Benefits of Marine Protected Areas and Fisheries Closures in the Northwest Atlantic

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ABSTRACT

This report considers the conservation benefits of Marine Protected Areas (MPA) and fishery closures in the Northwest Atlantic. The international experience with MPAs and fishery closures is first summarized. While conservation benefits have been observed, these are generally dependent upon the size of the area relative to the distributional range of the organisms being protected as well as rates of flux across the closure boundaries. The performance of seven temperate marine cases studies is evaluated in relation to a suite of generally accepted conservation objectives for an ecosystem approach to management. Four of these were initially designed as fishery closures and three as MPAs. While data to evaluate performance of some areas are lacking, the experience of these closures is generally consistent with that described in the international literature. Additional benefits are noted for the protection of spawning components and the habitat of sensitive life history stages of target species. Using the components of Management Strategy Evaluation as a guide, recommendations for further work on the design and implementation of potential MPAs for the Scotian Shelf are provided.

RÉSUMÉ

Ce rapport porte sur les bienfaits des zones de protection marine (ZPM) et des mesures de fermeture de la pêche dans l'Atlantique Nord-Ouest en matière de conservation. Il présente d'abord un résumé des expériences menées partout dans le monde dans des ZPM et dans des zones fermées à la pêche. Bien qu'on ait constaté des bienfaits en matière de conservation, ceux-ci varient généralement en fonction de la taille des zones protégées par rapport à l'aire de distribution des organismes visés, et des flux de passage dans les zones fermées à la pêche. Les résultats de sept études de cas portant sur des organismes marins d'eau tempérée sont évalués par rapport à un ensemble d'objectifs généralement acceptés pour une approche de gestion écosystémique. Quatre des cas à l'étude portaient sur des zones qui avaient été fermées à la pêche et trois sur des ZPM. Bien qu'on manque de données pour évaluer les résultats obtenus dans certaines zones, les observations faites à la suite des fermetures correspondent globalement à celles qui sont présentées dans la documentation internationale. On a observé en outre des avantages pour la protection de reproducteurs et d'habitats utilisés par les espèces visées à certains stades délicats de leur cycle de vie. Enfin, le rapport présente des recommandations en vue de travaux futurs sur la désignation et la mise en œuvre d'éventuelles ZPM sur le plateau néo-écossais. Ces recommandations s'appuient sur les éléments de l'évaluation de la stratégie de gestion.

INTRODUCTION

The enactment of the *Oceans Act* in 1997 heralded a new chapter in the conservation and responsible management of Canada's Atlantic, Arctic and Pacific oceans. Prior to 1997, the management of human activities impacting the oceans and their ecosystems had focused on establishing and implementing regulatory frameworks to address specific impacting activities. The 1857 *Fisheries Act* is an example of this. Revised in 1991, this Act has governed the activities of all fisheries undertaken in Canada's oceans for over 100 years. More recently, the 1992 *Canadian Environmental Assessment Act* is designed to protect environmental quality (e.g. water, air and sediment) from sources of pollution while the 2003 *Species at Risk Act* gives the government the regulatory authority over human activities that would put species at risk of extinction. While the earlier Acts were regulatory in nature, the *Oceans Act* of 1997 was enabling legislation. The Act outlined a new approach to managing oceans and their resources based on the premise that oceans must be managed as a collaborative effort amongst all stakeholders that use the oceans, and that new integrated management (IM) tools and approaches are required. It changed the legislative basis for oceans management and created a policy framework within which all the earlier and future acts would operate. It requires that the impacts of all human activities on Canada's ecosystems be incorporated into the planning and regulatory process of all marine resource management plans.

Soon after proclamation of the *Oceans Act*, the Department of Fisheries and Oceans (DFO) created an Oceans Directorate with the mandate to develop policy associated with the Act (DFO 2002a) - and to facilitate the comprehensive and coherent implementation of Integrated Management (IM) in Canada's oceans. One of the first tasks undertaken by the Directorate was the definition of draft Large Ocean Management Areas (LOMAs) as the geographical basis for IM, the first of which was established on the Eastern Scotian Shelf off Nova Scotia. This area became the focus of the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative (O'Boyle and Worcester 2009; Rutherford et al. 2005) which was initially established as a pilot study to test the design and implementation of IM. The ESSIM Strategic Plan (DFO 2007a) outlines the principles, planning model, framework and strategies to achieve a suite of objectives to guide the activities of all human uses of the ESSIM area.

Canada ratified the United Nations *Convention on Biological Diversity* in 1992 and soon after drafted the Canadian Biodiversity Strategy (EC 1995). This outlined a national plan to protect and conserve the natural biodiversity of Canada's terrestrial and aquatic ecosystems. The *Oceans Act* formally addressed this strategy in providing the legislative basis for Marine Protected Areas (MPAs) and associated policy (DFO 1999). DFO subsequently drafted a national plan to conserve sensitive habitat in each LOMA (DFO 2002a). Seven MPAs have since been established under the *Oceans Act*, the first of which was the Endeavour Hydrothermal Vents MPA off the coast of British Columbia in 2003. Six additional MPAs (one for every five LOMAs plus one other) are to be declared by the end of 2012.

To identify an MPA additional to the Gully on the Scotian Shelf, DFO Maritimes Region initiated a multi-step planning process (DFO 2009a). This benefited from the considerable work which had been undertaken over the previous decade on the identification and mapping of ecological priority areas in the ESSIM area. This included the development of a benthic community classification approach (Kostylev and Hannah 2007) and the development of criteria to identify ecologically and biologically significant areas (DFO 2004a), both of which have been used to describe ecological priority areas on the Scotian Shelf. The latter have been used to identify an Area of Interest (AOI) for ESSIM as the first step in the MPA creation process. This AOI was selected through determining 1) which ecological priorities areas best matched the ESSIM objectives for healthy ecosystems and 2) which areas already received protection from human impacts. The AOI selection process has involved extensive discussions with the stakeholder community and sets the stage for the next step in the process – evaluation of the AOI for recommendation as an MPA. The St Anns Bank AOI was announced on June 8, 2011, beginning the MPA designation process. This involves articulation of specific conservation objectives, boundaries, and regulations, culminating with final designation as an MPA.

In support of the MPA designation process, this report summarizes information on the potential fisheries benefits of existing fisheries closures and Marine Protected Areas with a focus on the Northwest Atlantic. It first provides a synopsis of international experience with spatial management tools such as MPAs. It then considers seven case studies of MPAs and fishery closures used in the Northwest Atlantic. It concludes with a synthesis of the benefits of MPAs for fisheries, based on international and regional experiences, and provides recommendations to both inform future decisions on the identification and designation of MPAs and assist communication of these benefits to ocean resource managers and stakeholders.

INTERNATIONAL EXPERIENCE WITH MPAS AND FISHERIES AREA CLOSURES

Before considering the international experience with MPAs and fishery closures, it is useful to have an operational definition of what these are. While FAO (2006) notes that there is no consistently applied definition of an MPA, the IUCN (Dudley 2008) defined a Marine Protected Area as:

> *"A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values"*

An analogous definition has been adopted by the 188 parties to the Convention on Biological Diversity (CBD COP7, 2004, Decision VII/5):

> *"any defined area within or adjacent to the marine environment, together with its overlaying waters and associated flora, fauna and historical and cultural features, which has been reserved by legislation or other effective means, including custom, with the effect that its marine and/or coastal biodiversity enjoys a higher level of protection than its surroundings"*

Based on these definitions, the key elements of MPAs are 1) defined spatial areas of the ocean, including the ecosystem components in both the water column and on the bottom, which 2) provide some level of protection from human impacts and 3) are codified in legislation. Of the various forms MPAs can take, some examples are (FAO 2006):

- spatial limits on fishing areas (as well as simple fishery closures)
- 'no take' areas in which there is a complete prohibition on entry or resource extraction (marine reserves)
- areas with ocean zoning schemes or other comprehensive controls on usage
- areas with regulation of specific designated activities, e.g. modes of fishery production (similar to fishery closures but more elaborate and to address wider range of issues e.g. habitat impacts)

- territorial rights systems and allocation-oriented area regulation (access rights included)

Thus, MPAs range in spatial scale and degree of protection of associated ecosystem components. Under this definition, the time/area closures prevalent in fisheries management and no-take marine reserves can be considered as forms of MPAs. They only differ in what activities are permitted in each. While this broader definition of an MPA is used in the report, where appropriate, fishery and conservation (MPAs) closures are clearly distinguished.

FAO (2006) convened an international workshop to review the performance of MPAs as a fisheries management tool (see http://www.fao.org/fishery/mpas/en for synopsis), considering topics such as concepts and definitions, relationship between MPA design and biology (e.g. drift and movement patterns), social issues with MPAs, governance and legislation, and the MPA planning and implementation process. The workshop produced a framework for MPA guidelines which is currently under further development.

The workshop highlighted a number of key issues with MPAs. At a minimum, an MPA should include explicit objectives concerning the conservation and sustainability of fishery resources. In the context of MPAs as a fishery management tool, networks should be employed, rather than a single MPA, to the extent that they are advantageous to achieving conservation and sustainability objectives, providing biodiversity and habitat benefits, and minimizing social impacts. Networks serve to:

- account for dispersal of early life history stages of fishery resources or movement of later life stages
- conserve and sustain multiple species of fishery resources which typically have different distributions and patterns of dispersal
- afford protection to diverse types of habitat and/or ecosystem types
- affect distributional aspects of social benefits and costs (i.e. ensuring that MPAs do not overly impact any stakeholder group)
- enhance effectiveness of governance, and
- improve learning through sharing experiences

The last two are important in that the process of designing and implementing MPA networks requires the engagement of full stakeholder community, rather than just any one group within this, thus affording benefits associated with governance and learning. In particular, the workshop noted that the utility of an MPA relative to achieving objectives depends to some degree on the effectiveness of governance. For this reason, governance structures and processes for MPAs should incorporate relevant multi-sectoral interests (e.g. mining, transportation, tourism, fisheries) to facilitate improved implementation and compliance.

The workshop outlined the design, implementation and monitoring requirements of MPAs, emphasizing that their use needs to be integrated into the broader fisheries management process. It noted that the effectiveness of MPAs depends upon compliance, which in turn is related to both the levels of sanctions and voluntary compliance. Further, the workshop considered that while MPAs may be a valuable element of a precautionary approach, they do not necessarily provide precautionary benefits. Applying a diversity of fishery management tools, including MPAs, is likely to be more precautionary than overly depending on any one tool.

Finally, the workshop considered the essential role of on-going monitoring of the effectiveness of MPAs in the evaluation of their performance relative to objectives, and more generally, in support of research. It noted that a monitoring program needs to be designed to account for connectivity between the area inside and outside of MPA boundaries and needs to address fishery resources and ecosystems, fishing activity, and costs and benefits including distributional effects.

Many of the above issues relating to the objectives, design and implementation of MPAs occur repeatedly throughout the international literature. Regarding objectives, Halpern (2003), in his study of 89 studies, emphasizes that success of marine reserves, a form of MPA, needs to be judged against its expectation, this based upon the stated objectives. Many studies recognize objectives of MPAs as those relevant to the management of fisheries and those relevant to the preservation of biodiversity (Hastings and Botsford 2003). Within these two broad categories, there has been a wide array of objectives articulated for MPAs, as illustrated by the Independent World Commission on the Oceans (IWCO 1998: p.200):

- protection of marine species at certain stages of their life cycle
- protection of fixed, critical, habitats (e.g., coral reefs, estuaries)
- protection of cultural and archaeological sites
- protection of local and traditional sustainable marine-based lifestyles and communities
- provision of space to allow shifts in species distributions in response to climate and other environmental changes
- provision of a refuge for recruits to commercial fisheries
- provides a framework for resolving multiple stakeholder conflicts
- provides models for integrated coastal zone management
- provision of revenue and employment
- provision of areas for scientific research, education, and recreation

All these objectives can be considered a subset of those for an Ecosystem Approach to Management (EAM). It is thus useful to consider EAM objectives frameworks more generally with respect to MPA networks. Such a framework was developed by DFO (DFO 2004b; O'Boyle and Jamieson 2006) to guide EAM, based upon a synopsis of conservation objectives used elsewhere. The DFO framework consists of a hierarchy of objectives and sub-objectives for the conservation and maintenance of the biodiversity, productivity and habitat of ecosystems (Figure 1). The biodiversity objectives relate to processes at the community, species and population level. The productivity objectives relate to processes at the base of the food chain, at the population level and along the food chain. Habitat objectives relate to physical and chemical processes both in the water column and on the bottom. This framework has been incorporated into the ecosystem health dimension of the ESSIM strategic plan (DFO 2007a). It is comprehensive enough to address the wide range of objectives expected to be stated for MPAs in the ESSIM LOMA. For this reason, it is used to guide the review of the temperate region MPAs considered in this report.

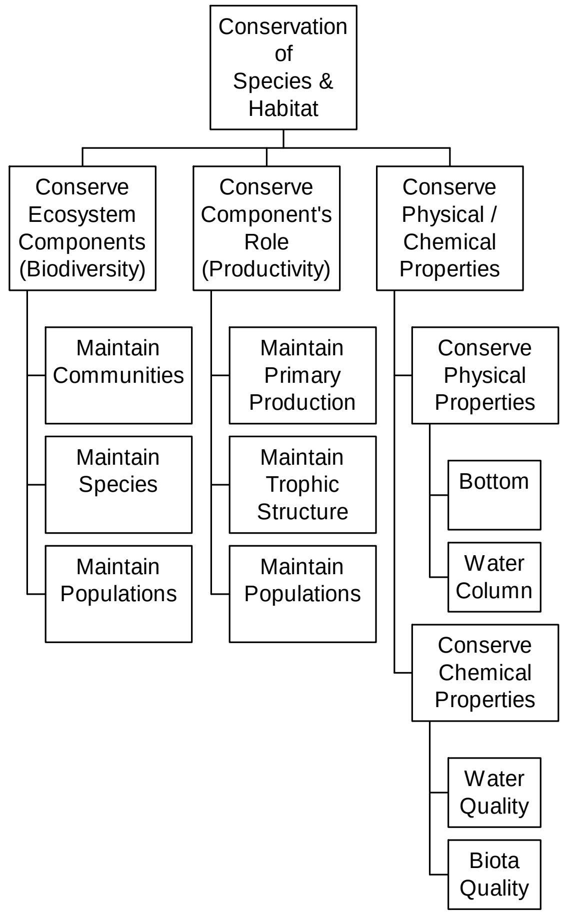


Figure 1. Conceptual Objectives Tree for the Environmental Dimension of Integrated Management in Canada (from Jamieson et al. 2001)

Regarding the design of MPAs, Botsford et al. (2003) emphasized that the theory underlying their design is still in its infancy. They articulated four principles to guide design. Two of these principles related to fisheries management, with the first stating that the effects on yield per recruit of adding reserves were broadly the same as increasing fish size limits, and the second stating that the effect on yield of adding reserves is the same as decreasing fishing mortality. Two principles related to biodiversity, with the first stating that reserves for biodiversity were most effective for species with low rates of juvenile and adult movement, and the second stating that reserves for fishery management are most effective for species with intermediate rates of adult movement (e.g. home ranges smaller than reserve sizes). They further noted that species with long distance larval dispersal generally require a large fraction of the coast to be protected by reserves for the population to persist. The fraction of settlement required to be protected is similar to the fraction of spawners per recruit used under common F_{MSY} proxies (e.g. 35 – 40% of the maximum spawners per recruit; F_{MSY} being the fishing mortality rate that results in Maximum Sustainable Yield). These principles, while still to be borne out through experience, are valuable in providing hypotheses on the benefits of MPAs which can be tested.

Regarding the performance of MPAs, recent work is suggestive of some general principles. Temporary closures (e.g. short seasonal closures) do not provide any guarantee against overfishing of a fish stock which can take place in other areas at other times. On the other hand, closures of major portions of the fishing grounds can affect fishing mortality and abundance in adjacent areas (Stefannson 2003). Thus, the size of a closure relative to the distribution of a resource is important. While closures of entire juvenile areas may have a positive effect, this has not been rigorously demonstrated although, as will be seen in this report, some positive benefits are evident. Many studies of the performance of MPAs thus far have either assumed isolated adult stock components or have focused on sessile organisms for which there is good evidence that the performance of MPAs is likely best (Hastings and Botsford 2003). For these species, Halpern (2003) determined that marine reserves, regardless of their size, and with few exceptions, lead to increases in density, biomass, individual size, and diversity in all functional groups. The diversity of communities and mean size of sessile organisms within a reserve were between 20 – 30% higher relative to unprotected areas. The density of organisms is roughly double in reserves while biomass is nearly triple. It is apparent that the crucial factors determining the effectiveness of MPAs in meeting conservation objectives are the rates of emigration of organisms from the area compared to the level of human impacts (e.g. fishing mortality) outside the area. Thus, MPA effectiveness should be generally lower for highly mobile as compared to sessile organisms.

