EMERGING ISSUES

State of the Scotian Shelf Report

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1 ISSUE IN BRIEF

This paper discusses a number of emerging issues that are beginning to impact or are expected to impact the economic, social and environmental health of the Scotian Shelf. This document follows the definition of "emerging issue" used in the recent *State of the Gulf of Maine Report* on Emerging Issues: "an issue, positive or negative, which is not yet generally recognized but which may have significant impact on human and/or ecosystem health in the 21st Century" (Wells 2010 from Munn et al. 1999). The issues selected for this paper are emerging in one of three ways. Issues are either already present on the Scotian Shelf, but are currently in a state of flux; are of concern on a global scale and may or may not already be impacting the Scotian Shelf; or are already recognized on the Scotian Shelf, but have not yet been addressed by management. The selection of topics was made in recognition of broader studies that have identified research directions with the greatest potential to address future opportunities and challenges in Canada's oceans (e.g. Council of Canadian Academies' *40 Priority Research Questions for Ocean Science in Canada*) and with the aim of avoiding duplication with issues already discussed in existing theme papers (see State of the Scotian Shelf website). Additionally, offshore issues were given priority, as detailed discussions of coastal issues in Nova Scotia can be found elsewhere (e.g. *Nova Scotia's State of the Coast Report*). Similar to other State of the Scotian Shelf theme papers, this report is informed by the driving forces-pressures-state-impacts-response (DPSIR) framework. However, due to the large number of topics discussed, it was not feasible in this brief report to apply the DPSIR framework in its entirety.

2 PRESSURES

State of the Scotian Shelf theme papers provide in-depth examinations of important pressures and drivers that presently affect the Scotian Shelf. Established pressures such as climate change, ocean acidification, and pollution have been well-documented in past reports and are not discussed here (see *Climate Change and Its Effects on Ecosystems, Habitats and Biota; Ocean Acidification* and *Marine Waste and Debris*). The pressures discussed below are exerting influence on human activities and thus affecting the Scotian Shelf ecosystem.

2.1 CHANGING CONSUMER DEMANDS FOR SEAFOOD

Demand for Scotian Shelf seafood products is not new, but consumers are increasingly seeking sustainable and traceable fishery and aquaculture options. Furthermore, commercial interest is expanding for both low-trophic level fish species and alternative products derived from ocean resources. These market pressures have already begun to affect activities on the Scotian Shelf, and will continue to do so in the future.

2.1.1 Sustainable and Traceable Fisheries

As mentioned in past State of the Scotian Shelf theme papers (see *Fish Stock Status and Commercial Fisheries* and *Trophic Structure*), there is growing interest in sustainable seafood options. Recent research from the World Wildlife Fund (WWF) found that 91% of Canadians feel that it is important that the seafood they purchase comes from sustainable and non-overfished stocks (WWF 2011). In Atlantic Canada, consumer demand for sustainable seafood products is evidenced by the success of initiatives such as community supported fisheries (e.g. Off the Hook) and eco-certification. The Marine Stewardship Council (MSC) is the primary eco-certification body at work in Atlantic Canada. A number of Scotian Shelf fisheries have received MSC certification, including Scotian Shelf shrimp, Scotian Shelf snow crab (trap), and swordfish. More fisheries are currently undergoing screening for future certification, such as Atlantic halibut (MSC 2013).

While the rise of eco-certified fisheries is encouraging, consumers still encounter challenges when making seafood purchasing decisions. For example, only 8% of Canadians surveyed by WWF felt they had access to adequate information about the source of their seafood (WWF 2011). Unregulated labelling can make it difficult for a consumer to accurately weigh the sustainability claims of a given seafood product (Nikoloyuk and Adler 2013). Some groups have criticized the criteria and standards used by certification bodies such as the MSC. For example some non-government organizations criticized the certification of the swordfish longline fishery off Nova Scotia due to its bycatch (EAC 2011).

As well as certification, other consumer initiatives exist. For example, SeaChoice has developed a widely used consumer guide that provides recommendations on the sustainability of specific seafood products (SeaChoice 2012). Another initiative, Ecotrust Canada's Thisfish (2011), allows for even more specific traceability by providing information on individual fish. In the future, the growing influence of these initiatives may place pressure on Scotian Shelf fisheries to adapt their fishing practices to meet certification requirements, and to communicate these changes to consumers.

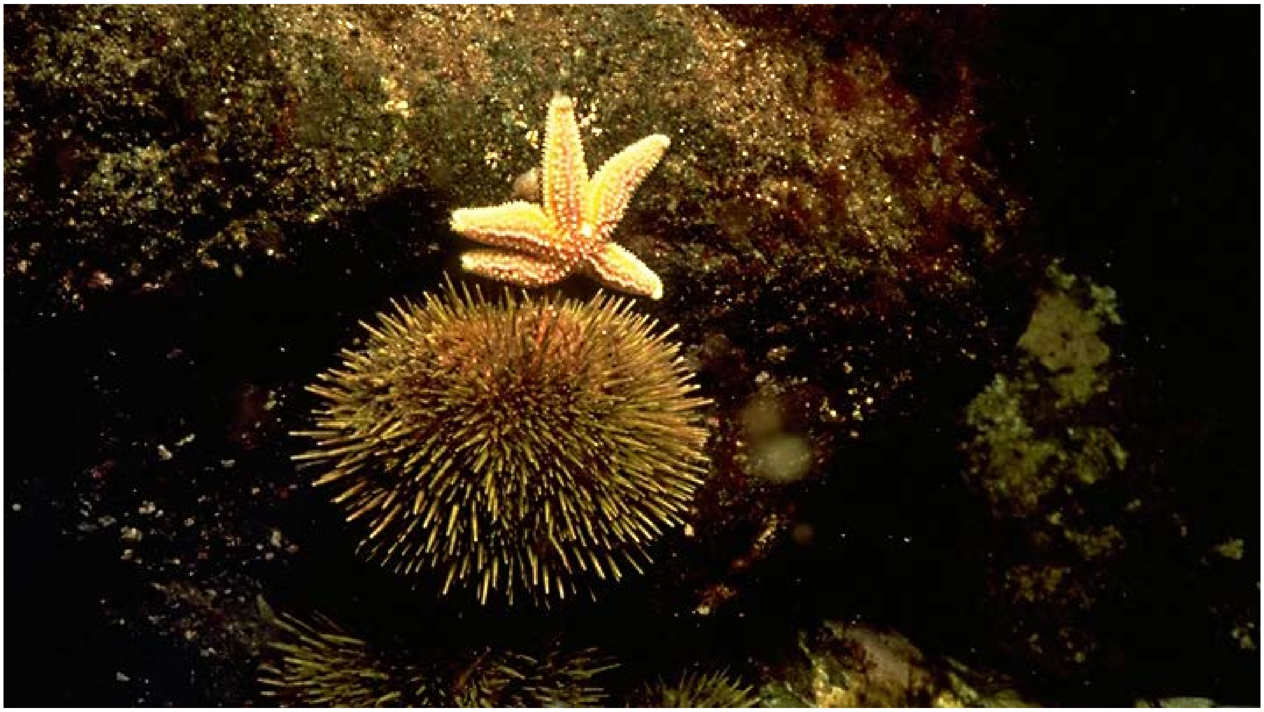
Although growing demand for sustainably caught seafood is present in the Nova Scotian market, it's not clear if there is the same demand in foreign export markets. Over 50% of Nova Scotia seafood is exported to the United States, Europe and Asia (for details see *Fish Stock Status and Commercial Fisheries*). There are mixed indications of demand in those markets for sustainable seafood (see Jacquet and Pauly 2007; MSC 2011; 2012a; 2012b). Since consumer pressures may not influence fisheries that are destined for other countries, non-market mechanisms may be required in order to increase the sustainability of export fisheries.

2.1.2 Sustainable Aquaculture Alternatives

Due to the depletion of wild fish stocks, much of the recent increase in global demand for seafood has been met by aquaculture. Overall aquaculture production in Nova Scotia increased from 1.5 million kilograms in 1994 to 8 million kilograms in 2011 (NSFA 2012b). The expansion of nearshore finfish (largely salmon) aquaculture in Nova Scotia, supported by the Nova Scotia Aquaculture Strategy, has been accompanied with some opposition due to competing coastal uses and concerns about environmental impacts (NSFA 2009a; 2009b). Some concerns associated with nearshore aquaculture expansion may be eased by moving facilities to offshore areas, to land-based systems, or by applying integrated multi-trophic aquaculture (IMTA).

