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Maritimes Region

Identification and Review of Ecologically and Biologically Significant Areas in the Bay of Fundy

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Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

The Bay of Fundy forms a significant part of the Gulf of Maine. Massive tides and water flow result in the cycling of nutrients out of the marshes, mudflats, and estuaries of the upper bay to the mouth and beyond. Anthropogenic disturbances in some areas have resulted in significant changes to the biodiversity. This report provides a summary of available ecological and species information for selected areas in the Bay of Fundy which have been determined to be ecologically and/or biologically significant according to criteria defined by Fisheries and Oceans Canada and the Convention on Biological Diversity. This report builds on previous efforts to identify ecologically important areas in the Bay of Fundy (Buzeta et al. 2003a; Buzeta and Singh 2008; AECOM Canada Ltd. 2011). Based on substantial evidence from published literature, the sum total of scientific and local knowledge, previous Fisheries and Oceans Canada workshops, and the recent peer-reviewed evaluations of significant areas (DFO 2012), the following sites in the Bay of Fundy are concluded to be Ecologically and Biologically Significant Areas:

- Long Eddy, Grand Manan
- Flagg Cove and Whale Cove, Grand Manan
- Southern Grand Manan, including Northeast Bank, Old Proprietor Shoal, Murr Ledges, Clark's Ground, and Kent Island
- Machias Seal Island
- Grand Manan Basin Right Whale Critical Habitat
- Whole of Quoddy Region
- Sam Orr's Pond, St. Croix Estuary, Passamaquoddy Bay
- Tongue Shoal, Passamaquoddy Bay
- Head Harbour Passage, West Isles archipelago, and The Passages
- The Wolves and White Horse Island
- Maces Bay
- Musquash Estuary
- Mary's Point, Grindstone Island, and Chignecto Bay
- Evangeline / Cape Blomidon and Minas Basin
- Horse mussel reefs North of Digby, off Margaretsville, NS
- Brier Island / Digby Neck

Détermination et examen des zones d'importance écologique et biologique dans la baie de Fundy

RÉSUMÉ

La baie de Fundy représente une partie importante du golfe du Maine. Des marées massives et de grands courants d'eau entraînent le transport de nutriments des marais, des vasières et des estuaires du haut de la baie jusqu'à l'embouchure et au-delà de celle-ci. Des perturbations anthropiques à certains endroits ont engendré des changements importants dans la biodiversité. Le présent rapport est un sommaire des renseignements écologiques et sur les espèces disponibles pour des endroits précis dans la baie de Fundy ayant été désignés comme zones d'importance écologique ou biologique selon les critères définis par Pêches et Océans Canada et la Convention sur la diversité biologique. Ce rapport est fondé sur les efforts antérieurs de détermination de zones d'importance écologique dans la baie de Fundy (Buzeta *et al.* 2003a; Buzeta et Singh 2008; AECOM Canada Ltd. 2011). Les sites ci-dessous de la baie de Fundy ont été jugés comme étant des zones d'importance écologique et biologique en raison de preuves concluantes de publications, de l'ensemble des connaissances scientifiques et locales, d'ateliers antérieurs de Pêches et Océans Canada et d'évaluations récentes de zones d'importance examinées par les pairs (DFO 2012) :

- Long Eddy, Grand Manan
- Flagg Cove et Whale Cove, Grand Manan
- Sud de Grand Manan, y compris le banc Bank, le haut-fond Old Proprietor, Murr Ledges, Clark's Ground et l'île Kent
- Île Machias Seal
- Habitat essentiel des baleines noires du bassin Grand Manan
- Ensemble de la région Quoddy
- Étang Sam Orr, estuaire de la Sainte-Croix et baie Passamaquoddy
- Haut-fond Tongue, baie Passamaquoddy
- Passage Head Harbour, archipel West Isles et Les Passages
- Îles Wolves et île White Horse
- Baie Maces
- Estuaire de Musquash
- Mary's Point, île Grindstone et baie de Chignecto
- Évangeline, cap Blomidon, bassin des Mines
- Récifs linéaires de modioles au nord de Digby, à l'écart de Margaretsville, en Nouvelle-Écosse
- Île Brier et isthme Digby

1. INTRODUCTION

The Bay of Fundy is a significant part of the Gulf of Maine, cycling nutrients out of the marshes, mudflats, and estuaries of the upper bay, out to its mouth and beyond. The Bay's massive tides and water flow, and their interaction, result in a nutrient exchange, and the numerous islands, shoals, and underwater ledges force water through narrow passages, concentrating plankton, resulting in an abundant food supply for diverse benthic, pelagic, and avian populations (Conkling 1995).

Despite this reported significance, the observed physical impacts of some human activities have resulted in major changes in community composition and trophic structure over time. The result has been a reduction in variability, and a general increase in the homogeneity of the megabenthos (Kenchington et al. 2006, 2007).

On the New Brunswick side of the Bay of Fundy, decreased ecosystem health and loss of biodiversity has been observed in the St. Croix Estuary, Passamaquoddy Bay. Reports comparing survey results show an overall decline in water quality and in the abundance and diversity of benthic species (MacKay et al. 2003). Sponges show a significant decline from high occurrence/diversity ratings to low/rare, and all other taxonomic groups show a general decline from a moderate rating to low/rare. Fish species diversity has also shown a decline from historical numbers (MacKay et al. 1978a; Scott 1983; MacKay et al. 2003). Anthropogenic disturbance may lead to changes in biodiversity (Valiela 1995; Mann 2000; Barnes and Hughes 1999; Wildish and Stewart 2004) with species diversity typically being lower in highly disturbed communities. Communities are less likely to re-establish under continued disturbance (Pickett and White 1985; Valiela 1995) and colonization by short-lived opportunistic or invasive species may occur (Eno 1996; Kenchington et al. 2006).

Over the next few years, Fisheries and Oceans Canada (DFO) will be working with federal and provincial partners to plan a network of Marine Protected Areas (MPAs) for the Scotian Shelf Bioregion that will aim to protect biodiversity and maintain overall ecosystem structure and function. The Bay of Fundy is one of three planning areas in this bioregion along with the Atlantic Coast of Nova Scotia and an Offshore planning area. With the many pressures on the Bay of Fundy ecosystem, it is essential to identify areas of ecological or biological significance and to ensure they are conserved through a general risk-averse approach to management that includes, where appropriate, the establishment of MPAs. The identification of these Ecologically and Biologically Significant Areas (EBSAs) is an important step in the development of the regional network of MPAs (CBD 2008).

Examples of previous and ongoing assessments of significant areas, and the criteria used, are summarized in Table 1. These efforts to identify EBSAs are limited by the relative paucity and/or narrow spatial extent of the available coastal data. For example, in some cases, the data may not be responsive to localized assessments, while in others, the sources, scales, and variables recorded may be disparate and not conducive to mapping analyses. These data challenges have resulted in a method that combines the collection of scientific information from existing literature with a Delphic approach used to gather expert input, which may validate, dispute and/or augment a list of significant areas (Clarke and Jamieson 2006). While collection and analysis of spatial information continues to improve, often it is expert opinion that initially creates some of the data layers that can show where ecologically important areas are located, especially in coastal areas where surveys are often more localized. At some point the information has to be used to manage, while still allowing for changes as new information becomes available (Agardy 2011). When scientific data are lacking, but expert opinion is available, managers should have the confidence to proceed with conservation decisions (CBD

1992), especially when evidence for an area's significance is supported/validated by more than one source (Breeze 2004).

Previous assessment efforts for the Bay of Fundy followed the above model, but National or International criteria available at the time used different terminology to define "significance" (Buzeta et al. 2003a). The development of criteria for EBSAs by DFO (2004) provided a nationally-agreed upon set of criteria, and in 2006 a subset of areas within the Quoddy Region, southwest New Brunswick, outer Bay of Fundy, were re-evaluated to test the transferability of the information to these new standards (Buzeta and Singh 2008).

Table 1. Criteria used in some of the previous assessments of significant areas.

Assessment	Criteria used	Citation
Prince Edward Island, Gulf of St. Lawrence	Regionally significant habitat for marine species, important to specific life stages, biodiversity, specific ecosystem features.	Therrien et al. 2001
Bay of Fundy and approaches	Endangered/threatened species; productivity; unique or ecologically significant; spawning, larval, nursery, or staging area; high biodiversity; education, research, monitoring; recommendations for protection.	Buzeta et al. 2003a
Eastern Scotian Shelf	Productivity, biodiversity, reproductive areas, bottle-neck areas, habitat for species at risk, rare/unique habitats, naturalness, critical area, fragile/sensitive, significance.	Breeze 2004
Atlantic coast of Nova Scotia	Significant habitat (SHACI) that contributes to function and sustainability, conservation of biodiversity, health of cultural and recreational components.	Schaefer et al. 2004
Atlantic coast of Nova Scotia	Significant habitat (SHACI)	McCullough et al. 2005
Minas Basin	EBSA criteria (uniqueness, aggregation, fitness consequences, naturalness, resilience).	Parker and Westhead 2007
Eastern Scotian Shelf	EBSA criteria	Den Heyer et al. 2006
Pacific North Coast	EBSA criteria	Clarke and Jamieson 2006
Gulf of St. Lawrence	EBSA criteria	Rice and Morry 2006
Atlantic coast of Nova Scotia	EBSA criteria	Doherty and Horsman 2007
Quoddy Region Bay of Fundy	EBSA criteria	Buzeta and Singh 2008
Atlantic coast of Nova Scotia	Oceans Act, EBSA, CBD, management/pragmatic criteria	Gromack et al. 2010

1.1. OBJECTIVES

The main objective of this report is to identify and describe EBSAs in the Bay of Fundy based on available information. The geographic scope for this report is the entire Bay of Fundy, and both

DFO and Convention on Biological Diversity (CBD) EBSA criteria are considered in evaluating the sites.

Additional objectives of the report are to:

- Review available ecological and species information for the Bay of Fundy through a literature review and by contacting local experts;
- Evaluate the areas previously identified as significant by Buzeta et al. (2003a) and Buzeta and Singh (2008) against the CBD EBSA criteria;
- Update and refine the description and rationale for the previously identified significant areas, as required; and
- Provide science-based recommendations to DFO managers on Bay of Fundy EBSAs.

1.2. DEFINITIONS FOR CRITERIA USED

1.2.1 Ecologically and Biologically Significant Areas

An EBSA is an area of high ecological or biological significance, and should receive a higher level of risk aversion when conducting management activities to aid in the protection of overall ecosystem structure and function (DFO 2004). Based on DFO (2004) and Clarke and Jamieson (2006), areas identified as ecologically or biologically significant must rank highly on one or several criteria, and consider:

- biological functions (e.g. spawning, rearing, feeding, migration),
- physical oceanography (e.g. upwellings, convergences),
- structural habitat features (e.g. complexity, rocky reefs, sponge reefs), and
- biodiversity (e.g. Species at Risk (SAR), genetic, species, assemblages, habitats)

The three main DFO (2004) EBSA criteria are:

- Uniqueness – the degree to which the characteristics of areas are unique, rare, distinct, and have few or no alternatives.
- Aggregation – of individuals of a species, of different species, of structural features, of oceanographic processes.
- Fitness Consequences – the degree to which the area is required by a population or species for various life stages and activities.

Two additional modifying criteria are subsequently applied:

- Resilience – the degree to which habitat structures or species are sensitive, easily disturbed, or slow to recover.
- Naturalness - degree to which areas are pristine and contain native species.

DFO (2007) has indicated that, in risk-averse management, EBSAs should receive higher priority than other properties. The highest priority should be assigned to areas that meet multiple EBSA criteria, those that support Ecologically Significant Species (ESS) and/or SAR, and degraded areas.

1.2.2 Convention on Biological Diversity Criteria

The CBD (2008) considers marine EBSAs to be areas with one or more of the following attributes:

- Uniqueness or rarity. Areas that contain species, populations or communities considered "the only one of its kind", rare, or endemic; and/or unique, rare, distinct, or unusual, habitats, ecosystems, or geomorphological or oceanographic features.
- Special importance for life history stages of species. Areas that are required for a population to survive and thrive.
- Importance for threatened, endangered or declining species and/or habitats. Areas containing habitat for the survival and recovery of endangered, threatened, declining species or areas with significant assemblages of such species.
- Vulnerability, fragility, sensitivity, or slow recovery. Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery. Biological productivity. Areas containing species, populations or communities with comparatively higher natural biological productivity.
- Biological diversity. Areas containing comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.
- Naturalness. Areas with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation (CBD 2008).

The commonality/overlap among DFO (2004) EBSA and CBD (2008) EBSA criteria are summarized in Table 2. Both sets of criteria are inclusive of the other, although terminology differs. Therefore, reference to "EBSA" criteria or attributes in this document, refers to both sets of criteria being used together, unless otherwise specified.

Table 2. Commonality among DFO EBSA and CBD EBSA criteria.

CBD(CBD 2008)	EBSA (DFO 2004)				
	Uniqueness	Aggregation	Fitness Consequences	Naturalness	Resilience /sensitivity
Uniqueness or rarity	Y	-	-	-	-
Important to life history stages	-	Y	Y	-	-
Threatened or Endangered species or habitat	-	Y	Y	-	-
Vulnerability, sensitivity	-	-	-	-	Y
Productivity	-	Y	-	-	-
Biodiversity	-	Y	-	-	-
Naturalness	-	-	-	Y	-

1.2.3 Ecologically Significant Species

An ESS is a species that plays a particularly important role in the ecosystem as, for instance, a key forage species, influential predator, or structure-providing species. Corals and sponges, for example, form three-dimensional biogenic structures that provide additional complexity and habitat for larval fish and invertebrates, and are sensitive to anthropogenic activities (DFO 2010).The removal or severe perturbation of an ESS would result in significant changes to the ecosystem (DFO 2006a). ESS "warrant a high degree of risk aversion in management, because of their role in maintaining ecosystem structure and function" (DFO 2006a, pp. 5). Along with

EBSAs, ESS are a key consideration in DFO's approach to identifying regional conservation priorities. Identification of ESS should be science-led but experiential knowledge should also be considered (DFO 2007). In this report, the presence of a potential ESS within an area being reviewed against EBSA criteria is noted to alert the reviewer that this might be an additional consideration for that EBSA. For example, the presence of structure-providing species, such as horse mussels, is noted if they are known to occur within an EBSA. While a formal list of ESS for the Bay of Fundy does not yet exist, the presence of a potential ESS[1] (i.e. listed in discussions so far) may still be one of the primary reasons some areas have been identified as an EBSA.

1.3. PREVIOUS EFFORTS TO DESCRIBE SIGNIFICANT AREAS IN THE BAY OF FUNDY

As part of preliminary requirements for integrated management, a subset of marine and coastal areas was identified as ecologically significant areas in the Bay of Fundy in 2003 (Buzeta et al. 2003a). Information for this evaluation was gathered from the scientific literature, scientists, community members, personal communications and questionnaires. Three types of information were identified: scientific surveys and analyses; scientific ecological knowledge (SEK); and traditional ecological knowledge (TEK), and local ecological knowledge (LEK). Scientific, traditional and local ecological knowledge are often grouped as experiential knowledge. In the course of the data gathering stage in 2001-2002, three workshops were held. The site specific information primarily included:

a) a description of the area (physical and biological description, list of species);

b) species importance within the area (geographically rare, threatened or endangered species, or a commercially threatened species);

c) biological/ecological characteristics (life cycle stage such as spawning, feeding aggregations, or migratory path);

d) biodiversity (list of species, reference to an estimate of biodiversity, local scientific and non-scientific knowledge);

e) images or videos available; and

f) data, reference material, logbook records.

At the time of the Buzeta et al. (2003a) assessment, criteria for an area's significance were based on those established for MPAs under Canada's *Oceans Act*, the International Union for the Conservation of Nature guidelines for the protection and management of marine resources, and published MPA principles (Gubbay 1995; Day et al. 2012). The criteria used were:

- importance as critical/significant habitat for a particular species;
- importance to a geographically rare, threatened or endangered species;
- biological/ecological importance to a life cycle stage, or life process, of a species (e.g. spawning, juvenile rearing, feeding aggregations, migratory path);
- aggregation of species (high biodiversity), or diversity of habitats and/or communities;
- naturalness (lack of disturbance or degradation);
- community values (cultural, economic, research, education); and

[1] A list of ESS for the Bay of Fundy has not yet been approved by DFO Science Branch so any reference to ESS in this document should be considered potential ESS.

- recommendations for protection.

Sites noted as significant in the Bay of Fundy in 2003, exhibiting at least six of the seven criteria used at that time, were West Isles (Head Harbour), The Passages, and Brier Island (Buzeta et al. 2003a). Other sites that were noted as significant, exhibiting two to five of the seven criteria included Flagg/Whale Cove, Southwest Grand Manan area, Machias Seal Island, right whale critical habitat, Passamaquoddy Bay/St. Croix River, The Wolves/White Horse Island, Maces Bay, Musquash Estuary, Chignecto Bay, Minas Basin, fish spawning areas/coastal juvenile areas, mussel reefs, and migratory bird staging areas (Buzeta et al. 2003a).

1.3.1 EBSAs in the Passamaquoddy Region

In 2008, a subset of areas within the Passamaquoddy (or Quoddy) Region, southwest New Brunswick, outer Bay of Fundy, was re-evaluated at an expert workshop to test the transferability of the information summarized by Buzeta et al. (2003a) to the new DFO EBSA standards (Buzeta and Singh 2008). A panel of experts, comprised of six scientists, looked at the transferability of the information reported in Buzeta et al. (2003a) to the new DFO EBSA criteria and the overlap with criteria used previously. Their recommendations provided guidance during the workshop, which was held at the St. Andrews Biological Station (SABS; St. Andrews, New Brunswick). The workshop included three independent breakout groups (a total of 25 participants) comprised of scientists, biologists, and well-known local experts from DFO, Environment Canada, universities, and non-government organizations (NGOs).

Only sites within the Quoddy Region were re-evaluated at that time. It was agreed that there was an abundance of information and expertise (scientific, traditional, and experiential) for the Quoddy Region, not only to test the transferability of information, but also to evaluate areas within Quoddy for DFO EBSA attributes. At the time, no ranking was implied for the rest of the Bay of Fundy and the intent was to follow this exercise with assessments of other areas within the Bay, allowing time to collect additional information where needed.

The main DFO EBSA criteria (DFO 2004) of uniqueness, aggregation, and fitness consequences were applied; the secondary dimensions, naturalness and resilience, were not commonly applied, because generally, the reviewers were not united on how to evaluate these secondary criteria.

