1990 or who never worked.

Source: N.S. Department of Development and N.S. Department Finance
(Original source: Statistic Canada, Census of Canada)

Table C.1-6: Population by Occupation

Antigonish County	1996
Management Occupations	755
Business, Finance and Administrative Occupation	1,200
Natural and Applied Sciences and Related Occupations	295
Health Occupations	560
Occupations in Social Sciences, Education, Government Services and Religion	805
Occupations in Art, Culture, Recreation and Sport	170
Sales and Service Occupations	2,520
Trades Transport and Equipment Operators and Related Occupations	1,430
Occupations Unique to Primary Industry	1,035
Occupations Unique to Processing, Manufacturing and Utilities	350
Total employed labour force 15 years of age and over	8,165

Source: Statistic Canada, Census of Canada 1996

TABLE C.1-7: POPULATION BY OCCUPATION 1996

Antigonish and Inverness Counties	Antigonish	Inverness
Management Occupations	755	690
Business, Finance and Administrative Occupation	1,200	1,160
Natural and Applied Sciences and Related Occupations	295	250
Health Occupations	560	380
Occupations in Social Sciences, Education, Government Services and Religion	805	595
Occupations in Art, Culture, Recreation and Sport	170	55
Sales and Service Occupations	2,520	1,460
Trades Transport and Equipment Operators and Related Occupations	1,430	1,610
Occupations Unique to Primary Industry	1,035	1,275
Occupations Unique to Processing, Manufacturing and Utilities	350	620
Total employed labour force 15 years of age and over	8,165	8,095

Source: Statistic Canada, Census of Canada 1996

The Nova Scotia Department of Finance currently produces information which documents fish landing volume and value, number of fishermen and the number of vessels by county (Table C.1-1). The Finance Department's 1998 publication uses 1995 data, supplied to them from Fisheries and Oceans Canada. They have not compiled this over time to provide a comparison of years.

C.1.1.3 Government Initiative

The utilization of fisheries resources is "regulated" and "managed" by different levels of government. The Federal Department of Fisheries and Oceans plays a key role in these efforts. Part of this department's mandate is insure the health of fish stocks. The information which they produce that is economic in nature often keeps the task of "conservation" as its focus.

There have been some unsuccessful attempts to introduce social and economic analysis into fisheries management research. The Canadian Atlantic Fisheries Scientific Committee (CAFSAC) has met with little success attempting an interdisciplinary approach to integrate biology and socio-economics.

> " The main reason for their failure are lack of committed input from economists, apparently due to the lack of manpower and resources, and a reluctance to divert the effort of CAFSAC assessment biologists into the study of fishery economics" (Mahon, 1986).

There does not seem to have been any independent assessment of their attempts or any current publication pertaining to more recent efforts. Perhaps the present organization of the "Policy and Economics" DFO branch is an outcome of this earlier CAFSAC work.

The Policy and Economics Branch pronounces purpose in research related to the fisheries management. They state that…

> " Management policies and regulation routinely affect economic performance in the private sector in a variety of ways. In the fisheries, for example, they can affect fishing revenue, harvesting cost, and the cost of managing the fishery. The type of fisheries management system used will influence how profitable the industry will be and how much the taxpayer must pay for fisheries management " (Anonymous, 1999f).

The Branch also states that it will have a role in helping to design regulatory programs, contributing to the development of annual fishing plans, providing advice on financial assistance proposals, collecting and analyzing commercial data, design and delivery of groundfish adjustment programs, cost recovery, revenue generation, and industry partnerships. They also plan to direct "attention" to programs formerly provided by the Canadian Coast Guard (Anonymous 1999f).

These activities in economic research and analysis cover a lot of territory. The government would seem to be motivated by a perceived need to address issues which are fundamentally economic in nature in order to take a more active role in promoting growth in the economy.

A common popular opinion, which will only be mentioned once here within the study area context, is that the government department responsible for fish quota allocation hinders the economy by allowing over fishing or by not allowing enough fishing. The Canadian Institute for Research on Regional Development included the following in its review of the areas fishery.

> "The fish plant in Arisaig, Antigonish County, has suffered from what its owner regards as unnecessary cuts in herring-stock allocations, which in the fall of 1996 resulted in severe loss of income

for both fishermen and the 110 workers" (Arseneault et al. 1997).

There is no discussion of the owner's comment. his issue is mentioned here in passing because it characterizes an element of "popular" opinion pertaining to the governments impact on the economics of the fishery.

C.1.1.4 An Example of Government Intervention-Environmental Emergencies

DFO maintains a Gulf Region Environmental Emergencies Response Plan. This region includes the St Georges Bay study area. The plan is to be used as a reference during emergencies. It states that ,

> " DFO will plan for pre-emptive interventions in the fishery, such as the restriction or closure of fisheries and aquaculture operations and purchase or quarantine of contaminated catches, and will implement these plan upon the decision of the Regional Director General" (Anonymous 1993b).

The reader may wonder what this has to do with economics. In the event of an emergency in which a fishery is jeopardized there should be a clear understanding of what the potential losses would be. The plan also makes provision for making "information available" on an optional cost recovery basis, if restitution claims are made against a polluter for damages or loss.

C.1.1.5 Impact of Reductions in Stock Allocation and Closures

The Cheticamp Development Commission produced a report in 1994 titled, Impact of the Fisheries Crisis in Northern Inverness County. This report presents the results of a study which had goals to,

> "...determine the impact of the fishing crisis in Cheticamp and

surrounding communities. It is to identify the direct and spin off effect of the present situation due to the quota reduction and closure of fish plants." (Aucion-Grace and Aucion, 1994)

The report documents the displacement of approximately 400 workers. Through an interview process the commission developed what they felt to be a representative sample of opinion regarding the community's relationship to the changes in fisheries resulting from stock closures. The study resulted in a number of recommendations. Most of them focused on a need for greater government support in the form of projects that would stimulate both economic benefit from fish habitat enhancement and projects that would encourage locally driven diversification of the areas economy.

Some discussion is made pertaining to the demographics of the Cheticamp area. This issue was important in context to older people facing the prospect of starting over on new "careers'.

C.1.1.6 Cheticamp Harbour Development

A marine services centre and industrial park market study was completed in 1987 for the Cheticamp area. While this report now dates back 13 years, it is mentioned because of the in-depth approach to assessing the local fishery economy. By way of example, the authors describe a rapidly growing fishery with an increase of over 300 fishermen within the DFO statistical districts 12 and 13 of Inverness County from 1980 to 1986. In 1985 they accounted for 385 vessels registered in the County and an additional 63 from outside of the area using ports in the County.

C.1.1.7 *Other Issues*

The First Nations fisheries are an important topic for which no study area specific information was found. Also, cooperative organization within the fisheries is important within the study area. In view of the history and number of co-ops in the area this subject should be reviewed further at a later date. Due the time constraint on the current report no mention is made of boat building, maintenance, storage and hauling.

It should be noted that an extensive review of the economics associated with fisheries for the entire province is made in Estimating the Economic Value of Coastal Ocean Resources: the Case of Nova Scotia by Maurice Mondale (1998). This publication may be of some use in sorting out sources of useful data relevant to the St. Georges Bay study area.

C.1.1.8 Research and Development

While this a broad topic for discussion, one case specific to the St. Georges Bay study area is reviewed here.

In 1992 the Nova Scotia Department of Fisheries carried out a study to determine if existing whelk populations in the Gulf region of Cape Breton would support "already defined markets". The study area included Mabou, Pleasant Bay and Bay St. Lawrence. This project was supported by the Technology and Inspection Division of the Nova Scotia Department of Fisheries. The intended "by-products" of the study included,

" 1) determining if a certain trap design excelled in catching performance.
2) determining if catch rates were related to bottom type.
3) determining size frequency distribution of whelks in the area sampled."

The economic benefits of this research are not estimated. The development of under utilized species may, however, have rewards for fisherman who are looking for new opportunities. The report states that the positive feedback they received from potential buyers suggests a large market for whelk meat (Moffatt,1992).

While this study may not have resulted in direct economic benefit for the region it does raise the issue of potential value to the industry in research and development. To this end, there does not seem to be any recorded assessment of the industry's or individual's needs for such work within the St. Georges Bay study area.

There is an important question raised here. How does the institutional research within the study area benefit the economy? For example, there are a number of departments and programs at St. Francis Xavier University which conduct research relevant to fisheries economics. What direct productive impact do these activities have on the fishery economy? There are limited connections between this research and the community. In view of this fact, current initiatives such as the Interdisciplinary Program are underway which aim at better integrating research with the needs of people involved in the fisheries.

The St.F.X. Extension Departments has a long history of working with community members on matters of cooperative economic organization. Their relationship to the Coastal Communities Network would seem, also, to represent a partnership with the community.

The scarcity of published material addressing a scale relevant to the study area which pertain to the subject on fisheries economics suggests that there are opportunities for the formation of further productive partnerships between the communities and existing institutions.

Summary

Fisheries economics is an important component of the study area economy. While the Department of Fisheries and Oceans collects and records fish landing volumes and values an important task remains to evaluate the impact of fishing and the resource brought to market on the economy of both the area and the province.

Employment, within the broad definitions of the fisheries and related occupations, is significant. An improvement in the documentation of employment patterns could provide a better understanding of how much the sector contributes to such economic indicators as household income and generated tax revenue.

While government policy regulation and legislation have impacts on the study area, little economic research has been conducted addressing the specific details and long term consequences at the study area level. When the government solicited public opinion in the wake of the "fisheries collapse" some communities expressed a desire to participate in fisheries work which would contribute to the protection and rejuvenation of fish and fish stocks.

Some fisheries related research and development exists in the study area. Given public desire for contribution to an improvement in the fisheries and institutional character of the area, there an opportunity for increased community partnerships as the research and development sector matures.

C.1.2 Aquaculture and Economics

Published material specific to the economics of aquaculture in the St. Georges Bay study area does not exist. However, there have been a number of academic papers, industry publications and government documents produced which are relevant to the study area.

Overall, in the province of Nova Scotia, economic study has not kept pace with the actual economic activity of aquaculture operators. The production of material by the government follows a pattern of re-action. A common starting point has been the notion typified by editorial comments made in the April, 1996 issue of the Nova Scotia Business Journal.

> "With decline of the commercial fishery over the past several years, aquaculture is considered to be a viable alternative for coastal communities to generate jobs and new wealth". (Anonymous, 1996c)

C.1.2.1 Aquaculture Development Strategy

In 1993, the same year as a moratorium on cod came into effect, the provincial government set about to develop an "aquaculture development strategy". The finished product was intended to be,

> "... a document which sets out two primary goals: 1. to develop a economic and regulatory environment in which aquaculture can flourish, and 2. to establish strict guidelines which will ensure environmental integrity is maintained." (Anonymous, 1996c)

The document Aquaculture Development Strategy has not been acquired or reviewed here.

C.1.2.2 A Revised Act

In February of 1996 a discussion draft for a revised provincial fisheries act was released. In its support for aquaculture the draft went as far as to recommend that the Department of Fisheries be called "Fisheries" and "Aquaculture". The revised "Fisheries and Coastal Resource Act" came into being later in 1996. The Act not only sets out the terms, conditions and guidelines for resource management, it also attempts to include "provisions" aimed at addressing broader topics, including the initiation of economic study and the amelioration of community concerns.

C.1.2.3 Aquaculture and the Greater Community

There has been a history of conflict between different members within communities where applications for aquaculture licenses are made. There are always many different expressions of interest. Perhaps foremost among these concerns is the, "Privatization of the commons" (Baily, 1995). Coastal bodies of water such as bays and harbours have been popularly viewed as property common to all people in the community. In order for a private aquaculture operator to carry out their occupation they must hold licensed rights to the water they use. This issue, however, is only a starting point. As John Phyne puts it in (Baily, 1995),

> "The conflict over aquaculture has far reaching implications for the residents of coastal communities."

He also expresses a passing concern about who has control over the invested capital and their commitment to the community, and then goes on to say that,

> " ...participatory co-management is a pressing need for the members of

coastal communities."

While not necessarily what this author had it mind, some steps in direction of co-management have been made.

C.1.2.4 Regional Aquaculture Development Advisory Committees

The Nova Scotia Fisheries and Coastal Resources Act has optional provision for community participation. As a result there are now a number of "Regional Aquaculture Development Advisory Committees" (RADAC) in existence. They were formed,

> " In an effort to facilitate economic development while simultaneously providing information to the local area , the concept of community-based decision making was initiated" (Anonymous, 1996c).

This expression of purposes provide opportunity for a degree of community participation. In the end decisions regarding the issue of aquaculture licenses rest with the Fisheries and Aquaculture minister and his office. The Fisheries and Coastal Resources Act states that the RADAC recommendations "may" be acted upon.

> " The idea was to establish a way for the Department of Fisheries and Aquaculture to receive advice from affected communities on aquaculture development" (Anonymous, 1996c).

The process of determining how these committees work and what role they play in the decision making is on-going. The people involved are not paid. They volunteer out of an expression of interest within the community. Ultimately,

> "The goal is for this approach to help screen applications while ensuring local support and awareness of aquaculture projects" (Anonymous, 1996c)

There is currently no RADAC in the Antigonish County area. The existence and status of an Inverness RADAC county is unknown.

C.1.2.5 Published Economic Studies

Cold-Water Aquaculture in Atlantic Canada is a text produced by The Canadian Institute for regional Development which contains a section which addresses economic, social and environmental issues. This text has not been reviewed.

Nova Scotia Aquaculture: Comparative Analysis of Development Issues and Species Economic Potential is a 1998 report produced by Gardner Pinfold consulting Economists for the Nova Scotia Department of Fisheries and Aquaculture. This document has not been reviewed. However, John Odenthal of the Nova Scotia Department Economic Development and Tourism states in his summary of the study,

> "....the study implies that current expectations about the economically sustainable size and scope of aquaculture in NS may be unrealistic."

He also says, without identification, that there are some important policy implications. This report should be reviewed in context to the St. Georges Bay study area

In the Aquaculture, Supplement to the August 1997 issue of the Nova Scotia Business Journal comments pertaining to economic issues are made without qualification. Marli MacNeil, president of the Nova Scotia Aquaculture Association, states that,

> "The association estimates that with every direct job created in finfish aquaculture, one job is created in related spinoff industry. Every 10 jobs created in shellfish aquaculture creates 6 spinoff jobs."

The spinoff estimates provided here, without information regarding source, are followed by a number of additional articles giving brief review of: fish food production, underwater camera systems, equipment, research and educational "markets".

The 1995-96 ACOA Roundtables Initiative, Roundtables Report summarizes roundtable discussions pertaining to the current state of Research and Development. Some points are raised regarding the need to address R&D funding. The specific relationship between R&D and economic environment is not discussed (Anonymous, 1996e).

C.1.2.6 Aquaculture Statistics

Department of Fisheries and Aquaculture statistical record of the value of aquaculture production at the county level do not represent an accurate account of activity for the study area. The record of production has been combined for 3 species. The only county for which this information may be of some use would be Antigonish. The other data include significant aquaculture operations in Inverness County which are outside of the St. Georges Bay study area.

C.1.2.7 Access to Aquaculture Information

With reference to the Nova Scotia Fisheries and Coastal Resources Act 1996, Part II Administration, section eight, sub-section three,

> " (3) Subject to the *Freedom of Information and Protection of Privacy Act*,
> (a) all information under the control of the Department is accessible to the public; and
> (b) the Minister shall ensure that information under the control of the Department is shared with other government departments and agencies.

1996, c. 25, s 8."

Summary

Available information presents a picture contrary to the often cited popular opinion that aquaculture enterprise can compensate for increasingly fewer opportunities in the traditional fisheries. However, the government has been working hard to provide suitable policy and legislative frame work to encourage the development of aquaculture operations. This includes initiatives to allow for public discussion and participation in communities pursuing opportunities in aquaculture.

There is some amount of research and development taking place in the province. The proponents of this work say that there is a need to procure a greater degree of financial support. While available statistical data relevant to the study area is lacking, the government has developed legislation to ensure that the ongoing and future work is accessible to the public.

Conclusions and Recommendations

One of the major goals of this research has been to assemble and to review coherently the main bodies of existing and accessible information pertinent to establishing baseline understandings of the physical, natural and human characteristics associated with the St. Georges Bay Ecosystem. Although contractually specified time constraints have imposed rather challenging limitations on this research undertaking, the preceding presentation of results represents a substantial step towards our goal of providing a coherent review of the core 'state of knowledge' respecting St. Georges Bay and its environs.

In review, the St. Georges Bay area is largely shallow water dominated by mud and sand substrates. The currents of the Gulf of St. Lawrence create a northeast current which flows across the mouth of St. Georges Bay and up the Cape Breton shore. This in turn initiates a clockwise gyre in St. Georges Bay itself. The bay has relatively long retention time (30-60 days) under normal conditions but this may be significantly shortened by high-energy events. The waters undergo a temperature range of up to 20°C over the period of a year. This results in the formation of a thermocline and stratification which affects chemical and biological productivity. Salinity of the waters in this region are generally between 28-31 ppt.

Nutrients are generally in relatively uniform and low concentrations, the exception being ammonia which has been reported in very high concentrations in this area. Primary production peaks in late winter, early spring and early fall. Copepods are the primary component of the zooplankton with the majority of the biomass being composed of six species forming four communities. There is a successional series in zooplankton communities as the year progresses.

Sediment deposition is greatest under isothermal water conditions of spring and fall and least during summer stratification. There are well over 100 different algal species in St. Georges Bay of at least four Classes. Macroalgal communities are dominated by *Chondrus crispus, Furcellaria,* and *Fucus*. Eelgrass also form an important vegetative component of the St. Georges Bay ecosystem. Very little is known of the benthic communities, though it is obviously diverse from the limited sampling conducted. Polychaetes are the dominant community member both numerically and in biomass. There are an estimated minimum 65 fish species in the study area representing 31 families, of which 35% are commercially exploited.

Seven species of whales and three seal species are also known to use this area. Another two whale species are suspected of occasional presence. Grey and hooded seal populations have been increasing over time, though determining by how much is difficult. Within the larger area of 4Tg there are an estimated 10,000 breeding pairs of seabirds, composed principally of cormorants, gulls, terns, gannets, kittiwakes and guillemots.

The water, sediment and biota of St. Georges Bay have been sampled for various contaminants. Heavy metals, PCBs, and organochlorines have been analyzed and are generally at relatively low levels. St. Georges Bay is often considered "clean" and used as a reference site, however sensitive tests using MFO induction indicate there may be some contamination of the environment.

Based on the landings and landed values supplied by DFO it is possible to make some generalizations regarding the extent and economy of the commercial fisheries in the St. Georges Bay area. An estimated total of 126,196 tonnes of fish have been landed in the 42 ports of which the top 6 represent two-thirds (66.8%) of the total catch. As far as landings can be used to accurately reflect a fishery, Atlantic cod has been by far the most important single species, followed in order by herring, snow crab, lobster and American plaice. It is significant that even with a moratorium on cod in 1993 a greater weight of this fish was landed between 1990 and 1992 than for any other species over a time period four times longer.

In examining values generated by the fishery lobster ranks first followed by snow crab, cod, bluefin tuna, and American plaice. Lobster and snow crab have generated over 25 million dollars in landed value in the St. Georges Bay area between 1990 and 1998. This represents 62.8% of the total landed values of all fish species at all ports ($309,253,000) during this time interval.

Cheticamp is the most significant fishing port in the area having landed over 53 million kg of fish which has generated, between 1990-98, over 93 million dollars in landed values. The other significant ports are Pleasant Bay, Margaree Harbour, Ballantynes Cove, Murphys Pond and Grand Etang. Catches, landed values and CPUE have been used extensively in this document to attempt to describe the fishery. However, it is essential that the limitations of these estimates be recognized. Many factors prevent port landings from reflecting actual catch, including:

Discarding at sea – Results in much greater mortality and impact on population dynamics than simple port landings indicate

Ghost fishing – Mortality and lost biomass affecting fishery and dynamics not accounted for by landings

Unrecorded sales – Local sales, bait sales, etc. Generally an unknown quantity in addition to the landed fish. Also sensitive to market conditions so fluctuates over time.

Misreporting and under-reporting of catch – conscious and inadvertent misrepresentation of fishing results, activity, etc.

In a similar fashion landed values do not reflect the true value of the fishery as they do not account for the added value of the processing, transportation to market, and ultimate delivery to the consumer. Thus, while the landings and values have been quoted extensively throughout, it is emphasized that these are estimates only and their accuracy is unknown until some of the variables mentioned above are controlled or accounted for in the context of more systematic study than has yet to be conducted.

The commercial fishery of gaspereau, American eel and smelt have followed similar historical patterns. These fish have traditionally been harvested in large numbers seasonally during their spawning migration. American eel are also harvested outside of the spawning migration. The populations have each supported a prolonged substantial fishery. Gaspereau and eel populations have declined sufficiently over recent years to hinder further prosecution of the fisheries.

Because all diadromous fish utilize marine and aquatic habitats, there are effectively double the numbers of potential impacts, and it is difficult to account for the effects of one environment at the exclusion of the other. In the case of the study area, the aquatic habitat does not seem to have the capacity to severely impact these species, although it could be argued that harvesting practices do. The interaction of species with the marine habitat is difficult to characterize because of the vastness of the habitat and large potential for unknown local effects. The smelt catch has not been as reduced as the others, but there is concern that in the absence of other viable fisheries, they will receive increased fishing pressure and be over exploited in the near future.