One alternative to coastal open-pen aquaculture is offshore aquaculture: the cultivation of either finfish or shellfish in exposed areas of the open ocean that are still within a country's Exclusive Economic Zone (Troell et al. 2009). Initial research projects in the Gulf of Maine have successfully cultivated cod in open pens 13 kilometres offshore (Rillahan et al. 2011). Though offshore aquaculture addresses the coastal use conflict, environmental impacts could still arise (Brenner et al. 2012; Kaiser et al. 2011; Rillahan et al. 2011). Ongoing offshore aquaculture research in the Bay of Fundy and in Newfoundland could help to locate sites on the Scotian Shelf with the potential to cultivate species such as sturgeon, char, halibut and cod (ACOA 2012a; ACOA 2012b). Another alternative is integrated multi-trophic aquaculture (IMTA), or the integration of finfish aquaculture with invertebrates such as mussels and/or algae to aid in the decomposition of wastes linked to environmental impacts (Ridler et al. 2007). IMTA research completed in the Bay of Fundy may assist the development of this type of aquaculture on the Scotian Shelf (Barrington et al. 2010; Chopin and Robinson 2004).

DFO has noted that sustainable aquaculture development will require the development of ecologically appropriate technology and environmentally sustainable practices (DFO 2013). Management and policy regimes, at both federal and provincial levels, need to address issues associated with sustainable aquaculture expansion. The 2012 report *Aquaculture in Canada* mentions that a movement exists towards integrating "legislation and regulations to facilitate sustainable development, improve financial viability, and encourage investment so that the full potential



of the sector can be achieved" (DFO 2012a). In addition, the Nova Scotia Aquaculture Strategy outlines the province's intentions to improve current legislation (i.e. licensing and leasing processes, environmental monitoring methods) to make aquaculture expansion in Nova Scotia sustainable (NSFA 2012a).

2.1.3 Fishing at Lower Trophic Levels

Over the past three decades, a significant trend in Scotian Shelf fisheries has emerged involving the type of species being harvested; species are from lower trophic levels than in the past. An ecosystem's trophic structure, also called "food chain" or "food web", represents the feeding relationships in an ecosystem (see *Trophic Structure*). Traditionally, Scotian Shelf capture fisheries were predominantly comprised of groundfish (Anderson et al. 2008). Over-fishing of these top predator fish species altered the trophic structure of the Scotian Shelf: the species they preyed on were released from predation pressure and became more abundant (Frank et al. 2005). This change has been reflected in Scotian Shelf fishery landings: in the mid-2000s, low-trophic level shellfish accounted for 80% of the value of landings (GPCE 2009). Traditional fisheries of Atlantic cod and haddock have now been replaced with lobster, crab, sea cucumber and sea urchin. Overall, the average trophic level of Scotian Shelf fish landings has declined sharply since the collapse of the cod fishery (Anderson et al. 2008). The ecological effects of "fishing down marine food webs" are not entirely understood (Anderson et al. 2008). Future cod stock recovery may have effects on some low trophic fisheries. Cod has been shown to exert top-down predatory control on lobster (Boudreau and Worm 2010), meaning that a cod recovery could potentially negatively impact the lucrative lobster fishery.

2.1.4 Alternative Products from Ocean Resources

Bioprospecting is the search for bioactive substances in natural environments. To date, the majority of bioproducts used in chemistry, pharmacology, cosmetics, food, and agriculture have originated from terrestrial ecosystems. Increasing activity to search for bioactive substances in the marine environment may increase environmental disturbances. International negotiations have repeatedly noted the lack of detailed information to support policy responses on the conservation and sustainable use of marine genetic resources (Leary 2008). Leary identified a number of knowledge gaps including legal frameworks and intellectual property rights in relation to the Convention on Biological Diversity. Patents on genetic resources are a significant part of the commercialization of new discoveries; for example, 135 patents using marine genetic resources were filed in the United States and Europe between 1973 and 2007 (Leary 2008).

In addition to bioprospecting for bioactive substances, there is already ongoing use of local marine resources for the functional food and nutraceutical industry. Nutraceuticals are isolated or purified products that offer a physiological benefit or provide protection against chronic disease; they are generally sold in medicinal forms (AAFC 2012). Nutraceutical products produced in Nova Scotia include fish oils, dietary supplements, and seaweed-based food additives (NSDA nd). Nova Scotia's Life Sciences and Biotechnology Industry Association, BioNova, emphasizes that most of the research and development efforts in the province's life science sector are focused on marine biotechnology, indicating a strong orientation towards exploiting ocean resources (BioNova 2007). The expansion of the marine bio resources industry is evidenced by the upcoming 2013 BioMarine International Business Convention, held in Halifax and co-organized by the National Research Council (BioMarine 2012).

2.2 ENERGY DEMAND

The International Energy Agency forecast that by 2035, global energy demand will increase

by one third (IEA 2012). With this significant growth, exploration and development of fossil fuels in offshore areas such as the Scotian Shelf is expected to intensify. In addition, development of ocean-based renewable energy sources is also expected to expand; these include tidal, wave and offshore wind energy.

2.2.1 Deep Water Oil and Gas Exploration

Deposits of crude oil and natural gas exist within sediments below the ocean floor of the Scotian Shelf (CCEI 2007). Current production includes natural gas from the Sable Offshore Energy Project; the Deep Panuke project is expected to begin production in 2013 (Encana 2013). In 2012, permits were issued to Shell Canada Limited and BP Exploration Company Limited to explore deep-water locations adjacent to the Scotian Shelf,

