Road Map for Aquaculture Investment in Nova Scotia

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Executive Summary

The Nova Scotia aquaculture industry was valued at approximately $53 million in 2007, marking a 25% increase in reported value over the previous year and a 250% increase in value since 1997. Aquaculture has the potential to become a much larger industry in the province, providing direct employment and income, and indirectly supporting a number of local businesses, particularly in rural areas. In an effort to assist the sustainable and responsible expansion of the industry, this study provides an investigation into important marine aquaculture siting criteria and identifies suitable marine areas for the future development of nine key commercial aquaculture species. The results of this work will form a Road Map for Aquaculture Investment in Nova Scotia.

This study was based largely on consultations with key Nova Scotia aquaculture stakeholders (*i.e.,* industry members and scientists) in order to identify important criteria for marine aquaculture site selection; to identify existing data and sources of information related to those siting criteria; and to identify areas along Nova Scotia's coast that are thought to have suitable biophysical conditions for marine aquaculture development of various commercial species. The species considered in this assessment included Atlantic salmon, rainbow trout, blue mussel, American oyster, European oyster, bay scallop, sea scallop, Atlantic cod, and Atlantic halibut. The research focused exclusively on marine production of these species in suspended culture systems.

An extensive literature review was conducted on marine aquaculture siting criteria and of previous assessments of marine aquaculture suitability in Nova Scotia. In addition, focused interviews were conducted with key members of the Nova Scotia aquaculture industry and a 1.5 day workshop was held in Halifax with key industry stakeholders. The workshop discussed marine aquaculture siting criteria and the suitability of different regions of Nova Scotia for future development of the industry. The results from the literature review and stakeholder consultations were compiled and analysed to present: 1) a review of key siting criteria for marine aquaculture (Section 3); 2) assessments of regional biophysical conditions and aquaculture suitability across Nova Scotia (Section 4); and 3) a summary of regional species-specific aquaculture potential in Nova Scotia (Section 5). The results of the research and consultation are described in the context of seven distinct aquaculture regions that were defined for the purposes of this study. These regions include Upper Fundy, Fundy-Yarmouth, South Shore, Eastern Shore, Cape Breton, Bras d'Or, and the Gulf Shore.

Results of the study reveal that in Nova Scotia there is wide variability in climatic and oceanographic conditions around the coast. This phenomenon provides the province with an excellent opportunity to develop a diverse aquaculture sector, with good potential for producers of many different commercial species to develop new sites. Results of the study indicate that there is excellent potential for aquaculture development for at least one of the studied species in every region of the province, and several regions of the province have biophysical conditions that are well-suited to the development of multiple species.

Atlantic salmon and rainbow trout are currently the dominant commercial species in the province, and this study indicates that there are still a considerable number of areas with excellent biophysical conditions suitable for the expansion of salmon and trout farming in several parts of the province, particularly the Fundy-Yarmouth and South Shore regions. The ability to farm rainbow trout seasonally provides a distinct advantage for this species in regions with colder winter water temperatures, such as the Eastern Shore and Bras d'Or Lakes, and it is recommended that future work examine the seasonal product potential for this species.

Stakeholder consultation on shellfish culture in Nova Scotia suggests that there is tremendous potential to expand this sector of the industry in the future. The variable biophysical conditions around the province are well-suited to the culture of a large number of commercial shellfish species that have distinct biological requirements. With the exception of one or two regions of the province, there are excellent biophysical conditions for the culture of sea scallop and blue mussel province-wide, providing for a great range of opportunities for prospective shellfish aquaculture developers. Several different regions of the province were found to have good potential for American and European oysters, including the Gulf Shore and Fundy-Yarmouth regions in particular. Results of the stakeholder consultation also indicated that microclimates exist in various parts of the province that would be well-suited for culturing these species, including the Cape Breton region for American oyster and the Eastern Shore region for European oyster. Further research and exploration in these regions will help identify the locations of these microclimates.

One of the best opportunities for future marine aquaculture development in the province that was identified during the stakeholder consultation was the culture of bay scallop in the Northumberland Strait. While many of the marine waters elsewhere in the province are typically too cold for successful culture of this species, the warm summer waters of the Northumberland Strait could allow for the rearing of this species to market size in just one grow-out season.

Atlantic cod and Atlantic halibut are emerging commercial aquaculture species that could help diversify Nova Scotia's finfish production, and results of the study suggest that there are several areas in the province with suitable biophysical conditions for the marine culture of these species, including Fundy-Yarmouth, South Shore and the Eastern Shore. The ability of Atlantic cod to tolerate colder water temperatures than salmonids provides this species with a particular advantage in regions with colder winter water temperatures, such as the Eastern Shore. Stakeholder consultation indicates there are also areas with good biophysical potential for halibut culture in the Minas Basin.

The report concludes with recommendations on future work that is required to ensure that the Nova Scotia aquaculture industry capitalizes on the opportunities identified. Key steps include: the development of increased knowledge and dissemination of information on biophysical conditions in Nova Scotia, particularly at a regional scale; the further examination of socioeconomic conditions in Nova Scotia as they relate to aquaculture development; the assessment of additional barriers to expansion of the industry; and the examination of seasonal product potential and value-added products for various species.

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1.0 Introduction

This Final Report presents the results of a study on siting criteria and regional aquaculture suitability in Nova Scotia, with a focus on marine grow-out operations. The identification and description of siting criteria and suitable areas for aquaculture forms the basis of a Road Map for Aquaculture Investment in Nova Scotia. The study was prepared by Jacques Whitford Stantec Limited for the Nova Scotia Department of Fisheries and Aquaculture (NSDFA).

1.1 AQUACULTURE IN NOVA SCOTIA

Aquaculture is a relatively young industry in Nova Scotia compared to other more established resource-based industries. Aquaculture makes an important contribution to Nova Scotia's economy, particularly in rural areas, and has the potential for further growth. In 2007, the aquaculture industry in Nova Scotia produced 10.2 million kilograms (kg) of food, for a total value of almost $53 million. This marks a 25% increase in reported value over the previous year and a 250% increase in value since 1997 (NSDFA 2009).

Atlantic salmon and rainbow trout raised to market size in the marine environment currently account for approximately 68% of the total farm sales in Nova Scotia. In 2007, blue mussel growers generated $3.5 million in sales from a production of 2.5 million kg, American oyster growers reported $820,000 in sales, and bay quahaug farmers had sales of $400,000 in 2007 (NSDFA 2009). Several species grown in Nova Scotia are raised by three or fewer producers and production statistics for these companies are kept confidential. In 2007, this confidential category amounted to $7.8 million in sales and included Atlantic cod, Atlantic halibut, Arctic char, soft shell clams and marine plants, among others (NSDFA 2009).

1.2 NEED FOR A ROAD MAP FOR AQUACULTURE INVESTMENT

The NSDFA is the lead provincial agency in the development and regulation of Nova Scotia's aquaculture industry. An important part of this role is to permit and approve new aquaculture sites to increase sector growth. Aquaculture has the potential to become a larger industry in the province, providing direct employment and income, and indirectly supporting a number of local businesses, particularly in rural areas; however, the future growth of the marine aquaculture industry in Nova Scotia is ultimately constrained by the availability of suitable sites.

The identification of a suitable marine site involves the assessment of a number of criteria. Local physical and biological conditions must meet the biological requirements of the species in questions and be suitable for the preferred culture technology. Access to infrastructure necessary to support the business must also be available, including wharves, roads, and processing facilities. Aquaculture is one of many activities that depend on and occur within Nova Scotia's coastal zone and the potential for conflict with other users is often perceived to be high. Human leisure and recreational activities often occur in areas with similar characteristics to those desired by aquaculturists – shelter from weather and wave action, warm uncontaminated water, and undeveloped isolated areas (*e.g.,* Cook 1984). As such, potential conflicts with other resource users must be assessed during site selection.

In order for the NSDFA to provide sound advice to investors on suitable locations of future aquaculture development, there must be a clear understanding of the important criteria for aquaculture site selection, and an identification of where those criteria are met or maximized in the coastal zone around the province. A defensible process to identify areas that are likely suitable for aquaculture development will not eliminate conflicts or controversy with other resource users; however, it will assist with more focused site selection and more informed dialogue among stakeholders. In order to expand in a sustainable and responsible manner, an investigation into important siting criteria and suitable marine areas is required to facilitate and enhance future growth, leading to an overall Road Map for Aquaculture Investment.

1.3 USE OF THIS STUDY

The Road Map for Aquaculture Investment reflects the most relevant biophysical, infrastructure and shared-use information (criteria) that may be used in marine aquaculture site selection. The NSDFA believes that a Road Map for Aquaculture Investment based on industry stakeholder knowledge and identification of important criteria for site development will be a valuable tool to assist in the expansion of the aquaculture industry.

The purpose of this study is for the NSDFA to learn from the aquaculture industry and scientific experts regarding siting considerations for future aquaculture development in the province. This information will then be made available to industry, other investors, and the public to facilitate the growth of the sector. The specific objectives of this study include:

- Identification and validation of marine aquaculture siting criteria;
- Identification of data sources related to the characterization of siting criteria;
- Identification of suitable areas for future aquaculture development along Nova Scotia's coastline; and
- Further development of the collaborative working relationship between the NSDFA and aquaculture stakeholders.

The Road Map for Aquaculture Investment will focus on the following species:

- Atlantic salmon - *Salmo salar;*
- rainbow trout (Steelhead) - *Oncorhynchus mykiss*;
- blue mussels - *Mytilus edulis*;
- American oyster - *Crassostrea virginica*;
- European oyster – *Ostrea edulis*;
- bay scallops - *Argopecten irradians*;
- sea scallops - *Placopecten magellanicus*;
- Atlantic cod - *Gadus morhua*; and
- Atlantic halibut - *Hippoglossus hippoglossus*.

The focus of the present study is on marine grow-out for key commercial species. Opportunities for land-based production, including hatcheries, freshwater production, and land-based tank systems, have not been assessed. Strictly bottom-culture species, such as clams and quahaugs, have also been excluded from the analysis, which is focused on species that are typically cultured in marine suspension systems.

This study is intended for use by the NSDFA, the aquaculture industry and other investors. It confirms important siting criteria for each of the above species and identifies marine areas believed suitable for grow-out operations. This study is not a detailed investigation of site-level conditions, nor does it speak to the feasibility of individual aquaculture operations. This study is not intended to be used for environmental assessment or permitting purposes, but rather as a strategic-level guide for future development of the industry. This study is not intended to preclude aquaculture development in any region of the province. Further consideration of site-specific conditions, including biophysical and socioeconomic conditions, is still required to inform decisions on new site development.

2.0 ASSESSMENT OF SUITABILITY FOR AQUACULTURE DEVELOPMENT

2.1 SUITABILITY ASSESSMENTS IN OTHER JURISDICTIONS

The identification and availability of suitable sites is a constraint faced by marine aquaculture developers worldwide. Different geographic regions possess a range of biophysical and socioeconomic conditions that favour particular species or forms of aquaculture. Efforts have been made in other jurisdictions beyond Nova Scotia to determine the overall suitability of particular geographic regions for different types of aquaculture development. The following is a brief review of some methods employed in other jurisdictions.

2.1.1 LENKA

A nationwide assessment on the suitability of Norway's coastal zone and rivers for aquaculture was conducted in the 1990s, an initiative referred to as LENKA (Ibrekk *et al.* 1993). This assessment was most applicable to salmon or trout farming in marine net-pens. A high degree of importance was placed on geographic mapping in the LENKA study, and a model was used to estimate carrying capacity of particular marine areas for fish production.

LENKA excluded zones of no interest, such as areas currently being used for other purposes. Important categories for existing use included operational fish farms, temporary protection zones for salmonids, nature conservation areas, defense areas, and areas earmarked by local authority planning procedures.

The study focused on four categories of siting considerations:

- Environment (*e.g.*, wave exposure, shallow areas, areas with critical temperatures, icing conditions, salinity, pollution);
- Current use (*e.g.*, housing, outdoor recreation, traditional fishing);
- Infrastructure (*e.g.*, road and electrical development, feed manufacture, slaughtering facilities, hazardous waste disposal facilities); and
- Special areas (*e.g.*, existing fish farms, protection zones, nature conservation areas).

LENKA divided the coast into three zones based on holding capacity (*i.e.,* ability to tolerate pollution loading), which was defined to be dependent upon annual water exchange rates derived from topographic information. The main existing factors that affect loading considered by the model were: sewage; agriculture; industry; natural background runoff; precipitation directly to the sea; and existing aquaculture permits.

Of note, LENKA lists the following characteristics that make aquaculture impossible or very risky:

- Critical exposure *(i.e.,* areas with wave heights over 2 m);

- Shallow areas (*i.e.,* depths less than 20 m, except in sounds/straights with strong currents);
- Critical temperatures (*i.e.,* ocean temperatures below 0° C for more than six weeks, at least once every five years);
- Freezing (*i.e.,* areas that are iced over at least once every fifth winter);
- Critical salinity (*i.e.,* areas whose salinity occasionally falls below 10 ppt); and
- Pollution.

2.1.2 Offshore Aquaculture Site Selection in Ireland

In 2004, a study of offshore aquaculture potential in Ireland was published and included details of a site selection exercise that was conducted to identify offshore sites with the potential for development (Watson and Drumm 2007). The exercise consisted of desk-top research, with no field work or primary data collection. Forty-six potential offshore sites were initially selected based on a minimum depth of 20 metres and according to the level of protection from exposure to wind and waves. These initial 46 sites were reduced to 15 based on proximity to landing facilities and proximity to protected areas. The list of potential sites was then reduced to 5 based on wave climate data in conjunction with the other criteria that were previously assessed. The final 5 proposed sites were each several square miles in size and were selected as priority areas for further detailed study to determine where to best locate fish farms. In addition to the parameters highlighted above, several other parameters were considered in the site selection exercise. Criteria considered included:

- Depth (minimum 20 m);
- Exposure;
- Proximity to landing facilities;
- Proximity to protected areas;
- Wave climate;
- Maximum current speed;
- Minimum and maximum temperature;
- Harmful algal bloom risk; and
- Heritage status.

2.1.3 Development of Open Ocean Aquaculture in the Bay of Fundy

In 2005, researchers at Fisheries and Oceans Canada in St. Andrews, New Brunswick conducted a constraint-mapping exercise to determine the availability of suitable sites for open ocean salmon culture in the Bay of Fundy (Chang *et al*. 2005). According to the study, the rationale for moving to open ocean salmon culture is that there are few or no remaining sheltered inshore sites for further expansion of the salmon farming industry in southwestern New Brunswick, and it has been suggested that some inshore sites be removed in order to improve fish health and environmental management in some bays.

The parameters used to model existing conditions in the Bay of Fundy and to determine where potentially suitable open ocean sites exist included:

- Physical environment (temperature, depth, tides, current speed, wave climate, circulation patterns);
- Existing aquaculture sites (zone of potential influence of 5 km-radius circle applied to each existing site based on tidal excursion and potential for spread of disease between farms, identification of areas designated as exclusion zones for new aquaculture development);
- Ship traffic (commercial shipping lanes, anchorages, ferry tracks);
- Commercial fisheries (geo-referenced fishing data, identification of valued habitat/spawning areas);
- Ecologically sensitive species (whales, wild Atlantic salmon, seabirds); and
- Marine protected areas.

Results of the constraint-mapping exercise revealed that there are virtually no areas in the Bay of Fundy where there were no current uses of marine resources; however, it was noted that the presence of a potential usage should not necessarily preclude the possibility of aquaculture sties, but that coastal zone managers should try to reduce conflict within areas of overlap. Some of the activities identified in the constraint mapping exercise are able to co-exist with aquaculture to some degree (*e.g.,* fishing). The authors noted that it would be advisable to avoid situating aquaculture in areas which are known to be critical habitats, such as important spawning or nursery areas for fish.

2.2 PREVIOUS AREA SUITABILITY ASSESSMENTS IN NOVA SCOTIA

A number of aquaculture suitability studies have been conducted in Nova Scotia, ranging from assessments of specific inlets and bays to determine overall aquaculture potential, to province-wide assessments of potential for a particular species. Key results from these studies have been integral to the present analysis, and discussion of results from these studies is included throughout this report, including details of the criteria used to judge suitability. This section provides a brief introduction to some of the key suitability studies that have been conducted in the province to date.

Identification of Potential Sea Scallop Culture Sites in the Nearshore Waters of Nova Scotia

This study was conducted by MacLaren Plansearch Limited (1986) and concentrated on nearshore areas (up to 12 nautical miles) for bottom grow-out locations of sea scallop. The study was based on available literature and databases with no fieldwork or primary data collection. Potentially suitable areas along the coast of Nova Scotia were mapped at a scale of 1:500,000. Suitability was classified for the coastal margin (area seaward from the shoreline for 3 nautical miles) and the outer coastal zone (3 to 12 nautical miles). Classifications of suitability were defined as suitable, possibly suitable, probably unsuitable, and unsuitable. Areas of inadequate information were not ranked. The province was divided into five regions for the purposes of the assessment, including: Northumberland Shore (New Brunswick coast to St. Georges Bay); Cape

Breton Island (St. Georges Bay to Chedabucto Bay); Eastern Shore (Cape Canso to Halifax Harbour); South Shore (Halifax to Yarmouth); and Bay of Fundy (Yarmouth to Minas Basin).

Coastal areas of Nova Scotia where the surficial sediments were dominated by silts or muds, or where the sediment load was easily resuspended, were considered to be unsuitable for culture. Locations where clean sand was abundant or areas of exposed bedrock were also determined to be unsuitable. A consensus was reached amongst experts interviewed that the presence of existing or historical scallop fishing grounds would likely indicate that the environmental conditions in that area were suitable for scallop culture unless substantial changes to the environment could be demonstrated (*e.g.*, the introduction of pollutants into a particular bay).

A Preliminary Assessment of Aquaculture Potential for Sea and Bay Scallop in the Annapolis Basin

In this study by Smith and Gaul (1988), bay and sea scallop were cultured at four stations in the Annapolis basin in order to evaluate spat collection and the potential for suspended culture of these species in the basin. Temperature and salinity data were collected over the course of the year-long study, in addition to recorded changes in shell height, survival rates, growth curves, and a discussion of the effects of location on these parameters.

In general, the study concluded that bay scallop perform best in the calmer, warmer waters of the head pond station relative to the more open, cooler waters in the western part of the basin. Sea scallop showed rapid growth and good survival rates throughout the basin; however, local sea scallop aquaculture was limited by the availability of spat within the Annapolis Basin at the time.

The Feasibility of Bay Scallop Culture in Nova Scotia: A Preliminary Study

In this study conducted by Mallet and Carver (1987), juvenile bay scallop were cultured in twelve sites along the coast and monitored for growth for four months, including five sampling trips. Temperature and salinity profiles were also taken at each site. The coastal sites included in the study were: Chance Harbour (Gulf Shore); Tracadie (Gulf Shore); Aulds Cove (Gulf Shore); Whitehead (Eastern Shore); Spanish Ship Bay (Eastern Shore); Ship Harbour (Eastern Shore); Ostrea Lake (Eastern Shore); Bedford Basin (Eastern Shore); Mahone Bay (South Shore); Port Medway (South Shore); Barrington Passage (Fundy-Yarmouth); and Argyle Head (Fundy-Yarmouth).

Substantial growth and survival were recorded, and suggested that bay scallop culture may be commercially feasible in certain areas of Nova Scotia, but that production strategies will depend on the ability of the bay scallop to overwinter. Results of the study revealed considerable variation in shell growth from location to location. Variation in growth among sites could not be related to any particular environmental characteristic. Temperature was closely correlated with growth rate, but temperature differences between sites were too small to account for the threefold difference in growth rates. The three sites with the poorest growth were those with the highest average sediment loading. In general, sites in this study with the lowest sediment loading were protected, deeper than 5 m, with rocky or packed sediment bottoms and low to

moderate river runoff. In general, sites on the Eastern Shore showed substantially higher growth rates than those on the Northumberland Strait and southern tip of the province. At the end of the study, longlines were sunk to a depth of 2 to 3 m off the bottom to test overwintering, and the highest mortalities were observed along the northern and eastern shores of the province.

Preliminary Survey of Marine and Estuarine Aquaculture Potential of Northern Nova Scotia

This study, conducted by David Scarratt and Associates (1993) for the Aquaculture Association of Nova Scotia, considered the potential for various species of finfish and shellfish in Northern Nova Scotia. The areas of study included coastal areas along the Mainland (Tidnish to Auld's Cove) and along Cape Breton Island from Long Pond to Petit Etang and Pleasant Bay. The study considered biophysical conditions, infrastructure, other resource users, market potential, government policy, as well as regional mapping and licensing.

The study generally concluded the culture of salmonids is limited in this area of the province due to lethal winter temperatures that drop below 0°C and due to shallow waters that preclude the use of net-pens. American oyster were shown to be native to the area under study, and able to survive winter and summer temperatures in the region. The challenge for American oyster culture in this region was identified as conflicts with wild oyster harvesters in the area. Blue mussels are also native to the area, and existing commercial and recreational harvest was identified. It was noted that there was clear potential for the culture of this species in the region. Results of the study also indicated that bay scallop have good potential in this region, largely because the species favours the warm fertile waters in the study area and because there is potential for harvest of market-ready bay scallop from a single growing season in this area.

Yarmouth County Aquaculture Site Identification Study

In this study, Muise and Associates (1993) conducted a survey of coastal inlets and harbours in Yarmouth County to identify all areas with potential for aquaculture production for a variety of finfish and shellfish species. Field studies were conducted to determine physical oceanographic conditions, including the collection of temperature and salinity data at 20 stations throughout the study area. Other factors considered in the analysis included local climatic conditions (wind and waves), as well as shellfish classification zones, exposure, and potential conflicts with the commercial lobster fishery. Twenty different coastal areas were assessed within the general areas of Pubnico Harbour, the inner and outer portions of Lobster Bay, the Tusket Islands, and Yarmouth Harbour.

In general the study identified significant potential for European oyster and surf clam, but concluded that the only immediate potential for finfish development was seasonal production of rainbow trout (due to lethal water temperatures in mid-winter). The region was found to have much of the necessary infrastructure required (boats, feed plants, processing and marketing skills, *etc.*) due to the major commercial fishing industry that has long been present in the region. The incidence of superchill throughout the study area, including the Tusket Islands, was found to

represent a significant risk to the farming of salmonids in the coastal waters of Yarmouth County. Temperatures were collected during the winter months to explore this phenomenon in more detail.

Estimate of Available Area, Production Capacity and Economic Value of Potential Aquaculture Development in Coastal Inlets in Three Nova Scotia Counties

This study, conducted by Murphy (1997), was designed to identify potential aquaculture development areas in subtidal waters greater than 5 m in depth in 44 inlets across Shelburne, Guysborough, and Richmond Counties and one inlet in Yarmouth County. Each county had an available Coastal Resource Information Atlas which was used to inform the study. The key parameters used in the assessment included: water depth, shellfish area classification, locations of wharves, breakwaters, and other fixed structures, ocean dumping sites, fish plants, sewage treatment plants, existing and pending aquaculture sites, traditional herring and mackerel net locations and eel trap locations, ferry crossings and navigation corridors. Baseline water quality parameters such as temperature, salinity and dissolved oxygen levels were not available in a comprehensive format for the study areas and were not considered.

For each harbour and inlet, estimates were provided on the total area available for finfish and shellfish culture, as well as estimates of the potential aquaculture areas that overlapped with fishing grounds. An estimated production capacity was calculated for each harbour and inlet based on the carrying capacity of the water body, and an annual production value was estimated based on the production capacity.

In general, the study concluded that over 3,700 ha of marine waters in the study area could have potential for aquaculture development. The majority of the suitable areas were found in Richmond and Guysborough counties. The study also concluded that available suitable area was the constraining factor for aquaculture development in these regions, and not the carrying capacity of the harbours and inlets. Potential conflicts with commercial fisheries and traditional fishing grounds, in particular lobster fisheries, were also frequently cited as potential limitations to aquaculture development in these regions, particularly in Shelburne County and Pubnico Harbour.

An Investigation of the Aquaculture Potential of the Bay Quahaug (*Mercenaria mercenaria*), the American Oyster (*Crassostrea virginicia*), and the Blue Mussel (*Mytilus edulis*) in Three Estuaries along the Northumberland Strait Coast of Nova Scotia

This study by Witherspoon (1984) was conducted to identify areas with potential for enhancing the abundance of wild and cultured shellfish stocks of oysters, quahaugs, and mussels. The study area included Wallace, Tatamagouche, and Fox Harbour, all of which are located in the Northumberland Strait in the southern part of the Gulf of St. Lawrence.

Within the results of the study, a detailed description of the physical and biological setting in the study areas was provided, including temperature, depth, and the effects on these species by predators, bacteriological contamination sources, and commercial fisheries. Recommendations were provided on strategies for enhancing the growth of these species in these particular areas.

Guysborough County Sustainable Aquaculture Initiative

A joint project was undertaken in 2001 to develop a coastal aquaculture planning tool for the Guysborough County Regional Development Authority (T. Balch, NSDFA, pers. comm. 2009). Partners in the project included federal and provincial government departments, aquaculture industry members, and private industry. The tool was designed to assist the aquaculture industry in sustainable site development and to inform coastal communities about aquaculture and provide a framework for coastal zone management. The study consisted of a constraint mapping exercise using GIS to identify areas for potential aquaculture site development. The constraint mapping was based on a range of criteria, including biophysical conditions such as temperature, salinity, depth, oxygen and turbidity, and other practical constraints such as navigation routes, parks, and closed areas. The data used to characterize the criteria were obtained from available government databases (*e.g.,* Fisheries and Oceans Canada, Environment Canada) and data gaps were filled by field studies which were used to collect information on water quality parameters and to take underwater video of the sea bottom. In addition to identifying potential sites for aquaculture development for a number of species of finfish and shellfish, the initiative was also designed to determine the carrying capacity of these areas (*i.e.,* what level of production could be sustainably harvested).