The panel of experts concluded that there was a high degree of transferability of the results reported in 2003 (Buzeta et al. 2003a) and those using DFO EBSA criteria (Buzeta and Singh 2008). Recommendations for EBSA designation, immediate precautionary measures, and a high level of risk-aversion in management decisions were made for the following sites:

- Quoddy Region overall, through its individual components; likely unique and irreplaceable in the Bay of Fundy.
- West Isles/Head Harbour, and The Passages, clearly and unquestionably satisfy the three primary criteria; considered hotspots within the Quoddy Region; given the highest priority for protection.
- The Wolves, satisfies two primary, and one secondary criteria.
- Maces Bay, satisfies one primary criteria.
- Sam Orr’s Pond was evaluated as a potential EBSA, with clearly unique biota, and Tongue Shoal met the criteria of high benthic biodiversity. However, these areas were not included as EBSAs at that time.

While the areas listed above were recommended as DFO EBSAs at the time, the DFO Canadian Science Advisory Secretariat review process was not available to formally review the work and recognize them as such.

2. METHODS

2.1. BAY OF FUNDY EBSA EVALUATIONS

The supporting evidence for EBSA qualities provided in this report includes reference material obtained through literature searches from published and unpublished scientific documents and information obtained through discussions with local experts. Information and reference material collected and summarized previously in Buzeta et al. (2003a) and Buzeta and Singh (2008) is included throughout.

Each area previously reviewed, or newly listed, was assessed against DFO (2004) EBSA, and CBD (2008) EBSA criteria (Table 3). Additionally, the presence of potential ESS was noted. Results of the assessment are presented systematically and outline the evidence and other supporting information under each of the criteria. This format was used in Buzeta and Singh (2008), based on that of Clarke and Jamieson (2006).

The Quoddy Region and its components, having been reviewed in detail previously (Buzeta and Singh 2008) including recommendations for EBSAs, feature prominently, and are expected to be more advanced in the review process than other areas within the Bay of Fundy.

Table 3. Summary of criteria used for 2012 EBSA assessments.

Origin	Acronym	Criteria	Citation
DFO Ecologically and Biologically Significant Areas	DFO EBSA(s)	Uniqueness; aggregation; fitness consequences; naturalness; resilience.	DFO 2004
Convention on Biological Diversity Ecologically and Biologically Significant Areas	CBD EBSA(s)	Unique or rare species, communities, habitats, or features; areas important for species life history stages or SAR; vulnerable or sensitive species or habitats; areas of high productivity, biodiversity, or naturalness.	CBD 2008
Ecologically Significant Species[2]	ESS(s)	Influence ecosystem structure and/or function; provide three dimensional structure important to biodiversity.	DFO 2006a

Parks Canada recently completed a regional analysis (AECOM Canada Ltd. 2011) to identify Preliminary Representative Marine Areas (PRMAs), which are areas that represent a region's physical, biological and cultural features. The key biological themes evaluated were the various connections that invertebrate, fish, bird and marine mammal species have established, the biological productivity, animal-sediment relationships, and the unique pelagic, benthic and intertidal systems. Due to the fact that these themes are similar to the concept of EBSAs, and PRMAs must also meet the criteria of naturalness, and the AECOM Canada Ltd. (2011) report is a recent analysis that includes many up-to-date distribution maps, the Parks Canada results feature prominently in this EBSA report.

As shown in Table 2, there is much overlap between the two sets of EBSA criteria. Therefore, in reviewing each area, the evidence to be applied is listed once, under the heading of the combined DFO EBSA and CBD EBSA criteria, as follows:

[2] Used to supplement EBSA assessments.

1. Uniqueness – includes species, populations, or communities, habitats, ecosystems, or geomorphological or oceanographic features, not commonly observed within the region, or considered “the only one of its kind", rare, or endemic; and/or unique, or unusual.
2. Aggregation – includes areas of high biological diversity or productivity; significant aggregation of individual species, including SAR; and/or aggregation of habitat features and oceanographic processes.
3. Fitness Consequences – includes habitat or conditions for life stages requirements of species, including SAR, or ESS.
4. Naturalness – includes evaluations by Parks Canada PRMAs.
5. Resilience - Areas that contain a relatively high proportion of sensitive habitats, habitat structures or species that are sensitive, biotopes or species that are functionally fragile, highly susceptible to degradation or depletion by human activity or natural events, or slow to recover. Direct supporting evidence was not common.

Bearing in mind that EBSAs should receive a higher level of risk aversion when conducting management activities to aid in the protection of overall ecosystem structure and function (DFO 2004), a section on Management Considerations is included to the review of each area, where key ongoing marine activities, previous recommendations for protection, and conservation initiatives are noted.

3. ASSESSMENT SUMMARY

Oceanographic features, such as fronts, eddies, and upwellings, are dynamic marine habitats that result in aggregations of low and mid-trophic level species and subsequently serve as foraging habitats for larger marine predators. Predictable upwelling regions can represent important foraging habitat for seabirds during migrations. Studies of these systems can be used to identify and predict hotspots of marine productivity, biodiversity, and important habitats for marine organisms (Thorne 2010). Underwater topographic features, including canyons and banks and other areas of bathymetric complexity are also useful in predicting aggregations. Therefore, areas of both biological and physical significance are considered when identifying EBSAs.

Physical oceanography directly impacts biological oceanography (Bakun 1996), with processes that enhance enrichment, concentration and retention. Tidal mixing fronts, such as those in the Bay of Fundy, provide unique habitat for predators and prey within the ocean (e.g. fishes and whales), as well as for species that interact with it (e.g. birds and humans). These physical processes which cause aggregations are very important. For example, studies, summarized by Johnston et al. (2005a), show that the distribution patterns of cetaceans correlate with physical features in their habitat. Features along the coast of Maine are not conducive to forming patches of copepods, but the physical processes found in Cape Cod Bay and Bay of Fundy are, and these result in the observed aggregations of North Atlantic right whales (*Eubalaena glacialis*), as well as fish and seabirds. Harbour porpoises (*Phocoena phocoena*) were also found to have restricted regions within their summer monthly ranges that coincide with fine-scale oceanographic features driven by tidal circulation that serve to aggregate prey.

3.1. AREAS IDENTIFIED AS EBSAS

A total of 16 areas were identified as EBSAs in the Bay of Fundy (Figure 1). Some of the EBSAs are discretely defined based on a specific feature (e.g. Tongue Shoal) while others are broader areas that encompass larger or multiple features (e.g. Mary’s Point, Grindstone Island, and Chignecto Bay). In the list below, areas that have been identified as PRMAs are noted as *PRMA*

or as *PRMA*^{p} if only partly listed as a special place by AECOM Canada Ltd. (2011). For the Quoddy Region, previous DFO EBSA recommendations (Buzeta and Singh 2008) are indicated as *EBSA-2008*.

Based on the substantial evidence from the published literature, and scientific and local knowledge, several workshops on significant areas in 2001 (Buzeta et al. 2003a), a previous DFO EBSA workshop (for Quoddy), and past and present evaluations of significant areas (Hunter and Associates 1982; PC/TNB 1985; IBA Canada 2012; Buzeta et al. 2003a; Buzeta and Singh 2008; AECOM Canada Ltd. 2011), the following are concluded to be EBSAs in the Bay of Fundy (with no ranking implied):

1. Long Eddy, Grand Manan – Identified on the basis of significant marine mammal and marine bird aggregations and high biological diversity as a result of aggregation of prey species available through persistent oceanographic processes, with these aggregations fulfilling requirements of critical life stages. (PRMA)
2. Flagg Cove and Whale Cove, Grand Manan - Identified on the basis of significant and unique aggregations of berried female lobster, as a result of habitat requirements not confirmed in other areas of the Bay of Fundy, with these aggregations fulfilling the critical physiological requirements for lobster egg development and extrusion. (PRMA)
3. Southern Grand Manan, including Northeast Bank, Old Proprietor Shoal, Murr Ledges, Clark's Ground, and Kent Island - Identified on the basis of significant aggregations of migrating or overwintering marine birds, including a uniquely high aggregation of razorbills, its proximity to the right whale habitat, the presence of SAR and potential ESS, and its strong natural character. (PRMA)
4. Machias Seal Island – Identified on the basis of aggregations of marine birds and the fitness consequences associated with nesting and rearing requirements. (PRMA)
5. Grand Manan Basin Right Whale Critical Habitat – Identified on the basis of the significant aggregations of North Atlantic right whales (SAR), and the associated fitness consequences of utilizing the area for feeding and calving, and the presence of a high percentage of juveniles. (PRMA^{p})
6. Whole of Quoddy Region – Identified on the basis of its individual components (EBSAs 7- 11, 1) and its perceived uniqueness and irreplaceability for all of the Bay of Fundy. The Quoddy Region meets all EBSA criteria. It functions as a whole, with ecological linkages between the different EBSAs within it. There is a strong consensus that the entire Quoddy Region should be managed by applying risk aversion (Buzeta and Singh 2008). Quoddy may be too large to be effectively managed as an EBSA; therefore, areas within it are individually reviewed. (EBSA-2008; PRMA)
7. Sam Orr's Pond, St. Croix Estuary, Passamaquoddy Bay – Identified on the basis of atypical (unique) warmer waters and flora and fauna. (PRMA within Quoddy)
8. Tongue Shoal, Passamaquoddy Bay – Identified on the basis of species aggregations, specifically high benthic species diversity. (PRMA within Quoddy)
9. Head Harbour Passage, West Isles archipelago, and The Passages – Identified on the basis of high levels of benthic biodiversity, aggregations of zooplankton, fish, birds, and marine mammals, the presence of juvenile finfish, and the associated fitness consequences. The area also supports a new (to science), possibly endemic, sponge species (Ginn et al. 1998), several SAR (harbour porpoise, North Atlantic right whale, Atlantic wolffish (*Anarhichas lupus*)) and ESS (sponges, rockweed, krill). The persistent structural, environmental, and oceanographic features that support this complex food web are not generally found elsewhere in the bay. (EBSA-2008; PRMA within Quoddy)

10. The Wolves and White Horse Island – Identified on the basis that it is an important wintering area for the endangered Harlequin duck (*Histrionicus histrionicus*) (SAR), and seabirds, a nesting site for cormorants, razorbills, kittiwakes, and possibly gannets. It is also known area of lumpfish and other finfish spawning, and an important area for feeding by basking sharks (*Cetorhinus maximus*). The area also has high benthic species richness, including dense communities of sessile sponges, hydroids and bryozoans. Distinct current-generated sedimentary bedforms that were initially thought to be horse mussel *(Modiolus sp.)* reefs (ESS) have also been identified in this area. This EBSA is also considered to have a high degree of naturalness and vulnerability associated with the density and diversity of sessile organisms. (EBSA-2008; PRMA)
11. Maces Bay – Identified on the basis of the high numbers of juvenile lobster and seabird aggregations, and the related fitness consequences. (EBSA-2008)
12. Musquash Estuary – Identified primarily on the basis of its naturalness, and its high value to wildlife and aggregations of waterfowl. It is considered a rare example of a fully functioning estuary system in the Bay of Fundy. (MPA)
13. Mary's Point, Grindstone Island, and Chignecto Bay – Identified on the basis of the extensive intertidal mudflats and tidal marshes that harbour large numbers of invertebrates which are the source of food for large aggregations of migrating shorebirds, and the fitness consequences associated with preparing for this migration. (PRMA^{p})
14. Evangeline / Cape Blomidon and Minas Basin - Identified on the basis of the large concentrations of the amphipod *Corophium volutator (*ESS), which attracts large numbers of migrating shorebirds, and the fitness consequences associated with building fat stores in preparation for migration; and the presence of the mud piddock clam (*Barnea truncata*) (SAR), which is not found elsewhere in Canada and may be endemic to Minas Basin. (PRMA)
15. Horse mussel reefs North of Digby, off Margaretsville, NS – Identified on the basis of this unique morphological characteristic, and the associated species aggregations (biodiversity), and the fitness consequences associated with food circulation and energy conversion provided through the processes of benthic-pelagic coupling. (PRMA^{p})
16. Brier Island / Digby Neck - Identified on the basis of three species of algae not found elsewhere in the Bay of Fundy (uniqueness) and the occurrence of subtidal species found intertidally here due to particular environmental conditions. Also an area of high concentration and diversity of copepods that attract large aggregations of many species of birds. (PRMA)

The CBD and DFO criteria that each of the sixteen EBSAs were found to satisfy are summarized in Table 4 and further described in Section 4 of this report. Other areas were evaluated but were not determined to be EBSAs at this time. These areas are briefly described in Appendix 1.

Table 4. Summary of EBSA attributes for areas reviewed in this report. References are cited as supporting evidence in Section 4. Sites evaluated are numbered sequentially around the Bay, but only those assessed as EBSAs are listed and numbered according to Section 4. Also listed for each EBSA, are Species at Risk (SAR), Ecologically Significant Species (ESS) present in each EBSA, previous recommendations of significance (PC/TNB 1985; Buzeta et al. 2003a; and Buzeta and Singh 2008, for Quoddy only), and the results of the recent Parks Canada report (AECOM Canada Ltd. 2011). See Figure 1 for locations.

DFO EBSA	Uniqueness	Aggregation	Aggregation, Fitness Consequences	Naturalness	Resilience/ Sensitivity	Aggregation	Aggregation, Fitness Consequences	ESS	Significant 2003	EBSA-2008 (Quoddy only)	Parks Canada Natural Area of Canadian Significance (NACS)1980	PRMA 2011
CBD EBSA	Uniqueness, rarity	Biological diversity	Special importance for life stages	Naturalness	Vulnerability, sensitivity, slow recovery	Biological productivity	Threatened/ endangered species/habitat					
1. Long Eddy, Grand Manan	-	Y	Y	-	-	-	-	-	-	-	Y	-
2. Flagg Cove and Whale Cove, Grand Manan	Y	Y	Y	-	-	-	-	Y	-	-	Y	-
3. Southern Grand Manan	-	Y	Y	Y	-	-	Y	Y	-	-	Y	Y
4. Machias Seal Island	-	Y	Y	-	-	-	-	-	-	-	-	-
5. Grand Manan Basin Right Whale Critical Habitat	-	Y	Y	-	-	-	Y	-	-	-	-	-
6. Whole of Quoddy Region	Y	-	-	-	-	-	-	-	-	-	-	-
7. Sam Orr's Pond, St. Croix Estuary, Passamaquoddy Bay	Y	-	-	-	-	-	-	-	-	-	-	-
8. Tongue Shoal, Passamaquoddy Bay	-	Y	-	-	-	-	-	-	-	-	-	-
9. Head Harbour, West Isles archipelago, and The Passages	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. The Wolves, and White Horse Island	-	Y	Y	Y	Y	-	Y	Y	-	Y	-	Y
11. Maces Bay	-	-	Y	-	-	-	-	-	-	Y	-	-
12. Musquash Estuary	-	Y	-	Y	-	-	-	-	-	-	-	-
13. Mary's Point, Grindstone Island, and Chignecto Bay	-	Y	Y	-	-	-	-	-	-	-	-	Y
14. Evangeline / Cape Blomidon and Minas Basin	-	Y	Y	-	-	Y	-	Y	-	-	Y	Y
15. Horse mussel reefs north of Digby, off Margaretsville, NS	Y	Y	Y	-	Y	-	-	Y	-	-	-	Y
16. Brier Island / Digby Neck	Y	Y	Y	-	-	-	-	-	Y	-	Y	Y

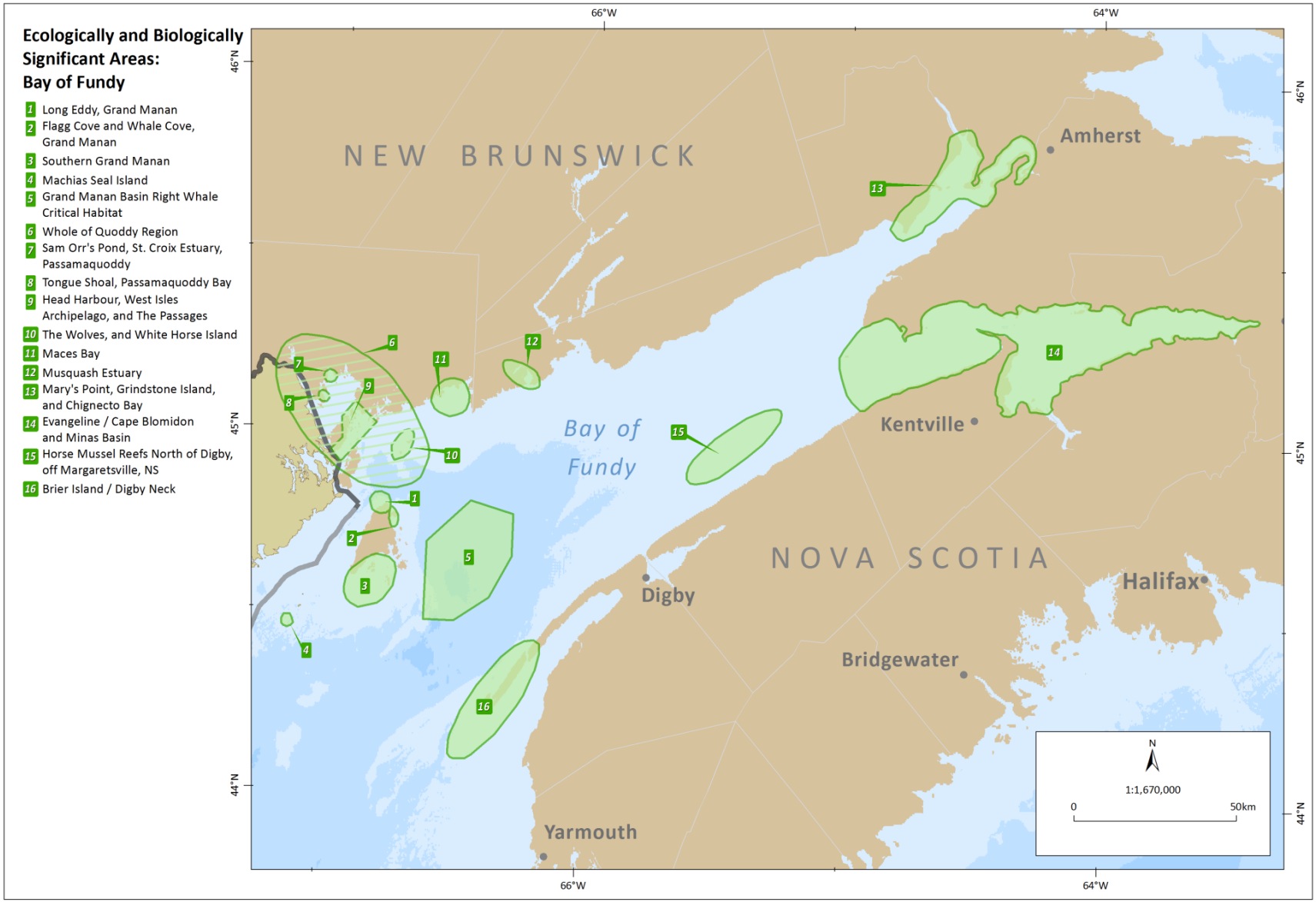

Figure 1. Location of identified EBSAs. Boundaries represent a best approximation of where a significant feature or features exist.