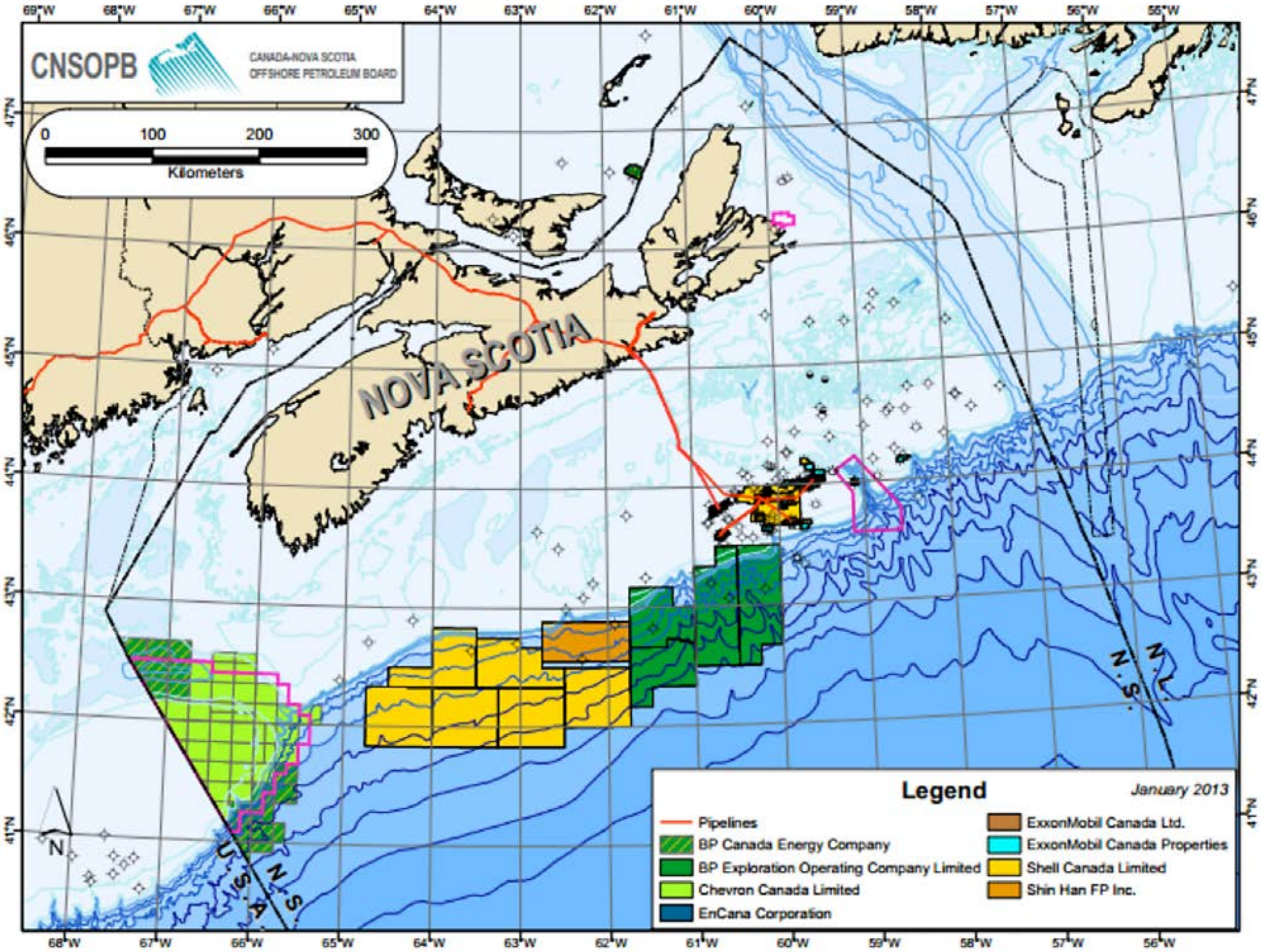


Figure 1. Map showing boundaries of exploration licenses on the slope and deep water adjacent to the Scotian Shelf (CNSOPB 2013).

illustrating a trend of oil and gas exploration in increasingly deep offshore waters (Figure 1).

Concerns surrounding the exploration and development of petroleum resources in the deep waters of the Scotian Shelf include impacts on seabirds, deep-water coral communities, deep diving whales, and commercial fisheries (Lee et al. 2011) (see *Incidental Mortality* and *Ocean Noise*). These concerns were heightened by the Deepwater Horizon incident in April 2010 in the Gulf of Mexico, when five million barrels of oil were released. Fisheries were closed for a year or longer, but the long-term impacts of this unprecedented oil spill are still unknown (McNutt et al. 2012; Ylitalo et al. 2012). In Nova Scotia, the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) is the entity responsible for "compliance, environmental protection; management and conservation of petroleum goods; and safety" (CNSOPB 2012). The *2012 Fall Report of the Commissioner of the Environment and Sustainable Development* reported that the CNSOPB generally achieved its responsibilities in terms of environmental protection (CESD 2012). The same report identified several areas where improvements in the Board's operations were recommended. These recommendations were acceped and efforts are underway to respond to them (CESD 2012; CNSOPB 2013a).

If these recommendations can be addressed, Nova Scotia will be well-situated to respond to the persistent global demand for petroleum by

Table 1. Mean power for tidal energy sites on the Scotian Shelf (after Cornett 2006).				
Site Name	**Latitude**	**Longitude**	**Mean Power Density (kW/m2)**	**Mean Potential Power (MW)**
The Hospital	43.44	-66.00	0.63	50
Ellewoods Channel	43.66	-66.05	0.63	1
Cape Sable	43.35	-65.66	0.63	15
Baccaro Point	43.44	-65.47	0.26	2
Great Bras d'Or	46.29	-60.41	1.22	3
Barra Strait	45.96	-60.80	0.26	3
Flint Island	46.17	-59.79	0.20	2
St. Ann's Harbour	46.29	-60.41	1.22	2

supplying new export markets, for example in the United States (NSDoE 2012a). This could provide significant economic benefit to the province. In 2006, the offshore petroleum industry contributed $800 million to Nova Scotia's GDP and employed over 600 people (GPCE 2009).

2.2.2 Marine Renewable Energy

The government of Nova Scotia has set ambitious renewable energy targets of 25% by 2015 and 40% by 2020 (NSDoE 2010). Tidal, wind, and wave energy are all forms of renewable marine energies suitable for development on the Scotian Shelf (Cornett 2006; DFO 2012b). Marine energy systems can also promote economic development, decrease reliance on fossil fuels, and potentially improve the stability of electricity prices in the province (NSDoE 2012b).

The Inventory of Canada's Marine Renewable Energy Resources has led to an increased recognition of the Canadian potential of tidal energy (Cornett 2006). Unlike wave and wind energy, tidal power is predictable and more reliable (Cornett 2006). Tidal energy is currently in the developmental stage and research is focussed in the Bay of Fundy; however tidal power potential of sites on the Scotian Shelf has been shown to be significant (see Table 1) (NSDoE 2012b).

As with tidal power, wave energy has received increased recognition due to the Ocean Energy Atlas project (Cornett 2006). Wave energy has great potential, but available energy varies seasonally and is unpredictable. As illustrated in Figure 2, several areas within the Scotian Shelf could support wave energy (Cornett 2006). However, despite promising research completed off the coast of Newfoundland (NRCan 2008), the *Nova Scotia Marine Renewable Energy Strategy* (2012b) indicated that wave energy is not a priority.

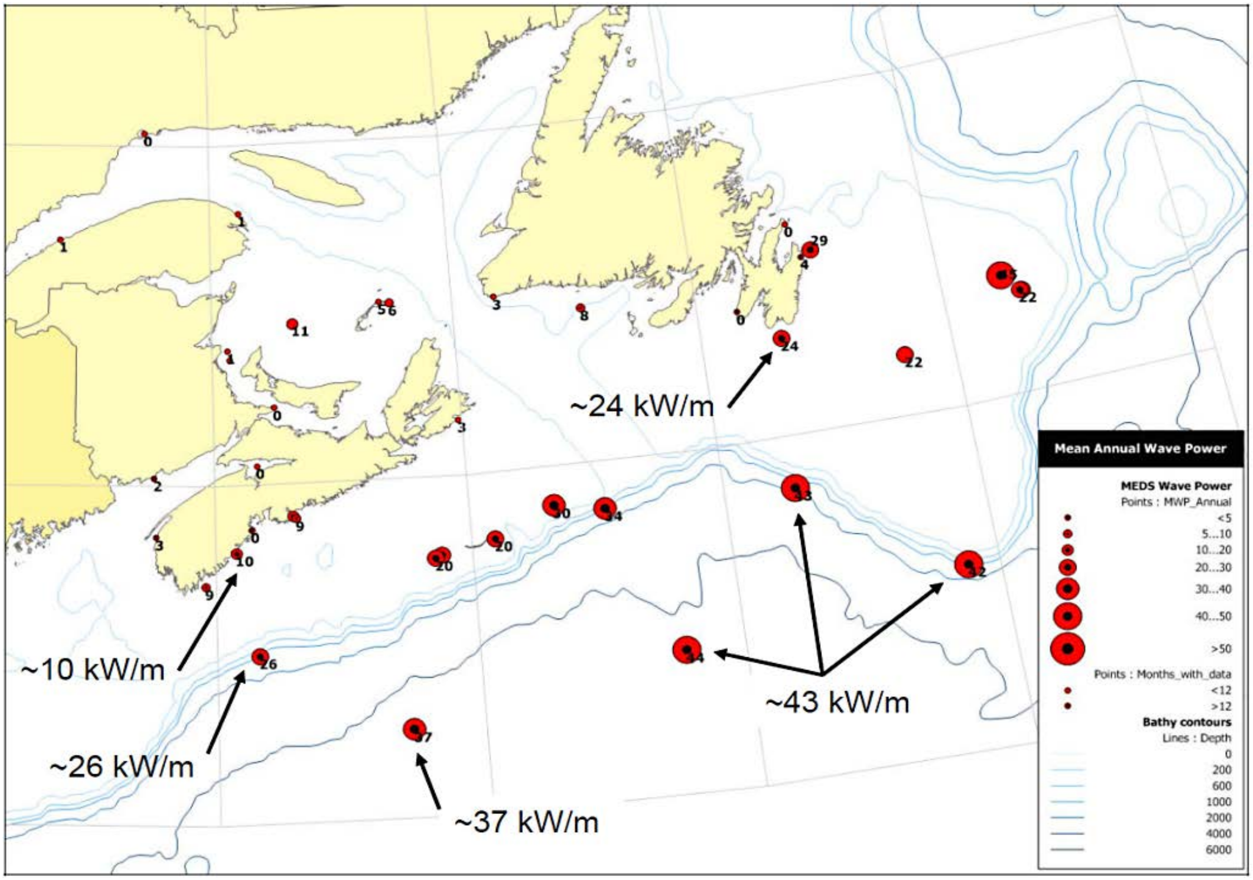


Figure 2. Annual mean wave power for sites in the Northwest Atlantic (after Cornett 2006).

