Environmental Function Analysis As A Beach Management Tool: The Eastern Shore of Nova Scotia Canada

By

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The undersigned hereby certify that they have read and recommend to Marine Affairs Program for acceptance a graduate research project titled "*Environmental Function Analysis As A Beach Management Tool: The Eastern Shore of Nova Scotia Canada*" by author in partial fulfillment of the requirements for the degree of Master of Marine Management.

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Signature of Author

Dedicated to my parents:

My dad: Guy Amyot
Who after beating cancer, road his bike from Lac-Mégantic (QC) to Halifax (NS).
Determined, Perseverant, and Passionate.

And

My mom: Gisèle Champs
Who is without a doubt, the best counsellor anyone can ever have.
Protective, Strong, and Loving.

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Abstract

Globally, sandy beaches are in a state of accelerated erosion and degradation due to various anthropogenic and natural stressors imposed on these complex coastal systems. In Nova Scotia, protection of sandy beaches has been a growing concern for management authorities. Within provincial jurisdiction, beach management and conservation strategies can be implemented mainly through two Acts: the *Provincial Parks Act* and the *Beaches Act*. However, the designation process associated with higher protection status lacks a systematic approach and is generally influenced by lobbying. Historically, beach management in Nova Scotia has focused on recreational use, facilities development, and standardization of beach management practices, which are poorly adapted to local environments and induce further degradation and conflicts. This graduate project seeks to increase the efficiency and legitimacy of beach management and conservation initiatives using a locally adapted Environmental Function Analysis (EFA) as a planning tool. EFA assesses environmental quality indicators to evaluate beach conservation value and use/development potential, suggests the most appropriate sites for conservation, use and development, and highlights conflict zones. Using a case study approach, four popular sandy beaches, found in the Halifax Regional Municipality (HRM) region of the Eastern Shore, were evaluated. EFA not only provides general observations allowing beaches to be compared and contrasted, but it also gives useful insight on individual beaches, allowing for better-informed decision-making and tailored management. The simplified EFA methodology proposed is user-friendly, provides conclusive results, and offers a cost-effective approach to sandy beach environment evaluation.

Keywords: beach management; conservation; use/development; environmental function analysis; environmental quality indicators; Nova Scotia; recreation; socio-ecological system.

List of Abbreviations

ATV: All-Terrain Vehicles
CEAA: Canadian Environmental Assessment Act
CEPA: Canadian Environmental Protection Act
CEPI: Collaborative Environment Planning Initiative
CRD: Conrad Beach
DA: Dimension Analysis
DFO: Department of Fisheries and Oceans Canada
EC: Environment Canada
EFA: Environmental Function Analysis
ERA: Environmental Risk Assessment
GIS: Geographic Information System
HRM: Halifax Regional Municipality
ICOM: Integrated Coastal and Ocean Management
ICZM: Integrated Coastal Zone Management
LTN: Lawrencetown Beach Provincial Park
MPS: Municipal Planning Strategy
MPA: Marine Protected Area
MTQ: Martinique Beach Provincial Park
NCC: Nature Conservancy of Canada
NGO: Non-Governmental Organization
NRC: Natural Resources Canada
NSDFA: Nova Scotia Department of Fisheries and Aquaculture
NSDNR: Nova Scotia Department of Natural Resources
NSDT: Nova Scotia Department of Transportation
NSE: Nova Scotia Environment
NSTDB: Nova Scotia Topographic Database
ORV: Off Road Vehicles
PON: Provincial Oceans Network
RHV: Rainbow Haven Beach Provincial Park
SA: Simulated Annealing
SARA: Species At Risk Act
SCP: Systematic Conservation Planning
SES: Socio-Economic Status
TAC: Total Allowable Catch
TEK: Traditional Environmental Knowledge
TIANS: Tourism Industry Association of Nova Scotia
UNESCO: United Nation Education, Scientific and Cultural Organization

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CHAPTER 1: GENERAL INTRODUCTION

1.0 Introduction

Coastal environments are increasingly being solicited for their ecosystem goods and services, especially sandy beaches. Today, more than 67% of the world's population lives within 60 kilometers of the coast and is expected to reach 75% by 2020 (Gray, 1997; Schlacher *et al*., 2008). Since 75% of ice-free coastal shorelines consist of beach ecosystems (Brown & McLachlan, 2002), economic development, resource extraction, and demand for leisure prospects triggered by population growth are putting unprecedented pressure on the world's beaches (Schlacher *et al*., 2008). Along with these human induced pressures on the landside, sea level rise induced by climate change gradually constricts sandy beaches on the seaside (Defeo *et al*., 2009; Schlacher *et al*., 2008).

The various anthropogenic and natural stressors imposed on sandy beaches has led to widespread erosion and degradation of these complex ecosystems and leads to severe consequences for both the social and ecological realms. In fact, sandy beaches are very valuable to coastal settlers as they support a variety of ecological, social, cultural, and economic goods and services (Schlacher *et al.*, 2008). Sandy beaches are not only prime recreational grounds supporting the tourism industry; they also provide important nursery grounds for many fish species, supporting fish stocks and sustaining local fisheries (Schlacher *et al*., 2007). Sandy beach ecosystems also offer important ecosystem services such as nutrient recycling, water filtration, coastal protection, and nesting and foraging sites for many vertebrate and invertebrate species including endangered fauna (Schlacher *et al.*, 2007). Therefore, due to the importance of ecological, social, and economic values of sandy beaches, an integrated approach to beach management, which focus on minimizing the impacts associated with human activities and climate change while maximizing the sustainable use of sandy beach ecosystems, is critically needed (Schlacher *et al.,* 2008).

In Nova Scotia, beach management and conservation have mainly been driven by the implementation of the *Beaches Act,* which restricts use and promotes beach conservation, and the *Provincial Parks Act,* which aims at sustainable use of beaches for recreational purposes. However, the designation process of protected beaches using these *Acts* lacks a systematic approach to beach conservation, use, and development planning. Presently, the *Beaches Act* designation procedures policy, which is yet to be approved by the Minister, relies on formal requests from either the Minister, Deputy Minister, or Nova Scotia Department of Natural Resources (NSDNR) to initiate the evaluation process and consider individual beaches to be protected, or not, under the act (see Appendix A). Historically, community movements and concerned citizens have provided the political legitimacy for these formal requests. Unfortunately, the reactive nature of this approach has left coastal planners with little pragmatic support to fulfill their conservation mandate. In a time where the Government of Nova Scotia is contributing to the design of an Integrated Coastal Zone Management (ICZM) strategy and recognizes that sandy beaches and associated dune ecosystems are under "high risk" (Government of Nova Scotia, 2009), the need for a more efficient approach to sandy beach conservation has become a priority.

Therefore, to support coastal managers of Nova Scotia with the designation process for beach conservation and development initiatives, this graduate project will propose an Environmental Function Analysis (EFA) as a planning tool which evaluates both the human and ecological component to prioritize beach conservation, underline management conflicts, and suggests beaches for use and development. Using a case study approach, four beaches found on the Eastern Shore will be evaluated within the modified EFA framework. The results obtained through this analysis will provide the basis for recommendations on future beach management practices in Nova Scotia.

This graduate project is divided as follows. First, *Chapter 1* will provide essential background information on sandy beach environments, functions, and key threats. Second, *Chapter 2* will review the literature on sandy beach management tools, elaborate on the historical development of EFA methodology, and present the case study and methods used. Third, *Chapter 3* will reveal the results obtained from the four analyzed beaches and will discuss in detail. Finally, *Chapter 4* will present an in-depth reflection on the state of sandy beach management in the province, provide recommendations, and suggest future direction for beach management research in Nova Scotia.

1.1 Nova Scotia Sandy Beach Environment

Sandy beach environments are dynamic and multidimensional systems found in the larger coastal zone and include a network of natural, socio-cultural, and management systems (Figure 1). The beach's natural system includes all living species, sediment, water, and air columns present, along with the processes that influence them. The socio-cultural system is comprised of all human uses of the beach, along with the interaction between users. And finally, the management system, which encompasses all national, regional, and local agencies who actively intervene in the beach environment by applying policies, environmental programs and enforcing norms (James, 2000).

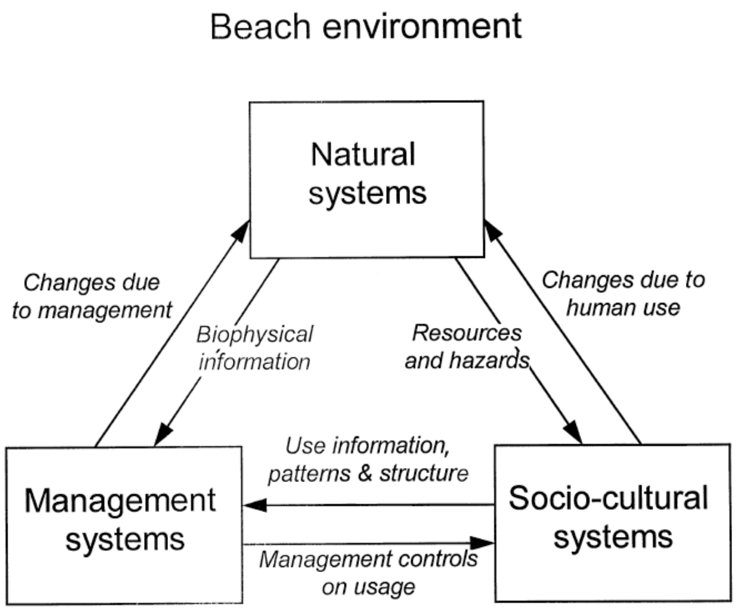

Figure 1: Conceptual model of the beach environment comprised of its major components and key interactions (from: James, 2000).

1.1.1 Ecological Sphere

Sandy beaches are dynamic systems where oceanic forces drive their physical state, biological composition, and ecosystem functions. Physically, beaches have been described as “accumulations of unconsolidated materials (for example sands, gravels, muds – or mixtures) that extend seaward from the landward edge of the beach, for example a dune scarp or seawall, to the water depth at which significant sediment motion is absent – the depth of closure (DoC)” (Williams & Micallef, 2009). However, because of the high interdependence of sandy beaches with other coastal ecosystems (*e.g.* salt marshes, lagoons, mud flats, *etc*.), in terms of biological resources and sediment exchange

(Brown & McLachlan, 2002), the natural system of sandy beaches extends beyond this definition. Consequently, all adjacent coastal ecosystems that significantly contribute to biophysical characteristics of a beach should be integrated in the evaluation of its ecological sphere.

1.1.1.1 Physical Features and Dynamics

The physical features of sandy beaches, summarized in Figure 2., are defined by the interacting forces of wave height, currents and exposure, tidal regimes, and sediment supply (McLachlan & Brown, 2006). Beach slope depends on the swash, which brings in sediment to supply the beach face (accretion), and backwash dynamics moving the sediment back to sea (erosion) (Brown & McLachlan, 2002). When sediment is coarse (0.5-2mm) water drains through the beach face and eliminates the backwash resulting in a steep beach slope, while fine sand (0.06-0.25mm) will remain engorged with the incoming water because of its low permeability, allowing the backwash to flatten the beach slope (McLachlan & Brown, 2006). (Though water filtration capacity varies according to sediment size and composition, a single sandy beach can filter up to 100 m^3 of seawater per m of beach per day (McLachlan & Brown, 2006)).

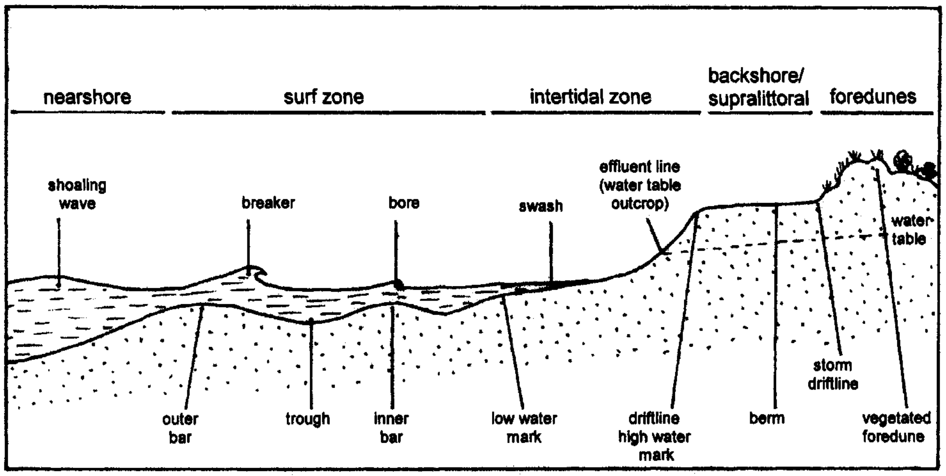

Figure 2. Physical features of a typical sandy beach at mid tide (from: McLachlan & Brown, 2006).

This results in large and flat dissipative beaches or in narrow and steep reflective beaches (Schlacher *et al*., 2008), though the majority of beaches are found between these extremes (McLachlan & Brown, 2006).

Beaches are formed by sand particles (*i.e.* quartz, silica, heavy minerals, shells fragments, *etc.*), which are washed out by waves via cliff erosion, river and estuary sediment delivery, offshore sandbars, and blown by the wind from dune systems (Brown & McLachlan, 2002). In addition, longshore currents, created by surface gravity waves, also allow for longshore drift to move sand along the coastline through the surf zone, nourishing neighboring beaches or coastal systems' sand dunes, lagoons, barrier islands, and salt marshes (Birds, 1996; Schlacher *et al*., 2008). Sand transport through longshore drift may exceed 100,000 m^3 every year (McLachlan & Brown, 2006); thus, altering this process in any way will have serious consequences on a beach sand budget. The ability of the system to transport the sand and bank it in various connecting sandy systems allows for sandy beaches to be extremely resilient to storm events, accentuated by seasonal extremes. As sandy shores absorb the energy of the crashing waves and erode away, sand is restored to the system during calmer periods, providing coastal land an effective and sustainable protection.

In addition to coastal water filtration and land protection, sandy beach ecosystems are also responsible for the purification of coastal water as they mineralize organic material and recycle nutrients, especially nitrate and phosphate (McLachlan & Brown, 2006). They also store water in dune aquifers and discharge freshwater to the nearshore (Defeo *et al*., 2009). All these physical and chemical characteristics of a sandy beach's interstitial environment also define the species composition and abundance it can shelter.

1.1.1.2 Flora and Fauna

Though beaches may not appear to possess a species composition that is as rich and diverse as other coastal systems due to the absence of attached vegetation in the intertidal zone, sandy beaches are far from a coastal desert. In fact, sandy shores support two distinct food webs that are both based on marine inputs such as phytoplankton, detached algae and other plant and animal detritus (Schlacher *et al*., 2008). The first, referred as the "small food web", is made of interstitial organisms such as bacteria, protozoan, microalgae and meiofauna found in and around sand grains (Defeo *et al*., 2009; Schlacher *et al*., 2008). The second, referred as the "large food web", is composed of macro-invertebrates such as crustaceans, molluscs, polychaetes, and clams, which burrow in the substrate and display a variety of feeding techniques such as predation, scavenging, and filter and deposit feeding (Defeo *et al.*, 2009; Schlacher *et al*., 2008). Defeo *et al.* (2009) reports high abundance of these macrobenthos (*ca*. 100,000 ind m^{-1})

and their biomass (>1000 g m^{-1}), particularly in dissipative to intermediate beach type in temperate zones, while more reflective beaches tend to be dominated by robust crustaceans such as crabs. These rich beach zones are prime feeding sites for shorebirds, who are, with finfish, the top consumers of this larger food web (Schlacher *et al*., 2008). In Nova Scotia, many migratory bird species, including a variety of endangered species, also use the dune system and the backshore zone to breed and nest. While on the sea bound limit of the beach, the surf zone shelters a variety of phyto- and zooplankton, prawn and shrimps, and juvenile finfish (Schlacher *et al*., 2008). In fact, beaches' surf zone provides prime nursery ground for a variety of commercially important fish (Schlacher *et al*., 2008).

Because sandy beaches are dynamic systems with unstable substrate and exposed to extreme conditions, sandy beach biota display high behavioral and physiological adaptability such as: burrowing, hard exoskeleton, mobility, rhythmic behavior, orientation mechanisms, and high behavioral plasticity (Brown & McLachlan, 2002; Schlacher *et al*., 2008). As a result, beach living organisms are often obligate species of these ecosystems.

1.1.2 Socio-Economic Sphere

Whether they are commercial, recreational, or cultural, human activities taking place on the sandy shores support a large array of interests and needs (James, 2000; Schlacher & Thompson, 2007).

1.1.2.1 Tourism and Recreational Activities

The tourism and leisure industry are key contributors to the economy of Nova Scotia and development of its local communities. In fact, the tourism industry alone represents 1.8 billion dollars annually in revenue and supports approximately 32,000 jobs throughout the province (TIANS, 2011).