Eighty-three percent of the available shellfish growing areas in the St. Georges Bay study area are closed to shellfish harvesting due to contamination problems. These areas are closed due to pollution from municipal sewage treatment plants, residential wastes along shorelines and industrial activities in harbours. Due to the number of closed shellfish areas, and the limited protected locations feasible for aquaculture operations in the area, there is very limited current aquaculture activity. Projected work must first deal with the issue of contaminated sites.

Throughout Nova Scotia's history forestry has been a major contributor to the economies of both local communities and the province as whole. It remains an important sector for rural employment in communities such as those in the study area. It is difficult to make an accurate estimation of the total economic value forestry contributes the economy. A few large pulp and paper companies dominate the local and provincial market for harvested wood. For more than twenty years this situation has motivated the industry to maximize the yield of trees harvested through the most efficient means available. In the province this promoted patterns of harvesting which resulted in significant pressure being placed on the resources capacity for renewal. After the Royal Commission recognition of problems in forestry, various levels of government began putting effort into programs aimed at the regeneration of wood supply in areas that had been extensively harvested. This work in itself has produce some degree of economic benefit.

There has been considerable effort put towards the promotion and expression of confidence in current industry practice and government management approaches.

Publications from both sources suggest that the industry and the resource have a long and productive future in the province. There is some evidence which is contrary to this optimistic view. Also, while some wood lot specific studies have been carried out, the aggregate impact of past and current forestry practices are unknown. Verification of the assertion that current forest industry practices are "sustainable" for both the business of production and the health of forests has not been supported by any independent research. This remains true as much for the St.Georges Bay study area as it does for the province.

Fisheries are obviously an important component of the study area economy. While the Department of Fisheries and Oceans collects and records fish landing volumes and values, an important task remains to evaluate the impact of fishing and the resource brought to market on the economy of both the area and the province.

Employment, within the broad definitions of the fisheries and related occupations, is significant. An improvement in the documentation of employment patterns could provide a better understanding of how much the sector contributes to such economic indicators as household income and generated tax revenue.

While government policy regulation and legislation have impacts on the study area, little economic research has been conducted addressing the specific details and long term consequences at the study area level. When the government solicited public opinion in the wake of the "fisheries collapse" some communities expressed a desire to participate in fisheries work which would contribute to the protection and rejuvenation of fish and fish stocks. Some fisheries related research and development exists in the study area. Given public desire for contribution to an improvement in the fisheries and institutional character of the area, there is an opportunity for increased community partnerships as the research and development sector matures.

Available information presents a picture contrary to the often cited popular opinion that aquaculture enterprise can compensate for increasingly fewer opportunities in the traditional fisheries. However, the government has been working hard to provide suitable policy and legislative framework to encourage the development of aquaculture operations. This includes initiatives to allow for public discussion and participation in communities pursuing opportunities in aquaculture. There is some amount of research and development taking place in the province. The proponents of this work say that there is a need to procure a greater degree of financial support. While available statistical data relevant to the study area is lacking, the government has developed legislation to ensure that the ongoing and future work is accessible to the public.

Coal, gypsum and barite have been the principle mineral resources extracted. Four coalfields have been mined in the study area, none of which are currently active. Gypsum was historically mined at three sites and more recently at Brierly Brook. No gypsum operations are currently active. Barite, iron and copper have all been mined in the area, but none of the mines are presently in operation. Limestone has also been extracted in Antigonish County, but this is not occurring at present.

Thirteen species of furbearers are trapped in the St. Georges Bay study area with muskrat, beaver, otter and coyote providing the greatest revenue. Total annual value of pelts for all species has ranged from $3,000 to $70,000 per county per year. The number of people participating in trapping appears to be stable in the last few years compared with the early 1990's.

As this overview reveals, there is a surprising volume of existing knowledge regarding the structure, function, and processes of St. Georges Bay and its environs, particularly with respect to physical and natural characteristics. In part, this richness of information reflects the long history of human settlement and utilization of the area. Notably, this state of affairs must also be attributed to the interest in the area by a few enthusiastic researchers at the Bedford Institute of Oceanography during a time when there were funds available to support research.

However, as the dates in the references cited list attest, since the 1980's a disturbing trend has developed, one that features a dramatic decline in basic science research focused on St. Georges Bay and its environs. The results of this research indicate that at least core elements of the area's physical and natural features are in need of research attention that, minimally, will update what is presently known. Existing research provides the critical foundation reference for developing a time-sensitive understanding of the Bay and its environs. Indeed, the richness of available documentation, although almost 'historic' in its time content, provides researchers concerned with developing an ecosystem understanding with a notable baseline and opportunity. Arguably, only a handful of such well-documented sites exist, thereby offering physical and natural science researchers the opportunity to work with and develop the complex that constitutes ecosystem dynamics and understandings. Certainly these features are also associated directly with the sensibility and likely success of developing ecosystem-levered management approaches such as integrated coastal zone management plans and proposals for marine protected areas.

Yet, at least a body of material exists respecting the physical and natural attributes of the area. This cannot be said with regard to the systematic documentation and examination of the area's social and economic attributes. With few exceptions, the specifics of human settlement, land use, industrial development and related activities have not received much by way of detailed and comprehensive study. The approach taken to social, economic, and historical research has been piecemeal, at best. The research done seems little more than an expression of either the particular interests of individual researchers or inquiries undertaken with an intention to satisfy the information needs of specific industry and/or community organisations. These qualities mean that little confidence should be associated with any generalisations made respecting the particulars of the study area's social and economic development such as settlement history, land use patterns, industrial impacts and the like. The social and economic research essential to attaining confident representation of these and other aspects of human attributes and activities within the St. Georges Bay and environs area remains to be done.

Recommendations

With the aforementioned qualities, conditions and attributes in mind, the results of the research reported here do provide us with the bases upon which to frame several recommendations respecting future research.

Compared to most marine areas in Maritimes, the Georges Bay Ecosystem Project is uniquely positioned to allow researchers to develop, in the near future, a useful, working ecosystem model. This potential and opportunity is achievable because:

1. A substantial amount of baseline data has already been collected, at all levels of organization, from hydrographic information and nutrient dynamics through to fisheries landings. Most Maritime areas have the higher level information, but lack any time series in the basic areas.

2. The St. Georges Bay Ecosystem Project has obtained the cooperation and participation of the majority of the stakeholder marine harvesting groups utilizing resources within the ecosystem.

3. The hydrographic characteristics of the area delineate a conveniently semi-closed system for study.

These qualities characterise the St. Georges Bay ecosystem as a site offering considerable potential for development of a working ecosystem model. Realizing this potential will require several steps in addition to defining and completing research undertakings targeted on either updating existing knowledge or filling various gaps in current knowledge.

At this point it would useful to the process of building a working ecosystem model to:

1. Strike a GBEP Steering Committee with representatives from all stakeholder groups The purpose of the Steering Committee would be to take 'ownership' of and provide momentum for GBEP through determination of research needs, definition of research projects, pursuit of the resources essential to supporting research and results dissemination activities, and development of linkages between GBEP research results and ecosystem management initiatives.

2. A GBEP Steering Committee would be positioned to initiate an application to designate St. Georges Bay as an ACAP II site. If successful, this would provide some of the resources critical to realising GBEP's research and applied goals.

3. Further develop working partnerships with Native and commercial harvesters for the purpose of accessing their experience, understandings and engagement in the GBEP process and outcomes.

4. Initiate primary research focused on documenting and mapping harvesters' knowledge of the ecosystem. As intended in this research's goals, initial contacts and relations have been developed with the First Nations community through the Mi'kmaq Fish and Wildlife Commission (MFWC). During consultation it was determined that the MFWC had a particular concern about and need for as much information as possible respecting the biology, ecology and fisheries respecting the American eel. The report contains the results of our effort to address these concerns and needs. In our view, the development of confident and collegial partnerships between Native and commercial harvesters and researchers is a critical prerequisite to engaging any systematic study and mapping of harvester ecological knowledge. Linked with this is the need to assure that research processes are designed and operationalised in a manner to contribute substantially to building research expertise, capacity and literacy among Native and commercial marine harvesting organisations. Accomplishing this requires that these organisations have a 'real voice' in specifying research questions as well as direct engagement in designing, conducting and interpreting research. After all, the goal of creating a working model of the ecosystem carries direct implications for those whose livelihoods rest upon marine resources and the ecosystem in which they are embedded.

5. As the report makes clear, there is an immediate need to attract, encourage, and, where possible, support collection of further baseline data, especially data concerning primary productivity, nutrients, diet, non-commercial fish, and, ideally, a detailed side-scan sonar bathymetric survey of Georges Bay. These activities would enable systematic up-dating of existing knowledge and contribute to filling gaps in knowledge. For example, much more needs to be known about the structure and function of the St. Georges Bay study area benthic communities.

6. Additionally, a working ecosystem model will require a much more thorough description and understanding of trophic dynamics. Completion of a detailed review of available materials respecting the diets of the major species and species groups within the Bay ecosystem is an essential next step. Results from this work may require specific primary studies focused on filling gaps in our current understandings with regard to diet compositions and predator-prey interactions.

7. Finally, it is critical that studies be undertaken for the purpose of determining the contribution of the estuaries to the overall biological productivity of the Bay system.

These recommendations respecting ecosystem-focused study are but a few of the more immediate steps which arise from the results of this study.

Given that the ecosystem study area under review includes estuaries and watersheds, there are several areas of current understanding with respect to these features and systems that would benefit from further study. For instance,

- Spatial and temporal variations in streamflow within the study region needs to be better understood. This is important for a number of reasons:
    - If landuse patterns are altered (eg. due to deforestation or agriculture), then it is likely that stream flow patterns are also altered. Although the total volume of water that passes through a watershed during a single year may not change, how that volume is distributed in time and space may change a great deal. For example, there could be an increase in stream discharge during rainfalls and a reduction in stream baseflow during other periods. Changes in streamflow distributed through a year would likely alter stream habitats by changing water levels, and by changing the volumes of sediment carried.
    - Future projections in terms of climate change must be understood in the context of this region. It is important to understand and examine the hydrological response of watersheds to current fluctuations in rainfall and temperature if we are to project into the future and predict how climate change might affect water resources within the St. Geroges Bay region.

- It is important that we better understand the effects of atmospheric deposition upon otherwise undisturbed watersheds within the region. This is necessary in order to determine whether natural biogeochemical cycles have been altered even before landuse changes have taken place, and the extent to which this has occurred.
    - A St. Francis Xavier University Council for Research grant has already been awarded to identify, instrument and begin monitoring a site within the St. Georges Bay region in the vicinity of Antigonish. This will be used to develop a long-term monitoring program of a naturally vegetated site within the region.
    - Also of use to developing an ecosystem understanding would be a study of the natural buffering capacity of various watersheds against acid rain, as often watersheds have a finite capacity to buffer acid rain.
- A much better understanding of groundwater contamination and influx of pollutants to surface and coastal waters is required.
    - Increased study of groundwater contamination, particularly due to sewage and septic systems would be useful. In addition, study of whether any such pollutants are being discharged into lakes, rivers, estuaries and other coastal areas would be useful in studying the potential for coastal eutrophication within the St. Georges Bay area.
- There is also a need for a better understanding of how changing land use patterns have altered water chemistry and water quality of surface and groundwaters.
    - It is important to determine the direct effects changing land use patterns have had upon water quality. Activities such as agriculture and deforestation may have pronounced effects on water quality within the region. Simultaneous surface water and groundwater analyses within a given locale would aid in understanding how fertilizer and pesticide use in the case of agriculture, for example, might alter water quality.

Again, these are illustrations of the sorts of studies which would add substantially to the current understanding of watershed, water quality and esturian dynamics within the St. Georges Bay ecosystem.

As noted earlier, the state of available comprehensive social and economic information respecting the St. Georges Bay study area has been found sadly wanting. Understanding the place and impact of human activities within the ecosystem is critical. Consequently, there is an immediate need to define and to develop systematic and comprehensive studies of the study area's socio-economic history and current characteristics. Ideally, the contribution of specific economic analysis to the St. Georges Bay Ecosystem Project would involve goals such as:

1. developing a longitudinal and detailed economic profile of human activities in the ecosystem with a focus of primary resource livelihoods and industries;
2. identifying the benefits and values currently and potentially derived from the resources in the ecosystem;
3. identifying resource use issues and conflicts;
4. exploring how the benefits and values derived from the resources in the ecosystem can be enhanced;
5. identifying appropriate economic policies that would contribute to achieving enhanced benefits and values; and,
6. exploring how resource use issues and conflicts in the ecosystem can be addressed through adopting appropriate processes and policies.

The GBEP Ecosystem Project Draft Report represents an important first step to addressing some of these areas. With a view towards future work it is useful to identify some of the main economic goals of integrated resource and ecosystem management. These goals are based on the underlying economic objective of efficiency. When the use of resources is economically inefficient, it implies that there are potential benefits to the community from policies that lead to efficiency gains. Thus, from an economic perspective, integrated resource and ecosystem management policies may be advised in order,

i. to improve information;
ii. to mitigate resource use conflicts;
iii. to alter resource use patterns or rates of resource use whenever there is reason to believe that resources are being used inefficiently;

iv. to promote the removal of non-competitive market conditions in resource-based industries; and,

v. to enhance the value-added from resource use for the communities that depend on them.

In addition to the specific economic attributes of human activities within the study area, it is also critical to develop an understanding of attitudes towards and behaviours respecting the ecosystem. For instance, specific studies of fishing strategies would contribute to a more sophisticated appreciation of what marine harvesters do, of why they do what they do, and of the importance to them of their practices. Additionally, there needs to be a more thorough understanding of the social and personal meanings of fishing within this livelihood's family and community contexts. The strength of marine harvester attachments to fishing as a way of living and livelihood has been widely documented and commented upon. However, the association of these strong attachments with ecosystem-related understandings has not been well developed or understood. Certainly some research focused in this area would assist in the goal of engaging Native and commercial marine harvesters, as partners, in the research work dedicated to developing an ecosystem model of the Bay as well as in the processes of defining and engaging an ecosystem approach to resource use and coastal zone management.

In our view, this research report provides a key baseline document that is essential as a place from which to define research needs and, perhaps, to develop research processes with some likelihood of contributing substantially to the achievement of a working model of the ecosystem. We think that the information contained within it provides a comprehensive review of the current state of understanding. As well, we think that the information and commentary contained in this document contribute direction respecting what needs or should be done in the immediate future, both in terms of process as well as in terms of specific research undertakings. Hopefully, others, after having read and digested the contents, will arrive at a similar set of conclusions.

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APPENDICES 1-14

Appendix 1: List of fish species found in St. Georges Bay. Compiled from Caddy et. al., (1977), Kenchington (1980), Koeller and Legresley, (1981), and Clay (1991). Classification from Scott and Scott (1988).

Family	Species	Scientific Name
Acipenseridae	American Atlantic sturgeon	*Acipenser oxyrhyncus*
Agonidae	Alligatorfish	*Aspidophoroides monopterygius*
Ammodytidae	American sand lance	*Ammodytes americanus*
Anguillidae	American eel	*Anguilla rostrata*
Atherinidae	Atlantic silverside	*Menidia menidia*
Bothidae	Windowpane	*Scophthalmus aquosus*
Charchariidae	Blue shark	*Prionace glauca*
Clupeidae	Alewife	*Alosa pseudoharengus*
	American shad	*Alosa sapidissima*
	Atlantic herring	*Clupea harengus*
	Blueback herring	*Alosa aestivalis*
Cottidae	Arctic hookear sculpin	*Artediellus uncinatus*
	Atlantic sea raven	*Hemitripterus americanus*
	Grubby	*Myoxocephalus aeneus*
	Longhorn sculpin	*Myoxocephalus octodecemspinosus*
	Mailed sculpin	*Triglops murrayi*
	Shorthorn sculpin	*Myoxocephalus scorpius*
Cryptacanthidae	Wrymouth	*Cryptacanthodes maculatus*
Cyclopteridae	Atlantic seasnail	*Liparis atlanticus*
	Atlantic spiny lumpsucker	*Eumicrotremus spinosus*
	Lumpfish	*Cyclopterus lumpus*
	Striped seasnail	*Liparis liparis*
Cyprinodontidae	Mummichog	*Fundulus heteroclitus*
Gadidae	Atlantic cod	*Gadus morhua*
	Fourbeard rockling	*Enchelyopus cimbrius*
	Pollack	*Pollachius virens*
	Silver hake	*Merluccius bilinearis*
	White hake	*Ruophysis tenuis*

Appendix 1: (con't).

Family	Species	Scientific Name
Gasterostidae	Black-spotted stickleback	*Gasterosteus wheatlandi*
	Fourspine stickleback	*Apeltes quadracus*
	Ninespine stickleback	*Pungitius pungitius*
	Threespine stickleback	*Gasterosteus aculeatus*
Labridae	Cunner	*Tautogolabrus adspersus*
Lamnidae	Porbeagle	*Lamna nasus*
Molidae	Ocean sunfish	*Mola mola*
Myxinidae	Hagfish	*Myxine glutinosa*
Osmeridae	American smelt	*Osmerus mordax*
	Capelin	*Mallotus villosus*
Petromyzontidae	Sea lamprey	*Petromyzon marinus*
Pholidae	Rock gunnel	*Pholis gunnellus*
Pleuronectidae	American plaice	*Hippoglossoides platessoides*
	Smooth flounder	*Liopsetta putnami*
	Winter flounder	*Pseudopleuronectes americanus*
	Witch flounder	*Glyptocephalus cynoglossus*
	Yellowtail flounder	*Limanda ferruginea*
Rajidae	Little skate	*Raja erinacea*
	Thorny skate	*Raja radiata*
	Winter skate	*Raja ocellata*
Salmonidae	Atlantic salmon	*Salmo salar*
	Brook trout	*Salvelinus fontinalis*
Scomberesocidae	Atlantic saury	*Scomberesox saurus*
Scombridae	Atlantic bonito	*Sarda sarda*
	Atlantic mackerel	*Scomber scombrus*
	Bluefin tuna	*Thunnus thynnus*
Stichaeaidae	Daubed shanny	*Lumpenus maculatus*
	Arctic shanny	*Stichaeus punctatus*
	Radiated shanny	*Ulvaria subbifurcata*
	Snake blenny	*Lumpenus lumpretaeformis*

Appendix 1: (con't).

Family	Species	Scientific Name
Stromateidae	Butterfish	*Peprilus triacanthus*
Syngnathidae	Northern pipefish	*Syngnathus fuscus*
Xiphidae	Swordfish	*Xiphias gladius*
Zoarcidae	Ocean pout	*Macrozoarces americanus*
	Vahl'e eelpout	*Lycodes vahlii*

Appendix 2: List of species, and scientific name, mentioned in the text.

Vegetation	Common Name	Scientific Name
Trees	Balsam fir	*Abies balsamea*
	American Beech	*Fagas grandifolia*
	Black spruce	*Piceae mariana*
	Dwarf birch	*Betula glandulosa, B. occidentalis, B. michauxii*
	Eastern hemlock	*Tsuga canadensis*
	Larch	*Larix laracina*
	Mountain ash	*Sorbsu sp.*
	Mountain maple	*Acer spicatum*
	Red spruce	*Picea rubens*
	Sugar maple	*Acer saccharum*
	White birch	*Betula papyrifera*
	White pine	*Pinus strobus*
	White spruce	*Picea glauca*
	Yellow birch	*Betula alleghaniensis*
Understorey	Blueberry	*Vaccinium sp.*
	Sheep laurel	*Kalmia angustifolia*
	Alpine whortleberry	*Vaccinium uliginosum*
	Cranberry	*Vaccinium oxycoccos*
	Sphagnum moss	*Sphagnum sp.*
	Bulrush	*Scirpus sp.*
	Beak rush	*Rhyncospora capillacea*
	Raspberry	*Rubus idaeus*
	Elderberry	*Sambucus sp.*
	Pin cherry	*Prunus pensylvanicus*
	Wood fern	*Dryopteris spinulosa*
	Wood sorrel	*Oxalis montana*
	Rosy twisted stalk	*Streptopus roseus*
	Starflower	*Trientalis borealis*
	Christmas fern	*Polystichum acrostichoides*
	Baneberry	*Actaea sp.*
	Hazelnut	*Corylus cornuta*
	Wild sarsparilla	*Aralia nudicaulis*

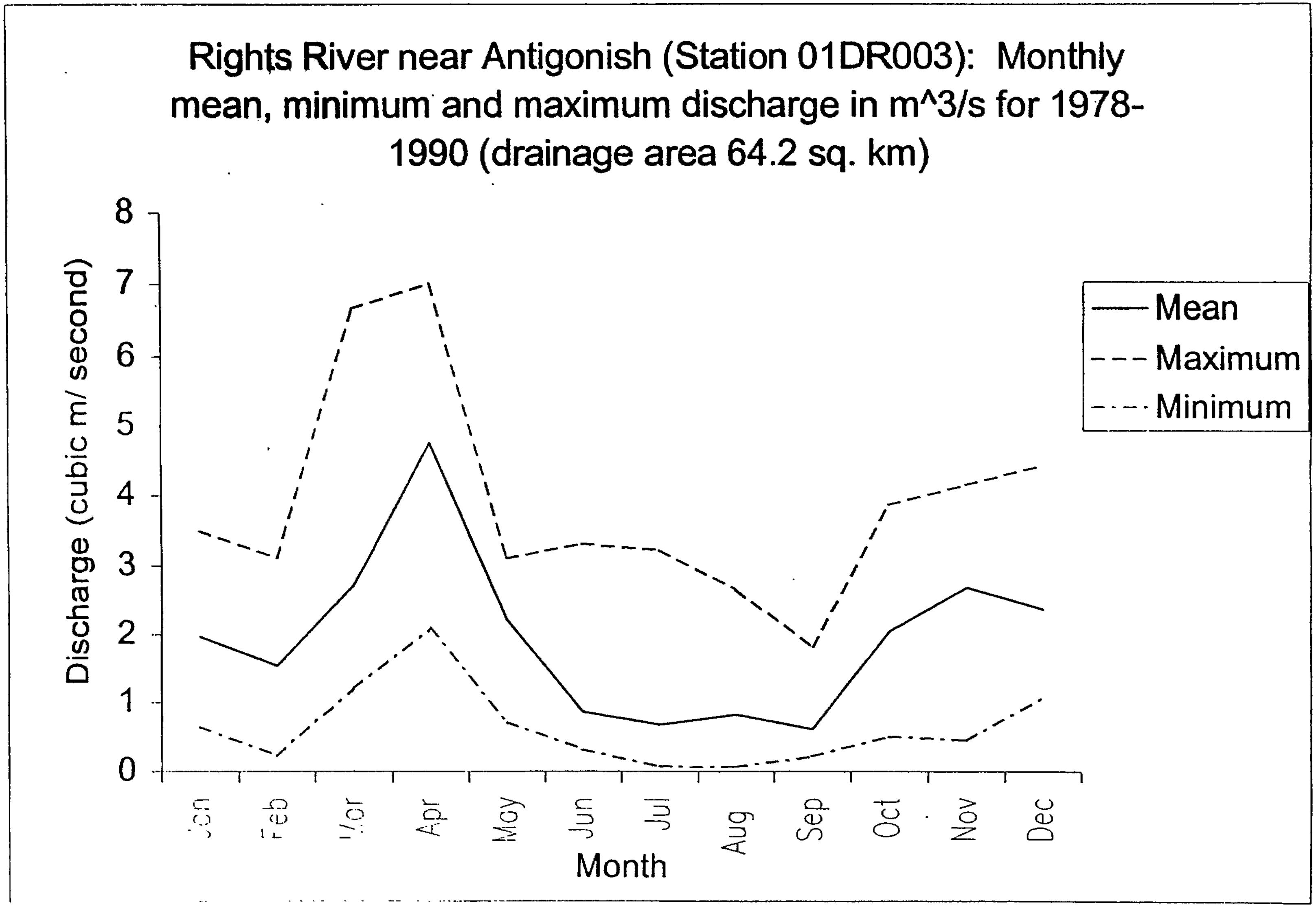
Appendix 2 (con't): List of species, and scientific name, mentioned in the text.