Wind energy in offshore areas is often more constant and powerful than in coastal locations (Cornett 2006). However, like wave energy, it is unpredictable. Despite this challenge, offshore wind energy has had considerable success in countries such as Denmark and Sweden (Breton et al. 2009). An established understanding of wind energy technology, as well as proposed developments on the west coast of Canada and in the Great Lakes (DFO 2012b) could eventually spur the placement of turbines on the Scotian Shelf.

3 IMPACTS

Other theme papers have examined current drivers and pressures and their impacts on the Scotian Shelf. Below, we discuss a number of emerging impacts that warrant greater monitoring to fill information gaps. They have been selected to inform resource managers and the interested public of impacts that conceivably may affect the Scotian Shelf in the near future, based on global observations and scientific theories. .

3.1 IMPACTS FROM INCREASED GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE

Global emissions of carbon dioxide increased by 3% in 2011, reaching an all-time high of 34 billion tonnes in 2011 (Olivier et al. 2012). Global energy demand is driving fossil fuel use, which increases atmospheric concentration of carbon dioxide. The resulting

changes in ocean temperature and ocean chemistry are occurring rapidly and will have significant impacts on the marine ecosystem. For a detailed analysis of climate change impacts that have already been observed on the Scotian Shelf, refer to *Climate Change and Its Effects on Ecosystems, Habitats and Biota*.

3.1.1 Impact of Ocean Acidification on Sound Transmission

Rising concentrations of atmospheric carbon dioxide is lowering the pH of oceans, a process known as ocean acidification (see Figure 3; for further detail see *Ocean Acidification*). This issue is particularly relevant to the Scotian Shelf because the North Atlantic is responsible for a disproportionally high amount of carbon dioxide uptake, and is also particularly vulnerable to pH changes (Sabine and Feely 2007). Impacts of ocean acidification on marine ecosystems are not fully understood and require further study.

For example, the potential effect of ocean acidification on ocean noise has yet to be fully

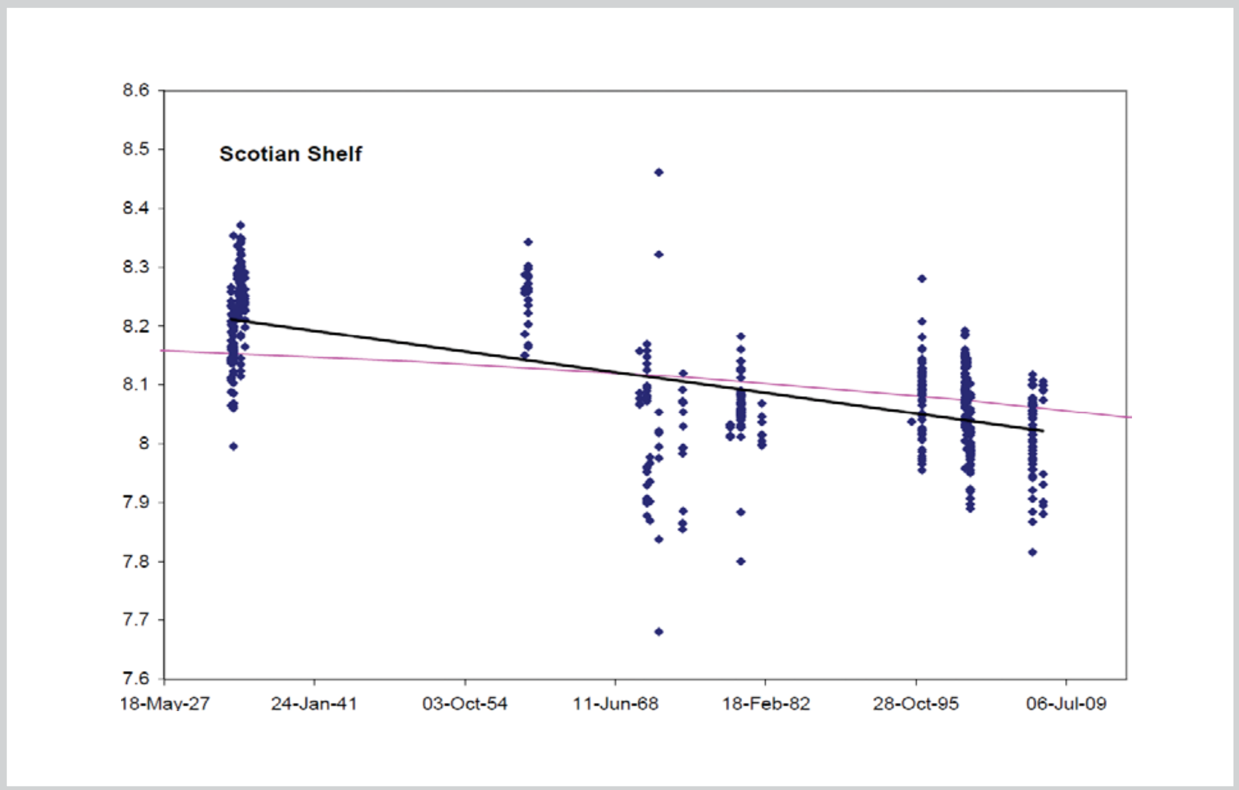


Figure 3. Decrease in pH on the Scotian Shelf over the past century (adapted from DFO 2009). Time is displayed as day-month-year. Blue points represent pH measurements from various locations on the Scotian Shelf, the black trend line indicates a decrease in pH with time, and the pink trend line represents the mean global ocean decrease in pH over the same time period.

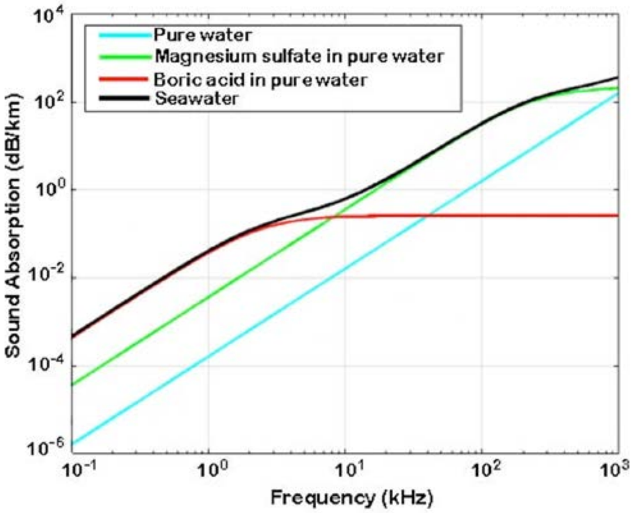


Figure 4. Sound absorption capacity vs frequency response of pure water, seawater and solutions of magnesium sulphate and boric acid (Brewer and Hester 2009 calculated from Ainslie and McColm 1998)….

researched. As the ocean becomes more acidic, the sound absorption capacity of sea water at low frequencies is decreased (University of Rhode Island 2011). As sound travels through the ocean, some of the energy in the sound wave is absorbed, causing the sound wave to become weaker. As borate ions are largely responsible for sound absorption and their concentration in seawater depends on pH, acidification would result in a decrease in sound absorption (see Figure 4) (University of Rhode Island 2011). Many marine mammals, such as the 23 species that inhabit and migrate through the Scotian Shelf, depend on sound for communication, navigation and hunting, so this impact could potentially affect their behaviour (DFO 2003).