Sandy shores of Nova Scotia are being recognized internationally for their natural beauty and uniqueness. Whether it is the National Geographic Traveler Magazine that ranked Nova Scotia South Shores as the world's best coastal destination, or The New7Wonder of Nature contest that nominated the Bay of Fundy, or the Parks Canada who prized The Joggins Fossil Center (also a UNESCO World Natural Heritage) with its Sustainable Tourism Award (TIANS, 2011), it is agreed that sandy shores of Nova Scotia are worth the visit. In 2010, 30% of tourists visited Nova Scotia specifically to explore and enjoy the landscape of its sandy beaches (TIANS, 2011). Though this trend is in significant decline from pre-recession years, where beaches attracted 42% of visitors in 2004 (TIANS, 2011), beaches and coastal site seeing remains one of the primary promotional assets used by the Tourism Industry Association of Nova Scotia (TIANS) to attract tourists in the province.

In addition to all expenditure deployed by this specific clientele, are all other economic gains produced from leisure activities that use sandy beaches as part of their recreational pursuits. In fact, sports such as canoeing, sea kayaking, boating, camping, hiking, and surfing are estimated to generate gross revenue of 19 million dollars annually in Nova Scotia (TIANS, 2008). Along with private recreational service providers, the province of Nova Scotia encourages the recreational use of its 31 provincial and two national parks where beaches are the main attraction. The high demand for beach access and recreation reflects a strong attachment by Nova Scotians and tourists to the coast.

1.1.2.2 Cultural and Spiritual Values

The cultural and spiritual value associated with the coasts and especially to sandy beaches is strong in Nova Scotia. With 13,300 kilometers of shoreline, thin continental land (nearly 65 kilometer from any coast), and main watersheds draining to the sea, it can be argued that Nova Scotia is in fact all coastland (Beaton, 2008). The historical context of the province has shaped this strong association between the people and its coastline. From the Mi'kmaq First Nation who collected marine resources in the summer and retreated inland during winter, and the establishment of the first European settlers around the 1600s, the people of Nova Scotia have always depended on the coast to survive. Therefore, it is not surprising to find that 70% of Nova Scotians have chosen to live by the coast (Government of Nova Scotia, 2009). People have come to identify themselves with their coastlines, where beaches represent a strong cultural icon of the Maritime life style.

1.1.2.3 Extractive Activities

Sandy shores in Nova Scotia provide a variety of commercial opportunities for residents and support subsistence living for many coastal communities. Activities such as fishing, clam digging, bait harvesting (also a popular recreational activity), and marine plant harvesting remain strong economic drivers in the province. As Table 1 shows, the landings revenue reported in 2009 by the fishing industry of Nova Scotia are non-trivial. Despite the early 1990's ground fisheries collapse in the province (Kearney, 2004), Nova

Scotia fishermen collectively earned more than half a billion dollars for their catches. Though there are significantly less fishing opportunities than in recent history, the fishing sector provides employment for approximately 14 thousand fishermen in Nova Scotia (DFO, 2007), people who depend on the quality and quantity of marine resources to sustain their household.

Table 1. 2009 Value of commercial landings in Nova Scotia (from: DFO, 2009a).

Fisheries	**Value (thousand dollars)**
Ground fish	86,100
Pelagic fish	28,371
Shellfish	471,870
Marine plant	223
Miscellaneous*	236
Total	**586,578**

* Miscellaneous include seal value

Since the surf zone of sandy beaches provides prime habitat for many commercially important fish and shellfish (*e.g.* Winter flounder, Capelin, Surf clam), it is argued that the sandy beach ecosystem actively sustains these commercial harvests.

In addition to these traditional fisheries, bait collection is also providing substantial earnings for Nova Scotia harvesters. In 2007, five million bloodworms (*Glycera dibranchiata*), primarily destined for the Eastern United States and Western Europe recreational fishing market, were collected from ultra dissipative sandy shores bringing 900,000 dollars in revenue to harvesters (DFO, 2009b). Without engaging in a discussion concerning the sustainability of these fisheries, the renewable nature of these resources suggests nonetheless that the total value of these fisheries far exceeds their annual revenues.

Sandy beaches and their associated dune systems also provide non-renewable resources, in the form of sand and gravel, which provide a locally accessible raw material supply and thus a more affordable alternative to built infrastructures. Despite the negative impacts associated with sand and dune mining and the historical intensity to which it has been practiced (discussed in section 1.2.1), resulting in the adoption of the *Beaches Act* in 1975, sand mining of unprotected beaches and dunes remains an important source of revenue for many private land owners and companies in Nova Scotia. Cap La Ronde, a tombolo situated south of Cape Breton, on Isle Madam, is a prime example of a private sand mining operation. Up to 30,000 tones of sand are extracted annually from this beach and sold to the Nova Scotia Department of Transportation (NSDT) for the building of local roads (Gasse, 2006, as cited by Beaton, 2008). According to Natural Resources Canada (2011), the total revenue associated with the exploitation of sand and gravel in 2010 for the province of Nova Scotia was 25.4 million dollars, which accounts for nearly 9% of its total non-metallic mineral production. Unfortunately, the province does not keep common inventories of the exact number and distribution of beaches being affected by sand mining, whether directly or indirectly.

1.1.3 Management Sphere

The management sub-system of the beach environment includes a web of interacting governmental and non-governmental organizations, acts, policies, regulations, and programs (James, 2000).

1.1.3.1 Federal Level

Canada's intertidal ecosystems are protected and managed under a variety of federal agencies that focus on the protection, conservation, and/or management of coastal habitats, resident animals, plant, and migratory species (Government of Nova Scotia, 2009a). While some agencies are very restricted in the application of their management programs, others harbor a large array of environmental initiatives. For example, Parks Canada may only apply its management plans through the implementation of the *Canada National Park Act* (2000), within the boundaries of the park (*e.g*. Kejimkujik Seaside Adjunct, Cape Breton Highlands National Park of Canada). Whereas others, such as Environment Canada (EC), implement various acts that aim at public protection against environmental pollution and contribute to sustainable development (*e.g*. *Canadian Environmental Protection Act (CEPA)*, 1999; *Canada Water Act*, 1985; *Canadian Environmental Assessment Act (CEAA)*, 1992). In addition, EC is also responsible for protecting Canadians natural heritage through the enforcement of legislation such as *Migratory Birds Convention Act* (1994), *Canada Wildlife Act* (1985), and the *Species At Risk Act* (*SARA*) (2002). Similarly, DFO is in charge of protecting and monitoring aquatic species and habitats under the *Fisheries Act* (1985), and *SARA* (2002).

Though many federal agencies are involved in the management and protection of a variety of components that directly affect sandy beach ecosystems, they have traditionally been implemented in "silo vision". However, with the adoption of the *Ocean Act* in 1997 and the development of Canada's Ocean Strategy, DFO was appointed to lead and facilitate the national integrated coastal and ocean management initiative (ICOM) (Government of Canada, 2002). In fact, Canada was not only planning its coastal and marine activities to reduce stakeholder conflicts while maximizing benefits, but it also aimed at coordinating all ocean management efforts across participating ministers (Government of Canada, 2002). In addition to syncing coastal and ocean related policies and programs, DFO also has the responsibility to develop and implement a national system of marine protected areas (MPAs) (Government of Canada, 2002), which would increase ecological resiliency of these marine habitats.

In Nova Scotia, beach management is being integrated in a *Coastal Strategy* designed by an interdepartmental group of agencies referred to as the Provincial Oceans Network (PON) (Government of Nova Scotia, 2009). Since the draft document has not yet been released and further public consultations will follow its publication, the final impact the Coastal Strategy will have on the beach environment remains to be evaluated. So far, there are no clear (federal) indications on how to pursue beach management in Nova Scotia.

1.1.3.2 Provincial Level

The NSDNR is the most active in the management and protection of sandy beaches and dunes found on crown land. In fact, the Parks and Recreation Division is responsible for on-site beach conservation, management, and recreational planning of all public beaches in the province through the implementation of the *Beaches Act* (1989), *Provincial Parks Act* (1989), and the *Trails Act* (1989). Some overlap exists under the *Wilderness Area Protection Act* (1998), where Nova Scotia Environment (NSE) shares management responsibilities in the case of the provincial wilderness protected areas that possess sandy beaches. In addition, Nova Scotia Department of Fisheries and Aquaculture

(NSDFA) administers clam and bait harvesting and aquaculture sites under the *Fisheries and Coastal Resources Act* (1996).

Though the bulk of beach management responsibilities are assigned to NSDNR, beaches with double designations (*e.g*. protected beach, park, park reserve, wilderness protected area) increase intra-departmental overlap and management priority confusion. For example, parks and protected beaches have different objectives. Under their respective Acts, provincial parks aim to enhance the recreational use of sandy beaches while protected beaches are intended for strict conservation of the beach ecosystem and limited human use and development. The high accessibility of certain provincial beach parks and the absence of carrying capacity maximums (*i.e.* number of visitors at any given time) have made the *Beaches Act* difficult to enforce on high traffic protected beaches (*e.g*. Lawrencetown beach).

1.1.3.3 Municipal/Local Level

Municipal agencies and local governments are responsible for land-use planning in Nova Scotia under the *Municipal Government Act* (1996) and the *Halifax Regional Municipality Charter* (2008). Under these Acts, municipalities may design a *Municipal Planning Strategy* (MPS) and apply zoning and sub-division by-laws. Even though these Acts have no specific dedication to sandy beach protection (nor to any other coastal ecosystems), municipalities may propose protective measures, such as setback, during land use planning. However, only 45% of the province landmass area established municipal strategy land-use planning in 2009 (Government of Nova Scotia, 2009). This suggests that many areas surrounding sandy beaches remain to be zoned by local governments and taken into consideration in municipal land planning. However, the strengthening trend for beach backshore municipal lots has been to zone for development. Since a property with ocean view may be sold for approximately 100,000 dollars more than a non-ocean view (Government of Nova Scotia, 2009), municipalities have been tempted to zone land adjacent to sandy beaches as private lots to be sold, unilaterally supporting coastal development.

1.1.3.4 First Nations, Aboriginals, Landowners, and NGOs

First Nations, Aboriginals, landowners, non-governmental organizations (NGOs) and multiple interest groups are also actively involved in the management sphere of sandy beach environments. First Nations and Aboriginal communities not only apply land-use planning on their traditional lands and waters (reserves), but they are also active collaborators with federal, provincial, and local agencies in coastal planning (Beaton, 2008). For example, Eskasoni First Nation has engaged in coastal management through a Collaborative Environment Planning Initiative (CEPI) on the Bras d'Or Lakes (Charles *et al.*, 2009).

Similarly, private landowners, NGOs, and local community groups participate, in collaboration with different levels of governments, in beach management through public consultations, advocacy and lobbying for management plans and policies, and land acquisitions (Beaton, 2008). However, stakeholders tend to promote beach management styles that are inspired by different cultural, ideological, and moral values (Hovardas & Poirazidis, 2007; Stocker & Kennedy, 2009; Thompson, 2007) leading to cultural models-based conflict (Thompson, 2007). For example, the Mi'kmaq First Nations and Aboriginal communities tend to associate a higher value to natural assets and prioritize coastal wildlife protection, while some private landowners focus on their individual property rights, independence, and claim dominion over their land and private beach (Charles *et al*., 2009). These types of management conflicts are frequent on the Nova Scotia beach systems and have yet to be directly addressed through statutory sandy beach management policy.

Overall, the management sub-system of the Nova Scotia sandy beach environment can be described as "[…] inefficient, ineffective, ambiguous and overly complicated due in part to the many agencies with overlapping or competing mandates in the coastal zone" (Government of Nova Scotia, 2010).

1.2 Key Threats Facing The Nova Scotia Beach Environment

Before a socio-ecological evaluation of Nova Scotia sandy beaches can be made, it is important to underline the main management challenges that particularly affect these coastal environments. Though not all beaches sustain all threats simultaneously, historical and present cumulative effects of these pressures are greatly influencing their current eroding and deteriorating state. (This section has been adapted from: *Beaches Of Nova Scotia: Key Management Issues and Policy Analysis*, J. Amyot, Marine Affairs, Dalhousie University, Halifax NS. unpublished material).

1.2.1 Mining

Nova Scotia beaches have historically been used as a source of sand and gravel for the construction of local roads (Piper & Bowen, 1976). In the 1880s, the high quality sand deposit of Mahone Bay islands was shipped by schooners and landed in Halifax to be transformed into concrete (NSDNR, 1993). At its peak in the mid 1970s, McNab's island was being exploited by seven operations extracting around 900 tons each day (NSDNR, 1993). This over exploitation led to the weakening of ocean shores and created instability and erosion which eventually led to extensive flooding and coastal destruction after severe storms (Piper & Bowen, 1976). In fact, sand mining not only enhances erosion by direct removal of sand, but it also negatively affects shorebirds and significantly decreases the abundance and diversity of meiofauna (Defeo *et al*., 2009).

Today, sand and gravel extraction activities have been reduced. However, despite the important ecological habitat and protective services that beaches provide to the coast of Nova Scotia, 3,932 kilotons of sand and gravel was removed from sandy systems in 2010 (Natural Resources Canada, 2011). Similarly to individual beaches and dune mined sites, the extent of all environmental impacts associated with the removal of beach sediment is not provincially monitored at this point.

1.2.2 Unsustainable Recreational Activities and Tourism

Many recreational activities may have deleterious environmental impacts on the beach ecosystem (Coombes *et al.*, 2008). For example, trampling of beaches and sand dune systems destroys the vegetation matrix, increases erosion rates (Schlacher, de Jager, & Nielsen, 2011), disturbs beach nesting seabirds such as the endangered Piping Plover (*Charadrius melodus)* (Fraser, Keane, & Buckley, 2005), and significantly reduces intertidal fauna abundance (Lucrezi, Schlacher, & Walker, 2009). The majority of non-extractive activities performed on the beach do not cause long-term damage to the ecosystem (Coombes *et al*., 2008). However, recreational impacts and mass beach tourism prevents beach biodiversity from thriving (Coombes *et al*., 2008).

Furthermore, the use of off road vehicles (ORVs), also called all-terrain vehicles

(ATVs), in and around Nova Scotia's beaches and related sand dune systems, has been demonstrated to induce long-term damage to beaches. The use of ORVs on beaches affects sand distribution, increases erosion, kills and injures invertebrates, while harassing nesting and feeding shorebirds (Schlacher, Richardson, & McLean, 2008; Sheppard, Pitt, & Schlacher, 2009). Though regulations under the *Beaches Act* prohibits the use of ORVs on protected beaches and sand dunes (*c.32, s.9, par. 1 & 2*), the narrow and vague definition of these systems allows for willing recreationists to drive in and around these sandy systems while seriously damaging the shorelines and their biodiversity.

1.2.3 Coastal Squeeze: Coastal Development and Sea Level Rise

Nova Scotia beaches are being constricted landward by coastal constructions such as roads, buildings, and coastal protection structures, while sea level rise creates erosion on the seaside. The potential for coastal development to become the most significant threat to sandy beaches in the short term is non equivocal. This is due to the fact that "[a]pproximately 86% of the coastline, including island and the shore of the Bras d'Or Lakes, is held privately and could be developed" (Government of Nova Scotia, 2009). For the moment, 80% of Nova Scotia's two kilometer belt coastline contains little or no development (Government of Nova Scotia, 2009). However, many clustered residential constructions are built near the shore, which accentuates the geological pressure put on the coast and increases land instability and erosion (NSDNR, 2010). So far, land subsidence induced a 30 cm per century sea level rise and is predicted to add to global sea level rise by 70 to 140cm for the next 100 years (Government of Nova Scotia, 2009). To prevent shore erosion associated with shoreline instability and sea level rise, hard engineering construction, such as seawalls, have been extensively built in some regions of

Nova Scotia. For example, in 2000, the Geological Survey of Canada has estimated that approximately 30.5 kilometers (38%) of Pictou County's shoreline was covered in hard engineering structures (Natural Resource Canada, 2008, as cited in Beaton, 2008). Armoring structures are very detrimental to the beach ecosystem, as they erode the dry intertidal zone, reduce habitat availability for intertidal fauna, and reduce prey availability for shorebirds (Bulleri, & Chapman, 2010; Dungan, 2008; Walker, Schlacher, & Thompson, 2008). As storm activities are expected to intensify and increase in frequency due to climate change, shorelines will be migrating inland at a faster rate (Defeo *et al*., 2009). If beaches are not given the appropriate space to retreat and be supplied with coastal sediment, they will erode away.

1.2.4 Water Quality and Land Pollution

Water quality and litter also impair beach ecosystems and recreational use. Coastal waters may be exposed to a variety of toxic substances from both land-based and offshore sources (Brown & McLachlan, 2002). Litter left behind by beach visitors or waste washed ashore by the sea can be ingested by coastal wildlife leading to nutritional stress and jeopardizing their survival. Fertilizer and pesticide runoff, raw sewage, and storm water pumped into the sea, create organic enrichment of the coastal waters (Brown & McLachlan, 2002). Over time, this decreases oxygen tension in the sand and enlarges the anoxic black sand layer found on polluted beaches (Brown & McLachlan, 2002). A surplus of nitrogen content in coastal water may also lead to toxic algal bloom and to eutrophication, depriving beach biodiversity of appropriate oxygen levels (Brown & McLachlan, 2002). Water pollution also causes distortion in the beach nutrient cycle provided by the beach ecosystem (Brown & McLachlan, 2002).