The above observations on the objectives, design and performance of MPAs based upon recent studies available in the international literature are valuable background for the case studies considered in the next section.

CASE STUDIES OF TEMPERATE MPAS

A number of MPAs and fishery closures have been established off the East Coast of North America. These include:

- Groundfish Closures, US Gulf of Maine Area (17,131 km^2)
- Haddock Spawning Closure, Browns Bank (12,332 km^2)
- Haddock Nursery Closure, Emerald/Western Bank (12,776 km^2)
- Lobster Closure, Browns Bank (6,554 km^2)
- Gully MPA, Scotian Shelf (2,364 km^2)
- Coral Conservation Areas, Scotian Shelf (439 km^2)
- Eastport Peninsula MPA, Newfoundland (2.1 km^2)

The rationale for the establishment of each of these areas (Figure 2) roughly splits into the two broad categories of fisheries management and biodiversity objectives noted above. The groundfishery closures in the US Gulf of Maine Area, on Browns and Emerald / Western banks as well as the lobster closure on Browns Bank are all related to the management of fishing pressure on specific ecosystem components (i.e. fish stocks). The remaining areas (Gully and Eastport MPAs and the coral conservation areas) can be considered biodiversity closures, related to the conservation and protection of a broad range of ecosystem components. The fishery related closures are much larger than the biodiversity closures, this due to the fact that they were designed with fish population – level protection in mind.

In the case studies below, the background of each is provided. This is followed by a discussion of their design and implementation (i.e. enforcement and monitoring). The performance of each area in achieving the objectives of EAM is then discussed. As will become evident, studies on the performance of the closed areas are limited, with relatively more information available on the fisheries compared to the biodiversity closures. This is due to the fact that the fisheries closures have a longer history and have received considerable attention from fishery stakeholder groups. This is particularly true of the US Gulf of Maine Area fishery closures which are the most extensive in spatial area and have been the subject of extensive research on their costs and benefits. The three biodiversity closures are more recent, generally smaller in size and, except for the Eastport MPA, have not yet been the subject of performance evaluation. To the degree possible, comment on the performance of all closed areas is provided.

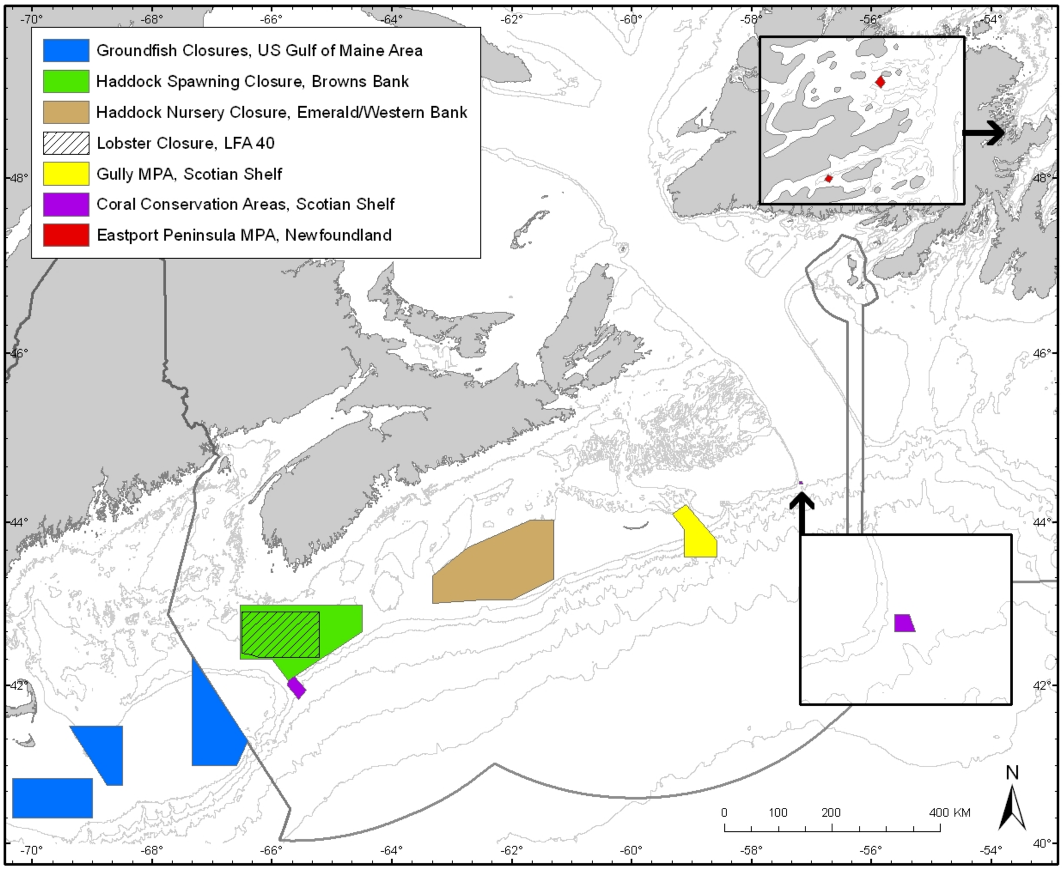


Figure 2. Location of closed areas of seven case studies considered in this report

GROUNDFISH CLOSURES, GULF OF MAINE AREA

Background

The groundfish closures in the Gulf of Maine Area have a long history. The region has supported important commercial fisheries since the 16th century (Fogarty and Murawski 1998). Although marked declines in some resources occurred prior to the onset of the 20th century (e.g. Atlantic Halibut), a broad range of pelagic (e.g. herring) and demersal (e.g. cod and haddock) fish species have supported commercial fisheries in the Gulf of Maine and Georges Bank region during the past 120 years (see for instance, the long-term landings of cod and haddock in Figure 3).

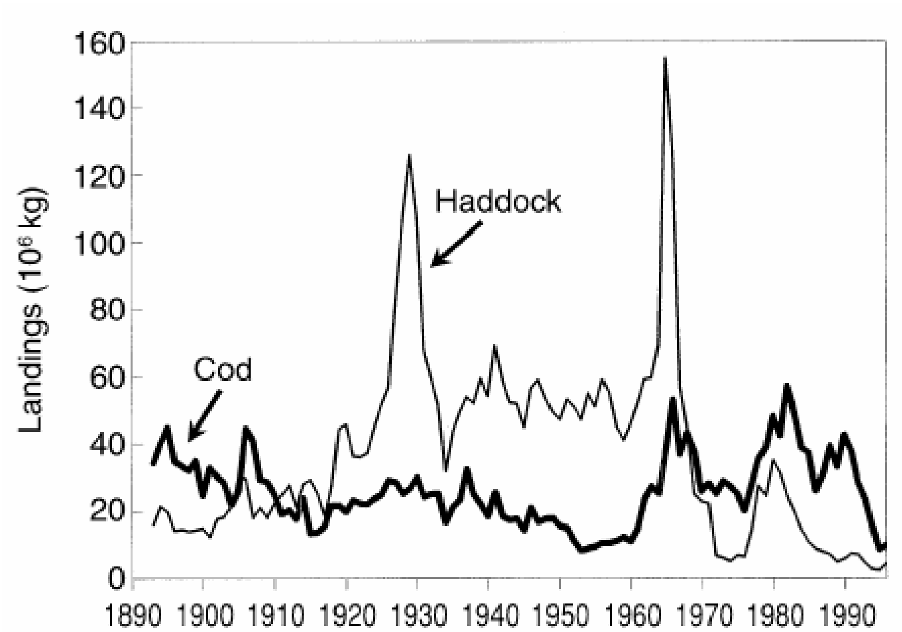


Figure 3. Landings of Atlantic cod and haddock from Georges Bank during 1893 – 1996 (from Fogarty and Murawski 1998)

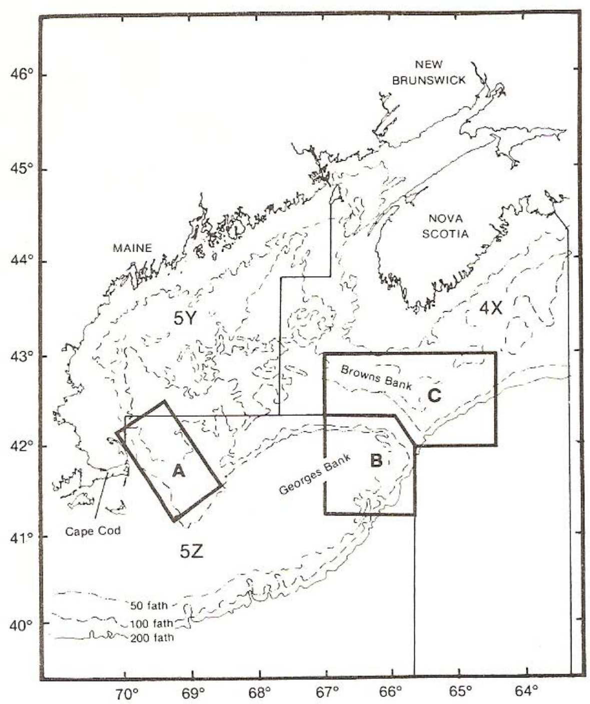
In the beginning of the 1900s, the concept of fisheries management was in its infancy. In the Northeast Atlantic, the International Council for the Exploration of the Sea (ICES) was established in 1902 to provide scientific advice to European governments on the sustainable harvesting of fisheries, this motivated by concern for the effects of fishing on fish stocks (Halliday and Pinhorn 1996). However, ICES, as an intergovernmental marine science organization, was and still is not directly involved in establishing fisheries management regulations. In the Northwest Atlantic, the North American Council on Fishery Investigations (NACFI) was established in 1920 with a similar mandate to that of ICES. The situation changed in 1949 when the International Commission for the Northwest Atlantic Fisheries (ICNAF) was formed, which had the mandate to manage Northwest Atlantic fisheries resources, based on science provided by its own scientific committee.

The early history of fisheries management on Georges Bank is comprehensively described by Hennemuth and Rockwell (1987). Prior to 1950, the fisheries on Georges Bank were essentially unregulated. In 1953, to address concerns related to massive discarding of fish and declines in the abundance of key species, ICNAF introduced minimum cod-end mesh size regulations (114 mm) in the Georges Bank haddock fishery. However, resource conditions deteriorated during the 1960s and early 1970s when European distant water fishing fleets targeted groundfish and other stocks along the Northeastern Coast of North America, including Georges Bank (Serchuk and Wigley 1992). It was apparent that more direct controls of fishing effort were needed and in 1970, the first fishery quota in the Northwest Atlantic (for NAFO 4X and Subarea 5 haddock) was introduced.

At that time, ICNAF had no provision for subdivision of a fishery quota into national allocations. Any country could enter the fishery and harvest the total allowable catch (TAC) as quickly as possible, and when the TAC was reached, the fishery would be closed to everyone. Closed areas and seasons were seen as an alternative to TAC regulation. ICNAF scientists estimated that a closure of the haddock fishery during March and April (when catch rates were highest) would reduce landings by 20 percent and - in conjunction with a TAC - would tend to spread the catch more evenly throughout the remainder of the year. Thus, in 1970, the first seasonal (March – April) fishery closures were introduced for haddock. Three spatial closures (Figure 4) were implemented: Cape Cod (A), Georges Bank (B), and Browns Bank (C), with all three areas closed during March and April to most gear capable of catching groundfish (hook gear and scallop dredges, however, were permitted). The closures were subsequently reviewed and frequently revised as their advantages and disadvantages became clearer with experience (Halliday 1988). By changing fishing patterns, fishermen were able to compensate for exclusion from the closed areas, and the realized reduction in the catch of Subarea 5 haddock turned out to be only about 50 percent of that predicted. By 1982, the Cape Cod (Area A) and Browns Bank (Area C) areas had been significantly modified, and the seasonal closures extended from March through May.

With extension of the 200 nautical mile limit of each country in 1977, both the USA and Canada introduced new management programs for the fisheries in their respective Exclusive Economic Zones (EEZs). In the US, the New England Fishery Management Council (NEFMC) and the National Marine Fisheries Service (NMFS) assumed responsibility for marine fisheries management, while in Canada, the Department of Fisheries and Oceans (DFO) assumed fisheries management responsibility. In 1979, the Northwest Atlantic Fisheries Organization (NAFO) replaced ICNAF as the regional management organization responsible for regulating fisheries straddling or outside of the 200 nautical mile limit.

a) 1970 - 71



b) 1982 - 87

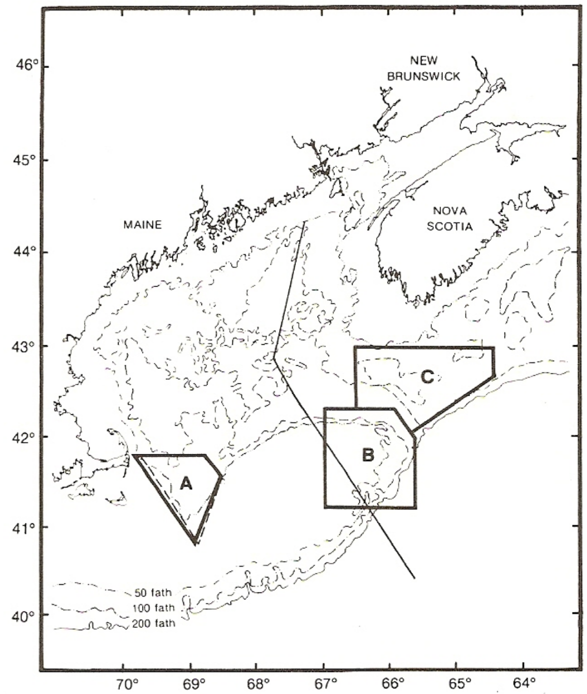


Figure 4. Haddock closed areas during (a) 1970-71 and (b) 1982-87; on the latter, solid lines indicate boundaries through 1986, dashed lines indicate changes implemented in 1987; the Canada – USA maritime boundary effective 12 October 1984 is also shown (from Halliday 1988).

In March 1977, the first US Fishery Management Plan (FMP) for cod, haddock and yellowtail flounder was implemented. This FMP continued many of the regulations developed under ICNAF, including stock-specific catch quotas (TACs) and closed areas. By 1982, catch quotas had become unpopular in New England and were replaced in 1983 by indirect controls on fishing mortality (e.g., minimum mesh sizes, minimum fish landing sizes, closed areas, and trip limits). These controls were implemented under the “Interim Groundfish FMP” developed by the NEFMC. In Canada, quotas continued to be used (Fogarty and Murawski 1998).

In October 1984, the World Court established a new Canada- US maritime boundary (Figure 4b). Since enactment of extended fisheries jurisdiction by both nations in 1977, both countries had been allowed to fish in the overlapping disputed zone, primarily on Georges Bank, which had further contributed to resource declines. Fishing fleet overcapacity had become an issue in both countries. In Canada, the capacity of the Southwest Nova Scotia fishing fleet was estimated to be almost four times larger that needed to achieve the $F_{0.1}$ target harvest rate (DFO 1986). The decline in the groundfish resources and growing unrest in the industry led to a DFO Task Force recommendation to establish Individual Quotas (IQs) in the mobile gear fleet (Hache 1989). IQs were subsequently implemented in 1991 (O’Boyle et al. 1994) and have since been expanded to almost all Canadian fleet sectors. The combination of overall quotas and individual (now also transferable) quotas has largely addressed the imbalance in fleet capacity.