2.3 APPROACH FOR THE ROAD MAP FOR AQUACULTURE INVESTMENT

This study was based largely on consultations with aquaculture stakeholders (*i.e.,* industry members and scientists) in order to learn what are considered to be important criteria for aquaculture site selection; to identify existing data and sources of information related to siting criteria; and to identify areas along Nova Scotia's coast that are likely suitable for aquaculture development for various species. The scope of this project did not allow for more detailed assessments, such as those described in Section 2.2, nor did it allow for detailed constraint mapping (as in Chang *et al.* 2005) or assessment of carrying capacity along the coast (as in Ibrekk *et al.* 1993). The following methods were used in the completion of this study.

2.3.1 Identification and Validation of Siting Criteria

Literature Review

A literature review was completed that included peer-reviewed technical articles, government documents and "grey" literature that was readily available. The literature review focused on general siting criteria used in other Canadian provinces and in other leading aquaculture producing countries, as well as a series of publications issued by the NSDFA in 1992 (the Aquaculture Development Planning Reports), which included discussions of key siting parameters for major commercial species. Methods that have been used to assess a coastal zone's capacity for aquaculture development and species-specific culture requirements were also researched, including studies from other jurisdictions and previous studies within Nova Scotia.

Stakeholder Consultation

Nova Scotia aquaculture industry stakeholders, representing a wide range of aquaculture interests (*i.e.,* industry, government and academia), were interviewed. Interviews were conducted by phone and in-person, using a semi-structured interview guide (see Appendix A). A total of 29 stakeholders were contacted and a total of 15 interviews were completed. The primary focus of these interviews was to discuss siting criteria for each of the key species of interest.

Stakeholder Workshop

A 1.5 day workshop was held in Halifax with an initial invitation list of approximately 50 industry stakeholders. A consultation plan was developed for the workshop, complete with agenda and workbook. The consultation plan defined the approach for the workshop, and included:

- Articulation of workshop goals;
- Presentation on findings of research;
- Validation of research findings and identification of remaining gaps;
- Discussion and adoption of siting criteria;
- Application of criteria to identify areas suitable for marine aquaculture; and
- Discussion of data and information availability with regard to identified siting criteria and suitable marine areas.

The workshop incorporated facilitated discussions, participant workbooks, and active GIS mapping in order to capture information and meet workshop objectives. Results from the workshop are summarized in Section 3.2.2.

2.3.2 Identification of Information and Data Sources Pertaining to Siting Criteria

Over the course of the literature review and stakeholder consultation, data and information that could be used to characterize Nova Scotia's coastal zone and its suitability for various types of aquaculture development were identified. Specifically, sources of useful data were identified through:

- Consulting with the NSDFA, as well as researchers and government agencies (*e.g.*, Fisheries and Oceans Canada, Environment Canada);
- Conducting literature and internet searches;
- Reviewing data sources from the Project Team's past experience in coastal zone development projects; and
- Utilizing university and government library sources.

A focus of the identification of information and data sources that pertain to siting criteria was on available geo-referenced data sets that can be publicly sourced or that are held by government agencies.

2.3.3 Compilation of the Road Map for Aquaculture Investment

The results from the literature review and stakeholder consultations were compiled and analysed to present: a review of key siting criteria for marine aquaculture, including biophysical conditions, infrastructure, other resource users, and ecologically-sensitive areas (Section 3.3); assessments of regional biophysical conditions and aquaculture suitability across Nova Scotia (Section 4.0); and a summary of regional species-specific aquaculture potential in Nova Scotia (Section 5.0). Challenges of defining siting criteria and suitable marine areas due to changes in the environment, changes in scientific knowledge, and changes in technology are discussed in Section 6.0. Finally, priorities for further work are identified in Section 7.0.

3.0 REVIEW OF SITING CRITERIA

A literature review of key documents related to aquaculture siting criteria and site selection was conducted. Results of the literature review are summarized in Section 3.1 and results from the consultation (interviews and workshop) are summarized in Section 3.2. An overall synthesis of siting criteria applicable to Nova Scotia is presented in Section 3.3, and a review of available data related to siting criteria is summarized in Section 3.5.

3.1 INFORMATION FROM THE LITERATURE

3.1.1 General Siting Criteria Applied in Other Jurisdictions

The literature review included an assessment of the key siting criteria used to guide aquaculture development in other jurisdictions. The focus of the review was on Canadian jurisdictions with larger, more established aquaculture sectors. A brief review of aquaculture jurisdictions outside of Canada was conducted; however, less emphasis was placed on these international examples given the context of the current study.

British Columbia

Proposals for new salmon farms in British Columbia must meet the following requirements and minimum separation distances (BCDFA 2009). Sites must be located:

- At least 1 km in all directions from a First Nations reserve (unless consent is received from the First Nation);
- At least 1 km from the mouth of a salmonid-bearing stream determined as significant in consultation with DFO and the province;
- At least 1 km from herring spawning areas designated as having “vital”, “major” or “high” importance;
- At least 300 m from inter-tidal shellfish beds that are exposed to water flow from a salmon farm and which have regular or traditional use by First Nations, recreational, or commercial fisheries;
- At least 125 m from all other wild shellfish beds and commercial shellfish growing operations;
- An appropriate distance from areas of “sensitive fish habitat”, as determined by DFO and the province;
- An appropriate distance from the areas used extensively by marine mammals, as determined by DFO and the province;
- At least 30 m from the edge of the approach channel to a small craft harbour, federal wharf or dock;
- At least 1 km from ecological reserves smaller than 1000 ha or approved proposals for ecological reserves smaller than 1000 ha;

- Not within a 1km line of sight from existing federal, provincial or regional parks or marine protected areas (or approved proposals for these);
- In order to not infringe on the riparian rights of an upland owner, without consent, for the term of the tenure license;
- Not in areas that would pre-empt important Aboriginal, commercial or recreational fisheries as determined by the province in consultation with First Nations and DFO.
- Not in areas of cultural or heritage significance as determined in the British Columba Heritage Conservation Act;
- Consistent with approved local government bylaws for land use planning and zoning; and
- At least 3 km from any existing finfish aquaculture site, or in accordance with a local area plan or Coastal Zone Management Plan.

New Brunswick

The lease application form in New Brunswick states what information is necessary for the government to make a decision on the appropriate siting of new farms (NBDAA 2009). These criteria are reviewed here as they highlight the key considerations that the New Brunswick government uses when siting a new farm:

- Annual maximum temperature (ºC);
- Annual minimum temperature (ºC);
- Current pattern (*e.g.,* circular, vortex);
- Average current speed (in knots);
- Current direction;
- Salinity;
- Tide amplitudes;
- Dominant winds;
- Ice characteristics (formation, thickness, movements, *etc.*);
- Bottom type of site;
- Need to know all adjacent properties;
- Water depth at lowest tide at three locations of site (closest and furthest from shore, and midpoint between);
- Other uses in area; and
- Wildlife in area.

Additional information may be required (*e.g.,* suspended particulate matter, particulate organic matter, chlorophyll, Secchi-disk depth, under water video record, sediment samples or any additional measurements). The extent to which this information is required is determined by the type of aquaculture activity to be carried out at the site, or may be site-specific.

General Siting Criteria in International Jurisdictions

A number of studies in recent years have shown that benthic community structure and function can be affected by excess organic waste (feed and feces) from salmon farms (Levings *et al*. 1995). To minimize effects, it is advantageous to locate farms to provide maximum dispersal of organic wastes and to utilize the natural assimilative capacity of water bodies. Even though scientific information is lacking, criteria to establish the distances between fish farms and critical salmon habitat, such as river mouths and spawning and rearing areas, have been proposed to try and avoid interactions between farmed and wild fish.

Levings *et al.* (1995) conducted a review of key salmon farming jurisdictions around the world to examine aquaculture siting procedures. The jurisdictions reviewed included the United States (Washington and Maine), Canada (New Brunswick and British Columbia), Scotland, Ireland, Iceland, and Norway. Details from each country are not summarized here; however, the research revealed that the following habitat and oceanographic siting criteria were used for siting salmon farms in one or more of the eight jurisdictions reviewed (Levings *et al.* 1995):

- Site boundary (in reference to low tide);
- Minimum depth;
- Distance between farms;
- Distance from critical fish habitat;
- Distance from ecologically sensitive areas;
- Oceanographic considerations; and
- Various zoning criteria for coastal use.

General Siting Requirements for Net-Pen Aquaculture

According to a comprehensive review of net-pen aquaculture by Beveridge (1996), there are three categories of net-pen site selection criteria that must be addressed to determine site suitability – physico-chemical conditions, weather and environments, and establishment and profitability (Table 3.1).

Table 3.1 General Siting Criteria for Net-Pen Aquaculture

Physico-Chemical Conditions	Weather and Environment	Establishment and Profitability
Temperature	Depth	Legal Aspects
Salinity	Shelter	Access
Pollution	Substrate	Security
Suspended Solids	Currents	Proximity to Markets
Algal Blooms	Fouling	
Disease Organisms		
Water Exchange		
Currents		
Fouling		

Source: Adapted from Beveridge (1996)

When selecting a site for net-pen culture, a species' optimum temperature and salinity conditions should be met since even immediately outside of these optima, feeding, food conversion and growth are adversely affected. Sub-optimal temperature and salinity conditions also contribute toward stress, leading to increased susceptibility to parasitic infections and reduced resistance to disease. Interestingly, rapidly fluctuating temperatures are often more harmful than seasonal changes (depending on the species).

The temperature regime of coastal areas may be greatly influenced by runoff from the land (*i.e.,* river discharges and surface freshwater runoff are colder in winter and warmer in summer than the receiving coastal seas). Sites that are strongly stratified for much of the year, and/or where algal blooms carry risks of periodically poor oxygen conditions, should be avoided if possible.

Phytoplankton blooms occur generally where there are high light and nutrient levels and warm temperatures combined with favourable hydrographic conditions. Presence of these blooms can physically affect fish (gills) and can deplete dissolved oxygen (DO). Sites prone to phytoplankton blooms should be avoided. Similarly, toxic dinoflagellate blooms tend to occur in warm water and are, therefore, restricted to summer months in temperate regions.

It is best to avoid nutrient-rich sites and sites where the water exchange period is longer than a few days. Good water exchange (flushing) at a site intended for intensive net-pen aquaculture is desirable to minimize the accumulation of materials below the net-pen. In the marine environment, this means sites where there are good bottom and surface currents and where the exchange period is in days rather weeks. The rate of fouling (organisms growing on marine net-pens and infrastructure) is higher in warmer, more productive waters and areas with slow currents.

Other key siting factors include weather (storms, ice), shelter and waves, current velocities, depth, and substrate. For most types of net-pen aquaculture, net-pens should be sited in sufficient depth to maximize the exchange of water, yet keeps the net-pen bottoms well clear of the substrate. It is best to hold fish at least 4 to 5 m above the benthos. It is important to recall that in the marine environment, tidal fluctuations must also be taken into account for any depth calculations.

General Siting Issues for Cold-Water Marine Fish

According to a study of aquaculture systems for cold-water marine fish by Moksness *et al.* (2004), temperature and salinity are the factors that will largely determine the range of species that can be grown at a site. Light also has a considerable impact on performance, but is more easily manipulated by the aquaculturist. Some water-quality issues can arise due to the fish farm itself (oxygen and ammonia levels); however, these issues can be largely mitigated with proper siting. Dissolved oxygen (DO) is one of the most important aspects of water quality as it affects metabolic activity. The location of a water intake or the position of net-pens in an estuary in relation to salinity changes are important considerations when selecting the site for a marine fish farm or in the choice of species.

3.2 CONSULTATION RESULTS

3.2.1 Interviews

Of the 15 interviews completed, nine were experts specialized in shellfish while six were specialized in finfish. In general, the experts interviewed listed siting criteria similar to what was found during the literature review. Some experts were able to go into great detail regarding specific species and their requirements for aquaculture success. Based on a general overview of the interview results, the most commonly cited biophysical criteria were:

- Water temperature (maximum, minimum, variation);
- Site depth;
- Flush rate;
- Current and wave action;
- Exposure;
- Bottom type;
- Available feed; and
- Ice conditions.

Commonly cited infrastructure needed for new sites were road and wharf access, and waste disposal sites. Social criteria were generally considered very important, and could be deal breakers for potential new sites. The general consensus from the interviews is that while a site must meet certain biophysical characteristics to support the efficient growth of a given species, the social factors must be taken seriously and must be a large part of the consideration in new site selection. The most commonly cited resource users to be considered when choosing a site were cottagers and other property owners, environmental groups, the provincial and federal governments (in particular Transport Canada with respect to potential navigable waters concerns), other aquaculture or industrial operations nearby, boaters and other recreational users.

Ecologically-sensitive areas were not generally discussed. Most farmers stated that they simply avoid considering areas that are protected. *Species at Risk Act* (*SARA*)-listed species were mentioned by some stakeholders (*e.g.,* the presence of Roseate Terns in Pubnico) though these considerations likely stem primarily from the environmental assessment process.

3.2.2 Workshop

A stakeholder workshop was conducted on April 7-8, 2009 in Halifax, Nova Scotia. The purpose of the workshop was to hear from aquaculture industry members and scientific experts on siting considerations for future aquaculture development in the province.

The workshop consisted of presentations by the study team on work completed to date, and facilitated discussions of key aquaculture siting criteria and regional aquaculture suitability in the seven project-defined aquaculture regions of the province. The workshop agenda is provided in Appendix B, and a list of workshop delegates is provided in Appendix C.

There was general agreement from participants at the workshop on the validity of the presented list of siting criteria (Table 3.2) and their respective measurements. In general, it was felt that all criteria were important, though some are more important than others depending on the species in question. These criteria can change over time, which is an important consideration for aquaculturalists. Additional siting criteria were added to the table as a result of comments from workshop participants, including proximity to species at risk and proximity to fishing grounds.

Results of the facilitated discussions on regional aquaculture suitability in Nova Scotia focused on identifying which species could be cultured successfully in the various regions around the province, and discussion of which criteria were the key determinants. In general, participants felt that most of the species under consideration had some potential in each of the seven proposed aquaculture regions in Nova Scotia, except where there where clear biophysical restrictions. Common constraints identified within regions included ice and ice movement, temperature, user conflicts (*e.g.,* the lobster fishery), and nuisance species (*e.g.,* tunicates). Key information provided by workshop participants on species suitability across the province has been incorporated into the discussion of regional aquaculture suitability in Sections 4.0 and 5.0. Workshop participants also cited many studies and sources of information that could be used to characterize key siting criteria, and these sources are discussed in the summary of available data and information in Section 3.5.

3.3 TYPES OF SITING CRITERIA

The results of the literature review and stakeholder consultations have revealed a substantial list of siting criteria that are important factors affecting area suitability for aquaculture in Nova Scotia. In an effort to simplify the presentation, individual criteria have been grouped into four general categories:

- Biophysical conditions;
- Infrastructure;
- Other resource users; and
- Ecologically-sensitive areas.

Table 3.2 provides a summary of the key siting criteria identified for Nova Scotia as it applies to marine grow-out operations for the species examined as part of this study.

Table 3.2 Key siting criteria for Nova Scotia marine grow-out aquaculture

Criteria Name	Unit of Measurement
Biophysical Conditions	
Wave Amplitude	metres
Wave Period	seconds
Water Depth	metres
Temperature	
- maximum	°C
- minimum	°C
- optimal	°C

Table 3.2 Key siting criteria for Nova Scotia marine grow-out aquaculture

Criteria Name	Unit of Measurement
Current Velocities	
- maximum	m/s
- minimum	m/s
- optimal	m/s
Salinity	ppt
Substrate Type	combined qualitative assessment
Ice Conditions	presence/absence
Seasonal Ice Movements	presence/absence
Tidal Amplitude	metres
Seasonal Weather Patterns	combined qualitative assessment
Dissolved Oxygen (DO)	mg/l
Suspended Solids	mg/l
Water Exchange Rate (flushing)	Days
Phytotoxins	presence/absence
Disease Organisms	presence/absence
Potential for Fouling	combined qualitative assessment
Presence of Food Supply (plankton)	combined qualitative assessment
Presence of Predators	presence/absence
Presence of Invasive Species	presence/absence
Presence of Naturally-Occurring Populations	presence/absence
Carrying Capacity of Receiving Waters	modeled output
Heavy Metal Pollution	concentration
Bacterial Contamination (E Coli levels)	Concentration
Infrastructure	
Site Access	
- roads and wharves	Distance
- waste disposal	Distance
- general services (fuel, food, *etc.*)	Distance
- processing facilities	Distance
Availability of Seed Stock/Juveniles	Distance
Other Resource Users	
Proximity to Existing Aquaculture Sites	Distance
Proximity to Fishing Grounds	Distance
Proximity to Navigational Routes	Distance
Proximity to Other Industry	Distance
Proximity to Agriculture	Distance
Proximity to Point Sources of Sewage Effluents	Distance
Proximity to Tourism Operators	Distance
Proximity to Recreational Users	Distance
Proximity to Residential Areas	Distance
Ecologically Sensitive Areas	
Proximity to Protected Areas	Distance
Proximity to Informally Recognized Areas	Distance
Proximity to Species at Risk	Distance
Proximity to Important Fish Habitat	Distance

3.4 SPECIES-SPECIFIC SITING CRITERIA

Each of the potential aquaculture species considered in this study have particular biophysical requirements that affect their survival, health, and growth rate. There are particular thresholds for each species that apply to many of the biophysical criteria listed in Table 3.2. Based on the literature review and results of the stakeholder consultations, the biophysical species-specific

thresholds that are of particular importance are temperature, salinity, and depth. Table 3.3 provides a summary of thresholds for key criteria for each of the nine species considered in this study. Values presented in this table have been derived from the literature review and stakeholder consultations and reflect a general consensus value. Specific values and ranges provided for each species are summarized in Appendix D.

The values in Table 3.3 reflect minimum, maximum, and optimal values that are specific to each species. Minimum and maximum values for temperature and salinity are the thresholds at which the survival of the given species is threatened. The optimal values for temperature and salinity reflect the range in which the species will achieve its maximum growth rate. The minimum and maximum values for depth are thresholds at which culturing the species with suspension technology is generally not feasible, while the optimal depth represents the depth at which culturing this species will be most technically feasible for suspension systems.

Table 3.3 Species-specific thresholds for temperature, salinity, and depth*

Criteria	Atlantic Salmon	Rainbow Trout	Blue Mussel	Bay Scallop	Sea Scallop	American Oyster	European Oyster	Atlantic Cod	Atlantic Halibut
Temperature (°C)									
Optimal	12 - 16	10 - 16	10 - 20	10 - 28	10 - 18	10 – 20	10 - 20	8 - 14	8 - 14
Minimum	-0.7	-0.7	-1	-2	-2	-1	0	-1.7	-0.7
Maximum	20	18	25	30	23	30	25	18	18
Salinity (ppt)									
Optimal	28 - 32	18 - 33	20 - 30	25 - 30	28 - 32	20 – 25	24 - 32	28 - 32	28 - 32
Minimum	0	0	15	20	20	18	20	0	0
Maximum	35	35	35	35	35	35	35	35	35
Depth (m)									
Optimal	15 - 20	10 - 20	15	-	20 - 40	1 – 6	2 - 10	15 - 20	15 - 20
Minimum	7	7	5	5	10	1	2	10	10
Maximum	-	-	-	-	100	-	-	-	-

*See Section 3.4 for clarification of maximum and minimum values

3.5 AVAILABLE DATA AND INFORMATION

Conditions related to the siting criteria listed in Tables 3.2 and 3.3 (see also Appendix D) can vary widely throughout the various geographic regions of Nova Scotia. Aquaculture developers require information and data to characterize these criteria in order to determine the suitability of a particular location for a particular species. The study team undertook a review of data and information that is available to characterize key siting criteria in Nova Scotia. Sources of information were identified through a literature search, as well as during interviews with key stakeholders and during the workshop. Detailed results of the data and information search are summarized in Appendix E.

In general, the review revealed four primary types of sources that can be accessed to collect data and information for particular criteria in different regions of the province. These include:

- Statistical databases;
- Regional oceanographic and ecosystem studies;
- Regional aquaculture suitability studies; and
- Short-term, site-specific oceanographic monitoring studies.

The statistical databases that were reviewed include several that are maintained by Fisheries and Oceans Canada. These databases typically cover long time series and are regularly updated to reflect recent conditions. They typically include province-wide data; however, the data generally consist of average values for more general areas rather than site-specific data, and are often limited to one or two criteria (*e.g.,* temperature, salinity).

A number of regional oceanographic and ecosystem studies have been conducted throughout Nova Scotia. These studies generally provide data and qualitative information on a wide range of criteria of interest, including oceanographic conditions, geological conditions, seasonal weather patterns, sensitive or protected habitats, native marine species and benthic habitats, commercial fishing activities, and other human activities such as tourism, agriculture and industry. The data and information provided in these reports is typically derived from existing literature and previous studies and generally includes key historical trends and threshold values (*i.e.,* maximum and minimum values). Time series data is generally not included in these reports.

A number of previous aquaculture suitability studies have been conducted in Nova Scotia, including assessments of particular harbours and inlets, and province-wide assessments of general conditions related to a particular species. In addition to providing conclusions on the suitability of various areas of the province for culturing particular species, these reports often provide short-term oceanographic monitoring data and general descriptions of oceanographic conditions in particular areas. While some of these studies are several years old, the data provided can help to establish historical trends, and in some cases the data may be the highest resolution data available for a particular area. A summary of several of these studies is provided in Section 2.2.

There are also a number of short-term, site-specific monitoring studies that have been conducted in particular locations around the province. These studies generally focus on a few key oceanographic parameters (*e.g.,* temperature, salinity, tidal amplitude) and report data for a specific time period (several months to several years).

This report focuses primarily on the first three types of data and information sources, and the key sources identified during the review are summarized in Appendix E. Less emphasis was placed on identifying short-term site-specific oceanographic monitoring studies due to concerns about the age of these reports and the short time frames over which data were collected. It is recommended that if interested in a particular geographic location, aquaculture developers conduct an independent search for these individual site-specific studies. There are a number of online search tools to assist with this task (*e.g.,* Fisheries and Oceans Canada's Waves database).

4.0 NOVA SCOTIA REGIONAL AQUACULTURE SUITABILITY

The climatic and geographic conditions along Nova Scotia's coastlines favour the cultivation of several types of marine species; however, these conditions vary greatly between localities and, depending on the precise combination of conditions in any particular area, the possibilities for aquaculture development will be either enhanced or restricted (Boghen 1995). Previous studies of aquaculture suitability in Atlantic Canada have attempted to define particular zones that exhibit similar biophysical conditions in an effort to simplify the discussion of where aquaculture potential lies within the region. For example, in a previous review of Atlantic Canada's marine resources and their suitability for aquaculture (Boghen 1995), seven distinct aquaculture zones were defined, including: 1) Bay of Fundy; 2) Atlantic Coast of Nova Scotia; 3) Bras d'Or Lakes; 4) Gulf of St. Lawrence; 5) Atlantic Coast of Newfoundland; 6) Gulf Coast of Newfoundland; and 7) Northern Gulf of St. Lawrence.

For the present study, the aquaculture regions of Nova Scotia have been defined as (Figure 4.1):

- Upper Fundy;
- Fundy-Yarmouth;
- South Shore;
- Eastern Shore;
- Cape Breton;
- Bras d'Or; and
- Gulf Shore.

Although the boundaries between these regions are not precise or based on specific criteria, locations within each of these defined regions generally share similar hydrographic and oceanographic conditions relative to the other defined regions. It is important to note, however, that within each region there can be locally-specific biophysical conditions that differ from the overall characteristics of the region. These local areas can only be identified through more detailed study and local knowledge, and it was beyond the scope of the present study to define these locations.

Given the general biophysical similarities within each region, general conclusions have been drawn with regard to aquaculture suitability for each of the proposed species within each of the seven regions. This section provides a general overview of the biophysical conditions within each region, and provides a brief assessment of the aquaculture potential. Some socio-economic conditions are also described; however, the assessments of species suitability for each region are based primarily on a consideration of biophysical conditions and on the results of the stakeholder consultation.

Legend

Nova Scotia Aquaculture Regions

- Bras d'Or
- Cape Breton
- Eastern Shore
- Fundy Yarmouth
- Gulf Shore
- South Shore
- Upper Fundy
- NS Provincial Jurisdiction

0 25 50
Kilometres

Scale 1 : 2,100,000
Project - 1048755.

Note: Proposed regional boundaries are approximate. Offshore boundaries are arbitrary.

N

GULF OF ST. LAWRENCE

NEW BRUNSWICK

P.E.I.