Insect	Spruce Budworm	*Choristoneura fumeriferana*
Amphibians	Wood frog	*Rana sylvatica*
Birds	Ruffed grouse	*Bonassa umbellus*
	Grey cheeked thrush	*Catharus minimus*
	Black guillemot	*Cepphus gryle*
	Herring gull	*Larus argentatus*
	Iceland gull	*Larus glaucoides*
	Black backed gull	*Larus marinus*
	Gannet	*Morus bassanus*
	Double created cormorant	*Phalacrocorax auritus*
	Great cormorant	*Phalacrocorax carbo*
	Black legged kittiwake	*Rissa tridactyla*
	Common tern	*Sterna hirundo*
	Arctic tern	*Sterna paradisaea*
	Greater yellow legs	*Tringa melanoleuca*
Mammals		
Cetaceans	Fin whale	*Balaenoptera physalus*
	Minke whale	*Balaenoptera acorostrata*
	Blue whale	*Balaenoptera musculus*
	Sperm whale	*Physeter macrocephalus*
	Long finned pilot whale	*Globicephala melas*
	Beluga whale	*Delphinapterus leucas*
	White beaked dolphins	*Lagenorhynchus albirostris*
	Atlantic white-sided dolphin	*Lagenorhynchus acutus*
	Harbour porpoise	*Phocoena phoceana*
Pinniped	Grey seal	*Halichoerus grypus*
	Hooded seal	*Crystophora cristata*
	Harbour seal	*Phoca vitulina*
Carnivores	Black bear	*Ursus americanus*
	Eastern couger	*Felis concolor*
Deer	Caribou	*Rangifer tarandus*
	Moose	*Alces alces*
	Whitetailed deer	*Odocoileus virginianus*

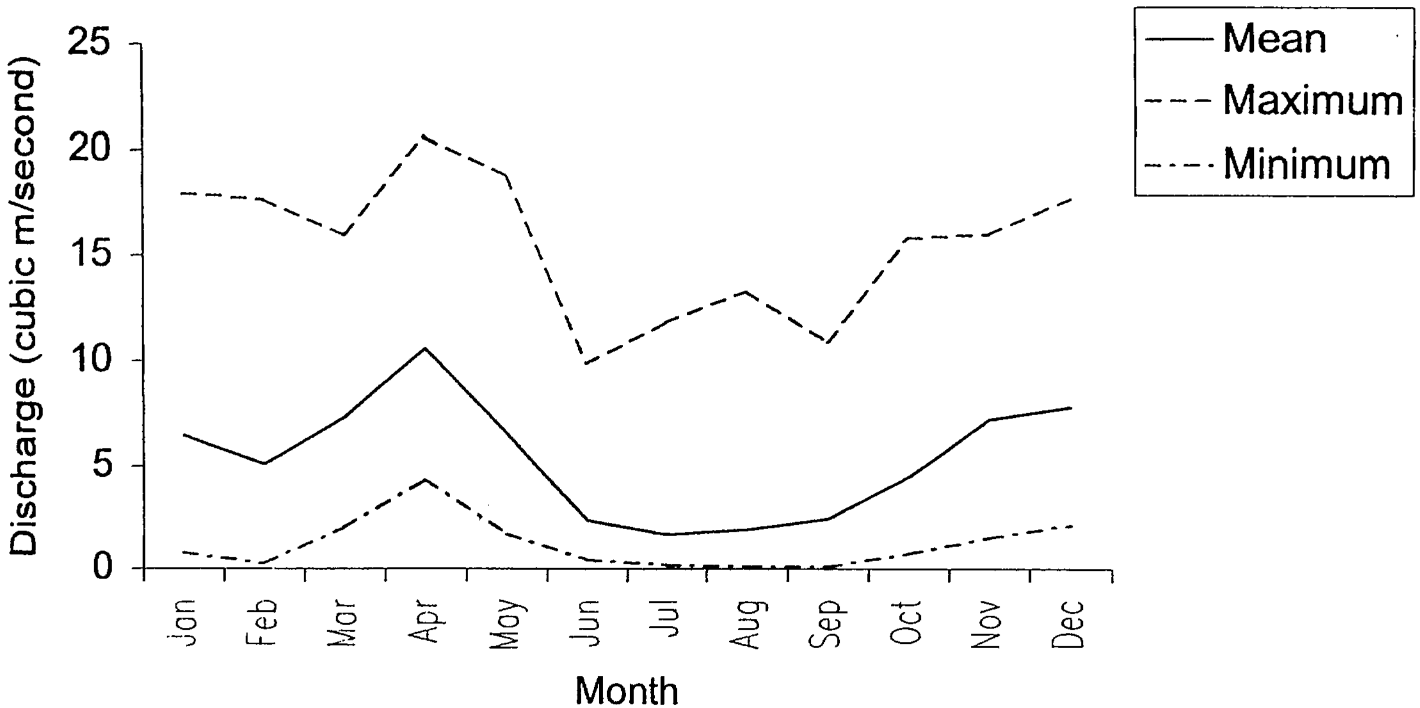
Appendix 2 (con't): List of species, and scientific name, mentioned in the text.

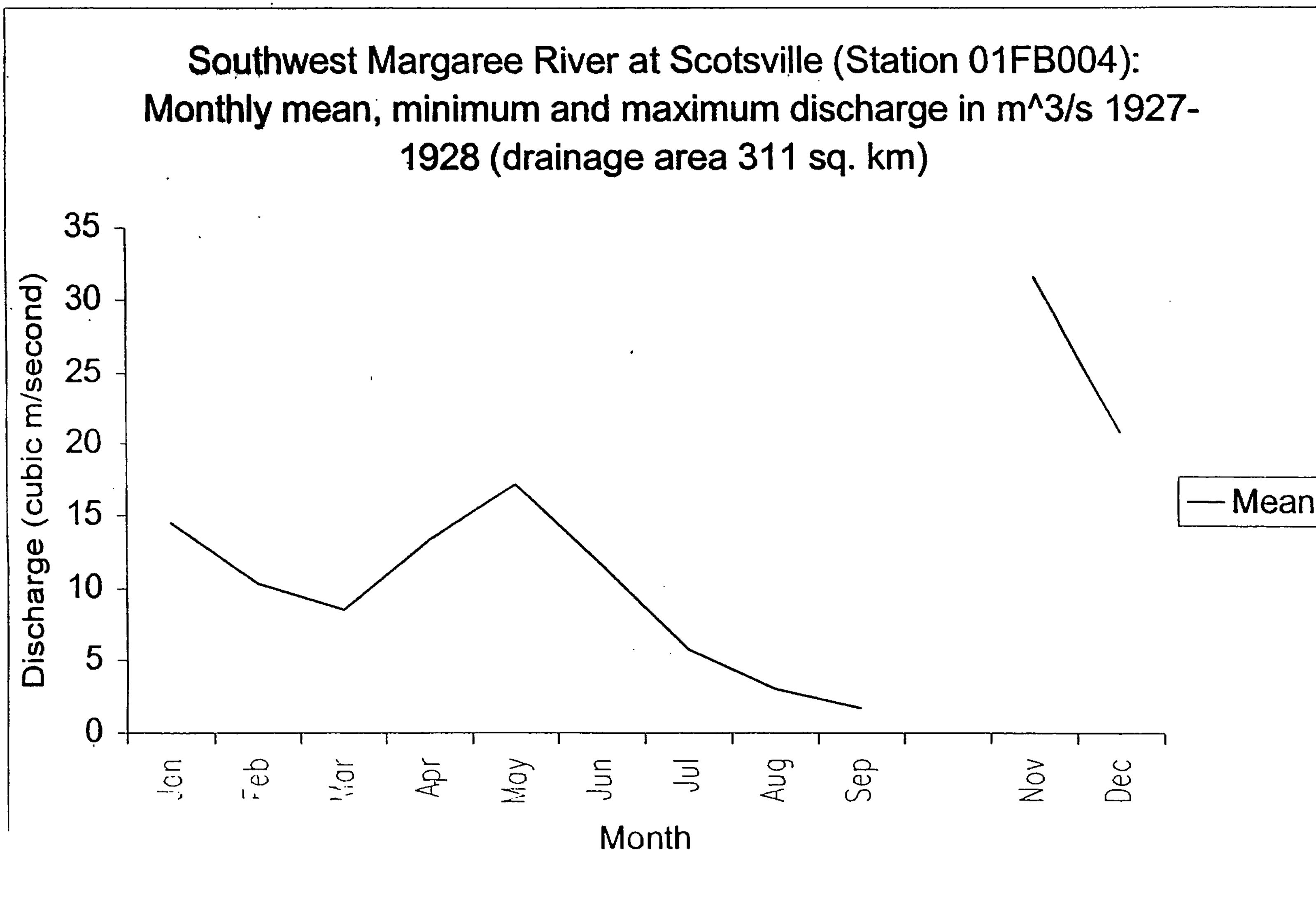
Furbearers	Beaver	*Castor candensis*
	Bobcat	*Lynx rufus*
	Coyote	*Canis latrans*
	Fisher	*Martes pennati*
	Fox	*Vulpes vulpes*
	Lynx	*Lynx lynx*
	Mink	*Mustela vison*
	Muskrat	*Onadata zibethicus*
	Pine marten	*Martes americana*
	Raccoon	*Procyon lotor*
	River otter	*Lutra candensis*
	Striped skunk	*Mephitis mephitis*
	Weasel	*Mustela erminea*
Insectivores	Common shrew	*Sorex cinereus*
Rodent/Lagamorphs	Red back vole	*Clethrionomyes gapperi*
	Red squirrel	*Tamiasciurus hudsonicus*
	Snowshoe hare	*Lepus americana*

Appendix 3: Hydrographs of historic records from hydrometric stations in St. Georges Bay study area

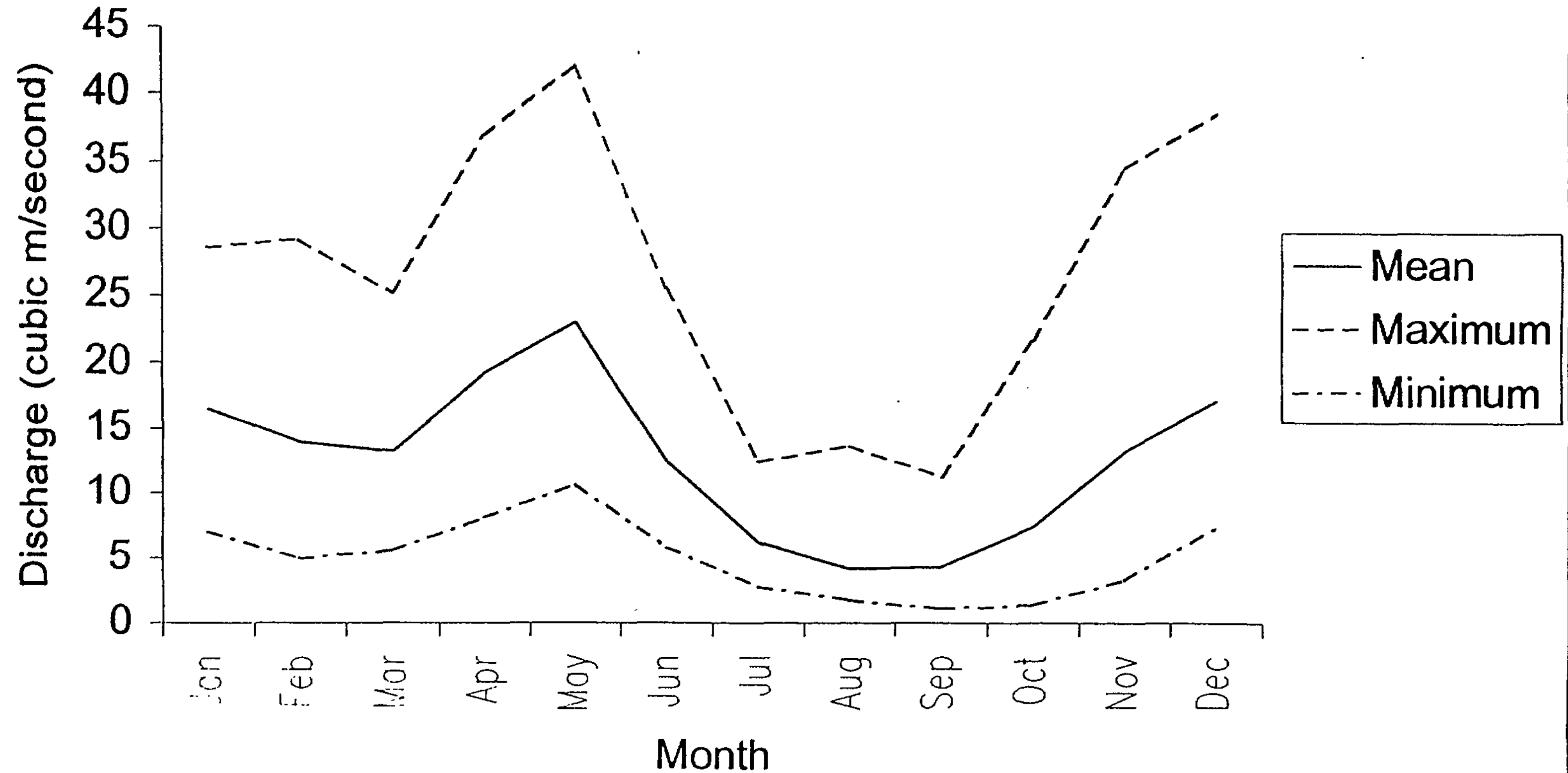


South River at St. Andrews (Station 01DR001): Monthly mean, minimum and maximum discharge in m^3/s for 1917-1997 (drainage area 177 sq. km)

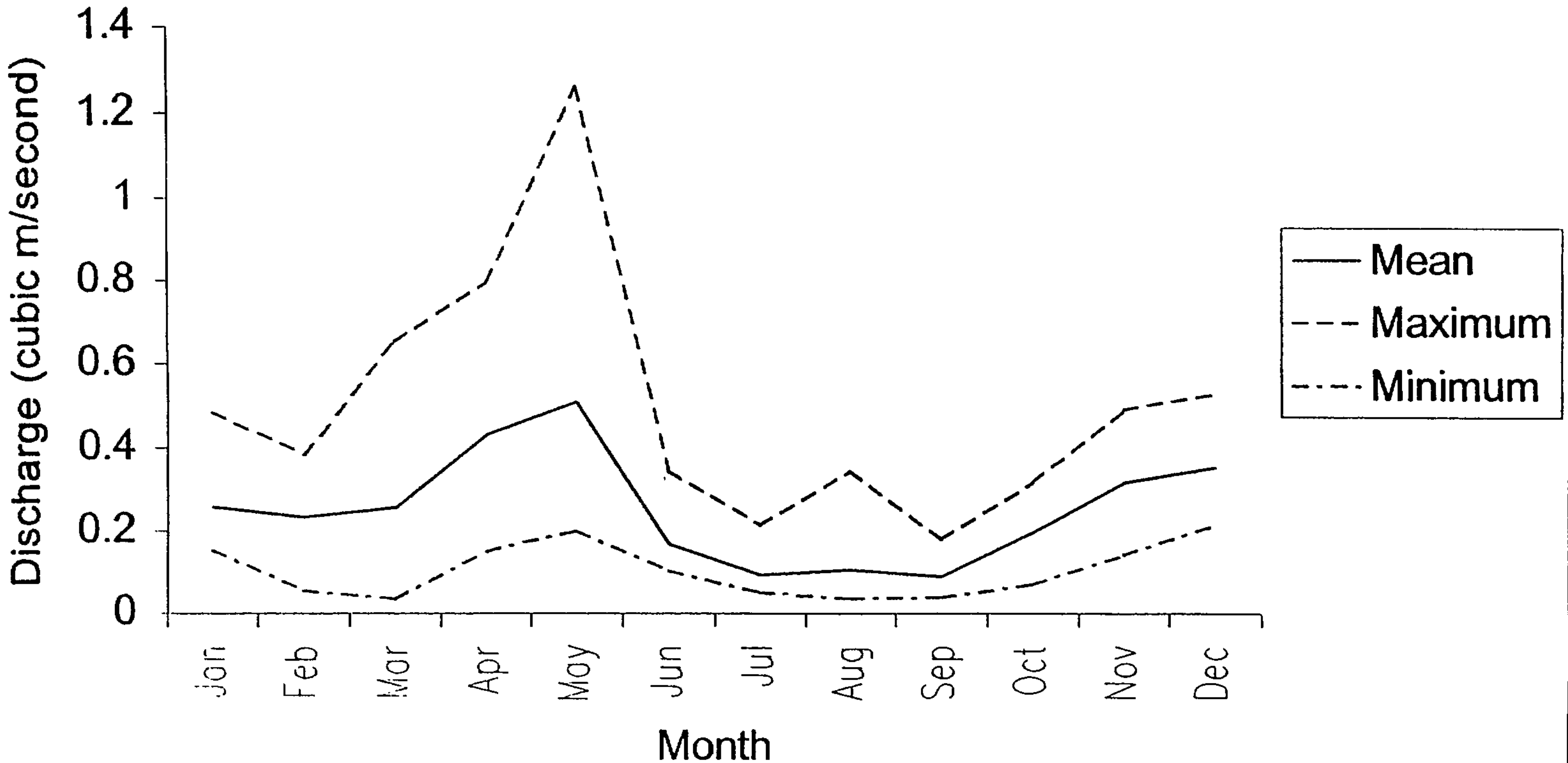


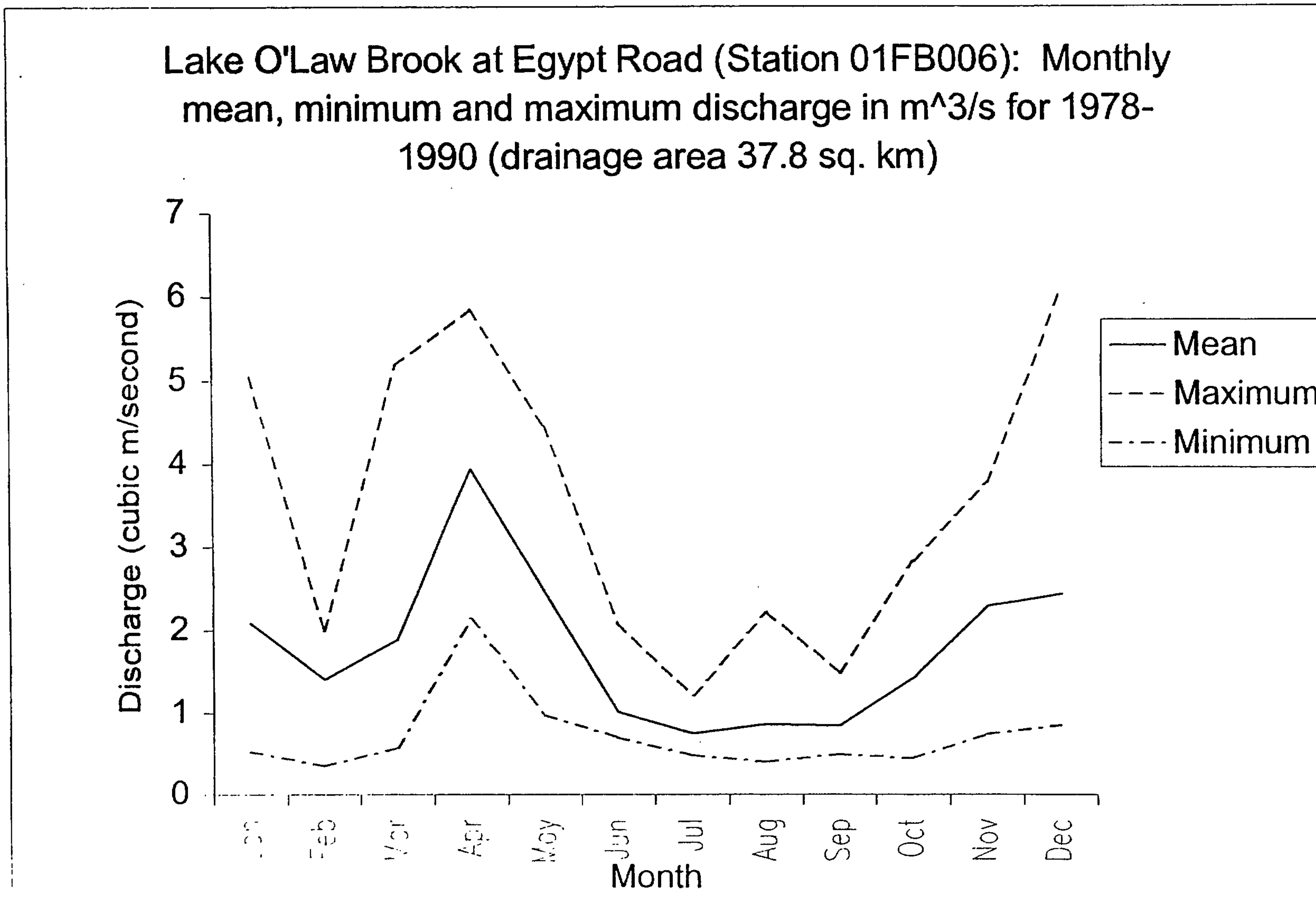

Southwest Margaree River at Scotsville (Station 01FB004):
Monthly mean, minimum and maximum discharge in m^3/s 1927-1928 (drainage area 311 sq. km)
Discharge (cubic m/second)
35
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Nov
Dec
Month
Mean