In the US, the NEFMC continued to employ input controls to manage the US domestic groundfish fishery. In 1985, the Northeast Multispecies FMP replaced the Interim Groundfish Plan, and extended management authority to a complex of 19 groundfish species/stocks. In 1986, an additional closed area was created off Southern New England (Nantucket Lightship Area) to reduce exploitation on yellowtail flounder and protect the stock during spawning. In 1994, Amendment 5 to Northeast Multispecies FMP was implemented and introduced a number of regulatory measures to address overfishing including fishing days-at-sea reductions, a moratorium on new vessel entrants, expansion of the closed area on Georges Bank from January through June, imposition of a haddock trip limit, mandatory logbooks, and an increase in the minimum cod-end trawl mesh size to 152 mm. Notwithstanding these measures, in December 1994 the Secretary of Commerce, acting under emergency authority, enacted year-round closures of Area I (old area A), Area II (US side of old area B) and the Nantucket Lightship Area to all fishing gears capable of retaining groundfish (i.e., trawls, gillnets, hook gear, and scallop dredges). The only gears permissible in the closed areas were lobster traps and, later, mid-water trawls for small pelagic species. In 1995, the NEFMC amended the Northeast Multispecies FMP to implement the year-round closures on a permanent basis. These closures remain in place to this day (Figure 5).

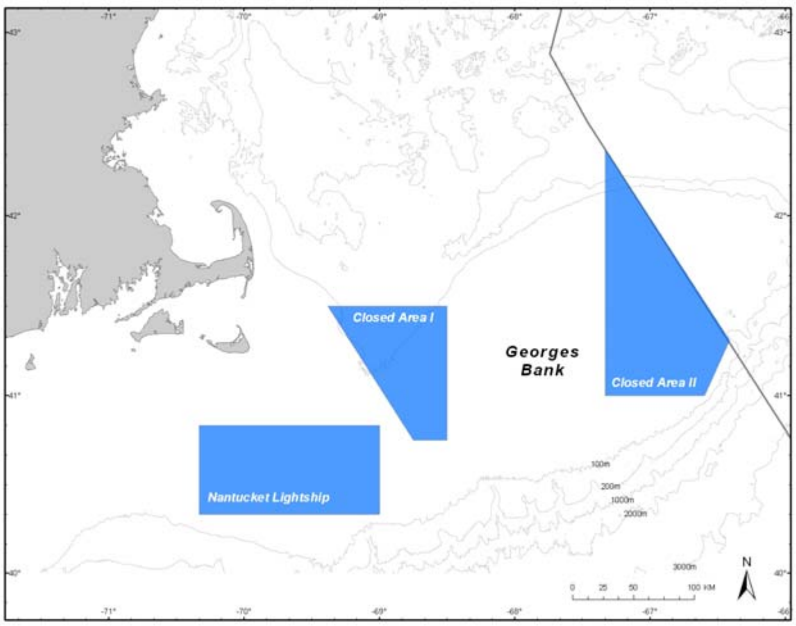


Figure 5. Groundfish closed areas in US Gulf of Maine area

Objectives

From the above background, it is clear that the US groundfish closed areas had their origin in the ICNAF haddock spawning closures, and were established by the US to reduce exploitation rates on cod, haddock and yellowtail flounder stocks in the Georges Bank and Southern New England areas. When the emergency year-round closures were implemented in December 1994, no explicit consideration was given to the potential benefits of the closed areas with regard to conservation of biodiversity, productivity, and habitat. Nevertheless, some of these benefits did accrue and are discussed below.

Design and Implementation

In relation to the initial placement of the three closed areas, they were designed to encompass important spawning regions for cod, haddock and yellowtail. Cod and haddock spawn principally during the winter and spring on the Northeast Peak of Georges Bank within Closed Areas I and II. The eggs and larvae are planktonic and are typically entrained within the clockwise circulation pattern on the Bank and thus transported to gravel settlement sites (Fogarty and Murawski 1998). Yellowtail flounder spawn in late spring and summer, and spawning occurs primarily in Closed Area II and the Nantucket Lightship area. Yellowtail eggs produced within Closed Area II would typically be retained on the Bank, while those spawned in the Nantucket Lightship Closed Area would be transported southwestward by the prevailing circulation patterns off southern New England. Closed Areas I and II therefore serve as recruitment source areas for Georges Bank while the Nantucket Shoals area (which is not located on the Bank proper) does not.

In relation to reduction of exploitation rate, Closed Area II encompasses a large percentage of the cod and haddock resident on Eastern Georges Bank and, along with quota regulation in the Canadian fishery on Georges Bank, has been effective in constraining exploitation. Closed Area I covers a smaller portion of the spatial distribution of cod and haddock on the Bank and the Nantucket Lightship area covers only a small portion of the Southern New England yellowtail stock. Hence, on face value, these latter two closed areas do not afford the same relative level of stock protection as does Closed Area II.

A key component of implementation is the capacity to monitor fishing vessel movements in and around the closed areas. The efficacy of the closed areas depends on the ability to monitor fishing vessel movements in and around these areas. In the US fishery, the primary source for catch location information is the Vessel Trip Report (VTR). Landings are assigned to stock units based on rectangular three-digit statistical areas self-reported by captains on their VTRs (NEFSC 2008). The current VTR system has been in place since 1994, when reporting changed from a voluntary interview system to mandatory submission of trip-related information (area fished, effort, gear characteristics, etc). The location information provided on the VTRs is, by design, relatively coarse. More precise data on fishing locations are provided by Vessel Monitoring Systems (VMS), which have been used in various US fisheries, beginning with the sea scallop fishery. The VMS program has been expanded to address other uses and benefits, including monitoring compliance with closed areas. Using VMS data, Murawski et al. (2005) analyzed the spatial distribution of US otter trawl fishing effort in relation to the closed areas. Their results show that fishing effort tended to be concentrated along the boundaries of Closed Areas I and II (Figure 6). Notwithstanding this, compliance with the closed areas was considered relatively high.

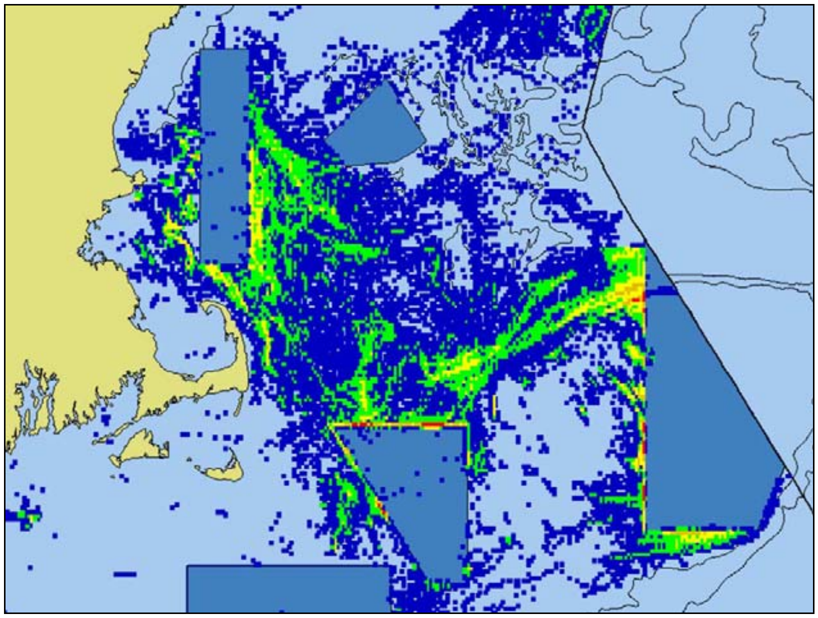


Figure 6. Otter trawl fishing vessel effort off the northeast USA, 2003. Data were obtained from vessels using VMS (vessel monitoring systems) using satellite tracking. Locations are plotted only for vessel speeds <=3.5 kts; data are aggregated to 1° square (from Murawski et al. 2005) .

Performance

Of all the case studies considered in this report, the groundfish closures in the US Gulf of Maine area have been the most thoroughly evaluated (e.g. Almeida et al. 2005; Collie et al. 2005; Lindholm et al. 2004; 2005; Link et al. 2005; Mendelson 2009; Murawski et al. 2000; 2005; Reid et al. 2005). As noted previously, the objective of these closures was to reduce exploitation on cod, haddock and yellowtail flounder, although several of the evaluations consider issues related to EAM objectives.

Since 1998, the Transboundary Resources Assessment Committee (TRAC) has conducted annual assessments of the three transboundary Georges Bank groundfish stocks: Eastern Georges Bank cod, Eastern Georges Bank haddock, and Georges Bank yellowtail flounder. For cod, fishing mortality since 1994 (when the year-round closed areas were implemented) has substantially declined, although stock biomass is still depressed (Figure 7). A similar trend in reduced fishing mortality is evident in the overall Georges Bank cod stock (NEFSC, 2008), of which the Eastern cod is the transboundary component (Figure 8).

A similar situation pertains between the Eastern Georges Bank haddock component (Figure 9) and the overall Georges Bank haddock stock (Figure 10). In both units, fishing mortality has also been reduced since 1994. However, while cod biomass remains low, haddock biomass has increased to record-high levels. The reduction in fishing mortality is due to the groundfish management programs in both countries, but it is also likely that Closed Area II has had a significant impact in reducing exploitation.

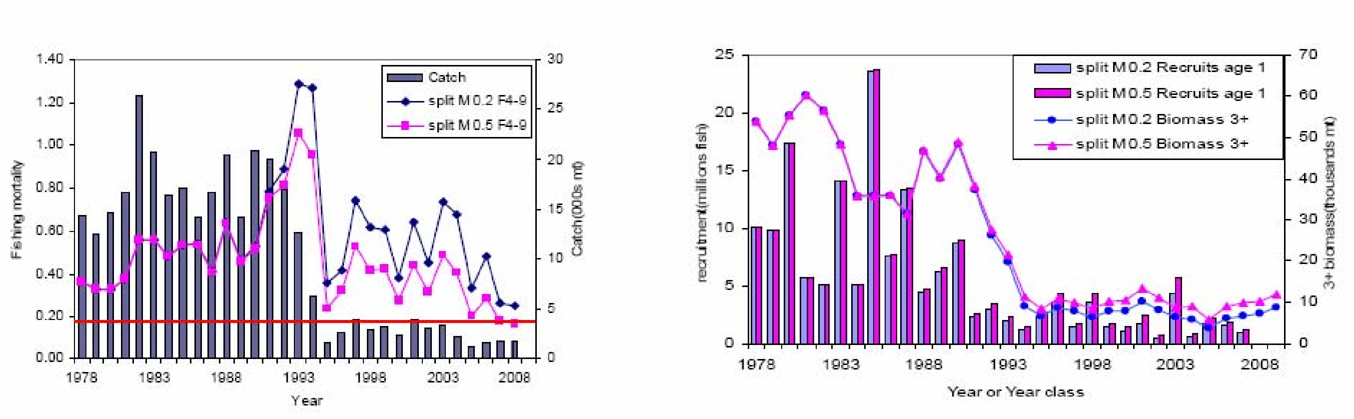


Figure 7. 5Zjm cod: catch and fishing mortality (left panel) and biomass and recruitment (right panel) (from TRAC 2009a).

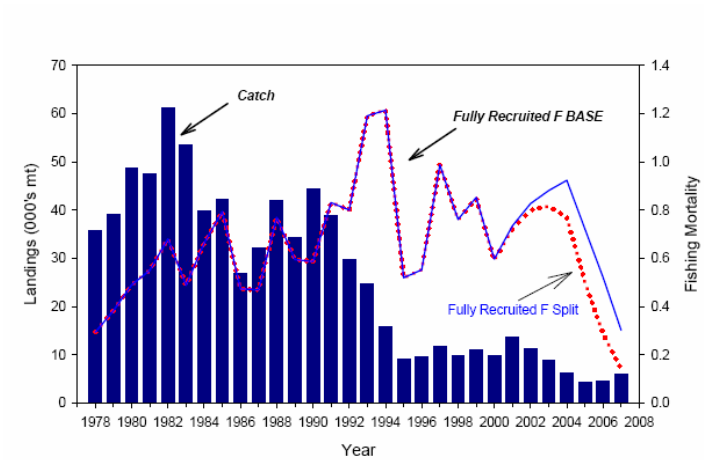


Figure 8. 5Z – 6 cod catch and fishing mortality (from NEFSC 2008); year round closure implemented in 1994.

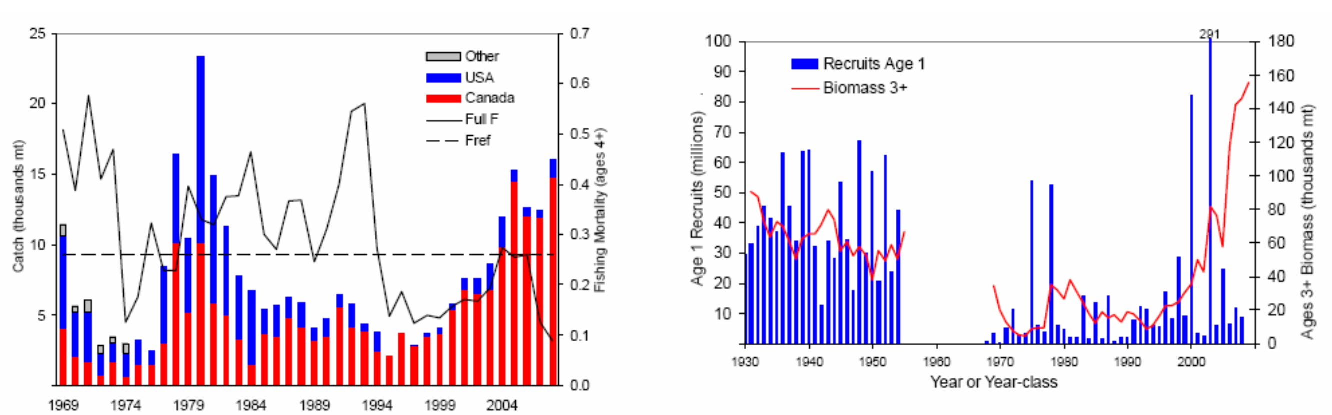


Figure 9. 5Zjm haddock: catch and fishing mortality (left panel) and biomass and recruitment (right panel) (from TRAC 2009b).

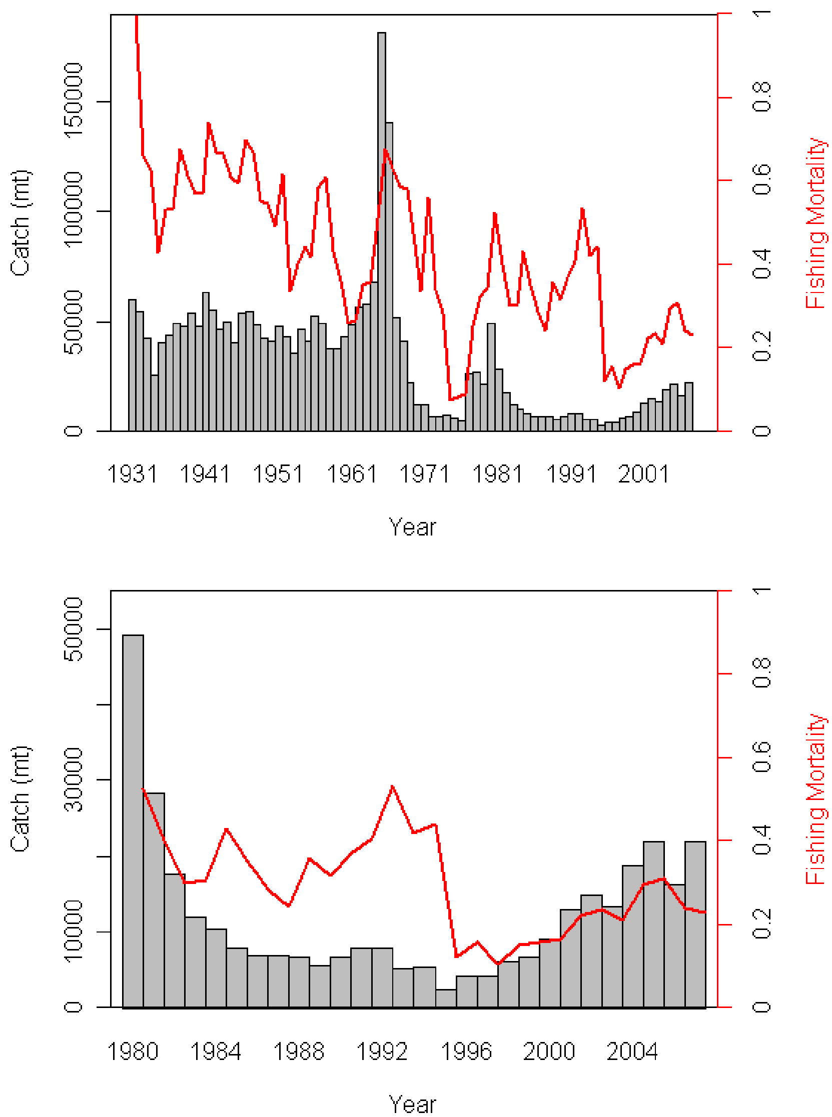


Figure 10. 5Z haddock catch and fishing mortality (from NEFSC 2008); top panel 1931 – 2007 and bottom panel 1980 – 2007 (from NEFSC 2008); seasonal closure implemented in 1970 and year round closure implemented in 1994.