NORTHUMBERLAND STRAIT

Gulf Shore

Cape Breton

Bras d'Or

CAPE BRETON ISLAND

Sydney

Pugwash

Pictou

Upper Fundy

Parsboro

BAY OF FUNDY

NOVA SCOTIA

Canso

Middleton

Musquodoboit Harbour

Sheet Harbour

Eastern Shore

Middle Bank

Digby

Halifax

Chester

Mahone Bay

Fundy-Yarmouth

Liverpool

THE GULLY

Yarmouth

Shelburne

GULF OF MAINE

South Shore

Western Bank

Emerald Bank

LaHave Bank

DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 4.1
NOVA SCOTIA Fisheries and Aquaculture	**AQUACULTURE REGIONS OF NOVA SCOTIA**	Stantec

4.1 UPPER FUNDY

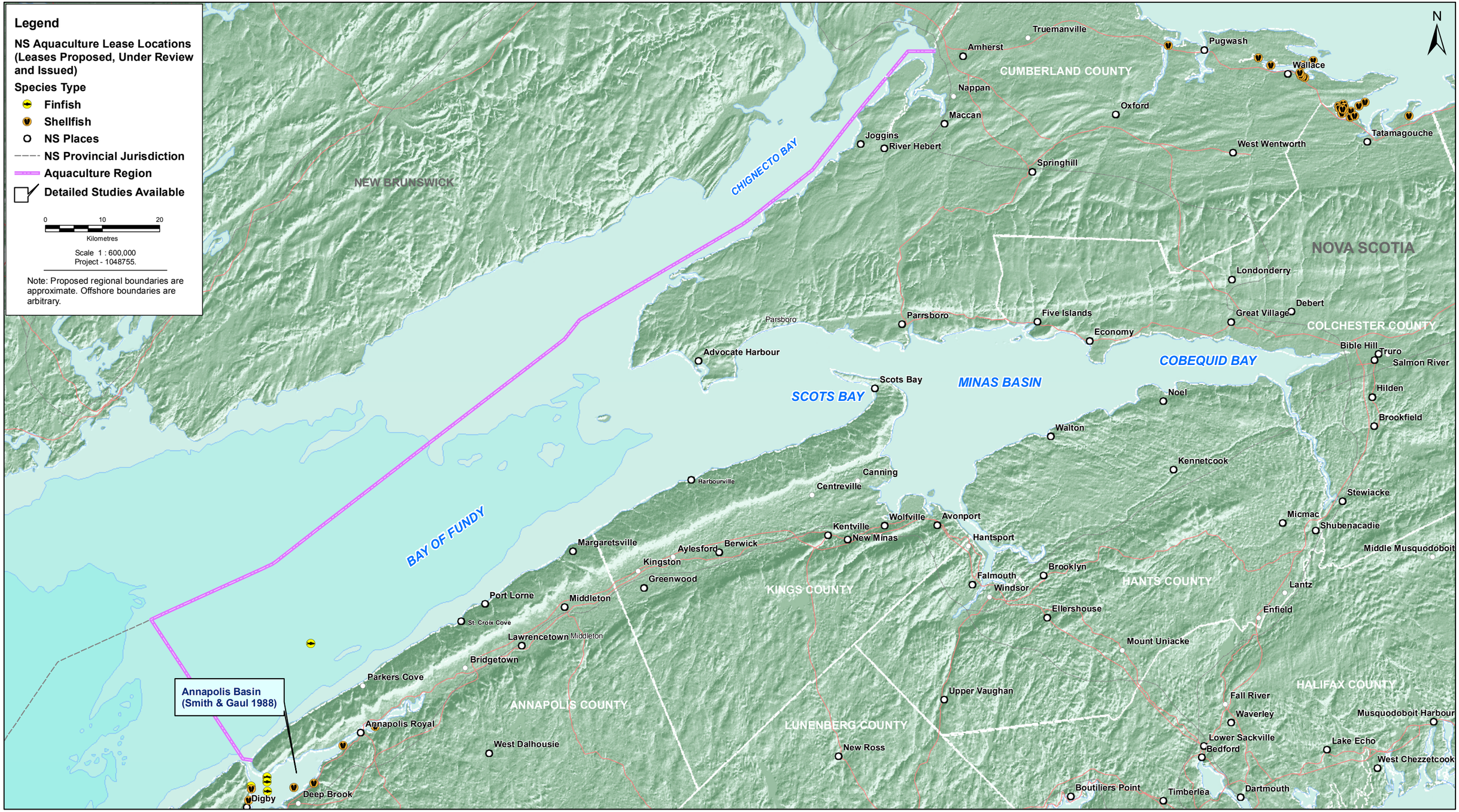
4.1.1 General Regional Conditions

For the purposes of the present study, the Bay of Fundy was divided into two distinct zones: the Upper Fundy region (Figure 4.2), which includes coastal areas along Annapolis and Kings County, and the Minas Basin; and the Fundy-Yarmouth area (Figure 4.3), which includes coastal areas from the Annapolis Basin and Digby Neck down to Clark's Harbour in Yarmouth County. The change in marine biophysical conditions between these two zones is substantial and has implications for aquaculture suitability.

The Upper Fundy Aquaculture Region is characterized by high tidal energy, relatively cool temperatures, and high exposure to wind and waves. The Bay of Fundy experiences some of the highest tides in the world, and the large tidal amplitude generally prevents the build-up of ice in the winter. Water temperatures typically range from 0°C in winter to 13°C in late summer. Although salmon farming has generally succeeded on the New Brunswick side of this region, the occasional dips below -0.7°C (the lethal temperature for salmon) in the winter have resulted in severe losses there in the past (Boghen 1995). The shoreline along the Nova Scotia coast in this region is much more exposed, generally lacking the sheltered areas that are prevalent on the New Brunswick side and experiencing greater tidal currents. The area of coastline between the Annapolis Basin and Scots Bay has a particularly high level of exposure to winds and waves, and generally lacks extensive marine infrastructure.

Tidal amplitude in the Bay of Fundy is in excess of 8 m (Aiken 1984). In general, tides in the Bay of Fundy range from 4 m near the mouth of the Bay to 12 m in the Minas Basin at the head of the Bay. Most of the offshore waters in the Bay of Fundy have depths of 50 to 200 m, with a maximum depth of 220 m. The largest wave heights in the Bay of Fundy are approximately 6 to 8 m, and the 100-year wave height is 10 m. The most frequent wave periods are four to six seconds. Approximately 30% of the waves have a period of 8 to 15 seconds and propagate into the Bay of Fundy from the Gulf of Maine (Chang *et al.* 2005).

There are currently very few existing aquaculture leases in this region, all being concentrated in the Annapolis Basin (Figure 4.2).



DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 4.2
NOVA SCOTIA Fisheries and Aquaculture	**UPPER FUNDY AQUACULTURE REGION**	Stantec

4.1.2 Regional Aquaculture Species Potential

Finfish

In a study of commercial aquaculture potential in Atlantic Canada, Scarratt *et al.* (1993) indicated that the upper regions of the Bay of Fundy, extending into the Minas Basin, were outside of the suitable range for commercial culture of finfish in marine net-pens. High exposure and the high tidal amplitude in this region present a number of technological challenges for net-pens. The threat of superchill is also a constraint for finfish in this region, as temperatures are known to drop below 0°C in the winter months in some areas, particularly in areas of shallower water. The presence of Inner Bay of Fundy Atlantic salmon, which are an endangered species under *SARA*, is an additional constraint on farming Atlantic salmon in this region.

As a result of the general biophysical conditions, the potential for culturing Atlantic salmon, rainbow trout, and Atlantic cod in this region is quite limited at this time and would involve a relatively high-level of risk given the biophysical conditions. Consultation with industry experts suggests that with technological development for high energy environments there could be some potential for culturing finfish in the offshore zone in this region. A recent application to NSDFA for a finfish site in the offshore area of Annapolis County (Figure 4.2) suggests that some aquaculture developers do feel they have the technological capabilities to successfully culture finfish in this area. Halibut farmers at the stakeholder workshop suggested that despite the general lack of suitable conditions for finfish culture, there are areas with good potential for halibut culture in the Minas Basin area.

Shellfish

Red tides (caused by the toxic dinoflagellate *Gonyaulax excavate*, which is responsible for paralytic shellfish poisoning, PSP) have made the Bay of Fundy much less suitable for mollusc culture (Boghen 1995). The marketing of mussels, or sea scallops with the roe attached, that are cultured in the Bay of Fundy is limited by the Canadian Food Inspection Agency due to the widespread presence of PSP. The potential for culturing molluscs is, therefore, quite limited and entails a relatively high level of risk as a result of the issues with PSP. The relatively cold temperature regime is also a limiting factor for oysters and scallops, particularly for American oyster, which thrive in waters that exceed 20 °C in the summer months. The Annapolis Basin area is above the normal northern range for bay scallop and maximum temperatures are low in comparison to other Nova Scotian areas were bay scallop have been successfully grown (Mallet and Carver 1987), such as the Northumberland Strait. An extensive commercial sea scallop fishery exists in the Bay of Fundy, primarily in the Digby Neck/Annapolis Basin area. The presence of wild sea scallop beds suggests that environmental conditions may be well-suited for culture of this species.

Detailed Aquaculture Studies Available

Smith and Gaul (1988) conducted an assessment of aquaculture potential for sea and bay scallop in the Annapolis Basin. The study was based on trial culture sites and data collection at four locations within the basin. MacLaren Plansearch Ltd. (1986) conducted an assessment of sea scallop culture potential in the Bay of Fundy, including areas along the coast from Minas Basin south to Yarmouth County.

FUNDY-YARMOUTH

4.1.3 General Regional Conditions

The Fundy-Yarmouth Aquaculture Region includes the Annapolis Basin, the coastline and marine waters of Digby County and Yarmouth County, and a small portion of southwestern Shelburne County (Figure 4.3). From a biophysical standpoint, this region is a transitional zone in many respects. The heavy tidal regime of the Bay of Fundy in the northern part of the region gives way to colder waters and a wind-driven wave climate along the more highly-exposed outer coast below Digby Neck down to Yarmouth. South of Yarmouth, the coastline begins to transition into a form more similar to the South Shore of Nova Scotia, with less exposure and a greater number of sheltered inlets, coves, and bays. In general, this region has a more moderate tidal flux (2 to 3 m) than the Upper Fundy region, and the risk of PSP diminishes as you move south of Digby Neck. The coastline south of Digby Neck is generally rocky, the waters are productive, and sheltered coves and bays are abundant in the south, although some have prevalent winter ice (Aiken 1984).

The Annapolis Basin and areas along Digby Neck are currently the most active in terms of existing aquaculture leases in the northern portion of this region. These areas have good protection from wave action and have warmer winter water temperatures relative to areas that are further south in the region. The area of coastline from Weymouth, south down to Yarmouth, has no existing aquaculture activity, believed to be due in large part to this area's greater exposure to ocean winds and waves and colder winter temperatures relative to other parts of this region. From Yarmouth down to Clark's Harbour, there are many coves and bays that provide shelter from wave action and, therefore, provide more opportunities for both finfish and shellfish development. This area features the most concentrated amount of aquaculture activity in this region. As of early 2009, there were 21 shellfish leases issued in Yarmouth County, and 8 finfish leases. In Digby County, there were 7 shellfish leases and 4 finfish leases.

The marine waters in this region are part of Lobster Fishing Area (LFA) 34, which is the most productive lobster fishery in Atlantic Canada, and the presence of this important fishery leads to potential conflicts over marine resources between fishers and aquaculturists. Despite the potential for conflicts, the historical presence of this large fishery does mean that good levels of marine infrastructure are present in this region (wharves, *etc.*). The lobster fleet is also part of a larger marine navigation user group in this region, including ferries from Digby to Saint John and from Yarmouth to Bar Harbour, and the major Bay of Fundy shipping lanes which pass north of Digby Neck. The waters north of Digby Neck are also home to a right whale sanctuary that must be avoided by marine vessel traffic, although the defined avoidance zone is well seaward of coastal waters.

BAY OF FUNDY

N

Port Lorne
Bridgetown
Parkers Cove
Annapolis Royal
West Dalhousie
Deep Brook
Digby
ANNAPOLIS COUNTY
Brighton
Digby Neck
Sandy Cove
St Marys Bay
Tiverton
Weymouth
Belliveaus Cove
Freeport
Saulnierville
DIGBY COUNTY
Meteghan
Mavillette
East Kemptville
Port Maitland
YARMOUTH COUNTY
South Ohio
SHELBURNE COUNTY
Tusket
Yarmouth
Plymouth
Jordan Falls
Shelburne
Wedgeport
Lower Argyle
Sandy Point
Lobster Bay
Clyde River
Woods Harbour
Barrington
Shag Harbour
Port La Tour
North East Point
Clark's Harbour

Yarmouth Harbour
(Muise & Associates 1993)

Lobster Bay
(Muise & Associates 1993)

Tusket Islands
(Muise & Associates 1993)

Argyle Head
(Mallet & Carver 1987)

Pubnico Harbour
(Murphy 1997)

Legend

NS Aquaculture Lease Locations (Leases Proposed, Under Review and Issued)

Species Type

- Finfish
- Shellfish
- NS Places
- Aquaculture Region
- NS Provincial Jurisdiction
- Detailed Studies Available

Scale 1 : 570,000
Project - 1048755.

0 10 20
Kilometres

Note: Proposed regional boundaries are approximate. Offshore boundaries are arbitrary.

DATE: November 2009	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO: 4.3
PREPARED BY: G. Mesheau		
NOVA SCOTIA Fisheries and Aquaculture	**FUNDY-YARMOUTH AQUACULTURE REGION**	Stantec

4.1.4 Regional Aquaculture Species Potential

Finfish

From a biophysical perspective, the potential for farming Atlantic salmon and rainbow trout in this region is generally good, and a number of finfish sites currently exist; however, finfish potential varies significantly throughout the region depending on the level of exposure and the risk of cold winter temperatures. Although there is the risk of lethal winter temperatures throughout this region (-0.7 °C, see Section 3.4), the risk is particularly high in exposed areas along the outer coast and in shallow bays. The tidal amplitude in the Digby area and the heavier wave action along the exposed part of the coast between Weymouth and Yarmouth also present significant challenges for finfish farming in net-pens.

There are some areas with excellent potential for finfish culture, particularly in the more sheltered areas near Digby, Pubnico, and Woods Harbour; however, ice can be an issue in these areas. Rainbow trout can be grown seasonally (6 to 9 month grow-out) and, therefore, have greater potential in this region relative to Atlantic salmon since trout can be harvested prior to the onset of cold winter temperatures. Some areas with excellent potential for culture of rainbow trout include Lobster Bay and sites around the Tusket Islands. Atlantic cod and Atlantic halibut are not currently being cultured in this region; however, areas that are generally suitable for Atlantic salmon and Rainbow trout should also be suitable for cod and halibut. Atlantic cod can generally tolerate lower temperatures than salmon or trout and could potentially be cultured in areas that are too cold for these other species.

Shellfish

The potential for successful shellfish culture in this region varies depending on the species. The potential for bay scallop is limited due to the relatively cool summer temperatures. With the exception of some sheltered areas with warmer microclimates, this species has low potential in Fundy-Yarmouth. Even in the relatively warmer waters of the Annapolis Basin, summer water temperatures are generally not warm enough for good growth of this species.

The potential for culturing American oyster is moderate due to the overall water temperature profile in the region, with the exception of some sheltered bays and inlets. PSP is also still a risk for this species in the northern part of the region. The optimal temperature range for European oyster is lower than for American oysters and there may be some moderate potential for this species in particular areas within this region; however, summer water temperatures are generally not high enough for good growth of this species in most parts of this region with the exception of some microclimates in sheltered areas.

There is excellent biological potential for blue mussel culture in many parts of the Fundy-Yarmouth region; however, successful culture of this species is limited by a number of other factors. The risk of PSP is still an issue for blue mussel in the northern part of this region, and user conflicts with the lobster fishery are a potential limiting factor in several bays and inlets. In an aquaculture suitability assessment of Yarmouth County in 1993, it was noted that a limited amount of water suitable for surface suspension systems was found in bays and inlets in the

area, and that the large tidal amplitude in the inner portions of the coast resulted in conditions in which the only available water during low tides was in the various navigation channels which could not be utilized for aquaculture (Muise & Associates 1993).

The biophysical potential for sea scallop culture in this region is generally quite good, although Lobster Bay (south of Yarmouth) lacks a resident scallop population, and reports from local divers suggest that only a small number of scallops are present near John's Island (Woods Harbour) and off Bunker Island (Yarmouth). An extensive commercial scallop fishery exists in the Bay of Fundy, with nearshore fishing activity concentrated on the Fundy side of Digby Neck. Although the Bay of Fundy region has high potential for scallop bottom culture, potential conflicts with wild scallop fishers would have to be mitigated (MacLaren Plansearch Limited 1986). The inlets and coves along the southwestern mainland coast (from Yarmouth to Brighton in St. Mary's Bay) are principally muddy bottom environments not suitable for scallop culture. There are some suitable sites along the western margin of St. Mary's Bay, from Freeport to Sandy Cove. Sandy sediments predominate close to shore and there is some historical presence of scallops in this area. Potential exists for culturing efforts to be directed to those areas not affected by bacteriological contamination (Sandy Cove) or extreme current velocities (between Westport – Freeport and Tiverton – East Ferry) (MacLaren Plansearch Limited 1986).

Detailed Aquaculture Studies Available

Muise and Associates (1993) conducted a detailed study of aquaculture potential for various commercial species in Yarmouth County. Twenty different coastal areas were assessed within the general areas of Pubnico Harbour, the inner and outer portions of Lobster Bay, the Tusket islands, and Yarmouth Harbour. MacLaren Plansearch Ltd. (1986) conducted an assessment of sea scallop culture potential from Yarmouth up into the Bay of Fundy and down to the South Shore of Nova Scotia. Mallet and Carver (1987) conducted an assessment of bay scallop aquaculture potential in Argyle Head.

4.2 SOUTH SHORE

4.2.1 General Regional Conditions

The South Shore Aquaculture Region spans the coastal waters from Clark's Harbour on the southwestern tip of the province up to Sambro just outside the Halifax Regional Municipality (Figure 4.4). From a biophysical standpoint, the South Shore represents one of the best opportunities for future aquaculture development in Nova Scotia. The coastline in this region contains abundant bays and inlets that are sheltered from wind and wave action and that have warmer winter water temperatures, and there is adequate depth all along the coastline. The temperature range is favourable to a wide range of species with commercial potential, and there is good infrastructure in place along the coast in terms of wharves and harbours.

There are currently a number of existing finfish leases in this region, as well as a number of existing shellfish leases. Existing leases are concentrated in areas with good protection from exposure to wind and waves.

The South Shore is also notably a region with historical conflicts between aquaculturists and other resource users. Other major interests in the coastal zone include tourism operators, commercial fishers, and ocean-front land owners. Efforts to overcome these potential conflicts are well underway by the aquaculture industry and the provincial government to be able to take advantage of the tremendous biophysical attributes.

4.2.2 Regional Aquaculture Species Potential

Finfish

The sheltered bays and inlets in the South Shore provide adequate depth, protection from exposure, and suitable temperatures for finfish culture. Although there is a risk of winter temperatures dropping below 0 °C, the risk of superchill has historically been less of a problem in this region. The southern Atlantic coast of Nova Scotia has been widely recognized as one of the few areas that are ideally suited to the culture of Atlantic salmon in Atlantic Canada (Boghen 1995). In addition to excellent potential for Atlantic salmon and rainbow trout, there is also great potential for Atlantic cod and Atlantic halibut. These species can typically be cultured in areas that are suitable for Atlantic salmon. Of twelve inlets assessed by Murphy (1997), Green Harbour was identified as a particular location where good potential exists for expansion of finfish culture.

Shellfish

A study by Murphy (1997) identified three particular areas in this region with great potential for shellfish development. These included Negro Harbour, Green Harbour, and Port L'Hebert. This was not based on temperature or salinity parameters, but rather on depth and degree of potential conflicts with commercial fishery activities and important wild fishing grounds, as well as other resource users.

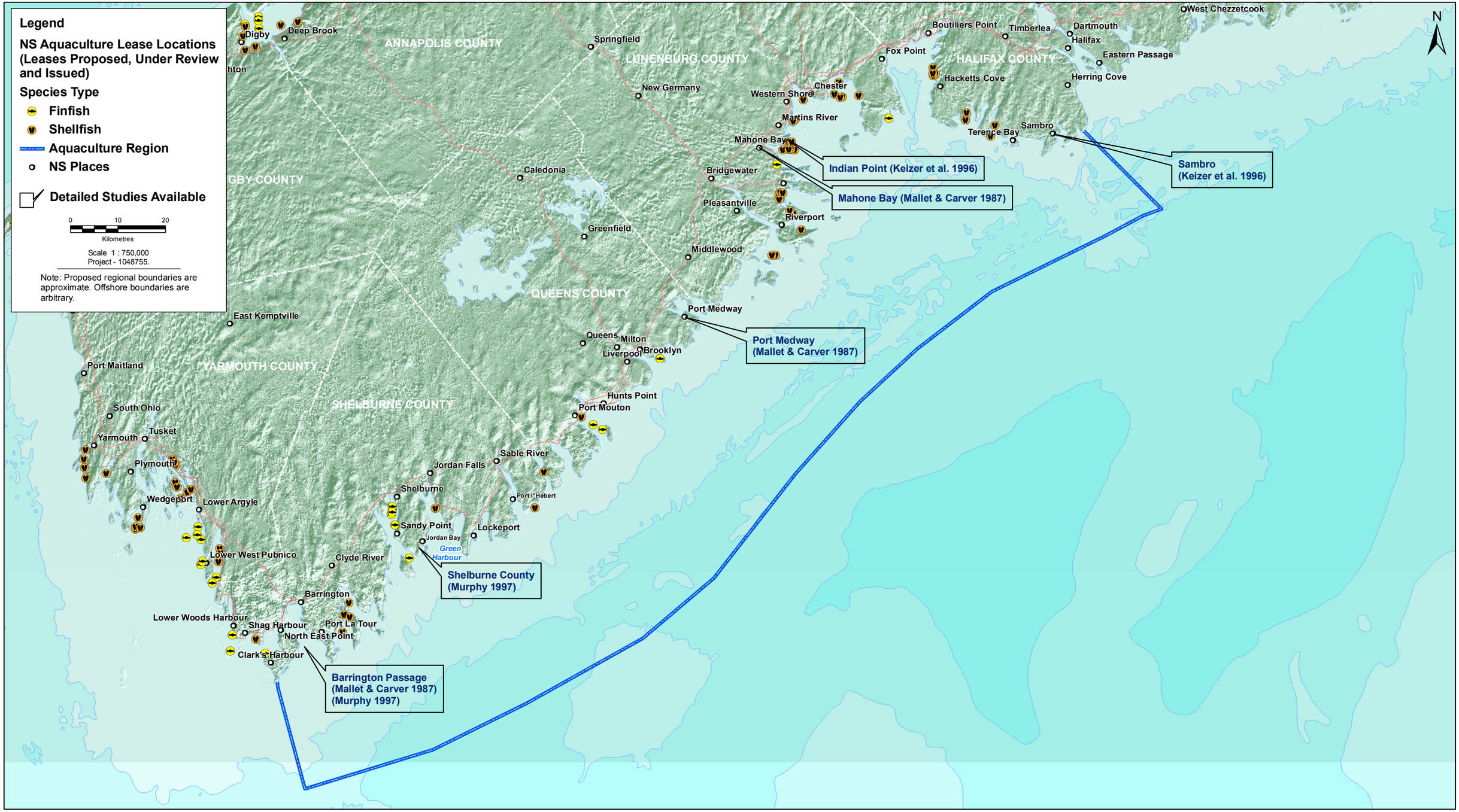
Along the South Shore, a study by MacLaren Plansearch (1986) identified several regions from Mahone Bay to Shelburne that were generally considered favourable for scallop culture, while regions south of Shelburne to Yarmouth were considered unfavourable. Mahone Bay was identified as having the best potential due to the presence of historical scallop beds, favourable bottom conditions, and suitable temperatures. Sea scallop are currently being cultured in Mahone Bay. In the MacLaren Plansearch study (1986), St. Margaret's Bay was not considered suitable for sea scallop due to restricted bottom circulation. Deep bays such as this with shallow sills often have poor exchange of bottom waters and are generally not desirable as culture sites. An abundance of relatively large rocks, as well as predominantly muddy bottoms west of Barrington Passage, indicated limited potential for scallop culture south and west of Shelburne (MacLaren Plansearch 1986). The potential for bay scallop is considered poor in this region due to the lack of warm temperatures required for this species to grow effectively.

Water temperatures in this region are generally not warm enough for American and European oysters; however, there are some sheltered areas that are suitable for these species that provide moderate potential for successful culture. Biophysical conditions in this region are well-

suited to the culture of blue mussel and there is excellent potential to culture this species throughout the region.

Detailed Aquaculture Studies Available

A study by Murphy (1997) assessed the aquaculture production potential for various species in 13 bays and inlets in Shelburne County. For each harbour and inlet, estimates were provided on the total area available for finfish and shellfish culture, as well as estimates of the potential aquaculture areas that overlapped with fishing grounds. An estimated production capacity was calculated for each harbour and inlet based on the carrying capacity of the water body, and an annual production value was estimated based on the production capacity. Mallet and Carver (1987) assessed the potential for bay scallop culture in three coastal areas of this region, including Barrington Passage, Port Medway, and Mahone Bay. MacLaren Plansearch Ltd. (1986) conducted an assessment of sea scallop culture potential in coastal areas throughout this entire region. A long-term monitoring program was conducted by DFO in Indian Point and Sambro from 1992 to 1994 (Keizer *et al*. 1996). Information collected over the course of this program included temperature, salinity, and dissolved oxygen.



DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 4.4
NOVA SCOTIA Fisheries and Aquaculture	**SOUTH SHORE AQUACULTURE REGION**	Stantec

4.3 EASTERN SHORE

4.3.1 General Regional Conditions

The Eastern Shore Aquaculture Region includes coastal waters between Sambro and Canso (Figure 4.5). Key areas within this region include the industrial activity in and around Halifax Harbour and its approaches, and the concentrations of existing aquaculture leases in Ship Harbour, Country Harbour, and Tor Bay. Water temperatures are increasingly colder as you move north in this region, and winter ice conditions can begin to become a challenge in the northern extent. In general, the region consists of very pristine, undeveloped coastlines. This is an advantage in terms of limiting conflicts with other users and in limiting contamination sources; however, it also limits the amount of infrastructure and, therefore, limits access to coastal waters. Bacteriological contamination is considerably more prevalent towards Halifax Regional Municipality and several of the more heavily developed areas (Jeddore Harbour, Musquodobit Harbour, and Cole Harbour) are permanently closed to shellfish harvesting.

4.3.2 Regional Aquaculture Species Potential

Finfish

A study of 21 inlets along the Eastern Shore by Murphy (1997) identified five areas with particularly good potential for increased finfish aquaculture in this region, including Ecum Secum, Liscomb Harbour, Country Harbour, Tor Bay, and Whitehead Harbour. Generally the southern half of this region is considered more suitable for salmonids as winter water temperatures are warmer than further north. Despite the overall increased risk of superchill in this region relative to the South Shore, there are areas of good potential for Atlantic salmon and rainbow trout. More detailed assessments of biophysical conditions should be conducted to identify areas that are more likely to meet the biophysical requirements of these species. The potential for rainbow trout extends further north within the region due to their ability to be cultured seasonally to avoid cold winter temperatures and ice. There is also good potential for Atlantic cod and Atlantic halibut, since these species can generally be cultured in areas that are found to be suitable for Atlantic salmon. Atlantic cod can tolerate lower temperatures than Atlantic salmon, and therefore could have greater potential in the cooler waters of this region.

Shellfish

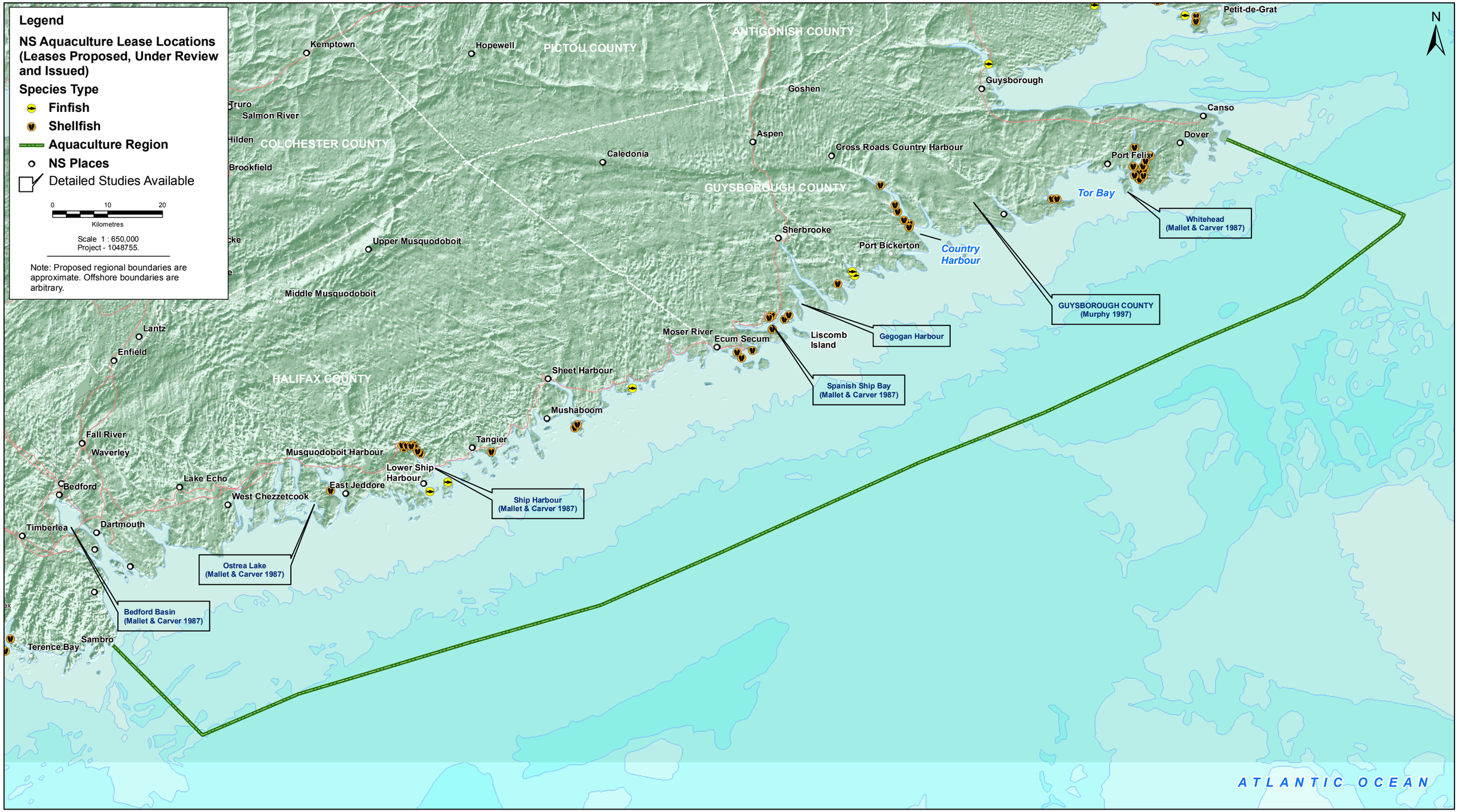
A study of 21 inlets along the Eastern Shore by Murphy (1997) identified four areas in this region with particularly good potential for shellfish development, including Marie Joseph Harbour, Gegoan Harbour, Indian Harbour, and Country Harbour. A study by MacLaren Plansearch (1986) indicated that along the Eastern Shore, naturally occurring sea scallop populations were found to be common and many of the small bays and coves were identified as suitable for culture. Peak bottom temperatures generally do not exceed 15 °C in this region, while adequate salinity and oxygen levels are maintained by prevailing oceanographic conditions. Areas where local current regime is intensified because of topographic or physiographic features (*e.g.,* near Andrews Island, south of Cape Canso) were identified as

especially good sites for potential culture. Shellfish closure areas are generally isolated along the Eastern Shore; however, Halifax Harbour and approaches were identified as being unsuitable due to pollution. Despite successful trials culturing bay scallops in this region during a study by Mallet and Carver in 1986, water temperatures in this region are generally too cold for bay scallop to be cultured successfully.

There is excellent potential in this region for the culture of blue mussel. Water temperatures are within a suitable range and water quality is good in most of the region with the exception of some of the more developed areas (*e.g.,* HRM). The potential for oyster culture is limited in this region by the cooler winter temperatures. Culture potential for American oysters is poor, while there is some moderate potential for European oysters in areas where adequate shelter is found and warmer water temperatures.

Detailed Aquaculture Studies Available

A study by Murphy (1997) examined the suitability of 21 bays and inlets in Guysborough County in an effort to identify areas with the best potential for future aquaculture development. Mallet and Carver (1987) studied five coastal areas in this region to determine areas suitable for culture of bay scallops, including Whitehead, Spanish Ship Bay, Ship Harbour, Ostrea Lake, and Bedford Basin. MacLaren Plansearch (1986) studied a stretch of coastline from Halifax Harbour to Cape Canso in an effort to identify suitable areas for sea scallop culture.



DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 4.5
NOVA SCOTIA Fisheries and Aquaculture	**EASTERN SHORE AQUACULTURE REGION**	Stantec

4.4 CAPE BRETON

4.4.1 General Regional Conditions

The Cape Breton Aquaculture Region includes the coastal waters from Cape North down to Canso on the edge of Guysborough County (Figure 4.6). Key geographic areas in this region include Chedabucto Bay in the south, which is the largest bay on the Atlantic coast of Nova Scotia, and the waters of Sydney Bight in the north, ranging from Scatarie Island up to Cape North. The Guysborough and Port Hawkesbury areas of Chedabucto Bay are characterized by a high level of industrial activity and marine ship traffic. St. Peter's Inlet in the northern part of the bay is the main link to the Bras d'Or and is known for a high level of recreational boat traffic. The shoreline from the northern edge of Chedabucto Bay up to Scatarie Island is generally sparsely populated and features rocky shores and boulder and cobble beaches. The waters of Sydney Bight, from Scatarie Island up to Cape North, are host to sea ice in the winter from the Gulf of St. Lawrence, and warmer, fresher water inputs from the Gulf of St. Lawrence in the summer. There is a substantial lobster fishery in the waters of Sydney Bight, and the area is host to a relatively large amount of marine traffic due to the presence of Sydney Harbour. Sydney Harbour is known to have high levels of industrial contamination, particularly in the inner harbour. In general, this region features high exposure to wind and waves, cold water temperatures and sea ice in the winter, and sparsely populated coastal areas with limited marine infrastructure. The bulk of existing aquaculture leases are in the Chedabucto Bay area and are primarily for shellfish. There are no existing aquaculture leases between the northern edges of Chedabucto Bay up to South Harbour in the extreme north of Victoria County.

4.4.2 Regional Aquaculture Species Potential

Finfish

Cold water temperatures, high exposure to wind and waves, and winter sea ice conditions place substantial limitations on finfish culture in this region. In a study of 14 coastal inlets in Richmond County, Murphy (1997) identified five areas that had reasonably good potential for further finfish development, including Guysborough Harbour, Strait of Canso South, Inhabitants Harbour, and Lennox Passage. All of these areas are in the Chedabucto Bay area, which provides the most sheltered areas in this region. Given the risk of lethal winter temperatures, it is thought that seasonal culture of rainbow trout in the sheltered areas around Chedabucto Bay may present the best opportunity for finfish culture in this region. The potential for successful culture of Atlantic salmon, Atlantic halibut, and Atlantic cod is generally low in this region due to exposure and cold water temperatures.

Shellfish

The best opportunities for shellfish culture are in the sheltered areas of Chedabucto Bay. In a study of potential aquaculture sites in Richmond County, Murphy (1997) identified three sites with reasonably good potential, all of which were in Chedabucto Bay (Inhabitants Harbour and East

and West Lennox Passage). Blue mussel and sea scallop have the best potential in this region, while the waters in this region are generally too cold for American and European oysters.

Similarly, the most promising sites for scallop culture identified in a study by MacLaren Plansearch (1986) were located in Chedabucto Bay. The study found existing wild sea scallop beds in this area, suggesting that environmental conditions may be favourable for the species. From Cape North to Scatarie Island, only a few potential bottom culture sites for scallops were identified, including St. Anne's bay, where scallops were already present. Water temperatures in this bay remain below 18 °C even in the summer peaks. In contrast, summer water temperatures are too warm south of neighbouring Cape Dauphin due to the outflow of the Great Bras d'Or Lake. Other preferred sites for sea scallop include Port Morien Bay and Mira Bay, both of which have historically contained scallop beds. The Sydney-Glace Bay area was found to be unsuitable for sea scallop due to the presence of industrial effluents. Waters in the Cape Breton region are generally too cold for successful culture of bay scallops, other than some isolated areas of sheltered warmer water in the southern part of the region.

Detailed Aquaculture Studies Available

Murphy (1997) studied 14 inlets in Richmond County for aquaculture suitability based on depth, exposure, and potential conflicts with other resource users. MacLaren Plansearch Limited (1986) studied the eastern coastline of Cape Breton and Chedabucto Bay to identify areas with good potential for sea scallop culture. Mallet and Carver (1987) studied the potential for bay scallop culture in Aulds Cove.

Legend

NS Aquaculture Lease Locations (Leases Proposed, Under Review and Issued)

Species Type

- Finfish
- Shellfish
- NS Places
- Aquaculture Region
- NS Provincial Jurisdiction
- Detailed Studies Available

Scale 1 : 700,000
Project - 1048755.

0 10 20
Kilometres

Note: Proposed regional boundaries are approximate. Offshore boundaries are arbitrary.

N

Cape North
St. Margaret Village
South Harbour
Pleasant Bay
CAPE BRETON ISLAND
Ingonish
Ingonish Beach
Chéticamp
Margaree Forks
Cape Dauphin
Alder Point
Glace Bay
Inverness
VICTORIA COUNTY
SYDNEY
Port Morien
Baddeck
Cape Breton
Mabou
Port Hood
Whycocomagh
Scatarie Island
Marion Bridge
Eskasoni
CAPE BRETON COUNTY
INVERNESS COUNTY
Big Pond
Louisbourg
Judique
Bras D'or Lakes
Gabarus
Gabarus Bay
Auld's Cove (Mallet & Carver 1987)
Creignish
RICHMOND COUNTY
Havre Boucher
St. Peter's
RICHMOND COUNTY (Murphy 1997)
Port Hastings
Grande Anse
Louisdale
L'Ardoise
Mulgrave
Port Hawkesbury
Lennox Passage
Arichat
Petit-de-Grat
Chedabucto Bay
Guysborough
Canso
GUYSBOROUGH COUNTY
Dover
Port Felix
New Harbour
ATLANTIC OCEAN

DATE: November 2009	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO: 4.6
PREPARED BY: G. Mesheau		
NOVA SCOTIA Fisheries and Aquaculture	**CAPE BRETON AQUACULTURE REGION**	Stantec

4.5 BRAS D'OR

4.5.1 General Regional Conditions

The Bras d'Or Aquaculture Region includes the entire Bras d'Or Lakes system in central Cape Breton Island (Figure 4.7). This includes shorelines in Cape Breton County, Richmond County, Inverness County, and Victoria County.

The Bras d'Or is one of the most unique regions of the province in terms of biophysical conditions. The Bras d'Or Lakes have a unique stratification, with a large freshwater layer covering a deeper saline layer. There is limited saltwater intrusion, with the saline layer overlain by 6 to 15 m of freshwater (Aiken 1984). Surface waters freeze in the winter, but the deep saline layer remains warmer (Aiken 1984). The Bras d'Or Lakes physical oceanographic character is that of minimal mixing, movement, and tidal change. A pronounced thermocline exists throughout much of the year, influenced by solar warming and freshwater inputs. Only in a few constricted areas does tidal exchange create enough turbulence to mix the waters of the surface layer with those below throughout the year (Parker *et al.* 2007). The Bras d'Or is an area of limited tidal movement. Both tidal currents and tide height tend to be very small in all but a limited number of locations. The narrow and shallow sections of the Great and Little Bras d'Or Channels that connect to the open ocean limit the volume of tidal exchange that can occur on each cycle. The combination of restricted access to the ocean and freshwater inflow keeps the salinity of the Bras d'Or Lakes in the range of about 20 to 26 ppt. In May, surface water salinity is about 30 ppt at the entrance to the Great Bras d'Or Channel, 25 to 26 ppt in deepwater basins, and 20 to 21 ppt in surface waters of East Bay and North Basin. Even lower salinities have been found in the sheltered bays and near the mouths of the larger rivers. Heavy rainfall events can significantly affect lake water surface salinity to a depth of 5 m (Parker *et al.* 2007).

Most of the Bras d'Or Lakes become ice covered in winter. Ice cover typically begins to form in January with a peak cover occurring in early March. Greater and longer ice cover occurs in the area north of the Barra Strait compared to Bras d'Or Lake and other areas to the south where greater wind and wave action inhibit formation and encourage ice breakup. All cover is usually gone by early May. Normal ice cover approximates 70%, but ice cover varies considerably. During cold winters there will be 100% coverage and ice can be as thick as 1.5 m (Parker *et al.* 2007).

There are currently large numbers of shellfish aquaculture leases held in the Bras d'Or Lakes region, including particularly large concentrations in St. Peter's Inlet in Richmond County and in Inverness County. Although there are limited numbers of finfish leases held in St. Peter's Inlet and Whycocomagh Bay, there are currently no producers culturing finfish in this region.

Legend

NS Aquaculture Lease Locations (Leases Proposed, Under Review and Issued)

Species Type

- Finfish
- Shellfish
- NS Places

0 5 10
Kilometres

Scale 1 : 350,000
Project - 1048755.

Note: Proposed regional boundaries are approximate. Offshore boundaries are arbitrary.

CAPE BRETON ISLAND
VICTORIA COUNTY
INVERNESS COUNTY
CAPE BRETON COUNTY
RICHMOND COUNTY
Great Bras d'Or
Bras d'Or Lakes
West Bay
Inverness
Mabou
Port Hood
Judique
Creignish
Havre Boucher
Port Hastings
Grande Anse
Whycocomagh
Baddeck
Eskasoni
Big Pond
St. Peter's
Alder Point
Port Morien
Cape Breton
Marion Bridge
Gabarus
N

DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 4.7
NOVA SCOTIA Fisheries and Aquaculture	**BRAS D'OR AQUACULTURE REGION**	Stantec

4.5.2 Regional Aquaculture Species Potential

Finfish

Winter ice conditions and cold temperatures generally limit the potential for finfish culture in this region. Given that large portions of the waters in this region freeze over during winter months, the use of net-pens is largely unfeasible. Rainbow trout have been cultured successfully in this region in the past, although with limited success, so there is moderate potential for developing seasonal rainbow trout sites. The potential for Atlantic salmon, Atlantic halibut and Atlantic cod is very low in this region.

Shellfish

American oyster aquaculture has occurred in this region for decades. Currently there is a large number of oyster leases in the Bras d'Or Lakes; however, most of them are underutilized due to a range of issues (*e.g.,* costs of production, loss of habitat, disease and user conflicts). The culture of oysters in this region is generally limited by low salinity levels and the narrow temperature range. It has been estimated that only five percent of the bottom habitat in this region is suitable for oyster culture (Parker *et al.* 2007). Oyster culture is limited to a small number of shallow bays where temperatures are warmer and salinities higher. There are also limited hard bottom habitats in this region, which features predominantly silt-laden substrates. The best opportunity for expanding oyster culture in this region is by employing off-bottom or suspension systems.

The presence of MSX in various parts of this region has decimated the shellfish culture industry, and in particularly oysters. Blue mussel culture in this region is restricted by the presence of *M. trossulus*, a species of mussel that is not well suited to aquaculture due to a weaker shell, lower annual meat yield, and lower growth rates.

The low salinity of the Bras d'Or Lakes is a limiting factor for the culture of sea scallops. Although there are some wild sea scallop beds in the north end of the Great Bras d'Or Channel, the salinity elsewhere in this region is too low for this species to be cultured successfully. Biophysical conditions are excellent for bay scallops in this region and there is good culture potential. The present challenge for bay scallop culture is that they are a non-native species to this area and would require a special permit to be introduced to this region.

4.6 GULF SHORE

4.6.1 General Regional Conditions

Gulf Shore

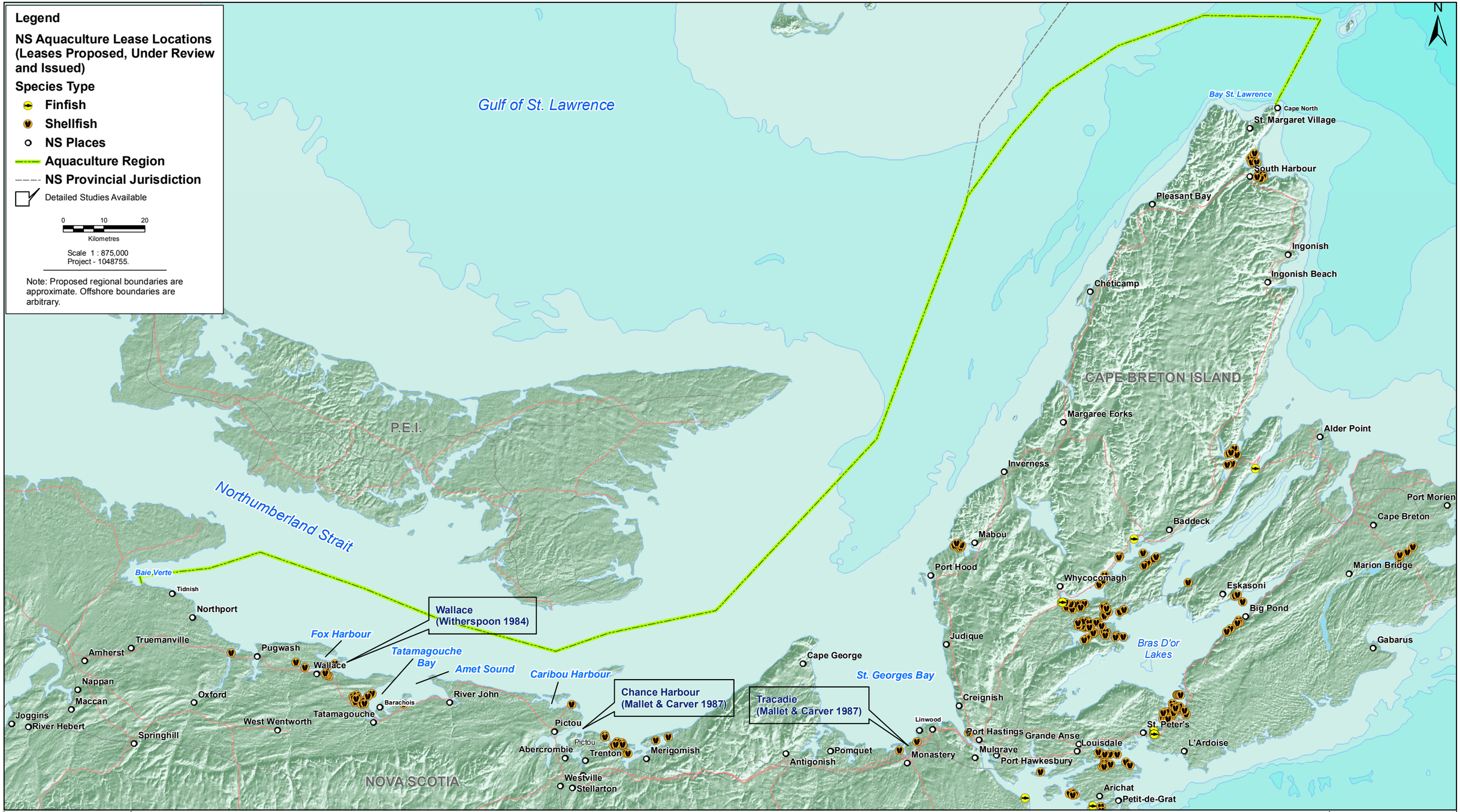
The Gulf Shore Aquaculture Region includes the coastal areas spanning from Baie Verte and Tidnish near the Nova Scotia/New Brunswick border, up to Cape North and Bay St. Lawrence in northern Cape Breton (Figure 4.8). The waters in this region include the Northumberland

Strait, St. George's Bay, and the more open waters of the Gulf of St. Lawrence along the Western Cape Breton coastline.

The Gulf of St. Lawrence is characterized by shallow water, low tidal action (no more than approximately 1 m in the southern portion) (Aiken 1984), and extensive winter ice formation between December and March. The temperature regime in this area varies from 0°C in winter to above 23°C in summer (Boghen 1995).

The Northumberland Strait is a long, narrow and shallow body of water that runs between Prince Edward Island and Nova Scotia. It is a unique area of Nova Scotia because it experiences summer water temperatures above 20 °C, with temperatures in shallow bays and estuaries sometimes exceeding 25 °C (Witherspoon 1984). This area is heavily influenced by tides, with tidal energy exerting the greatest influence on water currents than any other factors. The intertidal zone is narrow as the average tidal amplitude in areas such as Tatamagouche Bay and Wallace is only 2.5 m. The bottom sediment varies from gravel and sand in the upper part of the intertidal zone to soft mud in the lower intertidal and subtidal zones. Residence times for waters in the Northumberland Strait are on the order of weeks to months. Wild populations of warm water shellfish are found throughout the Northumberland Strait, including American oyster and blue mussel.

Beyond St. Georges Bay north along the western coast of Cape Breton, conditions transition from sheltered waters to a coastal zone that has greater exposure to wind and waves. Apart from some shellfish leases in the sheltered areas of Mabou, there is currently no aquaculture activity on the western coast of Cape Breton. In the Northumberland Strait there are currently over 20 shellfish leases, focused primarily in Tatamagouche Bay and Wallace Harbour. There are currently no leases for finfish culture in this region. There are very active commercial fisheries that operate in the Northumberland Strait, including fisheries for lobster, rock crab, snow crab, herring, and scallop. There is also a substantial recreational harvest in this area since it is a popular area for cottages in the summer months. Contamination issues resulting from sewage from municipalities and cottages are a potential problem in many harbours in this region and there are a large number of areas that are currently closed to shellfish farming. The development of new aquaculture sites in this region will require consideration and mitigation of potential interactions with cottagers and commercial fisheries.



DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 4.8
NOVA SCOTIA Fisheries and Aquaculture	**GULF SHORE AQUACULTURE REGION**	Stantec

4.6.2 Regional Aquaculture Species Potential

Finfish

The culture of finfish in the Gulf Shore Aquaculture Region is limited by the risk of lethal winter temperatures, high summer temperatures, predominantly shallow waters, and heavy winter ice conditions. Winter temperatures often fall well below zero and summer temperatures are frequently well above 20 °C. The temperature regime in this region is well outside the biological requirements for Atlantic salmon, rainbow trout, Atlantic cod, or Atlantic halibut. Ice conditions and shallow waters also generally preclude the use of net-pens to culture finfish.