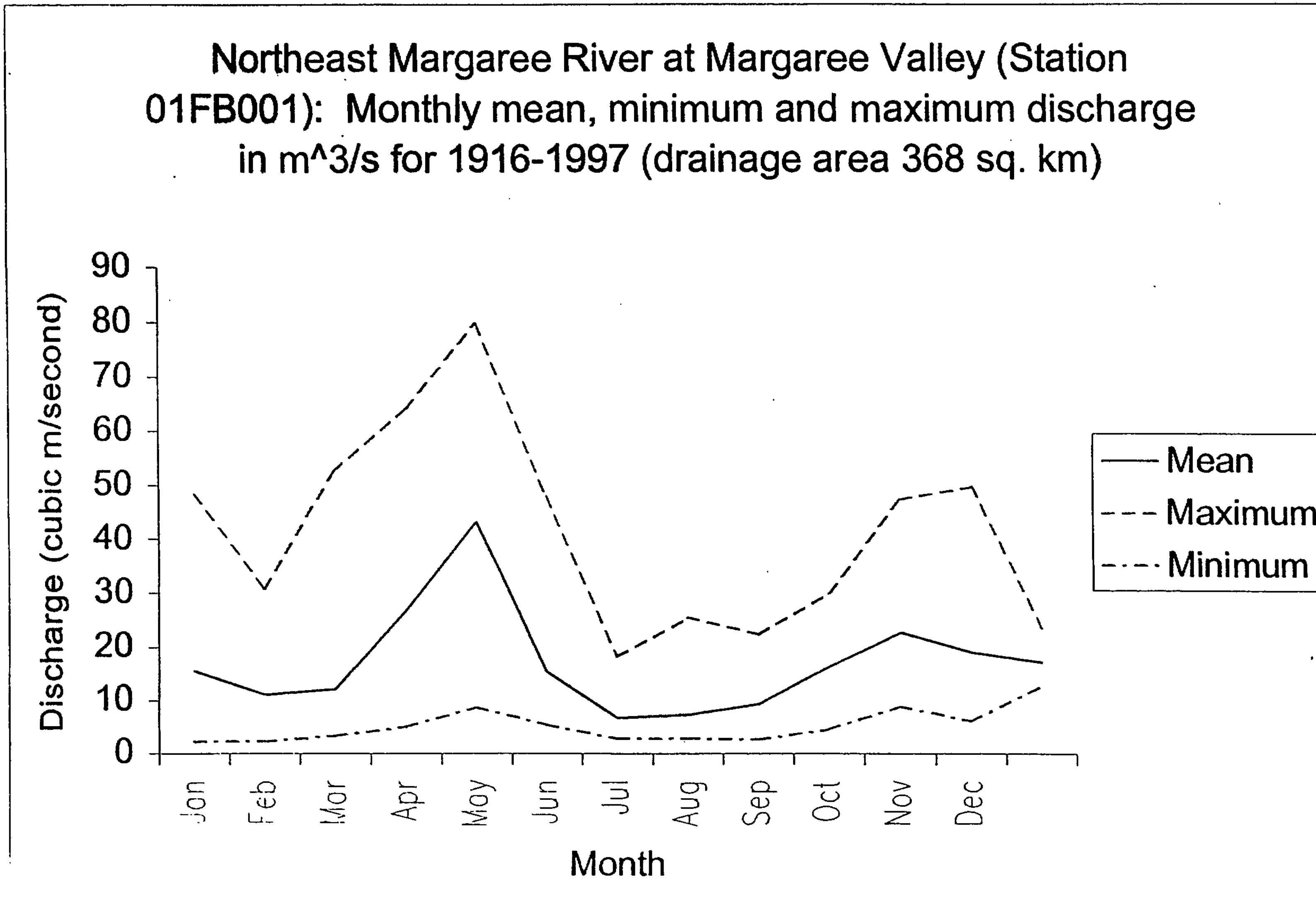
Southwest Margaree River near Upper Margaree (Station 01FB003): Monthly mean, minimum and maximum discharge in m^3/s for 1918-1997 (drainage area 357 sq. km)



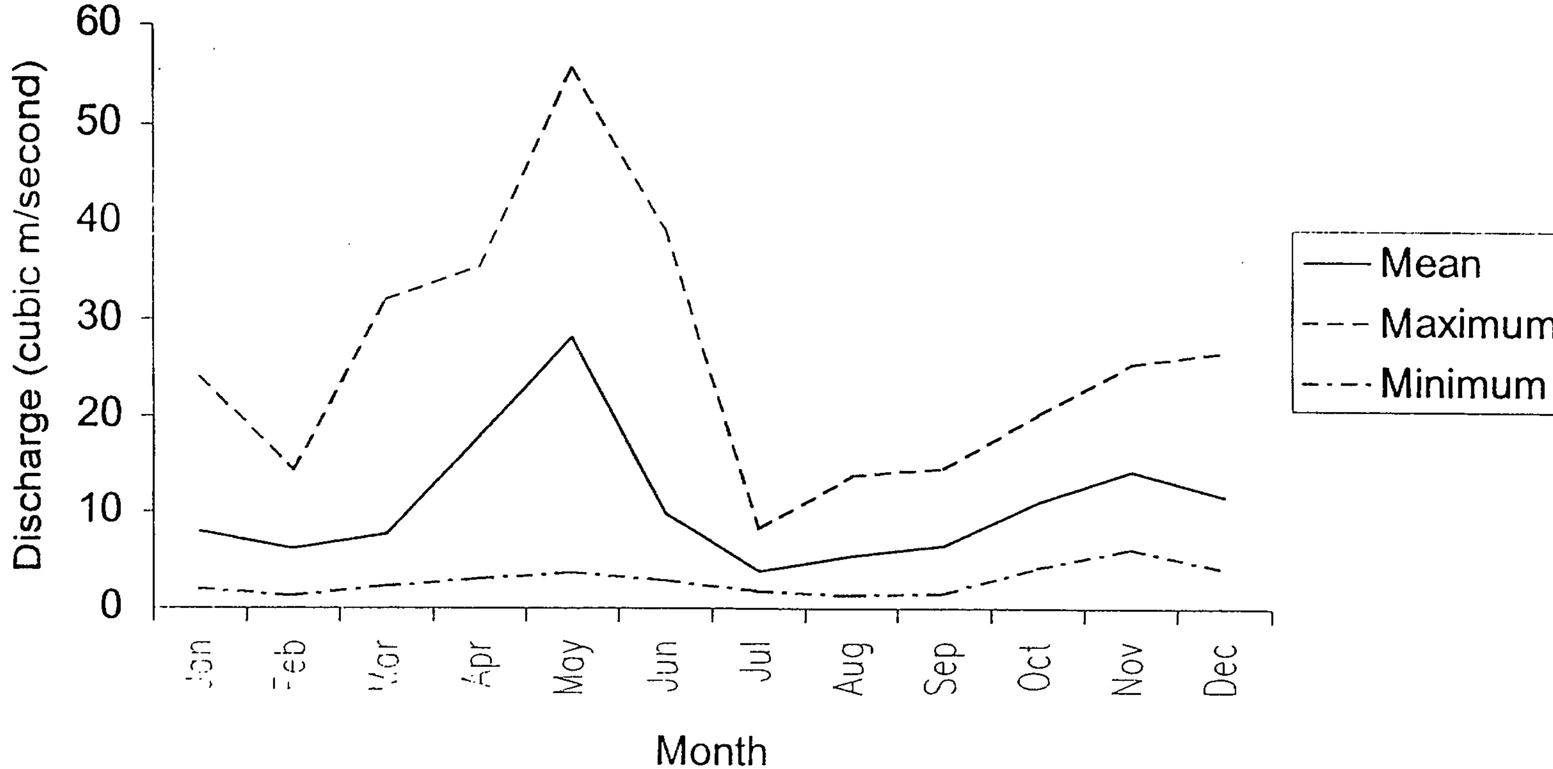
April Brook at Gillisdale (Station 01FB005): Monthly mean, minimum and maximum discharge in m^3/s for 1966-1979 (drainage area 6.22 sq. km)



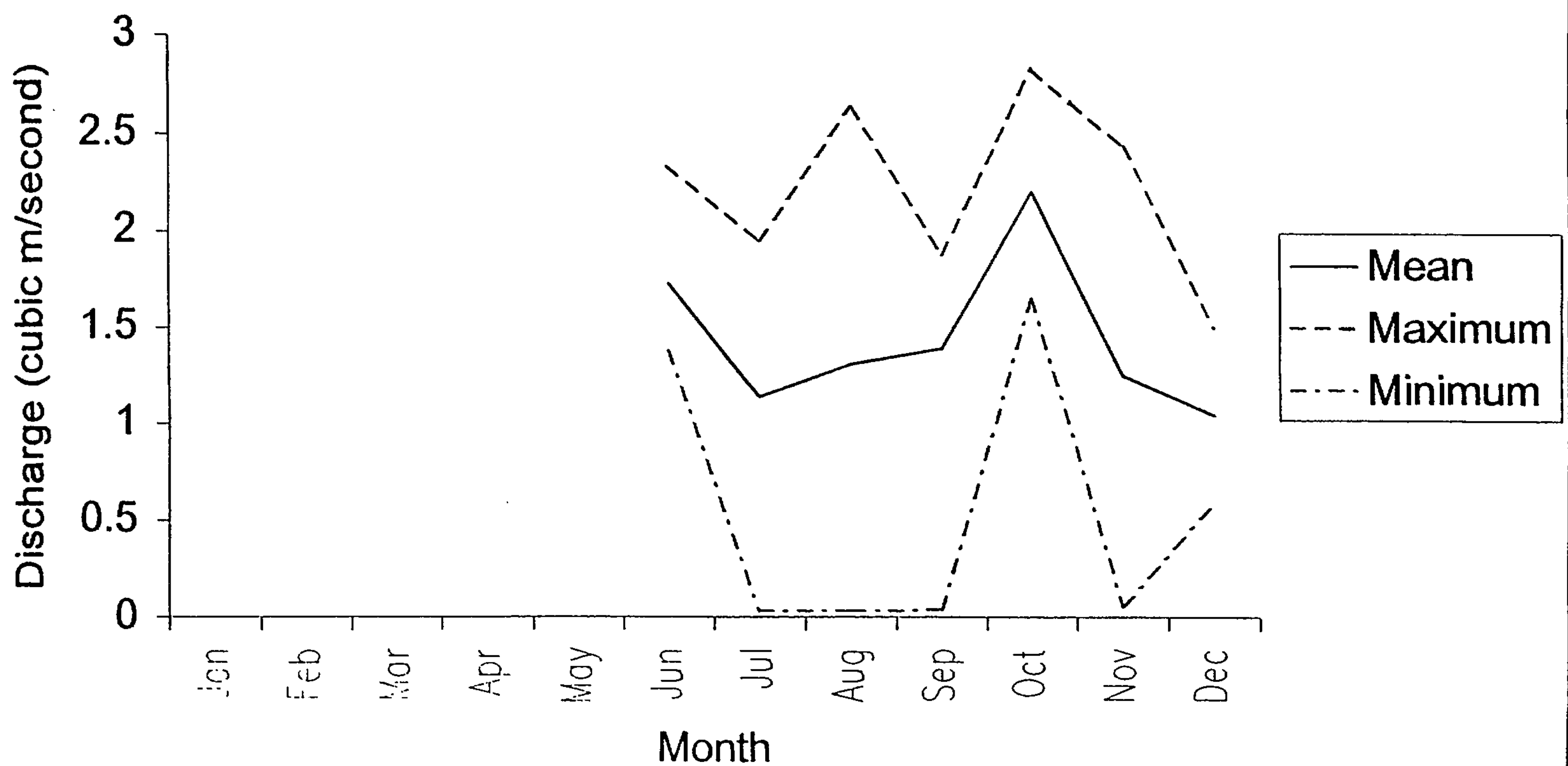

Lake O'Law Brook at Egypt Road (Station 01FB006): Monthly mean, minimum and maximum discharge in m^3/s for 1978-1990 (drainage area 37.8 sq. km)
Discharge (cubic m/second)
0
1
2
3
4
5
6
7
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Mean
Maximum
Minimum


Northeast Margaree River at Margaree Valley (Station 01FB001): Monthly mean, minimum and maximum discharge in m^3/s for 1916-1997 (drainage area 368 sq. km)
Discharge (cubic m/second)
90
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Mean
Maximum
Minimum

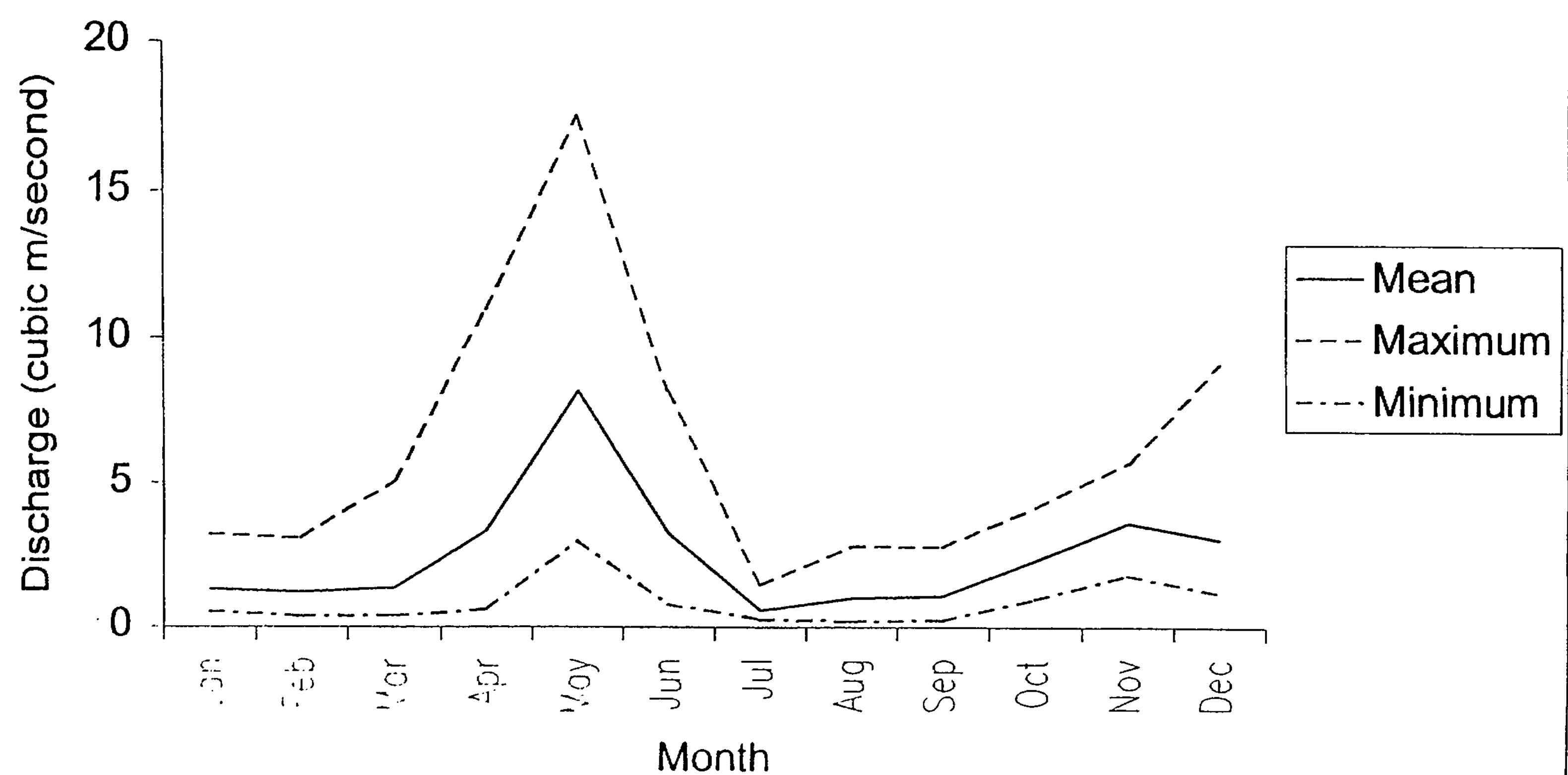
Cheticamp River above Robert Brook (Station 01FC002):
Monthly mean, minimum and maximum discharge in m^3/s for
1958-1997 (drainage area190 sq. km)



Cheticamp River below Artemise Brook (Station 01FC003): Monthly mean, minimum and maximum discharge in m^3/s for 1978-1989 (drainage area 37 sq. km)



Cheticamp River below Cheticamp Lake (Station 01FC001):
Monthly mean, minimum and maximum discharge in m^3/s for
1958-1977 (drainage area 49.2 sq. km)



Appendix 4: Groundwater quality associated with geological bodies in the St. Georges Bay study area

PARAMETERS IN MGL (CDWS)	Horton Group Inverness County	Windsor Group Inverness County	Horton Group Guysborough County	Windsor Group Hillsborough	Riversdale Group Inverness Richmond	Windsor Group Antigonish County	Mississippian Village of St. Joseph
SODIUM (*)	14.7	15	37.6		22.0	29.4	2.7
POTASSIUM (*)		16					0.66
CALCIUM (*)	488.9	25	36.7		40.2	257.0	11.0
MAGNESIUM (150)		5.4	9.0		7.7	21.9	1.3
HARDNESS (AS $CaCO_3$) (*)	107.0	85	128.8	154	137	1621.0	32.819
ALKALINITY (AS $CaCO_3$) (*)	1882.8	78	128	0	106		19.0
SULPHATE (500)	188	13	26	46.0	55	595	9.8
CHLORIDE (250)	1250	2.1	54.3	16.0	26.9	139	<5.0
FLUORIDE (1.5)	23.0	0.3					<0.1
SILICA REACTIVE (*)		7.1					7.1
TOTAL PHOSPHORUS		0.03			<0.01		
PHOSPHATE ORTHO (0.2)							
TOTAL PHOSPHATE							
TOTAL NITROGEN							
NITRATE & NITRITE (AS N) (10.0)	T	0.2	0.45	23.20	0.07	0.45	<0.01
KJEL NITROGEN							
AMMONIA (AS N) (0.5)		<0.1					
SURFACTANTS							
TOTAL ORGANIC CARBON (*)							
CHEMICAL OXYGEN DEMAND							
HUMIC ACIDS							
HYDROCARBONS							
PHENOLS (0.002)							
TOTAL DISSOLVED SOLIDS (500)		165	269		279	1861	
SUSPENDED SOLIDS (*)		2222					
COLOR (15 TCU)		10					
TURBIDITY (5 JTU)	<5	58				126	0.80
CONDUCTIVITY UMHO/CM (*)	2600	240					
FIELD TEMPERATURE (5°C)							
FIELD PH (UNITS) (6.5 - 8.5)					7.0	7.4	
LAB PH (UNITS)	7.0	7.6	7.6	7.2			6.0
ALUMINUM (*)		109					<0.10
ANTIMONY (*)		0.40					
ARSENIC (0.5)		<0.005					
BORON (5.0)		0.22					
BARIUM (1.0)		1.1					
BERYLLIUM (*)		<0.005					
CADMIUM (0.005)		0.06			<0.001		
CHROMIUM (0.05)		0.72					
COBALT (*)		1.3					
COPPER (1.0)		0.29	0.281		0.03	0.0628	<0.01
CYANIDE (0.2)							
IRON (0.3)	1.8	110	0.25	0.09	1.1	0.15	0.18
MANGANESE (0.05)	0.4	5.2	0.24	0	0.05	0.27	0.03
MERCURY (0.001)							
NICKEL (*)		0.29					
LEAD (0.05)		0.5	0.015		0.005	0.0183	<0.05
SELENIUM (0.01)		0.58					
SILVER (0.05)							
STRONTIUM (10 BG/L)							
TIN (*)		0.16					
URANIUM (0.02)							
VANADIUM (*)		0.17					
ZINC (5.0)		0.43	0.0938		0.01	0.368	<0.01