Proliferation of *E. coli* bacteria in coastal waters is also a hazard for beach recreationists and has resulted in many beach closures in Nova Scotia (Beaton, 2008). This bacterial pollution also contaminates filter feeders buried in the sand, including many shellfish traditionally harvested in Nova Scotia (Beaton, 2008). In fact, in 2010 all shellfish harvesting was prohibited due to bacterial infection of the bivalve within five kilometers of Queens, Shelburne, Yarmouth, Digby and Annapolis counties (DFO, 2010).

1.2.5 Biodiversity Loss

The biological diversity of Nova Scotia's beaches is threatened by a variety of management issues including bait and shellfish harvesting, biological invasions, and species at risk. Shellfish, such as Soft-shell clams (*Mya arenaria*), Quahogs (*Mercenaria mercenaria*), and Marine worms (*Glycera*) are both recreationally and commercially harvested on mudflats, intertidal beaches and estuaries (Beaton, 2008). Though shellfish closures, harvesting permits, and other regulations control this type of fishery, the extraction of many shellfish species allows for a large ecological impact (Beaton, 2008). Shellfish are often found in patches, which makes their targeted depletion more accessible for harvesters (Defeo *et al*., 2009). In addition, to access bait and shellfish, diggers have to turn over the sand and create a physical disturbance, leading to accidental death and injury of non-targeted species and habitat destruction (Defeo *et al*., 2009). Over-exploitation of bait species also directly impacts endangered shorebirds that depend on this resource for food, leading to population displacement (Defeo *et al*., 2009).

Invasive species are yet another issue which threatens the ecosystem integrity of Nova Scotia's beaches. Coastal environments are prone to biological invasions due to the high concentration of marine shipping and transport activities, which act as a vector for exotic species. Dry-ballasts, used by the eighteenth century shipping industry, contributed to the invasion of the European green crab (*Carcinus maenus*), which now dominates Nova Scotia's beaches as an omnivorous predator, creating additional pressure on the bivalve population (Beaton, 2008). Invasive species such as Dead man's fingers (*Codium fragile*), Smallmouth seabass (*Micropterus dolomieu*), MSX Oyster parasite (*Haplosporidium nelsoni*), and the Sea vase tunicate (*Ciona intestinalis)* have disrupted beach ecosystem functions and directly compete and hybridize with endemic species and thus weaken native biodiversity (NSDNR, 2010).

In fact, over 60 species found in Nova Scotia are determined to be at risk and where many use beaches at least partially in their life cycle (Mersey Tobeatic Research Institute, 2008). Though a variety of at risk species use beach habitats, the Piping Plover has dominated conservation efforts for this ecosystem. With only 40 breeding pairs, the Piping plover is one species for which Nova Scotia conservationists have dedicated much attention to its recovery (Mersey Tobeatic Research Institute, 2008). However, many other shorebirds, waterfowl, reptiles, mammals, fish, plants, and insect species (including migrating species) are under threat due to habitat loss and environmental degradation induced by human activities described above.

1.3 Conclusion

Nova Scotia's beaches are threatened by many human activities and natural changes, which has forced governments to engage in coastal planning to alleviate coastal erosion and degradation. However, beaches are not simple landscapes to manage. They are complex socio-ecological systems referred to as the beach environment; which encompass interacting natural, socio-cultural/economic, and management sub-systems.

Oceanic currents and tidal forces heavily influence the natural system, which then shapes the beach profile and influences the fauna and flora composition and abundance. Any activities that involve sand budget disturbances will alter physical beach characteristics and negatively impact its biota and ability to perform ecological services. This also has important consequences on the socio-economic sub-system since many commercial and recreational activities such as tourism, fishing, and shellfish harvesting depend on the quality of the sandy beach natural system. The management sub-system is also very complex due to the large number of stakeholders involved and the internal and external conflict between management units. This is mainly due to the multi-jurisdictional nature of the intertidal environment, where management responsibilities and priorities overlap and create inconsistencies within the management sphere. In addition, incompatible cultural models concerning sandy beach conservation and use add to the complicated legislative mix.

Overall, sand mining, poor water quality, land based litter, coastal squeeze, coastal biodiversity loss, and invasive species are not only issues affecting the natural system, but the sandy beach environment as a whole; threatening Nova Scotia's livelihoods and well-being, now and in the future. Though heavy bureaucracy and deep-rooted stakeholder conflicts may be inevitable, sandy beach environments must be preserved, protected and functional for the benefit of all. An integrative approach to beach management, where socio-ecological components are inventoried and assessed, is a clear step towards this goal.

CHAPTER 2: APPROACHES TO BEACH MANAGEMENT

2.0 Introductions and Context

The dynamics of the coastal zone, and the view of sandy beaches as mere recreational grounds, have traditionally oriented beach management towards reactive approaches focusing on two human-use components: coastal hazards protection, and recreational-use planning (Ariza, Jimenez, & Sarda, 2008; Ariza *et al*., 2010; James, 2000; Klein, 2001; Schlacher *et al*., 2008). In fact, beach managers have often used engineered technologies and techniques, focused on sand budget alteration, to counter the degrading state of beaches and secure their recreational value (Ariza *et al*., 2008; Dugan *et al*., 2008). For centuries, local authorities have used hard engineering structures (*e.g*. sea walls, riprap, jetties, groynes) as a solution to avoid local beach loss associated with natural coastal processes (Dugan *et al*., 2008, as cited in Nordstrom, 2000). Ironically, seawalls are also drivers of sand erosion and accentuate beach loss (*i.e.* placement loss) leading to a significant reduction of species diversity and abundance (Dugan *et al*., 2008). In addition to hard protective structures, North American and Western European coastal states are now prioritizing soft engineering methods (*i.e*. beach nourishment, beach restoration), which consists of mechanically importing sand onto an eroding beach, also leading to negative environmental impacts (Brown & McLachlan, 2002; Nordstrom, 2005; Speybroeck *et al*., 2006).

Underlining these beach management strategies, lies a consumer-based approach, converging towards a "clean", "comfortable", and "aesthetically pleasing" beach experience, providing an "attractive" and safe playground for its visitors, without much consideration for other environmental factors (Ariza *et al*., 2008). This oversimplified vision of the beach environment has led to the standardization of beach management practices, poorly adapted to local environments (Ariza *et al*., 2008), inducing further degradation and conflicts within the management sphere.

In fact, as discussed in Chapter 1, sandy beaches are complex, multi-faceted environments where natural, social, economic, cultural, and management units interact as a subset of ICZM. Since the adoption of the United States Coastal Zone Management Act in 1972, which seems to have engaged ICZM initiatives throughout the globe, the concept of managing coastal environments with an integrative, holistic, and ecosystem-based approach has been heavily suggested in the beach management literature (Ariza *et al*., 2008; James, 2000; Schlacher *et al*., 2008; Williams & Micallef, 2009). Therefore, though the protection against coastal hazards and supporting recreational use of beaches are important factors to consider, sandy beach management also needs to address the maintenance of other economic benefits derived from beaches, regulate renewable resources extraction, and include the protection and conservation of its biodiversity (Schlacher *et al.,* 2008). Unfortunately, aside from a few leading nations such as the USA, The Netherlands, and Sri Lanka, most coastal countries, including Canada, have yet to implement their national ICZM plan (Williams & Micallef, 2009). In this context, regional and local authorities need to rely on established conservation tools applied in other marine systems, or support the development of new ones to address the conservation and management of sandy beaches (Schlacher *et al*., 2008).

This chapter proposes an environmental function analysis (EFA) as a beach conservation and development planning method, which can be applied to the province of

Nova Scotia. First, a review of some of the mainstream conservation planning tools and innovative approaches to beach management are described and placed into regional context. Second, a list of objectives that highlights the management potential of EFA is presented. Third, a thorough background of the EFA methodology, and descriptions of indicators used are given. Finally, the study areas used in the application of this EFA method are portrayed to provide the maximum amount of socio-ecological context to the analysis.

2.1 Beach Management Tools

There are a variety of coastal conservation and development planning tools that can be applied to sandy shores. For example zoning, one of the oldest and most commonly used coastal spatial planning tools, is also described as the most effective management technique to address incompatible uses on the coast (Kay & Alder, 2005). Assigning geographically distinct regions to specific uses, zoning may assign conservation and protection sectors to the coastal zone, which can also be implemented in a variety of socio-economic, cultural, and political contexts (Kay & Alder, 2005). The basic principles of zoning have also influenced the model for marine protected areas (MPAs) such as the biosphere model, which incorporate a core area (strictly protected), buffer zone (strictly delineated), and transition zone (Kay & Alder, 2005). The application of MPAs and MPA networks has been recognized by international and national agreements and conventions (*e.g*. Convention on Biological Diversity, Health of the Ocean Initiatives (2007), Canada's Federal Marine Protected Areas Strategy (2005)) to be effective tools in restoration and conservation of biodiversity (Banks & Skilleter, 2010; Landry & Smith, 2008). To increase their conservation efficiency and systematic approach to marine conservation planning, MPAs are now being designed using systematic conservation planning (SCP). This technique uses geographic information system (GIS) data, which are then incorporated into conservation planning software, such as MARXAN (Harris *et al*., 2011). This program uses simulated annealing (SA) of algorithms to propose optimal solutions, and alternatives for the implementation of MPAs to coastal managers (Harris *et al.,* 2011).

The primary issue with applying these conservation options in sandy beach environments is the lack of biological data and spatial information associated with habitat and species available at local scale (Banks & Skilleter, 2010; Harris *et al*., 2011; Schlacher *et al.,* 2008). These knowledge gaps are filled using ecosystems surrogates based on the combination of various information derived from physical geography (*e.g.* geomorphology, coastal geography, oceanography, climatology), and integrated in coastal conservation planning (Banks & Skilleter, 2002, 2010).

In Nova Scotia, the federal Department of Fisheries and Oceans (Oceans and Coastal Management Branch), in partnership with other coastal experts, are in the process of using this particular technique to classify Nova Scotia's coastlines, creating 28 distinct classes (A. Gromack, personal communication, July 6th, 2010). While this method is suitable for regional conservation planning, using eco-regions of 100 to1000s of kilometers, it is not designed for a finer scale (1-10s kilometers). Therefore, these biophysically distinct classes provide little insights on local variations that affect specific sandy beach environments. Since MPA and SCP are focused on maximizing conservation potential on relatively large spatial scale, these conservation tools are not fitted to guide beach development and evaluating beach management options.

2.1.1 Innovative Beach Management Tools

Nonetheless, there are other innovative beach management tools that have been proposed in the literature to address conservation, use, and development issues. Williams and Micallef (2009) have singled out three methods that are of "exceptional interest" for beach managers: dimension analysis (DA), environmental risk assessment (ERA), and environmental function analysis (EFA).

Dimension analysis, an evaluation tool best suited for the problem definition stage, uses a characterization approach from several social and psychological dimensions (*i.e*. substantive, spatial, quantitative, and qualitative), to analyze the scope and scale of the issues, providing management options (Williams & Micallef, 2009). Unfortunately, this technique focuses on bathing area management, which may not be a suitable for some beaches with low visitation in Nova Scotia. Also, due to the high volume of data necessary of its analysis, this method is very time consuming.

ERA is an eight-step framework which aims to document the assessment process of a specific development project, evaluating all of its possible impacts to provide quantifiable information for the decision-making possess (Williams & Micallef, 2009). Though this is a process that would provide complete information on individual sandy beach environments in Nova Scotia, it can only be applied after a development project is proposed. To enhance proactivity in sandy beach management in Nova Scotia, the province needs a practical tool that will help evaluate conservation and development potential before proposals are to be examined by coastal managers.

The EFA method, based on assessment of ecological and socio-economic components, evaluates and ranks environmental quality and development potential indicators to assess multiple beaches simultaneously. This method is relatively rapid, simple, and is cost effective. In fact, EFA method uses small data sets, requires readily available data, and can be applied by any coastal manager or municipal land-use planner without extensive natural or social science expertise. Another advantage to this method is its focus on the evaluation of beach goods and services, and social and economic components, which makes it a perfect complement to ICZM (Williams & Micallef, 2009). Therefore, the use of an EFA to support decision-making on beach conservation and development planning seems the most appropriate for Nova Scotia.

2.2 List of Objectives

The following objectives are undertaken on this basis:

- Select and define environmental quality indicators for different environmental components (ecological and socio-economic), relevant to beach environments in Nova Scotia.
- Choose appropriate case study areas to apply the EFA (*i.e.* in the context of time and resource restraints related to this graduate project).
- Reduce the data/time burden associated with EFA by providing easily identifiable environmental quality indicators, which also solicits assessor judgment and expertise when ranking each indicator.
- Create aggregate indices and proxies to make EFA more practical in data-poor environments
- Identify sandy beach areas (using a conservation/use development matrix) where high conservation values or development potential guides appropriate management actions.

- Determine which management decisions (affecting a specific environmental indicator), can most effectively affect the conservation/use development potential of beaches.
- Discuss the optimal management action for the selected sandy beaches.

2.3 Environmental Function Analysis (EFA): Historical Development

Originally referred to environmental function evaluation, EFA was designed to merge conservation and land-use value of ecosystems and provide decision-makers with a systematic and objective approach to management. Here, the ethical approach (*i.e*. all living organisms have an equal right to live and prosper) is joined with the utilitarian argument (*i.e.* humankind is heavily dependent to ecosystem natural assets for its survival) to support nature conservation (de Groot, 1992). He defines ecosystem function, as the capacity of the natural environment and to satisfy human needs either directly or indirectly. The author also underlines the importance of socio-economic and cultural parameters in defining those needs, whether they are physiological or psychological. Inspired by the *Hierarchical Model of Ecosystems* (van der Maarel & Dauvellier, 1978; Braat *et al.*, 1979), de Groot (1992) categorized ecosystem functions into four main groups, now more generally called ecosystem goods and services:

1. Regulation functions— relate to the capacity of natural ecosystems to regulate fundamental ecological processes responsible for the maintenance of healthy environment such as clean air, water, and soil.
2. Carrier functions—provide space and substratum for human activities (*i.e.* habitation, agriculture, leisure).

3. Production functions—provide a variety of renewable and non-renewable resources usable for food, construction, energy, and future needs.
4. Information functions—relate to psychological health services provided by the natural environment: reflection, spirituality, and mental development. Also refers to all other functions that have not yet been documented.

The 37 different ecosystem functions of these four categories are listed in the following table. Most of these ecosystem functions can be associated with the sandy beach environment.

Table 2. Functions of sandy beach environments (from: de Groot, 1992).

Regulation Functions
1. Protection against harmful cosmic influences 2. Regulation of the local and global energy balance 3. Regulation of the chemical composition of the atmosphere 4. Regulation of the chemical composition of the oceans 5. Regulation of the local and global climate (incl. hydrological cycle) 6. Regulation of runoff and flood-prevention (watershed protection) 7. Watercatchment and groundwater-recharge 8. Prevention of soil erosion and sediment control 9. Formation of topsoil and maintenance of soil fertility 10. Fixation of solar energy and biomass production 11. Storage of recycling of organic matter 12. Storage and recycling of nutrient 13. Storage and recycling of human waste 14. Regulation of biological control mechanism 15. Maintenance of migration and nursery habitats 16. Maintenance of biological (and genetic) diversity
Carrier Functions
1. Human habitation and [First Nation, Aboriginal, Métis] settlement
2. Cultivation (crop growing, animal husbandry, aquaculture)
3. Energy conversion
4. Recreation and tourism
5. Nature protection
Production Functions
1. Oxygen
2. Water (for drinking, irrigation, industry, *etc*.)
3. Food and nutritious drinks
4. Genetic resources
5. Medicinal resources
6. Raw materials for building, construction and industrial use
8. Biochemicals (other than fuel and medicines)
9. Fuel and energy
10. Fodder and fertilizer
11. Ornamental resources
Information Functions
1. Aesthetic information
2. Spiritual and religious information
3. Historical information (heritage value)
4. Cultural and artistic inspiration
5. Scientific and educational information

Cendrero and Fisher (1997) took this ecosystem functions concept even further and proposed a methodological framework for the assessment of environmental quality of the coastal zone for planning management. The methodology first requires defining the area boundaries and identifying homogenous units within it. Second, regions are defined in term of environmental parameters, which include both natural and human characteristics. The original work suggests an exhaustive list of 80 environmental indicators assessing 27 different ecological and socio-economic components, which are used to monitor change and allow for comparison between each coastal site (Cendrero & Fisher, 1997). After indicators are selected, they are weighted according to their importance, and scored (1 to 3) according to their performance (*i.e.* worst, intermediate, best). The results obtained are used to construct normalized conservation (M-P) and use/development (M-N) indices (ranging from 0 to 1) which can be plotted in XY space to define qualitative regions (Figure 3).