3.2. CONCLUSIONS AND RECOMMENDATIONS

The sixteen Bay of Fundy EBSAs (Table 4; Figure 1) presented in this report were found to satisfy the DFO and CBD EBSA criteria and were endorsed for consideration in the bioregional MPA network planning (DFO 2012). The Bay of Fundy is further along in the EBSA identification process than the other planning areas in the Scotian Shelf Bioregion as a result of a longer history of analyses of significance (e.g. Buzeta et al. 2003a; Buzeta and Singh 2008; AECOM Canada Ltd. 2011), including previous reports in the literature and earlier reviews by DFO. A list of ESS that are known to occur within each EBSA should be developed along with an explanation of the role each play in the ecosystem. Despite some information gaps, the analysis presented in this report is considered robust.

The boundaries for the identified EBSAs should be refined and georeferenced. It was suggested that this be done as soon as possible to assist managers in planning and identifying the appropriate risk-averse management tools. Boundaries could be defined through oceanographic, structural or biological features (e.g. the distribution of the zooplankton *Calanus finmarchicus* was considered when defining the Grand Manan Right Whale Conservation Area). It is important to note that EBSA boundaries do not represent potential or proposed MPA boundaries.

4. SUPPORTING EVIDENCE FOR ASSESSMENTS

4.1. LONG EDDY, GRAND MANAN

4.1.1 Uniqueness

The oceanographic feature of Long Eddy is a predictable system of tidal currents and upwelling. This feature is so prominent that it can be seen from space. It supports a multi-species feeding aggregation of marine organisms, including numerous predators (e.g. cetaceans, seabirds) that forage on the concentrations of fish and plankton (Johnston et al. 2005a, b; Ronconi et al. 2007). In the late summer and early fall, this predictable oceanographic feature draws several hundred harbour porpoises, several minke whales, (*Balaenoptera acutorostrata*) and fin whales (*Balaenoptera physalus*), all within a 5 km square area, twice a day. By combining visual observations with advanced telemetry and prey mapping, one can see how the tidal energy helps entire food webs assemble and dissipate (Johnston 2011).

The area used by North Atlantic right whales is much larger than the defined Critical Habitat, however, most important areas are associated with strong upwellings, such as the Whistle Rip off the northern end of Grand Manan (Buzeta et al. 2003a). The island wake generated by tidal flow past Grand Manan provides an ecological context for the predictable aggregations of cetaceans and seabirds that forage in this area (Diamond, unpublished presentation, 2001[3]; Johnston 2007; Allard et al. 2014).

4.1.2 Aggregation

The oceanographic feature of Long Eddy aggregates prey in relatively large quantities and makes it available to predators employing different foraging strategies, thus supporting a predictable, multi-species feeding aggregation of marine organisms (Johnston et al. 2005b). This area is recognized to be important for marine mammals and other seabirds, most likely because of the strong tidal upwellings that create foraging opportunities (Ronconi 2010), and

[3] Oral and written presentation by T. Diamond at the Sensitive Marine Areas Workshop, January 17, 2001.

has actually been identified as one of two such hotspots in Grand Manan (R. Ronconi, Dalhousie University, personal communication, 2011).

The Long Eddy Island wake is one of the foraging hotspots for shearwaters in the lower Bay of Fundy, and for overwintering of razorbills (*Alca torda*), a species of regional concern (Ronconi 2010; Diamond, unpublished presentation, 2001). Distribution maps of birds observed along aerial survey tracks show high densities of shearwaters in the area north of Grand Manan, to The Wolves (Allard et al. 2014). Other avian species using the area in winter include common eider *(Somateria mollissima)*, thick-billed murre (*Uria lomvia)*, common murre (*Uria aalge)*, and dovekie *(Alle alle*) (Diamond, unpublished presentation, 2001).

Numerous marine mammals, such as North Atlantic right whales, fin whales, harbour porpoise, and seals (*Phoca vitulina* and *Halichoerus grypus*) aggregate in this area (Huettmann et al. 2005) and harbour porpoise distribution in the Swallowtail area (northern tip of Grand Manan) is high during summer months (Trippel et al. 1996). The Grand Manan archipelago has been identified as a marine NACS and includes Critical Habitat for North Atlantic Right Whale, and seabird colonies (Hardie 1979; Messieh, unpublished manuscript, 1992[4]).

4.1.3 Fitness Consequences

This area is one of the foraging hotspots for shearwaters in the lower Bay of Fundy, and for overwintering razorbills, a species of regional concern (Ronconi 2010; Diamond, unpublished presentation, 2001). Foraging hotspots provide migratory seabirds with the fat and fuel needed to complete their long-distance journey southward to coastal waters off Argentina, which takes about 28 days.

Harbour porpoises (SAR) must remain close to food resources and consume prey frequently to meet the energetic demands of maintenance, growth, and reproduction. Porpoises choose regions that exhibit predictable, tidally induced fine-scale oceanographic features, clearly detectable with remote sensing techniques, such as the Long Eddy island wake (Johnston et al. 2005a, b).

4.1.4 Management Considerations

Substantial reductions in bycatch of harbour porpoise can be achieved by reducing gillnet effort in the Swallowtail area in the northern tip of Grand Manan (Trippel et al. 1996). Due to the aggregations of razorbills and marine mammals, a protected area around Long Eddy was suggested by Huettmann et al. (2005), noting this is also an area avoided by fishermen for its shallow waters and tidal currents.

Castalia is a nearby New Brunswick Provincial Park and a bird sanctuary noted for an abundance and diversity of common and rare bird species (Hunter and Associates 1982).

Long Eddy is listed as a potential EBSA (Figure 1, number 1) on the basis of significant marine mammal and marine bird aggregations. High biological diversity, as a result of aggregated food supply made available through persistent oceanographic processes, fulfills the requirements of critical life stages.

4.2. FLAGG COVE AND WHALE COVE, GRAND MANAN

4.2.1 Uniqueness

These areas are considered to fulfil the physiological requirements for lobster egg development and extrusion because of the sheltered, shallow warm waters, with a peak average summer

[4] Unpublished manuscript by S. Messieh, “Critical marine habitats and fishery resources of the Scotia-Fundy Region” (1992).

temperature of 11.2°C (Campbell 1990). The berried females found here do not stay long in the area, migrating offshore, north or east from Grand Manan into deeper waters and subsequently to the Grand Manan Basin. Tagging studies showed that some lobsters returned to the same area (Campbell 1986).

4.2.2 Aggregation

Species diversity for benthic organisms for Whale Cove is one of the highest for Grand Manan. Other areas with high ratings are North Head, Southeast Ross Island, and Northeast White Head Island. The Whale Cove area is considered a key area of productivity as indicated by a diversity/abundance rating (MacKay et al.1979a). This is corroborated by local knowledge suggesting that these subtidal areas are biologically diverse (Bosien, unpublished presentation, 2001[5]).

Large aggregations of berried female lobsters are found in the shallow waters off North Head, in Flagg Cove and Whale Cove (Campbell 1990). Up to 90 berried females per 100 trap hauls were reported for 1982-1983, 94% were larger than 94 mm (carapace length), the largest being 220 mm, and an average mean density of 2.3/100 m^2 was observed in an area of Flagg Cove. The high density of large berried females has persisted (Lawton and Robichaud, unpublished manuscript, 2001[6]). Based on all the diving surveys done in southwest New Brunswick, and in Annapolis Basin, Flagg Cove remains a unique area for aggregation of berried lobsters during the summer (P. Lawton, DFO, pers. com., 2001).

4.2.3 Fitness Consequences

Campbell (1990) suggests that the seasonal migrations by lobsters to the shallow warmer waters found here speed up the development time of lobster larvae, fulfilling the physiological requirements for lobster egg development and extrusion, thus increasing the probability of their survival. All results from SCUBA surveys in 1989-1991 indicate that Whale Cove and Flagg Cove function as lobster spawning areas (Lawton and Robichaud, unpublished manuscript, 2001) and that the high density of large berried females has persisted. Information collected in 1999 from local knowledge also identified these areas as lobster spawning areas and these findings were confirmed by Campbell (1990).

4.2.4 Naturalness

Recently the occurrence of thalloid brown algae (*Chorda* sp*.)* has been observed (M. Strong, DFO, pers. com., 2011). The presence of this species is considered to be a sign of eutrophication (Schramm and Nienhuis 1996).

4.2.5 Resilience/Sensitivity

Correlation analysis for ecological associations suggests crustaceans are very sensitive to chemical contamination (Chang and Thonney 1992); therefore, this area of berried female lobster aggregation could be considered sensitive to some marine development activities. For example, transect surveys by Lawton and Robichaud (unpublished manuscript, 2001) reported a significant decrease in density in two survey areas in Flagg Cove, subsequent to the 1989 placement of an aquaculture site. After the removal of the aquaculture site in 1991, the surveys showed an increase in abundance of berried female lobsters, and by 1992 the numbers had significantly increased.

Burridge et al. (2005) found that American lobsters (*Homarus americanus*) are sensitive to the pesticide Salmosan (azamethiphos), used to prevent sea lice in cultured Atlantic salmon (*Salmo*

[5] Oral presentation by R. Bosien at the Sensitive Marine Areas Workshop, January 17, 2001.
[6] Unpublished report by P. Lawton and D. Robichaud, "Summer distribution of berried lobsters (*Hormarus americanus*) off Grand Manan Island, potential conflict with salmon aquaculture" (2001).

salar). The lobsters are especially sensitive to this chemical during their spawning and molting seasons, which occur in the summer and early fall, respectively. In Canada, the use of Salmosan in aquaculture was discontinued in April 2005 (Haya et al. 2005).

4.2.6 Management Considerations

In light of the evidence of lobster sensitivity to the anti-sea louse pesticide Salmosan, the potential for similar sensitivities to other chemicals should be taken into consideration when situating aquaculture sites.

Recently the occurrence of thalloid brown algae has been observed, a species considered to be a sign of eutrophication (Schramm and Nienhuis 1996). These concerns have prompted interest in this area's long term protection.

Flagg Cove and Whale Cove are listed as potential EBSAs (Figure 1, number 2) on the basis of significant and unique aggregations of berried female lobsters. These aggregations occur as a result of habitat requirements not confirmed in other areas of the Bay of Fundy, and the area fulfils the critical physiological requirements for lobster egg development and extrusion.

4.3. SOUTH GRAND MANAN, INCLUDING NOTHHEAST BANK, OLD PROPRIETOR SHOAL, MURR LEDGES, CLARK'S GROUND AND KENT ISLAND

4.3.1 Uniqueness

Up to 52,000 auks of five species, mostly razorbills, were recorded concentrated near Old Proprietor Shoals, during surveys in 1997-1998 (Huettmann et al. 2005). No similar or larger number of wintering razorbills has been reported for North America.

4.3.2 Aggregation

The Bulkhead and Old Proprietor Shoals southeast of Grand Manan are considered marine hotspots for wildlife. Upwellings and tidal rips attract large aggregations of seabirds and marine mammals (R. Ronconi, Dalhousie University, pers. com., 2011).

Generally, eastern and southeastern Grand Manan are considered significant areas for seabirds. These islands are important nesting and feeding areas for eiders and other seabirds (Diamond, unpublished presentation, 2001; Blinn, unpublished presentation, 2001[7]; Wheelwright 2001; Christie, unpublished presentation, 2001[8]). The area has the highest bird species richness in the Canadian Atlantic and is an important moulting ground for Bonaparte's gulls (*Larus philadelphia*), a noted fall staging area for migrating grey and red-necked phalaropes (*Phalaropus fulicarius* and *P. lobatus*), an important wintering area for black-legged kittiwakes, a summer feeding area for large numbers of Wilson's storm-petrels (*Oceanites oceanicus*), greater shearwaters (*Puffinus gravis*), and sooty shearwaters (*P. griseus*) (Huettmann et al. 2005). Bird colonies observed during aerial surveys of the Bay of Fundy provide evidence of the importance of the area southeast of Grand Manan, where densities were the highest (65,000 birds/km^2) (K. Allard, Canadian Wildlife Service, pers. com., 2012). High shorebird density was observed during aerial surveys of the Bay of Fundy (4,700/km^2) on the southern tip of Grand Manan (Allard et al. 2014).

Casual observations between 1992 and 1997 indicated that up to 25,000 razorbills may occur from December to February. Standardized surveys conducted in November 1997 and March 1998 recorded up to 52,000 auks of five species, mostly razorbills, concentrated near Old Proprietor Shoals (Huettmann et al. 2005). Huettmann et al. (2005), propose that fine-scale

[7] Oral presentation by B. Blinn at the Sensitive Marine Areas Workshop, January 17, 2001.
[8] Oral presentation by D. Christie at the Sensitive Marine Areas Workshop, February 16, 2001.

oceanographic features (such as Old Proprietor Shoals) concentrate prey predictably and serve periodically to concentrate predators, including razorbills, which would otherwise disperse over a broader range in winter. Recent winter observations of previously unrecorded concentrations of common murres in a relatively small area, approximately 5 km east of White Head Island, indicate that the Grand Manan region may be of importance to other murres as well (Huettmann, unpublished data, 2005; Sabine 2010).

Kent Island, located 9 km south of Grand Manan, is part of the Grand Manan archipelago, and is designated as an Important Bird Area (IBA) for Canada. It is a major stopover for tens of thousands of migratory shorebirds, and contains one of largest colonies of Leach's storm-petrels (*Oceanodroma leucorhoa*) (Wheelwright 2001). Approximately 200 bird species, 55 of which nest there, and 30 species of marine algae are listed for Kent Island (Bowdoin Scientific Station 2013). Greater shearwaters forage readily around the productive areas of upwellings of the Bulkhead and Long Eddy Rip. These foraging hotspots provide them with the fat and fuel needed to complete their migration south.

MacKay et al. (1979a) showed an abundance of lobsters in dive transects southwest of Grand Manan-Outer Wood Island, Three Islands, and White Head Island. Preliminary results of a lobster trapping survey show high relative abundance of lobsters in Seal Cove and Long Pond Bay (Lawton and Robichaud, unpublished manuscript, 2001). Generally, the results demonstrate the wide use of these shallow water habitats during the summer.

The area south of Grand Manan has been identified as having high finfish diversity in the springtime (Strong and Hanke 1995). Southeastern Grand Manan, as far down to the Murr Ledges, is known to have numerous seal haulout areas (CCRM 1999).

4.3.3 Fitness Consequences

Greater shearwaters forage around the productive upwelling areas of the Bulkhead, Old Proprietor Shoal, and Long Eddy in the North. These important foraging hotspots provide them with the fat and fuel needed to complete their long-distance journeys to breeding grounds (Ronconi 2010). The American oystercatcher (*Haematopus palliatus*), a species that disappeared from the northern limits of its breeding range by the early 1900s, was noted to breed in this area (Sabine 2010) and has been observed during summer in the Grand Manan archipelago in recent years (McAlpine and Smith 2010).

In the 1930s, Kent Island was one of the last refuges for breeding common eiders in the Gulf of Maine, when the species was close to local extirpation. Presently it is a major stopover for tens of thousands of migratory shorebirds (Wheelwright 2001). A significant proportion of razorbills breeding in North America spend at least part of the winter in the outer Bay of Fundy. Razorbills, like many other wide-ranging marine predators, often concentrate in relatively small areas like Old Proprietor's Shoal during winter, where predictable concentrations of prey occur. Clarke et al. (2010) confirmed that razorbills wintering off Grand Manan represent a large proportion of the North American population. Such an aggregation of birds in a small area makes the entire population vulnerable. Implications for the conservation of razorbills are considerable (Huettmann et al. 2005).

There are several reports in the literature on a small contribution to herring spawning in the Grand Manan area. Das (1968) found one instance of summer-fall herring larvae on the Murr Ledges in October 1963. Fishermen identified southeastern Grand Manan as an active spawning area for cod and haddock (Graham et al. 2002). Historical information available for spawning areas of lobster, herring, cod and pollock around Grand Manan point to southeastern Grand Manan (Coon 1998). The Gravelly and Bulkhead are known area of groundfish spawning (Burt 1997) and lobster migration (Campbell 1986). Southeastern Grand Manan is a known scallop spat settling area (CCRM 1999).

4.3.4 Naturalness

Southwest Grand Manan, an area of 199,250 ha, which includes the Northeast Bank, Old Proprietor Shoal, Clark's Ground, and Great Duck Island, was ranked as the most natural of the five PRMAs identified for Parks Canada.

The area is second to southwest New Brunswick for aquaculture, with 24 aquaculture installations and additional sites expected in the future. Apart from the nearshore concentration of aquaculture sites, southwest Grand Manan retains a strongly natural character (AECOM Canada Ltd. 2011). Southwest Grand Manan currently has lobster, herring, scallop and crab fisheries, and dulse (*Palmaria palmate*) is also harvested in the area.

4.3.5 Management Considerations

Wheelwright (2001) recommended that Kent Island should be designated an exclusion area for any aquaculture projects that threaten bird populations, long-term biological monitoring, or environmental education. Hunter and Associates (1982) also listed Kent Island in their report on Proposed Ecological Reserves, while identifying the whole Grand Manan archipelago as an area of regional significance to seaducks, shorebirds, alcids, pelagic seabirds, and phalaropes.

The high number of razorbills adds to the reputation of the lower Bay of Fundy as a marine ecosystem of international significance (Huettmann et al. 2005). Old Proprietor Shoal is one of two main areas of concentrated razorbill feeding activity that have been identified, along with Long Eddy to the north. The importance of Old Proprietor Shoal to seabirds and the significance of nearby areas to the North Atlantic right whale make this area a strong candidate for an MPA (Huettmann et al. 2005). Fishermen generally avoid this location because of its shallow waters and treacherous tidal currents.

Southwest Grand Manan, including the Northeast Bank, Old Proprietor Shoal, Clark's Ground, Great Duck Island, is listed as an EBSA (Figure 1, number 3) on the basis of significant aggregations of migrating or overwintering marine birds, including a uniquely high aggregation of razorbills, its proximity to North Atlantic right whale habitat, the presence of ESS, and its generally strong natural character.