Appendix 5: Water quality of surveyed lakes in St. Georges Bay study area

Lake	Co-ordinates	Watershed Name	Watershed Code	Survey Agency	Date Mo.	Date Yr.	Conduct. (μmhos/cm)	pH	Surface Area (ha)	Depth Max.	Depth Mean
ANTIGONISH COUNTY											
Cameron Lake	45°31'N; 61°59'W	South R.	NS48	DFO	07	73	55.2	6.4	29.6	9.5	4.8
College Lake	45°25'N; 62°05'W	West R.	NS51	DFO	06	76	28.0	5.4	4.0	1.0	0.3
Gaspereaux Lake	45°33'N; 62°03'W	West R.	NS51	DFO	08	73	153.3	8.0	87.1	4.6	1.9
Gaspereaux Lake	45°33'N; 62°03'W	West R.	NS51	L&F	08	75	220.0	9.2	87.1	4.6	1.9
Gillis Lake	45°32'N; 61°58'W	South R.	NS48	DFO	07	73	74.2	6.3	28.0	10.7	3.9
Gillis Lake	45°32'N; 61°58'W	South R.	NS48	L&F	08	75	108.0	7.0	28.0	10.7	3.9
Kimballs Lake	45°24'N; 61°57'W	South R.	NS48	L&F	06	77	35.0	7.0	2.8	7.5	2.6
Loch Katrine Lake	45°26'N; 61°56'W	South R.	NS48	DFO	08	77	39.5	6.8	112.1	27.0	10.0
McKay Lake	45°28'N; 62°07'W	West R.	NS51	L&F	08	79	30.0	7.0	8.8	2.0	1.1
Monastery Lake	45°36'N; 61°37'W	Tracadie R.	NS23	L&F	07	74	44.0	6.3	21.2	16.8	5.9
Polson Lake	45°24'N; 61°59'W	South R.	NS48	DFO	07	76	42.5	6.2	19.5	15.0	5.9
Pomquet Lake	45°37'N; 61°50'W	Pomquet R.	NS36	DFO	06	76	25900.0	8.1	17.4	5.8	1.4
St. Joseph's Lake	45°32'N; 61°05'W	West R.	NS51	L&F	08	75	320.0	7.3	19.9	5.4	3.0
Tracadie Lake	45°37'N; 61°36'W	Tracadie R.	NS23	L&F	07	75	140.0	7.0	27.7	10.7	1.9
Unnamed Lake	45°24'N; 61°58'W	South R.	NS48	DFO	06	77	44.0	6.8	2.1	4.7	2.4
Unnamed Lake	45°30'N; 61°55'W	South R.	NS48	DFO	08	77	65.0	6.3	2.4	4.5	2.4
INVERNESS COUNTY											
Lake Ainslie	46°08'N; 61°11'W	Margaree R.	CBW44	L&F	06,08	78	105.0	7.8	5735.8	18.0	5.7
Grand Lac	46°33'N; 61°01'W	Ruis du Lac	CBW38	L&F	08	75	200.0	8.0	29.3	8.1	3.4
Horton Lake	45°41'N; 61°23'W	Horton B.	CBW115	L&F	08	74	N/A	6.8	47.2	6.1	3.0
Lake O'Law	46°17'N; 60°58'W	Margaree R.	CBW44	L&F	09	76	35.0	7.5	27.1	30.0	9.3
MacIntyre Lake	45°39'N; 61°17'W	Little R.	CBC306	L&F	08	74	N/A	6.3	46.0	9.1	3.5
Pembroke Lake	46°30'N; 60°59'W	Grand Etang B.	CBW39	L&F	08	78	56.0	6.6	55.0	10.0	N/A
Petit Lake	46°33'N; 61°03'W	Grand Etang B.	CBW39	L&F	08	75	360.0	8.1	9.1	15.0	4.9
Presqu'ile Lake	46°41'N; 60°58'W	Presqu'ile B.	CBW32	CWS	06	47	274.0	7.8	4.4	3.0	2.1

Appendix 6: Canadian water quality guidelines for the protection of drinking water and aquatic life

Summary – Guidelines for Canadian Drinking Water Quality 1978

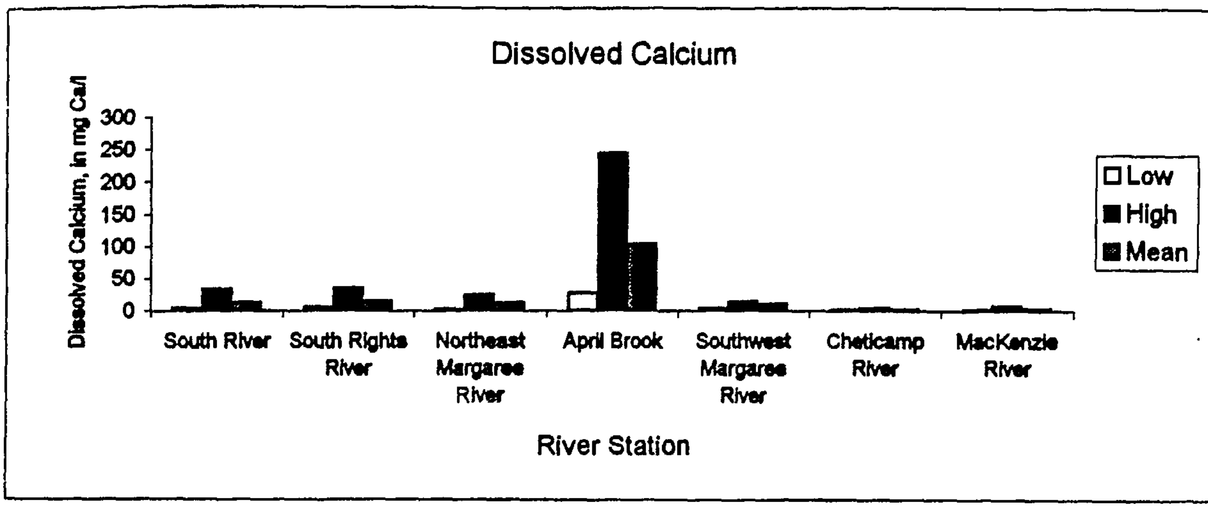
Parameter	Maximum acceptable concentration[1] in drinking water ($mg \cdot L^{-1}$)[2,3]
Inorganic Parameters	
Antimony	—
Arsenic	0.05
Asbestos	—
Barium	1.0
Boron	5.0
Cadmium	5 $\mu g \cdot L^{-1}$
Chloride	250
Chromium	0.05
Copper	1.0
Cyanide	0.2
Fluoride	1.5
Hardness[4]	—
Iron	0.3
Lead	0.05
Manganese	0.05
Mercury	1 $\mu g \cdot L^{-1}$
Nitrate (as N)[5]	10.0
Nitrite (as N)	1.0
pH	6.5-8.5[6]
Selenium	0.01
Silver	0.05
Sulphate	500
Sulphide (as H_2S)	0.05
Total dissolved solids	500
Uranium	0.02
Zinc	5.0
Organic Parameters	
Aldrin + dieldrin	0.7 $\mu g \cdot L^{-1}$
Carbaryl[4]	70 $\mu g \cdot L^{-1}$
Chlordane (total isomers)	7 $\mu g \cdot L^{-1}$
2,4-D	0.1
DDT (total isomers)	0.03
Diazinon	14 $\mu g \cdot L^{-1}$
Dieldrin + aldrin	0.7 $\mu g \cdot L^{-1}$
Endrin	0.2 $\mu g \cdot L^{-1}$
Heptachlor + heptachlor epoxide	3 $\mu g \cdot L^{-1}$
Lindane	4 $\mu g \cdot L^{-1}$
Methoxychlor	0.1
Methyl parathion	7 $\mu g \cdot L^{-1}$
Nitrilotriacetic acid (NTA)	0.05
Parathion	35 $\mu g \cdot L^{-1}$
Pesticides (total)[7]	0.1
Phenols	2 $\mu g \cdot L^{-1}$
2,4,5-TP	0.01
Toxaphene	5 $\mu g \cdot L^{-1}$
Trihalomethanes	0.35
Physical Parameters	
Colour	15 TCU[8]
Odour	—
Taste[4]	—
Temperature[4]	15°C
Turbidity	5 NTU[9]
Radiological Parameters[10]	
^{137}Cs (Cesium)	50 $Bq \cdot L^{-1}$
^{131}I (Iodine)	10 $Bq \cdot L^{-1}$
^{226}Ra (Radium)	1 $Bq \cdot L^{-1}$
^{90}Sr (Strontium)	10 $Bq \cdot L^{-1}$
^{3}H (Tritium)	40 000 $Bq \cdot L^{-1}$

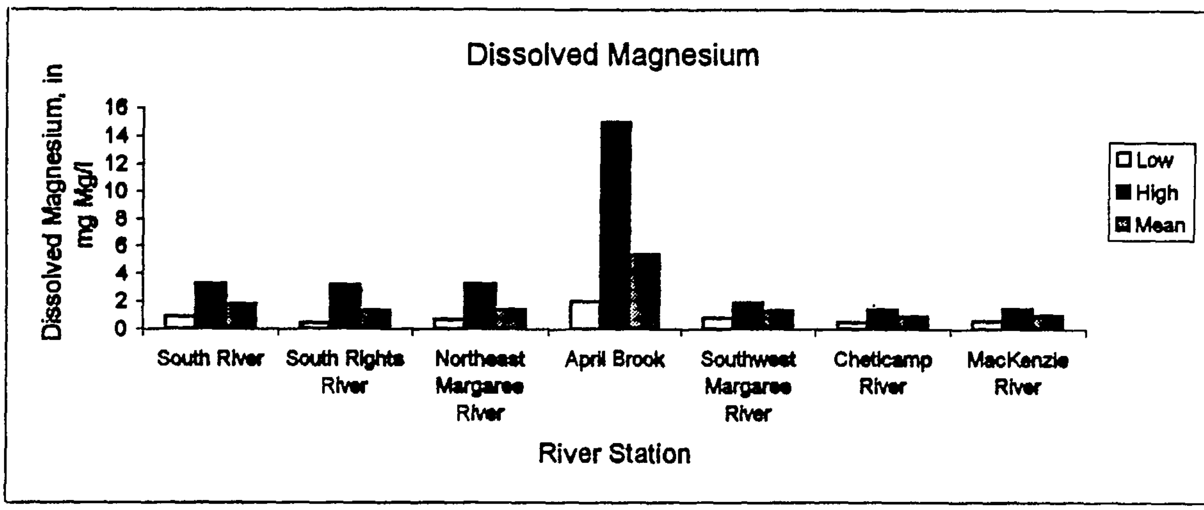
Appendix 6 (con't)

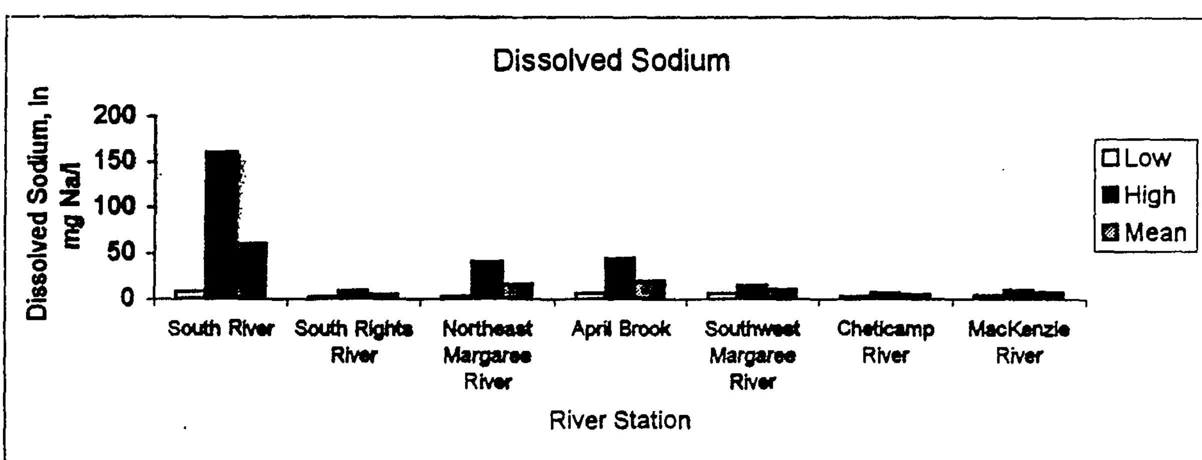
Parameter	Guideline
Inorganic parameters	
Aluminum[1]	0.005 $mg \cdot L^{-1}$
	0.1 $mg \cdot L^{-1}$
Antimony	ID[2]
Arsenic	0.05 $mg \cdot L^{-1}$
Beryllium	ID
Cadmium	0.2 $\mu g \cdot L^{-1}$
	0.8 $\mu g \cdot L^{-1}$
	1.3 $\mu g \cdot L^{-1}$
	1.8 $\mu g \cdot L^{-1}$
Chlorine (total residual chlorine)	2.0 $\mu g \cdot L^{-1}$
Chromium	0.02 $mg \cdot L^{-1}$
	2.0 $\mu g \cdot L^{-1}$
Copper	2 $\mu g \cdot L^{-1}$
	2 $\mu g \cdot L^{-1}$
	3 $\mu g \cdot L^{-1}$
	4 $\mu g \cdot L^{-1}$
Cyanide	5.0 $\mu g \cdot L^{-1}$
Dissolved oxygen	6.0 $mg \cdot L^{-1}$
	5.0 $mg \cdot L^{-1}$
	9.5 $mg \cdot L^{-1}$
	6.5 $mg \cdot L^{-1}$
Iron	0.3 $mg \cdot L^{-1}$
Lead	1 $\mu g \cdot L^{-1}$
	2 $\mu g \cdot L^{-1}$
	4 $\mu g \cdot L^{-1}$
	7 $\mu g \cdot L^{-1}$
Mercury	0.1 $\mu g \cdot L^{-1}$
Nickel	25 $\mu g \cdot L^{-1}$
	65 $\mu g \cdot L^{-1}$
	110 $\mu g \cdot L^{-1}$
	150 $\mu g \cdot L^{-1}$
Nitrogen	
Ammonia (total)	2.2 $mg \cdot L^{-1}$
	1.37 $mg \cdot L^{-1}$
Nitrite	0.06 $mg \cdot L^{-1}$
Nitrate	
Nitrosamines	ID
pH	6.5-9.0
Selenium	1 $\mu g \cdot L^{-1}$
Silver	0.1 $\mu g \cdot L^{-1}$
Thallium	ID
Zinc[3]	0.03 $mg \cdot L^{-1}$
Organic parameters	
Acrolein	ID
Aldrin dieldrin	4 $ng \cdot L^{-1}$ (dieldrin)

Parameter	Guideline
Benzene[3]	0.3 $mg \cdot L^{-1}$
Chlordane	6 $ng \cdot L^{-1}$
Chlorinated benzenes[3]	
Monochlorobenzene	15 $\mu g \cdot L^{-1}$
Dichlorobenzene 1,2- and 1,3-	2.5 $\mu g \cdot L^{-1}$
1,4-	4.0 $\mu g \cdot L^{-1}$
Trichlorobenzene 1,2,3-	0.9 $\mu g \cdot L^{-1}$
1,2,4-	0.5 $\mu g \cdot L^{-1}$
1,3,5-	0.65 $\mu g \cdot L^{-1}$
Tetrachlorobenzene 1,2,3,4-	0.10 $\mu g \cdot L^{-1}$
1,2,3,5-	0.10 $\mu g \cdot L^{-1}$
1,2,4,5-	0.15 $\mu g \cdot L^{-1}$
Pentachlorobenzene	0.030 $\mu g \cdot L^{-1}$
Hexachlorobenzene	0.0065 $\mu g \cdot L^{-1}$
Chlorinated ethylenes[3]	
Tetrachloroethylene	260 $\mu g \cdot L^{-1}$
Di- and trichloroethylenes	ID
Chlorinated phenols	
Monochlorophenols	7 $\mu g \cdot L^{-1}$
Dichlorophenols	0.2 $\mu g \cdot L^{-1}$
Trichlorophenols	18 $\mu g \cdot L^{-1}$
Tetrachlorophenols	1 $\mu g \cdot L^{-1}$
Pentachlorophenol	0.5 $\mu g \cdot L^{-1}$
DDT	1 $ng \cdot L^{-1}$
Dinitrotoluenes	ID
Diphenylhydrazine	ID
Endosulfan	0.02 $\mu g \cdot L^{-1}$
Endrin	2.3 $ng \cdot L^{-1}$
Ethylbenzene[3]	0.7 $mg \cdot L^{-1}$
Halogenated ethers	ID
Heptachlor + Heptachlor epoxide	0.01 $\mu g \cdot L^{-1}$
Hexachlorobutadiene	0.1 $\mu g \cdot L^{-1}$
Hexachlorocyclohexane isomers	0.01 $\mu g \cdot L^{-1}$
Hexachlorocyclopentadiene	ID
Phenols (total)	1 $\mu g \cdot L^{-1}$
Nitrobenzene	ID
Nitrophenols	ID
Phenoxy herbicides (2,4-D)	4.0 $\mu g \cdot L^{-1}$
Phthalate esters	
DBP	4 $\mu g \cdot L^{-1}$
DEHP	0.6 $\mu g \cdot L^{-1}$
Other phthalate esters	0.2 $\mu g \cdot L^{-1}$
Polychlorinated biphenyls (total)	1 $ng \cdot L^{-1}$
Polycyclic aromatic hydrocarbons	ID
Toluene	0.3 $mg \cdot L^{-1}$
Toxaphene	8 $ng \cdot L^{-1}$

Appendix 7.Concentrations of major ions in surface water of study area







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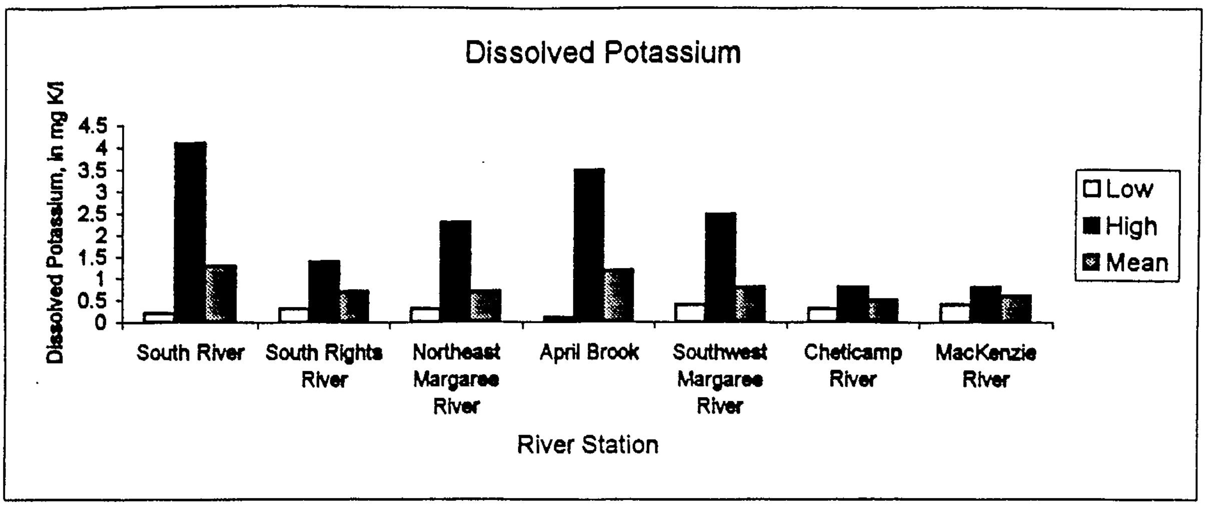