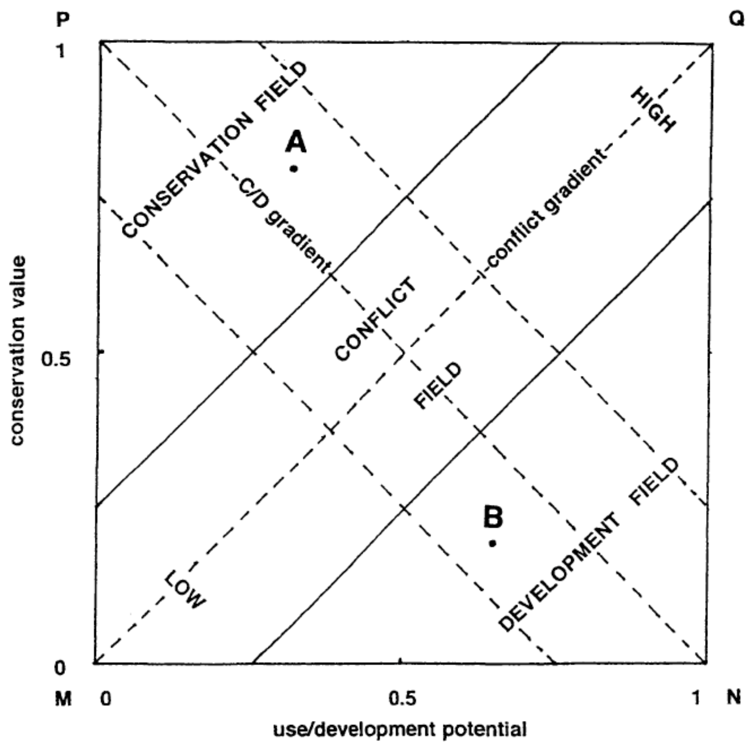

Figure 3. Conservation/use development matrix (from: Cendrero & Fisher, 1997).

On this conservation/ use development matrix, a coastal ecosystem found in the upper left corner (site A) indicated high conservation value with low use/development potential. On the other hand, the bottom right corner of the matrix (site B) suggests high use/development potential with low conservation value. Thus, the ecosystem represented by site A should be favored for conservation while site B should be favored for development for human use. However, sites might fall anywhere along the P-N conservation/development ratio gradient, and above or below the M-Q diagonal (*i.e.* where conservation value can be higher or lower than its development potential) yielding different results (Cendrero & Fisher, 1997). In addition, because the precision of the values attributed to each index may be low, the authors suggested a third zone referred to the conflict field, representing a region where conservation value and use-development potential are more or less similar. The M-Q diagonal also represents a gradient of conflict amongst conservation and development stakeholders. It was suggested that conflict between sites should be directly addressed using thorough socio-ecological based studies (van der Weide *et al.,* 1999). Finally, the central square of the conflict field is described as a zone for low definition (Cendrero & Fisher, 1997), where management decision can push results to either the conservation or development field.

Later, van der Weide *et al.* (1999) modified this framework, deemed too complex, by reducing the number indicators to 55, eliminating the weighting system, and replacing it by a simpler normalization operation. They then successfully applied the framework to compare two coastal wetlands in Turkey. In this analysis, van der Weide *et al.* (1999) underlines a few weak points concerning the methodology. First, the authors considered the overrepresentation of ecological components versus human aspect, which leads to a conservation bias. They also qualified the method as "too subjective" due to the lack of reliable quantitative data available for many ecological components, such as local water quality, pollution, *etc.* (Micallef & Williams, 2003; van der Weide *et al.,* 1999).

Micallef and Williams (2003) were the first to apply the EFA methodology on sandy beach systems, successfully evaluating the conservation/use development potential of four popular bathing sites in the Maltese Islands, and providing useful planning management advice. This first utilization of EFA on sandy beach environments was followed by Phillips *et al.* (2007), who conducted an application of EFA on 15 sandy beaches on the southwest coastline of the UK. Though these authors also proposed tweaked environmental indicators to match local conditions, the main contribution, was to propose a 5-point scale over a 3-point scale for the evaluation of indicators. In fact, four of the beaches analyzed moved from the conflict field to the use-development field after it was assessed with the 5-point scoring, providing better results and a clearer vision of the selected sites (Phillips *et al.*, 2007; Williams & Micallef, 2009).

2.4 Methodology Limitations and Proposed Modifications

Despite the successful application of the EFA framework to guide decision-making for sandy beach management, the absence of accurate local environmental data remains the biggest obstacle to scientifically objective analysis. To counter this limitation, the use of proxy indicators is proposed, to effectively compensate for the lack of available biological data. In fact, in the absence of indicator data (*e.g*. local coastal water contamination levels), scientists have relied on combination of various qualitative (*e.g.* bad, moderate, good, best, *etc.*) and quantitative (*e.g.* %vegetation cover, beach width, *etc*.) variables to evaluate environmental quality on sandy beaches (Cendrero & Fischer, 1997; de Araujo & da Costa, 2008; Micallef & Williams, 2004). In order to increase the objectivity of the somewhat subjective indicator scoring process, a Delphic approach is used to avoid personal biases. Relying on expert opinions, this has been underlined in the literature as a forward thinking procedure in assessing environmental and socio-economic components when hard data is unavailable (Phillips *et al*., 2007).

In the present study, an attempt was made to use an equal number of ecological and socio-economic indicators. Also, to address the overrepresentation of ecological-based indicators over the socio-economic ones, leading to an unfair advantage for conservation over development (Micallef & Williams, 2003; Phillips *et al*., 2007; van der Weide *et al.,* 1999), the methodology use in this graduate project will use an equal amount of both. Furthermore, to simplify even further the field investigation and limit double counting, this methodology proposes to use a maximum of 20 indicators, which requires easily accessible data and proxy indicators.

By applying these modifications to the methodology, it is expected that results yield will reveal with more precision the socio-ecological state of the selected sandy beaches, and be user-friendlier.

2.5 Environmental Quality Indicators for Nova Scotia' Sandy Beaches

Most environmental components and indicators chosen (Tables 3 and 4) have previously been successfully used, and publish in peer-reviewed EFA literature. However, because the number of indicators has been restricted to 20, many of them have been merged, and original environmental components, characteristics, and indicators were created. Here are the descriptions of each novel ecological indicator, along with the assumption associated with them.

2.5.1 Ecological Indicators

Coastal water composition and aesthetic qualities have long been use in sandy beach classification and rating systems to enhance human health safety and promote particular sites for tourism (de Araujo & da Costa, 2008; Micallef & Williams, 2004). However, local water quality assessments are not done on a regular basis for Nova Scotia beaches. In fact, a common proxy indicator for water quality in the province is shellfish harvesting closures (Beaton, 2008). In addition to shellfish closures, river outputs will also be included. Rivers surrounded by high development are assumed to deliver more runoff including contaminants to coastal waters than rivers surrounded by low development. Therefore, the abundance of freshwater supply in relation to the adjacent landscape will be used as a proxy indicator for water quality. Unlike litter left on the beach by people and by incoming waves, which is another frequent indicator of environmental quality (de Araujo & da Costa, 2008; Micallef & Williams, 2004), landscape considerations have not been directly addressed in sandy beaches EFA.

Nonetheless, because of the crucial role of surrounding sandy dunes, coastal wetlands, nearby islands, or any other system on which beaches rely for the exchange of sand (Bird, 1996; McLachlan & Brown, 2006), the structure and integrity of the local landscape, is judged essential to beach conservation and should be evaluated. It is assumed that a sandy beach surrounded by other natural coastal habitats, will be more resilient to coastal processes, sea level rise, and human use.

Table 3. Ecological indicators.

Ecological components	Characteristics	Indicators
Coastal water	Water quality	Shellfish harvesting closures (frequency) & River outputs (presence/absence & residential development)
	Aesthetics condition	Litter (qualitative)
Landscape ecology	Ecosystems connectivity	Associated coastal ecosystems* (presence/absence & size)
	Management	Ecosystems of conservation interest* (abundance & size)
Coastal biota	Species diversity and abundance	Beach type* (slope gradient)
	Management	Species of conservation interest (abundance & diversity)
Hazards	Coastal erosion/damage	Dune erosion/boardwalk erosion & damage (qualitative appraisal)
	Coastal sensitivity	Coastal sensitivity to sea level rise/flood/storm and migration potential (NRCan hard data & backshore features)
Geological and topographic features	Quality	Sediment composition and size
Resources	Landscape	Visual quality (qualitative)

*Original indicators proposed for EFA of sandy beaches

Another new indicator in terms of sandy beach ecology is the presence (or absence) and size of other coastal ecosystems that are actively managed for the purpose of conservation. It is assumed that conservation efforts being implemented on other sites will indirectly improve environmental condition for adjacent sandy beaches and increase their conservation potential. This indicator follows a similar logic as the abundance and diversity of species of conservation interest (*i.e*. rare, endangered, endemic, migrating species area, wildlife areas, *etc*.), which increases the conservation value of a site (Cendrero & Fischer, 1997).

Marine and terrestrial species abundance and diversity has been extensively used as indicators for environmental quality (Cendrero & Fischer, 1997; Micallef & Williams, 2003; Phillips *et al*., 2007; van der Weide *et al.,* 1999). However, the absence of sufficient local data has made its utilization difficult in the present study. As discussed in Chapter 1, coastal biota composition depends on beach slope, exposure, and sand type (Bird, 1996; McLachlan & Brown, 2006). Therefore, the use of the beach slope/type as proxy indicator for species quantity and quality is proposed. For example, a very steep and narrow beach is expected to have low species abundance and diversity, and a highly dissipative beach slope is expected to support richer species abundance and diversity.

Coastal hazards including coastal erosion and coastal sensitivity to sea level rise will also be evaluated using primarily qualitative approach. The severity of dune/backshore erosion will account for coastal erosion, while coastal sensitivity to sea level rise data will be evaluated on two fronts: hard data provided by *The Atlas of Canada* (Natural Resources Canada, 2007) and beach migration potential. Because this federal agency has grouped coastal sensitivity data and expressed them in “eco-region” format, the potential for beach to migrate inland will add extra aspects to the indicator. For example, an undeveloped backshore may be a geomorphologic landscape ready to shelter a migrating beach (*e.g*. salt marsh).

Geological and topographic feature such as sediment composition and size has also been used commonly in the EFA methodology. Though sandy beaches with mixed sediment composition may be preferable for species diversity, it is argued that beaches with homogenous, medium-fine grain size are the targeted ecosystem to conserve. Thus, sandy beaches with higher pebble, gravel, or boulder composition are considered less desirable than all fine sand beaches.

Finally, the last ecological indicator is probably the most subjective of all: *Visual quality*. However, all the previous work on EFA of beaches have included this landscape characteristics, most likely as a way to underlined the non-extractive use values of beaches. This also relate to the informative ecosystem function of de Groot (1992) as unique beaches with “pristine” natural features are assumed to offer greater conservation values than developed, occupied, or exploited beach sites.

2.5.2 Socio-Economic Indicators

All socio-economic indicators chosen have been used in previous EFA (Cendrero & Fischer, 1997; Micallef & Williams, 2003; Phillips *et al*., 2007; van der Weide *et al.,* 1999). Only the Socio-Economic Status (SES) indicator is a merger of other indicators including employment rate, educational attainment (grade 12) and median income (Government of Nova Scotia, 2011). All distance data were measured using Google Earth and all population related data were obtained from the provincial 2006 census provided by the Government of Nova Scotia (2011).

Table 4. Socio-economic indicators.

Socio-economic components	**Characteristics**	**Indicators**
Human dimension	Potential for use	Mining (intensity) Fishing, digging (intensity) Recreation potential (abundance of other leisure sites: camping, kayaking route, surfing spots, cycling trail, *etc*) Parking (no. sites & place) Accessibility (no. Km to nearest highway) Land use (diversity and size: residential, commercial, aquaculture) Coastal development (dist. closest house, building, engineering structure) Population density (persons/km^2) Beach area (length X width)
	Wellbeing	Socio-economic status (employment rate, education grade 12 & median income)

2.6 Study Areas

A case study of four sandy beaches found in the Halifax Regional Municipality (HRM) was selected for the application of this EFA framework and includes: Rainbow

Haven Provincial Park (RHV), Conrad beach (CRD), Lawrencetown Provincial Park (LTN), and Martinique beach (MTQ). Though all beaches are subject to similar oceanic and wind-driven processes coming from the Atlantic Ocean, (Figure 4) local socio-ecological characteristics amongst sites are quite variable.

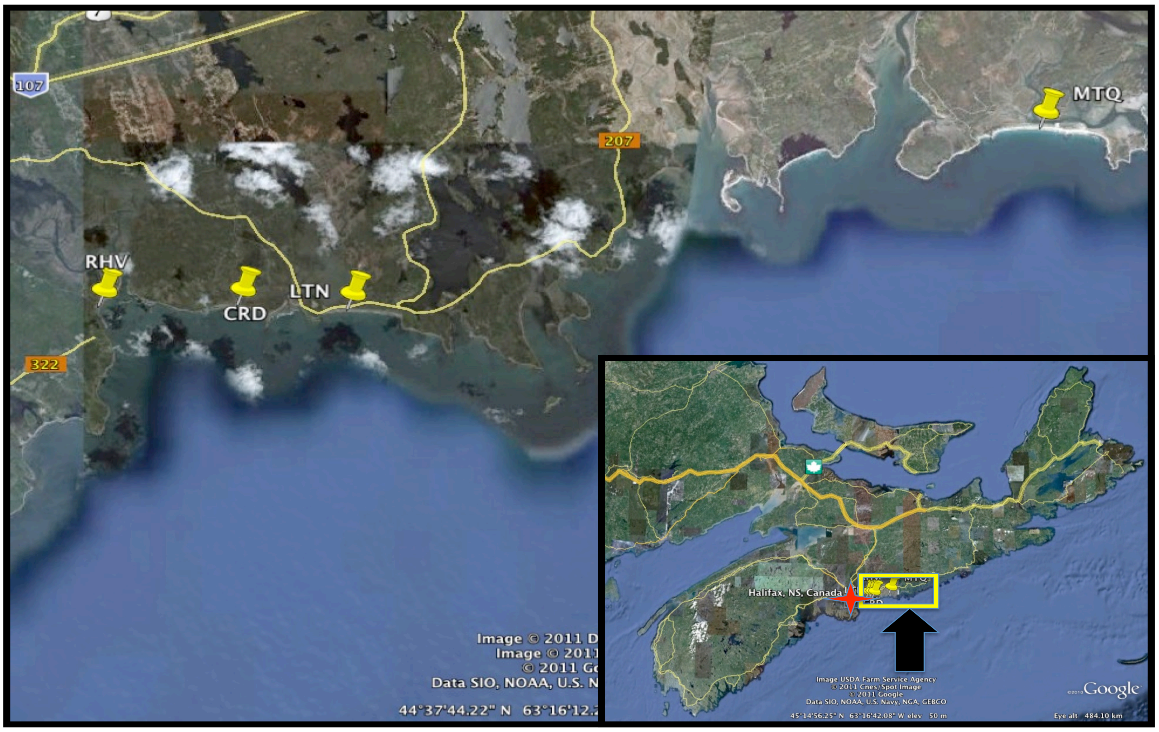

Figure 4. Location of beaches in the Eastern Shore of Nova Scotia.

2.6.1 Rainbow Haven Beach (RHV)

Rainbow Haven beach (44º38'42"N 63º25'13"W) is a *provincial park* characterized by sand, and cobble sediment with sand dunes of approximately 1.5 kilometers in length, covering 7.5 ha. This urban sandy beach is found in the community of Cole Harbour, which has one of the highest local population densities of all beaches found in Nova Scotia (278.6 ind. per km^2) and has among the highest socio-economic status (see Table 5). Rainbow Haven is also only 18 kilometers from the city of Halifax, making it one the most popular beach in the HRM region.

To support the incoming of visitors, RHV beach provides two parking lots of approximately 450-500 places. While one of these parking lots is situated on the backshore of the beach, they are both found within the beach-associated coastal wetland. Rainbow Haven also has boardwalks, which pass through the sand dunes, giving three access points to the beach. It also provides visitor facilities such as toilets, canteen, change house, and picnic tables. Litter is a constant problem at this beach and regular beach cleanup is necessary. Coastal erosion is also an important issue at this site where old and buried sand fences are reminders of past beach restoration efforts (Figure 5).

Figure 5. Dilapidated sand fences at Rainbow Haven Provincial Park.

This lifeguard-supervised beach is also situated near a camping site, cycling routes, and other recreational facilities. Finally, Rainbow Haven beach is surrounded by human development including residential construction, parking lots, connecting roads, and hard engineering structures, which obstruct the view to the Atlantic Ocean.

2.6.2 Conrad Beach (CRD)

Conrad beach (44º38'43"N 63º22'37"W) is both a *park reserve* (*i.e*. could be developed as a provincial park in the future) and a *protected beach* under the *Beaches Act.* This 1.75 kilometer long and 0.07 kilometers wide sandy beach (with some cobble sediment) is found 25 kilometer away from Halifax, in the community of Lawrencetown. Compared to Rainbow Haven, Lawrencetown has an intermediate population density (83.6 ind. per km^2; Table 5), and a rather elevated socio-economic status measured via local income and education level. While the sandy beach itself represents 12.25 ha, it also possesses a complex and large natural backshore composed of sand dunes, salt marshes, semi-permanent ponds, and an estuary, covering approximately 115 ha of coastal wetland. Also, this region is well known to provide habitat for endangered Piping plovers

With only 10 parking spots, the parking lot is not meant to receive many visitors at any one time. Furthermore, because it lies within a low marshland, the parking lot is sporadically closed during stormy periods for safety reasons, further limiting access to the beach. Aside from the unique boardwalk that gives access to the beach, there are no other facilities provided at this site.