3.1.2 Timing of Seasonal Ecosystem Events

As discussed in other theme papers, climate change has a strong potential to alter seasonal ecosystem events on the Scotian Shelf. This, for example, could disrupt predator-prey relationships or reproduction success of some species. The timing of these events can differ in response to both seasonal environmental variability and anthropogenic climate change (FAO 2013). A key component of the Scotian Shelf ecosystem is phytoplankton, as the rest of marine ecosystems rely on this primary producer (see *Primary and Secondary Producers*). A complex picture is emerging of how climate change may affect phytoplankton abundance and distribution generally and on the Scotian Shelf in particular. For example, Sameoto (2004) showed that annual phytoplankton blooms on the Scotian Shelf have been occurring earlier in the year, and that abundance increased over the period from 1991-2000. While climate change's effects on ocean temperature, salinity and circulation may explain these changes, Frank et al. (2005) suggest that the collapse of Scotian Shelf cod stocks resulted in cascading effects through lower trophic levels of the food web, including an increase in phytoplankton. However, a global study showed that overall phytoplankton abundance in seven of nine ocean regions, including the North Atlantic, is declining (Boyce et al. 2010). These inconsistent findings emphasize why this is an emerging issue on the Scotian Shelf that requires further investigation into the various mechanisms, including climate change, that affect the timing of important ecosystem events like seasonal phytoplankton blooms.

3.2 IMPACTS FROM DEBRIS AND POLLUTANTS

Marine pollution in all its forms has long been recognized as a threat to marine ecosystems around the world. The theme papers *Marine Waste and Debris*, *Water and Sediment Quality*, and *Incidental Mortality* review the current range of these impacts on the Scotian Shelf. Here, we focus on two issues that have not yet been studied on the Scotian Shelf, but nonetheless pose a potentially significant threat.

3.2.1 Microplastic Particles

Microplastics are micro-sized (≤5mm) particles of plastic in the marine environment that originate from solid waste entering the ocean via land or sea based sources (e.g. waste water discharge, illegal dumping and shipping) (GESAMP 2010). A particular challenge is the high resistance of microplastic to aging, and its minimal biological degradation in the marine environment (Moore 2008). Microplastics are a concern for the Scotian Shelf ecosystem for a number of reasons: not only are they ingested by marine animals, but they may act as vectors for transporting harmful substances (GESAMP 2010). As microplastics are not currently monitored on the Scotian Shelf the extent of current impacts is unknown, but there is evidence of microplastics throughout the western North Atlantic (Cole et al. 2011; Morét-Ferguson et al. 2010), and no reason to suggest that the Scotian Shelf would be an exception to this pattern.

As plastic debris persists in the marine environment, it fragments into increasingly smaller pieces which are more likely to be ingested by smaller marine organisms (Browne et al. 2008). Also, the buoyancy of smaller pieces of plastic increases the likelihood of mixing with surface food sources (Boerger et al. 2010). The ingestion of plastic by larger organisms like seabirds, marine mammals, turtles and some fish species has been well documented; however, the ingestion of these microplastics by lower trophic organisms has not been as thoroughly investigated. A laboratory study on ingestion of microplastics found several marine invertebrates and filter-feeders were able to ingest microplastics, including lugworms, amphipods, barnacles and even mussels (Browne et al. 2008). Little is known about the effects of ingestion of microplastics by species at the base of the food web and it is unknown if microplastics can be transferred across different trophic levels (Moore 2008). For example, it is still uncertain whether or not microplastics are being deposited in deep sea sediments (Betts 2008, GESAMP 2010). The movements of these plastics also need special attention. For example, plastic fragments with biofilms may sink, but may then become buoyant once the biofilm has been removed (GESAMP 2010). Marine managers should be aware of these knowledge gaps, and moving forward, the quantity and nature of microplastics on the Scotian Shelf should be monitored.

As microplastics decrease in size, the possibility for chemical transport through absorption of chemicals or leaching out increases (Teuten et al. 2009). Evidence suggests that microplastics act as a medium for transporting bioaccumulating toxic substances (GESAMP 2010), invasive species (Barnes 2002), and persistent organic pollutants (POPs) (Ritter et al. 2007). Microplastics provide a new habitat within pelagic ecosystems, and some marine insects use microplastic particles as a surface on which to lay eggs (Goldstein et al. 2010). This new habitat could lead to changes in marine insect populations, with repercussions for the broader ecosystem. Also of concern are chemicals added to plastics during the manufacturing process, which may then leach out upon ingestion (Teuten 2009). There is also evidence that some bacteria may contribute to the decomposition of marine plastic, which could potentially reduce the quantity of microplastic debris (Zaikab 2011). It is possible but not well understood how this plastic decomposition may constitute a new entry point in the food chain. The potential for microplastics to carry disease-causing organisms is discussed in section 3.4, Emerging Diseases. More information is clearly required about the sources, distribution, fate, and potential impact of microplastics in the marine environment, as we lack adequate knowledge of their potential physical and chemical effects on marine organisms (GESAMP 2010).

3.2.2 Emerging Chemical Contaminants

The theme paper *Water and Sediment Quality* summarizes the state of contamination of Scotian Shelf waters by known pollutants (i.e., halocarbons, hydrocarbons and metals). The same report lists a number of emerging contaminants that are not routinely monitored on the Scotian Shelf, including flame retardants, pharmaceuticals, organophosphate esters, chlorinated paraffins, perfluorinated compounds (PFCs), and antifouling biocides. Some of these chemical constituents had not historically been considered contaminants and are now present in the environment on a global scale. Still others are new chemicals manufactured for the presumed benefit of society, and are entering the environment through pathways such as agricultural applications and disposal of industrial and municipal waste water. There are a number of programs in Canada that monitor chemical contaminants in marine environments. There is also legislation that requires contaminant emitters to report pollutant releases of 346 different anthropogenic substances (see National Pollutant Release Inventory). However, there is a gap in monitoring of emerging chemical contaminants in Canada. In contrast, the United States Geological Survey currently analyzes for 168 emerging contaminants including pharmaceuticals, fire retardants, polyaromatic hydrocarbons (PAH), plasticizers and household chemicals.

Of particular concern are compounds with the potential to disrupt the endocrine systems of marine organisms, meaning possible interference with normal hormone production. This disruption could result in, for example, problems with the reproductive cycle. Mearns et al. (2012) summarizes a number of studies where pollutants disrupted endocrine function in a number of marine species. Endocrine-disrupting alkylphenols can kill larvae at relatively low concentrations, and they are thought to have adverse effects on segmented worms and molluscs as well (Laufer et al. 2012). Further experiments are needed to understand endocrine-disrupting compounds, and to help predict the effects of mixtures of these substances (Rodríguez et al. 2007).

3.3 EMERGING DISEASES

As the result of climate variability and human activity, disease-causing pathogens (e.g., viruses, bacteria and fungus) have emerged in many regions of the world's oceans (Harvell 1999). Research and monitoring on this topic is lacking on the Scotian Shelf; however, species that are important to the aquaculture and fishing industries (e.g., oysters and quahogs) have been shown to be vulnerable in nearby regions, such a coastal Massachusetts (Cook et al. 1998; Perrigaut et al. 2011).

While these pathogens occur naturally in marine environments, their prevalence, and therefore potential to cause negative effects, is often increased due to sources such as sewage effluent, runoff, ship waste, industrial processes and recreational activities (Zielinski et al. 2009). For example, globally, stressors associated with fish and shrimp aquaculture (e.g. displaced animals, high density culture, artificial feeds) coupled with increasing human stressors on wild populations (e.g. over-exploitation), have led to a number of new diseases affecting many marine species (Walker and Winton 2010). Climate change, specifically rising sea surface temperatures, is another pressure that has been linked with increasing occurrence and distribution of disease-causing pathogens in marine animals (Bally and Garrabou 2007; Harvell et al. 1999; Munn 2006; Ward and Lafferty 2004; Ward et al. 2007). A warmer climate is generally expected to increase the prevalence of hosts infected with disease-causing pathogens (Harvell et al. 2009). However, Lafferty (2009) noted that little evidence exists that current climate warming has already expanded the range of infectious diseases, and that other factors may be to blame for recent increases in diseases. Six of nine marine species studied by Lafferty (2009) have seen an increase in disease prevalence, but climate change was the suspected cause in only corals and sea turtles. The same study predicted that climate change will mostly cause a shift in the range of infectious diseases, as opposed to a net increase in their distribution.