4.4. MACHIAS SEAL ISLAND

4.4.1 Aggregation

Located about 19 km southwest of Grand Manan, Machias Seal Island is considered an important nesting area for seabirds in the Bay of Fundy. Considerable numbers of breeding Atlantic puffins (*Fratercula arctica*), razorbills, Arctic terns (*Sterna paradisaea*), and common terns (*Sterna hirundo*) are found in this area (Hicklin and Smith 1984). Other bird species that use the area include Leach's storm-petrel, spotted sandpiper (*Actitis macularia*), razorbills, and black duck (*Anas rubripes*) (Wein and Jones 1975; Brylinsky et al. 1997).

4.4.2 Fitness Consequences

Roseate tern (*Sterna dougallii*), an endangered species under the federal *Species at Risk Act*, regularly occurs in this area, although nesting has not been confirmed (IBA Canada 2012). The razorbill and Arctic tern are species of regional concern (Diamond, unpublished presentation, 2001).

4.4.3 Management Considerations

This area (Figure 1, number 4) exhibits the EBSA attribute of aggregation for marine birds and fitness consequences associated with nesting on the island. The area is recommended as an Ecological Reserve (Wein and Jones 1975) for its value as a bird nesting area, particularly for the Arctic tern, and the Atlantic puffin. It is listed as a National Area of Canadian Significance

(PC/TNB 1985) and identified for its significance to alcids, pelagic seabirds, shorebirds, terns, and waterfowl (Hicklin and Smith 1984). It is also rated as a highly important area from an anthropocentric point of view (Burt 1997). The Marine Conservation Biology Institute identified it as one of the areas of highest priority for protection (MCBI 1999). It was declared a Federal Migratory Bird Sanctuary in 1944 (Diamond, unpublished presentation, 2001).

The island is visited frequently but visitors must adhere to strict guidelines. Diamond (2001) suggested that a minimum protection zone of 5 km be established around the Island to help conserve food gathering by birds.

4.5. GRAND MANAN BASIN RIGHT WHALE CRITICAL HABITAT

4.5.1 Uniqueness

Grand Manan Basin is recognized as an exceptional area (mainly due to unusual biological processes) in the analysis of candidate PRMA sites (AECOM Canada Ltd. 2011) and has been recognized as Critical Habitat for North Atlantic right whales (Brown et al. 2009). The North Atlantic right whale is a migratory species that travels along the east coast of North America primarily from eastern Florida to the Gulf of St. Lawrence and Newfoundland (Brown et al. 2009). There are certain areas along the migration route that are particularly important to the North Atlantic right whale. Such areas may be designated as Critical Habitat (under Section 2 of the *Species at Risk Act*, 2002), which is defined as “habitat necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or in an action plan for the species”. Grand Manan Basin is very important for feeding and a high percentage of juveniles have been seen in the area. There are many important areas for marine mammals in the lower Bay, but most are associated with strong upwellings (Buzeta et al. 2003a).

Grand Manan Basin represents one of only two summer aggregation areas for North Atlantic right whales (Brylinsky et al. 1997). It is a major feeding area that attracts between one half and two-thirds of the existing population (estimated at 350) during the summer and fall (Brown et al. 2009).

4.5.2 Aggregation

Distribution studies of krill (*Euphausiacea* sp.) in the Bay of Fundy show the highest concentrations in the Grand Manan Basin/Brier Island area (AECOM Canada Ltd. 2011). Large concentrations of northern krill (*Meganyctiphanes norvegica*) (ESS) are estimated for this area, providing food for whales, fish and seabirds. Euphausiids and copepods were most abundant in October and November, however, copepods showed a more regular distribution, but high diversity and concentrations were also found in this area (Percy et al. 1997; AECOM Canada Ltd. 2011).

As a result of high productivity, several cetacean species, including the endangered North Atlantic right whale, and large pelagics, such as basking sharks and seabirds, aggregate in this area to feed. Areas of concentration for sharks are the same as those where the North Atlantic right whales are found in the summer. The basking shark is listed as a species of Special Concern under Canada’s *Species at Risk Act* (2002). Wilson’s storm-petrel and other seabirds are abundant throughout the summer, and it is also a critical summering area for Arctic seabirds (Diamond, unpublished presentation, 2001).

4.5.3 Fitness Consequences

This area contributes 90% of the total primary production (Prouse et al. 1984) and represents one of two tidal pumps which support biological production in the Bay of Fundy (Percy et al. 1997). Sixty North Atlantic right whales were counted in the Bay of Fundy on one day in mid-

September 2011, out of an estimated total population of 400-500. Grand Manan Basin is an important nursery area for this species. Twenty-one North Atlantic right whale calves were recorded to have survived their trip to the Bay of Fundy from Florida in 2010 (CBC 2011). North Atlantic right whales typically remain in the area between July and October but can arrive as early as June and remain up to December (Buzeta et al. 2003a). This area is also an important summering area for Arctic seabirds (Diamond, unpublished presentation, 2001).

4.5.4 Naturalness

The Bay of Fundy, and subsequently, the Grand Manan Basin is a hive of various human activities including fishing, tourism and vessel traffic, which can have impacts on North Atlantic right whales and their habitat. Low-frequency vessel noise in this area may be significant and has been recognized as a concern (Rolland et al. 2011).

4.5.5 Resilience/Sensitivity

Recent estimates of the size of the North Atlantic right whale population in Atlantic Canadian waters suggest it is about 350 individuals (Brown et al. 2009). Whaling reduced historical numbers of North Atlantic right whales and there has been some growth since the activity stopped, but mortality from entanglement and vessel strikes still occurs (Brown et al. 2009). North Atlantic right whales seem to be most sensitive to fixed gear fisheries (i.e. gillnets and pot gear) (Brown et al. 2009). Whales may be sensitive to low-frequency vessel noise, leading to chronic stress. There may be implications for all baleen whales in heavy vessel traffic areas (Rolland et al. 2011).

4.5.6 Management Considerations

The goal of the Recovery Strategy for the North Atlantic Right Whale in Atlantic Canadian Waters is to “achieve an increasing trend in population abundance over three generations” (Brown et al. 2009, p. 33). The Strategy outlines threats to the North Atlantic right whales while in the vicinity of Grand Manan and lists objectives for achieving the goal. Collectively, the objectives focus on reducing incidences of mortality caused by entanglement, vessel strikes and other human activities.

This area is listed as an EBSA (Figure 1, number 5) on the basis of significant aggregations of North Atlantic right whales (SAR), and the associated fitness consequences of utilizing the area for feeding and calving, and the presence of a high percentage of juveniles.

4.6. WHOLE OF QUODDY REGION

This area is considered ecologically distinct from the inner Bay of Fundy, where estuaries, salt marshes, and mudflats, abound. At the mouth of the Bay, in the Quoddy Region, the benthic community stands out as a defining ecological characteristic. Plankton concentrations are found in many narrow passages and shoals, fostering an unusual abundance of filter feeders, which in turn release larvae and eggs, adding to the food available for larger organisms (Conkling 1995).

This region is considered a hotspot for marine species diversity and productivity in the Northwest Atlantic Ocean. Ocean currents and circulation patterns, high tides, upwellings, and a short, energy-efficient food chain support high concentrations of marine life. The diverse benthic topography provides a variety of habitats and supports many life cycle requirements. This area also supports several commercially important biological communities (Lotze and Milewski 2002; AECOM Canada Ltd. 2011).

The recognition of the area’s richness began with Aboriginal peoples more than 10,000 years ago, followed by French settlers in the 1600s and the general observations of Champlain in 1604. Scientific observations began in the late 1800s, most notably on marine invertebrates. Research in this area formally began in 1908; since then there have been numerous references

to the Quoddy Region's abundance of resources and ecological significance (Larsen 2004; Chang and Rudi 1999).

There is considerable redundancy in reference material when it is applied to the large Quoddy Region, as well as to smaller areas being reviewed within it (e.g. Head Harbour). As previously suggested by workshop participants and scientists (Buzeta and Singh 2008), for the purposes of appropriate management of the Quoddy Region, the whole Region is reviewed first, followed by the review of its individual components within.

4.6.1 Uniqueness

From a geological time perspective, scientists suggest that the Quoddy Region is ecologically unique as a result of recent and rapid geological evolution. It is these rapid changes in geology and oceanography that have occurred since the last glaciation, that have resulted in the present distribution and richness of biota. Changes in sea level through geological time allowed the spread of warm water species into the region. In time, the tidal range continued to increase in this area, breaking down the thermal stratification, resulting in tidal mixing. This resulted in very cold waters in the summer, but relatively mild temperatures in the winter (Larsen 2004).

From a contemporary perspective, scientists suggest that the Quoddy Region is ecologically unique and zoogeographically complex as a result of the large tidal amplitudes, combined with the Region's benthic topography and the effect that the many islands have on the tidal currents, and the temperature regimes that are reflected in the variety of biological assemblages (Trites and Garrett 1983; F. Page, DFO, pers. com.). In summary, the Quoddy Region is considered a unique ecosystem within the Bay of Fundy, with its high biodiversity and hydrographic conditions, as a result of geological history. These characteristics are not observed elsewhere in the Bay (Larsen 2004; MacKay, unpublished presentation, 2005[9]).

4.6.2 Aggregation

Tidal currents and upwellings concentrate zooplankton, attracting herring and mackerel (*Scomber scombrus*), and consequently harbour porpoise, humpback whales (*Megaptera novaeangliae*), and marine birds. It is estimated that this system supports the highest biodiversity in the Bay of Fundy, with over 2,000 species recorded (A. MacKay, St. Croix Estuary Project, pers. com., 2006; AECOM Canada Ltd. 2011).

The feeding aggregations of 19 species of marine mammals (e.g. North Atlantic right whales, humpback whales, harbour porpoise), and the high diversity of sessile marine invertebrates, have prompted science-based NGOs to call for its protection (MCBI 1999).

4.6.3 Fitness Consequences

Quoddy is an important feeding area for marine mammals, including the endangered North Atlantic right whale, and the harbour porpoise, currently listed as a species of special concern (COSEWIC 2009a). The outer areas of the Quoddy Region, especially its islands are critical habitat for red-necked phalaropes in late July to early September (Messieh, unpublished manuscript, 1992), and for breeding, staging, and/or wintering marine birds, herons, cormorants, alcids and terns (AECOM Canada Ltd. 2011).

Intertidal and subtidal seaweeds (e.g. *Laminaria, Ascophyllum nodosum, Fucus*) found on the outer Bay are significant contributors to primary production (80% of total annual production) within the Inner Bay, and an important source of nutrients to offshore waters (AECOM Canada Ltd. 2011). Intertidal and subtidal seaweed communities are considered important nursery grounds for pollock, and refuge for at least 22 fish species (Rangeley and Kramer 1995; Mann 2000), and seaweed rafts are an important habitat and feeding area for pelagic seabirds,

[9] Oral presentation by A. MacKay, "Save Passamaquoddy Bay" (2001). 60 pp.

invertebrates, and fishes (Parsons, unpublished thesis, 1986[10]). The Quoddy Region has also been identified as critical marine habitat for 1-2 year old herring (Messieh, unpublished manuscript, 1992).

4.6.4 Naturalness

This region has a long history of habitation and resource use. Aboriginal people lived around Passamaquoddy Bay for thousands of years, utilizing a diversity of species (e.g. shellfish, herring, pollock, cod, porpoise). Permanent European settlements were established by the late 18th century and fisheries (e.g. cod, haddock, herring), and several industries (e.g. sawmills, pulp and paper mills, fish processing plants) followed. Thus, there is a long history of declining abundance of species, habitat alteration and destruction. As these fisheries declined, fishing shifted to lower trophic levels, along with the establishment of cultured species (e.g. salmon). Major shifts have been recorded, including the decline or loss of large predators and habitat-building species, and the increase in abundance of opportunistic species. Thus, the Quoddy Region is considered to have been degraded over the past 200 years. However, compared to other highly impacted coastal areas, the Quoddy Region still sustains diverse and productive marine fauna and flora, which could be regenerated or preserved if wise management actions are chosen (Lotze and Milewski 2002).

The Quoddy Area, including Passamaquoddy Bay, the St. Croix River, Deer Island, Campobello Island, The Wolves, and Seeley's Head, to the north western part of Grand Manan Island, was assessed as the least natural (most highly impacted) area of the five areas identified by AECOM Canada Ltd. (2011). It has the largest number of aquaculture sites in the Bay of Fundy, and this is expected to grow. There is concern that this activity has degraded the estuarine embayments of Quoddy (AECOM Canada Ltd. 2011), and exposed biota to harmful chemicals (e.g. cypermethrin-based pesticides) that target crustaceans (French 2011).

There are also significant herring and lobster fisheries, scallop, urchin, and sea cucumber drag fisheries, as well as a tourism industry. There is concern with the recent expansion of the sea cucumber fishery into areas not previously accessed by habitat destructing gear (Buzeta et al. 2003a).

4.6.5 Resilience/Sensitivity

This region is considered to have the highest environmental vulnerability and environmental risk, on the eastern Canadian seaboard (Yuen 1976). In the event of an environmental disaster, estimates based on tidal velocities suggest that contamination of much of the Quoddy Region would occur within a week (Loucks et al. 1974).

4.6.6 Management Considerations

The whole Quoddy Region is considered an EBSA (Figure 1, number 6) for its individual components, assessed below. However, the whole of Quoddy may be too large to be effectively managed as an EBSA. It should be recognized that there are many definitions of the boundaries for the Quoddy Region, depending on the study or discussion focus. Smaller areas within it are individually reviewed, and should be zoned for enhanced protection according to their individual EBSA attributes (Buzeta and Singh 2008).

The general area, inclusive of Cobscook Bay, Maine, is recognized as a significant ecosystem within Bay of Fundy-Gulf of Maine, and this region has been suggested for protection (Buzeta et al. 2003a). It is considered a marine oasis of international significance that warrants special management attention (CCNB 2004). Concerns include dragging, aquaculture, and large-scale

[10] Unpublished M.Sc. Thesis by G. Parsons, "Floating algal rafts and their associated fauna in Passamaquoddy Bay, New Brunswick", Acadia University, Wolfville, NS (1984).

industrial development, but these are discussed as part of specific locations mentioned below (i.e. The Passages, Head Harbour).

Based on the hard bottom and high diversity of sessile marine invertebrates, the Quoddy Region was identified as one of the highest priority areas for protection in the Gulf of Maine (MCBI 1999). The Quoddy Region was suggested for a pilot study on Integrated Marine Planning (Buzeta et al. 2003a), whereby an interdisciplinary discussion group identified the region as the larger management envelope for a smaller pilot study within. The region was identified by the group as a biological hotspot containing a diversity of habitats and marine activities (i.e. scientific, cultural, and economic). The group also felt the region had potential for Canada-USA transboundary collaborations, thereby making it a good candidate for a coastal management area. The Quoddy Region has also been proposed as an MPA due to the feeding aggregations of marine mammals. Reasons to support such a conservation initiative included the presence of the endangered North Atlantic right whale (SAR), harbour porpoise (SAR), and several other species of whales found aggregated in this region during late summer and early fall (AECOM Canada Ltd. 2011).

Brilliant (unpublished presentation, 2001[11]) suggests that the Quoddy Region's ecological significance is not as promoted as its role as an aquaculture and fishing centre, and that it is often overshadowed by the upper Bay, which is recognized for its mud flats, salt marshes and bird migration areas. The Quoddy Region has the largest number of aquaculture sites in the Bay of Fundy, and this is expected to grow (AECOM Canada Ltd. 2011). There is concern that this activity has degraded the estuarine embayments of Quoddy (AECOM Canada Ltd. 2011), and exposed biota to harmful chemicals (e.g. cypermethrin-based pesticides) that target crustaceans such as sea lice (French 2011). Other crustaceans, including larval and juvenile lobsters, and krill, are also sensitive to these chemicals.

4.7. SAM ORR'S POND, ST. CROIX ESTUARY, PASSAMAQUODDY BAY

4.7.1 Uniqueness

Sam Orr's Pond, located on the northern shore of Passamaquoddy Bay, exhibits water temperatures and biota that are atypical to this area. Water temperatures in the summer are consistently above 20°C, with cyclical fluctuation of surface salinities ranging from 4‰-30‰ (Mortimer and Downer 1961). The pond has a large number of elvers (*Anguilla rostrata*) present (Mortimer and Downer 1961) and the quahaug (*Mercenaria mercenaria*) typical of warm water areas, has been present in this area for over 10,000 years (Reid et al. 1962). The quahaug was a food source for the Abenaki tribes, which imparts an historical and traditional importance to this area.

4.7.2 Aggregation

The St. Croix Estuary is a true estuary, and has the mixed faunal assemblages typical of both high and low salinities (MacKay et al. 1978a). Northern Passamaquoddy Bay, St. Andrews Point, and the St. Croix Estuary are key areas of productivity, as indicated by diversity/abundance ratings (MacKay et al. 1978a).

Hardwood Island was considered to have a large and diverse avian population, with a large nesting colony of great blue herons (*Ardea herodias*), nesting ospreys (*Pandion haliaetus*), and herring gulls, and was an important stopover for migratory birds (Wein and Jones 1975). The island is also home to a large and important common eider nesting colony (Diamond,

[11] Oral presentation by S. Brilliant at the Sensitive Marine Areas Workshop, January 17, 2001.

unpublished presentation, 2001). The area near St. Andrews has high densities of purple sandpipers (9.2 birds/km2), observed along aerial survey tracks (K. Allard, pers. com., 2012).

4.7.3 Fitness Consequences

The areas around St. Andrews, Chamcook, Digdeguash and Magaguadavic are regionally significant to birds, as feeding and staging areas for ducks, shorebirds, eagles and osprey (Hunter and Associates 1982), with several small islands in the north of Passamaquoddy Bay important for rearing and as migration stop-overs for sea ducks, gulls, sandpipers and phalaropes (Christie 2001). Hardwood Island is a breeding site for herons, gulls and common eiders (Thomas 1983), and Hog Island has eider and cormorant colonies (Diamond, unpublished presentation, 2001).

Birch Cove has a significant juvenile lobster population occupying the shallow boulder/cobble habitats, and the area from McCann Head to Creighton Point, is reported as being a lobster nursery area. Northern Passamaquoddy Bay (Birch Cove, Bocabec Cove, Dicks Island and Hog Island) has a higher relative abundance of lobsters than other areas of the Bay (Lawton 1993).

Cod spawning locations have also been reported in northern Passamaquoddy Bay (McKenzie 1934); however, in a report on fishermen's knowledge of spawning areas, there was no evidence that this area still exists (Graham et al. 2002). Many coastal spawning areas have been lost, but the importance of coastal areas to the life cycles of many fish is still being demonstrated, and juvenile cod have been captured in beach seines in Passamaquoddy Bay (MacDonald et al. 1984).