Table 5. Community, populations, and selected socio-economic data of beaches (from: Government of Nova Scotia, 2011).

Beach	Rainbow Haven	Conrad Beach	Lawrencetown	Martinique
Designation	Provincial park	Park reserve, Protected beach	Provincial park, Protected beach	Provincial Park
Community	Eastern Passage	Lawrencetown		Musquodoboit Harbour
Beach Area (ha)	7.5	12.25	8.2	22.4
Population density (ind.per km²)	278.6	86.3		12.8
Median Annual Income ($)	32,835	35,020		28,683
Education Attainment (Grade 12+)	84.2	87.7		79.3
Unemployment (%)	28	26.7		42.4

2.6.3 Lawrencetown Beach *(LRT)*

Lawrencetown beach (44º38'37"N 63º20'18"W) also has a double designation, since it is a *provincial park* and a *protected beach* under the *Beaches Act.* This beach is 2.05 kilometers in long, 0.04 kilometer wide, covering approximately 8.2 ha. It is 26 kilometer from Halifax, and is the most popular beach in the area. The sand and cobble beach face is supported by a well-vegetated sand dunes system. However, Highway 207, which gives direct access to the beach's parking lots, completely disconnected the dunes with the coastal wetland backshore.

These four parking lots, which are all constructed along the coastline, provide beach visitors with a total of approximately 250 places. In addition, each parking lot offers two boardwalks, which cross over the sand dunes and give access to the beach. However, because of heavy storm related damage (Figure 6), only six of them are in usable condition.

Figure 6. Storm induced damage in Lawrencetown Beach Provincial Park.

Lawrencetown beach also provides inviting recreational amenities such as change house, toilets, a canteen, and picnic tables. This beach is most popular for its constant waves and surf, where strong rip tides and currents necessitate lifeguard supervision. In fact, Lawrencetown is famous as a board surfing location. A camping site is also found within a few kilometers of this beach.

2.6.4 Martinique Beach (MTQ)

Martinique beach (44º41'31"N 63º07'32"W) is a *provincial park* characterized by its white sand and sand dune systems. Its beach face is approximately 3.2 kilometer long and 0.07 wide, covering 22.4 ha of coastline. This beach is situated 55.3 kilometer away from the city of Halifax, in the small community of Musquodoboit Harbour. With the smallest population density (12 ind. per km^2), Musquodoboit Harbour is also the most socio-economically depressed area between the three regions (see Table 5).

The beach has two sections: a small pocket beach (0.3 km) and a long split beach (3.05 km). However the first beach section is not all crown land. In fact, half of the west portion of this small beach is privately owned, and flanked by residential development and a seawall. Nonetheless, for the 0.15km long crown-owned section, there is a boardwalk; three access paths, and a small parking of about 10 spots. The largest portion of the beach is found 300 meters further down the beach access road, which continues for nearly 1km along the backshore, at the landward edge of the dune system. This small road gives access to eight different boardwalks, and seven parking lots for which hold a maximum 10 places each. The long beach road and widespread parking lots not only erode the back dunes, but also disconnect the beach from its sandy backshore, made up of a highly productive coastal wetland and scattered islands.

In 1961, the Government of Nova Scotia protected 507 hectares of this wetland for waterfowl conservation purposes, creating the *Martinique Game Sanctuary* (NSDNR, 2011a). Twenty-six years later, the entire Musquodoboit Harbour Outer Estuary was deemed important for wetland conservation, and protected under the *RAMSAR Convention on Wetlands*. This 1,925 ha of wetlands include a complex landscape of intertidal mudflats, salt marshes, bogs and ponds, which are protected by the barrier beach against waves (NSDNR, 2011a). Nonetheless, because of its strong tidal currents, the harbour remains ice-free allowing Marine eelgrass (*Zostera*) and marsh fauna to proliferate, providing an oasis for staging and wintering bird species (Ramsar Convention on Wetlands, 2000). In fact, this region is a well-known feeding ground, especially for American black ducks (*Anas rubripes*) and Canada geese (*Branta canadensis)*, which have been recorded up to 6,000 of individuals in some years (Ramsar Convention on Wetlands, 2000). These species of conservation interest add to the endangered Piping plover, which usually nests between two breached dunes on the far east of Martinique beach (Figure 7).

Bayers Island, which was acquired by the Nature Conservancy of Canada (NCC) in 2009 to be protected from residential development, is yet another site of conservation interest near Martinique beach (NCC, 2009). Just at the east tip of the sandy beach, Bayers Island is a continuation of a sand/cobble/dune landscape (NCC, 2009). The spruce and balsam fir forested island also harbors many birds or prey and coastal birds such as the Osprey (*Pandion haliaetus*), Bald eagle (*Haliaeetus leucocephalus*), and the Great blue heron (*Ardea herodias*) (NCC, 2009). The island also has mudflats and eelgrass beds (NCC, 2009)**,** which are considered to be ecosystems of conservation interest.

However, feeding birds are not the only ones to use this abundance of mudflats and marine invertebrates. In a recent interview, provincial beach planner A. Lynds (personal communication, May 24, 2011) reported that this site it is also used by recreational and commercial clam and bait diggers. Unfortunately, the advance erosion of the sandy dunes is threatening this integrity of the entire system and the human activities it supports (Figure 7).

Figure 7. Breached sand dunes and exposed Piping plover nesting ground at Martinique Provincial Park.

2.7 Methods

After each ecological and socio-economic indicator was scored (1 = lowest/worst – 5 = highest/best) the results were normalized. For each component, the sum of the score allocated to each indicator was divided by the total maximum score. For example, at Rainbow Haven, coastal water quality is measured thought two indicators: the combination of shellfish closure frequency & river outputs (scored 2 out of 5), and litter (also scored 2 out of 5). Their sum (4) was then divided by the maximum value (5+5 = 10). Thus, 4/10 = 0.4, resulting in a normalized score. Similarly, the total score of all indicators for the conservation value and socio-economic potential were summed and divided by the maximum value. For example, for all ecological components, Conrad beach has a total indicator score of 40 (3+4+5+5+3+5+3+4+4+4 = 40), which was divided by the maximum possible value (*i.e.* score of 5 on 5 for the 10 indicator = 50). Thus, 40/50 = 0.8. This is the normalized score for the conservation value of Conrad beach. This normalization process is crucial in the absence of a weighting system because it permits for the standardization of the environmental indicators, which allows the underlining environmental characteristics to be compared between sites and underlines the components of low value for further scrutiny (Phillips *et al.*, 2007).

CHAPTER 3: RESULTS AND DISCUSSION

3.1 Results

The tabular results consist of two broad categories (Ecological and Socio-economic value; Table 6). Under each of these two headings are 7 aggregate indices consisting of mostly paired variables. The Human Dimension category is somewhat different since one of the subvariables (Potential for use) consists of aggregating 9 use variables.

These single variables are the primary source of data for each beach. Various levels of aggregation reduce the dependence of indicators on single variables and allow broader comparisons collated from these sources. As expected, examination of the individual variables shows that the more isolated beaches (Conrad and Martinique) have higher values among ecological variables, while Rainbow Haven and Lawrencetown have higher values in the socio-economic variables (Table 6).

Among the individual non-normalized variables, there was only a single 1, for Lawrencetown susceptibility to erosion/damage, due to the proximity of the boardwalk and parking lot to the dunes. There were however, a number of 5 values, related to conservation, management, and visual appeal for both Conrad and Martinique. Among the aggregate pairs, there was usually agreement between the two variables in raw scores.

Table 6. Value allocation and normalized score for four sandy beaches in HRM.

Environmental components			**Evaluation of Characteristics**			
Ecological value	**Characteristics**	**Indicators**	**RHV**	**CRD**	**LRT**	**MTQ**
Coastal water	Water quality	*Shellfish harvesting closures & River outputs*	2	3	3	3
	Aesthetics condition	*Litter*	2	4	2	3
		Normalized score	*0.4*	*0.7*	*0.5*	*0.6*
Landscape ecology	Ecosystems connectivity	*Associated coastal ecosystems*	2	5	2	4
	Management	*Ecosystems of conservation interest*	2	5	2	5
		Normalized score	*0.4*	*1*	*0.4*	*0.9*
Coastal biota	Species diversity and abundance	*Beach type*	3	3	3	4
	Management	*Species of conservation interest*	3	5	3	5
		Normalized score	*0.6*	*0.8*	*0.6*	*0.9*
Hazards	Coastal erosion/damage	*Dune erosion/boardwalk damage*	3	3	1	2
	Coastal sensitivity	*Coastal sensitivity to sea level rise & migration potential*	2	4	2	4
		Normalized score	*0.5*	*0.7*	*0.3*	*0.6*
Geological and topographic features	Quality	*Sediment composition and size*	3	4	2	4
		Normalized score	*0.6*	*0.8*	*0.4*	*0.8*
Resources	Landscape	*Visual quality*	1	4	2	5
		Normalized score	*0.2*	*0.8*	*0.4*	*1*
		Total	23	40	22	39
Normalized score for conservation values			***0.46***	***0.8***	***0.44***	***0.78***

			Evaluation of Characteristics			
Socio-economic value	**Characteristics**	**Indicators**	**RHV**	**CRD**	**LRT**	**MTQ**
Human dimension	Potential for use	*Mining*	n/a	n/a	n/a	n/a
		Fishing, digging	n/a	n/a	n/a	5
		Recreation potential	5	2	4	2
		Parking	5	2	4	4
		Accessibility	5	4	5	2
		Land use	4	3	4	2
		Coastal development	5	3	4	2
		Population density	5	4	4	2
		Beach area	3	3	3	5
	Wellbeing	*Socio-economic status*	4	4	4	3
		Total	*36*	*25*	*32*	*27*
Normalized score for use/development potential			***0.9***	***0.625***	***0.8***	***0.6***

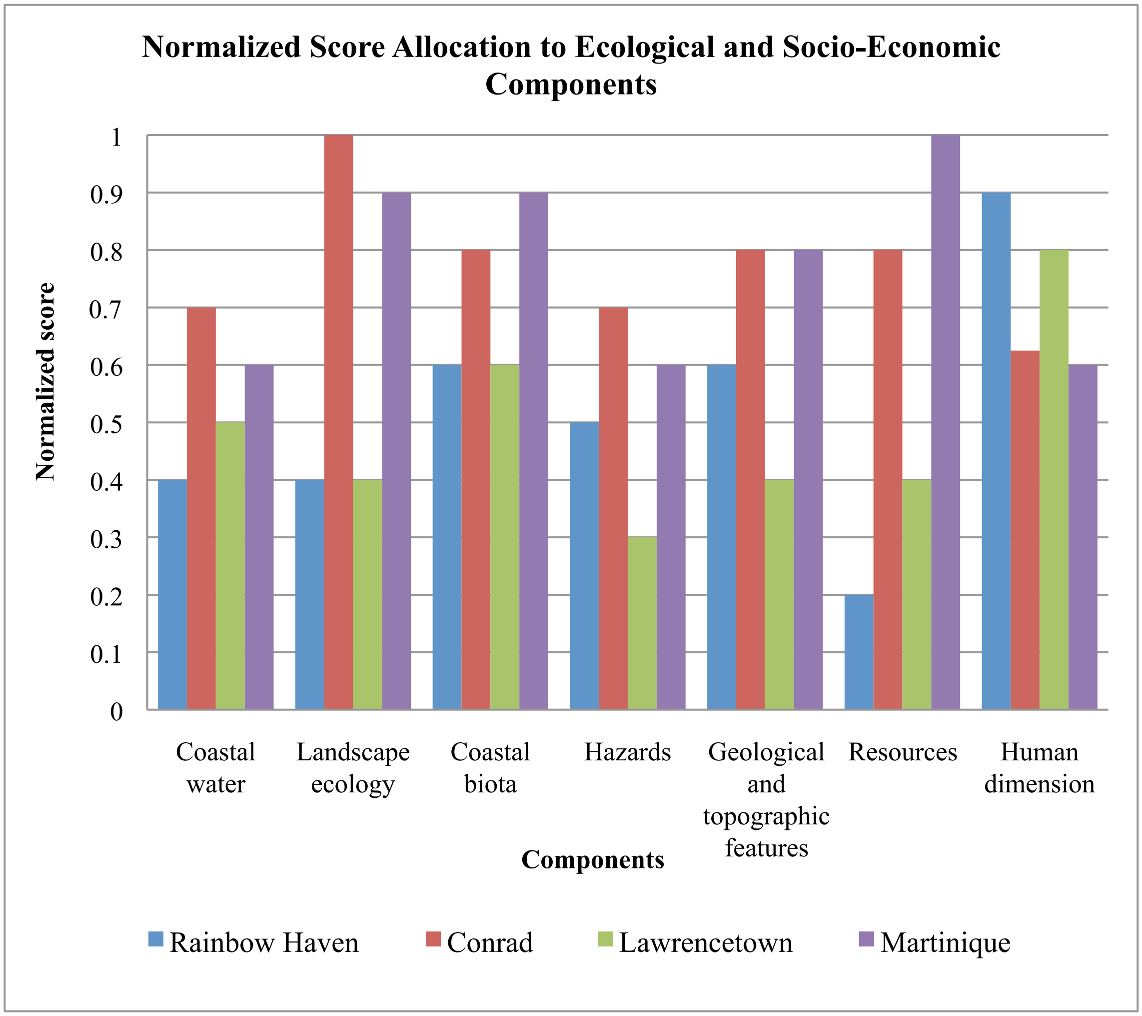

Figure 8. Comparison environmental quality components between the four sandy beaches studied.

The normalized scores for the aggregate indices are compared among beaches graphically (Figure 8), and certain trends are apparent. For example, it is clear from Figure 3.1 that the *Resources* component at Rainbow Haven (0.2) is substantially lower than all other sites analyzed (0.4-1.0). The low score allocated to the *Visual quality* indicator at Rainbow Haven (1 out of 5) explains this poor performance. Another ecological component that visually stands out for its low score is the *Hazards* component in Lawrencetown (0.3), explained by high coastal sensitivity to sea level rise, dune erosion, and boardwalk damage.

As suggested by the individual scores, it is also apparent from this histogram, that Conrad and Martinique beach have higher normalized scores for all ecological components than Rainbow Haven and Lawrencetown beach. The difference is especially significant for the components of *Landscape ecology* and *Resources.* In fact, Conrad and Martinique scored about 2x higher than Rainbow Haven and Lawrencetown for *Landscape ecology,* and received scores of 0.8 and 1 for *Resources* while Rainbow Haven and Lawrencetown received a low normalized score of 0.2 and 0.4 respectively.

On the other hand, the latter sandy beaches show higher normalized scores for the *Human dimension* component than Rainbow Haven and Martinique. This graph also shows that the normalized score of Rainbow Haven and Lawrencetown beach are often equal or in a very close range of one another. In fact, both beaches scored 0.4 for *Landscape ecology,* 0.6 for *Coastal biota*, while normalized scores of all other environmental components are no more than 0.2 apart.

In addition to the environmental components, the normalized score for overall conservation value and use/development potential was plotted for each sandy beach (Figure 9). This graphical illustration clearly shows which beaches have higher conservation value and lower development potential, which should be allowed higher protection level; and which ones have lower conservation value and higher development potential, where use and development should be favored. Specifically, Conrad and Martinique beach have higher conservation value and lower development potential, while Rainbow Haven and Lawrencetown beach have lower conservation values and higher development potential. This suggests that Conrad and Martinique beach be favored for enhanced environmental protection, while Rainbow Haven and Lawrencetown beach be managed for primarily for use and development.