As discussed above, microplastics are an emerging pollutant worldwide (Harrison et al. 2011). It is known that oceanic plastic debris can lead to invasions of foreign species (Barnes 2002), but the potential for interactions between microplastics and disease-causing organisms is less understood (Harrison et al. 2011). In one study, the most common genus of bacteria found on plastic debris (*Vibrio*) was one known to cause disease in both humans and animals (Amaral-Zettler et al. 2011).

4 ACTIONS AND RESPONSES

4.1 INFORMATION ACCESSIBILITY

The Commissioner of the Environment and Sustainable Development has stated that "solid, objective, and accessible information is essential to identify and respond to the quickening pace and complexity of environmental change, in Canada and globally" (CESD 2010). Availability of and access to information is a prerequisite for successful management initiatives (Mossbauer et al. 2012) to address the multiple complex existing and emerging issues on the Scotian Shelf. The European Commission (2012a) suggested, for example, that existing data should be standardized,

integrated with socioeconomic data, and organized in information systems that can work together to help identify gaps, steer coastal and marine monitoring and spatial data acquisition and improve assessment and policy advice (Meiner 2011). Although there are some promising information management initiatives in Canada (e.g. RDSWG 2011; Canadian Space Agency 2013), a concerted and coordinated investment in marine data and information infrastructure could help to improve the accessibility of information necessary for the sustainable development of oceans and coasts.

4.1.3 The Open Data Movement

The principle of data accessibility is taken a step further with the open data movement. Open data means data and information that is freely available to use without restrictions. Some benefits of open government data include improved public services, oversight of public sector activities, reduced costs of collecting and managing data, creating business opportunities, building trust with citizens, and creating platforms for public engagement (Deloitte Analytics 2012). However, unintended harmful consequences (e.g., unintentionally revealing the location of commercially valuable endangered species habitat) should be anticipated and avoided. In Canada, the open data movement is represented by two related federal government initiatives: the Open Data Portal (data.gc.ca) and the Federal Geospatial Platform (Canadian Space Agency 2013). Several open data initiatives have been established at the provincial (e.g. British Columbia data.gov.bc.ca) and municipal levels (e.g. Halifax Regional Municipality Open Data Pilot). The Government of Nova Scotia is exploring Open Data options for geographic data (GeoNova 2013).

Coastal mapping plays an important role for decision makers (O'Dea et al. 2011), and Internet-based coastal management portals are becoming a more common way to provide access to geospatial data. They are often in response to supporting policy initiatives (e.g. U.S. *Coastal Zone Management Act* and the European Union Water Framework Directive) (ICAN 2013, European Commission 2012b). Such a portal has not been realized for the Scotian Shelf.

4.2 INTEGRATED COASTAL AND OCEANS MANAGEMENT ON THE SCOTIAN SHELF

Integrated Coastal and Ocean Management (ICOM) is an emerging issue on the Scotian Shelf as identified by a number of authors (Hedley 2006; Dutka et al. 2010; Rutherford et al. 2010). In order to move forward with integrated oceans management, Rutherford et al. (2010) suggest that there must be: more consistent higher level commitment and advocacy; dedication of long-term funding; development of measurable goals and targets with timelines; more effective strategies; and implementation of comprehensive monitoring and adaptive management. The Eastern Scotian Shelf Integrated Management (ESSIM) initiative is the most significant effort for ICOM on the Scotian Shelf to date. Drafting the ESSIM plan involved over ten years of stakeholder involvement to develop from concept to final draft plan (1998-2007). The absence of endorsement of the final draft plan by the Minister of Fisheries and Oceans has been interpreted by partners and stakeholders as a shortage of commitment and consistency at a higher level. Implementation of the plan has thus been voluntary and unofficial. The final meeting of the Stakeholder Advisory Council (SAC), one of the components of the collaborative planning model in the ESSIM plan was held on May 23, 2012 ending the ESSIM Initiative (McCuaig and Herbert 2013) and the SAC's shared "responsibility for leadership and guidance in meeting the vision for the ESSIM Initiative" (DFO 2007: 23). However, the Regional Committee on Coastal and Ocean Management (RCCOM) has continued to meet. The RCCOM is comprised of federal and provincial governments and its continued work is seen by some as an ESSIM success story (Dutka et al. 2010). Several other tangible outcomes and benefits from ESSIM have been identified (Hedley 2006; Dutka et al. 2010; McCuaig and Herbert 2013). In general, voluntary and unofficial implementation of management strategies for the ESSIM plan has led to moderate to significant progress on some strategies and limited progress on others (McCuaig and Herbert 2013).

Future progress for ICOM on the Scotian Shelf requires improvements some of which are described by Rutherford et al. (2010) above. Two specific improvements that have been identified are: drafting a detailed implementation plan soon after the management plan is finalized to maintain momentum and senior level support (McCuaig and Herbert 2013); and providing greater leadership for implementation (Dutka et al. 2010).

4.2.1 Indicators for Ecosystem Based Management and Valuation

Ecosystem based management (EBM) is an approach that seeks to broaden the scope of traditional resource management by treating ecosystems as whole entities affected by a broad range of factors (Curtin and Prellezo 2010). Instead of managing for a single species or single issue, EBM tends to evaluate multiple simultaneous "drivers" or "pressures" affecting a geographic region (Curtin and Prellezo 2010).

In order to implement EBM, indicators are needed that can provide timely insight into the behaviour, state and trajectory of a system as complex as a marine ecosystem. Active and adaptive management can only occur when robust indicators are routinely collected, as is the case, for example, with national economies (Gibbs 2012). Gibbs argues for dynamic indicators and supporting monitoring systems that focus on flows and rates. New technologies should eventually provide the needed information to support new indicators (Gibbs 2012). Past Scotian Shelf theme papers of the State of the Scotian Shelf Report have identified dozens of indicators, both biological and socioeconomic. However, not all of the indicators identified are being consistently measured; data gaps are common and data confidence is varied. It may be helpful for Scotian Shelf managers to know what indicators are actively being monitored on the Scotian Shelf, and have routine access and assess these datasets. In addition, the suite of indicators as identified in the theme papers should be reviewed to meet the needs of operational management.

4.2.2 Ecosystem Services Valuation

Ecosystem services valuation has been increasingly used as a tool to assist in the implementation of EBM. Ecosystem services are the benefits humans obtain from ecosystems, including food, fuel, clean air, genetic information, and climate regulation processes, as well as cultural, spiritual, educational and recreational benefits that contribute to human health and well-being (UNEP-WCMC 2011). The Economics of Ecosystems and Biodiversity (TEEB) project (2012) suggested that according to some estimates coastal and ocean biomes may provide as much as two-thirds of global ecosystem services. A better understanding of the economic value of marine ecosystems could substantially improve the management of critical marine resources; improve governance, regulation, and emerging ocean policy; and, provide better understanding of the potential economic challenges that arise from a rapidly changing ocean environment (TEEB 2010, 2012). New economic opportunities might also be revealed through demonstrating the economic value provided by ocean and coastal biomes (TEEB 2012). For example, Fujita et al. (2013) suggest an approach called "ecomarkets," whereby new kinds of markets for coastal ecosystem goods and services not recognized by conventional markets are created based on area and resource use privileges. DFO is currently pursuing another application of ecosystem services, as discussed in the 2012 Fall Report of the Commissioner of the Environment and Sustainable Development, which is to identify and assess the specific ecosystem services provided by existing or planned marine protected areas (CESD 2012).

4.2.3 Emerging Aspects of Marine Spatial Planning

Marine spatial planning (MSP) has been identified as an important tool to support ecosystem-based management (Ehler 2008). Doherty (2005) suggests that zoning, an aspect of MSP, could play a role in ecosystem-based management on the Scotian Shelf. MSP is heavily influenced by increasing demand for ocean space and ecologically responsible decision-making about new uses of the sea (Douvere and Ehler 2009).

Table 2: Factors required for successful MSP implementation (from Ehler 2008).

1.	Legal authority and political support for MSP; ideally statutory and enforceable.
2.	Sound information base of both natural and social science.
3.	Clear and measurable objectives.
4.	Early and frequent stakeholder involvement.
5.	Consideration of plans and objectives in other sectors of the economy.
6.	Integration with plans for adjoining coastal areas, terrestrial land-use plans, and coastal watershed plans.