4.7.4 Naturalness

During the 1960s, black liquor and other wastes from the pulp and paper industry, were dumped directly into the St. Croix River. The health of the Estuary declined dramatically and the commercial fishery all but disappeared. This extreme level of pollution continued into the early 1970s until a waste treatment facility was upgraded. By 1977 there was improvement in the state of the Estuary (MacKay et al. 2003). While conditions have improved, inputs from industrial, domestic, and air-borne sources remain, resulting in a very low overall water quality rating, and making it unlikely that any significant restoration can be accomplished (MacKay et al. 2003).

Excessive nutrient enrichment occurs in areas of Passamaquoddy Bay and Letang Estuary. This is largely due to finfish aquaculture, which has resulted in impoverished fauna directly below and/or beyond the cages (Hargrave et al. 1983; Wildish and Pohle 2005; Pohle et al. 2007).

4.7.5 Management Considerations

Sam Orr's Pond - (Figure 1, number 7) was identified as an EBSA on the basis of (unique) atypical warmer waters, and the associated flora and fauna.

The St. Croix River was designated a Canadian Heritage River in 1991 (CHRS 2011). St. Croix Estuary was proposed as an Ecological Reserve for its regional significance as a feeding and staging area for ducks, geese, shorebirds and gulls (Hunter and Associates 1982).

The coastal habitat surrounding Sam Orr's Pond is protected as part of the Caughey-Taylor Nature Preserve (NTNB 2013); however, nearby marine activities should be monitored. It continues to be used as a study site by many scientists and students. Hardwood Island was recommended as an Ecological Reserve (Wein and Jones 1975) for its diverse avian population, and for the purpose of preserving this natural area for science and education. Aquaculture next to Hog Island is of concern due to the higher relative abundance of lobsters (Lawton 1993). The industry is also thought to cause a disturbance to eider and cormorant colonies on the island (Diamond, unpublished presentation, 2001).

A previous review of information according to EBSA criteria (Buzeta and Singh 2008) concluded that St. Croix River and Passamaquoddy Bay, as a whole, may meet some of the requirements for an EBSA, but evidence is not strong, and naturalness is very low with significant environmental issues to address.

4.8. TONGUE SHOAL, PASSAMAQUODDY BAY

4.8.1 Aggregation

Tongue Shoal is considered to have higher than average species richness, including species not commonly found in Passamaquoddy Bay (MacKay et al*.* 1978a; A. MacKay, pers. com., 2006). Molluscs, echinoderms and marine plants, are common; sponges and tunicates are poorly represented, most probably due to temperature and salinity fluctuations in the area, although water quality may also be a factor (MacKay et al*.* 1978a).

4.8.2 Management Considerations

Tongue Shoal (Figure 1, number 8) was selected as an EBSA on the bases of species aggregations, specifically high benthic diversity, and there is concern that this area may be impacted by sea cucumber dragging nearby (Voutier et al. 2006; M. Strong, pers. com., 2011). As a precautionary measure, dragging, dredging, or other activities with a potential for benthic impacts, should be restricted until further study.

4.9. HEAD HARBOUR PASSAGE, WEST ISLES ARCHIPELLAGO, AND THE PASSAGES (HH/WI)

The Head Harbour area is interchangeably called Head Harbour Passage, West Isles (which may/not include The Passages), or outer Quoddy Region and Quoddy Isles (which may/not include northern Grand Manan). Occasionally it is also included as part of, or actually erroneously named, The Passamaquoddy Area. Whenever possible, the name used in the reference material has been maintained, otherwise the general term HH/WI will be used.

Reference to The Passages generally includes Big Letete, Little Letete, Pendleton, and occasionally Western Passage (this one is often specified separately). Western Passage supplies 61% of the water entering Passamaquoddy Bay, Big Letete Passage supplies 34%, and 5% passes through Little Letete Passage (Bumpus et al. 1959). Big Letete and Little Letete Passages are narrow, high velocity channels north of Deer Island. The currents in these channels are caused by the frictional resistance of the tidal water movements against the complex benthic topography.

Ships Harbour, on the east side of MacMaster Island facing Letete Passage, is a sheltered harbour containing one of the few saltwater ponds in the area, home to sticklebacks and mummichogs, and to the birds such as herons and kingfishers, that feed on them and the numerous small crustaceans.

Prior to European settlement, MacMaster Island was frequented by the Passamaquoddy Tribe. There are several shell midden sites on the island, and as members of the Passamaquoddy-Scoodic Tribe struggle to preserve their link to their heritage, places such as Ships Cove become culturally significant. As a result there is interest in protecting the area (Akagi 2001). While cultural significance *per se* is not part of the EBSA assessment, statements made by the Passamaquoddy Tribe should be considered because the coastal communities that thrived were enabled by persistent environmental conditions (e.g. geomorphology, water temperature, currents, upwellings) that result in the aggregation of resources.

Many of the references to The Passages are the same as those for the HH/WI. This redundancy has been avoided by combining The Passages and HH/WI; however, The Passages are referred to separately when information pertains solely to them.

Due to the long history of research in this area, and the proximity to academic institutions, there has been a lot of information collected and recorded for the Quoddy Region.

4.9.1 Uniqueness

This area has been historically identified as unique, making the area a focus for benthic research since 1908 (P. Larsen, Bigelow Laboratory for Oceans Sciences, pers. com., 2007). The area is significant because of the turbulence and upwelling associated with strong tidal currents. As the waters funnel through The Passages, plankton is concentrated and bottom-dwelling animals feed on the passing abundance. They themselves produce eggs and larvae, creating a further localized increase in plankton and productivity (Mann 2000; MacKay 2005; Christie 1983). The combination of these features, and the high diversity of benthic fauna, marine mammals, and avifauna, compacted into a small area, have made this area significant and ecologically unique (Buzeta et al. 2003a; Larsen 2004; AECOM Canada Ltd. 2011). The Passages around the Deer Island Archipelago are considered special and represent one of the areas with the finest biodiversity of benthic organisms in the Bay of Fundy (Thomas, unpublished presentation, 2001[12]).

Uniqueness results from the combination of persistent features, the large tides, complex benthic topography, and the tidal streams around these scattered small islands, resulting in a diversity of current velocities, eddies and gyres. This causes many shear zones, upwellings, and convergences that force plankton to the surface in concentrated patches (F. Page, pers. com.). Rocky outcrops, boulders, and cobble are common (except for sheltered areas where sand and mud predominate), increasing the benthic complexity of the topography, in sharp contrast to that of Passamaquoddy Bay.

These features and processes result in an ecosystem that harbors the highest levels of diversity of benthic macro-invertebrates in the Bay of Fundy, with a gradient in species richness from southern Maine to Head Harbour, and from St. Croix Estuary to HH/WI (P. Larsen, pers. com., 2007; Buzeta 2008). Additionally, the presence of two of the larger ascidian species, the sea peach (*Halocynthia pyriformis*), and a species of tunicate (*Boltenia ovifera*) indicate physical conditions related to hard substrates, and moderate to strong currents, not generally seen in other areas (Hatfield et al. 1992; Ginn et al. 2000; A. Logan, University of New Brunswick, Saint John, pers. com., 2001). These are possible ESS and their abundance provides additional habitat and a protective canopy for juvenile cod (*Gadus morhua*) (Buzeta and Strong, unpublished dive log, 2001; D. Methven, University of New Brunswick, Saint John, pers. com.), and increased numbers of upright and massive (ESS) sponges (e.g. *Haliclona oculata, Myxilla spp.*).

Statistical analyses of benthic survey data collected by MacKay et al. (1978a-c; 1979a-c) identified the West Isles as having higher than average species richness. This was significantly correlated to environmental factors (temperature, salinity) and benthic complexity (Greenlaw et al. 2007a, b), leading to the conclusion that it is these persistent features, as well as additional factors (current speed, dispersal and colonization processes), that provide suitable habitat for more species. Specifically, regardless of annual fluctuations in abundances of individual organisms, the characteristics of the HH/WI are conducive to higher benthic species richness (Buzeta 2008). This highly diverse benthic community does not appear to be generally distributed throughout the region (MacKay et al. 1978c; Lawton 1992, 1993; Buzeta 2008).

[12] Oral and written presentation by M. Thomas at the Sensitive Marine Areas Workshop, January 17, 2001.

4.9.2 Aggregation

There are visible, but highly mobile, aggregations of species that form part of a food chain that include Northern krill (ESS)**,** mackerel, herring, squid, common and Arctic terns, herring gulls, Bonaparte's gulls, northern (red-necked) phalaropes, fin whales, humpback whales, minke whales, and harbour porpoise (SAR) (Smith et al. 1984; Gaskin 1977). These aggregations move according to tidal cycles, especially in the areas between the West Isles, Head Harbour Passage, White Horse Island and The Wolves (Gaskin and Smith 1979). High numbers of species have been recorded in this area, including 836 invertebrates, 96 fishes, 70 birds, 20 mammals, and 223 plants (Hardie 1979).

Humpback whales frequent Letete Passage, Head Harbour Passage, and waters off Campobello and Deer islands, among other areas. Fin whales are observed off Deer and Campobello islands and other parts of the outer Bay of Fundy. Harbour porpoise congregate in the Quoddy islands and their passages out to The Wolves, and off upper Grand Manan (MacKay et al. 1978c; Burt 1997; AECOM Canada Ltd. 2011). The many ledges in HH/WI are known seal haulouts (CCRM 1999; Buzeta et al. 2003a; PC/TNB 1985).

The Passages have current velocity maximum ranges, upwellings, convergences, and rips abound. The high current velocities and substrate characteristics (cobble, boulder, ledge, vertical cliffs) of Little Letete Passage result in very rich benthic communities of organisms adapted to feeding in these extreme current conditions. Generally, The Passages have very high percent coverage of benthic organisms with walls rich in biota that make it unique (Thomas 1983). GIS video surveys along Big Letite Passage demonstrate that the presence of vertical rock walls and high currents result in an abundance and diversity of epifauna, including a large number of sponges. Lawton (1992, 1993) states that the presence of vertical rock walls and high currents result in a highly diverse and abundant community of sessile organisms found in The Passages.

A new species of sponge has been documented in this area (Ginn et al. 1998) and there was also an increased coverage of upright (e.g*. Haliclona oculata*) and massive (e.g*. Myxilla* spp.) sponge species recorded. These increased numbers of upright and massive sponges were significantly correlated to vertical rock slopes, boulders, and rock walls (Ginn et al. 2000), with large sponges commonly found at the bottom of the ledges (Thomas 1983).

There is a high population density of filter feeding organisms in HH/WI, with a particularly diverse sponge community (ESS), as described by Ginn (1997) and potentially more species not yet described (Thomas 1994; Thomas, unpublished presentation, 2001). In Little Letite Passage, sponges such as *Isodictya deichmannae, I. palmata, Halichondria panacea, Pellina sitiens, Melonanchora elliptica* [largest sponge in North Atlantic (1 m) (Harvey-Clark 1997)], *Haliclona oculata* (stalked, upright sponge up to 1 m high, and *H. loosanoffi*) are common (Ginn et al. 2000). In such areas, the majority of the sponges are of the encrusting type, followed by those classified as massive and upright (Ginn 1997). Most sponges, with the exception of encrusting sponges, are found on hard bottom as compared to gravel or cobble. In Big Letite Passage, video transects identified sponges along the walls to the entrance of Ships Harbour, and near Green's Point (Owen, 2008; Singh, unpublished report, 2011[13]). *Haliclona* and *Halichondria* were recorded by MacKay (1978a-c) in the Deer Island / Campobello / Head Harbour Passage area.

The Passages also sustain an extraordinary field of sea cucumbers (*Cucumaria frondosa*). This area has been described by Thomas (unpublished presentation, 2001) as being "paved with sea cucumbers", which provides another sub-habitat for additional organisms, resulting in high

[13] Unpublished report by R. Singh, "Areas identified as sponge habitats in the Quoddy Region of the Bay of Fundy" (2011).

diversity. There is also a large variety of anemones that live on the back face of the rock walls, away from the current. (Thomas, unpublished presentation, 2001). Photographic transects in Head Harbour Passage found species richness to be high, with brachiopods, sponges, hydroids, anemones, echinoderms and tunicates, all contributing to a highly three-dimensional surface down to about 30 m, where hard substrates are usually replaced by sediments. Sponges are relatively common, particularly in the Wilson's Beach-Pope Islet transect, but are somewhat reduced on the Spruce Island-East Quoddy Head transect (Logan 1988; Singh, unpublished report, 2011).

Black guillemots (*Cepphus grille*), common eiders, red-breasted mergansers (*Mergus serrator*), and scoters (*Melanitta* sp.) are common in and around Big Letete and Little Letete Passages (Thomas 1983). Phalaropes, gulls, and terns frequent Head Harbour passage, feeding on the ample food supply consisting of organisms like zooplankton, euphausiids, herring, and squid (AECOM Canada Ltd. 2011).

Compilations of species lists suggest roughly 1,500 benthic species may occur in Passamaquoddy – West Isles – Cobscook area (Larsen 2004). The ledges, rock walls, boulders and cobble found around the many islands (Casco and Simpson) provide habitat for a vast array of marine life (Lawton 1992, 1993), including interesting and diverse benthic faunal assemblages/aggregations (Thomas 1983) with higher species diversity than in adjacent areas. Species diversity surveys indicated that some of the areas within HH/WI (Adams, Simpson, Sandy, Spruce, Tinker, and Black Rock, within Head Harbour, and off Deer Island Point) generally have the highest levels of diversity of benthic macro-invertebrates in the Bay of Fundy (MacKay et al. 1978c; PC/TNB 1985).

There are increased numbers of species that may be considered ESS, such as upright and massive sponges, that significantly correlate to structural features (vertical rock slope, boulders, rock walls) (Thomas 1983; Ginn et al. 2000). A series of in situ and remote video transects located sponges in several locations among the islands and ledges (e.g. Simpson, Mowatt, Sandy, Spruce, Casco) (MacKay et al. 1978c; Owen 2008). Locations of sponges were mapped by Singh (2011).

Boulders support brachiopod communities (*Terebratulina septentrionalis*), and the tunicates (*Halocynthia pyriformis* and *Boltenia ovifera*) (ESS) are abundant. The soft coral *Gersemia* is abundant at shallow depths along the length of the wall (Logan et al. 1984). Nubble Island exhibits an *Edwardsia elegans-Corymorpha-Coryphella* community found in shallow waters (MacKay et al. 1978c; M-I. Buzeta and M. Strong, unpublished dive log, 2001). Casco, Spruce, and White Islands, with steeply inclined rock faces and boulders, are subject to high tidal ranges flowing through the constricted passages, conditions that result in a very diverse and abundant community of sessile organisms. The deeper zones studied (18 m) showed the greatest species richness, including sponges, hydroids, anemones, brachiopods, and tunicates (Logan et al. 1984). Simpson Island Cove is rich in benthic finfish, including small aggregations of winter flounder (*Pseudopleuronectes americanus*), juvenile cod, juvenile and ripe redfish (*Sebastes fasciatus kellyi*), and spawning and spent lumpfish and their egg masses. Aggregations of juvenile groundfish species (cod, redfish) are seen among many of the island's (Mowatt, Sandy, Casco, Simpson) rock walls and caves (M. Strong and M-I. Buzeta, unpublished video dive log, 2001). Sandy Island exhibits both physical and biological diversity. For example, a variety of substrate types, different slopes, and a range of current velocities have been observed along with many species, including a rarely seen burrowing cucumber *Sclerodactyla* spp., the soft coral *Gersemia rubiformis,* stalked tunicates and massive sponges (ESS) (Logan and Noble 1971; Logan et al. 1984; Noble et al. 1976).

There is a gradient in hydrographic conditions from estuarine to oceanic from St. Croix Estuary out to the middle of the bay, with the West Isles area having a more stable temperature and salinity regime, which is significantly correlated with higher number of benthic species (Buzeta

2008). Species richness is lower closer to shore where estuarine conditions prevail (e.g. St. Croix Estuary and Passamaquoddy Bay), while diversity is highest at HH/WI (Buzeta 2008).

Additionally, the availability of hard substrate, along with complex bottom topography, estimated from multibeam data (J. Hughes-Clarke, University of New Brunswick, Ocean Mapping Group, pers. com.), provides habitat for more sessile invertebrates. Thus, the high level of benthic species diversity is also a result of availability of substrate, higher complexity, and the distribution of this substrate within a matrix of soft sediments (Hubbell 2001). Both topographic complexity, and species richness estimated from abundance data along benthic transects (MacKay et al. 1978a-c; 1979a-c), were higher in this region than in adjacent regions (Buzeta and Singh 2008), with a strong relationship between the two (r^2= 0.86) (Greenlaw et al. 2007a, b).

4.9.3 Fitness Consequences

The area is considered one of the principal areas for enhancement of Fundy waters as they pass from Saint John to the West Isles, and an area where zooplankton depletion or enrichment occurs (Hunter and Associates 1982). Western, Letete, and Head Harbour Passages support aggregations of zooplankton, especially euphausiids, and schools of herring and squid (AECOM Canada Ltd. 2011). Due to the turbulent waters, shears, tidal rips, and upwellings, the area is rich in food sources. In the Letete Passages, there is a huge amount of water passing through, providing opportunities for larval settlement and perhaps, more importantly, the provision of a food supply for filter feeders (Thomas, unpublished presentation, 2001). Current velocities are high enough in Little Letete to keep out a large population of sea urchins, and in the absence of their grazing, there is much better development of small attached organisms on the rock surface.

The HH/WI area appears to be an important habitat for several cetacean species, including the endangered North Atlantic right whale (Buzeta and Singh 2008). There are also records of humpback, finback, and harbour porpoise mother and calves in this area (Buzeta and Singh 2008). White Island and the area close to the tip of Campobello Island seem to be important feeding areas for fin whales (Gaskin and Smith 1979). Significant numbers of female harbour porpoise (ESS) and calves occur in the Simpson Island area (Smith et al.1984), and the HH/WI area appears to be the centre of the harbour porpoise feeding and aggregation area (SENES Consultants Ltd. 2006). Harbour porpoises must remain close to food resources and consume prey frequently to meet the energetic demands for maintenance, growth, and reproduction (Johnston et al. 2005a). As a result, they choose regions that exhibit predictable, tidally induced, fine-scale oceanographic features that are clearly detectable with remote sensing techniques, such as the Head Harbour headland wake off the northern tip of Campobello (Johnston et al. 2005a).