The most significant effects of these closed areas are found for organisms that remain relatively contained within their boundaries, the most protected species being sessile organisms such as scallops (more on this below). Of the three groundfish species, haddock tended to be most associated with Closed Area II whereas cod and yellowtail tended to 'spill out' of the closed areas to a greater degree.

Gravel bottoms, substrates with high structural complexity, are known to be an important habitat for the early juvenile demersal phases of cod and haddock, providing shelter from predation (Fogarty and Murawski 1998). However, gravel regions, which typically support rich epibenthic fauna, are particularly vulnerable to disturbance by fishing gear. Collie et al. (2005) evaluated the effects of fishing gear on gravel habitats in Closed Area II, and observed significant shifts in species composition and increases in certain benthic megafauna. Among the taxa that increased were species of crabs, molluscs, polychaetes, and echinoderms. Following the year-round closure of the area in December

1994, larger benthic species began to dominate the biomass of the invertebrate community. These results and those from related studies were used by the NEFMC to designate a Habitat Area of Particular Concern (HAPC) for juvenile Atlantic cod in a portion of Closed Area II.

Given the beneficial effects of closed areas for relatively sessile organisms, the positive effects of Closed Area II on the sea scallop population in this area have been significant. The NEFMC Sea Scallop FMP implemented in 1982 initially maintained an open access domestic fishery without constraining the number of participants or areas fished. However, in 1994, the NEFMC established license and days-at-sea allocations in this fishery. Sea scallop dredge vessels were also prohibited from fishing in the three groundfish closed areas. By 1996, only two years after implementation of the year-round groundfish closed areas, sea scallop biomass in Closed Area II had tripled, and was projected to increase another 23% by 1998. The US fishing sea scallop industry successfully petitioned to have Closed Area II opened in 1999 for a limited fishery. US sea scallop landings in 1999, after the opening of Closed Area II, nearly doubled and the value of the fishery increased from $75 million to $121 million. Due to the success of the limited fishery, the NEFMC approved continued limited access fishing in the southern portion of Closed Area II. In 2004, a rotational management scheme for harvesting scallops was introduced (Hart 2003; Valderrama and Anderson 2005). Under this regimen, the Georges Bank closed areas were incorporated in an area rotation program that allowed access to the closed areas through allocation of a certain number of “trips” with possession limits. Although the closed areas have been successful in increasing sea scallop biomass, groundfish bycatch issues have arisen, particularly with scallop bycatches of Southern New England yellowtail flounder, a stock which still remains depressed.

Relative to EAM productivity objectives, the Georges Bank and Nantucket Lightship Closed Areas have had mixed success, with some stocks (e.g. haddock and sea scallops) exhibiting significant increases and others (e.g. cod and yellowtail flounder) decreases.

With respect to the biodiversity dimension of EAM, it is nearly impossible to assess the impact of the closed areas on this aspect of the ecosystem. However, given the marked reductions in fishing effort in the Georges Bank and Gulf of Maine regions over 15 years (in part due to the closed areas), positive benefits to biodiversity have likely accrued.

Regarding habitat concerns, some studies have indicated that the closed areas have had beneficial effects (Collie et al. 2005), although the results from other studies are equivocal. Collie et al. (2009) observed that colonization of gravel habitats was more rapid for free-living species (many of which are prey for fish) than for structure-forming epifauna. Hermsen et al. (2003) noted that mobile fishing gear disturbance conspicuously reduced benthic megafaunal production in gravel habitats, but when such fishing ceased, benthic megafaunal production increased. Link et al. (2005) found few differences in the nekton and benthic communities due to the closed areas, but emphasized that benthic substrate type was a more important consideration than simply whether a region was inside and outside a closed area.

To summarize, the key benefits of the Gulf of Maine fishery closures have been:

- Some reduction of fishing mortality on groundfish in the absence of quotas, particularly the protection of juvenile haddock
- Protection of sea scallop resulting in enhanced production
- Some benefits to community biodiversity
- Some benefits from protection of bottom habitat

HADDOCK SPAWNING CLOSURE, BROWNS BANK

Background

Much of the background on the haddock spawning closure on Browns Bank was provided above. To summarize, this and the US Gulf of Maine area fishery closures were instituted in 1970 under ICNAF to reduce exploitation rates of NAFO Div. 4X and 5Z haddock respectively. It is important to note that when the NEFMC extended the Georges Bank closure to be year-round in 1994, the one on Browns Bank continued as a seasonal fishery closure (not year-round) to protect the spawning haddock in Southwest Nova Scotia. It has been in its current configuration since the late 1980s (Figure 11).

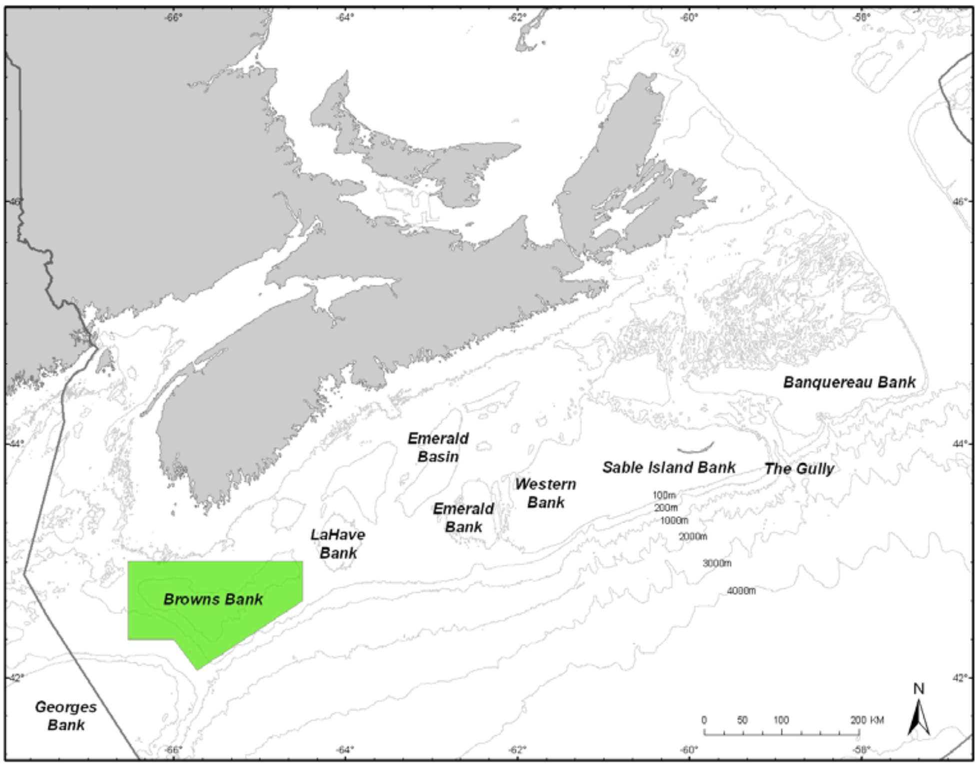


Figure 11. Haddock Spawning Closure on Browns Bank

Objectives

The primary objective of the Browns Bank fishery closure was to reduce NAFO Div. 4X haddock exploitation to a low level. The stock had experienced poor recruitment and declining abundance in the late 1960s but had come to support the most important Canadian haddock fishery on the East Coast. Thus its decline was foreseen as having severe adverse economic consequences for the region. Compared to Georges Bank (NAFO Div. 5Z) and Scotian Shelf (NAFO Div. 4VW), the 4X haddock stock was still relatively abundant and there were further concerns on the redirection of fishing effort from these banks (Halliday 1988).

The important additional objective mentioned earlier was the use of the Browns Bank closure in spreading catch throughout the year. As with other groundfish, haddock are most concentrated when in pre-spawning and spawning aggregations. By closing the spawning season to fishing, the expectation was for the TAC to be harvested during a longer period of time during the year.

Halliday (1988) points out that the institution of the Georges Bank spawning closure in 1970 can be credited to US fishermen who strongly believed that protection of fish while they are in the act of spawning had some direct biological benefit. This was accepted by Canadian fishermen for the Browns Bank closure and thus could be considered a third objective of the closed area.

Design and Implementation

The evolution of the Browns Bank haddock closure is summarized by Halliday (1988). When the closed area was first established, fishing gear capable of catching demersal species, including hook gear and scallop dredges was prohibited during March - April. This prohibition has remained in place until the present.

The initial placement of the closure (area C in Figure 4) was based upon limited scientific information on the location of haddock spawning on Browns Bank. This is contrary to the situation for Georges Bank where Closed Area B was based upon an analysis of the distribution of ripe, spawning and spent fish in commercial and research vessel catches, plankton egg distributions and seasonal egg production curves. During 1970 – 87, a number of spatial changes were made to Closed Area C. In 1972, the area was reduced by removing a portion at the western end and to the south east to allow prosecution of spring fisheries for argentine and silver hake. As well, the seasonal closure was extended to May.

Increasingly, haddock bycatch issues came to dominate discussion on changes to the closed area boundary. Canada wished to return to the pre-1972 boundary to limit haddock bycatch but met strong resistance from the USSR given its argentine and silver hake interests. A compromise was negotiated in 1975 which involved extension of the Browns Bank closed area to the east and to include February. However, in 1976, attempts to address bycatch concerns through additional extensions were resisted and the area boundary returned to that in force during 1972 – 74 (Figure 4b). To compensate, the bycatch allowance for both cod and haddock was reduced to one percent. This brought the NAFO Div 4X regulations in line with those of NAFO Subarea 5 (Halliday 1988).

The only subsequent change was as a consequence of the Hache Task Force (1989) which recommended extension of the closed area from March 1st to June 15th. This extension has remained to the present.

As with the US Gulf of Maine area closures, the Browns Bank closed area is enforced through a combination of at – sea observers, overflights and VMS. Given the broad industry support for the closed area, compliance has likely been high and there have been limited calls for either removal or reduction of the size of the area (B. Wood, Enforcement Operations Division, DFO, Dartmouth, NS, pers.comm.).

Performance

There has been no evaluation of the Browns Bank closure and thus performance on achievement of EAM - related objectives must be inferred from stock assessment and associated documentation.

Reduction of exploitation rates was the primary initial reason for the Browns Bank groundfishery closed area. A number of authors (e.g. Stefansson 2003; Stefansson and Rosenberg

2006; Murawski et al 2005) point out that seasonal closures are of only limited utility as fishing can occur once the area is opened to the fleets. The potential conservation benefits of seasonal closures are dissipated due to the effort influx following the opening of these areas. DFO (2010a) indicates that exploitation rates of 4X haddock were very high in the 1970s and were not significantly reduced until the mid-1980s when TACs were substantially reduced (Figure 12). The haddock stock responded by increasing in abundance, primarily since the late 1990s (Figure 13). Thus, it cannot be stated that the Browns Bank closure was effective in reducing exploitation rates of haddock. Regarding other stocks of Southwest Nova Scotia, those of cod and pollock are still depressed.

The other aspect of the productivity objective is prevention of the disruption of spawning. Fishery biologists have consistently argued that the reduction in the overall exploitation rate through TACs was more effective than benefits gained through spawning closures. Certainly, recent 4X haddock assessments indicate that this is the case. This has also been the experience on Georges Bank. There, year – round closures have been effective for haddock but not for cod and yellowtail. Notwithstanding this, it is possible that spawning closures, by spreading catch to other parts of the year, have been successful in safeguarding the 4X haddock stock from the same fate as cod and haddock stocks to the east. Closed areas for spawning for Eastern Scotian Shelf cod (NAFO Div. 4VsW) were never implemented. This stock was composed of a spring and fall spawning component; Frank et al. (1994) postulate that due to excessive fishing pressure, perhaps attracted to the high catch rates during the spawning season, the spring spawning component was fished out, with significant negative consequences for the stock.

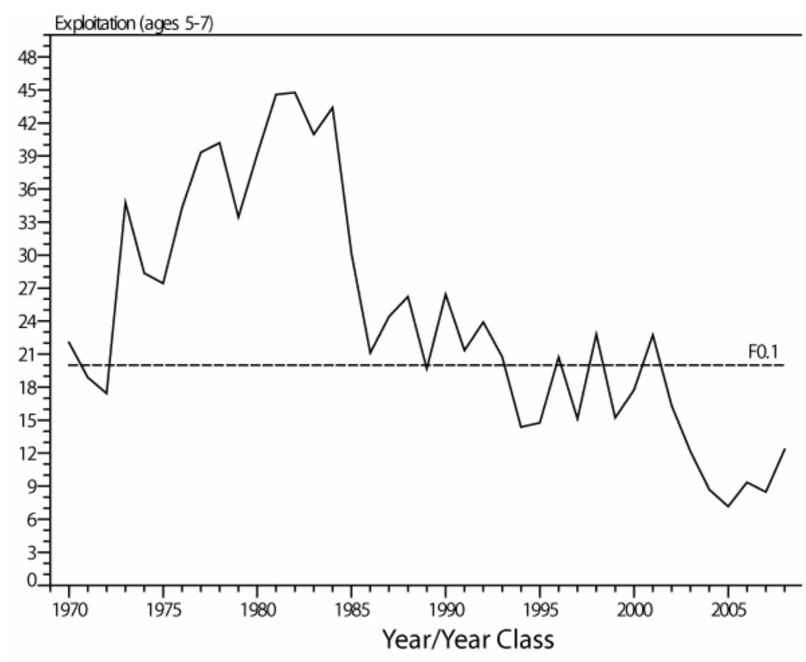


Figure 12. Exploitation rate (ages 5-7) for 4X haddock, 1970-2008 (from DFO 2010a)

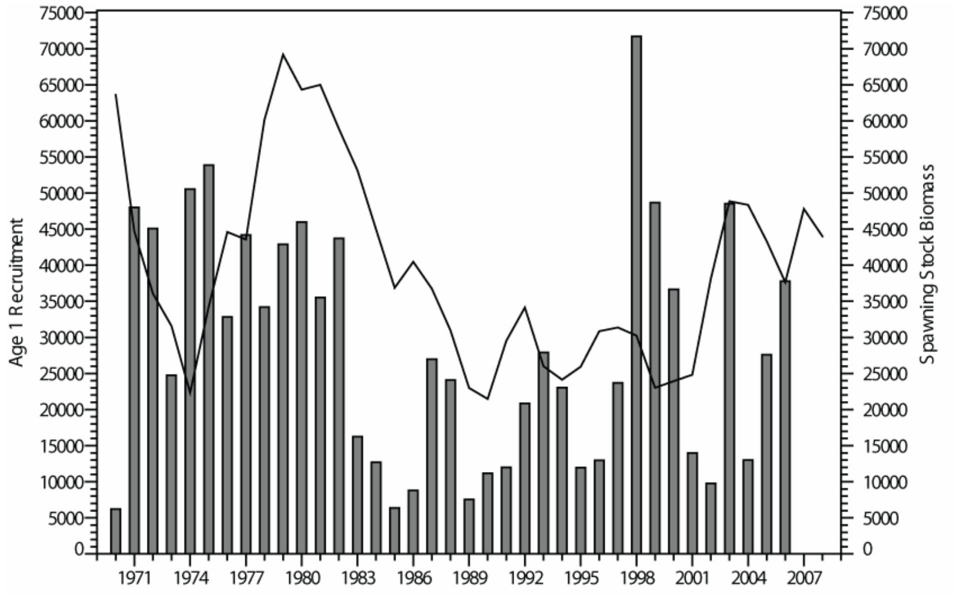


Figure 13. Spawning stock biomass (ages 4+) (line) and Age 1 recruitment (10^3) in the subsequent year (bars) for 4X haddock (from DFO 2010a)

Regarding biodiversity, while there have been large scale changes in the Scotian Shelf ecosystem (Frank et al. 2007), it is not possible to determine whether or not the Browns Bank, or indeed any other closure, had any role in mitigating the negative effects of high exploitation.