Shellfish

There is excellent biophysical potential for new shellfish aquaculture development in the Gulf Shore. American oyster and blue mussel are native to the area and generally do well in the temperature regime in these waters. The area is particularly attractive for American oyster due to the high summer temperatures (Aiken 1984) and this species is also able to withstand the colder winter temperatures. European oyster also have excellent potential to be successfully cultured in this region. Blue mussels are robust and winter-hardy, but some are susceptible to summer kill when temps exceed 20 °C for extended periods. There are existing commercial and recreational fisheries for mussels in the area, and seed mussels are available throughout (Scarratt 1993). Bottom culture is favoured for these species in this region due to heavy winter ice conditions; otherwise, suspension gear must be submersible to survive winter ice conditions, although in some areas the shallow depths may pose limitations for suspension culture.

Sediments along most of the coast in the Gulf of St. Lawrence tend to be a mixture of sand and gravel conducive to scallop culture, although the predominance of silts and muds in sheltered areas (*e.g.* Tatamagouche Bay or Merigomish Harbour) limits the potential for sea scallop culture in those areas. Survival of sea scallops in this region is sensitive to summer temperatures, particularly in shallow waters, which should be avoided (MacLaren Plansearch 1996). The lack of reported scallop beds from Merigomish Island to Cape George indicate that these areas are not likely suitable for sea scallop culture.

Due to the warm and fertile waters in this region, particularly in the Northumberland Strait, there is tremendous potential for bay scallop culture, as bay scallops have the potential for harvest after a single growing season, making it an ideal candidate species for this region, Good growing potential has been identified for this species in a number of Northumberland shore sites (Mallet and Carver 1987).

Detailed Aquaculture Studies Available

There are several previous studies that have examined aquaculture potential in this region. Scarratt (1993) looked at potential for a number of commercial species in the coastal waters from Tidnish up to Pleasant Bay and Cape St. Lawrence in Inverness County. In all, the study provided assessments of aquaculture potential for 51 distinct areas along this stretch of

coastline. MacLaren Plansearch Ltd. (1986) studied the Northumberland Shore, from the New Brunswick coast to the western entrance of St. George's Bay, and from St. Georges Bay up along the coast of Cape Breton, to determine areas suitable for sea scallop culture. Witherspoon (1984) assessed Fox Harbour, Tatamagouche Bay and Wallace Bay for the potential to culture of bay quahaug, American oyster, and blue mussel. Mallet and Carver (1987) studied sites in Tracadie and Chance Harbour to determine the suitability of these areas for bay scallop culture.

5.0 SUMMARY OF BIOPHYSICAL SUITABILITY BY SPECIES

Nova Scotia is a relatively small province; however, results of this study reveal that there is wide variability in climatic and oceanographic conditions around the coast. This variability means that the biological requirements of commercial aquaculture species can be met in some regions of the province, but not others. This phenomenon is not a barrier to development, but provides the province with an excellent opportunity to develop a diverse aquaculture sector, with good potential for producers of many different commercial species to develop new sites. Results of the study show that there is excellent potential for aquaculture development for at least one of the studied species in every region of the province, and several regions of the province have biophysical conditions that are well-suited to the development of multiple species. Atlantic salmon and rainbow trout are currently the dominant commercial species in the province, and this study indicates that there is considerable room for expansion of salmon and trout farming in several parts of the province. Sea scallop and blue mussel have good potential in the greatest number of regions in the province, allowing for a wide range of opportunities for prospective aquaculture developers. The study also reveals that there are many good potential areas for the farming of new species such as Atlantic cod and Atlantic halibut.

Based on the regional assessments of aquaculture suitability provided in Section 4.0, a summary of province-wide aquaculture potential has been developed for each of the nine studied species. For each species, a figure has been developed indicating the level of potential for future development of that species in each of the seven aquaculture regions in Nova Scotia. The level of potential has been rated according to biophysical conditions only, given currently available and preferred technologies. The following defines the rating system employed.

Poor – Biophysical conditions in this region are generally not suitable for the species being assessed, or marine conditions preclude the deployment of the preferred culture technology. Culturing the given species in this region would involve a high-level of risk and would require substantial investment in technological systems to control rearing conditions. Although technological advances may improve the feasibility of culturing the given species in this region in the future, in the short-term the potential for development is low.

Moderate – In general, the biophysical conditions in this region are not well-suited to the species being assessed; however, there are localized areas within the region where the biophysical requirements of the species could be met and where it could be feasible to deploy the preferred culture technology. The level of risk associated with developing a new culture site in this region can be reduced and managed by conducting additional site-specific analyses of biophysical conditions in order to identify suitable sites within this region.

Good – The biophysical conditions in this region are well-suited to the requirements of the species being assessed, and deployment of the preferred culture technology is feasible. The requirement for technological intervention to control rearing conditions is limited in this region relative to other regions. Successful culture of the given species, or a related species, has been proven in this region.

These ratings are based on professional judgement as a consensus from the literature, stakeholder interviews, and results of the stakeholder workshop. The ratings are not intended to preclude aquaculture development of any species in any region of the province. It is possible that a species could be cultured successfully in a region that is rated as “poor” for that species. It is also possible for a new site development to fail despite the fact that the region is ranked as “good”. These rankings are intended to provide a general guide on the level of risk associated with developing a new site in a particular region, and to identify some of the better opportunities for each of the nine species, based largely on biophysical conditions. More detailed site-specific assessments are required to make further determinations of aquaculture suitability within each of the regions.

5.1 SPECIES SUITABILITY SUMMARIES

The maps in this section provide a province-wide summary of area suitability for aquaculture development for the nine proposed commercial species. The rationale behind these rankings is generally provided in Section 4.0, and the ranking methodology is described above in Section 5.0. A general summary of areas with potential for development for each species is provided below.

According to input and feedback from the NS aquaculture industry, Atlantic salmon is the most important commercial aquaculture species in the province and there is good potential to further develop the culture of this species in several parts of the province (Figure 5.1). Excellent potential exists in the western and southwestern areas of the province due to a favourable water temperature profile and the availability of areas sheltered from wind and wave action. Consultation with the aquaculture industry also indicates that there are areas with good potential along the Eastern Shore, and further research and exploration in this region will help identify these suitable microclimates.

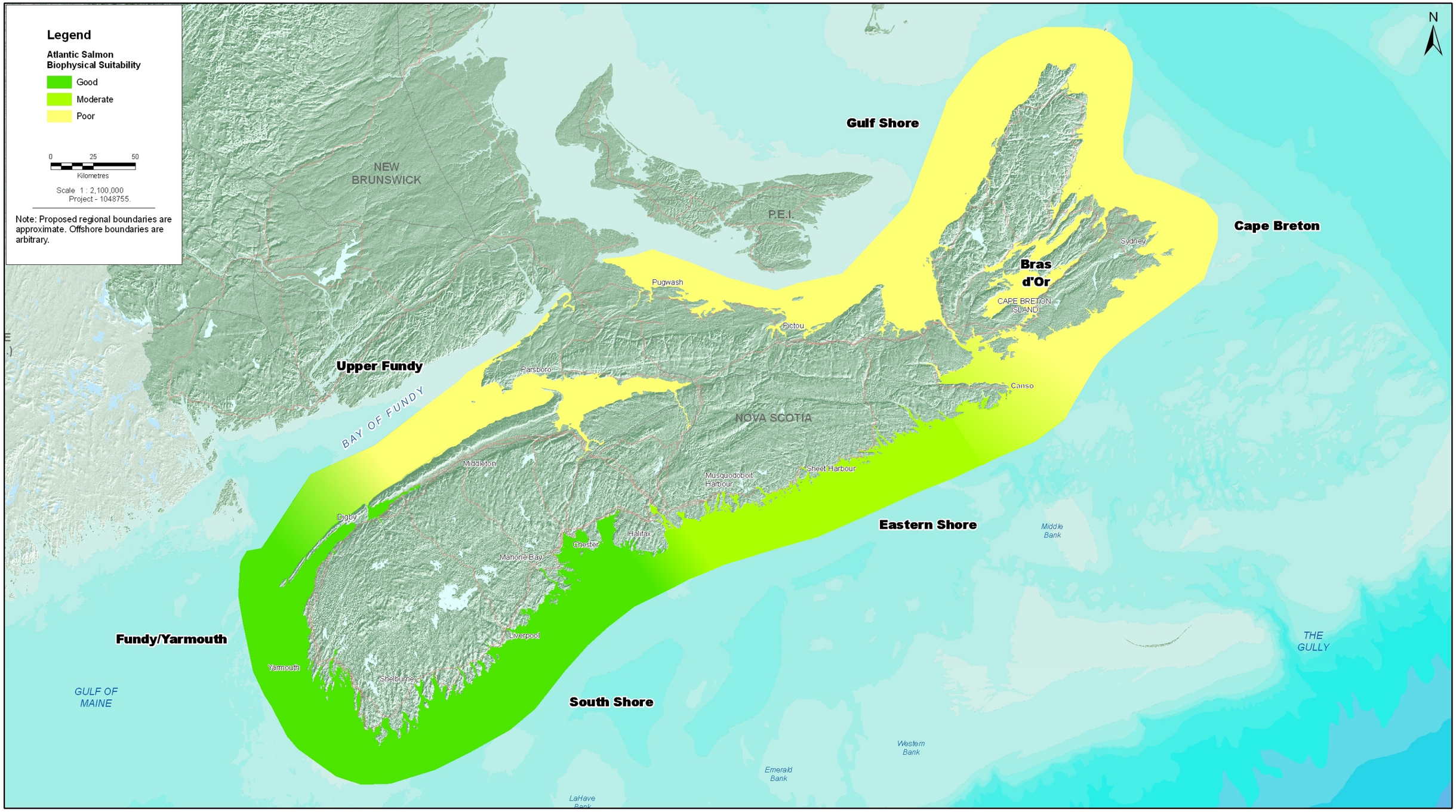
Rainbow trout is currently the second most important commercial aquaculture species in the province, and results of this study indicate that there is excellent potential for expansion of trout farming (Figure 5.2). The areas with greatest potential for rainbow trout are generally found in the western and southwestern areas of the province, similar to Atlantic salmon. In addition, rainbow trout can be successfully cultured on a seasonal basis in order to avoid cold winter water temperatures, which gives the species a distinct advantage over Atlantic salmon and increases the geographic range in which they can be successfully cultured. Some of the key areas where seasonal culture of rainbow trout has good potential include areas along the Eastern Shore, in Chedabucto Bay and Arichat Harbour.

With the exception of the Upper Fundy and Bras d’Or Lake regions, biophysical conditions throughout the province are well-suited for culture of blue mussel (Figure 5.3). Blue mussels are a hardy shellfish species, and the wide geographical range of good areas for culturing this species indicates that there is great potential for increasing the level of production. Areas with excellent potential include the South Shore, Eastern Shore, and Northumberland Strait.
The successful culture of American oyster generally requires warm water temperatures, and as such, the area of the province with the greatest potential for culturing this species is in the warm waters of the Northumberland Strait (Figure 5.4). Results of the stakeholder consultations also

indicate that there are smaller areas of good potential for this species located throughout the Fundy-Yarmouth region, as well as the Cape Breton and Bras d'Or regions. The areas with greatest potential for the culture of European oyster include the Gulf Shore region and the South Shore (Figure 5.5). The biophysical conditions in these regions are well suited to the European oyster and the species has been successfully cultured in both regions. Results of the stakeholder consultation also indicate that there are areas with good biophysical conditions for European oyster in the Fundy-Yarmouth and Eastern Shore regions of the province. Further research and exploration in these regions will help identify the locations of these microclimates.

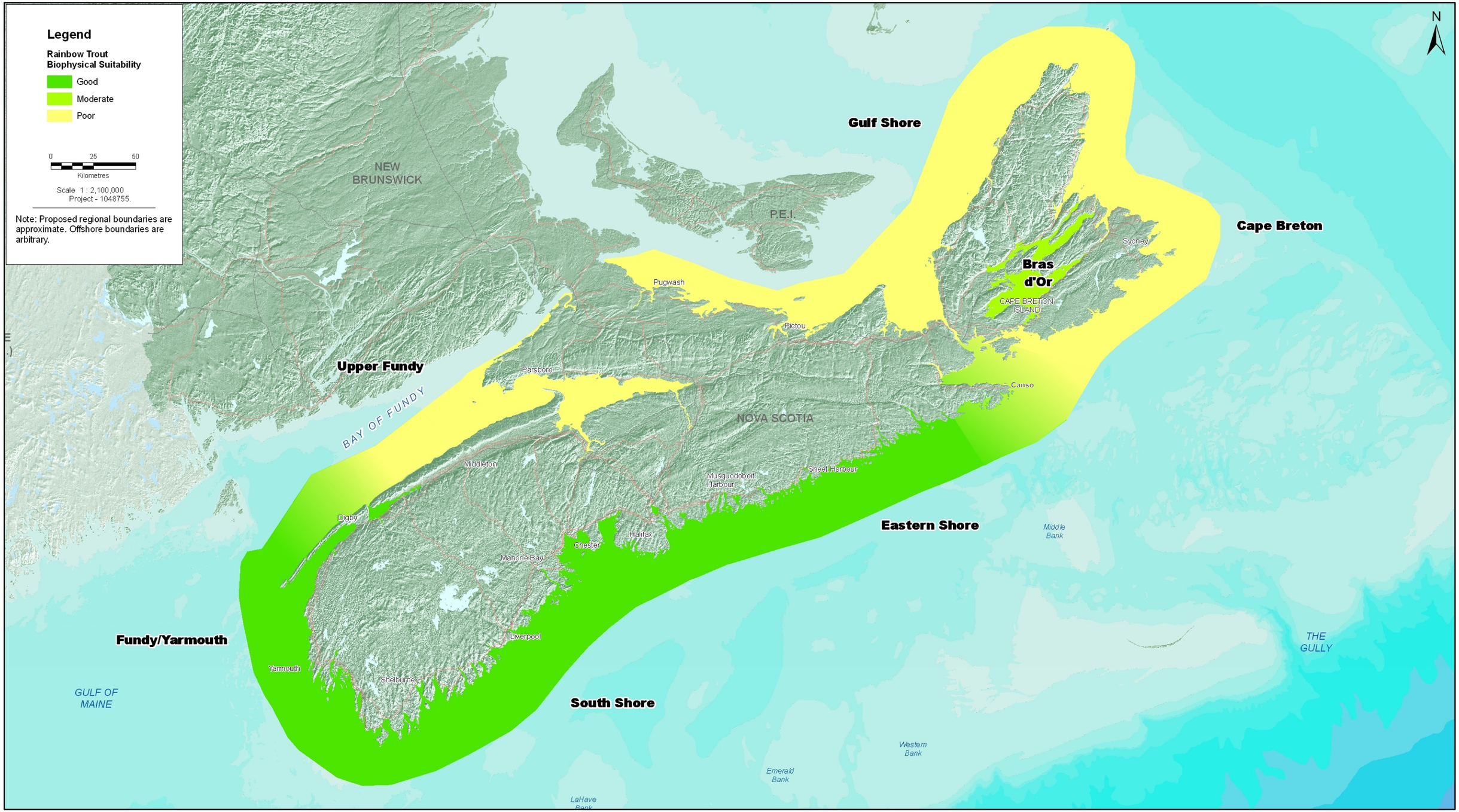
Due to its particular biophysical requirements, the geographical range of areas with good potential for culture of bay scallop is slightly limited relative to the other commercial species assessed in this study (Figure 5.6); however, there is excellent potential for expanding the culture of this species in the Gulf Shore region, and isolated areas with good potential in the western and southwestern part of the province. Results of the stakeholder consultation indicated that one of the best aquaculture development opportunities in Nova Scotia is the culture of bay scallop in the Northumberland Strait, where this species can be reared to market size in one grow-out season. This provides the bay scallop with a distinct advantage over other shellfish in the marketplace and represents an economic opportunity for prospective aquaculture developers in the province. There is also excellent biophysical potential for bay scallop culture in the Bras d'Or Lakes. With the exception of the Bras d'Or Lakes, biophysical conditions around the province are generally well-suited to the culture of sea scallop and there is good potential for increasing the production of this species in Nova Scotia (Figure 5.7).

Two species with emerging commercial aquaculture potential in Nova Scotia are Atlantic cod and Atlantic halibut. While neither of these species are widely farmed around the province at this time, results of the stakeholder consultation indicate that there are several areas with good potential for the culture of these species. Biophysical conditions are well-suited for Atlantic cod along the coast in the Fundy-Yarmouth and South Shore regions (Figure 5.8). Due to cod's ability to tolerate colder water temperatures than salmonids, there is also good potential for development of this species in the cooler waters of the Eastern Shore region. The areas with greatest potential for culture of Atlantic halibut include the Fundy-Yarmouth and South Shore regions of the province (Figure 5.9). Results of the stakeholder consultation also indicate that there are microclimates with good potential along the Eastern Shore and in the Minas Basin area in the Upper Fundy region. These emerging species represent a great opportunity to diversify the culture of finfish in Nova Scotia, and results of this study reveal that there are several coastal areas around the province with suitable biophysical conditions for these species.



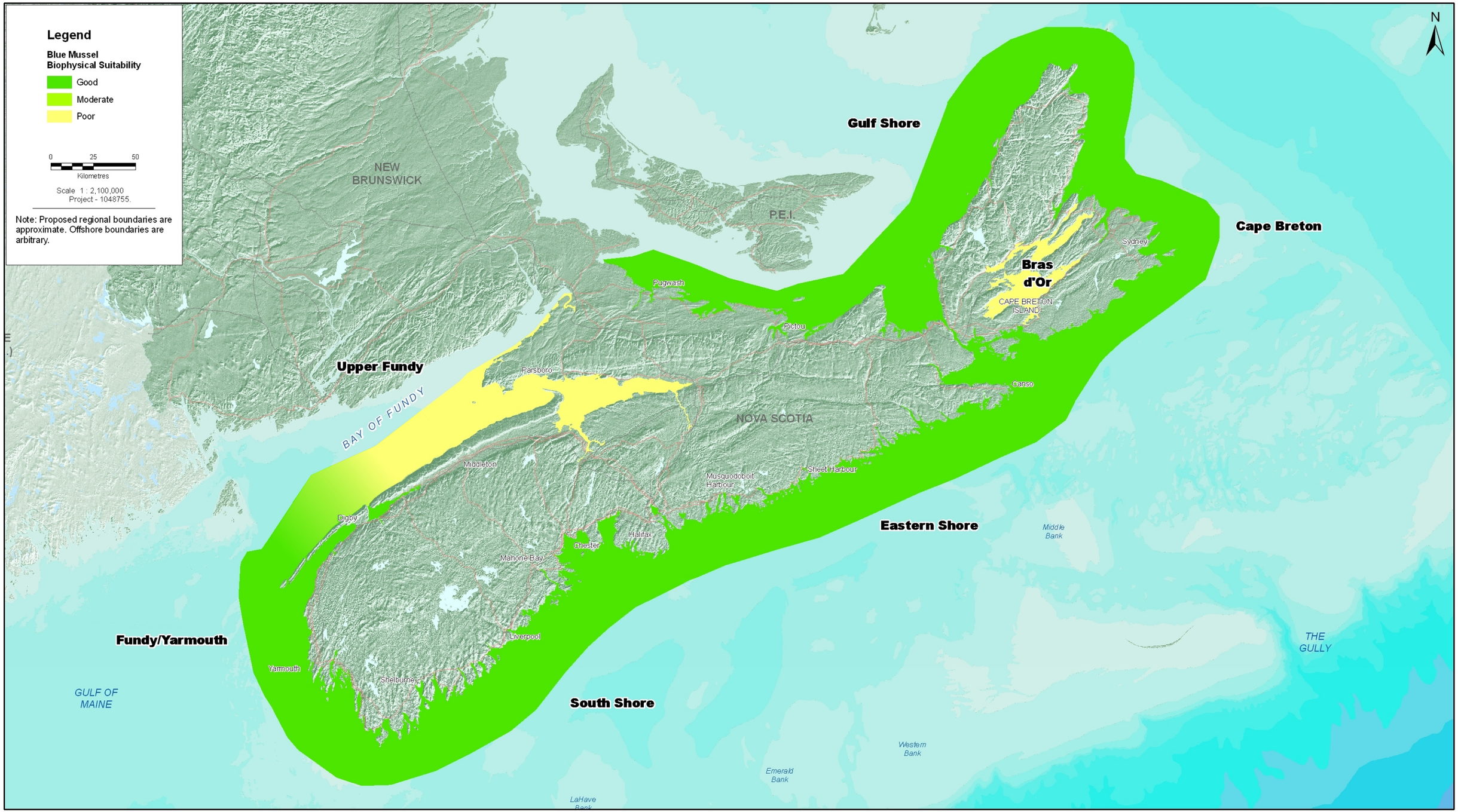
DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.1
NOVA SCOTIA Fisheries and Aquaculture	**ATLANTIC SALMON - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.



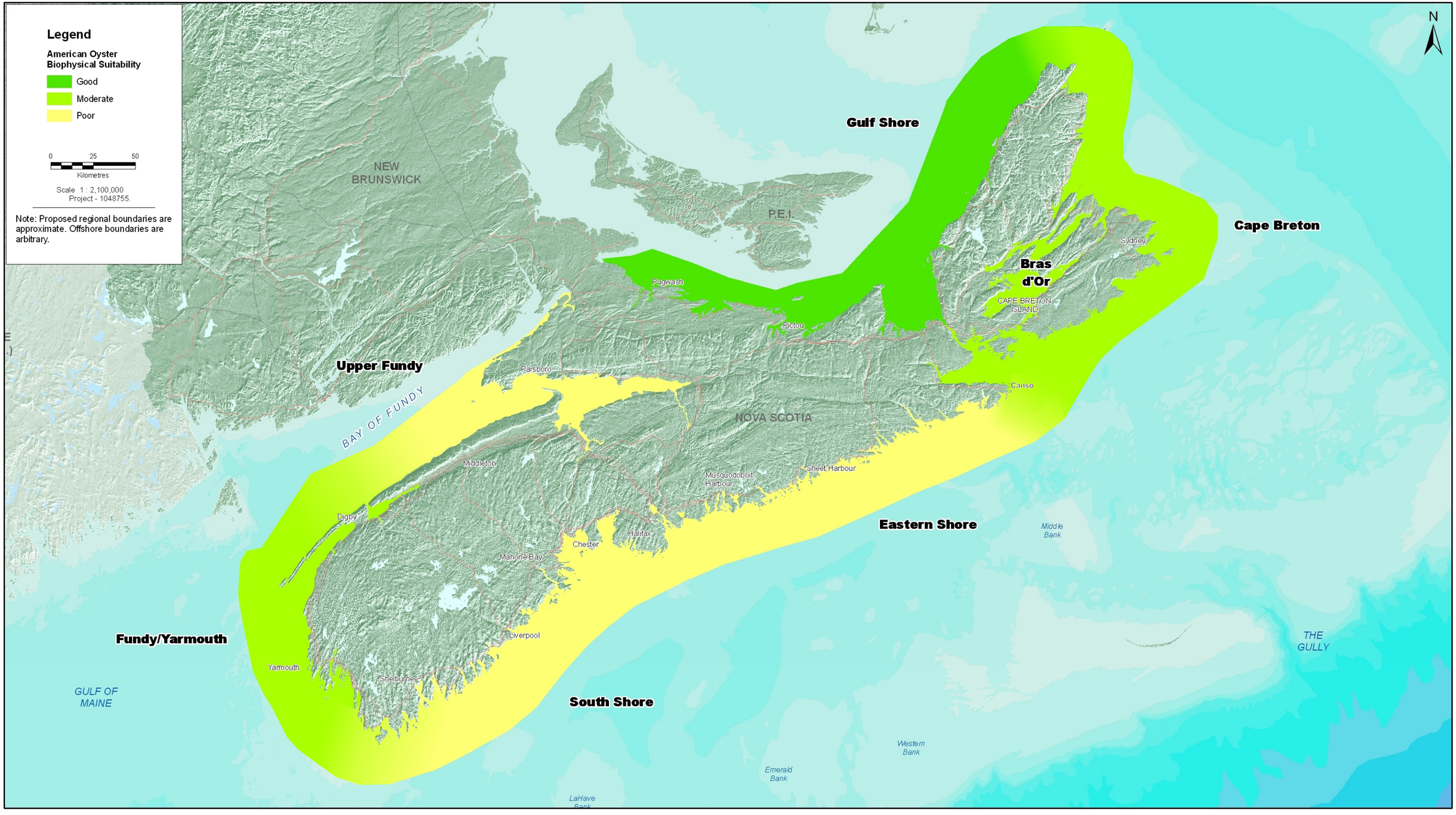
DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.2
NOVA SCOTIA Fisheries and Aquaculture	**RAINBOW TROUT - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.