The waters and islands of HH/WI are of major Canadian significance (Environmentally Significant Area (ESA)) because of high concentrations of migrating, feeding, and breeding birds (e.g. phalaropes, ducks, shorebirds) (Hunter and Associates 1982). This area attracts large numbers of Bonaparte's gulls, and has been known to support over 50% of the Canadian population of red-necked phalaropes (Lotze and Milewski 2002), and possibly host the entire breeding population of eastern Canada, Greenland and Iceland (Duncan 1996).They are attracted here between July and September, by upwelled plankton, the euphausiid *Thyanoessa*, and the copepod *Calanus finmarchicus* (ESS). Red-necked phalarope abundance has been severely reduced since 1990 (PC/TNB 1985; Diamond, unpublished presentation, 2001; K. Davidson, Canadian Wildlife Service, pers. com., 2001; Brown et al. 2010; Brown and Gaskin 1988, 1989). Up to two million of this species, perhaps most of the North American breeding population, formerly congregated in this region during fall migration, but the species almost entirely disappeared from this staging area in the late 1980s for unknown reasons (Brown et al.

2010). Recently, small flocks of 6-10 phalaropes have been recorded in the Quoddy Region by tour operators and local biologists (M. Strong, pers. com., 2011).

The intertidal zones with high biomass of rockweed species (ESS), and associated crustaceans, gastropods, and juvenile fish, are important to marine birds (e.g. eiders, loons, great blue herons, belted kingfishers, sandpipers, plovers) (Christie 1983). Several of the small islands, such as Sandy Island, are important nesting sites for the common eider and Tinker Island is important for the cormorant (*Phalacrocorax auritus*) (Buzeta et al. 2003a). Western Passage and Letete Passage are used during the fall migration of Bonaparte's gulls and Arctic and common terns (Diamond, unpublished presentation, 2001).

The large sponge species found in this area, such as *Melonanchora elliptica* (ESS), adds to the habitat complexity and provides refuge for lobster, crabs, juvenile cod and cunner (*Tautogolabrus adspersus*). Sponge reefs can form bioherms and observations suggest that they provide refuge for shrimp and small fish, and therefore fitness consequences are associated with their presence (Conway 1999, Stocker and Pringle 2000). A large number of stalked ascidians (*Boltenia ovifera*) are found at Mowatt Island (Hatfield et al. 1992), Sandy, and Casco, providing refuge for several species of juvenile fish (cod, pollock), and cunner. Spot dives verified large numbers of juvenile cod found amongst the refuge provided by the complex rocky habitat, and the attached stalked ascidians and sponges (M. Strong and M-I. Buzeta, unpublished video and dive log, 1999-2001).

Berried lobsters are present during the summer months and they are widely dispersed among the rock wall, ledge, and boulder habitats fringing the islands (Lawton 1992, 1993). The presence of juvenile and ripe redfish, spawning and spent lumpfish and their egg masses, at Simpson, Mowatt, Sandy, and Casco islands, is known locally and was verified during spot dives (M. Strong and M-I. Buzeta, unpublished video and dive log, 1999-2001). Spawning of lumpfish is known to occur in shallow water on rocky substrates (Daborn and Gregory 1983), and the males guard the egg mass for 6-8 weeks. Their presence makes these areas critical habitat, contributing to the fitness of the local and overall populations. Coastal areas in the lower Bay of Fundy support the life cycles of many fish species (MacDonald et al. 1984); however, many spawning areas have been lost. Local knowledge, surveys, and video observations, suggest that the HH/WI may contribute to the life cycle of a high number of species.

Juvenile cod have been reported in Passamaquoddy Bay, and captured in beach seines (MacDonald et al. 1984) and video images were confirmed as juvenile cod near Simpson, Casco, and Mowatt islands (M. Strong and M-I. Buzeta, unpublished video and dive log, 1999-2001). Local knowledge, as well as video observations, suggest that in the coastal areas of the Quoddy Region, specifically the hardbottom habitat found in the West Isles area, large numbers of juvenile cod are associated with the species complex areas where the tunicate *Boltemia ovifera* is found, and where cunner are also found (M-I. Buzeta, unpublished video log, 2001).

Spawning lumpfish have been observed and photographed in the West Isles and The Wolves Islands and Atlantic wolffish (SAR) have also been observed in several locations among the ledges and islands. Research surveys do not include shallow coastal areas, however, several dens, with adult pairs, are routinely observed by local divers and biologists (M. Strong and M-I. Buzeta, unpublished video and dive log, 1999-2001). These pairs are known to persist in these locations for years. Sexually mature fish are thought to move inshore to shallow waters to spawn, but adult Atlantic wolffish are relatively sedentary and may remain at these sites (O'Dea and Haedrich 2002).

4.9.4 Naturalness

The HH/WI area has been described as pristine and natural (CCNB 2004; MacKay 2007); however, the Quoddy Area as a whole was assessed as the least natural (most highly impacted) area of the five areas identified as PRMAs (AECOM Canada Ltd. 2011). There are a

large number of marine activities in the area, including fishing, rockweed harvesting, and aquaculture. The aquaculture industry is expected to grow and there is concern that this activity has degraded estuarine embayments (AECOM Canada Ltd. 2011), and exposed biota to harmful chemicals (e.g. cypermethrin-based pesticides) (French 2011). Scallop dragging used to occur mostly in the deeper, soft sediments, which allowed the nearshore, shallow habitats to retain their ecological integrity. In 1999, the sea cucumber fishery began (Voutier at al. 2006) and has expanded into shallow rocky areas high with benthic biodiversity.

Concerns related to loss of naturalness include siltation, eutrophication, and degradation of habitat. Impacts from nearby activities threaten the ecological integrity of the highly biodiverse benthic communities (Buzeta et al. 2003a). Observations from decades of field courses in this area depict the decline of several hard-bottom species (M. Owen, University of Western Ontario, pers. com., 2011). Where some species of gastropods were once common (e.g. *Neptunia, Colus*), few or none have been obtained in recent collection efforts. The hermit crab (*Pagurus*) was commonly collected with little effort but, more recently, only three Acadian hermit crabs (*Pagurus acadianus*) were observed and no hermit crabs of the *Pagurus pubescens* species were observed (M. Owen, pers. com., 2011). Large horse mussels, which were themselves a substratum for attached hydrozoans, bryozoans, and barnacles (*Balanus*), used to be easily collected. In 2011, drags around Greens Point, and the ledges adjacent to Whitehorse Island, did not yield a single horse mussel. Large sponges have virtually disappeared from these collections, as have plumose anenomes (*Metridium*) and other anenomes (*Urticina*). Their absence can be interpreted as an indicator of repeated disturbance of the benthic substrata by drag fisheries, as they remain reasonably common in vertical rockwalls (M. Owen, pers. com., 2011).

4.9.5 Resilience/Sensitivity

Mobile bottom-contacting fishing gear can alter or damage physical features of the seafloor, as well as benthic populations and communities, through sediment redistribution and removal of epifauna, thus reducing overall complexity (Auster et al. 1996). Sea cucumbers and slow-growing, vulnerable, long-lived epifauna, such as sponges and other filter feeders, prefer hard rocky substrates with high to moderate currents. They usually co-occur in the same areas, and are part of a highly complex and diverse assemblage of species (Singh, unpublished report, 2011). The relative lack of mobility of these organisms makes them more likely to be affected by human activities. Organisms involved in benthic-pelagic coupling provide a link for contamination of higher trophic levels (Smith et al. 1988).

4.9.6 Management Considerations

From a management perspective, it is more ecologically appropriate and practical to identify the HH/WI and Passages as a whole because of the number of interconnected sites exhibiting EBSA attributes. These attributes include: species aggregations (invertebrate, avian, marine mammal) and persistent environmental (temperature and salinity) ranges, and oceanographic (upwellings, currents, benthic complexity) features aggregated in a small area; uniqueness of species assemblages, and of environmental features (range of temperature and salinity, geomorphology, benthic complexity) that provide the mechanism for species aggregations (Buzeta 2008).

The Passamaquoddy-Scoodic Tribe reflected on the spiritual importance and cultural significance of this area, and has expressed an interest in protection measures. Prior to European settlement, this area was frequented by the Passamaquoddy Tribe for hunting, fishing, and ceremonial gatherings (Akagi 2001).

The community in Head Harbour Passage is animal-dominated and in its deeper sections, often shows three-dimensional bottom relief from horse mussel shells, and associations that suggest it minimizes the possibility of dislodgement by other species (Hatfield et al. 1992). Horse

mussels have been found to be sensitive to bottom fishing disturbance. Studies found they were always absent from disturbed areas, but present in undisturbed sites (Collie et al. 1997, 2000).

The HH/WI and The Passages have long been recognized as unique and significant, and in many cases this includes recognition as a priority for protection. It has been identified as a Natural Area of Canadian Significance, and proposed as a National Marine Park (PC/TNB 1985), where specific mention was made of developing underwater trails (Casco, Spruce) due to the high benthic biodiversity. It is documented as an ESA, and an important avifauna area (PC/TNB 1985; Diamond, unpublished presentation, 2001; K. Davidson, pers. com., 2001). On the basis of its oceanography, the tremendous volume of water that passes through the area, and the diverse and abundant benthic biota, local experts have called for protection of the area (Logan, unpublished presentation, 2001[14]). It was identified as one of the highest priority areas for protection in the Bay of Fundy because of its high diversity of benthic fauna (MCBI 1999). HH/WI and The Passages were proposed as an Ecological Reserve for the Province of New Brunswick, based on a very high diversity and abundance of marine invertebrates, fish, birds and mammals (Hunter and Associates 1982). An MPA discussion group (Chopin and Wells 2001) concluded that there is sufficient information out there for “some” areas to be protected; specifically mentioned was Head Harbour, because of the marine mammal aggregations and migration paths for many species of seabirds (Gaskin and Smith 1979). The area was suggested for a pilot study on Integrated Marine Planning by an interdisciplinary discussion group, for its diversity of habitats and marine activities (a biological hotspot), sufficient capacity, and potential for Canada-USA transboundary collaborations (Buzeta et al. 2003b). Protection of this area, known as a stop-over for migratory red-necked phalaropes, is considered a requirement for their dwindling populations (Brown et al. 2010). A petition sponsored by St. Croix Estuary Project was issued for DFO to *Declare Head Harbour Passage and West Isles an Emergency Marine Protected Area*, on the premise that it would prevent unsuitable development until a proper management plan could be established, that would protect this unique and vital habitat (French 2007). The Passages display the finest biodiversity for benthic organisms in the Bay of Fundy, and are recommended for protection as a marine sanctuary, with no fishing of any kind, no moorings, and no shoreline development (Thomas, unpublished presentation, 2001).

This area, along with the northern end of Grand Manan and the waters between the two, including The Wolves, are considered to have both representative features, as well as special features, because of the combination of high benthic diversity and areas for pelagic feeding for birds and marine mammals (AECOM Canada Ltd. 2011).

Recommendations included the establishment of coastal management areas, MPAs, or biosphere sites (Buzeta et al. 2003a). Impacts from nearby activities threaten the ecological integrity of the highly biodiverse benthic communities found in HH/WI. Relatively un-impacted areas (e.g. West Isles), as opposed to those heavily utilized by marine industries (e.g. Letang Inlet), should be considered for protection (Brilliant 2001).

There is concern that the sea cucumber fishery occurs almost exclusively in Letete Passage, an area of structurally complex benthic habitats, with long-lived upright epifauna (sponges, anemones) (Thomas 1994; Ginn 1997; Ginn et al. 2000) that are more sensitive to fishing disturbance. Until recently, dragging occurred mostly in the deeper, soft sediments for scallops, but sea cucumber dragging has focused efforts in The Passages (Voutier et al. 2006). Although other areas were explored and fished since 1999, 90% of fishing effort has been in The Passages (mostly Letete Passage) (Rowe et al. 2009). Mobile bottom-contacting fishing gear can alter or damage physical features of the seafloor, as well as benthic populations and

[14] Oral presentation by A. Logan at the Sensitive Marine Areas Workshop, January 17, 2001.

communities (DFO 2006b). Sea cucumbers prefer hard rocky substrates with high to moderate currents and sponges and other filter feeders usually co-occur in the same areas (Singh, unpublished report, 2011). Given the high biological and ecological significance of The Passages, and the lack of information to determine the impact of the sea cucumber fishery on the benthos, the recommended action has been to err on the side of caution, and to recommend limiting the sea cucumber fishing zones (Rowe et al. 2009).

The HH/WI area is the anchor for the Biodiversity Discovery Corridor (CMB 2007), an initiative that serves as focal points for collaborative scientific studies. The goals are to compile an inventory of marine species, to develop an understanding of conservation of marine biodiversity, and to be a reference point for monitoring change. Additionally, nearshore, sessile, benthic communities are good indicators of disturbance as their relative lack of mobility makes them more likely to be affected by human activities, and organisms involved in benthic-pelagic coupling provide a link for contamination of higher trophic levels (Smith et al. 1988). As such, the reefs and ledges around the West Isles still exhibit this quality and are useful monitoring and baseline study areas, if left unperturbed.

The spread of fishing effort to areas previously avoided in HH/WI reduces refugia for species vulnerable to disturbance, including juvenile cod and other species. Bottom trawling is likely detrimental to the Atlantic wolffish, listed as a species of Special Concern under the *Species at Risk Act* (2002), as it destroys or disrupts fish habitat. There is concern that these areas had not previously seen much inshore dragging activity, but are now being threatened with developing fisheries (Bosien 2001). Analyses of the sea cucumber fishery data confirms this dragging effort overlaps with areas identified for their biodiversity, complex habitats, and presence of ESS (e.g. sponges) (Voutier et al. 2006; M. Strong, pers. com., 2011).

There is a preponderance of supporting evidence that this area is ecologically significant and potentially sensitive to many ongoing, and new marine activities, and large-scale industrial development. Head Harbour Passage, near Casco Island, has been selected for development of in-stream tidal energy in New Brunswick (EPRI 2006a). Although, based on biological parameters (biodiversity and abundance, SAR), it was found to be one of the least suitable sites for such industrial development, due to high species diversity and abundance, and therefore not recommended for in-stream tidal energy development (HMSC 2008).

The underlying significance of this area to the fishing and tourism industries relates directly to the EBSA criteria of aggregations (i.e. benthic species richness, aggregations of seabirds, fish, seals, porpoise and whales). The rich and diverse assemblages of seabirds, marine mammals, and benthic invertebrates, have led to the development of the ecotourism industry that includes kayaking, SCUBA diving, fishing, and marine mammal and bird watching.

A panel of experts (Buzeta and Singh 2008) suggested that if EBSAs are to succeed as a management tool in nearshore areas, management approaches should be developed and tested in the HH/WI area, where there is substantial information available, far more than for other areas.

Concerns related to nearby activities that increase levels of siltation, eutrophication, and degradation threaten the ecological integrity of the highly biodiverse benthic communities (Buzeta et al. 2003a). Nearby activities expose biota to harmful chemicals (e.g. cypermethrin-based pesticides) that target sea lice (French 2011). Other naturally occurring crustaceans (e.g. larval and juvenile lobsters, krill), and a myriad of food items for fish, birds, and marine mammals, are also sensitive to these chemicals.

There is substantial information and recommendations in the literature to identify HH/WI and The Passages as an EBSA (Figure 1, number 9), including evidence of high benthic biodiversity; aggregations of zooplankton, fish, birds, and marine mammals, and juvenile fish; and the fitness consequences associated with juvenile and rearing stages of fish, avian, and

marine mammal species. Several SAR (harbour porpoise, North Atlantic right whale, Atlantic wolffish) and ESS (sponges, rockweed, krill) also impart a high importance to this area, as well as the persistent structural, environmental, and oceanographic features, that support this complex food web.

4.10. THE WOLVES AND WHITE HORSE ISLAND

The area between the northern end of Grand Manan and The Wolves and White Horse Island area is considered to be ecologically significant, representative, and unique, due to the diversity of benthic fauna and aggregations of marine birds and mammals (AECOM Canada Ltd. 2011).

4.10.1 Uniqueness

Two areas with possibly current-generated sedimentary bedforms have been identified to the northwest and southeast of The Wolves (B.J. Todd, Natural Resources Canada, pers. com., 2013). These spatially complex seabed features were initially thought to be horse mussel reefs based on the interpretation of multibeam sonar imagery (V.E. Kostylev et al., unpublished report, 2009[15]). In northeast Bay of Fundy, mussel reefs are long, linear structures, up to 4 m high and 1000 m in length (Wildish et al., 1998; V.E. Kostylev et al., unpublished report, 2009). The depth at which they occur suggests that they have been present for about 9,000 years (S. Robinson, DFO, pers. com., 2012).

4.10.2 Aggregation

The Wolves area supports a diverse community of organisms, including sessile sponges, hydroids and bryozoans, due in part to the combination of strong currents and hard substrate in the area (MacKay et al. 1979b).

The shallow water immediately inshore of the islands is used for feeding and staging by harlequins in winter and eiders in summer (Diamond, unpublished presentation, 2001). Significant densities of pelagic seabirds have been observed during aerial surveys of the Bay of Fundy northeast of Grand Manan, to The Wolves and White Horse, including gannets, phalaropes, and fulmars (*Fulmaris* sp.) (K. Allard, pers. com., 2012). Auks departing Old Proprietor Shoals and Long Eddy use the shelf edge as a corridor and disperse widely, including around The Wolves Islands (Huettmann et al. 2005).

4.10.3 Fitness Consequences

The Wolves, and generally the outer Quoddy area including the numerous small islands, are important staging areas for seaducks and support 2,500 pairs of breeding common eiders (Brylinsky et al. 1997; Hicklin and Smith 1984). The Wolves are identified as an important wintering ground for the endangered harlequin duck (Lotze and Milewski 2002). White Horse Island is an important nesting area for black guillemots, a large colony of double-crested cormorants (*Phalacrocorax auritus*) and razorbills (Mawhinney and Sears 1996). The area has possibly supported the re-establishment of the northern gannet (Corrigan and Diamond 2001) (although the chick disappeared before fledging) and it has a newly re-established (1992) breeding colony of black-legged kittiwakes (Kehoe and Diamond 2001). There are sightings of over a dozen mature and immature Atlantic puffins, and a nesting pair of puffins. Sightings of parasitic jaegers (*Stercorarius parasiticus*) were also photo-confirmed. The island itself, and the

[15] Unpublished report by V. Kostylev, C. Dickson, and R. Parrott, “Mapping of Horse mussel (*Modiolus modiolus* L.) reefs on Multibeam Imagery from the Bay of Fundy”, produced in 2009 under the interdepartmental agreement between the Oceans and Coastal Management Division, Oceans, Habitat and Species at Risk Branch of the Department of Fisheries and Oceans and the Geological Survey of Canada Atlantic of Natural Resources Canada.

surrounding waters, are critical as nesting and feeding habitat (Corrigan and Diamond 2001; Kehoe and Diamond 2001; Diamond, unpublished presentation, 2001).