Ehler (2008) defines factors that are needed for successful MSP implementation (see Table 2). MSP has been implemented in marine areas where conflicts for use of ocean space made other management techniques difficult to implement. For example, in Belgium and the Netherlands, where conflicts for the use of marine space were clear, MSP was a response to new national objectives for offshore wind farms and European requirements for marine protected areas (Douvere and Ehler 2009). In contrast, levels of competition for offshore ocean space have not yet materialized on the Scotian Shelf to the same degree as the North Sea. If new uses of marine space on the Scotian Shelf are realized (e.g. offshore wind farms, wave energy, marine bioprospecting) the need for marine spatial planning for the Scotian Shelf may increase. In addition, the need to implement climate change adaptation measures may require proactive planning of human activities in certain parts of the ocean, a process that can be supported by MSP. The Gully Marine Protected Area, the first MPA on the Scotian Shelf, is a local example of MSP as regulations define three zones of acceptable use. A range of other spatial planning measures are already at play on the Scotian Shelf, like the MPA network planning process (see *National Framework for Canada's Network of Marine Protected Areas*), but there is an opportunity for these efforts to exhibit greater coordination.

An important emerging aspect of MSP is its ability to allow for greater public participation. One example is the ESSIM plan, which saw the establishment of an open and inclusive process for involving stakeholders in the development of an integrated ocean management plan (Hall et al. 2011). However, there is no policy direction or legislative mandate that requires MSP to be included in Canadian ocean management (Douvere and Ehler 2009). New technology can also play a role in facilitating public input in marine spatial planning. SeaSketch is an innovative GIS platform and web-based tool that enables collaboration over the internet; allowing ocean resource managers to work with partner agencies and stakeholders to make decisions about ocean resources (McClintock and Paul 2012). Systems like SeaSketch could fundamentally transform the landscape of marine planning (Rumore 2012), although the tool is intended to help, not supplant, a well-designed collaborative planning processes. Another emerging application of MSP is the use of marine cadastres: information systems that chart rights and interests present in a marine area (Sutherland 2003). While this technique is evolving rapidly in other jurisdictions (e.g., USA and Australia), only a modest case study has been performed for Nova Scotia, in St. Margaret's Bay (Boateng 2009).

MSP yields the best results when it is underpinned by accurate spatial information. Acoustic imaging technology, like multibeam echo sounding, is now able to provide a picture of the ocean floor, revolutionizing the ability to collect invaluable contextual information for marine benthic habitat management (Pickrill and Kostylev 2007). In the context of a national marine mapping program, this bathymetry information has the potential to significantly advance our understanding of seafloor ecosystems (Brown et al. 2011). For example, Ireland's national marine mapping program has successfully supported the integrated management of multiple marine activities, collectively projected to be valued at over €400,000 million by 2016 (PricewaterhouseCoopers 2008). While many individual marine mapping projects occur in Canada, Canada has failed to develop a national marine mapping program, despite the success of early investments.

4.2.4 Marine Protected Areas Network Planning

Like integrated oceans and coastal management, the federal government has faced challenges in implementing Marine Protected Areas (MPAs). A recent report of the Commissioner of Environment and Sustainable Development concluded that DFO had not met its commitment to create a network of MPAs, although some progress towards that goal is being made (CESD 2012). MPAs were originally conceived in the context of larger ocean management plans such as ESSIM. Although these larger plans have taken longer, and in the case of ESSIM, the initiative has come to an end, the network model of MPA planning has benefitted from this work. MPAs can provide a range of benefits for fisheries, local economies and the marine environment (Toropova et al 2010). The network model for MPA planning is in progress and will help in responding to pressures on the Scotian Shelf ecosystem.

4.3 CLIMATE CHANGE ADAPTATION

Consequences of climate change in the marine environment of Atlantic Canadian include impacts on species, pest and pathogen distributions, aquaculture operations, and offshore operations (Vasseur and Catto 2008). DFO (2013) has recently identified six risks to aquatic ecosystems and society stemming from climate change: 1) ecosystem and fisheries degradation and damage; 2) changes in biological resources; 3) species reorganization and displacement; 4) increased demand for emergency response services; 5) infrastructure damage; 6) changes in access and navigability of waterways. While many management actions aim to mitigate these impacts, the focus is increasingly shifting toward management aimed at adaptation. In their *Planning Guide for State Coastal Managers* (2010), the National Oceanic and Atmospheric Administration (NOAA) advised that climate change adaptation will require new plans, laws and regulations, as well as changes to existing ones. It recommended that "all planning and rulemaking activities should consider climate change and future conditions so outcomes support, and do not deter, adaptation efforts" (NOAA 2010).

Climate change has been found to adversely impact the life cycle and workability of marine-related infrastructure (CBCL 2012). Infrastructure that is built with a multi-year design life deteriorates in the context of higher tides, stronger surges and/or accelerated erosion through increased wave action. Impacts on fisheries and infrastructure would be limited over the next 20 years, but significant in 50 to 100 years (CBCL 2012). For infrastructure adaptation, CBCL (2012) recommends keeping up maintenance in the short term, planning for increases in maintenance and protection in the medium term, and a range of adaptation options for the longer term, including abandonment. It is also possible that an increase in the severity and frequency of storms may trigger an increased need for search and rescue operations (Vasseur and Catto 2008). Debate remains as to whether or not storm severity and frequency on the Scotian Shelf has or will increase because of climate change (Masson and Catto 2013).

In relation to fisheries, it is possible that changes to species due to climate change may not be discernible from natural variability over the next 20 years (CBCL 2012). The challenge will be deciding when and how to change laws, regulations, quotas or harvest seasons in order to adapt to the impact of climate change that might only be significant in 50 to 100 years. These changes, both climate-related and regulatory, will have significant social and economic impacts on marine industries and dependent communities. Aquaculture operations would also need to be flexible as to the species cultivated and the timing of cultivation. A Washington State report (Adelsman and Whitely Binder 2012) also recommends measures that would significantly change the operation of fisheries and aquaculture sensitive to ocean acidification (see also *Ocean Acidification* theme paper).

Natural Resources Canada (NRCan) published climate change impact and adaptation reports in 2004 and 2008 which outline climate change adaptation in the natural resource, food, infrastructure, industry, natural environment, and health sectors. Since 2010, DFO's Aquatic Climate Change Adaptation Services Program (ACCASP) has supported large ocean basin climate change risk assessments; the development of new knowledge through science and technology to improve DFO's understanding of the impacts of climate change; and the development of science-based and applied climate change adaptation tools for use by DFO decision makers and the Canadian public. Two adaptation tool projects relevant to the Scotian Shelf were funded in 2012-2013: Incorporating Climate Change into Marine Protected Area Network Planning and Pilot Tools for Estimating Waves and Sea-level Extremes under Uncertain Climate Change Conditions (ACCASP 2013a, 2013b).

Handbooks have been published to guide municipalities in the creation of climate change adaptation plans (CIP 2011; Service Nova Scotia 2011). However, these handbooks do

Table 3: Climate change adaptation measures recommended by NOAA (2010)	
1.	Impact Identification and Assessment
2.	Awareness and Assistance
3.	Growth and Development Management
4.	Loss Reduction
5.	Shoreline Management.
6.	Coastal and Marine Ecosystem Management
7.	Water Resource Management and Protection

not directly address the particular vulnerabilities of communities dependent on fishing or other marine industries linked to the offshore. The range of existing planning resources for marine industry dependent communities may be inadequate for capturing the impacts of climate change on the offshore environment.

In examining the scope of adaptation measures suggested by NOAA (see Table 3), the present adaptation responses for offshore areas of the Scotian Shelf do not fully address the range of recommended measures. The Atlantic Climate Adaptation Solutions projects that have recently been active in coastal areas of Nova Scotia have focussed on adapting to socioeconomic impacts of climate change, such as flood mapping and infrastructure damage. Consequently, a broad ecosystem-based approach to climate change adaptation planning may be needed to better prepare for climate change impacts.