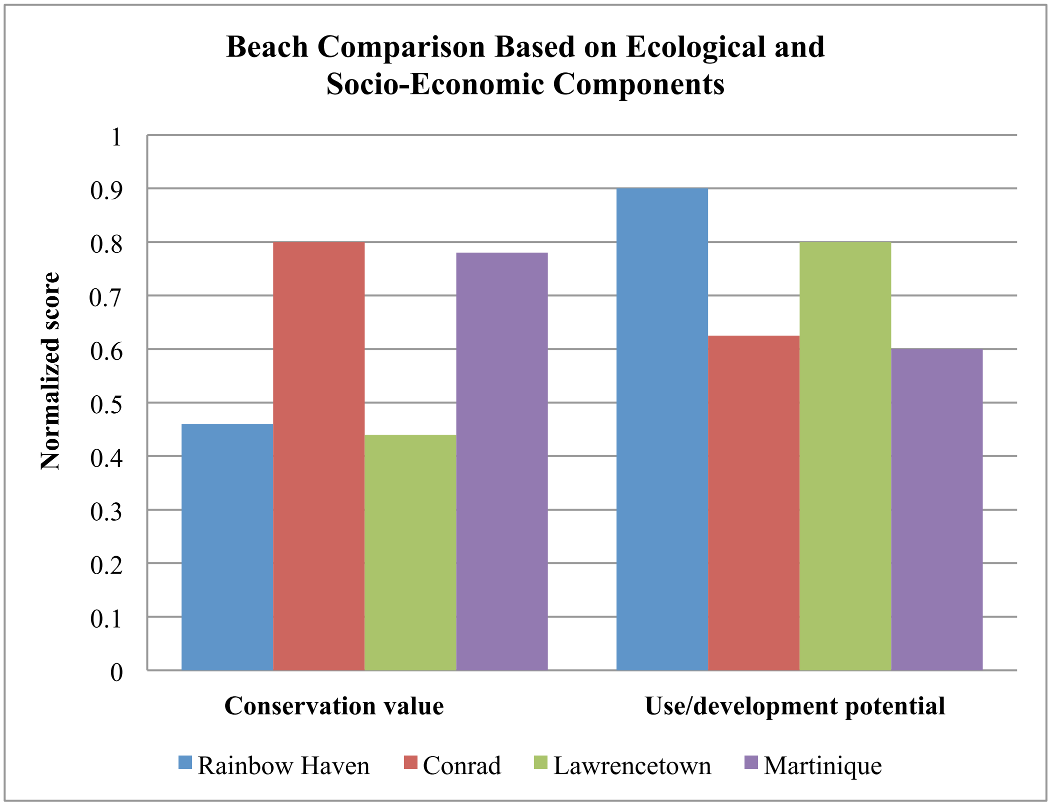

Figure 9. Sandy beach evaluation based on conservation value and use/development potential.

3.2 Discussion

The highest level grouping is shown as a bivariate comparison for the beaches (Figure 9). As mentioned previously, Rainbow Haven and Lawrencetown have lower conservation values and higher use/development potential, while Conrad beach and Martinique Provincial Park present higher conservation values and lower development potential. This initial analysis suggests that higher protection status be granted to

Martinique and Conrad beach. However, the conservation/use development matrix (Figure 10; see Chapter 2), illustrates a high degree of conflict at both Martinique and Conrad beach. While this suggests a deeper socio-ecological analysis to assist beach management at these sites, the dedication of Rainbow Haven and Lawrencetown to use and development is unambiguous.

3.2.1 Rainbow Haven Beach Provincial Park

With a use/development potential of 0.9, Rainbow Haven Provincial Park reaches the highest human dimension score of all other beaches studied. This is not unexpected due to its proximity to Halifax, high accessibility from the highway, large parking lots (which has been reported to overflow on peak season), and abundant recreational facilities. In addition, high population density, elevated socio-economic status, and abundant coastal development make this particular site prone to use and development. In fact, Rainbow Haven use/development potential outweighs its conservation value (0.46), leading this beach site well into the development region of the conservation/use development matrix (Figure 10).

The low score associated with many ecological components and indicators explains this outcome. For example, in addition to the high abundance of litter left behind by beach users and other debris transported on shore by waves, many small rivers and other waterways deliver contaminants to this coastal region, resulting in poor coastal water quality. In fact, these small rivers and waterways, which are found across Upper Lawrencetown, Cole Harbour, and Forest Hills, are surrounded by urban development, which contribute to the pollution load of these freshwater systems, then transferred to the coastline (Government of Nova Scotia, 2009).

Another important aspect affecting the conservation value of Rainbow Haven is its fractured coastal landscape. In fact, the two parking lots and roads connecting them are built on coastal wetland, creating impervious surfaces over vegetated sedimentary environments. Furthermore, the abandoned sand fences and close proximity of residential development seriously affects its visual quality. Although erosion is a legitimate concern all along the Atlantic coast, Rainbow Haven beach is somewhat more protected against the oceanic waves and less sensitive so sea-level rise due to its sheltered geography. However, the heavy recreational usage and coastal development associated with this site, obviates the significance this natural protection.

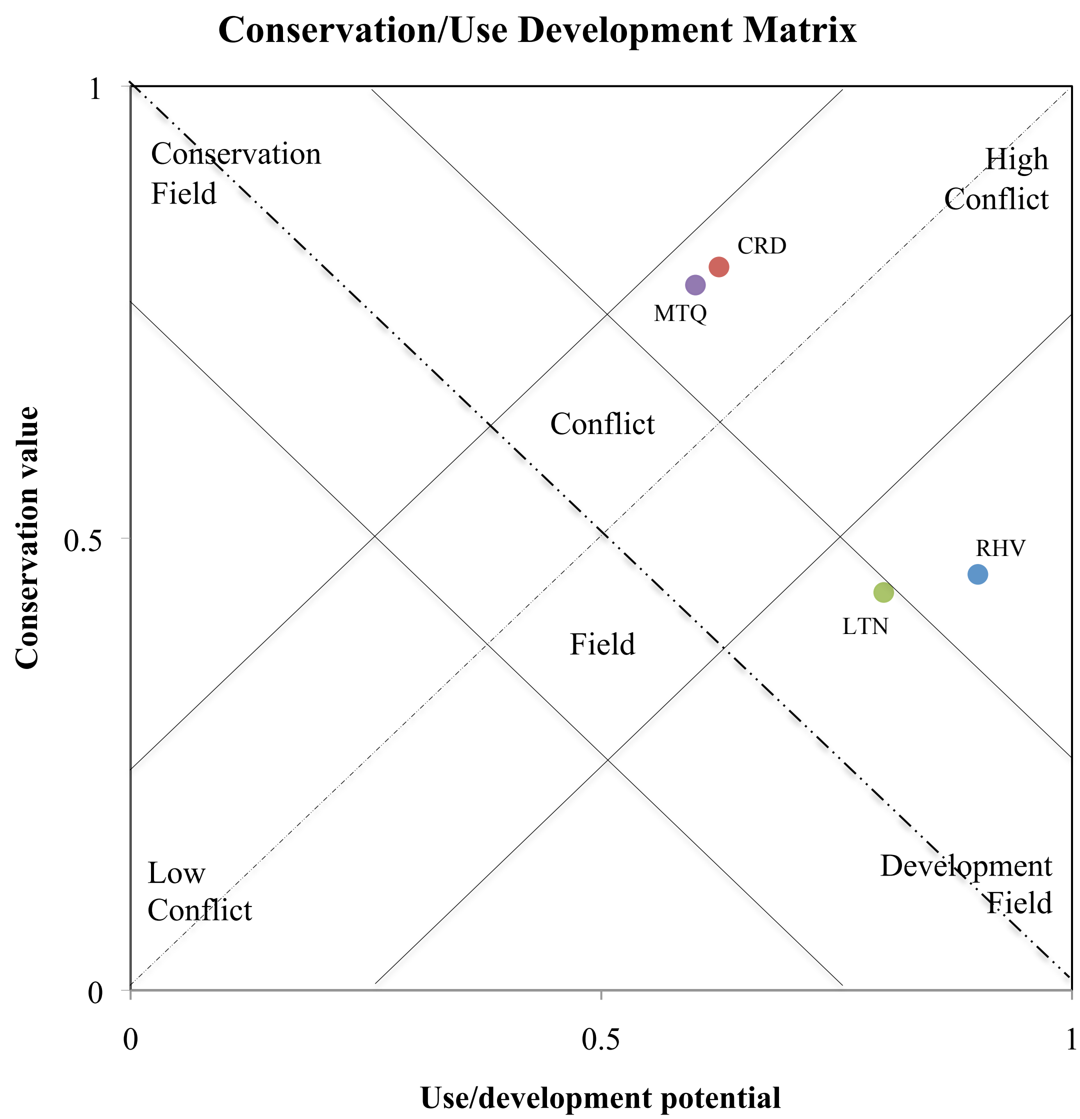

Figure 10. Position of the four beaches of the case study within the conservation/use development matrix developed by Cendrero and Fischer (1997).

3.2.2 Conrad Beach

As shown in Figure 9, Conrad beach received a normalized score for conservation value of 0.8 while its use/development potential (0.63), falls in the conflict field of the conservation/use development matrix (see Figure 10). While the ecological indicators of this site rated fairly high (3-5), many indicators of the human dimension also received high scores. In fact, Lawrencetown's higher population density, high accessibility, and elevated socio-economic status would suggest substantial potential for recreational use. However, its very limited parking space and the near absence of recreational facilities, holds back full development potential. In addition, high ecological values associated with coastal landscape connectivity, limited coastal development, and the presence of the endangered Piping plover as a species of conservation interest, opposes further use and development.

3.2.3 Lawrencetown Beach Provincial Park

With a normalized use/development potential score of 0.8 and a conservation value of 0.44, Lawrencetown beach conservation initiatives associated with its legal protection are overwhelmed by its intense recreational use, intrusive coastal development, high sensitivity to sea level rise, and low migration potential, leading this protected site to fall well into the development field of the matrix (Figure 10).

The popularity of its surf, high accessibility, and large amounts of parking combined with dense local population, with relatively high socio-economic status, explains this high use/development potential. In addition, the urban design associated with its recreational facilities and public roads fragments the sand dune system, which has accelerated the erosion process, negatively affecting its cumulative conservation value.

Though Lawrencetown beach is recognized as possible Piping plover nesting grounds (NSDNR, 2011b), it is argued that this fragile species will less likely choose such a highly disturbed site. Furthermore, the large amount of cobble sediment found at this site is thought to be inappropriate for these sandy beach-nesting birds.

3.2.4 Martinique Beach Provincial Park

Martinique beach received a normalized score of 0.78 for conservation value and 0.60 for its use/development potential, which suggests that despite a higher conservation value, use and development indicators scored fairly high. Consequently, Martinique Provincial Park falls within the conflict field of the conservation/use development matrix.

Martinique's high conservation value is readily associated with the high quality and abundance of its associated coastal ecosystems (*e.g*. seagrass meadows, salt marshes, bogs, mud flats, *etc*.), the presence of Piping plovers and other endangered wildlife, the high conservation interest of its adjacent ecosystems (Bayers Islands, Musquodoboit Harbour, and Martinique Game Sanctuary), its exceptional visual quality, and high migration potential. However, the advanced state of dune erosion, accentuated by the multiple boardwalks, parking lots, and beach access road, seriously hampers Martinique conservation value.

In addition, Martinique development potential is relatively high in part due to intense invertebrate digging activities and large beach area (22.4 ha), which suggests a higher carrying capacity of beach users. However, its use and development potential is also impeded by a low population density, long distance to the nearest highway (12.2 km), limited coastal development, and lower diversity of land-uses. Overall the difference between conservation value and use/development potential is not significant enough to avoid conflict (Figure 10).

3.2.5 Comparative Analysis

These results are consistent with previous EFA's on sandy beach systems. In fact, as Phillips *et al.* (2007) underlined, beaches found near large cities or towns, which have already been extensively developed for their recreational use, are found in the use/development quadrant of the matrix. As a result, these sites would benefit from enhance recreational facilities and services, while other better ecologically suited beaches would benefit form conservation efforts.

In this case study, it is suggested that both Rainbow Haven and Lawrencetown Beach Provincial Parks would benefit from further beach development and facilities restoration/embellishment. This is not to say that beach use and development may be done without regards to the natural sphere of the beach system. In fact, as emphasized by van der Weide *et al.* (1999), beaches that are managed for development should go through environmental impact assessment procedures to ensure that ecological impacts would be within "acceptable limits". Furthermore, these results also suggest a redistribution of the conservation efforts associated with Lawrencetown legal protection (*ie*. under the *Beaches Act*) to a more ecologically valuable beach.

For beaches found in the conflict field of the matrix, Phillips *et al*. (2007) and Micallef and Williams (2003) concluded that these sites are often found in region where high recreational and touristic facilities are available, and where wildlife is thriving. This is somewhat the case for Conrad and Martinique in slightly different ways. In the case of Conrad beach, though recreational facilities on the beach site are nearly absent (no toilets, or canteen), its proximity to other tourist conveniences near Lawrencetown could potentially correspond to an increase in visitor flow. However, it is suggested that the high demand for beach access associated with a large local population, high accessibility, and elevated socio-economic status, is actually more significant in driving Conrad's use/development potential. Similarly for Martinique beach, one of the main factors affecting the use/development score is not its recreational potential. Though some recreational facilities are present, it is actually the large beach area and the intense digging activity present in the lagoon behind the beach site that most contribute to the use/development potential score. However, in both cases the high ecological score is readily associated with rich biodiversity and presence of endangered species.

Due to the large diversity of local characteristics affecting sandy beaches in Nova Scotia, it is very difficult to assign a general pattern that would explain why beaches appear in the conflict field of the conservation/use development matrix. In fact, van der Weide *et al.* (1999) suggested that a deeper analysis of the socio-ecological conflict be done prior to adopting any type of management actions that would push the site either toward the conservation or development side, while the *status quo* can either lead to balance between the two realms (sustainable beach use), or to ecological degradation of the system (Phillips *et al*., 2007).

3.3 Scenario Analysis

After a crude analysis of how each environmental components affects each sandy beach, a scenario analysis can be used to determine with more precision which management decisions can most effectively affect the conservation/use development potential of beaches and direct it into the chosen field. This is most relevant to the case of sandy beaches found within the conflict field (Conrad and Martinique). However, because Rainbow Haven and Lawrencetown beach both fell into the development field, there is no pressing need for further analysis of these sites.

Since Conrad and Martinique beach are found closest to the conservation field, it is suggested that either an increase in their conservation value or reduction in their use/development potential would most effectively remove the beaches from the conflict field. However, in the case of Conrad beach, this seems to be impractical. First, with the exception of water quality, which scored 3, all its ecological components scored high (4 or 5), and changing any of them would not push Conrad out of the conflict field. Second, socio-economic factors that are most influencing the use/development potential are all related to environmental components that are not easily changed, nor that are socially desirable to change (*i.e.* socio-economic status, population density, accessibility to highway). Even if the parking were removed, this would only bring down the use/development potential of Conrad by 0.025, which is insignificant. In these circumstances, it is suggested that Conrad beach is in a state of sustainable use, and that any management initiatives that would aim at translocating it to the conservation field would be ineffective. Nonetheless, since the score of environmental indicators may change over time, this stable state could also change.

Since this pattern is not observed at Martinique beach, it is suggested that a scenario analysis would provide further insights on which management alternatives. For example, one management action that could improve the conservation value of Martinique would be to invest in a extensive dune restoration program that would include vegetation planting, removal of the beach access road and of the majority boardwalks that fracture the dune system. Properly restored dunes would increase coastal connectivity, reduce coastal sensitivity to sea level rise, reduce dune erosion, and potentially increase species abundance and diversity. These changes could increase the total ecological score for Martinique beach to approximately 43/50 pushing out of the conflict zone and into the conservation field (see Figure 11). Though this option might be time consuming and costly, it does not limit human use, except to reduce vehicle access.

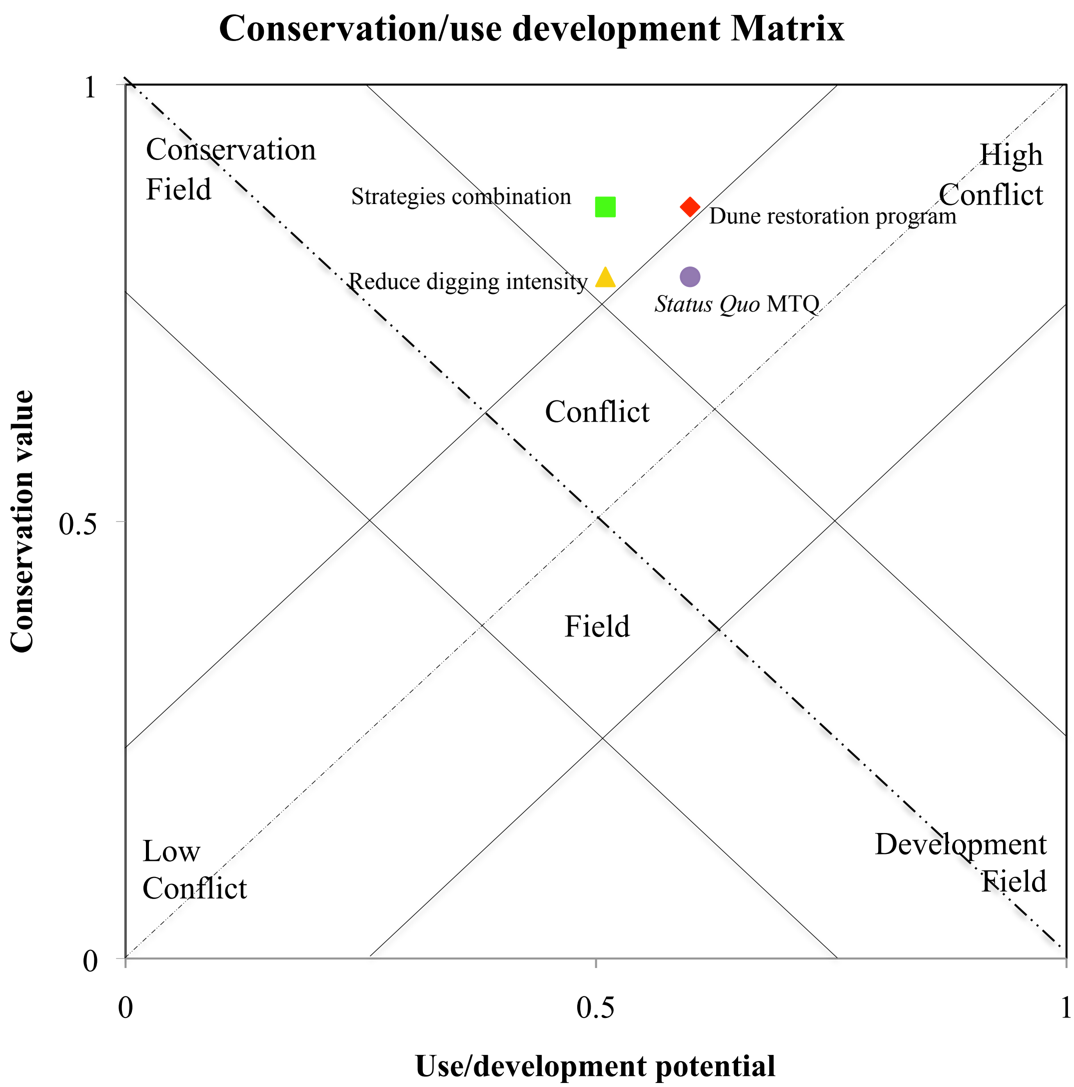

Figure 11. Scenario analysis using the conservation/use development matrix.