Regarding habitat, there have been a number of studies which have documented the benthic communities off Southeast Nova Scotia and in the closed area (Breeze et al. 2002; Horsman and Shackell 2009). However, without comparable studies before imposition of the closed area in 1970, it is not possible to state whether or not it has been effective in protecting sensitive habitat. Likely, benefits would be transitory given the seasonal nature of the closure.

In summary, while there may have been some benefits to the conservation of the 4X haddock stock (i.e. protection of 4X cod and haddock during spawning season), given the seasonal nature of the Browns Bank closure, it did not appear to be effective in reducing exploitation rates on 4X cod and haddock. Additional benefits for the habitat and ecosystem are likely limited.

HADDOCK NURSERY CLOSURE, EMERALD / WESTERN BANK

Background

Similar to NAFO Div. 4X haddock, NAFO Div. 4VW haddock move out of the deep water of the Shelf and spawn on the banks during early spring. Both prior and subsequent to extended jurisdiction, these spawning aggregations have been the target of international and domestic fishing fleets. ICNAF concerns for excessive harvesting of 4X and 5Z haddock were equally applicable to 4VW haddock. Indeed, as noted above, the status of the 4VW stock was considered as poor as that of 5Z (Halliday 1988). Thus, the initial ICNAF proposal for haddock seasonal closed areas also included one for 4VW haddock (Figure 14). However, due to opposition based upon anticipated interference to sliver hake and cod fisheries, Canada abandoned the 4VW closed area and only pursued those for 4X and 5Z.

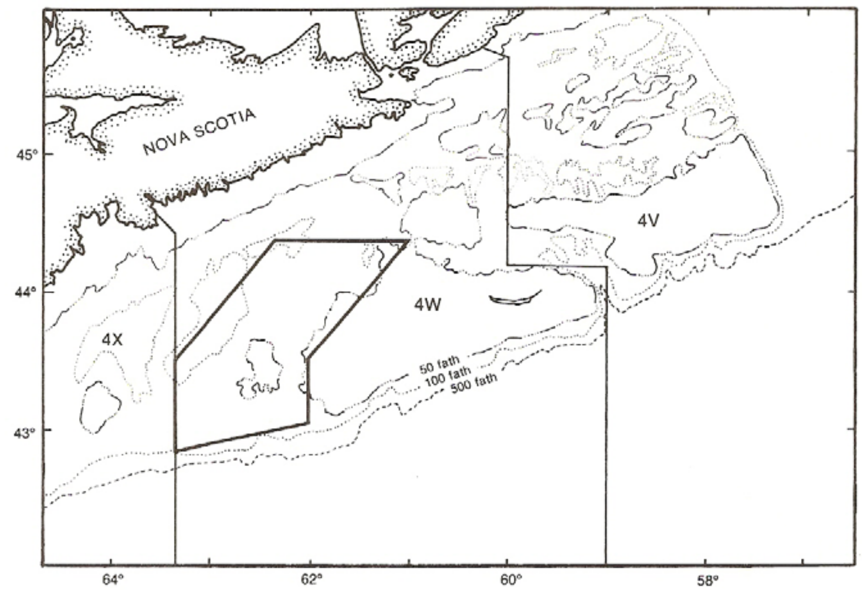


Figure 14. Example 4VW haddock closed area considered by ICNAF prior to 1970 (from Halliday 1988)

After extended jurisdiction, the stock began to rebuild. A succession of strong year classes in the early 1980s produced a prevalence of juvenile haddock in the vicinity of Emerald and Western Banks by the mid – 1980s. While the reported landings were less than the TAC, there were reports of extensive discarding, due to the presence of large amounts of unmarketable sized haddock (Frank et al. 2000). In 1984, DFO closed 4W to trawlers in an attempt to avoid these discards but this only diverted the fishing fleet to 4Vs and did not alleviate the problem.

In November 1986, the Scotia-Fundy Groundfish Advisory Committee recommended closing the 4VW haddock nursery area year-round to all groundfishing for 1987 to protect the juveniles and allow continued stock rebuilding. This closure (Figure 15) has been in place since then.

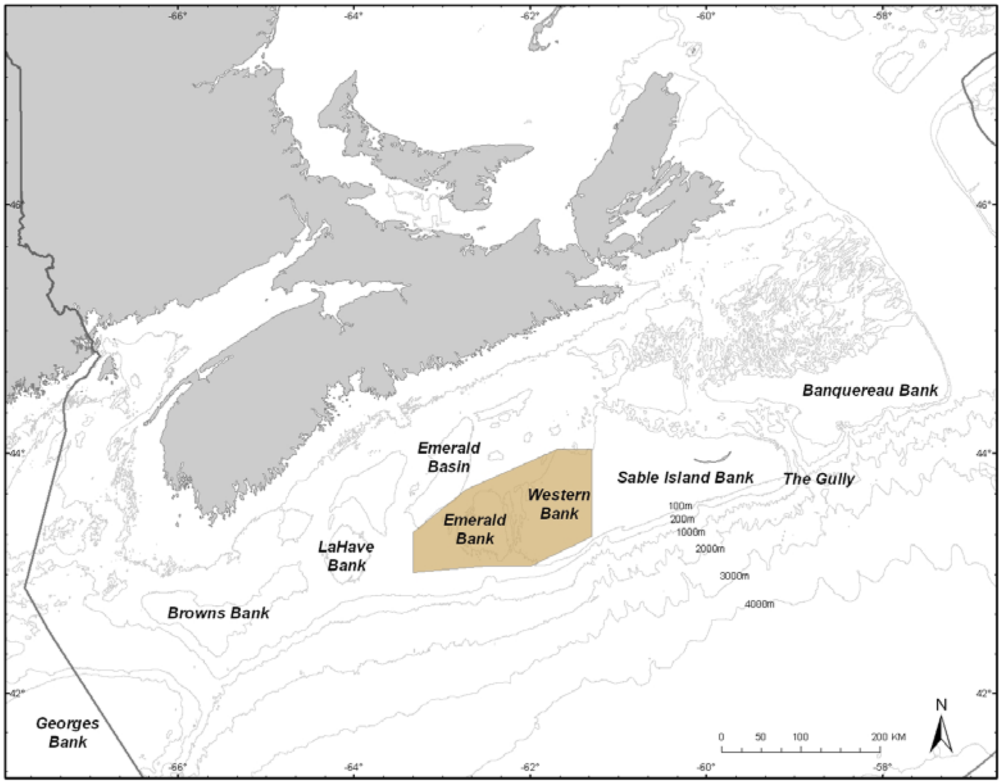


Figure 15. Haddock closed area on Emerald / Western Bank of the Scotian Shelf

Objectives

The objective of the haddock nursery in NAFO Div. 4VW was very specific – the protection of juvenile haddock in NAFO Div. 4VW. There were no other considerations related to either biodiversity or habitat protection.

Design and Implementation

Fanning et al. (1987) undertook an analysis to determine the coordinates of the closed area. Based upon DFO summer bottom trawl survey information, observer records, published reports and discussion with fishermen, two potential areas for a nursery closure were identified, one on Emerald / Western Bank and the other in the Gully. Boundaries for each of these areas were defined and potential bycatch issues identified. The major domestic fisheries in 4VW at the time were for cod, haddock, pollock, redfish and flatfish. The bycatch analysis indicated that the focus of the haddock nursery should be Emerald / Western Bank.

The resultant closed area on the central Scotian Shelf is relatively large (approx. 12,776 km^2) encompassing two major offshore banks (Figure 15). It represents about 13% of the total area of the NAFO Div. 4VW haddock stock which is resident on the Shelf, although these haddock are more closely associated to 4W rather than 4V.

It was initially intended that the area would be closed to all groundfishing (scallop dredging was and is still allowed in the area). It was later decided that groundfish fixed gear could fish inside the area as it was felt that this gear caught relatively older fish compared to mobile gear. However, it later became apparent (Halliday 2002) that fixed gear could catch smaller haddock by changing hook size and bait. Thus, prohibition of fishing was again extended to all groundfish gear types (including fixed gear) in 1993. This has remained in effect until the present. As noted above, however, scallop fishing is not restricted from the closed area. Indeed, scallop fishing in Div. 4W has generally been unrestricted in terms of effort (quotas were first implemented in 1994) and location, although the fleet has primarily fished the shallow, sandy bottom of Western Bank with no scallop fishing taking place on Emerald Bank or the western half of Western Bank. Only the easternmost part of the closed area has been subjected to scallop fishing (Frank et al. 2000).

Collectively, the available information indicates that the closed area has been only partially closed to all fishing since 1987 and has experienced a mixture of fishing activity, albeit at a lower level than surrounding areas that were not under similar restrictions.

Enforcement consists of the same regulatory tools as used in NAFO Div. 4X – VMS, at-sea observers, enforcement overflights and so on. Given the support of the fishing industry for the closed area, compliance is likely high (B. Wood, pers.comm.). It is important to note however, that in September 1993, the 4VsW cod fishery was placed under moratorium. As well, the 4VW haddock fishery has been effectively closed since then due to both the abundance of small fish and potential cod bycatch (DFO 2004c). Other groundfish fisheries on the Eastern Scotian Shelf are also impacted by cod bycatch. This has effectively reduced groundfishing in the region to minimal levels.

Performance

Frank et al. (2000) undertook an evaluation of the effectiveness of the 4VW haddock nursery. They considered that the objective of protecting juvenile haddock was only partially met. There appeared to be no increase in post-closure recruitment or juvenile survival. They gave three reasons for this: 1) the proportion of juveniles within the closed area steadily declined and a majority of year-classes during the post-closure period remained unprotected, 2) the closed area remained open to fishing by groundfish fixed gear whose catches inside the closed area and surrounding areas steadily increased, and 3) the resident haddock stock deteriorated in terms of growth and condition due to a combination of historical over-exploitation and large-scale environmental changes. As noted above, scallop dragging has continued in the easternmost part of the area. Studies of habitat association in NAFO Div. 4X indicate that scallop are preferentially found on gravel lag substrate (Robert 2001), an area where juvenile haddock are also found. Thus, the possibility exists for negative impacts on haddock productivity. However, as noted above, Frank et al. (2000) report that scallop fishing primarily occurs on the sandy bottom areas of Western Bank so the impact on haddock may be limited. This potential interaction between scallop and haddock warrants further study.

Notwithstanding these issues, significant numbers of juvenile haddock were still resident in the closed area and thus an increase in survival would have been expected. Since then, the stock has increased in biomass to levels observed historically (Clark and Emberley 2009; Figure 16) although the size of these haddock is small with the majority of the stock under the legal size limit of 43 cm in length (DFO 2004c; Figure 17).

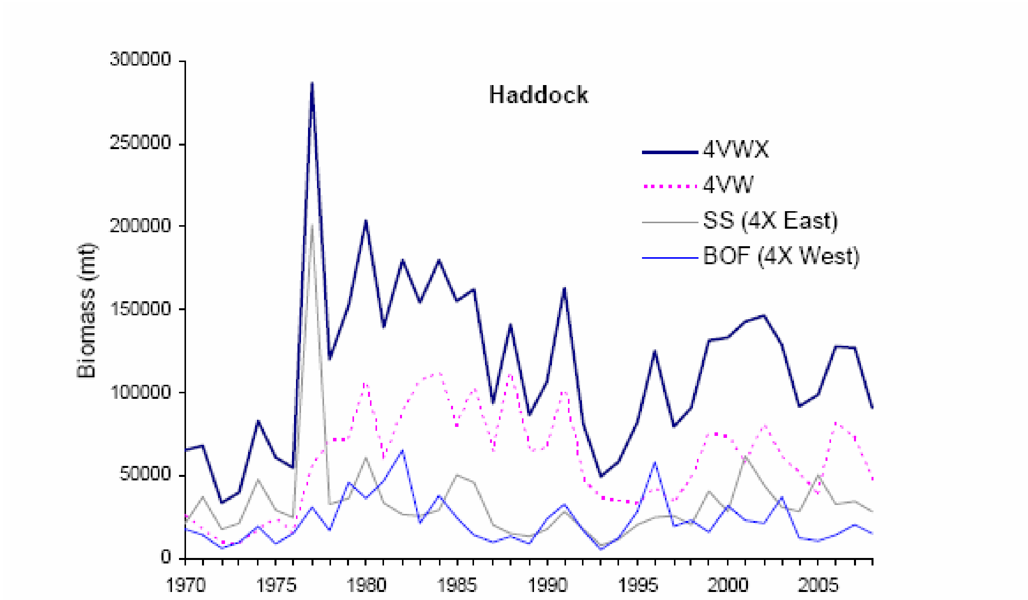


Figure 16. Haddock biomass trends from the Scotia-Fundy summer research vessel survey (from Clark and Emberley 2009)

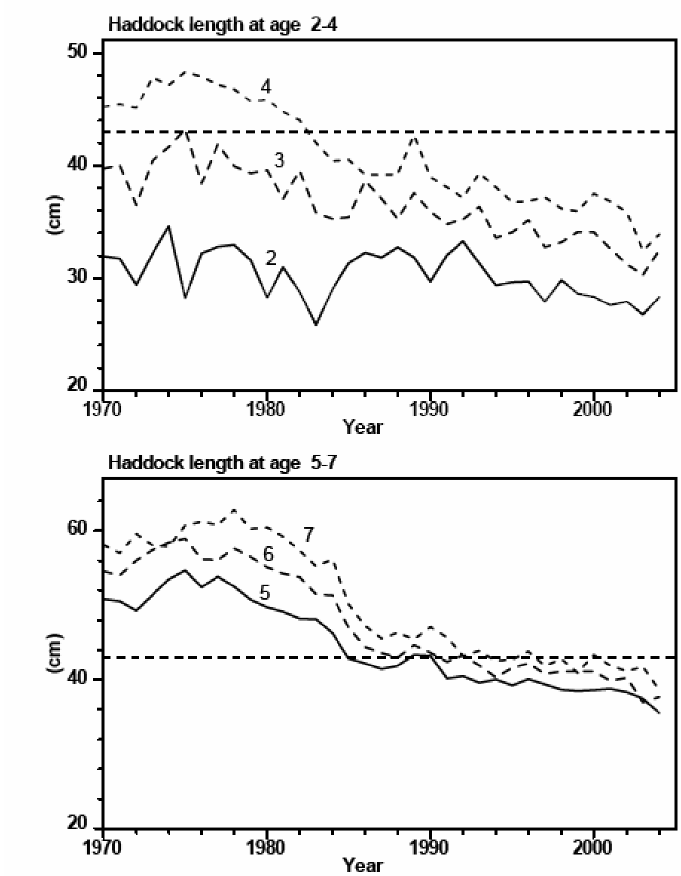
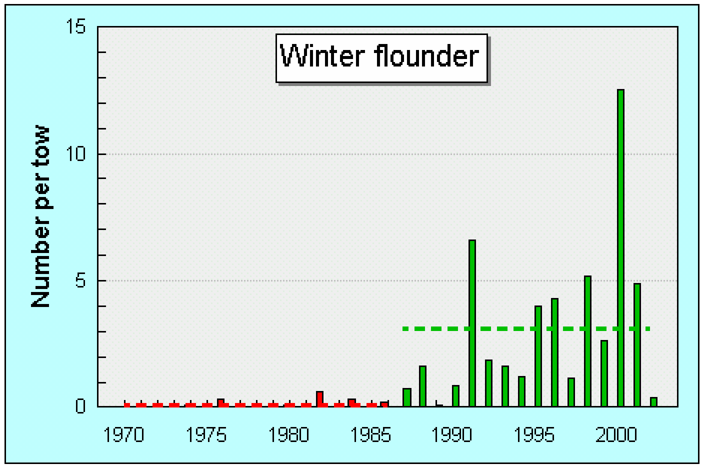
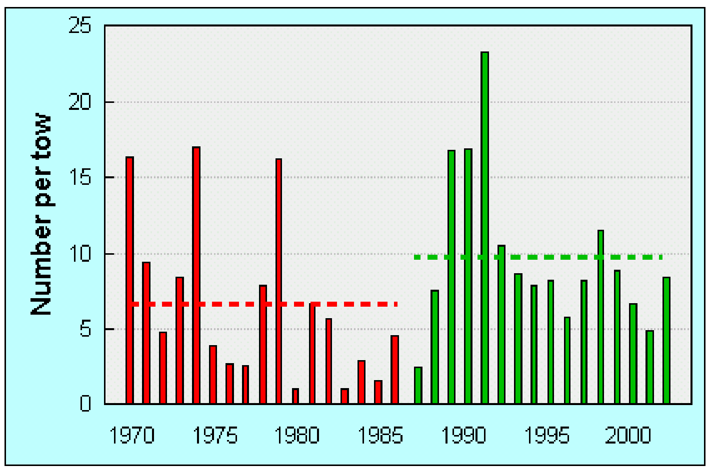


Figure 17. Length (cm) of age 2 – 4 (top panel) and age 5 – 7 (bottom panel) 4VW haddock during 1970 – 2004 (from DFO 2004c); the dashed line at 43 cm represents the legal size limit

a) Winter Flounder



b) American plaice



c) Silver Hake

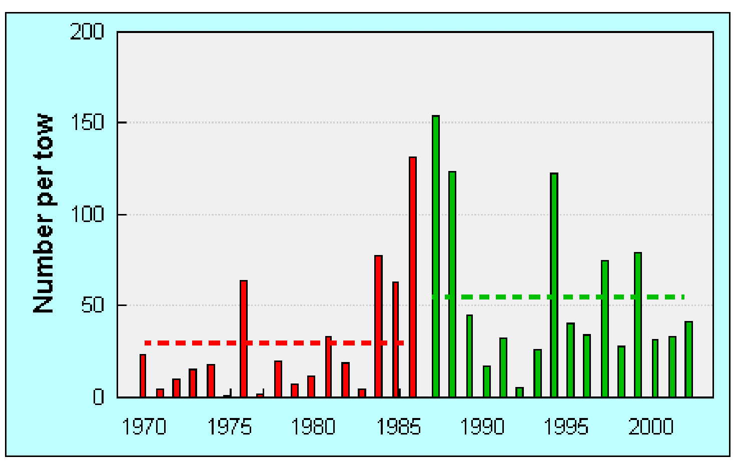


Figure 18. Abundance of winter flounder (a), American plaice (b) and silver hake (c) in DFO summer survey in 4VW closed area; bars pre and post 1985 indicate relative change in abundance since imposition of the closure (K. Frank, Ocean Sciences Division, DFO, Dartmouth, NS, pers. comm.)