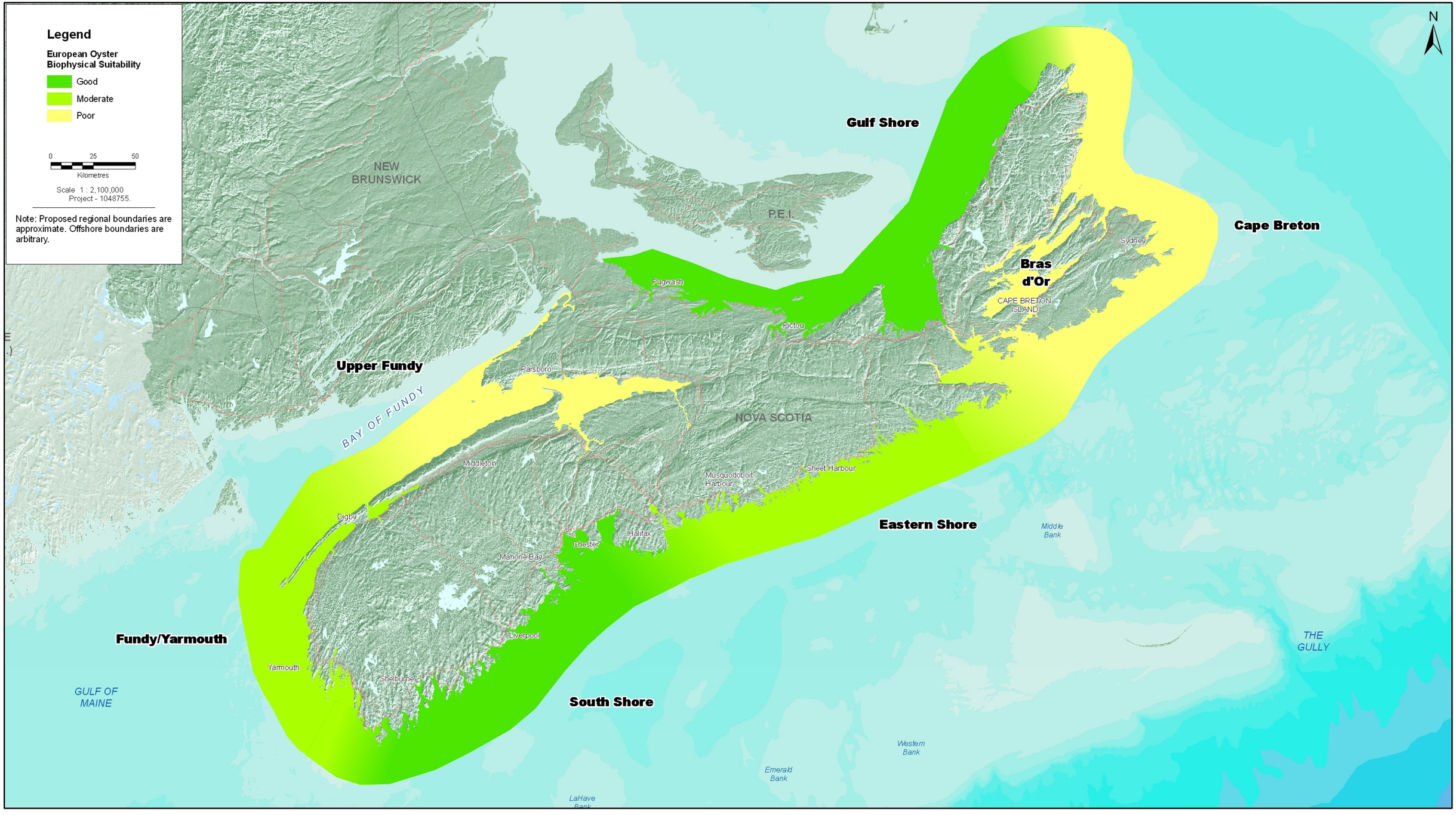
DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.3
NOVA SCOTIA Fisheries and Aquaculture	**BLUE MUSSEL - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.



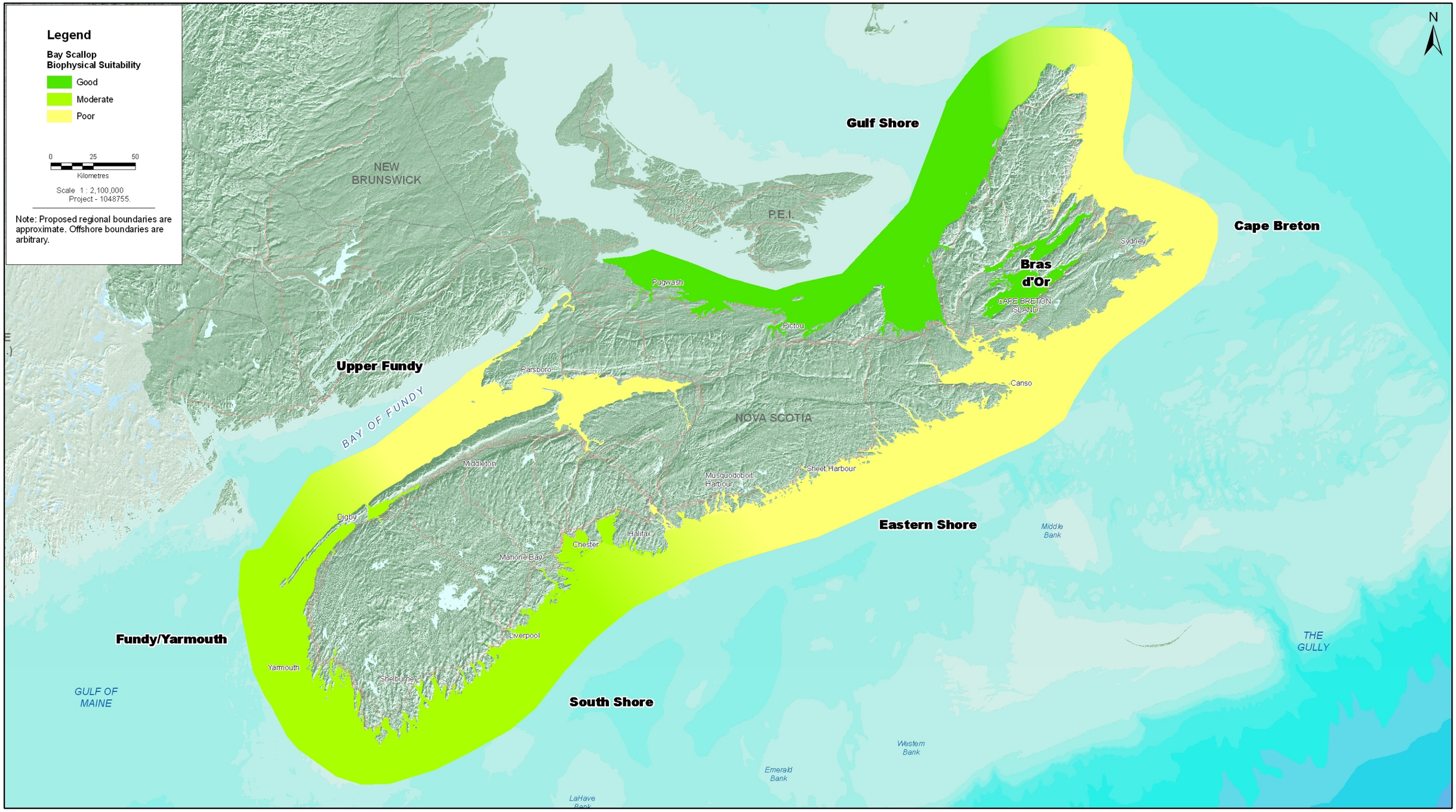
DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.4
NOVA SCOTIA Fisheries and Aquaculture	**AMERICAN OYSTER - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.



DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.5
NOVA SCOTIA Fisheries and Aquaculture	**EUROPEAN OYSTER - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.



DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.6
NOVA SCOTIA Fisheries and Aquaculture	**BAY SCALLOP - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.

Legend

Sea Scallop Biophysical Suitability

- Good
- Moderate
- Poor

0 25 50
Kilometres

Scale 1 : 2,100,000
Project - 1048755.

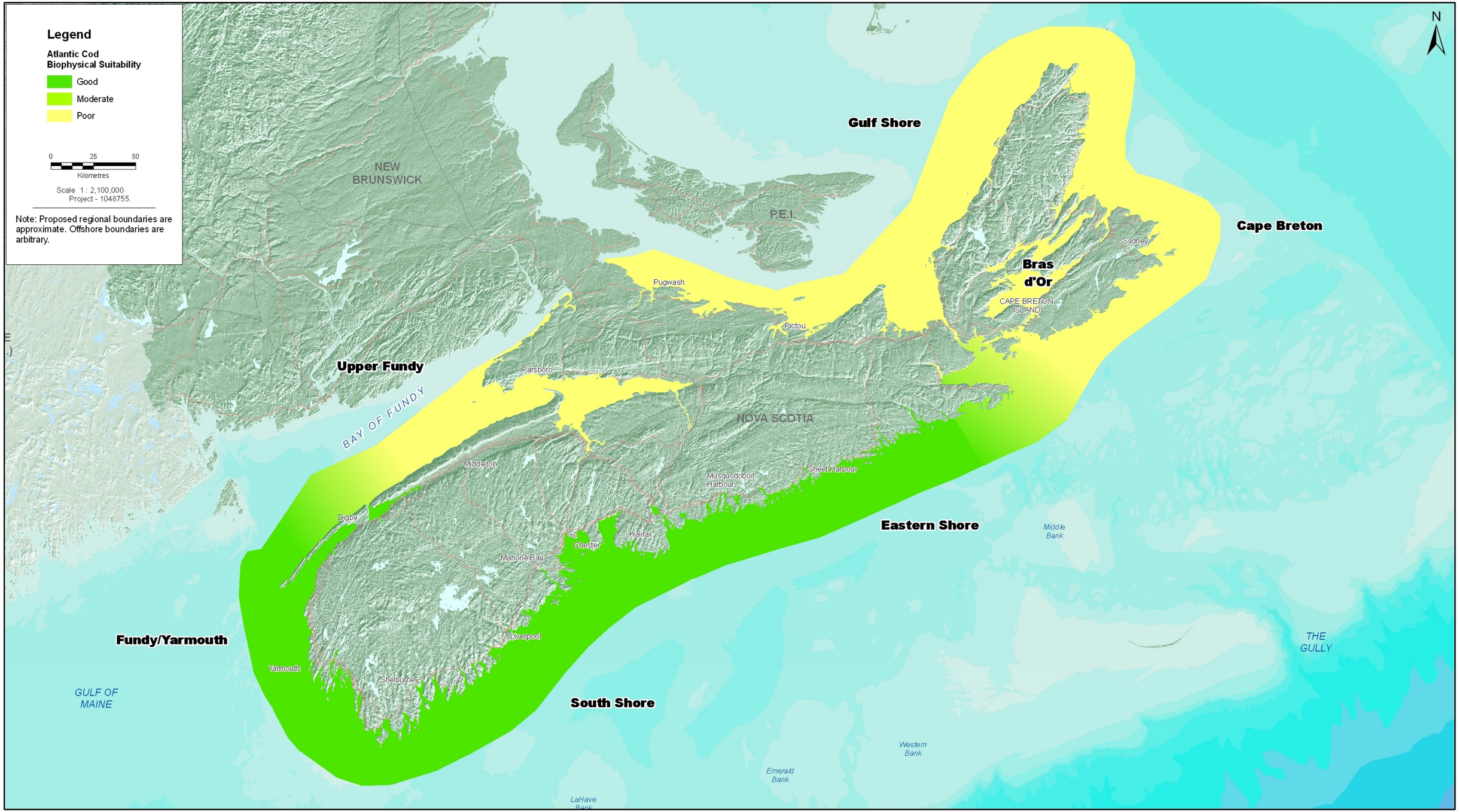
Note: Proposed regional boundaries are approximate. Offshore boundaries are arbitrary.

N

NEW BRUNSWICK
P.E.I.
NOVA SCOTIA
Gulf Shore
Cape Breton
Eastern Shore
Upper Fundy
Fundy/Yarmouth
South Shore
BAY OF FUNDY
GULF OF MAINE
THE GULLY
Middle Bank
Western Bank
Emerald Bank
LaHave Bank
Bras d'Or
CAPE BRETON ISLAND
Sydney
Pugwash
Pictou
Parsboro
Canso
Middleton
Musquodoboit Harbour
Sheet Harbour
Digby
Halifax
Chester
Mahone Bay
Liverpool
Yarmouth
Shelburne

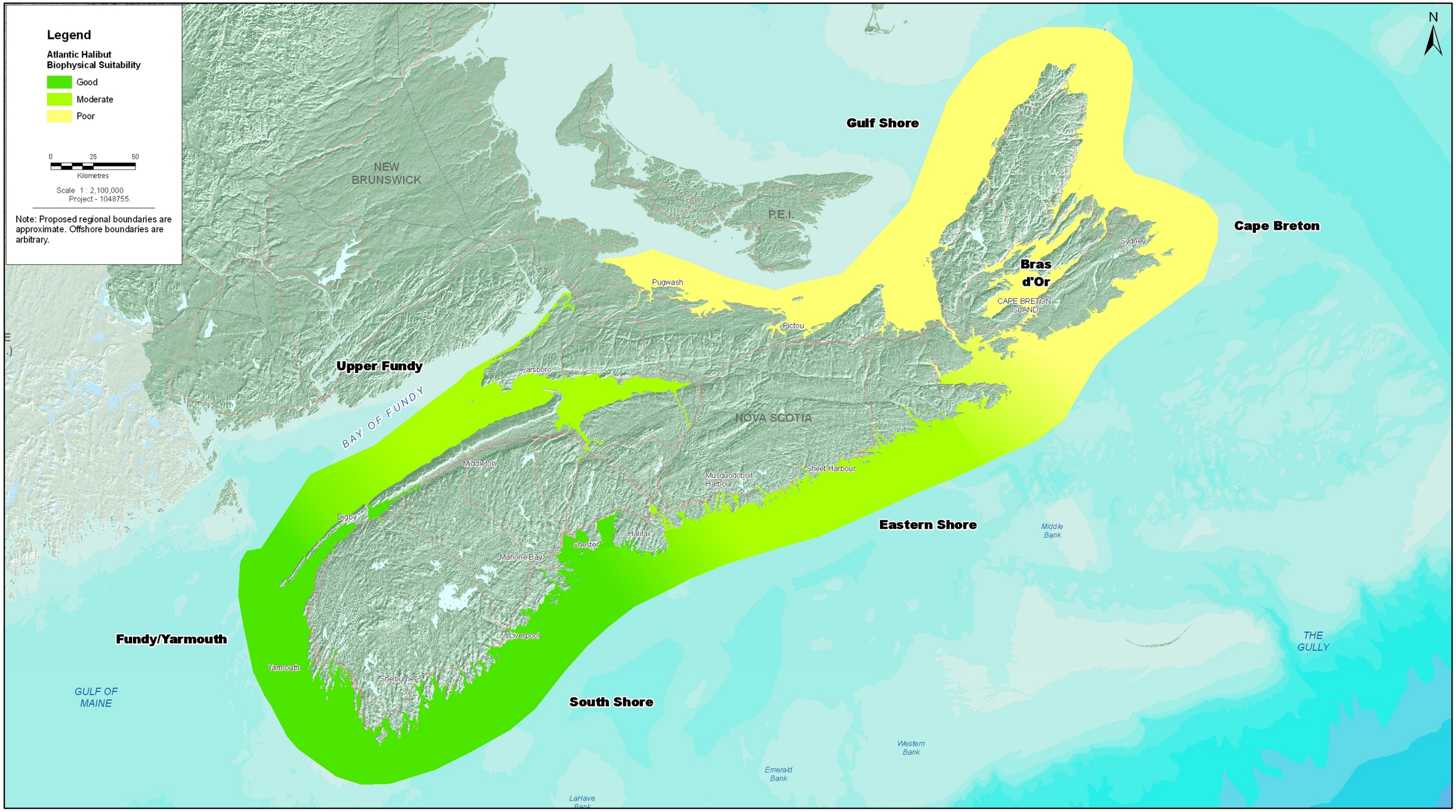
DATE: July 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.7
NOVA SCOTIA Fisheries and Aquaculture	**SEA SCALLOP - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.



DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.8
NOVA SCOTIA Fisheries and Aquaculture	**ATLANTIC COD - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.



DATE: November 2009 PREPARED BY: G. Mesheau	Road Map for Aquaculture Investment in Nova Scotia	FIGURE NO.: 5.9
NOVA SCOTIA Fisheries and Aquaculture	**ATLANTIC HALIBUT - REGIONAL BIOPHYSICAL SUITABILITY**	Stantec

Note: Rating of regional aquaculture suitability has been based on general biophysical conditions only. The figures do not convey site-specific conditions and are not intended to preclude aquaculture development in any region of Nova Scotia. The figures are intended as a general guide to suitability and should not be used to make specific investment decisions.

6.0 THE CHALLENGE OF CHANGE

The suitability of a site for aquaculture development can change for a number of reasons, such as changing environmental conditions (*e.g.,* climate change), changing scientific knowledge regarding the necessary conditions for individual criteria, and changes in technologies that, in turn, help to overcome siting limitations. During interviews, stakeholders were asked to reflect on these types of changes and how they may affect site suitability.

6.1 CHANGING ENVIRONMENTAL CONDITIONS

There were some differences of opinion when it came to possible environmental changes and how these changes might affect siting criteria and aquaculture operations. For the most part, respondents stated that changes in environmental conditions will very likely have an effect on site suitability, but the timing, direction, and magnitude of the impacts cannot be known at this point.

Some initial comments on possible effects from climate change are effects on:

- Temperature (especially maximums and minimums) and, therefore, the geographic range for a specie's culture;
- Sea level rise;
- Plankton composition and algal blooms;
- Number of days of super chill per year;
- pH changes;
- Wind conditions;
- Winters and ice conditions;
- Storm severity and frequency; and
- Invasive species (abundance and new species).

Some respondents commented that it would be best for their aquaculture operations if the temperature got colder or stayed the same, while others thought that a one degree increase in temperature would benefit them. This is dependent on the species being farmed.

One respondent stated that climate change is already having effects on grow-out operations in terms of ice conditions, the presence of new species, and changes to the populations of existing species. Some respondents do not believe changes in the environment will significantly affect site suitability. Impacts to sites are predicted to be largely species-dependent.

6.2 ADVANCEMENTS IN SCIENTIFIC KNOWLEDGE

In general, respondents believe that advancements in scientific knowledge will assist the aquaculture industry. New scientific knowledge will be particularly useful for newly farmed or alternate species, such as Atlantic halibut and Atlantic cod. Continued efforts in monitoring and

data collection will contribute to the larger body of knowledge, particularly with respect to site-specific conditions.

Strain selection work could be beneficial to improving the species being grown in Nova Scotia. For example, some strains of rainbow trout can live and grow more successfully in cold water than others. Some work is being done internationally on genetically-modified organisms that have built-in antifreeze to survive cold temperatures. However, some industry members feel that the industry in Nova Scotia is not interested in pursuing genetic modification to this extent.

Continued scientific research in moving aquaculture into the offshore or other high energy environments will assist the industry to grow by opening up new culture sites. Land-based aquaculture is also believed to be an area of future growth for the industry.

Despite studying certain diseases, such as MSX, for more than fifty years, many unknowns remain. It was noted in interviews that new scientific knowledge would assist in the development of a management plan for the Bras d'Or region. Further research on invasive species, such as tunicates, will assist the industry in effective pest control.

Much is known about commonly farmed aquaculture species, and siting criteria are detailed in a number of different literature sources. It is important to disseminate this knowledge to aquaculturalists and potential new entrants into the industry. A solid understanding of the species to be farmed is crucial to success. Partnerships between researchers and growers are essential, particularly because growers observe the limiting factors of a species culture in the field across a wide range of conditions.

6.3 ADVANCEMENTS IN TECHNOLOGIES

Technological advancements for working offshore or in high energy environments will benefit the industry by allowing it to operate in these new areas successfully. For example, advancements in net-pen design continue to improve. It was suggested that perhaps technological advancements will help with pest deterrence in the future as well.

Feeding systems are now being used by larger companies, though they are expensive. This allows fish to feed during high winds or storms when boats cannot get out to the site. This saves on operating costs and reduces lost feed days. Feed cameras are also used extensively now, which saves on wasted feed. Feed has also been improved to have less breakage. Similarly, new water-borne feeding systems also reduce feed breakage, as opposed to traditional airborne feed systems.

Some respondents believe that new technologies will come in the form of marginal changes and improvements upon existing technology more so than creating substantial, new inventions. It may be wise to look back instead of ahead in some situations. For example, oyster aquaculture has been practiced in Southeast Asia for thousands of years; the industry could use this historical knowledge to improve practices in Nova Scotia. Technology transfer was also noted as useful and commonly done in Nova Scotia. For example, continuous socking for mussels is

now being practiced in the province, which was adopted from New Zealand. Some new technologies exist internationally, but are not currently used in Nova Scotia for various reasons, such as cost.

7.0 REQUIRED FUTURE WORK

This report is one stepping stone in the effort to expand the marine aquaculture industry in Nova Scotia. From the results of this research and industry consultations, the Jacques Whitford Stantec Limited Project Team recommends that future work by the NSDFA focus on three key areas:

- *Increased knowledge and dissemination of information on biophysical conditions in Nova Scotia.* This report has provided general descriptions of the biophysical conditions in each of the seven defined aquaculture regions across the province and a high-level analysis of how these conditions affect suitability for each of the species examined. Based on the available literature and results of the stakeholder consultations, this report has also identified three key siting criteria that should be explored further: temperature, salinity, and depth. Further effort should be focused on compiling existing data and making available information on these three criteria in each of the aquaculture regions across the province. This could include the generation of regional or sub-regional maps showing where these criteria are generally suitable for key commercial species and using this information to conduct constraint mapping exercises.

- *Further examination of socioeconomic conditions in Nova Scotia.* Although socioeconomic conditions were not generally included in the assessments of regional aquaculture suitability in this report, results of the stakeholder consultations revealed that issues such as conflicts with other resource users and availability of infrastructure have significant implications in site selection and, more importantly, site availability. For instance, there are particular areas of the province identified as having tremendous potential from a biophysical perspective for culturing commercial species, but stakeholders indicated that potential conflicts with other resource users places limitations on the availability of these sites. Efforts that are currently underway by the NSDFA to identify and address these socioeconomic barriers should be continued. While biophysical conditions can be a very difficult and costly barrier to overcome, there is good potential to overcome socioeconomic barriers within the province and allow for expansion of the industry.

- *Assessment of additional barriers to expansion of the industry.* Results of the stakeholder consultations revealed that in addition to the biophysical and socioeconomic barriers to expansion of the marine aquaculture industry that were identified in this study, there are additional financial barriers to development of the industry in Nova Scotia. These included levels of government funding and the industry's ability to leverage and access capital for development. The NSDFA should continue to discuss these issues with industry stakeholders and develop ways to address the barriers.

- *Examination of seasonal product potential and value-added products*. While cold seawater temperatures can be a constraint to aquaculture potential in some regions of the province, there is potential for some species, such as rainbow trout, to be harvested seasonally in order to avoid cold winter temperatures. This posses unique challenges to the sale of fresh product because it enters the market over a relatively narrow time period, potentially resulting in depressed prices. However, there is good potential to develop value-added products outside of the fresh market to mitigate this situation.

8.0 Closure

This report has been prepared for Nova Scotia Department of Fisheries and Aquaculture. Any uses that a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. Jacques Whitford Stantec Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken, based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted scientific practices current at the time the work was performed. Conclusions and recommendations presented in this report should not be construed as legal advice.

The conclusions presented in this report represent the best technical judgement of Jacques Whitford Stantec Limited based on the available data and information obtained from the work. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

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APPENDIX A
STAKEHOLDER INTERVIEW GUIDE

Jacques Whitford Stantec Limited
3 Spectacle Lake Road
Dartmouth, Nova Scotia B3B 1W8

INTERVIEW GUIDE: Roadmap for Aquaculture Investment

We are contacting you on behalf of the Nova Scotia Department of Fisheries and Aquaculture. We have been asked to interview members of the scientific community and aquaculture industry on siting criteria for cultured species in the province.

The Department has requested this work in order to gain a better understanding of the corporate body of knowledge with respect to marine-based aquaculture siting criteria and data sources for Nova Scotia's coastal zone. The work is also to identify the need for further work on siting criteria to assist the industry to grow and prosper.

We would like to ask you to participate in an interview. You will be asked questions about your role in and knowledge of the aquaculture industry with a focus on siting criteria for the following species:

- Atlantic Salmon
- Rainbow Trout (Steelhead)
- Blue Mussels
- American Oyster
- Scallops (Bay and Sea Scallops)
- Atlantic Cod
- Atlantic Halibut

Information that you provide during this interview may be presented in our report to the Department and other stakeholders, with an attribution to the individual and organization providing the information. If you identify criteria, data or locations, this information may be presented and mapped in a public report. However, during the interview please identify any specific information that you wish not to be reported or for which you have confidentiality concerns.

1.0 GENERAL INFORMATION

Date: _____, 2009

Participant's Name:_____

Organization: _____

Address: _____

_____

Telephone: _____

E-mail: _____

Alternate Contact: _____

2.0 BACKGROUND ON COMPANY/ORGANIZATION/AFFILIATION WITH INDUSTRY

2.1 What is your involvement in the aquaculture sector?
(Prompt for details, *i.e.* what species do you grow and where, what are you studying, etc.)

3.0 SITING CRITERIA

3.1 Based on your expert opinion, what are the key criteria to the proper siting of aquaculture operations?
(Prompts: biophysical conditions, infrastructure, other resource users, ecologically-sensitive areas) What information do you need to know/have to be successful? Is data available for any of these criteria? If so, where can we find this data? (Record using tables such as the one below)

Project No.: 1048755

Table 3.1 Siting Criteria & Data Sources for Species X

Biophysical Conditions		Infrastructure		Other Resource Users		Ecologically-Sensitive Areas	
Criteria	Data Sources	Criteria	Data Sources	Criteria	Data Sources	Criteria	Data Sources

3.2 What criteria are most important?

3.3 What are the deal breakers?

3.4 Of the criteria you mentioned, what ones are currently being used in Nova Scotia? Are there some criteria that that you would like to use/would be ideal to use that cannot currently be used? If so, what ones and why? Prompt to identify barriers such as data gaps, etc.

3.5 Do you believe changing environmental conditions, such as climate change, will affect siting criteria? If so, what criteria and how will they be affected?

3.6 Do you think changes in scientific knowledge will affect siting decisions? If so, what criteria will be most affected and why?