Another option that should be considered would be to decrease use and development potential by significantly reducing clam and bait digging intensity (from a

5/5 to a 1/5). This would also relieve Martinique from the conflict field, and move it into the conservation field. However, this could have serious socio-economic impact on the local community that depends on this resource for their livelihood.

Unfortunately, neither of these options would create condition in which Martinique would be a beach site found far in the conservation field. Only a combined strategy (increasing conservation potential and reducing use/development potential) would move Martinique beach further away from the conflict zone.

3.4 Sources of Errors and Uncertainties

There are various methodological and fundamental limitations associated with the use of an EFA to evaluate conservation values and use/development potential sandy beaches. First, the number of indicators used (20) is considerably lower than what other authors have evaluated (78 by Cendrero and Fischer (1997); 55 by van der Weide *et al.* (1999); 43 by Micallef and Williams (2003); 53 by Phillips *et al.* (2007)), leading to coarser results. Though many indicators proposed by the original work of Cendrero and Fischer (1997) were considered irrelevant for Nova Scotia (*e.g.* volcanic irruptions, tsunami frequency, earthquakes magnitudes), many others could have bring further insights and enhance results accuracy (*e.g*. local water pollution content, turbidity, terrestrial and marine biomass, erosion rates). However, the absence of hard biological and environmental data made their inclusion impossible and proxy indicators were used instead, which by default increases uncertainties associated with environmental quality evaluations.

The absence of baseline data for ecological components also creates an inequality between socio-economic and ecological indicators. In fact, all socio-economic indicators were supported by either updated NSDNR GIS data (derived from the Nova Scotia Topographic Database (NSTDB)), Nova Scotia Community Counts statistics (derived from 2006 census maps), or direct measurements using Google Earth. On the other hand, for the exception of *Coastal sensitivity to sea level rise* data, obtained from the NRC Atlas of Canada, and *Species of conservation interest*, obtained from NSDNR GIS species at risk layer, all ecological indicators were compiled using available management reports, field observations, and experts' opinions and experiences. Thus, these important biological and environmental information gaps, and the difference in the quality of data assessed between ecological and socio-economic components, are sources of uncertainties that filter down to the conclusions.

Though methodological limitations related to environmental data deficiencies can be significantly improved with field research and coastal resource inventories, the fundamental constraint of individuals' interpretations of indicators is less easily resolved. For example, Cendrero and Fischer (1997), van der Weide *et al.* (1999) and Micallef and Williams (2003) have all categorized renewable and non-renewable resources characteristics as ecological components, partly because these resources are protected and extraction is very restricted. Thus, their presence would increase a site' conservation value. On the other hand, Phillips *et al.* (2007) argued that if these natural resources were made available through development policies, their presence would increase the use/development potential for a region (*e.g*. sand mining, oil extraction). In the case of Nova Scotia, sand extraction does occur and though restricted under the *Beaches Act,* the

Minister can use his/her discretionary power and allow mining activity. Thus, the mere presence and abundance of sand does not guarantee conservation. On the other hand, the government of Nova Scotia has recognized sandy beaches and dunes as rare ecosystems that require conservation. In these circumstances, non-renewable resources (sand and other beach sediments) are represented in EFA as both as a socio-economic component (under sand mining) and as a non-extractive conservation values (under geological and topographic features).

Unemployment rate is yet another indicator that may be open to interpretation. Phillips *et al.* (2007) has argued that high unemployment rates support use and development potential because they offer available labour markets to establishing businesses and socio-economic benefits to the hosting region. However, in the case of this project, unemployment rates were statistically combined with education attainment and median annual income (*i.e.* socio-economic status). In contrast, it is argued that high economic status (thus, low unemployment) supports use and development potential, the rationale being individuals with more dispensable income are expected to engage in recreational activities, uses tourism facilities and purchase services more frequently than individual with lower socio-economic status. Thus, regions of higher socio-economic status are expected to be stimulated, supporting use/development potential.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

4.1 New Observations and Interpretations

Factors that seem to be ruling the environmental quality pattern on public sandy beaches in Nova Scotia, despite their conservation value score, are the negative effects associated with the invasive nature of park recreational facilities. Nova Scotia beach park urban design has indeed favored the maximization of beach access points while offering less adequate protection to ecological features necessary for the sustainable use of sandy beaches.

This pattern is clearly observable on Martinique beach where, despite a high conservation value, the abundant boardwalks, widespread parking lots, long access road, and the intense digging activities pushes this site in the conflict field of the conservation/use development matrix. On the other hand, Conrad beach, which might instinctively be though to have higher development because of its proximity to Halifax and high accessibility to the highway, has in fact a higher conservation ratio. Conversely, this result is primarily explained by the simplicity of access to the beach. In addition, its protected status under the *Beaches Act,* prohibits the removal of any resource from the beach and restricts other human activities that disturb wildlife.

In fact, the negative effects associated with the intrusiveness of coastal recreational facilities are especially appreciable on sandy beaches found on the Atlantic Coast. This is because Atlantic sandy beaches are much more sensitive to sea level rise and are fully exposed to intense storms, leading to accentuated erosion rates. Since these natural stressors are associated to global climate change, they are expected to increase in frequency and intensity over time (Defeo *et al*., 2009). Thus, it is anticipated that recreational facilities and related activities will further exacerbate ecological degradation and challenge the sustainable use of sandy beaches found on the Atlantic Coast.

In addition to sustainable planning on public beaches, the absence of a systematic approach to the designation of sandy beach protection under the *Beaches Act,* can lead to ineffective beach conservation strategy. The protection status of Lawrencetown Provincial Park is a prime example of a low conservation valued beach attributed a protected designation. Though the efficiency of the *Beaches Act* has been seriously critiqued, demanding its revision (see Appendix B), it is the only provincial legislation whose focus is to conserve oceanic sandy beaches in the province. Thus, any effort related to *Beaches Act* enforcement, should aim to maximize the positive effects it has on the environment.

Therefore, using a tool such as EFA, as a preliminary step, can provide useful information to decision-makers on which beach to focus conservation efforts, designate under the *Beaches Act*, consider use and development, or require further analysis to direct management.

However, as Micallef and Williams (2003) indicate, the observations and results obtain thought EFA are limited in time and space. In order words, the results presented in this project are bound to the specific time of evaluation (2011) and by the period the data was collected (2004-2011). Thus, any future reference to environmental quality trends on sandy beaches should first refer to a baseline before evaluating the sustainability of a particular site. Similarly, spatial characteristics of EFA must be taken in consideration especially when comparing environmental quality components of different size beaches or when the difference between socio-economic and ecological characteristics is large (*e.g.* Rainbow Haven Provincial Park). In such cases, further field work should be engaged to insure accuracy associated with the EFA methodology (Micallef &Williams, 2003).

Nonetheless, the EFA framework is an effective management tool that can be adapted to specific coastal environments by adjusting the environmental indicators. In fact, this valuation method can be use to:

- Built a baseline data on sandy beach environment quality
- Allow for comparison and contrast of different beach sites based on individual environmental components
- Provide insights on the most appropriate management planning (conservation vs. use/development)
- Prioritize sites based on conflict level and potential loss of conservation value
- Evaluate potential effects different management options may have on the sandy beach environment (*i.e*. scenario analysis)
- Support monitoring of environmental quality change on sandy beaches and other coastal systems.

4.2 Advancement of the EFA Framework

The EFA proposed in this research project is thought to be an improvement over previous versions. First, reducing the number of environmental quality indicators and components to 20 made the use of EFA more practical and effective for coastal planners. Second, in the absence of adequate data, combining environmental indicators enhanced their reliability and comprehensiveness. Introducing new environmental characteristics such as *Management* and *Landscape connectivity* embodies the integrative nature of sandy beaches, both at the social and ecological level.

Finally, contrary to many indicators proposed in previous EFAs, the ones chosen here can be monitored at low-cost, are relevant for other coastal management policy, and are easy for decision-makers and the general public to interpret, all of which are essential characteristics of environmental indicators (Frederiksen, Mavor, & Wanless, 2007).

4.3 General Conclusions

Overall, this novel application of EFA is found to provide useful socio-ecological insights for the planning and management of sandy beaches. In the context of the graduate project, four sandy beaches in HRM were analyzed according to the cumulative normalized score calculated from ecological and socio-economic indicators, and categorized according to their conservation value, use/development potential, and conflict level. Adapted from the Cendrero and Fischer (1997) methodology, results were plotted in a conservation/use development composed of three main fields (conservation, use/development, and conflict field) in which beach sites can be associated. This graphical illustration allows for a contrasting and comparing beach sites' ability to provide ecosystem functions necessary for ecological prosperity and human activities and development at a local scale.

Results have shown that beaches found near large urban centers and that have already sustained appreciable coastal development tend to fall within the development field of the matrix. Furthermore, beaches found in proximity to cities and large towns that shelter wildlife and associated coastal ecosystems, especially when of conservation interests, tend to fall within the conflict field. None of the beaches evaluated in the case study fell only solidly within the conservation field. However, based on results presented by van der Weide *et al*. (1999), Micallef and Williams (2003), and Phillips *et al.* (2007), it can be speculated that beaches found in the conservation field would be found farther away from urbanized settlements, be difficult to access, and show low to no coastal development.

Not only does EFA provide general observations allowing sites to be compared and contrasted, but it also gives useful insight on individual beaches allowing for better-informed decision-making and management. The simplified EFA methodology is user-friendly, provides conclusive results, while offering a cost-effective approach to beach evaluation.

The sandy beach environment is a complex multi-dimensional socio-ecological system that is highly threatened by various key human activities and natural processes. Though the input provided by EFA framework can only be part of the complex solution needed to address the various problems face by the coastal environment, it can be a substantial contributor to ICZM by providing the basis for discussions of conservation, use/development, and address conflict.

4.4 Recommendations

Though a systematic approach to the application of the *Beaches Act* using EFA is desirable in order to enhance the effectiveness of sandy beach conservation in Nova Scotia, it will not be sufficient to ensure beach environment protection or sustainable use. Some suggestions may be made for integrated beach conservation and improved beach management practices.

4.4.1 Sandy Beach Resources Inventories

Considering the high risk of degradation the sandy beach systems are facing, it is suggested that an integrated sandy beach management plan and proactive conservation strategy be implemented. However, before any type of planning can take place, beach managers must first be provided with up-to date biophysical data, through inventory of resources. Over the years, limited budget resources and project prioritization have seriously limited beach planners' access to essential coastal data that would allow for better-informed recommendations and management strategies. This adds to the already limited biophysical data found on the local scale (*e.g.* pollution level, water quality, erosion rates, species abundance and diversity, *etc.*). However, because beach resource inventories may require considerable time and resources, it is suggested that data related to sandy beach environment be collected from existing data found in different departments of NSDNR (GIS layers, scientific reports, point-counts, results of research studies, *etc.*). This information could then be digitized if necessary and transformed into GIS layers, increasing access to environmental data to facilitate future analysis. This collaborative effort to catalogue beach resources could subsequently be improved over time though appropriate field inventories.

4.4.2 Improved Provincial Beach Park Management Practices

Beach management plans are an integral part of their sustainable use. Unfortunately, none of the provincial beach parks rely on common or individual management plans, which seriously affect the ability to foresee issues, prevent degradation, and provide scenarios to enhance environmental sustainability of sandy ecosystems. In fact, observations and results gathered from this graduate project suggest that many beaches parks are not protected against degradation. In fact, many factors or ecological damage are pressured by the implementation of the provincial park facility design. Parks are more readily managed to enhance recreational use of beaches and prioritize aspects of security, waste, parking accessibility, *etc*. It is argued that, although these aspects are key to recreational beach management, they are too narrow in scope for sustainable beach management. Therefore, it is strongly suggested that individual beach management plans be developed for beach parks, and be supported by a clear sustainable approach to coastal tourism and recreation.

Since sandy beaches are so highly threatened, it is suggested that all activities and behavior occurring on public beaches be defined and regulated in order to avoid unnecessary harm. In other words, all existing beach regulations and allowed activities should be reviewed and be adjusted to reflect the management goal.

For example, the presence of dogs is tolerated as long as they are on leashed and controlled by their owner. Field observations and corroborated anecdotes conclude that many dog owners deviate from this beach regulation, allowing their pet to run free on the beach. The negative impact associated with wildlife harassment by dogs may be of serious concern, especially on beaches where endangered species are found. If it is found that dogs have indeed a significant impact on beach wildlife, potential solutions can be developed, consulted, and applied. (*e.g*. dog ban on protected beaches, dog beach parks, owners fine, *etc*.).

Another activity that has been tolerated in provincial parks is the use of ATV on its beaches for maintenance purposes. Though this is not a recreational use of an ATV, its use by beach keepers may have cumulative ecological impacts and send a mixed message to the public concerning motorized vehicle on sandy beaches. Though the negative effects associated with this activity may vary according to individual sites, it is suggested that these regulations and practices be reviewed and adjusted when necessary.

Another important aspect related to good beach management practice is the essential role of public education, permanent postings and public relations campaigns. Many Provincial Parks limits these public education postings to Piping plover notices, which is only one aspect of sandy beach ecology that needs conservation. In fact, information concerning coastal ecology, wildlife, and natural phenomenon can provide context for the public in order to appreciate the beach environment and comply with regulations. For example, properly labeled zones (*e.g*. “Please stay off dunes”) accompanied by a short explanatory text, can positively enforce beach regulations and support the development of environmental values for coastal environments.

4.4.3 Integrated and Committed Approach to Sandy Beach Conservation

As mention in Chapter 1, sandy beaches do not exist in isolation of other coastal systems. Thus, for sandy beach conservation planning to be comprehensive, it needs to take in consideration other surrounding ecosystems that are susceptible to negative impacts. An integrative approach to coastal conservation, which would include adjacent wetlands, islands, lagoons, *etc*. is necessary to provide appropriate measures susceptible to positively affect sandy beaches. In other words, a sandy beach conservation strategy may not be successful is it only concerns the region “seaward of the mean high water mark”, as defined by the *Beaches Act*. The implementation of intertidal protected areas along with integrated coastal ecosystem and habitats conservation strategy may offer interesting options.

To avoid further degradation of the sandy beach environment, more sandy beaches must be protected. A commitment to sandy beach conservation must be pursued using different approaches. First proposed is the EFA, which provides a systematic approach to effective beach conservation planning. The application of an EFA would allow identification of beaches that possess high conservation value, low development potential, and limited conflict. It is suggested that beaches found in the conservation field be attributed higher protection status.

4.3.4 Direction for Future Investigations

Integrated sandy beach management is a relatively young field (50 years) that offers many different opportunities for research. However, some subjects that would bring considerable insights involve:

- Public survey analysis (mapping beach activities and expectations)
- Beach conservation using community co-management
- The role of First Nations and Traditional Environmental Knowledge (TEK) in coastal conservation
- Best practices of conflict resolution between public and privately owned beach
- Investigating sandy beaches carrying capacity for recreational users.

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Appendix A

NOVA SCOTIA
Natural Resources

***Beaches Act* Designation Procedures Policy**

Approval

Approved By:

Approval Date:

Effective Date:

Review

Next Review Date:

To Be Reviewed By: Director of Parks and Recreation

History

Previous Revision: N/A

First Implemented: As of effective date

Beaches Act Designation Procedures Policy

March 31, 2009

Policy Statement

Under the *Beaches Act* the purpose of the Act is:

a) "Provide for the protection of beaches and associated dune systems as significant and sensitive environmental and recreational resources";

b) "Provide for the regulation and enforcement of the full range of land-use activities on beaches, including aggregate removal, so as to leave them unimpaired for the benefit and enjoyment of future generations;

c) Control recreational and other uses of beaches that may cause undesirable impacts on beach and associated dune systems. R.S., c. 32, s. 2."