There are thus stock productivity changes that confound the ability to determine whether or not the closed area has been beneficial to 4VW haddock stock conservation. Nevertheless, the haddock has increased and the closed area may have played some role in this.

It is important to note that the abundance of other non-target species (e.g. winter flounder, plaice, and silver hake) has also increased in the closed area (Figure 18). Thus, it is evident that the closed area has had broader beneficial effects throughout the ecosystem.

Contrary to the 4X closure, that in 4VW was year-round. Also, while enclosing most of Emerald Bank to the west, it straddled Western Bank to the east. It thus has afforded an opportunity to study fishing impacts on the benthic habitat. Since 1990, a collaborative research program between the DFO Maritimes and Newfoundland & Labrador Regions has been undertaken to study the potential impacts of mobile fishing gear on benthic marine ecosystems in Atlantic Canada (Gordon et al. 2006). As part of this research, a number of experiments have been conducted on Western Bank to better understand the short and long-term effects of bottom trawling on the benthic habitat. This and the other research conducted as part of this program have significantly added to the international literature on the habitat impacts of fishing. Collectively, this literature has shown that mobile bottom gears can damage/reduce structural biota and habitat complexity (Rice 2006). There is a gradient of impacts, with greatest impacts on hard, complex bottoms and least impact on sandy bottoms i.e. greatest impacts on low energy environments and least (often negligible) impact on high-energy environments. Trawls and mobile dredges are the most damaging of the fishing gears. They can change the relative abundance of species, particularly decreasing the abundance of long-lived species with low turnover rates but can increase the abundance of short-lived species with high turnover rates. They affect populations of surface-living species more often and to greater extents than populations of burrowing species. Overall, the impacts of mobile bottom gears are less in high-energy / frequent natural disturbance environments than in low energy environments where natural disturbances are uncommon. Mobile bottom gears affect populations of structurally fragile species more often and to greater extents than populations of "robust" species.

While ongoing monitoring on the benthic habitat in the closed area is lacking, it can be inferred from the above that the 4VW closed area has been somewhat beneficial to the benthic habitat on Emerald and Western Bank, somewhat in the sense that some scallop dragging has continued on the banks. The broader implications of this are difficult to discern. However, there was evidence that the protection of epibenthic habitat on Georges Bank likely contributed to enhanced juvenile survival. These beneficial effects may have also occurred in the Emerald / Western closed area.

In summary, the key conclusions on the benefits of the Emerald / Western fishery closed area are:

- limited evidence that the 4VW juvenile haddock closure has been beneficial to overall stock productivity (due to confounding effects of growth declines)
- Increases in abundance of non-target species in closed area, indicating broader beneficial effects throughout ecosystem
- inferential evidence that the expected benthic habitat improvements will have improved juvenile haddock survival

LOBSTER CLOSURE, BROWNS BANK

Background

The management unit of lobster resource off Southwest Nova Scotia is the Lobster Fishing Area (LFA) within which biological characteristics (e.g. growth and reproduction) are generally similar. Landings from LFA 34 are the highest in the region in comparison with those from LFA 33 off Southern Nova Scotia and in the Bay of Fundy (LFAs 35, 36 and 38) (Figure 19). Lobster in LFA 41 (50 nautical miles from the coast to the upper continental slope) are managed separately from lobster in inshore areas. Of significance is that the offshore fishery in LFA 41 started relatively late (in 1972) whereas the inshore fisheries have been underway since at least the 1890s. It is also important to note that these populations are likely part of a larger metapopulation within the whole Gulf of Maine area (DFO 1996). Thus, all the lobster in these various LFAs are linked through the biological processes of larval drift and adult migration.

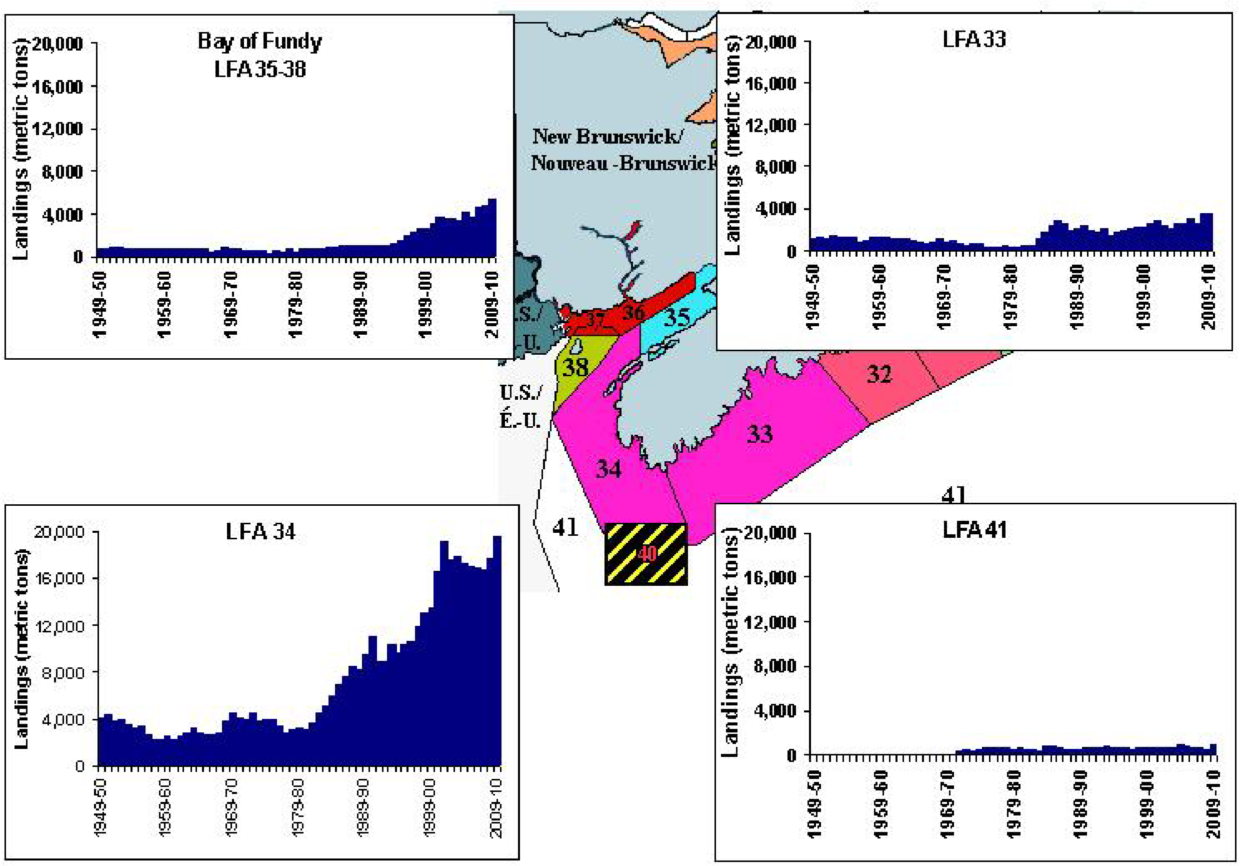


Figure 19. Landings of lobster by LFA off Southwest Nova Scotia (D. Pezzack, Population Ecology Division, DFO, Dartmouth, NS, pers. comm.)

Lobster fishing mortality in the inshore LFAs was and still is controlled through a combination of input controls including seasons, trap limits, gear regulation, lobster size limits, prohibition of the retention of berried females and so on. Quotas have only been introduced in the offshore LFA 41 fishery. In the late 1970s, lobster abundance in the region was near an historical low; there were protests and letters to the Minister of Fisheries and Oceans to close down the newly established offshore fishery. Some inshore vessels in LFA 34 had begun to expand their fishing from the traditional nearshore grounds (<55m depth) and were fishing German and Browns Bank and the Tusket Basin, which exacerbated the situation. The trend of inshore lobster vessels fishing further and further offshore has continued to the present. By the mid 1980s, approximately 100 vessels were fishing this deepwater, midshore area (Duggan and Pezzack 1995). This number remained relatively constant into the mid 1990s and in recent years, there have been an increasing number of new larger vessels capable of fishing further from shore and in almost any weather (Pezzack et al. 2006).

Stimulated by the severe resource situation, a workshop of Canadian and US scientists was held in 1978 (Anthony and Caddy 1979) on the status of lobster assessment science in the Gulf of Maine. There was discussion on the population structure and specifically the linkage between the inshore and offshore components. It was be1ieved that the offshore mature stock component moved into the inshore grounds in the summer and into the deeper water in the winter. Significant numbers of mature lobsters were observed in the offshore area which was thought to be a refugium as it was felt that lobster produced by this component contributed to recruitment in the inshore.

The situation is now known to be more complex. Lobsters seasonally move from deep to shallow water. The summer migration of adults from the offshore area to the coast does not occur but rather the movement occurs between the deep and shallow areas of the offshore banks. Larval drift studies (Drinkwater et al. 2001) indicate that lobster larvae do drift into the Bay of Fundy area but few larvae from the offshore banks make it into the inshore zone (<50 m) of, for instance, Lobster Bay (Figure 20). The most likely source of lobster larvae for the inshore area is local production. In the deeper midshore region off Lobster Bay, the primary sources of larvae lobster appear to be from German and Browns Bank (Drinkwater et al. 2001).

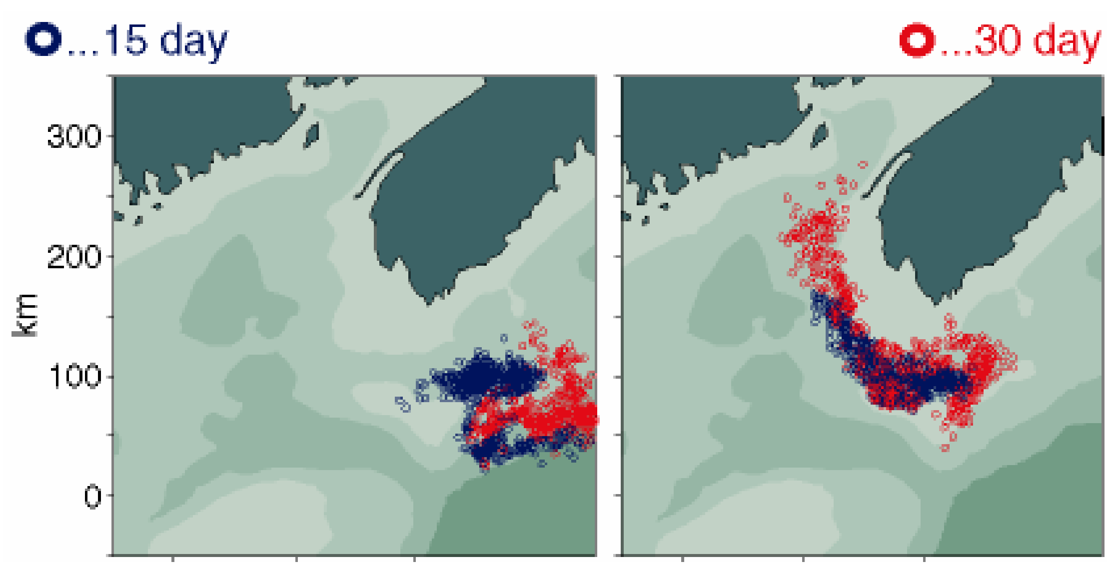


Figure 20. Drift of larval lobster from Browns Bank: left panel is for larvae at the surface and right panel for larvae at 10 m depth. Colour indicates time from release of particle – blue for 15 days and red for 30 days (from Drinkwater et al. 2001)

The combination of the perceived linkage between the inshore and offshore lobster stocks and the movement of inshore effort increasingly into the offshore area led DFO, in 1979, to establishment of a closed area for lobster on Browns Bank (termed LFA 40). Except for a minor modification in the early 1980s, the LFA 40 closed area (Figure 21) has remained relatively the same since then.

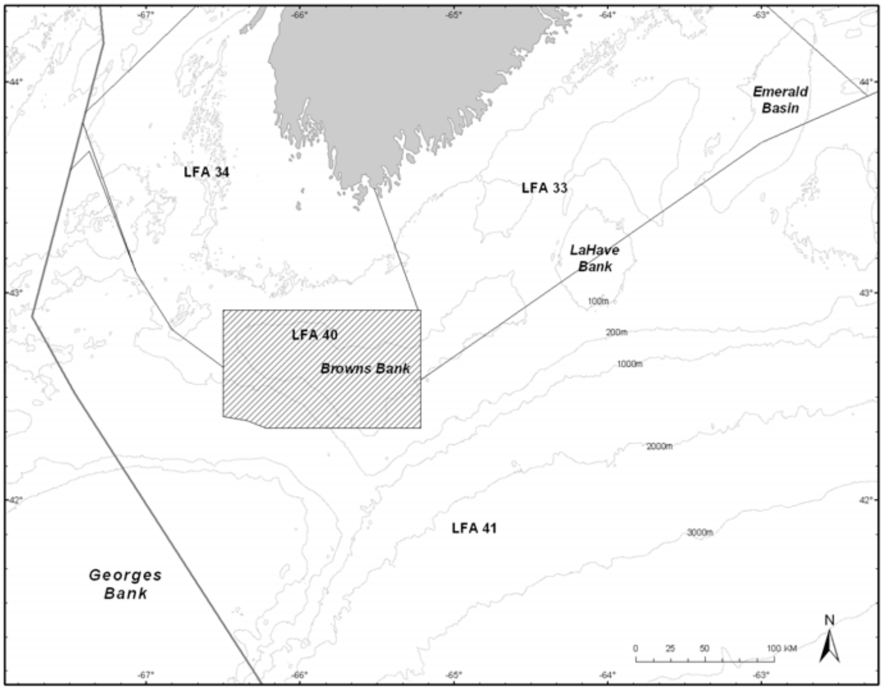


Figure 21. Lobster Closure (LFA 40) off Southwest Nova Scotia

Objectives

The primary objective for establishing the LFA 40 closed area was the protection of mature lobster females which were considered to contribute recruitment to lobster in the inshore LFAs. Additional objectives for establishing the closed area were as an additional input control on the inshore fleet (D. Pezzack, pers. comm.) and to provide a buffer zone between the inshore and offshore fleets (J. Tremblay, Population Ecology Division, DFO, Dartmouth, NS, pers. comm.). As noted above, unlike the offshore fleet, the inshore fleet was not limited by TAC and thus without this closed area, it could have expanded onto Browns Bank.