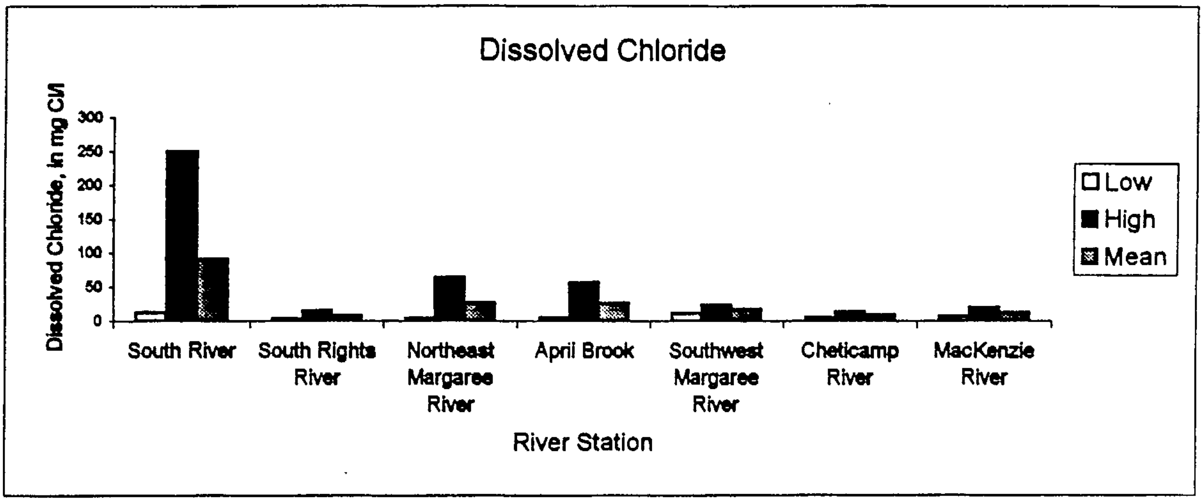

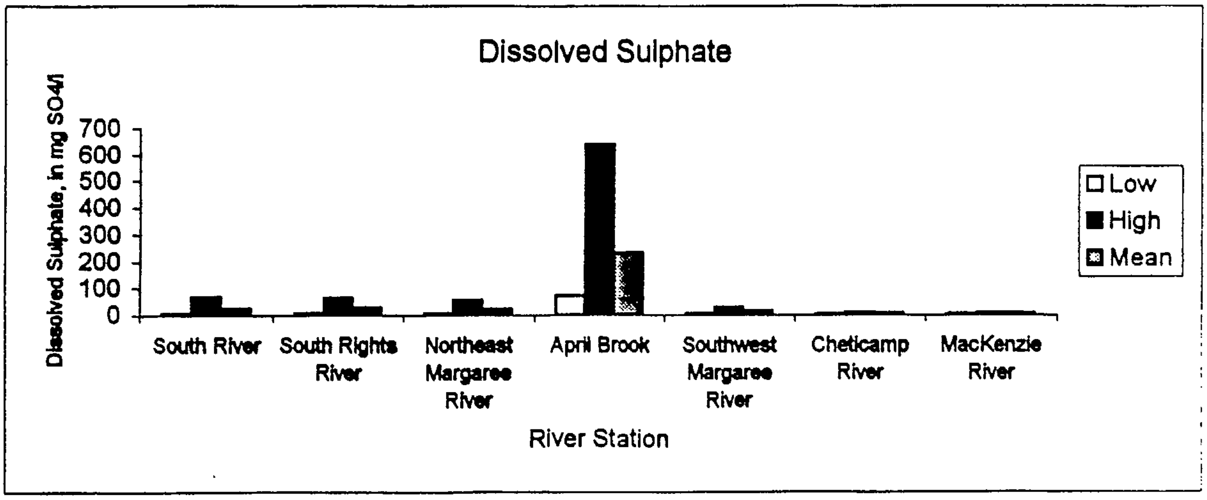

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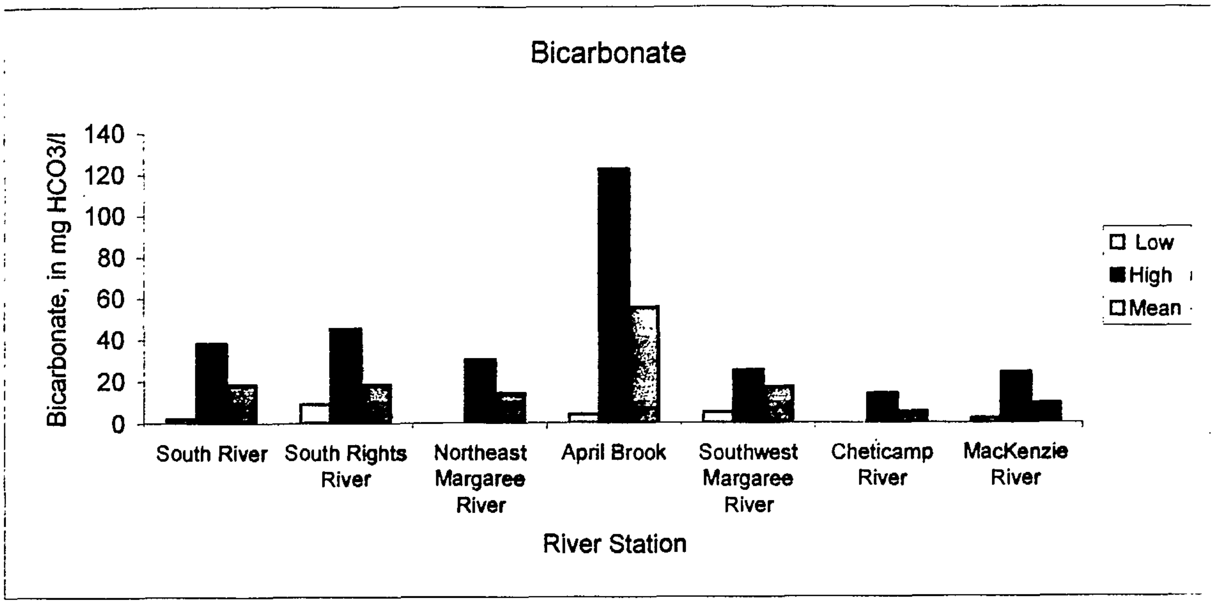
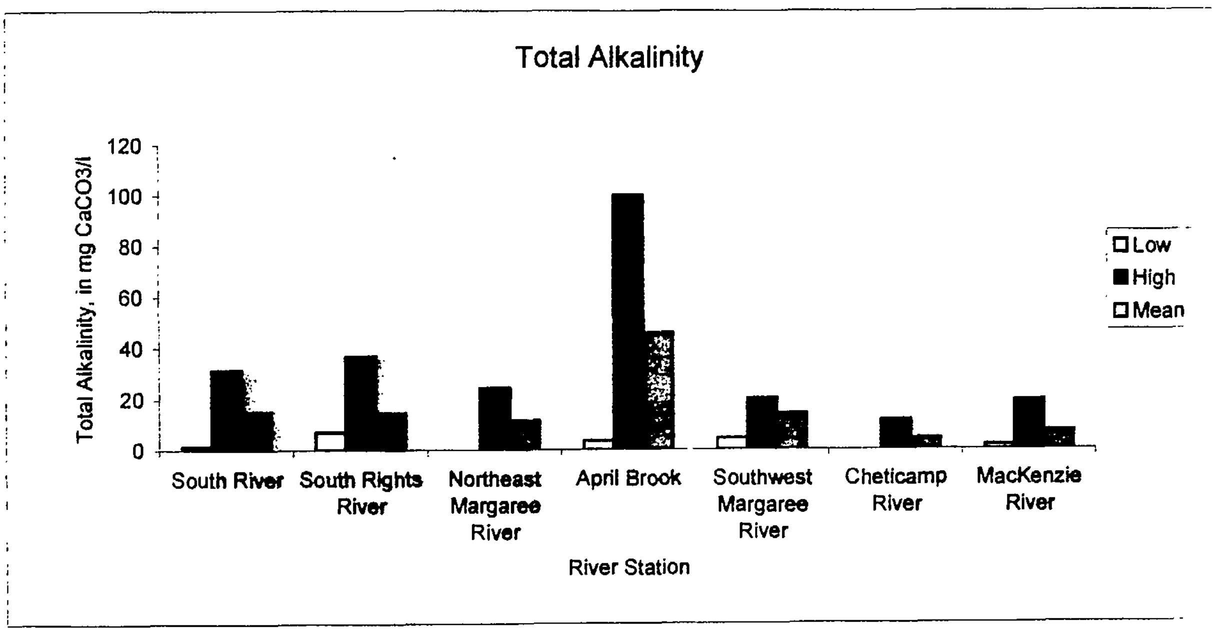
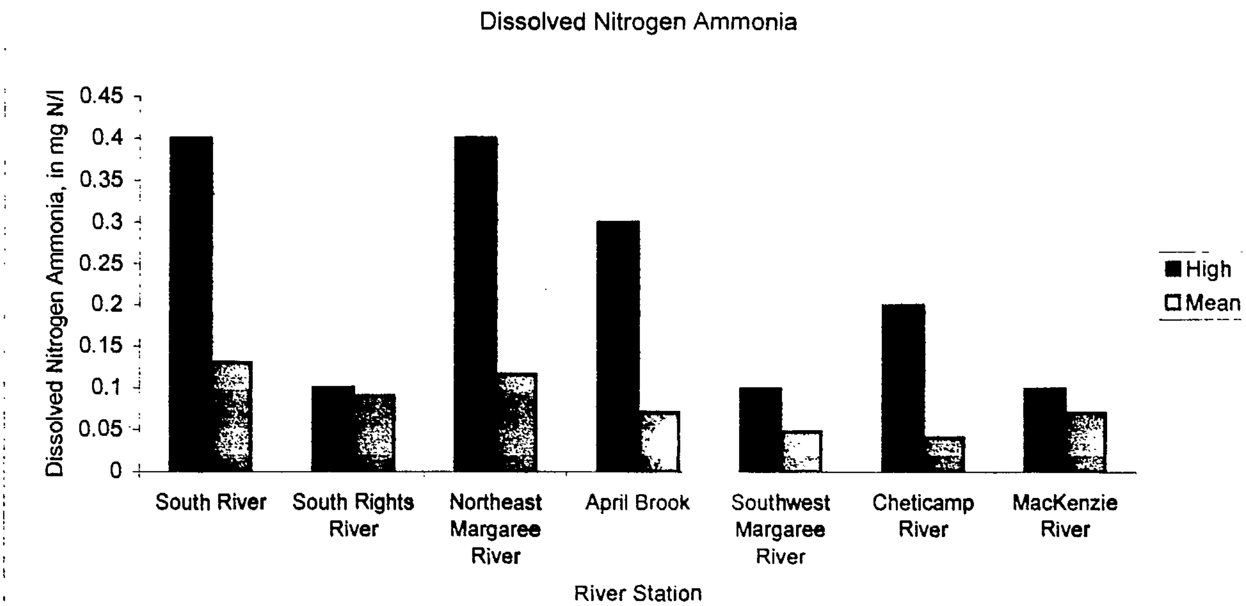
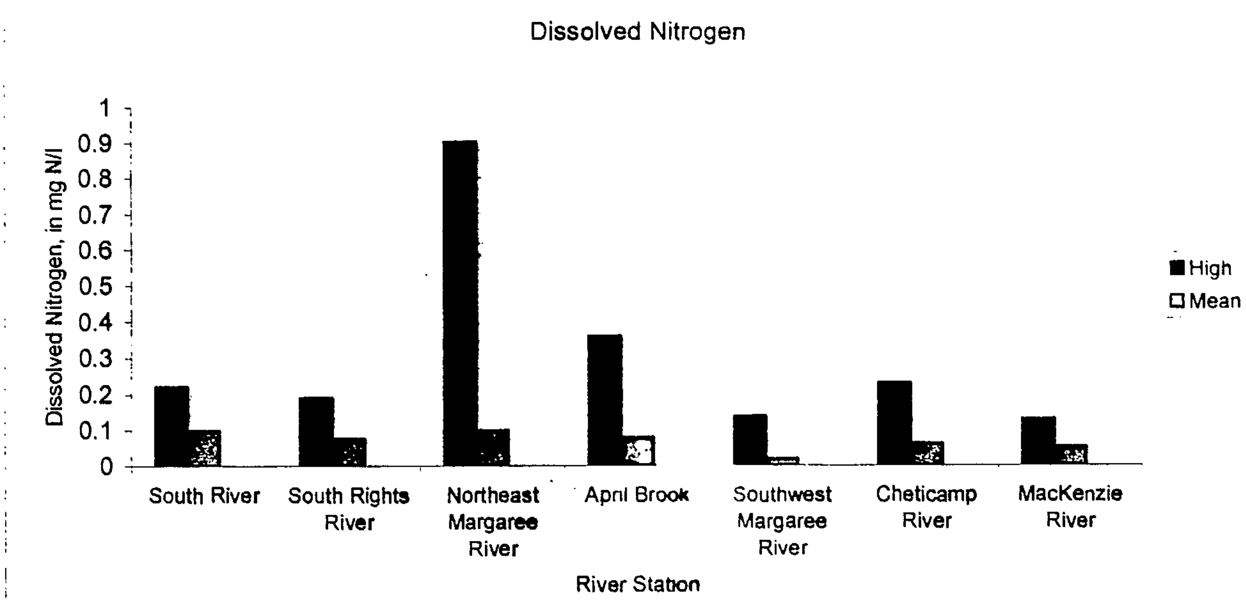




Appendix 8. Concentrations of nutrients in surface water of the study area watersheds





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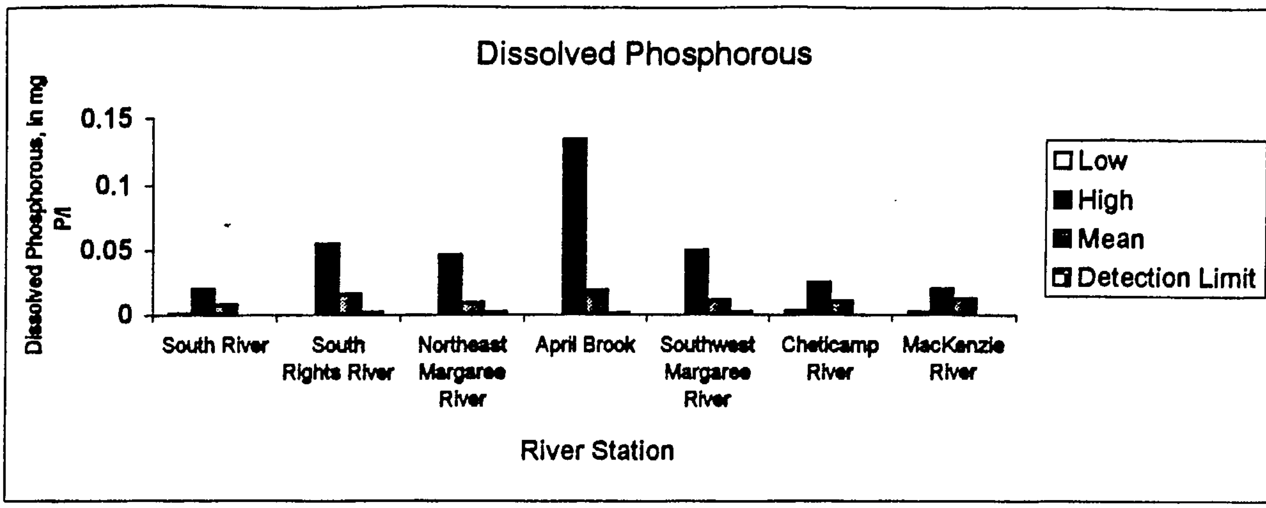
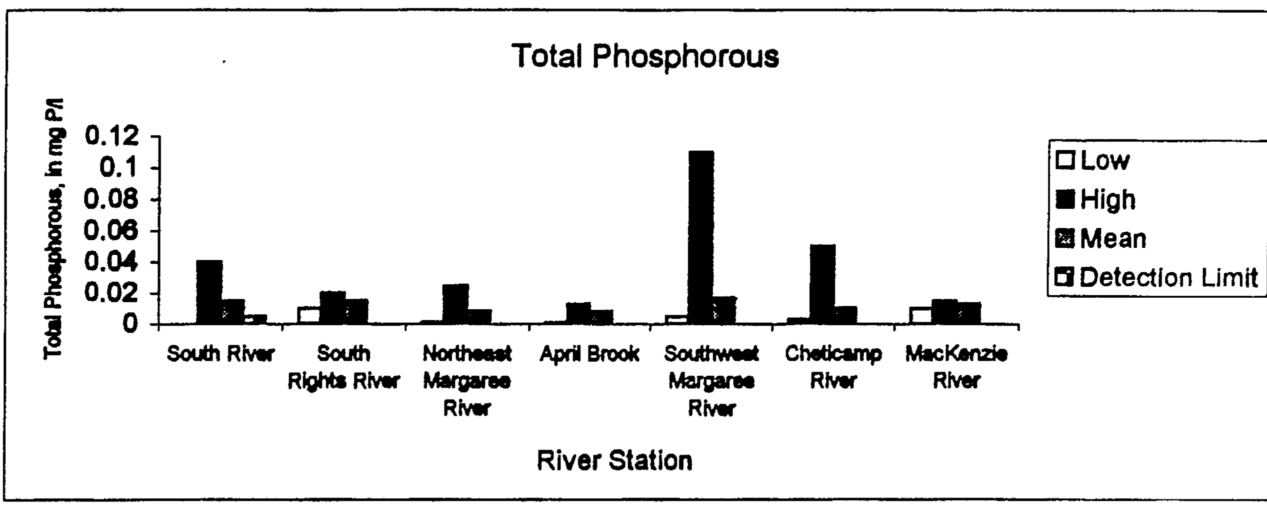
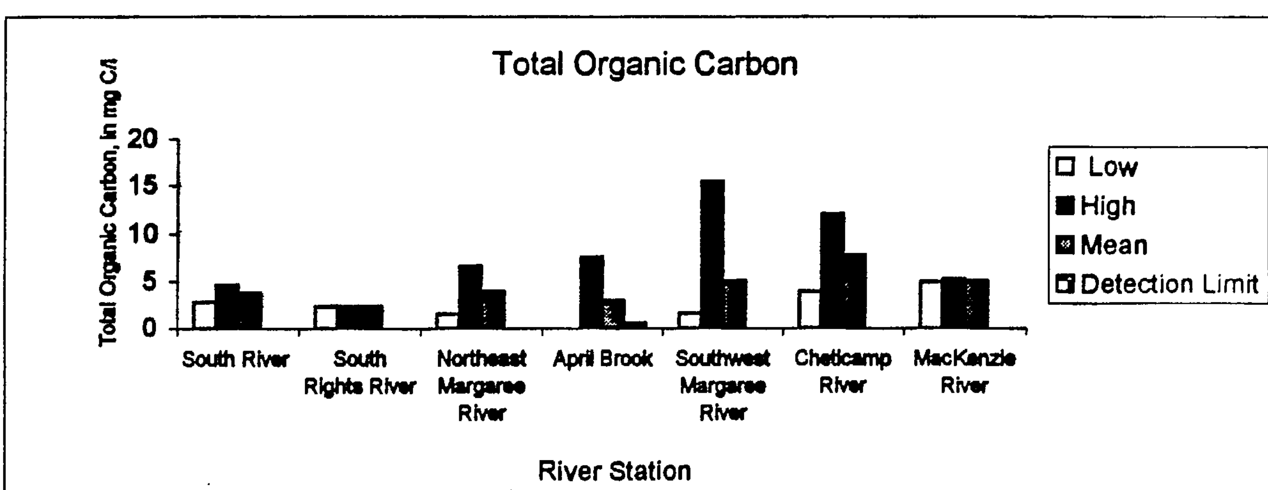
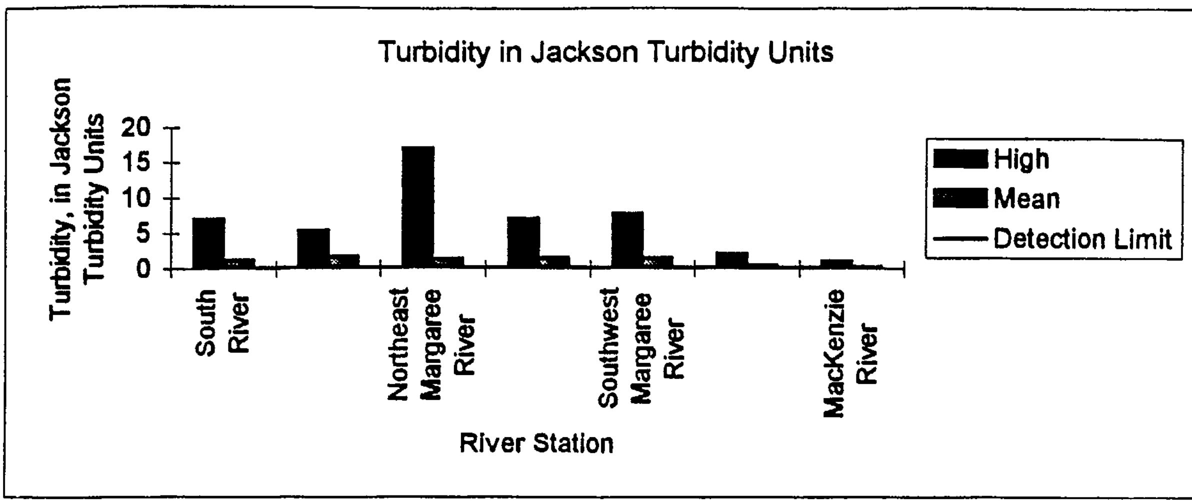
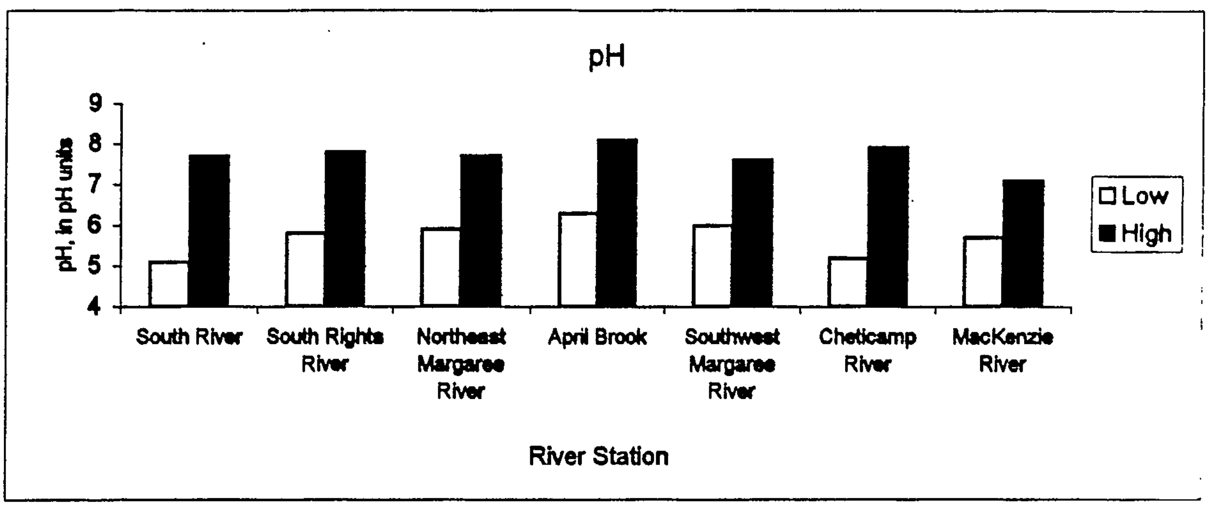