3.7 Are there technological developments or advancements that may help to overcome siting limitations?

3.8 What should be done by the Department or others to assist the industry in proper siting, to ultimately support the industry and encourage growth?

3.9 Are there other sources of information that we should access with regard to siting criteria in Nova Scotia? Are there other individuals with whom we should speak?

APPENDIX B
WORKSHOP AGENDA

Road Map for Aquaculture Investment in Nova Scotia

April 7, 2009, 1:00pm – 4:30 pm &
April 8, 2009, 8:30am – 4:00pm

Four Points by Sheraton Hotel
1496 Hollis Street, Halifax, Nova Scotia

Nova Scotia Department of Fisheries and Aquaculture

Day 1: April 7, 2009

Time	Activity	Responsibility
Afternoon Session		
1:00 - 1:30	Sign-in	Stantec
1:30 - 1:50	Welcome • Introductions • Workshop objectives and agenda	Marshall Giles (NSDFA) and Ken Donnelly (Lura Consulting)
1:50 - 2:30	Findings To Date • Project scope of work and method • Preliminary findings to date	Kent Gustavson (Stantec)
2:30 - 2:45	Questions on Findings to Date	Group Q&A
2:45 - 3:00	Nutrition Break	Provided
3:00 - 4:00	Review and Discussion of Draft Siting Criteria	Facilitated Group Discussion
4:00- 4:30	Introduction of Mapping Approach • Presentation of GIS • Mapping method	Kent Gustavson and Greg Mesheau (Stantec)
4:30	Adjourn	Ken Donnelly (Lura Consulting)

Day 2: April 8, 2009

Time	Activity	Responsibility
Morning Session		
8:00 – 8:30	Day 2 - Sign In	Stantec
8:30 - 8:45	Review of Previous Day's Work	Ken Donnelly (Lura Consulting)
8:45 - 10:15	Mapping of Area Suitability • Identification of suitable areas by region and species • Identification of unsuitable areas by region and species	Facilitated Group Discussion
10:15 - 10:30	Nutrition Break	Provided
10:30 - 12:00	Mapping of Area Suitability (continued)	Facilitated Group Discussion
12:00 - 1:00	Lunch	Provided
Afternoon Session		
1:00- 2:45	Mapping of Area Suitability (continued)	Facilitated Group Discussion
2:45- 3:00	Nutrition Break	Provided
3:00 - 3:30	Discussion of Information Sources and Gaps • Identification of information sources and gaps by region and species • Identification of key research needs	Facilitated Group Discussion
3:30 - 3:45	Review of Workshop Results	Kent Gustavson (Stantec)
3:45 - 4:00	Wrap-Up & Closing Remarks	NSDFA and Ken Donnelly (Lura Consulting)

APPENDIX C
LIST OF WORKSHOP DELEGATES

Participant	Affiliation
Government	
Andrew Bagnall	NSDFA
Toby Balch	NSDFA
Carla Buchan	NSDFA
Mike Cherry	DFO - Maritimes Region - Habitat
Luc Comeau	DFO
Joe Crocker	DFO - Maritimes Region - Habitat
Roland Cusack	NSDFA
Carla Dale	DFO
Alan Dwyer	DFO - Antigonish
Marshall Giles	NSDFA
Gordon Greencorn	NSDFA
Margaret Hawkins	DFO – St. George
Joe Hanrahan	NSDFA
Ralph Heighton	NSDFA
Allen Holmes	NSDFA
Stephen Lanteigne	DFO
Brent Law	BIO
John Lowe	NSDFA
Jack MacNeil	DFO
Chuck McKenna	NSDFA
Fred Page	DFO - St. Andrews Biological Station
Clary Reardon	NSDFA
Greg Roach	NSDFA (Assistant Deputy Minister)
Guy Robichaud	DFO - Moncton - Habitat
Shawn Robinson	DFO - St. Andrews Biological Station
Eugene Samson	NSDFA
Mark TeKamp	NSDFA
Cindy Webster	DFO
Bill Whitman	NSDFA
Garnet Whyte	NSDFA
Andy Woyewoda	NRC IRAP

Participant	Affiliation
Industry	
Doug Bertram	IFP
Brian Blanchard	Scotian Halibut
Glen Brown	Admiral Fish Farms
Paul Budreski	Aqua Delights Seafoods
Peter Darnell	Indian Point Marine Farms
Sherman d'Entremont	Cold Water Fisheries Inc.
Nolan d'Eon	Eel Lake Oyster Farm
Robert Fortune	Atlantic Aqua Farms Partnership
Paul Merlin	Merlin Fish Farms
Brian Muise	AANS
Charles Purdy	Bay Enterprises Ltd.
Brian Rogers	Rogers Consulting Inc.
Robin Stuart	Bounty Bay & SM Aqua
Robert Taylor	Ocean Legacy

APPENDIX D
SPECIES-SPECIFIC SITING CRITERIA

Atlantic Salmon - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	8 - 12	°C	12 - 16 °C		Saunders, 1995
	2 - 14	°C			Workshop
	8 - 14	°C		optimal range for growth	Gardner Pinfold, 1998
	2 - 16	°C		upper range is 14 °C for large fish (> 4 kg)	Hill, 1992a
	4 - 12	°C			Gardner Pinfold, 1998
	5 - 14	°C			Interview
	0 - 14	°C			Muise & Associates, 1993
	8 - 14	°C			Rosenthal et al, 1995
	2 - 15	°C			Workshop
Minimum Temperature	-0.7	°C	- 0.7 °C		Saunders, 1995
	-0.8	°C			Beveridge, 1996
	-0.7	°C			Gardner Pinfold, 1998
	-0.7	°C			Workshop
	-0.7	°C			Hill, 1992a
	-0.7	°C			Interview
	-0.7	°C			Rosenthal et al, 1995
	-0.5	°C			Workshop
Maximum Temperature	16	°C	20 °C		Saunders, 1995
	18	°C			Workshop
	23	°C			Hill, 1992a
	16	°C			Gardner Pinfold, 1998
	16	°C			Interview
	16	°C			Rosenthal et al, 1995
	16	°C			Workshop
Optimal Salinity	30 - 31	ppt	28 - 32 ppt		Workshop
	18 - 33	ppt			Hill, 1992a
	18 - 33	ppt		optimal growth range	Gardner Pinfold, 1998
Minimum Salinity	0	ppt	0 ppt	minimum	Gardner Pinfold, 1998
	0	ppt			Rosenthal et al, 1995
Maximum Salinity	35	ppt	35 ppt		Rosenthal et al, 1995
	35	ppt		maximum	Gardner Pinfold, 1998
Optimal Depth	12 - 15	m	15 - 20 m		Workshop
	18 - 24	m			Interview
Minimum Depth	10	m	7 m		Gardner Pinfold, 1998
	10	m			Interview
	9	m		at low tide	Hill, 1992a
Optimal Current Velocity	20 - 40	cm/s	50 - 80 cm/s		Workshop
	<100	cm/s			Interview
	50 - 150	cm/s			Gardner Pinfold, 1998
Minimum Current Velocity	10	cm/s	10 cm/s		Workshop
Maximum Current Velocity	75	cm/s	100 cm/s		Workshop
	150	cm/s			Interview
Dissolved Oxygen	6	mg/L	6 - 10 mg/L	should not be below this value	Workshop
	8 - 10	mg/L		optimal - fish won't feed below 6 mg/l	Workshop
Maximum Wave Height	1	m	1 m		Gardner Pinfold, 1998

Rainbow Trout - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	10 - 16	°C	10 - 16 °C		Gardner Pinfold, 1998
	10 - 16	°C			Dube & Mason, 1995
	2 - 16	°C		optimal range ends at 12°C for fish > 4 kg	Hill, 1992b
	7.2 - 14.5	°C		optimal range for growth	Gardner Pinfold, 1998
	0 - 16	°C			Muise & Associates, 1993
	8 - 16	°C			Rosenthal et al, 1995
	15	°C			Interview
	8 - 15	°C			Workshop
Minimum Temperature	-0.7	°C	- 0.7 °C		Gardner Pinfold, 1998
	0	°C		because -0.7 is fatal	Hill, 1992b
	0	°C			Dube & Mason, 1995
	-0.7	°C			Rosenthal et al, 1995
	0	°C		could be lower for seasonal sites	Workshop
Maximum Temperature	25	°C	18 °C		Gardner Pinfold, 1998
	22	°C			Hill, 1992b
	15	°C			Dube & Mason, 1995
	18	°C			Rosenthal et al, 1995
	18	°C			Workshop
Optimal Salinity	18 - 33	ppt	18 - 33 ppt	optimal range for growth	Gardner Pinfold, 1998
	18 - 28	ppt			Muise & Associates, 1993
	18 - 33	ppt			Hill, 1992b
Minimum Salinity	0	ppt	0 ppt		Gardner Pinfold, 1998
	0	ppt			Rosenthal et al, 1995
Maximum Salinity	35	ppt	35 ppt		Rosenthal et al, 1995
	35	ppt			Gardner Pinfold, 1998
Optimal Depth	3 - 8	m	10 - 20 m		Workshop
	> 9	m		at low tide	Muise & Associates, 1993
	18	m			Interview
Minimum Depth	9	m	7 m		Gardner Pinfold, 1998
	9	m			Hill, 1992b
Optimal Current Velocity	> 38	cm/s	> 38 cm/s		Muise & Associates, 1993
Dissolved Oxygen	7 - 10	mg/L	7 - 10 mg/L		Workshop
	8 - 10	mg/L			Muise & Associates, 1993
Maximum Wave Height	1	m	1.5 m		Gardner Pinfold, 1998
	1.5 - 2	m			Muise & Associates, 1993

Blue Mussel - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	10 - 20	°C	10 - 20 °C		Gardner Pinfold, 1998
	8 - 12	°C			Muise & Associates, 1993
	10 - 20	°C			Mallet & Myrand, 1995
	10 - 20	°C			Rosenthal et al, 1995
	-1.5 - 18	°C			Workshop
	0 - 20	°C		optimal range for growth	Gardner Pinfold, 1998
Minimum Temperature	-2	°C	- 1 °C		Gardner Pinfold, 1998
	-1	°C			Workshop
	-1.5	°C		exposure over prolonged period	Muise & Associates, 1993
	-2	°C			Rosenthal et al, 1995
	0	°C		exhibit little growth at temps greater than zero	Mallet & Myrand, 1995
	< 0	°C		can grow at temperatures well below zero	Scarratt, 1992a
Maximum Temperature	25	°C	25 °C		Gardner Pinfold, 1998
	20	°C		growth rates are reduced above this temperature	Mallet & Myrand, 1995
	25	°C			Rosenthal et al, 1995
	20	°C			Workshop
	> 20	°C			Scarratt, 1992a
Optimal Salinity	18+	ppt	20 - 30 ppt		Gardner Pinfold, 1998
	30 - 32	ppt			Interview
	20 - 32	ppt			Muise & Associates, 1993
	25 - 30	ppt			Rosenthal et al, 1995
	15 - 25	ppt			Workshop
Minimum Salinity	15	ppt	15 ppt		Gardner Pinfold, 1998
	20	ppt		shell growth is reduced below this level	Mallet & Myrand, 1995
	15	ppt			Rosenthal et al, 1995
	10	ppt		exposure over short periods	Muise & Associates, 1993
Maximum Salinity	35	ppt	35 ppt		Rosenthal et al, 1995
	35	ppt			Gardner Pinfold, 1998
Optimal Depth	8	m	15 m	prefered, at low water	Gardner Pinfold, 1998
	10	m			Interview
Minimum Depth	2	m	5 m	mussel socks should have min 2 m below at low tide	Scarratt, 1992a
	2	m		bottom culture	Muise & Associates, 1993
	10	m		longlines	Muise & Associates, 1993
Opitmal Current Velocity	50 - 100	cm/s	50 - 100 cm/s		Gardner Pinfold, 1998
	50 - 100	cm/s			Scarratt, 1992a
Minimum Current Velocity	1	cm/s	1 cm/s		Muise & Associates, 1993
Dissolved Oxygen	< 5	mg/L	5 mg/L		Workshop
Maximum Wave Height	1	m	1 m		Muise & Associates, 1993
Tidal Amplitude	0 - 10	m	0 - 10 m		Muise & Associates, 1993

Bay Scallop - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	5 - 28	°C	10 - 28 °C	growth rate generall increases in this range	Mallet and Carver, 1987
	10 - 15	°C			Couturier et al, 1995
	12 - 25	°C			Rosenthal et al, 1995
	10 - 28	°C			Muise & Associates, 1993
Minimum Temperature	-2	°C	- 2 °C		Mallet and Carver, 1987
	-2	°C			Couturier et al, 1995
	0	°C			Rosenthal et al, 1995
	-1.5	°C		exposure over prolonged period	Muise & Associates, 1993
Maximum Temperature	30	°C	30 °C		Mallet and Carver, 1987
	30	°C			Rosenthal et al, 1995
	30	°C			Couturier et al, 1995
Optimal Salinity	21 - 33	ppt	25 - 33 ppt	natural populations generally appear in this range	Mallet and Carver, 1987
	> 25	ppt			Couturier et al, 1995
	25 - 35	ppt			Rosenthal et al, 1995
	21 - 33	ppt			Muise & Associates, 1993
Minimum Salinity	15	ppt	20 ppt		Scarratt, 1992b
	14	ppt			Muise & Associates, 1993
	20	ppt			Rosenthal et al, 1995
	22	ppt		filtration rates decline below this level	Mallet and Carver, 1987
Maximum Salinity	35	ppt	35 ppt		Rosenthal et al, 1995
	35	ppt		full seawater	Scarratt, 1992b
Minimum Depth	10	m	5 m	at low water, longlines	Muise & Associates, 1993
	5	m		to accommodate lantern nets	Scarratt, 1992b
	2	m		bottom culture	Muise & Associates, 1993
Minimum Current Velocity	1	cm/s	1 cm/s		Muise & Associates, 1993
Optimal Dissolved Oxygen	5 - 10	mg/L	5 - 10 mg/L		Muise & Associates, 1993
Maximum Wave Height	1	m	1 m		Muise & Associates, 1993
Tidal Amplitude	0 - 10	m	0 - 10 m		Muise & Associates, 1993

Sea Scallop - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	< 18	°C	10 - 18 °C		MacLaren Plansearch Ltd., 1986
	10 - 20	°C			Rosenthal et al, 1995
	15 - 25	°C			Couturier et al, 1995
	5 - 18	°C			Enright, 1992b
	5 - 18	°C			Muise & Associates, 1993
Minimum Temperature	-2	°C	-2 °C		Rosenthal et al, 1995
	0	°C			Enright, 1992b
Maximum Temperature	20 - 23.5	°C	23 °C	lethal	MacLaren Plansearch Ltd., 1986
	23	°C		lethal limit	Couturier et al, 1995
	25	°C			Rosenthal et al, 1995
	23	°C			Enright, 1992b
	23	°C			Muise & Associates, 1993
Optimal Salinity	> 20	ppt	25 - 32 ppt		MacLaren Plansearch Ltd., 1986
	30 - 32	ppt			Couturier et al, 1995
	25 - 35	ppt			Rosenthal et al, 1995
	>25	ppt			Enright, 1992
	32	ppt			Muise & Associates, 1993
Minimum Salinity	20	ppt	20 ppt		MacLaren Plansearch Ltd., 1986
	20	ppt			Rosenthal et al, 1995
	20	ppt			Enright, 1992b
	25	ppt			Muise & Associates, 1993
Maximum Salinity	35	ppt	35 ppt		Rosenthal et al, 1995
	35	ppt		full seawater	Enright, 1992b
Optimal Depth	< 50	m	20 - 40 m		MacLaren Plansearch Ltd., 1986
	5 - 50	m		optimal for growth	Muise & Associates, 1993
	10 - 30	m		at low water, for longlines	Muise & Associates, 1993
Minimum Depth	5	m	10 m		MacLaren Plansearch Ltd., 1986
	10 - 20	m			Enright, 1992b
Maximum Depth	90	m	100 m		Enright, 1992b
	100	m			MacLaren Plansearch Ltd., 1986
Optimal Current Velocity	0 - 20	cm/s	1 - 20 cm/s		Enright, 1992b
Minimum Current Velocity	1	cm/s	1 cm/s		Muise & Associates, 1993
Optimal Dissolved Oxygen	near 10	mg/L	5 - 10 mg/L	saturation	MacLaren Plansearch Ltd., 1986
	5 - 10	mg/L			Muise & Associates, 1993
Minimum Dissolved Oxygen	5	mg/L	5 mg/L	saturation	MacLaren Plansearch Ltd., 1986
Tidal Amplitude	0 - 10	m	0 - 10 m		Muise & Associates, 1993

American Oyster - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	8 - 25	°C	10 - 20 °C		Gardner Pinfold, 1998
	10 - 20	°C		optimal range for growth	MacLeod, 1992
	10 - 20	°C			Muise & Associates, 1993
	4 - 28	°C			Interview
	8 - 25	°C			Rosenthal et al, 1995
	-1.5 - 25	°C			Workshop
	15	°C		highest temperature for good growth	Workshop
	10 - 20	°C		optimal range for growth	Gardner Pinfold, 1998
Minimum Temperature	4	°C	- 1 °C	speciews will not feed below this temperature	Interview
	5	°C		species hibernates at or below this temperature	MacLeod, 1992
	4 - 5	°C		species will not feed below this temperature	Workshop
	-1.5	°C			Muise & Associates, 1993
	-2	°C			Rosenthal et al, 1995
	-1	°C			Workshop
	-2	°C			Gardner Pinfold, 1998
Maximum Temperature	40	°C	30 °C		Gardner Pinfold, 1998
	24	°C			Workshop
	40	°C			Rosenthal et al, 1995
	30	°C			MacLeod, 1992
	>20	°C			Workshop
Optimal Salinity	15 - 25	ppt	20 - 30 ppt	optimal range for growth	Gardner Pinfold, 1998
	30 - 32	ppt			Interview
	20 - 22	ppt			Interview
	20 - 30	ppt			Muise & Associates, 1993
	23	ppt			Rosenthal et al, 1995
	10 - 25	ppt			Workshop
	20 - 30	ppt			MacLeod, 1992
Minimum Salinity	5	ppt	18 ppt		Gardner Pinfold, 1998
	18	ppt			Rosenthal et al, 1995
	20	ppt		produce a less "salty" taste below this level	MacLeod, 1992
Maximum Salinity	35	ppt	35 ppt		Rosenthal et al, 1995
	35	ppt			Gardner Pinfold, 1998
Optimal Depth	1 - 6	m	1 - 6 m		Gardner Pinfold, 1998
	6	m		depth must be below 6 m if there is ice cover	Workshop
	1 - 6	m			MacLeod, 1992
Minimum Depth	2	m		bottom culture	Muise & Associates, 1993
	10	m		longlines	Muise & Associates, 1993
Optimal Current Velocity	156 - 260	cm/s			Gardner Pinfold, 1998
	< 50	cm/s			Workshop
Minimum Current Velocity	1	cm/s	1 cm/s		Muise & Associates, 1993
Maximum Current Velocity	100	cm/s	100 cm/s		Workshop
Dissolved Oxygen	< 4	mg/L	4 mg/L		Workshop
Maximum Wave Height	1	m	1 m		Muise & Associates, 1993
Tidal Amplitude	0 - 10	m	0-10 m		Muise & Associates, 1993

European Oyster - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	5 - 24	°C	10 - 20 °C		Interview
	10 - 15	°C			Gardner Pinfold, 1998
	10 - 18	°C			Muise & Associates, 1993
	8 - 20	°C			Rosenthal et al, 1995
	7 - 20	°C			Gardner Pinfold, 1998
Minimum Temperature	0	°C	0 °C		Gardner Pinfold, 1998
	0	°C			Rosenthal et al, 1995
	0	°C		exposure over a prolonged period	Muise & Associates, 1993
Maximum Temperature	24	°C	25 °C		Gardner Pinfold, 1998
	25	°C			Rosenthal et al, 1995
	16 - 18	°C			Enright, 1992a
Optimal Salinity	28 - 32	ppt	24 - 32 ppt		Interview
	20 - 25	ppt			Enright, 1992a
	24 - 32	ppt			Muise & Associates, 1993
	25 - 30	ppt			Gardner Pinfold, 1998
Minimum Salinity	20	ppt	20 ppt		Gardner Pinfold, 1998
	20	ppt			Rosenthal et al, 1995
Maximum Salinity	35	ppt	35 ppt		Rosenthal et al, 1995
	35	ppt			Gardner Pinfold, 1998
Optimal Depth	0 - 6	m	0 -6 m	minimum is for just below surface	Gardner Pinfold, 1998
	0 - 3	m		minimum is for just below surface	Enright, 1992a
Minimum Current Velocity	1	cm/s	1 cm/s		Muise & Associates, 1993
Optimal Dissolved Oxygen	5 - 10	mg/L	5 - 10 mg/L		Muise & Associates, 1993
Maximum Wave Height	1 - 2	m	1 m		Gardner Pinfold, 1998
	1	m			Muise & Associates, 1993
Tidal Amplitude	0 - 10	m	0 - 10 m		Muise & Associates, 1993

Atlantic Cod - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	8 - 12	°C	8 - 16 °C	for Newfoundland cod	Muise & Associates, 1993
	6 - 12	°C			Walden, 2000
	7 - 9	°C			Rosenthal et al, 1995
Minimum Temperature	-1.7	°C	-1.7 °C	lethal level	Muise & Associates, 1993
	-1	°C			Rosenthal et al, 1995
Maximum Temperature	15	°C	18 °C		Rosenthal et al, 1995
	24	°C			Walden, 2000
	15 - 16	°C		for Newfoundland cod	Muise & Associates, 1993
Optimum Salinity	14	ppt	28 - 32 ppt		Muise & Associates, 1993
Minimum Salinity	2 - 3	ppt	2 - 3 ppt		Muise & Associates, 1993
Minimum Dissolved Oxygen	0.8	mg/L	3 mg/L	lethal level	Muise & Associates, 1993
	3	mg/L		below this level oxygen consumption is limited	Muise & Associates, 1993

Atlantic Halibut - Siting Criteria Thresholds

Criteria	Value	Units	Consensus Value	Comments	Source
Optimal Temperature	9 - 11	°C	8 - 16 °C		Gardner & Pinfold, 1998
	9 - 11	°C			Rosenthal et al, 1995
	9.7	°C			Moksness et al, 2004
Minimum Temperature	-0.7	°C	-0.7 °C	lethal limit	Gardner & Pinfold, 1998
	4	°C		will not grow below this temperature	Forster, 1999
	-0.7	°C			Rosenthal et al, 1995
	4	°C		poor growth below this temperature	Brown et al, 1995
Maximum Temperature	14	°C	18 °C		Gardner & Pinfold, 1998
	14	°C			Forster, 1999
	14	°C			Rosenthal et al, 1995
	13	°C			Brown et al, 1995
Optimal Salinity	20 - 34	ppt	28 - 32 ppt		Gardner & Pinfold, 1998
Maximum Wave Height	1	m	1 m		Gardner & Pinfold, 1998
Minimum Dissolved Oxygen	5	mg/L	5 mg/L		Gardner & Pinfold, 1998

APPENDIX E
DATA AND INFORMATION SOURCES

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Biophysical Conditions								
Temperature	Yarmouth County Aquaculture Site Identification Study (Muise, 1993)	Dennis Point, Abbott's Harbour, Argyle Sound, Central Argyle, Argyle River, Abram's River, Sluice Point, Morris Island, The Tiddle, Wedgeport, Pinkney's Point, Ardnamerchan Cove, Robert's Island, Chebogue River, Yarmouth Harbour, Ram Island, Etoile Island, Tucker Island, Deep Cove, John's Island	September 1992 to March 1993	Weekly recordings	Contact authors		NA	Hard copy of data was provided with the document as a separate attachment. Contact authors or NSDFA to request this data.
	DFO Hydrographic Climate Database	Province-wide	From 1910 to present	Ranges from individual observations to monthly averages and time series. Resolution can be changed using the query tool, and recordings are for various depths	Data files are requested using a query tool and are returned in CSV files	None, but must register to access the query tool	Free	Available online at http://www.mar.dfo-mpo.gc.ca/science/ocean/database/Doc2006/clim2006app.html
	DFO Sea Surface Temperature Database	Province-wide	1985 - 2005	Weekly averaged surface temperature from satellite readings	Data files are requested using a query tool and are returned in CSV files	None, but must register to access the query tool	Free	Available online at http://www.mar.dfo-mpo.gc.ca/science/ocean/database/Doc2006/sst2006app.html
	DFO Ocean Data Inventory	Province-wide	1960 - present	Monthly averaged mean, max and min temp at various depths	Data files are requested using a query tool and are returned in CSV files	None, but must register to access the query tool	Free	Available online at http://www.mar.dfo-mpo.gc.ca/science/ocean/database/Doc2003/odi2005app.html
	DFO Coastal Time Series	Province-wide	1978 - present	Daily, monthly, or seasonally averaged temperatures at various depths	Data files are requested using a query tool and are returned in CSV files	None, but must register to access the query tool	Free	Available online at http://www.mar.dfo-mpo.gc.ca/science/ocean/database/Doc2003/cts2003app.html
	DFO Coastal Shallow Water Temperature Climatology for Atlantic Canada	Province-wide	1960 to present	Monthly summaries of min, max, and mean temp at various depths expressed according to NAFO fishing zone	No digital files to download, displayed in online text	None	Free	Available online at http://www.mar.dfo-mpo.gc.ca/science/ocean/coastal_temperature/coastal_temperature.html
	DFO Temperature-Salinity Climatologies	Province-wide		Montly averages at various depths. Also shows animated online maps that display the seasonal changes in bottom and surface temperature over the course of an average year in each region	Online text and maps, no digital files availabe for download	None	Free	Available online at: http://www.mar.dfo-mpo.gc.ca/science/ocean/tsdata.html. Data are based on the DFO Hydrographic Climate database
	Physical Oceanography of the Bras d'Or Lakes (Gurbutt et al, 1993)	Bras d'Or Lakes	1972 - 1974	Detailed temperature and salinity data collected at various depths over the course of 2 years, summarized in various statistical means	No digital files, data is provided in text, tables, and charts within the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Nearshore, Shallow-Water Temperature Atlas for Nova Scotia (Petrie and Francis, 1993)	Province-wide	Average from data ranging from 1970 to early 1990's	Monthly average, min, and max temperatures	Digital data not available, hard copy only	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO Community Aquatic Monitoring Program (CAMP)	Gulf of St. Lawrence/Northumberland Strait	2003 - 2006, expected to continue to be updated	Montly average temperatures, provided in tables in hard copy document	Available online, no digital maps or data sets	None	Free	Available online at http://www.glf.dfo-mpo.gc.ca/os/camp-pcsa/index-e.php
	A Preliminary Assessment of Aquaculture Potential for Sea and Bay Scallops in the Annapolis Basin (Smith and Gaul, 1988)	Annapolis Basin	May to December 1987	Surface and bottom temperatures recorded bi-weekly or monthly over course of study	Temperature data summarized in charts in appendix of hard copy report	None	Free	Data collected for a specific study in the basin.
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	The Feasibility of Bay Scallop Culture in Nova Scotia: A Preliminary Study (Mallet and Carver, 1987)	Chance Harbour, Tracadie, Aulds Cove, Whitehead, Spanish Ship Bay, Ship Harbour, Ostrea Lake, Bedford Basin, Mahone Bay, Port Medway, Barrington Passage, Argyle Head	August to December 1987	Monthly average temperatures	Temperature data summarized in tables in appendix of hard copy report	None	Free	Data collected for a specific study in these inlets