There were no other stated objectives relevant to the EAM objectives framework.

Design and Implementation

LFA 40 has been closed year-round to all lobster fishing since 1979. It is a rectangular box that encloses all of Browns Bank less than 50 fathoms depth (Figure 21). The box straddles the 50 mile offshore line with much of the closed area taken from LFA 34. It was modified slightly in the early 1980s prior to the Canada/USA boundary settlement as USA vessels were fishing the southwest corner of the box in the Northeast Channel (D. Pezzack, pers. comm.). The area is closed to only fixed lobster gear; fixed and mobile groundfish gear and scallop dredges are permitted in the area.

Regulatory tools such as VMS, at-sea observers and overflights are available but there is no information on their use and effectiveness. Notwithstanding this, there is continued broad support for the area and for this reason, compliance is likely high (B. Wood, pers. comm.)

Performance

In relation to the EAM productivity objective, DFO (2006a) indicates that lobster landings from LFA 34 have increased steadily since imposition of the closure in 1979 (Figure 22) although over this period, fishing effort has also increased. The vessels that would have fished the Browns closed area fished outside of it and, as noted above, fleet size grew during the 1980s and 1990s. Landings from the outer portion of LFA 34 now exceed that of LFA 41. In the latter, lobster abundance indicators have been either stable without trend or have trended higher since 1999 (DFO 2009b). In LFA 41, the number of lobster removed has not been influenced by the closure as the fishery is managed under TAC.

These trends need to be put into the perspective of broader changes in lobster landings along the east coast. Beginning in the late 1970's, lobster landings increased over the entire range of the species - from Newfoundland to New Jersey. Lobster responsible for the initial increase would have been hatched 7- 10 years earlier than imposition of the Browns Bank closure, suggesting that the latter is not responsible for the increase in landings in either LFA 34 or 41.

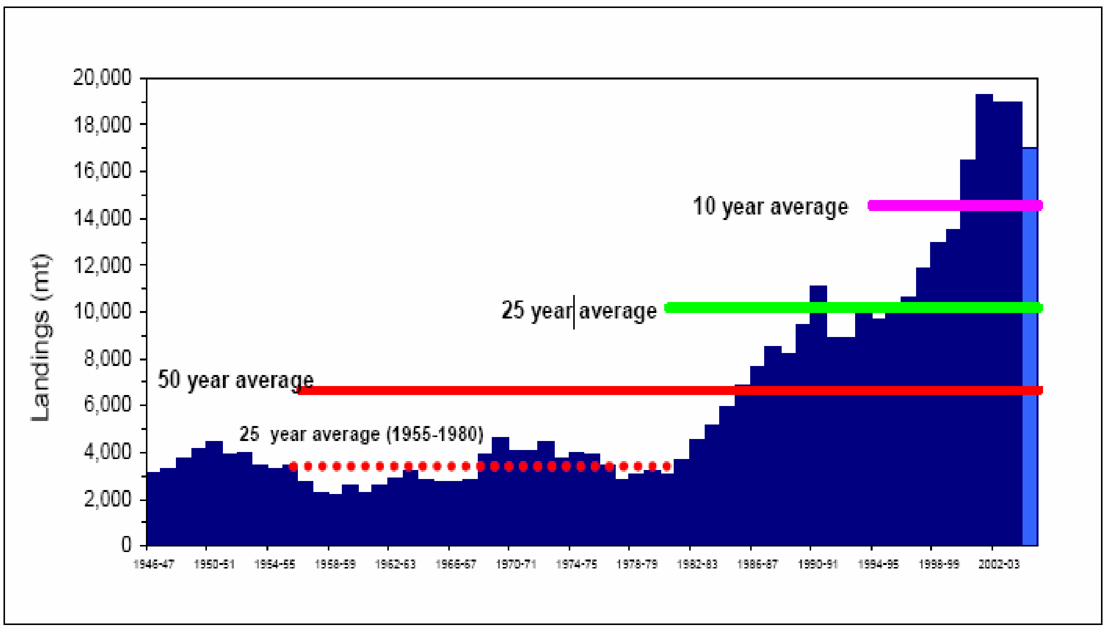


Figure 22. Long-term trends in LFA 34 lobster landings (from DFO 2006a)

Thus, it is likely that the LFA 40 closure has little relationship to the increased landings and thus improved mature lobster survival. Given the size of the closed area in relation to the distribution of the lobster stock, the lack of certainty regarding effectiveness is perhaps not surprising. As noted above, research in the late 1970s indicated that there were large numbers of berried females on western Browns Bank in the summer. It was hypothesized that it was the main source of larvae for the large inshore fishery. Work since then indicates that the situation to be more complex with retention gyres over the bank, circulation models that do not take larvae to the nearshore areas and recent genetic work indicating the possibility of more structure in the Gulf of Maine than previous thought (Drinkwater et al. 2001; Kenchington et al. 2009). Mature lobsters seasonally migrate between deep and shallow water. As the closed area also includes some deepwater areas in the Northeast Channel, there is the possibility of year-round protection (in addition to the LFA 41 TAC) for a portion of the lobsters but given the fishing activity around the box and movements into Crowell and Georges Basin and the slope east of the bank suggested by recent tagging data (D. Pezzack, pers. comm.), the extent of protection provided by the closed area is uncertain and may not be significant. Further, Browns Bank was only closed to lobster vessels; scallop and fish draggers continue to operate there, which may catch lobster as a bycatch, which is not allowed to be retained. Data on this bycatch by these vessels operating in LFA 40 are not available for most years. Injury and death of lobsters by mobile gear can occur, which is a concern during the summer when molting individuals and berried females are present in the area. These non-lobster fishery impacts would further reduce any benefits for lobster productivity that the closed area might have.

A possible benefit of the closure would be if there is significant larval settlement on Browns Bank (i.e. local seeding). Lobsters do not generally migrate long distances until mature, so if larvae settled on the bank, either produced within LFA 40 or outside this area, they would not likely be exposed to a fishery until they mature, which in this area is one to three years after they reach legal size. This settlement could be reduced by bottom contacting fishing gears.

In relation to the biodiversity objectives of the EAM framework, while it has not been formally evaluated, LFA 40 may be beneficial to the protection of Right Whales and Leatherback turtles, both considered endangered species and listed under Canada's *Species at Risk Act*. A Right Whale conservation area has been established in Roseway Basin (Figure 23) just to the east of LFA 40 (DFO 2007b). It is conceivable that having a year-round closure to lobster gear would reduce the potential of Right Whale entanglement (K. Smedbol, Science Branch, DFO, Dartmouth, NS, pers. comm.). Confirmation of this would require further study.

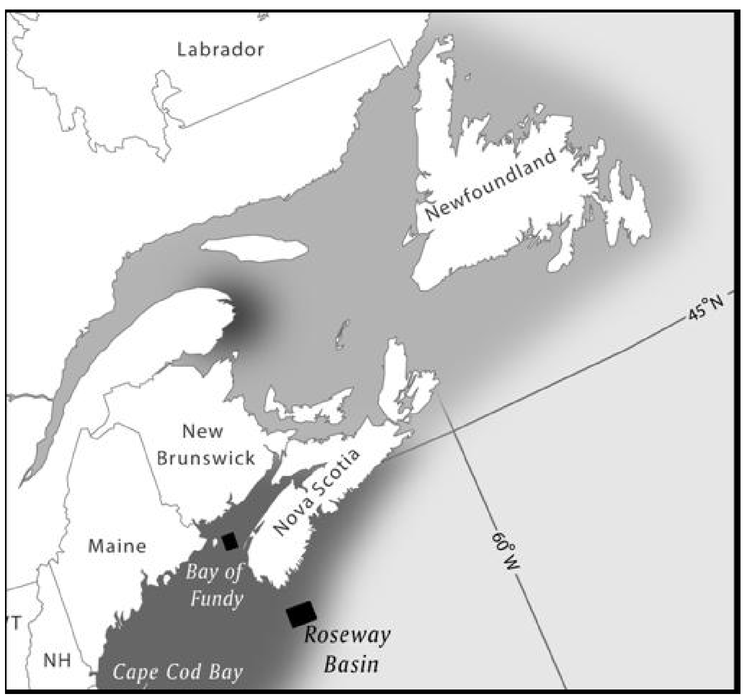


Figure 23. Roseway Basin Right Whale conservation area off Southwest Nova Scotia (from Smedbol 2007)

In summary, it is not possible to be definitive on the conservation benefits of the lobster closed area (LFA 40) off Southwest Nova Scotia:

- In comparison to the distributional range of early life and mature stages of lobster, it is likely that only partial protection of stock from fishing pressure is afforded
- There may be benefits in relation to the protection of endangered species such as Right Whales and Leatherback turtles but these remain to be confirmed

GULLY MPA, SCOTIAN SHELF

Background

The Gully is an area approximately 40 kilometers east of Sable Island, on the eastern Scotian Shelf. A deep canyon feature with depths over 2000 m, the Gully separates Banquereau and Sable Banks (Figure 24). The uniqueness of this large canyon feature on the Scotian Shelf, and the biological significance of the area have attracted the interest of a number of government agencies, researchers, and conservationists since at least the 1980s.

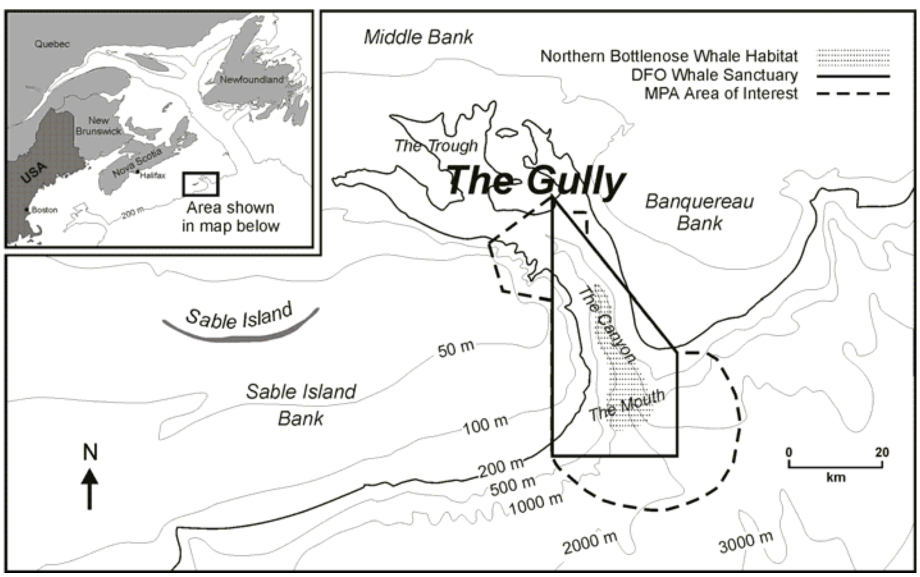


Figure 24. Location of the Gully canyon on the Eastern Scotian Shelf (from Fenton et al. 2002)

Conservation interest in the Gully began with the work of Dr. H. Whitehead of Dalhousie University, who had been conducting cetacean studies, primarily directed at northern bottlenose whales (*Hyperoodon ampullatus*) in the Gully since 1988.

In 1990, a tanker exclusion zone was established around Sable Island and the Gully by LASMO Resources, initial operators of the Panuke-Cohasset hydrocarbon field to the west of Sable Island.

In 1992, Parks Canada identified the Gully and the Sable Island regions as one of three National Areas of Canadian Significance (NACS) in a study to identify a National Marine Park on the Scotian Shelf (Lane and Associates 1992). The biological, physical, and historical significance of the region gave it a high ranking for a potential protected area. However, potential user conflicts with existing and proposed oil and gas activities, shipping, fisheries, and its inability to provide significant visitor opportunities, were identified as limitations with the site.

In 1994, DFO designated a Whale Sanctuary in the Gully area in an effort to reduce ship collisions with and noise disturbance of whales (Figure 24, solid line). Also in 1994, a workshop was organized by Environment Canada (Canadian Wildlife Service) to address conservation issues pertaining to the Gully (CWS 1994). The main conclusions were that the Gully is biologically significant, that the extant conservation strategies were inadequate to protect the significant biological resources, and that there was a need for an overall conservation strategy.

Then in 1996, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Scotian Shelf population of the Northern Bottlenose Whale as 'Special Concern'. Soon after, the World Wildlife Fund (WWF) identified the Gully as a potential site for a protected area as part of its Endangered Spaces Campaign (WWF 1997). A WWF report details the biophysical characteristics and some of the related management issues for the area (Shackell et al. 1996). The status of the Scotian Shelf bottlenose population was uplisted to 'Endangered' in 2002 and listed under SARA in 2006 (DFO 2007c)

Also in 1997, the Sable Offshore Energy Project (SOEP) Joint Review Panel Report identified concerns for potential impacts of the project and future developments on the Gully area (SOEP 1997). The project was located to the west of the Gully. The Gully was identified as a 'unique ecological site' and 'valued ecosystem component' in the SOEP Environmental Impact Statement (SOEP 1996). The Panel recommended that prior to regulatory approval, SOEP submit its Code of Practice outlining protection measures in the Gully as part of their final Environmental Protection Plan. As well, the Panel recommended that SOEP contribute to research activities in the Gully that would provide the baseline data for Environmental Effects Monitoring programs. In turn, these data would assist in determining the impact of the project and further resource developments on the Gully.

These events provide relevant context to the enactment of Canada's *Oceans Act* in 1997. While this act is primarily enabling legislation (framework in which other acts are to operate), Part II of the *Act* stipulates that '…the Minister will lead and coordinate the development and implementation of a national system of marine protected areas on behalf of the Government of Canada', thus providing the legislative basis for implementation of MPAs in Canada. DFO subsequently developed policies for MPAs (DFO 1999; 2005). The Gully then became the focus of potential designation as one of the first MPAs in Canada.

In 1997, DFO initiated development of the Gully Conservation Strategy (DFO 1997) to address growing conservation interest. The intent of the strategy was to identify an overall objective and goals for the conservation of the Sable Gully and to propose management actions which would help guide decisions on future uses and management measures in the area. The first phase of the strategy was a review of available science. This provided a description of the environment and ecosystem of the Gully and surrounding area and characterized the unique or special features of the Gully in the context of the Scotian Shelf system (DFO 1998; Harrison and Fenton 1998). The second phase consisted of a description of conservation issues and stakeholder viewpoints. Released in 1998, the Gully Conservation Strategy included conservation objectives, goals and recommendations for planning and management.

In December 1998, the Minister of Fisheries and Oceans announced that a core area of the Gully had been selected as an Area of Interest (AOI) in the Marine Protected Areas (MPA) Program. The Gully AOI included the deep canyon, the Whale Sanctuary and a range of other habitats valued for their biological communities and covered an area of approximately 1850 square kilometers (Figure 24, dashed line) . The Minister also described the need for integrated oceans management and a more systematic approach to MPA selection. The Minister recommended that: 1) DFO lead and facilitate an integrated management planning process for the Eastern Scotian Shelf and 2) that DFO lead the development of a comprehensive plan for the selection and prioritization of MPAs on the Scotian Shelf. Both undertakings ensured that the Gully became part of the Eastern Scotian Shelf Integrated Management planning process.

Following DFO analyses and stakeholder consultations (discussed below), the Gully MPA (Figure 25) came into force in 2004.