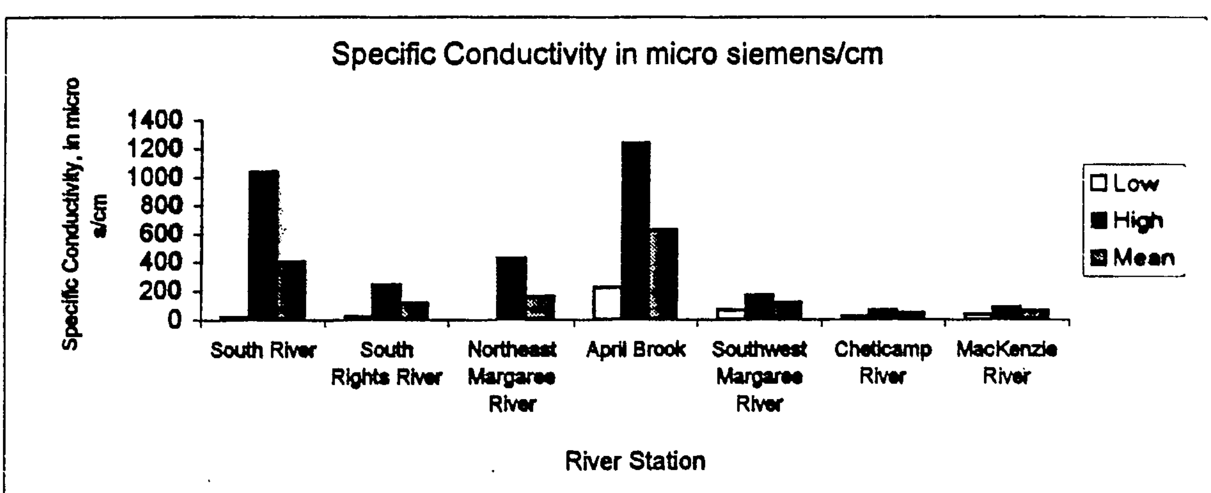




Appendix 9: Physical descriptors of surface water in study area







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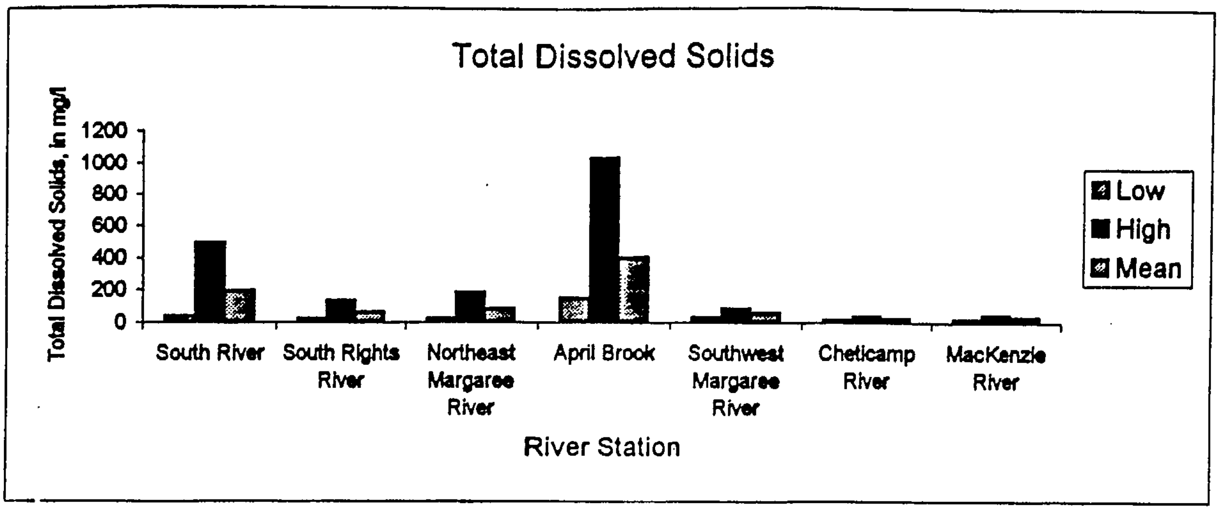
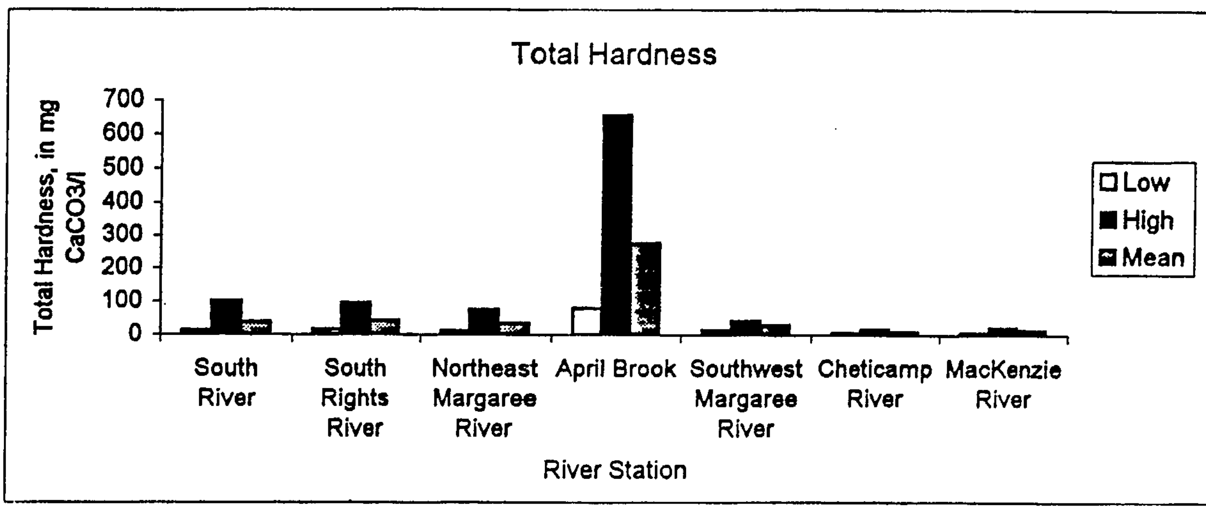
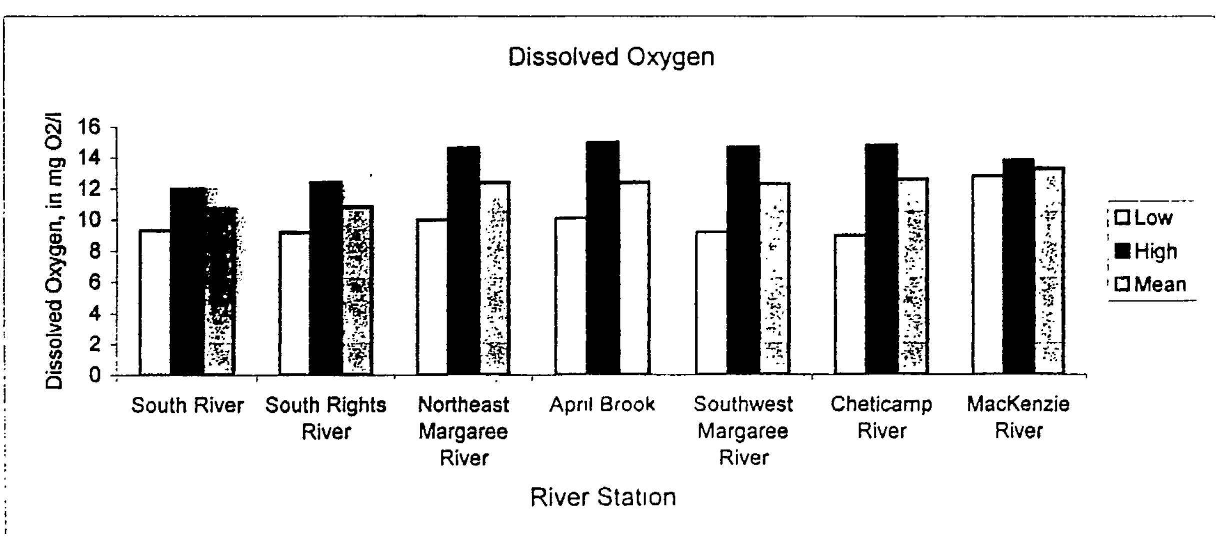
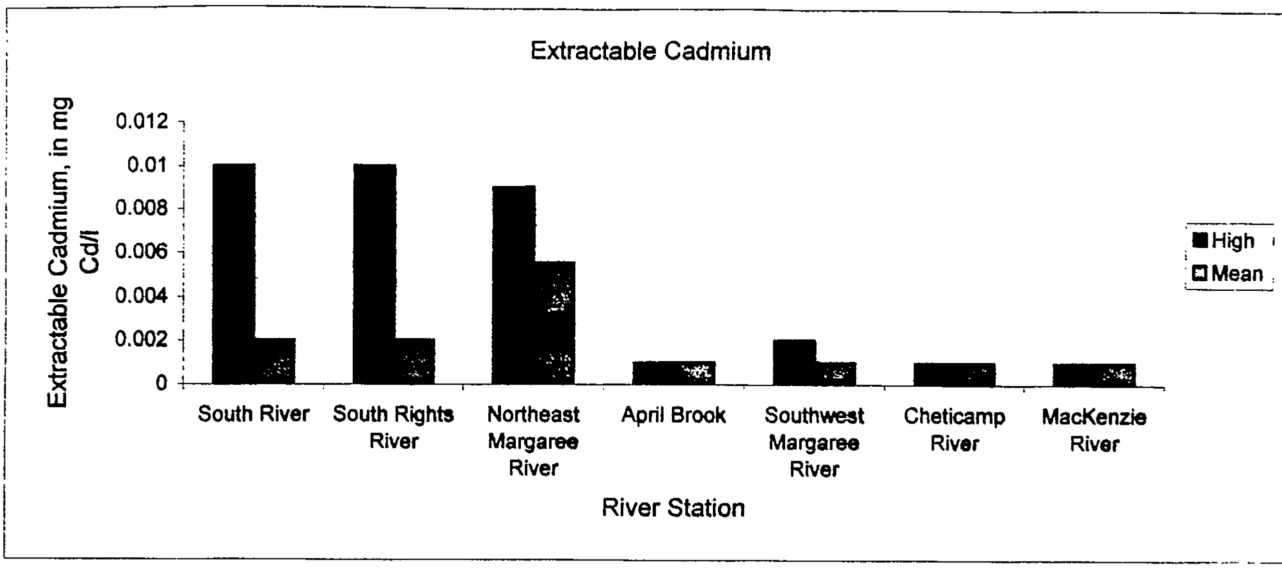
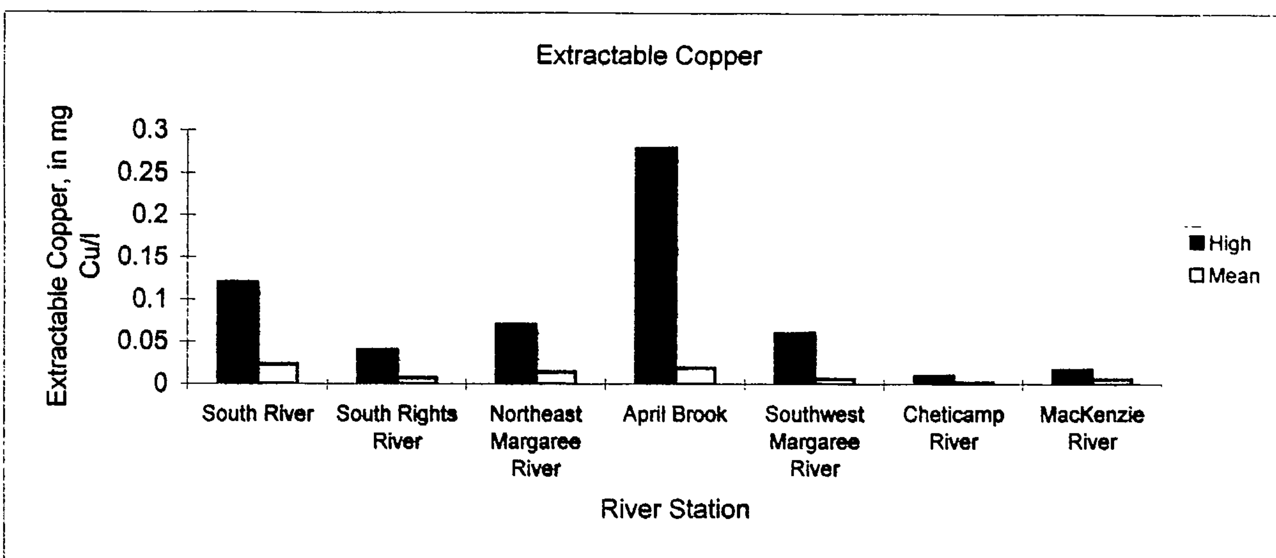


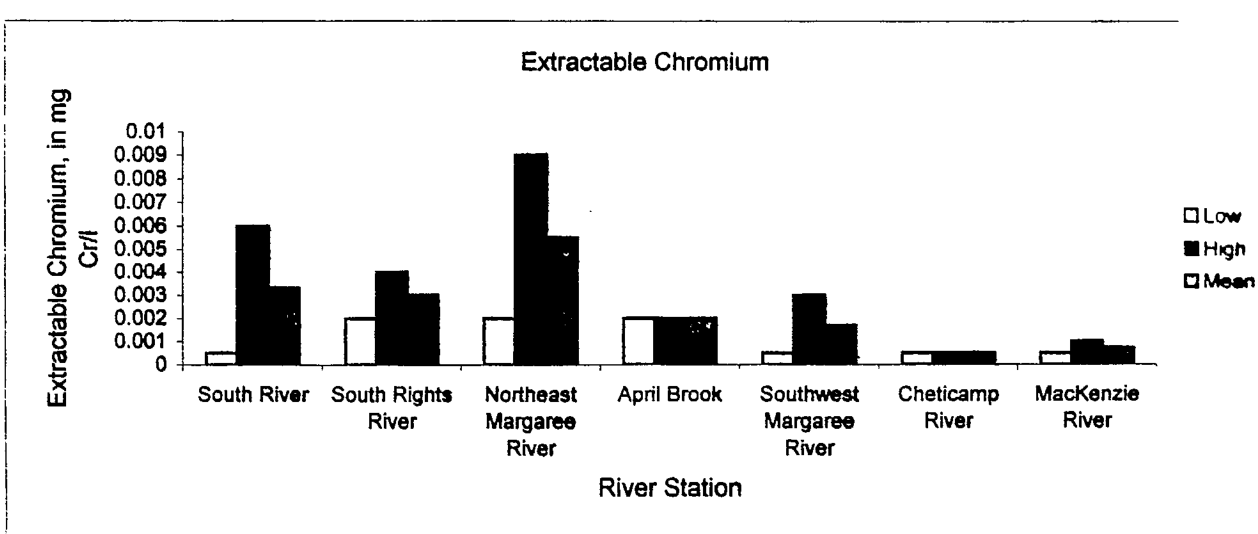




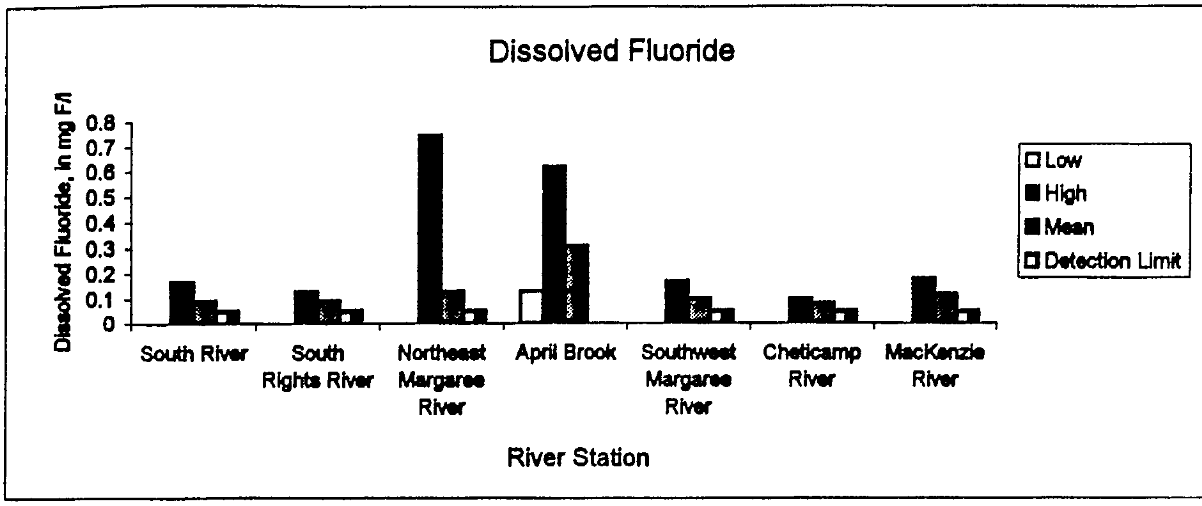
Appendix 10: Concentrations of metals and ions in surface waters of the study area.

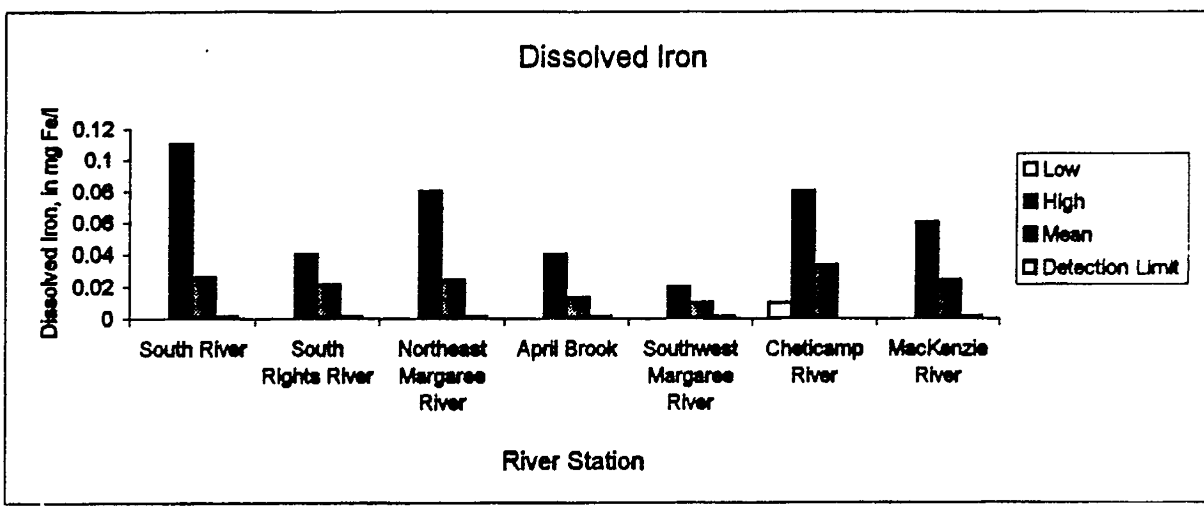


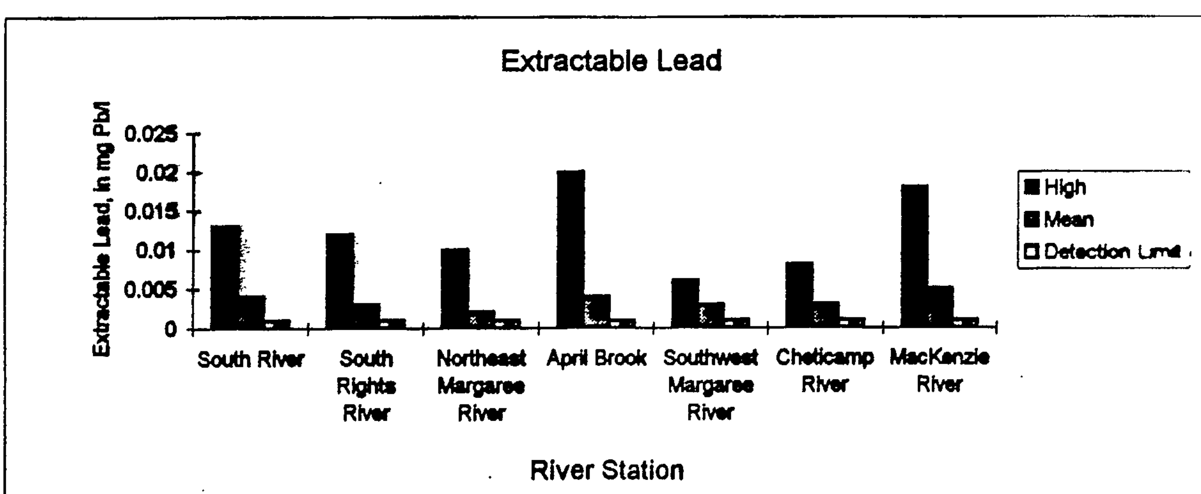




Appendix 10: (con't)