There are nearby records of haddock spawning, and cod and lobster nursery areas (Coon 1998). There is also a record of lumpfish spawning in the shallow waters of South Wolf Island (M-I. Buzeta, unpublished dive log, 2002). Spawning occurs in shallow water on rocky substrates, and males guard the nests for 6-8 weeks until the young hatch, while females presumably swim out into deeper water (Daborn and Gregory 1983). The linear seabed features initially thought to be mussel bioherms present an intricate biophysical relationship between current flows, substrate, and biological processes, creating a mechanism for benthic-pelagic coupling (Wildish et al. 1998), and increasing habitat availability, refuge, and biodiversity (Witman 1985; AECOM Canada Ltd. 2011; S. Robinson, pers. com., 2012).

The waters between Head Harbour Passage and The Wolves are a feeding area for fin, minke, humpback, and occasionally North Atlantic right whales (SENES Consultants Ltd. 2006). The Wolves and surrounding areas are very important to basking sharks (S. Turnbull, Executive Director, Canadian Shark Conservation Society, pers. com., 2012). Other shark species are more mobile but research suggests that the outer Quoddy Region seems to be very important for porbeagle sharks (*Lamna nasus*), which are listed as Endangered by COSEWIC (2009a). High concentrations of these sharks are found in The Passages and The Wolves, although they can also be found elsewhere in the Bay. Sharks are likely following the same routes as the whales, entering into the Bay to feed and remaining for at least a month. There is a much higher percentage of large female sharks, and while some may be pregnant, they are present in this area strictly to feed and then move down to the mating grounds. Juvenile sand tiger sharks (*Carcharias taurus*) are often caught within The Passages area, and the white shark, which is listed as Endangered under the *Species at Risk Act*, seems to be sighted in areas frequented by harbour porpoise and seals (S. Turnbull, pers. com., 2012).

4.10.4 Naturalness

The Wolves are unspoiled areas, providing shelter to the endangered harlequin ducks (NTNB 2012). A significant bed of the kelp *Laminaria* is found, due to the increased photic zone.

4.10.5 Resilience/Sensitivity

The diverse benthic communities near The Wolves, which include sessile sponges, hydroids and bryozoans (MacKay et al. 1979b) can be sensitive to disturbance (Collie et al. 1997, 2000). The linear seabed features in this area may support distinct communities that are sensitive to disturbance but further research is needed to describe these features.

4.10.6 Management Considerations

White Horse Island is recommended for protected status based on its importance to migratory birds (Diamond 2011). Southern Wolf Island is a place of international significance through several designations, including as an IBA (IBA Canada 2012), with major breeding areas of common eiders and harlequin ducks.

This area (Figure 1, number 10) potentially satisfies the EBSA criteria of Uniqueness and Resilience/Sensitivity because of the distinct seabed features in the area (originally thought to be horse mussel reefs). The area also meets the Aggregation and Fitness Consequences EBSA criteria, based on its importance as a wintering area for the endangered harlequin duck (SAR) and several seabirds. It is also a known spawning area for several fish species, an important feeding area for basking sharks, and an area of benthic species aggregation (high species richness). Finally, The Wolves area is considered to have a high degree of naturalness.

4.11. MACES BAY

4.11.1 Aggregation

Maces Bay, like other areas in the Quoddy Region, is considered important habitat, for many species (Lotze and Milewski 2002). King eiders (*Somateria spectabilis*) are rarely seen in the Bay of Fundy but have been recorded in Maces Bay (Brylinsky et al. 1997). The ledges in Maces Bay also provide ideal haulout locations for seals (Buzeta et al. 2003a).

There is some evidence to suggest that berried female lobsters may aggregate along the eastern side of the French Ledges, the southwestern side of Mole Island, and on the north side of Mole Island. Depressions found in the sand were interpreted by experienced biologists to be those created by berried females, and several berried lobsters were also encountered during survey dives off the exposed areas of the Brothers Islands, and around Point Lepreau, suggesting some significance as a lobster nursery area (Lawton 1992, 1993). Additionally, anecdotal observations by research divers suggested that densities of small juvenile lobsters were very high (Lawton 1992; P. Lawton, pers. com., 2001).

4.11.2 Fitness Consequences

Maces Bay is identified as Regionally Significant because of its importance to feeding and breeding sea ducks, brant (*Branta bernicla*), shorebirds, gulls, terns and cormorants (Hunter and Associates 1982). The area has been designated an IBA because tens of thousands of seaducks, including common eider and black scoter (*Melanitta nigra*), migrate through it. This is considered a good area for inshore marine birds, as the rocky tidepools attract migrant shore birds in late summer, purple sandpipers and brant in spring. Areas along the coast of Point Lepreau west to Red Head, including Salkeld Islands in Maces Bay and New River Island in Pocologan Harbour are considered important to nesting colonies of common eiders and are important brood-rearing habitats (i.e. rockweed along mainland shore) (Diamond, unpublished presentation, 2001).

Within Maces Bay, Pocologan Island and French Ledges showed high juvenile lobster densities. In particular, the Pocologan Island-French Ledges contains significant numbers of juvenile lobsters. Relative abundance of lobsters in the Barnaby Head-Lepreau Harbour area indicates that it is prime lobster nursery habitat (Lawton 1992, 1993). High scallop spat densities were also observed in the areas around Brothers Island and off Barnaby Head (Lawton 1992, 1993). Productivity in this area, as related to the abundance of benthic invertebrates, is recorded to be lower than that of the West Isles or The Wolves (MacKay et al. 1979c).

4.11.3 Resilience/Sensitivity

Avian prey items such as small arthropods, and lobster life cycle stages are sensitive to chemicals used in the aquaculture industry to manage sea lice infestations (Burridge et al. 2005).

4.11.4 Management Considerations

Activity approvals for this area should consider the impact on the ecological functions related to avian and lobster life cycle requirements. The area had been recommended as an aquaculture exclusion zone due to its importance to lobster (Lawton, unpublished report, 2000[16]).

Important research/monitoring sites for diversity of seaweeds are located in Maces Bay and Lepreau Harbour (Chopin et al. 2001). There are concerns that these areas are threatened with siltation and eutrophication. Management recommendations specific to these seaweed study

[16] Unpublished report by P. Lawton, “Sensitive areas from a lobster production perspective in the Fundy Isles Region of the Bay of Fundy” (2000).

areas include establishment of a network of areas with enhanced management or protection that diminish the risk of anthropogenic impacts on long-term studies (Bates et al*.,* unpublished presentation, *2*001[17]).

This area (Figure 1, number 11) fits the EBSA criteria of Fitness Consequences (e.g. seabirds, lobsters) and Aggregation (e.g. seals), with information for the most part restricted to avian and lobster requirements generally found in other areas evaluated. It is recommended that further surveys or spot observations be made to confirm reports of berried female lobsters before evaluation as an EBSA.

4.12. MUSQUASH ESTUARY

Musquash Harbour, the salt marshes, the head of the harbour, Musquash Head, and Gooseberry Island have received much scientific attention; several ecological summaries are available (MacKay 1975; Thomas 1983; Singh et al. 2000; Singh and Buzeta 2007).

4.12.1 Uniqueness

The area is described as one of the last ecologically intact estuaries in the Bay of Fundy (CCNB 2004; Platt 1998). It has been suggested as an ecological reserve because of its significance as a characteristic example of a salt marsh ecosystem along the coast (Wein and Jones 1975). It was also identified it as a Regionally Significant area (Hunter and Associates 1982). The Musquash marsh is classified as a Class I salt marsh which means it is deemed to be large with a known or assumed high value to wildlife and represents the highest priority for protection and management (Roberts 1993).

4.12.2 Aggregation

The shoreline classification between Point Lepreau and Saint John Harbour describes eight sections of shoreline that have marshes; some of the largest marshes are found at Musquash (CCRM 1999). MacKay (1975) recorded the number of species in the Musquash area, and determined that the areas of high abundance ratings were to be found at the entrance to Musquash Harbour.

4.12.3 Fitness Consequences

Musquash has been identified as a Regionally Significant area (Hunter and Associates 1982), and has been classified as a Class I salt marsh, with known or assumed high value to wildlife (Roberts 1993). Thirty-five benthic species were reported on the intertidal mudflats of the Hepburn Basin area, with the amphipods *Corophium volutator* and *Gammarus lawrencianus* being the dominant species on which the abundant waterfowl feed upon (Gratto 1986).

4.12.4 Naturalness

Musquash has been identified as a significant area and has been used for research and teaching. It is considered a remarkable example of an estuary and salt marsh system because it has not been adversely impacted. There is no single species of importance. Musquash Head is an example of a typical rocky headland community. The ecology of the area is complex and the whole area is worthy of protection (Thomas, unpublished presentation, 2001).

4.12.5 Management Considerations

Musquash (Figure 1, number 12) meets the EBSA requirements primarily on the basis of its naturalness, and its high value to wildlife and aggregations of waterfowl. The Musquash Estuary

[17] Presentation by C. Bates, T. Chopin, and G. Saunders, “Conservation in the Bay of Fundy: A macroalgal perspective”, at the Sensitive Marine Areas Workshop, January 17, 2001.

was officially established as an MPA under the *Oceans Act* on December 14, 2006. Boundaries for the MPA include all the marine areas inside a line drawn from Musquash Head through the southern tip of Gooseberry Island and extending to the coastline at the western tip of Gooseberry Cove. The estimated total area of the MPA is 11.4 km^2. The Musquash Estuary Management Plan for the Marine Protected Area and Administered Intertidal Area outlines the management vision, conservation objectives and priorities for the protection of this marine ecosystem (DFO 2008).

Class I marshes are large with a known or assumed high value to wildlife and represent the highest priority for protection and management (Roberts 1993). Because of their significance and for their value as waterfowl habitat, marshlands around Musquash have been acquired by Eastern Habitat Joint Venture and the Nature Conservancy of Canada to achieve their protection (Richard, unpublished presentation, 2001[18]; Maillet, unpublished presentation, 2001[19]).

4.13. MARY'S POINT, GRINDSTONE ISLAND, AND CHIGNECTO BAY

4.13.1 Aggregation

The defining physical features of this area are the extensive intertidal mudflats and marshes, which support an extremely high invertebrate biomass (namely the amphipod, *Corophium volutator*), that provide food for large aggregations of migrating shorebirds (Majka, unpublished presentation, 2001[20]; Hicklin 1987) including semipalmated sandpipers (Hicklin, unpublished presentation, 2001[21]) and purple sandpipers (Allard et al. 2014). The high productivity of intertidal mudflats is fuelled by benthic diatoms and adjacent salt marshes (AECOM Canada Ltd. 2011).

4.13.2 Fitness Consequences

The area includes critical/significant habitats, such as the extensive intertidal mudflats and tidal marshes that harbor a variety of invertebrates which are the source of food for migrating shorebirds (Majka 2001). The upper Bay of Fundy is probably the most IBA in eastern North America for migrating shorebirds (Hunter and Associates 1982). Mary's Point is considered the most important migration site for semipalmated sandpipers in eastern North America (Hicklin 2001). It is also important for purple sandpipers (Allard et al. 2014). Grindstone Island is recognized as having ecological significance because of its large colony of great blue herons, and as a breeding area for the double-crested cormorant, common eider, great black-backed gull, and herring gull (Majka 2001; Davidson, unpublished presentation, 2001[22]).

The upper Bay of Fundy is probably the most important area in eastern North America for migrating shorebirds (Hunter and Associates 1982). It is of critical importance to the world population of semipalmated sandpipers (*Calidris pusilla*), the most abundant species present (800,000-1.3 mil., Hicklin 1987). The extensive mudflat system in the upper Bay of Fundy harbours huge populations of the amphipod *Corophium volutator* (ESS) on which the sandpipers feed to build fat stores needed for their direct flight to South America (Hicklin 1987; Sabine 2010). Large lobsters migrate into Chignecto Bay in the summer months to molt, extrude new eggs or release larvae, and it may be an important spawning area (Campbell 1986).

[18] Oral presentation by S. Richard at the Sensitive Marine Areas Workshop, February 16, 2001.
[19] Oral presentation by J. Maillet at the Sensitive Marine Areas Workshop, February 16, 2001.
[20] Written presentation by M. Majka at the Sensitive Marine Areas Workshop, February 16, 2001.
[21] Oral presentation by P. Hicklin at the Sensitive Marine Areas Workshop, February 16, 2001.
[22] Oral presentation by K. Davidson at the Sensitive Marine Areas Workshop, February 16, 2001.

4.13.3 Naturalness

Anthropogenic activities (e.g. agriculture, aquaculture) along/within embayments result in higher nutrient concentrations. Keizer and Gordon (1985) found there is a net influx of nitrogen and silicate into Cumberland Basin from Chignecto Bay during the early summer, which stimulates growth of benthic diatoms and marsh plants, but for the rest of the year there is a net export (AECOM Canada Ltd. 2011).

4.13.4 Management Considerations

Mary's Point (Figure 1, number 13) is considered an EBSA on the basis of the extensive intertidal mudflats and tidal marshes that harbour large numbers of invertebrates which are the source of food for large aggregations of migrating shorebirds, and the fitness consequences associated with preparing for this migration.

The area is a Ramsar Site and a Western Hemisphere Shorebird Reserve but these designations do not infer any legal obligation for protection. However, a portion of the area falls within the Shepody National Wildlife Area. It was also proposed as an Ecological Reserve (Hunter and Associates 1982). It is recommended that the area have some form of permanent protection against environmental impacts from activities that include the extraction of bait worms, recreational mud sliding, alteration of marshes, siltation of ledges by nearby dredging, and lumbering of the shorefront (Majka 2001). Shepody Bay is one of the key focus areas for Eastern Habitat Joint Venture land acquisitions, to ensure the protection of salt marshland (Richard 2001).

Chignecto Bay was identified as an area of Regional Significance to dabbling ducks, sea ducks, shorebirds and mergansers (Hunter and Associates 1982), and Shepody Bay West is an IBA (IBA Canada 2012). Chignecto Bay is a Western Hemisphere Shorebird Reserve, and includes the Chignecto National Wildlife area. These biologically rich mudflats are considered to require legislated protection, as they are critical as a foraging/roosting area for the world population of the semipalmated sandpiper during their southward migration. Further, there is a recommendation to declare the intertidal zone of the Bay of Fundy as a conservation area protected by the federal and provincial governments (Hicklin 2001). Significant areas identified by Majka (2001) and Davidson (2001) include New Horton, Daniels Flats and Johnson Mills. These areas are of interest to Canadian Wildlife Service for protection of shorebirds.

4.14. EVANGELINE / CAPE BLOMIDON AND MINAS BASIN

Minas Basin includes Ile Haute, Minas Channel, Advocate Bay, Greville Bay, Cape D'Or, Spencers Island, Cape Split, Scots Bay, Parsborro, Southern Bight where Evangeline Beach is located, and Cobequid Bay with the Salmon and Shubenacadie Rivers (Percy 2001). More than one third of the area is tidal mudflat, with a large number of small salt marshes scattered along the coastline.

4.14.1 Uniqueness

The mud piddock clam (SAR) is a warm water species found in Minas Basin, but nowhere else in Canada. The Atlantic Mud-piddock is the only species of Barnea in Canada and it is listed as Threatened by COSEWIC (2009a). The Canadian population is the most northerly population in the world and it is separated by over 350 km from the next nearest population. The population is likely a remnant of warm-water, postglacial, marine fauna and is of scientific interest (environmental adaptations, high improbability of genetic exchange), and could be endemic to Canada (COSEWIC 2009b).

4.14.2 Aggregation

A significant bed of the kelp (*Laminaria spp.*), dulse, and the coralline alga (*Corallina officinalis*), is found near Cape Blomidon, where the water remains relatively clear due to the strong tidal current and hard substrate (AECOM Canada Ltd. 2011). The Minas Basin mudflats harbors huge populations of the amphipod *Corophium volutator,* on which semipalmated sandpipers feed in the Fall, in preparation for their migration (Hicklin 1987; Parker and Westhead 2007; Sabine 2010; J. Paquet, Canadian Wildlife Service, pers. com., 2012). Shad, alewives and other fish feed on swarms of mysid shrimp along the muddy bottom.

The largest numbers of black ducks in the Bay of Fundy have been recorded in Minas Basin (Brylinsky et al. 1997). Boot Island National Wildlife Area is an area of significant great blue heron habitat. Shorebird density observed during aerial surveys of the Bay of Fundy recorded high densities (4,700/km^2) at Cobequid Bay, Avon River, and the marshes and mudflats from Blomidon, Evangeline Beach to Split Rock (Allard et al. 2014).

Ile Haute is the site of nesting peregrine falcons (*Falco peregrinus*) (Davidson 2001) and common eiders breed on the island (Brylinsky et al. 1997). There is little information on the marine biota surrounding the island. Scallop beds are known to surround the vicinity and echinoderms are the primary taxa (CCRM 1999). It was identified as one of the areas of highest priority for protection (MCBI 1999) and is considered a relatively undisturbed coastal island.

One-day surveys (Stewart and Lavender 2010) carried out between Parrsboro and Cape Spencer, sighted 38 marine mammals, including pods of harbour porpoise, a pod of white-sided dolphin (*Lagenorhynchus acutus*), and harbour seal (*Phoca vitulina concolor*). Overall, 395 seabirds, waterfowl and shorebirds were sighted during the survey. Most were spotted in Minas Passage and included greater shearwater, Northern gannet, red phalarope, Pacific loon (*Gavia pacifica*), and white-winged scoter (*Melanitta fusca*).

4.14.3 Fitness Consequences

Mudflats are identified as significant areas for birds. The most abundant resident infauna is the amphipod *Corophium volutator*, the clam *Macoma baltica*, and the snail *Ilyanassa obsolete* (Hicklin 2001). The mud piddock clam (SAR) is a warm water species found in Minas Basin, and this population may have been genetically isolated which means it may be a new species (COSEWIC 2009b). Mudflat diatoms contribute half of the primary production, with phytoplankton and salt marshes contributing the rest (Percy et al. 1997). Production by the amphipod *Corophium volutator*, which attracts large numbers of migrating shorebirds (Brylinsky et al. 1997), is highest at the Evangeline Beach, Southern Bight. The 1978 estimates are over 3 g Carbon/m^2 for Evangeline, as compared to 0.26 g Carbon/m² in Minas Basin and 1.6 g Carbon/m² for Shepody Bay (Peer 1984).