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Salinity	Yarmouth County Aquaculture Site Identification Study (Muise, 1993)	Dennis Point, Abbott's Harbour, Argyle Sound, Central Argyle, Argyle River, Abram's River, Sluice Point, Morris Island, The Tiddle, Wedgeport, Pinkney's Point, Ardnamerchan Cove, Robert's Island, Chebogue River, Yarmouth Harbour, Ram Island, Etoile Island, Tucker Island, Deep Cove, John's Island	September 1992 to March 1993	Weekly recordings	Contact authors		NA	Hard copy of data was provided with the document as a separate attachment. Contact authors or NSDFA to request this data.
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO Temperature-Salinity Climatologies	Province-wide		Montly averages at various depths. Also shows animated online maps that display the seasonal changes in bottom and surface temperature over the course of an average year in each region	Online text and maps, no digital files availabe for download	None	Free	Available online at: http://www.mar.dfo-mpo.gc.ca/science/ocean/tsdata.html. Data are based on the DFO Hydrographic Climate database
	DFO Hydrographic Climate Database	Province-wide	From 1910 to present	Ranges from individual observations to monthly averages and time series. Resolution can be changed using the query tool, and recordings are for various depths	Data files are requested using a query tool and are returned in CSV files	None, but must register to access the query tool	Free	Available online at http://www.mar.dfo-mpo.gc.ca/science/ocean/database/Doc2006/clim2006app.html
	DFO Community Aquatic Monitoring Program (CAMP)	Gulf of St. Lawrence/Northumberland Strait	2003 - 2006, expected to continue to be updated	Montly average salinity levels, provided in tables in hard copy document	Available online, no digital maps or data sets	None	Free	Available online at http://www.glf.dfo-mpo.gc.ca/os/camp-pcsa/index-e.php
	Physical Oceanography of the Bras d'Or Lakes (Gurbutt et al, 1993)	Bras d'Or Lakes	1972 - 1974	Detailed temperature and salinity data collected at various depths over the course of 2 years, summarized in various statistical means	No digital files, data is provided in text, tables, and charts within the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	A Preliminary Assessment of Aquaculture Potential for Sea and Bay Scallops in the Annapolis Basin (Smith and Gaul, 1988)	Annapolis Basin	May to December 1987	Surface and bottom salinity recorded bi-weekly or monthly over course of study	Salinity data summarized in charts in appendix of hard copy report	None	Free	Data collected for a specific study in the basin.
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	The Feasibility of Bay Scallop Culture in Nova Scotia: A Preliminary Study (Mallet and Carver, 1987)	Chance Harbour, Tracadie, Aulds Cove, Whitehead, Spanish Ship Bay, Ship Harbour, Ostrea Lake, Bedford Basin, Mahone Bay, Port Medway, Barrington Passage, Argyle Head	August to December 1987	Monthly average salinity	Salinity data summarized in tables in appendix of hard copy report	None	Free	Data collected for a specific study in these inlets
Carrying Capacity of Receiving Waters	Oceanographic, Geographic, and Hydrological Parameters of Scotia Fundy and Southern Gulf of St. Lawrence Inlets (Gregory et al, 1993)	141 coastal inlets in Scotia-Fundy and Gulf of St. Lawrence	published in 1993	bay/inlet level	Data values provided in hard copy in the report, hard copy maps provided in report, digital maps available upon request to authors or to DFO. Digital maps produced using inFOcus and QUIKmap at scales ranging from 1:10,000 to 1:200,000	Hard copy document is available online, obtaining digital maps could be challenging given the date of publication and mapping software used. Available online at http://www.mar.dfo-mpo.gc.ca/science/ocean/ceice/ceice.html	Hard copy document is free, however there may be a cost to obtain digital files	This document provides data for a wide range of important oceanographic and hydrological features in inlets and harbours across Nova Scotia. Although the report is quite dated, most of the data presented in the report should still be relevant and of use. This document also contains data on the volume and dimensions of each inlet, as well as data on freshwater inputs
	Estimate of Available Area, Production Capacity and Economic Value of Potential Aquaculture Development in Coastal Inlets in Three Nova Scotia Counties (Murphy, 1997)	44 inlets in Shelburne, Richmond, and Guysborough counties, as well as Pubnico Harbour in Yarmouth County	published in 1997	bay/inlet level. Hard copy map scales range from 1:10,000 to 1:75,000	Not clear if digital versions are available. Hard copy maps are provided in the report.	Access to digital maps may be limited due to date of publication	Free	Specific depth data is not provided, although there is discussion of depth profile for each inlet and a map indicating areas of greater than 5 m and greater than 10 m depth that would be suitable for aquaculture
	Nearshore and offshore bathymetry mapping (CHS 2009)	Province-wide			GIS layer		Varies according to chart requested	Digital bathymetry charts obtained from the Canadian Hydrographic Service. Available online at: http://www.cartes.gc.ca/index-eng.asp

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Wave Regime	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	The Wind and Wave Climate Atlas	Province-wide	Published in 1991	na	Data is provided in charts and graphs in hard copy	None	Free	Available online at: http://www.meds-sdmm.dfo-mpo.gc.ca/MEDS/Databases/Wave/TDC_e.htm
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO Integrated Science and Data Management Waves Program	Province-wide	Historical and current wave data	na	Data is provided in a range of formats, including online maps and chart summaries, as well as downloadable CSV files	None	Free	Available online at: http://www.meds-sdmm.dfo-mpo.gc.ca/MEDS/Databases/Wave/WAVE_e.htm
Current Velocities	Oceanographic, Geographic, and Hydrological Parameters of Scotia Fundy and Southern Gulf of St. Lawrence Inlets (Gregory et al, 1993)	141 coastal inlets in Scotia-Fundy and Gulf of St. Lawrence	published in 1993	bay/inlet level	Data values provided in hard copy in the report, hard copy maps provided in report, digital maps available upon request to authors or to DFO. Digital maps produced using inFOcus and QUIKmap at scales ranging from 1:10,000 to 1:200,000	Hard copy document is available online, obtaining digital maps could be challenging given the date of publication and mapping software used	Hard copy document is free, however there may be a cost to obtain digital files	This document provides data for a wide range of important oceanographic and hydrological features in inlets and harbours across Nova Scotia. Although the report is quite dated, most of the data presented in the report should still be relevant and of use. This document also contains data on the volume and dimensions of each inlet, as well as data on freshwater inputs
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO Near-Bottom Current Meter Summary	Various locations around the province where current meters are positioned	Data currently available is from 1976 - 2000	Data is collected for currents where instruments are located within 10 metres of the bottom	Data is available in Microsoft Excel or CSV	None	Free	Available online at http://www.mar.dfo-mpo.gc.ca/science/ocean/current_statistics/BottomCurrents.html. Data available include max, min, and mean current speeds and directions
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Dissolved Oxygen (DO)	DFO Community Aquatic Monitoring Program (CAMP)	Gulf of St. Lawrence/Northumberland Strait	2003 - 2006, expected to continue to be updated	Montly average dissolved oxygen levels, provided in tables in hard copy document	Available online, no digital maps or data sets	None	Free	Available online at http://www.glf.dfo-mpo.gc.ca/os/camp-pcsa/index-e.php
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
Tidal Amplitude	Oceanographic, Geographic, and Hydrological Parameters of Scotia Fundy and Southern Gulf of St. Lawrence Inlets (Gregory et al, 1993)	141 coastal inlets in Scotia-Fundy and Gulf of St. Lawrence	published in 1993	bay/inlet level	Data values provided in hard copy in the report, hard copy maps provided in report, digital maps available upon request to authors or to DFO. Digital maps produced using inFOcus and QUIKmap at scales ranging from 1:10,000 to 1:200,000	Hard copy document is available online, obtaining digital maps could be challenging given the date of publication and mapping software used	Hard copy document is free, however there may be a cost to obtain digital files	This document provides data for a wide range of important oceanographic and hydrological features in inlets and harbours across Nova Scotia. Although the report is quite dated, most of the data presented in the report should still be relevant and of use. This document also contains data on the volume and dimensions of each inlet, as well as data on freshwater inputs
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO Tides, Currents, and Water Levels	Province-wide	Updated to present, includes some historical data	no mapping	Available online, online text	None	Free	Available online at: http://www.lau.chs-shc.gc.ca/english/Canada.shtml
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Modelling the Tides of the Bras d'Or Lakes (Dupont et al, 2003)	Bras d'Or Lakes	Published in 2003	Discussion of historical tidal amplitude and currents coupled with more recent modelling of tidal amplitude	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO ISDM Tide and Water Level Inventory	Province-wide	Varies according to location, but generally from 1970 to present	Hourly, daily, and montly average values	Available online, online text or downloadable CSV files	None	Free	Available online at: http://www.meds-sdmm.dfo-mpo.gc.ca/MEDS/Databases/TWL/TWL_inventory_e.htm
Ice Conditions	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Canadian Ice Service	Province-wide	Historical ice coverage data is available as well as current ice conditions	Data can be obtained in seasonal, weekly, or daily summaries on various types of charts	Data is provided in online maps and charts as well as in online graphs	None	Free	Available online at http://ice-glaces.ec.gc.ca/App/WsvPageDsp.cfm?ID=1&Lang=eng

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Seasonal Weather Patterns	Environment Canada National Climate Data and Information Archive	Province-wide at particular weather stations	Historical up to current day	Data is available for hourly, daily, and monthly averages	Data is provided in html text on the website, and can also be summarized in charts or downloaded in Excel or CSV files	None	Free	Available online at http://www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	The Wind and Wave Climate Atlas	Province-wide	Published in 1991	na	Data is provided in charts and graphs in hard copy	None	Free	Available online at: http://www.meds-sdmm.dfo-mpo.gc.ca/MEDS/Databases/Wave/TDC_e.htm
Suspended Solids	The Feasibility of Bay Scallop Culture in Nova Scotia: A Preliminary Study (Mallet and Carver, 1987)	Chance Harbour, Tracadie, Aulds Cove, Whitehead, Spanish Ship Bay, Ship Harbour, Ostrea Lake, Bedford Basin, Mahone Bay, Port Medway, Barrington Passage, Argyle Head	August to December 1987	Monthly average values for particulate organic matter, total particulate matter, and particulate inorganic matter	Data summarized in tables in appendix of hard copy report	None	Free	Data collected for a specific study in these inlets
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Water Exchange Rate (flushing)	Oceanographic, Geographic, and Hydrological Parameters of Scotia Fundy and Southern Gulf of St. Lawrence Inlets (Gregory et al, 1993)	141 coastal inlets in Scotia-Fundy and Gulf of St. Lawrence	published in 1993	bay/inlet level	Data values provided in hard copy in the report, hard copy maps provided in report, digital maps available upon request to authors or to DFO. Digital maps produced using inFOcus and QUIKmap at scales ranging from 1:10,000 to 1:200,000	Hard copy document is available online, obtaining digital maps could be challenging given the date of publication and mapping software used	Hard copy document is free, however there may be a cost to obtain digital files	This document provides data for a wide range of important oceanographic and hydrological features in inlets and harbours across Nova Scotia. Although the report is quite dated, most of the data presented in the report should still be relevant and of use. This document also contains data on the volume and dimensions of each inlet, as well as data on freshwater inputs
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
Substrate Type	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO Community Aquatic Monitoring Program (CAMP)	Gulf of St. Lawrence/Northumberland Strait	2003 - 2006, expected to continue to be updated	Montly average salinities, provided in tables in hard copy document	Available online, no digital maps or data sets	None	Free	Available online at http://www.glf.dfo-mpo.gc.ca/os/camp-pcsa/index-e.php

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Presence of Food Supply (plankton)	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO BioChem Database	Province-wide	1921 - present	Accessed through a database query which allows a number of different parameters to be defined which influence resolution	Data is returned electronically via database query and results are CSV format	None, but must register to access database query	Free	Available online at: http://www.meds-sdmm.dfo-mpo.gc.ca/biochem/Biochem_e.htm
Presence of Predators	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
Presence of Naturally-Occuring Populations	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Carrying Capacity of Receiving Waters	Estimate of Available Area, Production Capacity and Economic Value of Potential Aquaculture Development in Coastal Inlets in Three Nova Scotia Counties (Murphy, 1997)	44 inlets in Shelburne, Richmond, and Guysborough counties, as well as Pubnico Harbour in Yarmouth County	published in 1997	bay/inlet level. Hard copy map scales range from 1:10,000 to 1:75,000	Not clear if digital versions are available. Hard copy maps are provided in the report.	Access to digital maps may be limited due to date of publication	Free	Carrying capacity is considerd for each inlet for both finfish and shellfish
Heavy Metal Pollution	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO BioChem Database	Province-wide	1921 - present	Accessed through a database query which allows a number of different parameters to be defined which influence resolution	Data is returned electronically via database query and results are CSV format	None, but must register to access database query	Free	Available online at: http://www.meds-sdmm.dfo-mpo.gc.ca/biochem/Biochem_e.htm
	Environment Canada National Pollutant Release Inventory (NPRI)	Province-wide	1994 - present	Point source for each reported facility, as required under the authority of the *Canadian Environmental Protection Act* (1999).	Data is returned electronically via online database query (by pollutant or location), or MS Access database downloadable	None	Free	Available online from Environment Canada at: http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=B85A1846-1
Bacterial Contaminants (E. Coli)	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
Infrastructure								
Site Access (roads, electricity, etc.)	Small Craft Harbours Branch - DFO	Province-wide	last updated in 2007		Available in hard copy and in digital format in DWG (Autocad) format		Free	Map shows all harbours in which DFO Small Craft Harbours owns marine infrastructure (wharves, breakwaters, etc.). The map also indicates harbours in which ownership of the marine infrastructure has been divested to other
	Community-Based Coastal Resource Mapping Projects	Eastern Bay of Fundy; Annapolis/Digby Counties; Yarmouth County; Shelburne County; Queens/Lunenburg Counties; Halifax County; Guysborough County; Richmond County; Eastern Cape Breton County; Victoria County; Bras d'Or Lakes	1993 - 1999	Varies, but generally 1:10,000	Planimetric base maps; digital and hard-copy hydrographic charts	Not available online, must contact regional development agencies or relevant community groups in the area of interest. Can also contact Denise McCullough at DFO, Tel: 902-426-4274 - Fax: 902-426-3855 - Email: mcculloughd@mar.dfo-mpo.gc.ca	Free	Maps were produced over the course of several years, with most recent one being completed in 1999. As such, map information could potentially be out of date unless the community has updated the map since the initial developmente phase.
Availability of Seed Stock/Juveniles								

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Other Resource Users								
Proximity to Existing Aquaculture Sites	NSDFA Aquaculture Site Mapping Tool	Province-wide	Last updated in 2008	Ability to zoom in from province-wide view to site-specific view	Online mapping tool	None	Free	Available online at: http://www.gov.ns.ca/fish/aquaculture/aquamap.shtml
	Community-Based Coastal Resource Mapping Projects	Eastern Bay of Fundy; Annapolis/Digby Counties; Yarmouth County; Shelburne County; Queens/Lunenburg Counties; Halifax County; Guysborough County; Richmond County; Eastern Cape Breton County; Victoria County; Bras d'Or Lakes	1993 - 1999	Varies, but generally 1:10,000	Planimetric base maps; digital and hard-copy hydrographic charts	Not available online, must contact regional development agencies or relevant community groups in the area of interest. Can also contact Denise McCullough at DFO, Tel: 902-426-4274 - Fax: 902-426-3855 - Email: mcculloughd@mar.dfo-mpo.gc.ca	Free	Maps were produced over the course of several years, with most recent one being completed in 1999. As such, map information could potentially be out of date unless the community has updated the map since the initial developmente phase.
Proximity to Fishing Grounds	Estimate of Available Area, Production Capacity and Economic Value of Potential Aquaculture Development in Coastal Inlets in Three Nova Scotia Counties (Murphy, 1997)	44 inlets in Shelburne, Richmond, and Guysborough counties, as well as Pubnico Harbour in Yarmouth County	published in 1997	bay/inlet level. Hard copy map scales range from 1:10,000 to 1:75,000	Not clear if digital versions are available. Hard copy maps are provided in the report.	Access to digital maps may be limited due to date of publication	Free	Fishing grounds are identified and areas where aquaculture potential exists but that overlap with traditional fishing ground are identified on the maps and in the text
	Identification of Potential Sea Scallop Culture Sites in the Nearshore Waters of Nova Scotia (MacLaren Plansearch Ltd., 1986)	Province-wide, out to 12 nautical miles offshore	published in 1986	Hard copy map scales is 1:500,000	Not clear if digital version of map is available, hard copy map provided with the report	Access to digital maps may be limited due to date of publication	Free	Locations of historical sea scallop beds are identified in the text and on the related map
	Northumerland Strait Ecosystem Overview Report	Northumberland Strait	Historical trends, data up to 2005	Qualitative and quantitative information presented in the text	Available online, no digital maps or data sets	None	Free	All associated reports for this study can be found at http://www.northumberlandstraiteoar.com/library.htm. Provides a well-rounded overview of the biophysical and socioeconomic conditions in the area
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	DFO Coastal Habitat Inventory	Gulf of St. Lawrrence	1993- present	Generally 1:10,000 to 1:50,000, nearshore and inshore fisheries	Online mapping tool	None	Free	Available online at: http://glfgeo.dfo-mpo.gc.ca/tfk-ctp/content-contenu.asp?Language=EN
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Community-Based Coastal Resource Mapping Projects	Eastern Bay of Fundy; Annapolis/Digby Counties; Yarmouth County; Shelburne County; Queens/Lunenburg Counties; Halifax County; Guysborough County; Richmond County; Eastern Cape Breton County; Victoria County; Bras d'Or Lakes	1993 - 1999	Varies, but generally 1:10,000	Planimetric base maps; digital and hard-copy hydrographic charts	Not available online, must contact regional development agencies or relevant community groups in the area of interest. Can also contact Denise McCullough at DFO, Tel: 902-426-4274 - Fax: 902-426-3855 - Email: mcculloughd@mar.dfo-mpo.gc.ca	Free	Maps were produced over the course of several years, with most recent one being completed in 1999. As such, map information could potentially be out of date unless the community has updated the map since the initial developmente phase.
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Canadian Science Advisory Secretariat Publications - Science Advisory Reports and Research Documents	Province-wide fishing zones	1977 - present	na	online reports	None	Free	CSAS publications provide details on aquaculture and wild capture fishery activities, wild stock status, and ecosystem assessments.

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Proximity to Navigational Routes	Estimate of Available Area, Production Capacity and Economic Value of Potential Aquaculture Development in Coastal Inlets in Three Nova Scotia Counties (Murphy, 1997)	44 inlets in Shelburne, Richmond, and Guysborough counties, as well as Pubnico Harbour in Yarmouth County	published in 1997	bay/inlet level. Hard copy map scales range from 1:10,000 to 1:75,000	Not clear if digital versions are available. Hard copy maps are provided in the report.	Access to digital maps may be limited due to date of publication	Free	Specific navigational routes are not identified; however, potential conflicts between navigational corridors and aquacuture are identified for each inlet
	Community-Based Coastal Resource Mapping Projects	Eastern Bay of Fundy; Annapolis/Digby Counties; Yarmouth County; Shelburne County; Queens/Lunenburg Counties; Halifax County; Guysborough County; Richmond County; Eastern Cape Breton County; Victoria County; Bras d'Or Lakes	1993 - 1999	Varies, but generally 1:10,000	Planimetric base maps; digital and hard-copy hydrographic charts	Not available online, must contact regional development agencies or relevant community groups in the area of interest. Can also contact Denise McCullough at DFO, Tel: 902-426-4274 - Fax: 902-426-3855 - Email: mcculloughd@mar.dfo-mpo.gc.ca	Free	Maps were produced over the course of several years, with most recent one being completed in 1999. As such, map information could potentially be out of date unless the community has updated the map since the initial developmente phase.
	Canadian Hydrographic Services Nautical Charts	Province-wide	current					Available online at http://www.charts.gc.ca/index-eng.asp
Proximity to Industry	Environment Canada National Pollutant Release Inventory (NPRI)	Province-wide	1994 - present	Point source for each reported facility, as required under the authority of the *Canadian Environmental Protection Act* (1999).	Data is returned electronically via online database query (by pollutant or location), or MS Access database downloadable	None	Free	Available online from Environment Canada at: http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=B85A1846-1
Proximity to Agriculture	GEONova Atlas of Nova Scotia	Province-wide	not available	Online map query tool allows user to zoom from 1:4,000,000 to 1:1,000 to see the location and extent of agricultural lands across the province	Online maps, can also be printed from website	None	Free	Available online at http://www.gov.ns.ca/geonova/home/products/softpage/ns_atlas.asp
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
Proximity to Tourism Operators	Community-Based Coastal Resource Mapping Projects	Eastern Bay of Fundy; Annapolis/Digby Counties; Yarmouth County; Shelburne County; Queens/Lunenburg Counties; Halifax County; Guysborough County; Richmond County; Eastern Cape Breton County; Victoria County; Bras d'Or Lakes	1993 - 1999	Varies, but generally 1:10,000	Planimetric base maps; digital and hard-copy hydrographic charts	Not available online, must contact regional development agencies or relevant community groups in the area of interest. Can also contact Denise McCullough at DFO, Tel: 902-426-4274 - Fax: 902-426-3855 - Email: mcculloughd@mar.dfo-mpo.gc.ca	Free	Maps were produced over the course of several years, with most recent one being completed in 1999. As such, map information could potentially be out of date unless the community has updated the map since the initial developmente phase.
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
Proximity to Recreational Users	Community-Based Coastal Resource Mapping Projects	Eastern Bay of Fundy; Annapolis/Digby Counties; Yarmouth County; Shelburne County; Queens/Lunenburg Counties; Halifax County; Guysborough County; Richmond County; Eastern Cape Breton County; Victoria County; Bras d'Or Lakes	1993 - 1999	Varies, but generally 1:10,000	Planimetric base maps; digital and hard-copy hydrographic charts	Not available online, must contact regional development agencies or relevant community groups in the area of interest. Can also contact Denise McCullough at DFO, Tel: 902-426-4274 - Fax: 902-426-3855 - Email: mcculloughd@mar.dfo-mpo.gc.ca	Free	Maps were produced over the course of several years, with most recent one being completed in 1999. As such, map information could potentially be out of date unless the community has updated the map since the initial developmente phase.
	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
Proximity to Residential Areas	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html

Data and Information Sources for Siting Criteria

Name	NS Data Source	Spatial Coverage	Temporal Coverage	Scale of Data	Digital Data Format	Access Restrictions	Acquisition Costs	Notes
Ecologically Sensitive Areas								
Proximity to Protected Areas	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
Proximity to Informally Recognized Areas	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
Proximity to Important Fish Habitat	Ecosystem Overview and Assessment Report for the Bras d'Or Lakes Nova Scotia (Parker et al, 2007)	Bras d'Or Lakes	Published in 2007	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Halifax Regional Municipality - Units 4 - 6 (McCullough et al, 2005)	Halifax County, parts of Lunenburg and Guysborough Counties	Published in 2005	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html
	Significant Habitats: Atlantic Coast Initiative (SHACI) - Sydney Bight - Unit 11 (Schaefer et al, 2004)	Northern Cape Breton, from Scatarie Island to Cape North	Published in 2004	Data provided is from a range of literature sources and previous studies. No long-term time series, but generally key thresholds and seasonal changes	No digital data sets, all data is provided in text, charts, tables, and maps in the report	None	Free	Available online in the DFO Waves database at http://inter01.dfo-mpo.gc.ca/waves2/index2.html