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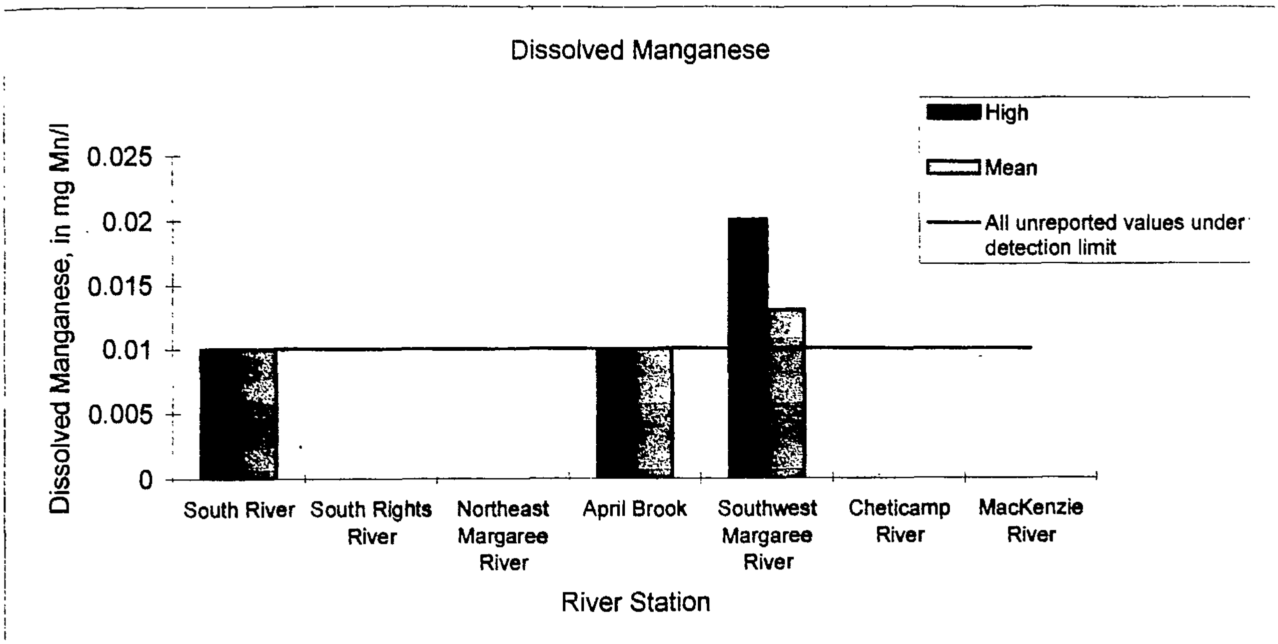

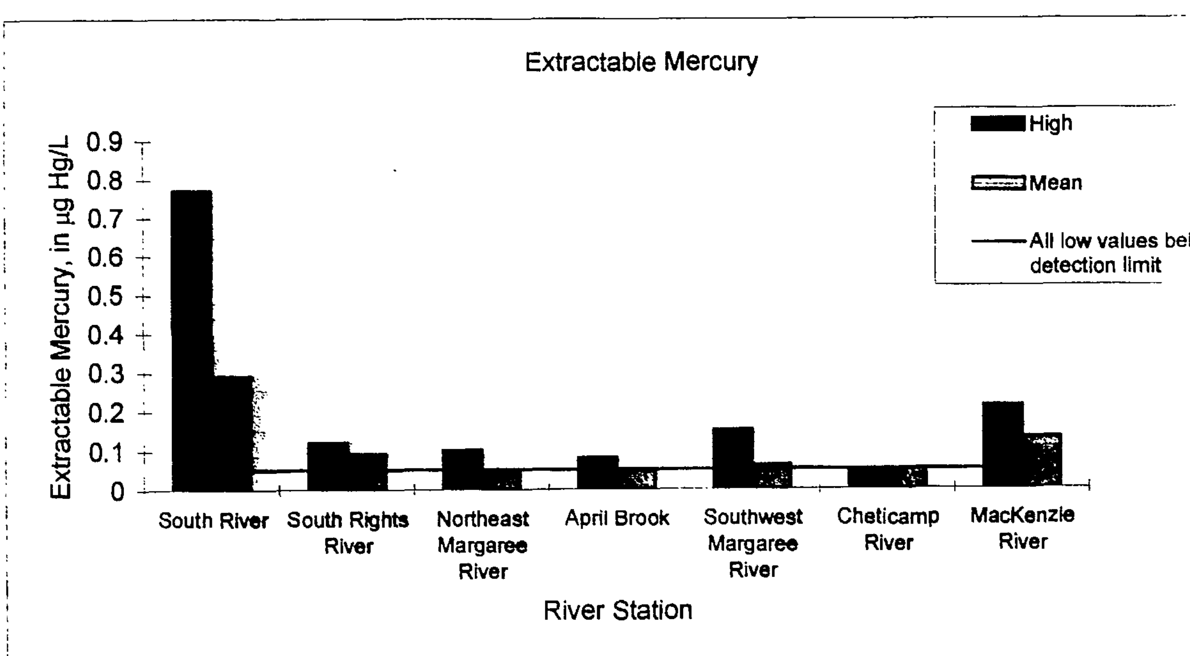

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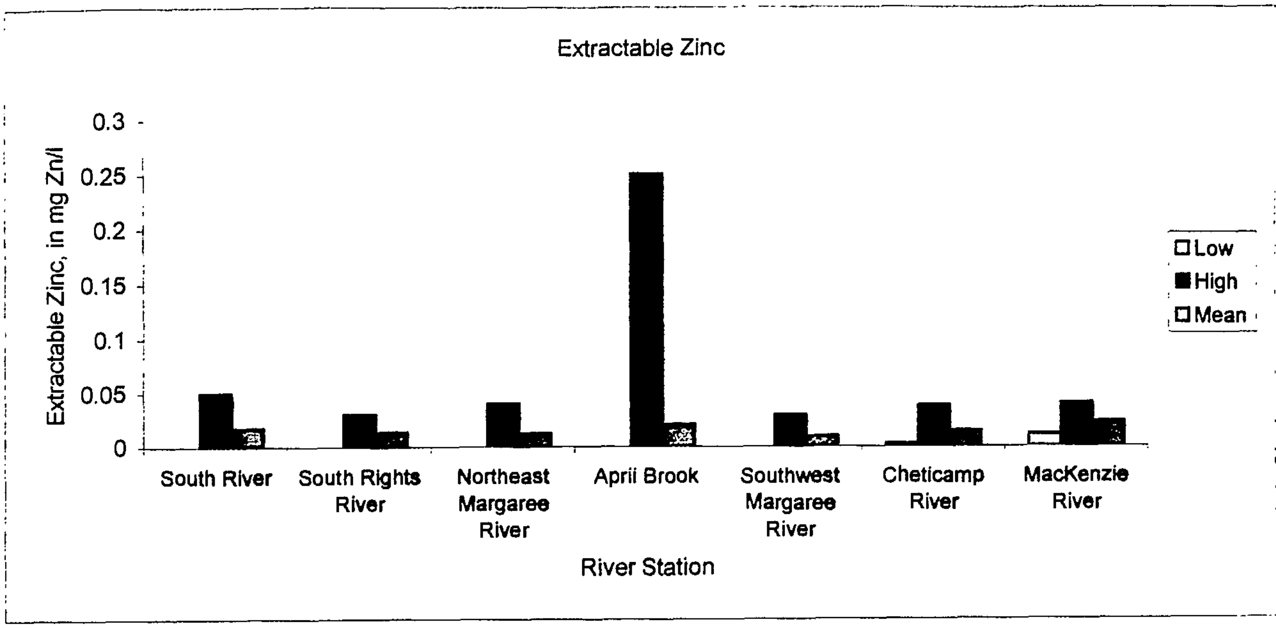

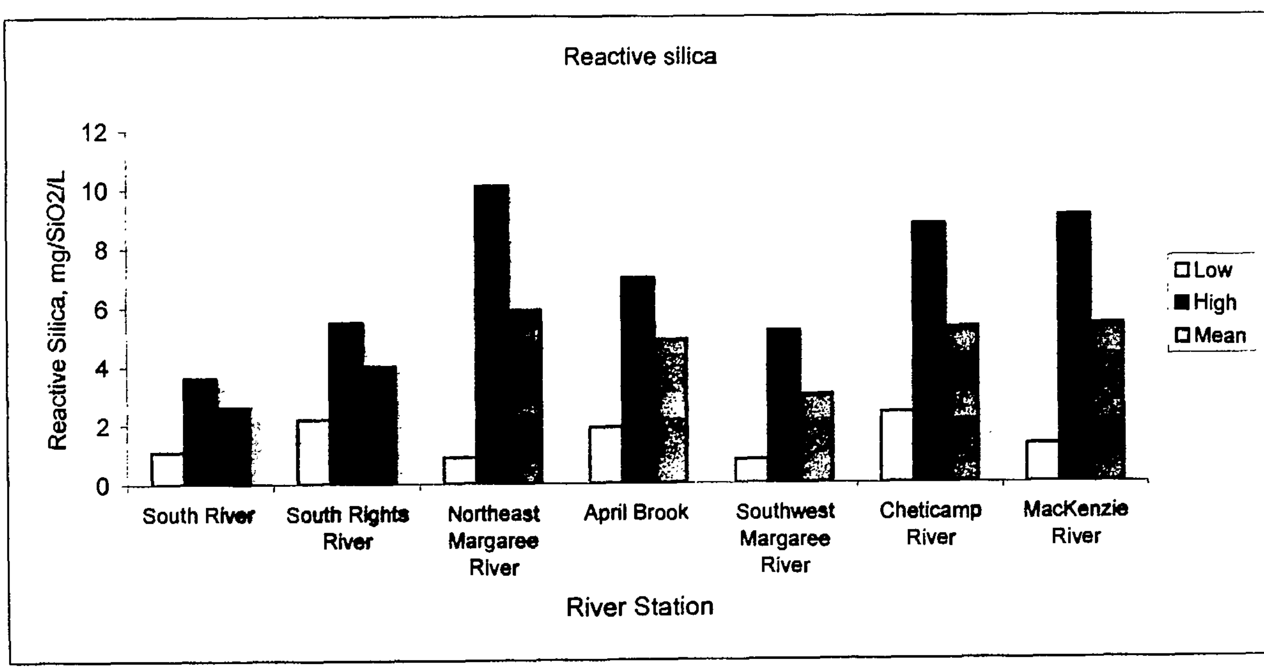

Appendix 11: Dredging cycles and volumes of harbours within St. Georges Bay study area.

SMALL CRAFT HARBOURS - MAINTENANCE DREDGING REQUIREMENTS

NO.	HARBOUR NAME	DREDGE LOCATION	DREDGE CYCLE	AVG. VOLUME (C.M.)	APPROX. COST PER PROJECT	DUMPSITE
1	BAILEYS BROOK	CHANNEL	1	4000	$ 28,000.00	PRIVATE LAND
2	ARISAIG	CHANNEL AND BASIN	3	2500	$ 20,000.00	PRIVATE LAND
3	LIVINGSTONES COVE	CHANNEL AND BASIN	1	1500	$ 15,000.00	PRIVATE LAND
4	BALLANTYNES COVE	BASIN	1	500	$ 3,500.00	PRIVATE LAND
5	CRIBBONS POINT	BASIN	1	500	$ 3,500 00	PRIVATE LAND
6	BAYFIELD	BASIN	10	1500	$ 15,000.00	PRIVATE LAND
7	BARRIOS BEACH	CHANNEL	10	15000	$ 200,000.00	OCEAN DISPOSAL
8	HAVRE BOUCHER		0	0	$ -	N/A
9	AULDS COVE	BASIN	5	1000	$ 9,000 00	PRIVATE LAND
10	JUDIQUE BAXTERS	CHANNEL AND BASIN	1	3000	$ 30,000 00	PRIVATE LAND
11	LITTLE JUDIQUE PONDS	BASIN	4	1000	$ 9,000 00	PRIVATE LAND
12	LITTLE JUDIQUE HARBOUR	CHANNEL AND BASIN	2	3000	$ 40,000.00	PRIVATE LAND
13	PORT HOOD	BASIN	5	1200	$ 10,000.00	PRIVATE LAND
14	PORT HOOD ISLAND		0	0	$ -	N/A
15	MURPHYS POND	CHANNEL AND BASIN	10	3000	$ 35,000 00	PRIVATE LAND
16	MABOU HARBOUR	CHANNEL	10	10000	$ 200,000.00	OCEAN DISPOSAL
17	FINLAY POINT	CHANNEL AND BASIN	3	1500	$ 15,000.00	PRIVATE LAND
18	INVERNESS	CHANNEL	3	7000	$ 72,000 00	DFO FEDERAL PROPERTY
19	BROAD COVE MARSH		0	0	$ -	N/A
20	MARGAREE	CHANNEL AND BASIN	5	2000	$ 14,000.00	PRIVATE LAND
21	GRAND ETANG	BASIN	5	1500	$ 12,000.00	PRIVATE LAND
22	CHETICAMP POINT	BASIN	6	1000	$ 9,000.00	PRIVATE LAND
23	CHETICAMP	CHANNEL	10	50000	$ 650,000.00	OCEAN DISPOSAL
24	PLEASANT BAY	CHANNEL AND BASIN	3	4000	$ 36,000.00	PRIVATE LAND

Appendix 12: Populations of communities with the St. Georges Bay study area, 1991 (Statistics Canada)

Afton	254	Margaree Forks	269
Brierly Brook	255	Margaree Valley	299
Tracadie	280	Pleasant Bay	334
Linwood	287	Port Hastings	362
North Grant	301	Grand Etang	384
Maryvale	313	Petit-Etang	394
St.Andrews	332	Mabou	412
Heatherton	357	Judique	444
Frankville	386	Plateau	460
Monastery	424	Port Hood	835
Greenwold	431	Cheticamp	979
Havre Boucher	481	Inverness	1,935
Pomquet	512		
Lower South River	652		
Antigonish	4,924		

Appendix 13: Abandoned and active landfills/waste diposal sites and sewage treatment facilities in the St. Georges Bay study area, 1998.

Study area abandoned landfill sites and dumps

Notes	Location
Dumping over steep embankment	Inverness Cabot St.
Coal tailings, iron staining	Inverness, Devco Mine
Possible drinking water well on site	Inverness, Mann Ave.
Small domestic dump	Route # 105
Crab processing plant on site, possible drilled well	Petit D'etang
Dumping over embankment	Marsh Brook Road
Possible monitoring wells on site l	Judique, Pig Cove
Large are should be gated	Port Hood Coal Mine
	Port Hood near Route #19
Dumping into river, rat problem in the past	Rankin Road near Mabou
PCBs, race track on site	Port Hastings, Barberton Road
Large dump	Antigonish, Brierly Brook
	Antigonish, College Road
Private use	Mattie Site
Municipal site	James River

Study area active solid waste disposal sites

Location	Notes
Beech Hill	
Kenloch	Municipal landfill (20 acres)
Pleasant Bay	County, Open dump (1 acre)

Municipality	Plant Address	Type	Size M^3/day	Receiving Water	Effluent Limits
Antigonish	Antigonish Town	Aerated Lagoon	3780	Wrights River	15/15 1000/100ml
Antigonish	Havre Boucher	Extended Aeration	265	Havre Boucher Harbour	30/30
Antigonish	Heatherton	Extended Aeration	142	Pomquet River	30/30
Antigonish	Lower South River	RBC	174	South River	20/20
Antigonish	St. Andrews	Extended Aeration	68	South River	20/20
Antigonish	Afton Reserve	RBC	79	Afton River	20/20
Antigonish	Ant. East H.S.	Extended Aeration	26	Tracadie River	
Antigonish	Tracadie Elem. School	Extended aeration	19	Tracadie Harbour	
Antigonish	Cove Motel	Extended Aeration		Strait of Canso	
Antigonish	North Grant Trailer Park	Extended Aeration	26		
Inverness	A&W, Port Hawkes. Motel	Extended Aeration	26	Strait of Canso	30/30
Inverness	Cheticamp	Oxidation Ditch	909	Cheticamp Harbour	30/30
Inverness	Duck Cove Inn	Underdrain Sand Fil	11	Margaree River	
Inverness	Inverness Village	Aerated Lagoons	909	Northumberland Strait	30/30
Inverness	Judique	Oxidation Ditch	73	Brook	5/5
Inverness	Mabou Village	Extended Aeration	227	Mabou Harbour	20/20
Inverness	Port Hastings	Contact Stabilization	159	Strait of Canso	30/30
Inverness	Port Hawkesbury Town	Trickling Filter	2240	Strait of Canso	60% BOD5 removal
Inverness	MacPuffin Motel	Extended Aeration	11	Strait of Canso	30/30
Inverness	Troy Lodge & Cottages	Extended Aeration	11	Strait of Canso	30/30
Inverness	Troy Trailer Park	Extended Aeration	57	Brook	
Inverness	Whycocomagh	Oxidation Ditch	655	Skye River	20/20
Inverness	Sealladh Breagh Gift Shop	Septic & Underdrain San	11	Margaree River	No limits specified
Inverness	Irving Mainway, Port Hastings	Facultative Lagoon		Strait of Canso	93% BOD removal
Inverness	Port Hood	Extended Aeration		St. Georges Bay	30/30 200/100ml

Appendix 14: Outdoor attraction and recreational activities in the St. Georges Bay Eosystem project study area.

National Parks	Cape Breton Highlands Natioanl Park
Provincial Parks	Arisaig Provincial Park Bayfield Provincial Park Beaver Mountain Provincial Park Pomquet Beach Provincial Park Mabou Provincial Park Port Hood Station Provincial Park Southwest Margaree Provincial Park Trout Brook Provincial Park Lake O'Law
Walking/Hiking Trails	Antigonish Landing Trail Beaver Mountain Provincial Park Fairmont Ridge Hiking Trail Cape Breton Highlands National Park (27 trails) Cape Mabou Highlands Cuties Hollow
Outdoor Adventure Tours	Turnstone Nature Tours, Antigonish Cape Breton Naturalist Tours, Grand Etang
Riding, Hay, Sleigh Rides	Cameron Farm Horseback Riding, Inverness Normaway Inn, Margaree Valley
Skiing (downhill)	Keppoch Mountain, Antigonish
Skiing (cross-country)	Antigonish Golf Club Beaver Mountain Provincial Park Cape Breton Highlands National Park Normaway Inn, Margaree Valley Ski Margaree valley
Snowmobile Clubs/Trails	Sno-dogs Snowmobile Club, Antigonish Alpine Snowmobile Club, Port Hood Highlands Snowmobile Club, Cheticamp Inverness Capers Snowmobile Club, Inverness
Golf Clubs	Antigonish Golf Club Le Portage Golf Club, Cheticamp

Appendix 14: (con't) Festivals and events through the year in communities in the St. Georges Bay Ecosystem project study area.

Month	Event	Location
February	Carnaval d'Hiver	Pomquet
May	Scottish Concerts	Mabou
	Merigomish & District Fire Department Lobster Supper	Lismore
June	Fishermens Lobster Picnic	Judique
	Fishermens Picnic	Mabou Harbour
	Fire Departments Ladies Auxiliary Lobster Dinner	Inverness
	Mabou Celidh	Mabou
July	Acadien & Scottish Concerts	Cheticamp
	Thursday Night Celidh	Inverness
	Adult Square Dances	South West Margaree
	Gaelic Singing	Margaree Harbour
	3 Fiddler Concert & Celidh Dances	Margaree Valley
	Highland Games	Antigonish
	Judique on the Floor Days	Judique
	Highland Games (Clan Sutherland)	Antigonish
	Lake Ainslie Heritage Festival	East Lake Ainslie
	Festival d'Art et d'Artisanat	Cheticamp
	Inverness Gathering	Inverness
	Belle Cote Days	Belle Cote
	Chestico Days Summer Festival	Port Hood
	Festival de l'Escaouette	Cheticamp
	Summer Festival	Margaree Forks
August	Stepdancing Festival	Port Hood
	Creignish Celidh by the Sea	Creignish
	Kintyre Farm Scottish Concert	Judique
September	Eastern Nova Scotia Exhibition	Antigonish
	Summer Fun Days at MacKinnon Campground	East lake Ainslie
	Cabot Trail Bicycle Tour	Cape Brteon Highlands
	Mabou Parish Bazaar	Mabou
	Feis Mhabu	Mabou

Appendix 14 (con't): Museums, theatres, and art galleries in the St. Georges Bay Ecosystem project study area.

Antigonish Heritage Museum	Antigonish
Festival Antigonish (*theatre*)	Antigonish
Augustinian Monastery	Monastery
Margaree Salmon Museum	North East Margaree
Margaree Bicentennial Museum	East Margaree
Marion Elizabeth Schooner Museum	Margaree Harbour
Ross House Studio	Margaree Harbour
Acadian Museum	Cheticamp
Dr. Elizabeth LeFort Gallery and Museum: Les Trois Pignons	Cheticamp