Policy Objectives

To define the process that DNR will follow to consider a beach for determination under the *Beaches Act.*

To ensure that the review of a potential protected beach is consistently and fairly applied in all cases.

To ensure that the best recommendation possible is put forth with respect to consideration for determination under the *Beaches Act*.

Policy Guidelines

1. Public must have confidence in the process.

2. Science shall be foremost in the rationale as beaches are a dynamic system in which natural processes must be recognized and impacts understood.

3. Maintaining ecological integrity of the site is critical to maintaining ecological services, components and processes.

Procedures

Lead in the process will be the Parks and Recreation Division which has administrative responsibility within the department for the *Beaches Act*.

Other resources within and exterior to the department shall be accessed as required.

Should the area of interest for determination encompass Crown Land, an IRM review will be conducted.

Initial Considerations:

Protection of a beach or area of shoreline may be provided by a number of legislative tools, some of which may or may not be limited by land tenure.

The *Beaches Act* applies to "that area of land on the coastline lying to the seaward of the mean high watermark and that area of land to landward immediately adjacent thereto to the distance determined by the Governor in Council, and includes any lakeshore area declared by the Governor in Council to be a beach". For this Policy the emphasis is on those lands that lie landward above the mean high watermark and are commonly referred to as 'protected beaches' and have a defined boundary line.

The flow chart below (Figure 1), identifies land tenure as an initial decision point in the determination process. The *Beaches Act* may be applied to either privately owned land or provincially owned crown land. For an area of land that is entirely owned by the province, either the *Provincial Parks Act* or the *Beaches Act* may be utilized. The decision on which legislation is most appropriate is to be dictated by overall management objectives for the resource.

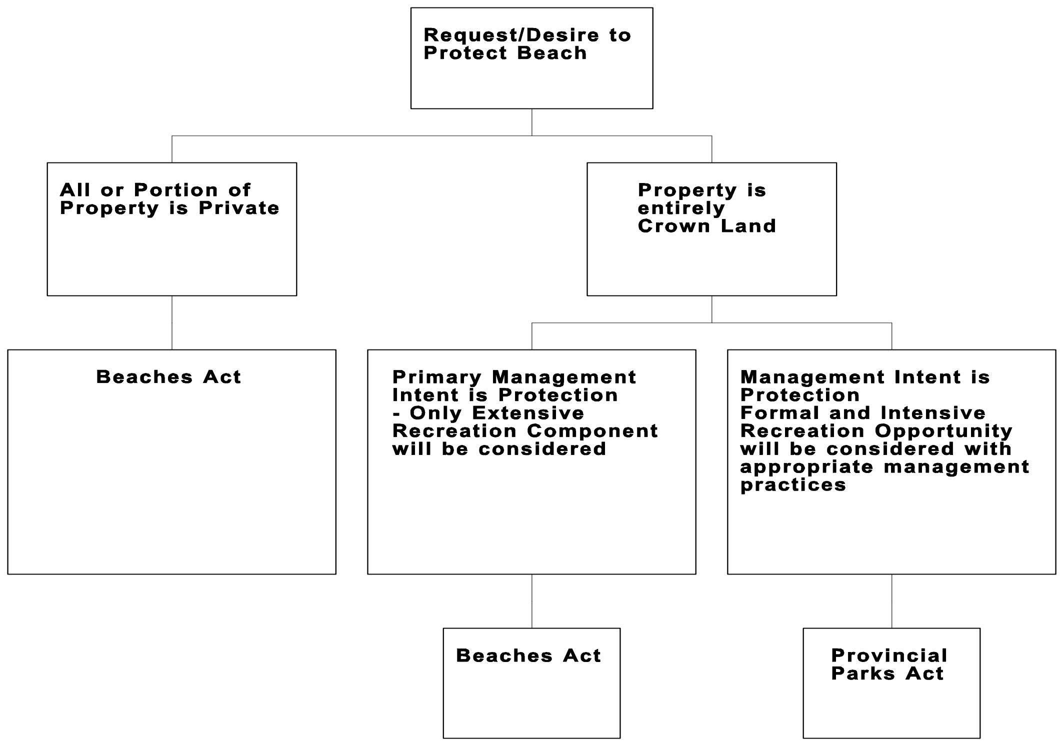
The *Beaches Act* is considered most appropriate when the primary objective is protection, with a secondary objective to provide low impact and limited outdoor recreation opportunities (extensive recreation). The *Provincial Parks Act*, on the other hand, is suitable for a beach area when formalized intensive outdoor recreation opportunities are desired within a broader protection objective.

It is the intent of this Policy to provide a process that limit the number of geographic areas with overlapping legislation. However, special circumstances may support the two Acts being used for a single geographical area.

Requests to consider a beach for determination under the *Beaches Act* must come from the Minister or Deputy Minister of the Department. A preliminary review of the issues that generated the request shall determine an overall priority for action. Areas with either an immediate or ongoing threat to the ecological integrity of the beach will be afforded the higher priority. Human induced adverse alteration of any ecosystem component, process or service are further criteria for setting priorities among competing areas of interest.

The department may also advance individual beaches for determination under the *Beaches Act*.

Figure 1.



Defining the Beach:

The *Beaches Act* provides a definition of a beach that in fact is a boundary definition for the purposes of applying the legislation, however, it does not adequately describe the natural features and systems that may be associated with a beach.

For the purposes of this policy a beach is:

"An area of land and water comprised of a series of individual characteristics and elements that combine to form a series of interactions."

Beaches are not a static entity, but rather are very dynamic. It is therefore critical to gain an understanding of the ecological features and interactions that comprise each individual beach area. An inventory and analysis is to be conducted in order to establish a geographic representation of the ecosystem unit, hereinafter referred to as the 'beach', with consideration for the following.

Inventory:

To attempt to define the ecological unit of an individual beach, an inventory of ecological processes, components and services must be compiled. The following is a list of potential inventory data to consider:

A. Natural elements, processes, services

- flora
- fauna
- habitat
- geomorphology
- geology
- cultural uses
- species-at-risk
- climatie change (global warming)

B. Human induced elements

- development
- man made structures
- recreational use
- access
- land tenure (ownership) and associated land use, legal claims

Analysis:

The inventory data provides some initial insights, however, further analysis is required to determine the ecosystem components and geographic area that encompass the ecological unit ('beach'). The analysis would also evaluate the area to provide its relative significance on a provincial, regional and local scale, projected impact of sea level rise and the type of ecological threats.

Communications

The Minister will be briefed with a proposed recommendation on continuance of the determination process based upon an initial analysis of the area and the issues that caused the area to be highlighted for consideration.

A communication plan will be developed in consultation with the Director of Communications, either if the process continues or ceases.

The department will make arrangements to brief the impacted landowner(s) whose lands are encompassed by the defined beach, as well as the community at large through a public information session. The intent of the public session is to present factual information and expert analysis and to determine the overall importance of the beach in the community. The session will also to ensure that the landowners and community are informed of the various issues for a particular beach.

Opinions and comments will be sought from the public to identify or confirm threats, provide resource based interests and individual objectives, and possible options for the future management of the site.

Non-government organizations and agencies, specifically interested in coastal issues, will be notified of the public review where they are known to the department.

The appropriate Municipal units shall be informed of the process and invited to participate.

Comments may be received by the Department up to 30 days after the information session. Arrangements shall be made to receive comments by mail, telephone or the department's website.

Should the situation warrant, the time frame for feedback may be adjusted to reflect either imminent threats to the beach or the need for greater consultation.

In the situation where the lands in question are all Crown Land under the administration and control of the Department of Natural Resources contact with adjacent landowners is not applicable, however, public input should still be sought as described above.

The department also has commitments for consultation with the Mi'kmaq under the DNR Consultation Policy that must be addressed for Crown Land.

Delineation of Lands for Consideration:
The area of beach shall have an internal DNR Program based review (ex Wildlife Division) to ensure all issues are considered. Where the lands involved are Crown Land an Integrated Resource Management review will be prepared as well.

Upon completion of the public review, the department will analyze the comments and data and define a preliminary boundary for consideration.

Using the preliminary boundary, the department will research and confirm ownership of the lands within the defined area and develop a statement of impacts and options for future management of the site under the *Beaches Act*.

Recommendations to Proceed:

A recommendation regarding determination under the *Beaches Act* will be reviewed by the Director of Parks and Recreation with Executive Director of Renewable Resources, Deputy Minister and Minister.

Upon approval to proceed with determination from the Minister, all appropriate documentation will be prepared for Cabinet review (Memo to Treasury and Policy Board, Report and Recommendation to Executive Council, survey plan and description, Cabinet Briefing Note, Communications Plan, etc).

Determined Beaches - Public Notification:

Upon determination under the *Beaches Act* and receipt of the Order In Council the following notices shall occur:

- Registered letter to individual landowner(s) having land within the boundary
- Posting of signs at known entry points to the land
- Record Note of Determination with plan and description at the local lands registry office
- Publish notice containing a description of the beach in a weekly or daily paper that services the general community
- Publish a notice containing a description of the beach in the Gazateer

Procedural Summary:

The following is a summary of the steps the Department shall take when determining an area of land to be a beach under the *Beaches Act*:

Step:

1. Ascertain if *Beaches Act* is the most appropriate legislative option
2. Inventory beach resources, values, threats, land tenure
3. Complete an internal review
4. Analyze data and define geographically the ecological unit (“beach”)
5. Complete a public consultation on the proposed beach area
6. Prepare a preliminary boundary for the beach identifying with land tenure
7. Prepare impact statements
8. Prepare documentation for Ministerial review

9. Executive Council documentation completed for consideration

10. Prepare Notice of Determination of a Beach

11. Public notification of an approved Order In Council under the *Beaches Act.*

Accountability:

Senior Management is responsible for approving this policy, implementing this policy within the department and ensuring that this policy is periodically reviewed.

The Director of Parks and Recreation is responsible for implementing this policy, designating staff to carry out this policy and arranging for any necessary resources in support of this policy.

Monitoring

The Executive Director of Renewable Resources and the Director of Parks and Recreation will monitor designations to ensure consistent application of this policy.

References

Beaches Act

Provincial Parks Act

Inquiries

Inquiries pertaining to this policy should be directed to the Director of Parks and Recreation.

Effective Date

Appendix B

(Adapted from: *Beaches Of Nova Scotia: Key Management Issues and Policy Analysis*, J. Amyot, Marine Affairs, Dalhousie University, Halifax NS. unpublished material).

The *Beaches Act:* Critiques, Comparison, and Recommendations

Problem

The *Beaches Act* has been critiqued many times over the years for its vague wording and absence of clear definitions. For example, Piper and Bowen (1976), from the Institute for Environmental Studies, prepared a report for the Nova Scotia Department of Land and Forest concerning beach maintenance and sand mining. The authors point out how the definition of a "beach" is "[…] very limited, applying only to the area seaward of the mean high water mark". Piper and Bowen (1976) also point out that the region above this natural line is only considered a "beach" if it is designated by the Governor in Council". Finally, the report underlines that a beach "protected" under the *Beaches Act* does not provide protection from sand mining since it can discretionarily be permitted by the Minister (Piper & Bowen, 1976).

More recently, Jacques Whitford Environment Limited (2003) conducted a review for the Nova Scotia government about coastal development on protected beaches. This consulting agency underlined the lack of clear definition and absence of appropriate regulations that would guide coastal development planning on protected beaches. These critiques were also restated in 2008 by the Ecology Action Center's (EAC) discussion paper and demanded a rewording of the beach definition and the implementation of a clear, bold, and leading beach management strategy (Beaton, 2008).

Unfortunately, the government of Nova Scotia has yet to revise the definition. Its narrow beach definition also lacks inclusivity of other coastal systems that actively participate in the formation and conservation of beaches. Though the act includes dune-associated systems, it does not provide the flexibility and clarity needed to account for the dynamism and extend of these sandy systems. Also, as previously mentioned, the large discretionary power of the Minister concerning sand mining seems contradictory. Indeed, in the regulations of the Act the "Minister" is defined as the Minister of Natural Resources, who is also responsible for the mineral resource branch strategic development (The Nova Scotia Legislature, 2009). If the Minister in charge of protecting beaches is also responsible for allowing its exploitation, there is an obvious conflict of interest.

The *Beaches Act* was originally designed to address mineral extraction and regulate recreational uses of the beach. However, beaches are increasingly confronted with coastal development and sea level rise, along with the consequence of climate change and other contemporary issues. The *Beaches Act* has not been adapted to account for these new challenges and remains silent on vital subjects such as mandatory set-backs, maximum and minimum distances from the shore and to other structures, possible compensatory measure for private owners, *etc*.

Furthermore, both the *Beaches Act* and *Beaches and Foreshores Act,* focus on the direct utilitarian values of beaches as being the primary purpose for beach conservation. The Acts' dedication of beaches states, "The beaches of Nova Scotia are dedicated in perpetuity for the benefit, education and enjoyment of present and future generations of Nova Scotians" (The Nova Scotia Legislature, 2000). The Act does not recognize other direct and indirect values associated with beach ecosystems' goods and services, which would allow for a more inclusive protection of beaches biological and physical characteristics.

The *Beaches and Foreshores Act,* which addresses the granting and leasing of flats, beaches, or foreshores for exploitation purposes, is not specifically concerned with beach protection or conservation. Aside from prohibiting oyster cultivation without a lease from this act, and limiting it to "[…] five acres and the length of the area so leased shall not exceed twice the breadth thereof" (The Nova Scotia Legislature, 1998), the *Beaches and Foreshores Act* is poorly defined for conservation objectives. The Minister of Lands and Forests only leases or grants the territory to be exploited and seems to have little regulatory power concerning the amounts of biological matter being removed.

Other Maritime Legislative Models

Other comparable jurisdictions have adapted their beach conservation policy to better mold to the systems dynamic nature. For example, from the *Environmental Protection Act* of PEI, the beach ecosystem does not include the backshore dunes, but includes territory up to 4.82 kilometers seaward (Government of Prince Edward Island, 2010a). On the other hand, the province of New Brunswick defines the "coastal area" as the air, water, and land found within 1 kilometer landward of any coastal feature (Government of New Brunswick, 2011). The state of Maine defines beaches as a type of coastal wetland, which includes all tidal, subtidal lands, and salt-tolerant vegetated land limited to the wetland's boundaries (State of Maine Government, 2011). Maine also recognizes the "shoreline" as areas found within 250 feet (76.2 meters) of the normal coastal wetland's high water mark, which includes beaches (State of Maine Government, 2011).

The province of New Brunswick has also developed a coastal zoning plan that provides clear guidelines concerning beach uses that focus on development. The New Brunswick's Coastal Area Protection Policy, which designates the coastal region into three defined zones (A: core; B: buffer zone, and C: transitional), lists the acceptable activities in each zone, limiting residential development near beaches (Government of New Brunswick, 2002).

Also, both PEI and the State of Maine have introduced mandatory setbacks in their legislation to conserve their coasts. The PEI's *Planning Act* imposes a buffer zone of a minimum width of 60 feet (18.3 meters), or 60 times the annual erosion rate of an area adjacent to a beach (Government of Prince Edward Island, 2010b). The state of Maine imposes the most conservative requirements with a mandatory setback of 250 feet (76.2 meters) from coastal wetlands and 75 feet (22.86 meters) from a stream (Government of Maine, 2011).

Recommendations and Conclusions

Nova Scotia's beaches are threatened by human activities and natural changes, which has forced government to engage in coastal planning to alleviate coastal erosion and degradation. However, beaches are not simple landscapes to manage. They are complex systems shaped by oceanic currents and tidal forces, nourished by surrounding sand sources, and not restricted to sand dunes. Any activity that involves sand budget disturbances will alter physical beach characteristics and negatively impact its biota.

While historical sand mining over-exploitation promoted the adoption of the *Beaches Act*, contemporary issues such as coastal development and mitigation for sea-level rise have not driven its revision. Though beaches are primarily conserved for their direct recreational value, many coastal plants and animals depend on a productive, healthy, and minimally disturbed habitat to survive and contribute to the biological web. However, many species are at risk in the province as a result of unsustainable tourism, invertebrate harvesting, pollution, habitat loss and invasive species.

The *Beaches Act* and the *Beaches and Foreshores Act* constitute inefficient tools to conserve and protect Nova Scotia's beaches. The Act's definition of a "beach" should be revised to include all potential systems that contribute to its sand budget, including nearby barrier islands, lagoon, marshes, or other wetlands. Also, clear regulations concerning coastal development, including armoring structures, should be added along with a coastal zoning plan. The shoreline should also be defined as a distance from the normal high water mark in order to implement mandatory setbacks. Finally, since beaches are subject to various destructive pressures, both Acts should apply to all beaches found in the province to preserve their physical and biological integrity.

In the face of climate change and intensified weather events, the revision of these Acts and regulation seems to be a necessary first step into an ongoing adaptive management strategy to mitigate our unsustainable use of coastal shorelines.

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