The upper Bay of Fundy region is important to many shorebird species during autumn migration. It is of particular importance to semipalmated sandpipers, the most abundant species present. Specific fall staging sites for semipalmated sandpipers in the upper Bay of Fundy include Minas Basin and Cobequid Bay (Hicklin 1987; J. Paquet, pers. com., 2012). Sandpipers feed on the huge populations of *Corophium volutator*, building fat stores in preparation for migration (Hicklin 1987; Brylinsky et al. 1997; Sabine 2010). Spencers Island, Cape d'Or, the shallows of Southern Bight-Minas Basin and Cobequid Bay, are considered important to black ducks, dabbling ducks, blue-winged teal (*Anas discors*), mergansers and geese, and are listed as IBAs in the Bay of Fundy (IBA Canada 2012; Parker and Westhead 2007).

Plankton tows found juvenile lumpfish at Cape Chignecto, the Minas Channel, and the Nova Scotia coast (Daborn and Gregory, 1983). Spawning occurs in shallow water on rocky substrates. Males guard the nests until the young hatch, while females presumably swim out into deeper water. Striped bass (*Morone saxatilis*) spawn in the Shubenacadie River and the

winter run of tomcod (*Microgadus tomcod*) attracts bald eagles (*Haliaeetus leucocephalus*), making this an important wintering area for this species (Hicklin and Smith 1984).

Herring spawning at Scots Bay was reported by Leim (1924), and later by Iles and Sinclair (1982) and Gordon and Dadswell (1984). There is strong evidence that the early life history of Minas Basin herring is completed within the basin (Bradford and Iles 1992), as ichthyoplankton surveys located the largest numbers of larvae in the basin near the beginning of Cobequid Bay. Large numbers of spawning herring have been documented near the entrance to Minas Basin and along the Nova Scotia shore, as well as in historical spawning sites in Minas Channel (Stephenson et al. 1999).

Spawning by flounders, herring, and mackerel, occur in Minas Basin and Scots Bay (Leim 1924; Iles and Sinclair 1982; Gordon and Dadswell 1984; Bradford and Iles 1992). Minas Basin supports spawning activities for Atlantic silverside (*Menidia menidia*) in Southern Bight (Imrie and Daborn 1981). Dogfish migrate into the Upper Bay to incubate young. The young spend the later parts of the summer and fall feeding here before leaving on their seaward migration (AECOM Canada Ltd. 2011).

4.14.4 Naturalness

Scots Bay/Southern Bight Area, to Cape Blomidon and across the Minas Channel to Parrsboro, is considered one of the least natural of the five PRMAs identified due to the level of adjacent industrial and agricultural development and current population densities (AECOM Canada Ltd. 2011). Ile Haute is considered a relatively undisturbed coastal island (MCBI 1999).

4.14.5 Management Considerations

Locations of sensitive habitats identified by aerial surveys highlighted Cobequid Bay and Minas Basin as areas with high salt marsh and mudflat densities (Allard et al. 2014). Southern Bight is a biologically rich mudflat recommended for protection (Hicklin 2001).

The locations of Nova Scotia coastal wetlands (salt marshes, coastal fresh water wetlands, coastal saline ponds) have been documented by the Nova Scotia Department of Natural Resources in the Wetlands Inventory Program (NSDNR 2013). Many of these coastal features occur in Minas Basin. The Southern Bight of Minas Basin is an IBA, a Western Hemisphere Shorebird Reserve, and a Ramsar Site (IBA Canada 2012).

Evangeline Beach has been brought to the attention of the Nature Conservancy of Canada because of its ecological significance to shorebirds (Maillet 2001) and it is identified as a Marine Natural Area of Canadian Significance by Parks Canada (PC/TNB 1985).

Concerns about the extraction of the sand layer in Scots Bay have been expressed. Concerns focused on the potential impacts on herring spawning grounds and benthic organisms, and the effects on coastal erosion and benthic sediment plumes (Percy et al. 1997). The unregulated harvesting of the baitworm *Glycera* in Minas Basin is also of concern, as it is an important prey species to black-bellied plovers (*Pluvialis squatarola*) (Shepherd 1993). There is also a tidal instream energy conversion site at Minas Basin (EPRI 2006b).

Within Minas Basin, Evangeline / Cape Blomidon (Figure 1, number 14) was determined to be an EBSA, on the basis of the large concentrations of the amphipod *Corophium volutator* (ESS), which attracts large numbers of migrating shorebirds, and the Fitness Consequences associated with building fat stores in preparation for migration.

4.15. HORSE MUSSEL REEFS NORTH OF DIGBY, OFF MARGARETSVILLE, NS

4.15.1 Uniqueness

Horse mussel reefs (ESS) that occur off the Nova Scotia coast represent a unique morphological feature in the Bay of Fundy. They were first identified in 1995 north of Digby (Wildish et al. 1998). More recently, approximately 1500 mussel beds were mapped and measured in the Bay of Fundy, with a high density found off Margaretsville (Kostylev, unpublished report, 2009). Other significant features in Annapolis Basin and Digby Gut area are also noted in this section.

4.15.2 Aggregation

Compelling evidence from aerial surveys suggests that the mouth of the Annapolis Basin is of importance to all seabirds (e.g. 11.36 gannets per km surveyed, along with fulmars). Purple sandpipers were observed along the Digby shores (9.2/km^2, highest densities along survey) (K. Allard, pers. com., 2012; Allard et al. 2014).

Lobster tagging studies in Annapolis Basin found the highest numbers near Digby Gut, with migration outwards in the fall (Lawton et al. 1995). Horse mussels are most abundant in areas above Digby Gut. Dense hydroid communities were associated with the horse mussels, which alter the bottom profile and provide habitat for other species (Fuller et al. 1998).

4.15.3 Fitness Consequences

The Annapolis River is recognized as an important clam spawning area, supplying the rest of Annapolis. In the past, fishermen have suggested a closure to clam digging (A. Bull, Fundy Fixed Gear Council, pers. com., 2000). As noted above, there is also an abundance of horse mussel reefs, located north of Digby, Nova Scotia, off Margaretsville (Kostylev, unpublished report, 2009).

Juvenile lumpfish have been observed inside Annapolis Basin and just out from Digby Gut, between July and October (Daborn and Gregory 1983). While many coastal spawning areas have been lost, the importance of coastal areas to the life cycles of many fish is still being demonstrated. Distribution studies for the various stages of cod eggs show that areas of cod spawning in the Bay of Fundy and Scotian Shelf include coastal zones along the Nova Scotia coast, above Digby Gut (Hanke et al. 2000). Reports of Atlantic sturgeon juveniles and dead ripe female sturgeon in the Annapolis River suggest a spawning population (Percy et al. 1997).
Naturalness

The area from Digby Neck to Brier Island has about 12 aquaculture sites, with an additional two large sites being planned for the Digby Neck area. The cumulative impacts of a variety of fisheries, fish processing plants, and active harbours have disturbed the natural character of this area (AECOM Canada Ltd. 2011).

4.15.4 Resilience/Sensitivity

Horse mussel reefs are sensitive to bottom fishing disturbance. The most obvious effect of trawling seems to be the leveling of the substrate and the disturbance of the horse mussel clumps resulting in a loss of the emergent epifauna (Collie et al. 2000).

4.15.5 Management Considerations

The Canadian Parks and Wilderness Society identified horse mussel reefs for protection measures (CPAWS 2012), with the goal to conserve this special marine feature.

Estuaries and mudflats are highly productive areas, as are the rivers and streams that flow into them. These are often close to human development and activities that have a high potential for impacting their health. In Nova Scotia, many of these areas have been designated as significant

(e.g. Ramsar wetlands). The total area of provincial land currently protected is 8.2%, and about half of that protected land is within 2 km of the coastline.

In a report by the Fundy Fixed Gear Council (A. Bull, pers. com., 2000.), fishermen suggested the closure of the Annapolis River to clam digging due to the importance of this area as a clam spawning area that supplies the rest of Annapolis. The horse mussel reefs found north of Digby Nova Scotia, are identified as an EBSA (Figure 1, number 15). These features are considered to be unique and the structure they provide results in higher species diversity (Aggregation).

4.16. BRIER ISLAND/DIGBY NECK AREA

4.16.1 Uniqueness

At least three species of algae, including *Eudesme virescens, Desmotrichium undulatum,* and *Myrionema strangulans*, have only been recorded here and nowhere else in Bay of Fundy (Mills and Laviolette 2011).

As a result of its location at the mouth of the Bay of Fundy, where it is exposed to oceanic conditions and strong currents that sweep across shoals, many subtidal species are found intertidally in this area. These oceanic conditions also bring an abundance of zooplankton, and stable year round water temperatures that support additional species intertidally (MacKay 1977; Mills and Laviolette 2011).

4.16.2 Aggregation

Its location at the intersection of bird migratory routes along the coast of North America, along with a number of environmental features, combine to make the Brier Island / Digby Neck area prime for bird aggregations including brant, fulmars, shearwaters, petrels, frigatebirds, gannets, herons, egrets, ibises, plovers, sandpipers, phalaropes, terns, jaeger, and auks (Mills and Laviolette 2011). There are significant differences in phalarope abundance and zooplankton biomass between control sites and localized upwelling or convergence zones at Brier Island, suggesting tidal currents are important in structuring the surface plankton community. As a result, these biophysical interactions create important red-necked phalarope foraging habitat (Brown and Gaskin 1989). Distribution studies of euphausiids show the highest concentrations are found in the Grand Manan Basin-Brier Island area, as well as the highest copepod diversity and concentrations (Iles 1975).

It is an important feeding area for greater and sooty shearwaters in July and September when dense swarms of the euphausiids *Meganyctiphanes norvegica* are aggregated at the surface, and Wilson's storm-petrels also feeds on copepods in this area (Messieh, unpublished manuscript, 1992). Distribution maps of birds observed during aerial surveys of the Bay of Fundy provide compelling evidence of the importance of the Brier Island area to all birds. Specifically, phalaropes, purple sandpipers, and shearwaters, which all show high densities (top 5%) along the survey track (K. Allard, pers. com., 2012; Allard et al. 2014). This area is also an important fall staging site (J. Paquet, pers. com., 2012). Red-necked phalaropes have diminished in the Quoddy Region since 1990, while numbers have been increasing in the Brier Island area. The idea of an alternate staging ground has not been verified, but it has been suggested that some of the birds are now going to Brier Island (Duncan 1996; Thorne 2010). The Brier Island area is a very important feeding area for birds year-round. Greater and sooty shearwaters, and red phalaropes are numerous off Brier Island in the fall during migration (Hicklin and Smith 1984).

A large number of fish species have been recorded in the Brier Island - Digby Neck area and finfish diversity was greater than15 species per tow (1990-1993 data) (Strong and Hanke 1995). The Brier Island shores along Grand Channel show a relatively high diversity of species assemblages due to the mixed substrates and tidal currents. Kelp beds dominate around the

island. Four sponge species were observed (MacKay 1977) during diver transects: bread sponge (*Halichondria panacea*), finger sponge (*Haliclona oculata*), *Isodictya deichmannae*, a very large sponge associated with horse mussels (ESS), and the small sea vase sponge *Scypha ciliate* (Fuller et al. 1998). It has a lower diversity of benthic macroinvertebrates than that found in the Deer Island area. Horse mussels are found in several areas off Brier Island in association with dense hydroid communities and providing habitat for other species (Fuller et al. 1998).

The Brier/Digby Neck area is surrounded by waters rich in marine life, including humpback, fin and minke whales and white-sided dolphins (AECOM Canada Ltd. 2011). A study of porpoise by-catch showed that a large number of porpoise are present off Brier Island (Trippel et al. 1996).

4.16.3 Fitness Consequences

The food chain in this area includes copepod and euphausiid aggregations, mackerel, herring, squid, gulls, shearwaters and red phalaropes, and the cetacean megafauna (Smith et al. 1984). The phenomenon of surface swarming is considered significant to seabirds and baleen whales. Grand Passage represents one of two tidal pumps that support biological production (Percy et al. 1997). This tidally generated ecosystem is important for herring, birds, and cetaceans, including the North Atlantic right whale (Gordon and Dadswell 1984).

It is a very important feeding area for birds year round and for greater and sooty shearwaters and red phalaropes in the fall during migration. The Digby Neck/Brier Island area is an important red and red-necked phalarope fall staging site (J. Paquet, pers. com., 2012).

Summer surveys by DFO indicate that the Nova Scotia coast of the Bay of Fundy, southwest of Digby and near Brier Island, is one of the important habitats for Atlantic wolffish (SAR) (Horsman and Shackell 2009). High numbers of cod eggs were found in the Brier Island/Digby Neck area, signifying this was a cod spawning area (McKenzie 1934).

4.16.4 Management Considerations

The area is recommended as a potential MPA by academics because it is representative of important outer Bay features, and has significant marine mammal and bird diversity (Willison, unpublished report, 1997[23]); and is a high priority area for protection because of high benthic diversity (MCBI 1999). Brier Island is listed as an IBA in the Bay of Fundy. The shoals of northeast Brier Island were identified as a Natural Area of Canadian Significance (PC/TNB 1985).

Aquaculture sites are located at Grand Passage, between Long Island and Brier Island (CCRM 1999). There is also concern based on the large number of porpoise bycatch reported for gillnets set off Brier Island, which indicates vulnerability to this activity (Trippel et al. 1996).

The area around Brier Island including Digby Neck (Figure 1, number 16) is identified as an EBSA, because it exhibits the attributes of Uniqueness, with three species of algae recorded nowhere else in the Bay of Fundy and with subtidal species that occur in the intertidal zone. The high concentration and diversity of copepods and other zooplankton attract large aggregations of birds and cetaceans.

[23] Unpublished document by M. Willison, V. Barry, N. Bellefontaine, I. Judson, S. Onyschuk, and E. Rankin, “A preliminary assessment of several Bay of Fundy candidate sites for MPA designatior under the Canada *Oceans Act”,* Dalhousie University, Halifax, NS (1997).

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APPENDIX 1. OTHER ASSESSED AREAS

In developing this report, several locations were identified as potential Ecologically and Biologically Significant Areas (EBSAs) but, due to lack of clear evidence or other reasons, were not included in the final list of EBSAs for the Bay of Fundy. These areas, or components of these areas, could be identified as EBSAs at a later date as more information becomes available.

GRAND MANAN

The waters surrounding Grand Manan Island appear to be important for a range of species, including birds, cetaceans and fishes. The area is one of six key areas for seabirds in the northwest Atlantic because of its high concentrations of northern gannets (*Morus bassanus*), black-legged kittiwakes (*Rissa tridactyla*), herring gulls (*Larus* spp.), and great black-backed gulls (*Larus marinus*) (Sabine 2010). High densities of piping plovers (*Charadrius melodus*) (1.35 birds/km²) and purple sandpipers (*Calidris maritime*) (9.2 birds/km^2) have also been observed around Castalia saltmarsh (K. Allard, pers. com., 2012). Also, large numbers of common eiders breed in this area (Hicklin and Smith 1984).

North Atlantic right whales are commonly found in the waters to the north and east of Grand Manan (Buzeta et al. 2003a; Smedbol 2007). This area is also important to basking, mako (*Isurus oxyrinchus*), and blue sharks (*Prionace glauca*). The white shark (*Carcharodon carcharias*) has also been sighted in the area (S. Turnbull, pers. com., 2012).

The Fisheries and Oceans Canada summer groundfish surveys indicate that the Grand Manan area is an area of relatively high finfish diversity (Strong and Hanke 1995). The same surveys suggest that the area between Grand Manan and The Wolves is important for cod (AECOM Canada Ltd. 2011). Cod also spawn in the area (Hunt and Neilson 1993). Herring spawning is also known to occur north of Grand Manan (Stephenson et al. 1999), while winter flounder (*Pleuronectes americanus*) and American plaice (*Hippoglossoides platessoides*) spawning occurs to the east of the island (Scott and Scott 1988).

The eastern and southern shores of Grand Manan are considered sensitive from a lobster production perspective (Lawton and Robichaud, unpublished manuscript, 2001). High catch rates occur off eastern Grand Manan and juveniles and adults are abundant in shallow water habitats during the summer.

SAINT JOHN HARBOUR TO ALMA

The stretch of coastline from Saint John Harbour to Alma includes a range of significant features. The Saint John Estuary includes populations of short-nose sturgeon (*Acipenser brevirostrum*), Atlantic sturgeon (*Acipenser oxyrinchus*) (Litvak, unpublished presentation, 2001[24]; Percy et al. 1997). All of these are Species at Risk (COSEWIC 2009a). This river has the highest records for diversity of anadromous and diadromous species in Bay of Fundy streams and rivers (Hunter and Associates 1982).

Several IBAs occur near Saint John, including Manawagonish Island, Saints Rest Marsh and Beach, and Quaco Bay (IBA Canada 2012). Some of the largest marshes (hundreds of acres) are at Saints Rest Marsh and Beach (Conkling 1995). Many of the small marshes distributed throughout the Bay of Fundy are under pressure (Griffin 2001).

[24] Oral presentation by M. Litvak at the Sensitive Marine Areas Workshop, January 17, 2001.

Several areas along the New Brunswick shore have been reported as significant for juvenile lobster or scallop spat (Lawton 1992). A coastal lobster spawning area was identified between Quaco Head and Martin Head (CCRM 1999).

St. Martins to Alma seems to be an important area for porbeagle sharks, which are considered Endangered by COSEWIC (2009a), and thresher sharks (*Alopias* sp.), which are listed as vulnerable to extinction by the World Conservation Union (IUCN 2009).

Fundy National Park includes examples of two coastal environments (Owens 1977): Chignecto Bay's sandstones and shales with expansive intertidal mudflats, and the North Shore's sedimentary cliffs and beaches. Two small salt marshes are located at Point Wolfe and Alma River. Forty-seven algae species, eighty-five invertebrate taxa, seven fish species, and numerous shore birds were listed during studies of the intertidal zone (Carter and MacGregor, 1971).

The Saint John River is potentially an EBSA due to the presence of short-nose sturgeon, Atlantic sturgeon, and Atlantic salmon. However, naturalness is considered low, with significant environmental issues to address. The Saint John to Alma area includes sites with EBSA attributes, including significant large marshes and several SAR. However, a previous review of this area by a scientific panel concluded that evidence specific to EBSA attributes was not associated with any one specific site (Buzeta and Singh 2008).

ST. MARY'S BAY

Nineteen Species at Risk have been observed in this area, including Atlantic salmon, beluga whales (*Delphinapterus leucas*) , Atlantic cod, piping plovers, and blue whales (*Balaenoptera musculus*) (AECOM Canada Ltd. 2011).

Herring larvae are present in St. Mary's Bay and are believed to have been transported from the nearby spawning grounds on Trinity Ledge and Lurcher Shoals (Das 1968).

The Assembly of Nova Scotia Mi'kmaq Chiefs spoke out against proposed aquaculture facilities in St. Mary's Bay, citing the decline of Atlantic salmon populations, and the poor returns of grilse that spend time in the ocean before returning to their native spawning rivers (ANSMC 2011).