4.4 SCIENCE AND TECHNOLOGY

Given the scientific complexity of the issues discussed in this report, it is clear that scientific and technological responses will be crucial in addressing emerging issues on the Scotian Shelf. The direction of scientific research in Canadian oceans is critically important, and has been recently commented on by two significant studies. The Royal Society of Canada Expert Panel (2012) recommended improved monitoring programs, a national program for mapping ocean habitat, the strengthening of basic and discovery-oriented research, and a comprehensive research program to forecast changes to marine biodiversity caused by climate change. Meanwhile, the Council of Canadian Academies (CCA) has identified priority areas for science investment. Among those relevant to the Scotian Shelf are the need for increased understanding of deep water areas and the role of microbial biodiversity (CCA 2012). In order for these scientific advancements to have tangible benefits on the Scotian Shelf, they must be integrated into policy. Although the integration of science in policy is a perennially popular topic, the strengthening of the science-policy interface can be seen as a missed opportunity in many cases (Kinder 2010). There is increasing demand that the science advice process not only be transparent to the public but actually involves the public and includes local and traditional knowledge (Kinder 2010).

4.4.1 In situ Monitoring Sensors and Platforms

New types of technology are being utilized in ocean observation. For example, the Ocean Tracking Network (OTN) has employed acoustic tracking technology using receivers and tagged animals on the Scotian Shelf. There are two locations of multiple acoustic receiver deployments: offshore of Halifax and in the Cabot Strait (OTN 2012). Autonomous Vehicles are starting to be deployed to collect oceanographic information and are very cost effective over ships and buoys for some data collection tasks. Alternatively, cabled network observatory platforms have the advantages of high power, high band width, high temporal resolution, longevity, and interactivity, and are already well established on the west coast of Canada (OTN 2012).

There were 65 ocean observing system (OOS) projects in Canada as identified by the Ocean Science and Technology Partnership in 2010. The observations collected and disseminated by the responding systems were diverse in the types of data collected, addressed issues at the regional and local level, and were used for research (76.2 %), regulatory (42 %) and operational (53.6 %) monitoring purposes (OSTP 2011). Concerns identified were OOS sustainability and lack of coordination, in contrast for example to the Integrated Ocean Observing System in the United States which works closely with eleven regional associations to establish core capabilities that meet both national requirements and regional user needs.

4.4.2 Ocean Fertilization

As the effects of climate change are increasingly apparent, interest in large scale mitigation is growing as well. Ocean fertilization is a type of geoengineering, the "deliberate large-scale intervention in the Earth's climate system, in order to moderate global warming" (Royal Society 2009). One controverial technique introduces iron into the marine environment with the goal of stimulating a phytoplankton bloom, with the aim of increasing the amount of absorbed atmospheric carbon dioxide. In July 2012, a private company deposited approximately 100 tonnes of iron sulphate into the ocean off the Pacific Coast of Canada, resulting in a claimed phytoplankton bloom 10 thousand square kilometres in size (Lukacs 2012).

The practice is considered a breach of the United Nations' Convention on Biological Diversity and the London Convention and Protocol on dumping wastes at sea and in 2013, amendments were proposed to the London Convention to clarify this. The Intergovernmental Panel on Climate Change concluded that its effectiveness is unproven (IPCC 2007). Much more extensive research would be needed to determine if ocean fertilization is a viable climate change mitigation method and in fact, the July 2012 event was widely criticized (Tollefson 2012). Specifically, better mathematical models of the ocean's biogeochemical processes would be needed to predict the side-effects of large-scale ocean fertilization (Lampitt et al. 2008). While unlikely to occur on the Scotian Shelf, this event shows the interest in human interventions to combat the effects of climate change.

4.4.3 Using DNA to Assess Biodiversity

Another influential scientific advancement does not pertain to a specific technological application, but rather to a shift in a whole field of scientific inquiry. Developments in genetic understanding of biodiversity are rapidly transforming traditional concepts of biodiversity, and this paradigm shift may have significant impacts on approaches for studying and measuring marine life. Marine scientists have started to exploit advances in the use of DNA sequencing techniques. The advance of these techniques and the integration with traditional methods of taxonomy for species identification will influence the field of ecology and potentially change approaches to monitoring and conserving biodiversity (Vandenkoornhuyse et al. 2010). For example, the Marine Barcode of Life and its partner the Census of Marine Life are international initiatives aiming to identify and categorize marine life by utilizing DNA barcoding. DNA barcoding is expected to substantially increase the number of documented marine species. Genetic techniques have been explored for utility in biodiversity conservation (Krishnamurthy and Francis 2012), invasive species and biological invasions (Miura 2007) and environmental chemical contamination (Veldhoen et al. 2012). These developments may suggest changes to the indicators used to monitor biodiversity on the Scotian Shelf.

5 SUMMARY TABLE

SUMMARY TABLE

INDICATOR	DPSIR	LEVEL OF PRIORITY[1]	SCOTIAN SHELF (SS) EMERGING ISSUE CHARACTERIZATION[2]	PROPOSED INDICATORS
Consumer demand for sustainable and traceable seafood	Pressure	1	Presently evolving on SS	Export revenue from certified fisheries Landed value from certified fisheries Percent stocks eco-certified[3]
Fishing at lower trophic levels	Pressure	1	Presently evolving on SS	Average trophic level of landings[3]
Deep water oil and gas exploration	Pressure	1	Presently evolving on SS	Average water depth of oil and gas developments on the SS
Microplastic particles	Impact	1	Global concern with potential to impact SS	Abundance of microplastic particles on the SS Range/distribution of microplastic particles on the SS Microplastic particles ingested by marine animals
Emerging chemical contaminants	Impact	1	Global concern with potential to impact SS	Number of regulated emerging chemicals
Information accessibility	Response	1	Recognized but requires additional attention on the SS	Number of data-providing organizations with approved open data policies and procedures
Climate change adaptation	Response	1	Recognized but requires additional attention on the SS	Integration of climate change into existing DFO planning processes[3]
In situ monitoring sensors and platforms	Response	1	Presently evolving on SS	Number of ocean observing systems with SS data Number of SS ocean observing systems that are collaborating with a national coordinating body
Sustainable aquaculture alternatives	Pressure	2	Presently evolving on SS	Number of offshore aquaculture operations Number of IMTA operations
Marine renewable energy	Pressure	2	Presently evolving on SS	Percent of Nova Scotia's energy use from renewable marine sources

SUMMARY TABLE (continued)

INDICATOR	DPSIR	LEVEL OF PRIORITY[1]	SCOTIAN SHELF (SS) EMERGING ISSUE CHARACTERIZATION[2]	PROPOSED INDICATORS
Timing of seasonal ecosystem events	Impact	2	Global concern with potential to impact SS	Timing of phytoplankton blooms[3] Match-mismatch of ecosystem events[3]
Emerging diseases	Impact	2	Global concern with potential to impact SS	Number of diseases (of marine organisms) new to the SS Distribution and spread of marine invasive species[3]
Ecosystem based management and ecosystem service valuation	Response	2	Recognized but requires additional attention on the SS	Total area of habitat protected by conservation and management measures[3] Marine management plans take an ecosystem rather than a single-species approach
Emerging aspects of marine spatial planning	Response	2	Recognized but requires additional attention on the SS	Management tools use a spatially-explicit approach
Alternative products from ocean resources	Pressure	3	Presently evolving on SS	Number of businesses using marine resources for alternative products in Nova Scotia
Impact of ocean acidification on sound transmission	Impact	3	Global concern with potential to impact SS	Ocean pH level[3] Research studies into ocean acidification[3]
Ocean fertilization	Response	3	Global concern with potential to impact SS	Number of national and international laws and regulations addressing ocean fertilization
Using DNA to assess biodiversity	Response	3	Global concern with potential to impact SS	Species diversity[3] Number of species identified using DNA techniques on the SS

[1]Levels of priority are meant to categorize the relative importance of the various issues in terms of their imminent significance to the Scotian Shelf. Level 1 issues require immediate action; level 2 issues need to be addressed in the short to medium term; level 3 issues should be treated as a "watching brief," meaning that managers should remain alert to future developments.

[2]As per the definition of emerging issue presented in the "Issue in Brief" section of the report, the issues reported in this paper are characterized in one of the following three ways: an issue that is already present on the Scotian Shelf, but the situation is rapidly evolving; a globally recognized issue that may or may not already be impacting the Scotian Shelf, and which requires additional monitoring to fill information gaps; and issues that have been already recognized on the Scotian Shelf, but which have not been adequately addressed and require additional attention or management action.

[3]This indicator has been used in another theme paper.

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