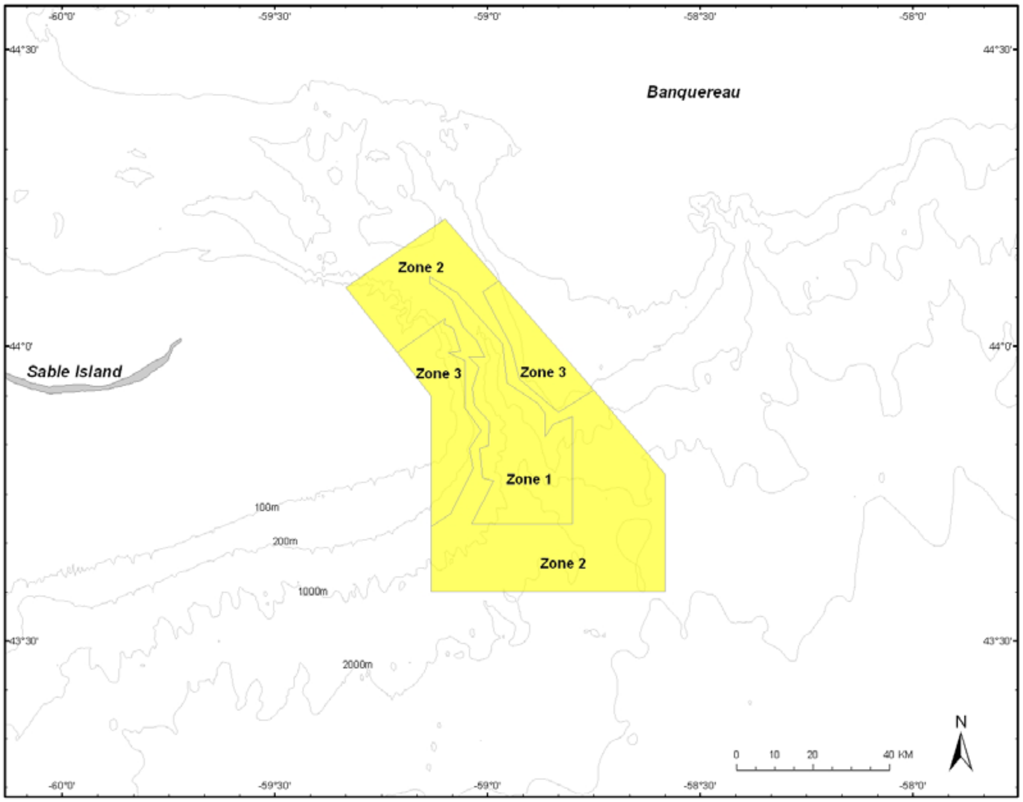


Figure 25. The Gully Marine Protected Area boundaries showing the three zones with different protection levels

Objectives

The Gully MPA management plan (DFO 2008) outlines the vision and objectives of the area. The vision is stated as '*To protect the marine ecosystem of the Gully MPA for future generations by providing effective programs for management, conservation, research, monitoring, and stewardship*'. The objectives to attain this vision are organized into three themes.

The first theme relates to conservation and is the most pertinent to this report. The conservation objectives for the Gully MPA are aimed at protecting the ecological integrity of the Gully, which includes the natural biodiversity, productivity, and ecosystem components, functions and properties. The conservation objective (to protect the health and integrity of the Gully ecosystem) is divided into sub-objectives:

- Maintain the productivity of the Gully ecosystem

- Protect the natural biodiversity of the Gully
- Protect the physical structure of the Gully and its physical and chemical properties

These parallel the ecosystem objectives in the ESSIM Plan (DFO 2007a) but with a focus on the Gully.

The second theme of the Gully MPA management plan relates to management and stewardship. Two objectives are: 1) establish effective management of the Gully MPA, and 2) promote stewardship activities.

The last theme relates to research and monitoring which aims to develop a better understanding of the Gully ecosystem through research and monitoring of natural processes and the effects of human activities.

Relevant to this report are components of the ecosystem considered a priority of the Gully plan. The priorities for 2008 – 2012 are:

- Protecting cetaceans (whales and dolphins) from impacts caused by human activities
- Protecting seafloor habitat and associated benthic communities from alteration caused by human activities
- Maintaining or restoring the quality of the water and sediments of the Gully
- Conserving other commercial and non-commercial living resources

<u>Design and Implementation</u>

A comprehensive history of the Gully MPA initiative is provided by Fenton et al. (2002). Before developing conservation measures and regulations for the MPA, DFO undertook a series of socio-economic assessments to better understand resource values and historical patterns of human use in the Gully. A socio-economic profile describing past, present, and future activities in the Gully was completed in 1999 (GTA consultants 1999). Detailed studies of fisheries were conducted by DFO with the assistance of a Fisheries Working Group. Reviews of mineral and hydrocarbon potential were completed by Natural Resources Canada and the Canada-Nova Scotia Offshore Petroleum Board.

During the design of the MPA, DFO incorporated the findings from the scientific investigations and socio-economic assessments. Throughout the design process, DFO met with groups and individuals to present the results of assessments and scientific research projects and consider the feedback and viewpoints received. The regulatory proposal was presented in a series of meetings during the fall of 2002, and in January 2003, the multi-stakeholder Gully Advisory Committee was formed to provide focused input and advice to DFO. The Committee reviewed and commented on the regulatory proposal in the spring and summer of 2003.

Draft regulations for the Gully MPA were released by the Government of Canada for public comment in December 2003. Following a review of input received during December 2003 and January 2004, minor changes were made to the regulations and in May 2004, regulations were enacted to formally designate the Gully MPA (Figure 25).

Significant to the design of the Gully MPA is the zonation of permitted activities. The MPA contains three management zones with varying levels of protection based on the conservation objectives and ecological vulnerability of each zone. Zone 1, comprising the deepest parts of the canyon, is preserved in a near-natural state with full ecosystem protection. Zone 2 imposes strict protection for the canyon head and sides, feeder canyons and the continental slope. The adjacent sand banks, which are prone to regular natural disturbance, comprise Zone 3. Thus, there is a gradation of allowed human disturbance from Zone 1 (none) to Zone 3 (some).

General prohibitions against disturbance, damage, destruction or removal of any living marine organism or any part of its habitat within the MPA apply to the entire water column and include the seabed to a depth of 15 m. The regulations also prohibit any activities in the vicinity of the MPA that contravene these general prohibitions. This requirement recognizes that human activities outside the MPA, including the depositing, discharging and dumping of substances, have the potential to cause harmful impacts within the MPA. The potential effects of activities occurring outside the MPA are addressed through existing environmental review processes.

Regulatory exceptions and DFO Ministerial activity plan approvals are used to allow for uses that do not compromise the conservation objectives of the MPA. Fishing for halibut, tuna, shark and swordfish under a federal fishing license and approved management plan are allowed in Zones 2 and 3. Scientific research and monitoring may be approved in all three zones, provided an activity plan is submitted and the research meets all regulatory requirements. Subject to plan submission and Ministerial approval, other activities may be permitted in Zone 3, provided that they do not cause disturbance beyond the natural variability of the ecosystem. Search and rescue, international navigation rights and activities related to national security and sovereignty have also been permitted in the MPA.

Under these regulations, there are a few fisheries permitted to operate in certain areas of the Gully. These are fisheries directing for halibut and carried out by bottom longline, and for swordfish, shark, and tuna, generally carried out by pelagic longline. Besides these excepted fisheries, there are several fisheries within 30 km of the Gully that are not permitted in the MPA. These include snow crab (northern edge of Sable Island Bank/Gully trough), exploratory crab (slope), surf clam (Banquereau) and quahog (Sable Island Bank). A fishery for redfish occurs in the general area but little activity has occurred near the MPA in recent years.

In relation to implementation, as with the other closed areas off Nova Scotia, DFO is responsible for enforcement of the Gully MPA and is employing monitoring tools discussed elsewhere in this report (e.g. overflights, VMS). In addition, the Nova Scotia Swordfish Association has developed a Code of Conduct for responsible sea turtle handling and mitigative measures. This applies to all areas in which the large pelagic fleet operates, including the Gully. In general, there appears to be good compliance with the Gully MPA (B. Wood, pers. comm.)

<u>Performance</u>

DFO is responsible for developing indicators and reference points and an associated monitoring program for each conservation objective of the MPA management plan in order to permit performance evaluation. Until this program can be implemented and the results considered, it is not possible to fully evaluate the performance of the Gully MPA. Some general observations can be made however.

Regarding commercially fished stocks, most groundfish stocks on the Eastern Scotian Shelf are depressed and catch is mostly bycatch to other fisheries. The Gully covers only a small percentage of the distribution of most if not all these stocks, so benefits are expected to be limited. Having said this, the Gully is another area of juvenile haddock concentrations, the other being Emerald / Western Bank (Fanning et al. 1987). The Gully MPA would then afford the 4VW haddock stock the same conservation benefits as noted for the 4VW haddock closure.

Regarding the biodiversity objectives, the benefits for bottlenose whale are evident as this species was influential on the design of the MPA. Other species such as marine turtles will be afforded protection by the Gully MPA to the extent that they use the Gully.

Regarding habitat, a considerable amount of research has been conducted on the benthic fauna of the Gully (e.g. Kostylev 2002), which will provide a baseline for the long-term benefits of protection of this community. Given that this is a year-round closure, the benthic fauna is likely experiencing the same general pattern of change as indicated in the US Gulf of Maine and 4VW closures (e.g. increases in the abundance of long-lived species with low turnover rates and growth of shelter forming epifauna). The extent to which these changes benefit other ecosystem components (e.g. fish stocks) are contingent upon the degree of the linkage between the habitat and stock productivity.

In summary, the key benefits of the Gully MPA are:

- Some protection of juveniles of the 4TVW haddock stock
- Protection of marine turtles, bottlenose whales and other marine mammals to the extent that they use the Gully
- Protection of benthic fauna in the Gully with the expectation of increases in the abundance of long-lived species with low turnover rates and growth of shelter forming epifauna (e.g., corals)

CORAL CONSERVATION AREAS, SCOTIAN SHELF

Background

Breeze and Fenton (2007) provide a comprehensive synopsis of coral areas and their management off Nova Scotia. Although corals were documented off Nova Scotia's coasts in the nineteenth century, conservation and research efforts only began in the late 1990s. These species are largely found in deep channels, submarine canyons, and steep slope areas (Breeze et al. 2002). Twenty-three species of cold-water coral have been confirmed in the region (Mortensen and Buhl-Mortensen 2005; Mortensen et al. 2006). Conservation efforts have focused on large gorgonian corals and on the stony coral *Lophelia pertusa*. DFO conducted opportunistic coral research in this area starting in 1997, with photographic and video observations in areas reported to have high coral densities and examination of bycatch records from DFO groundfish surveys. A dedicated coral research program took place during 2001–2003, with the goal of collecting information on the distribution, abundance, biology, and condition of corals in order to inform management.

While Canada has used the *Fisheries Act* to protect marine habitat, this has generally been in association with commercial fish species. It wasn't until proclamation of the *Oceans Act* in 1997 that the conservation of habitat, such as coral, not directly associated with commercial fisheries received attention in the context of protected areas.

There are currently three areas with management measures to protect corals: the Gully MPA, the Northeast Channel Coral Conservation Area, and the Stone Fence Lophelia Coral Conservation Area (Figure 26). These areas were established using different legislation and for different purposes. DFO established the Northeast Channel Coral Conservation Area and the Lophelia Coral Conservation Area in 2002 and 2004 respectively. In 2006, a coral conservation plan was developed which provides the objectives and long term strategy to protecting and understanding these important benthic habitats.

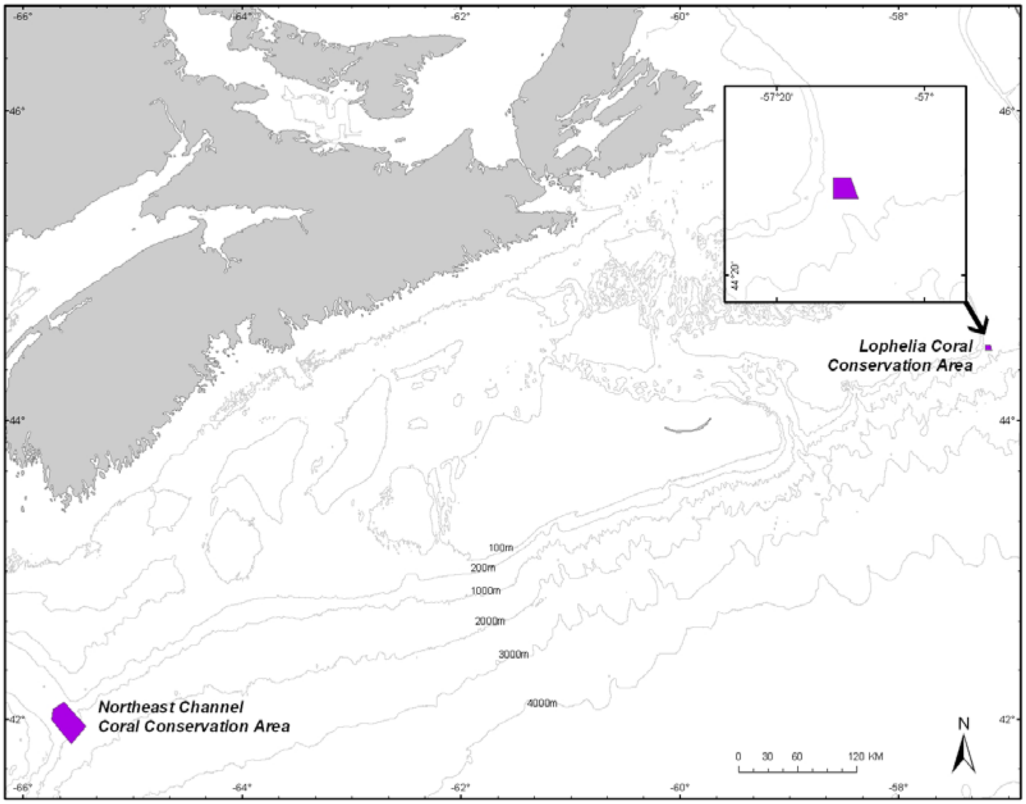


Figure 26. Coral Conservation Areas on the Scotian Shelf

Objectives

The objectives of the coral conservation plan (DFO 2006b) are similar to those for the Gully MPA. They are grouped into the three themes of conservation, management and research. The overall conservation objective is to 'conserve the health and integrity of coral communities', with sub-objectives being 1) minimizing of the impacts from human activities on coral communities and 2) protection of and, where necessary, restoration of important coral habitats.

Contrary to the Gully MPA, these objectives are very focused upon a specific ecosystem component (corals) and make no reference to other benthic fauna.

Design and Implementation

The Northeast Channel area was initially identified as an important area for corals based on reports from fishers (Breeze et al. 2007). Conservation interest began in the late 1990s. Surveys in 2000 and 2001 confirmed high abundances of the gorgonian corals as well as damage from fishing activities (Mortensen et al. 2005). The channel is a highly used fishing area with few other activities. Thus, DFO used a fisheries closure under the *Fisheries Act* rather than an MPA under the *Oceans Act*.

A DFO - industry working group was formed to advise on the design of the closure. Several boundary proposals were submitted and through examination of scientific survey and fishing activity data, and a closure boundary was developed that captured the highest concentrations of intact corals observed in the channel. In 2002, this proposal was discussed with stakeholders who raised concerns, particularly longline fishers who actively fished in a portion of the proposed area. After further analysis and discussion, the closure was finalized. In the largest part of the area (restricted fisheries zone), fishing with bottom-contact gear would not be permitted. In a small part of the area (limited fisheries zone), fishing for groundfish using longline or handline gear would be permitted if the vessel carried an at-sea observer. In 2003, there was a minor adjustment to the boundaries of the limited fisheries zone to simplify monitoring and management.

In 2003, DFO researchers found a damaged *L. pertusa* reef complex at the Stone Fence off eastern Nova Scotia. The general location of the reef had long been suspected from fishermen's reports. The reef complex was very small (about 1.5 km^2) and the main activity in the area was groundfishing. As this was the only known location with living *L. pertusa* off Canada's east coast, DFO sought to protect the reef and allow for its recovery, again using a closed area under the *Fisheries Act*. This objective was made clear with fishing associations from the outset, with the aim of developing a closure for all bottom impacting fisheries, beginning with the 2004 fishing season. Lessons learned from the Northeast Channel and Gully experiences were applied to the development of the Stone Fence coral conservation area.

Fishing activity in a 150 km^2 area surrounding the reef complex - an area many times the size of the reef - was examined in detail to identify users and potential socio-economic impacts. Much of the information was obtained from the commercial landings and observer databases maintained by DFO. The two main fisheries that used bottom gear were a halibut fishery carried out by longliners and a redfish fishery that used otter trawlers. Many proposals for a closed area boundary were considered with numerous issues raised and debated (see Breeze and Fenton 2007 for details). The final boundary configuration did not include the deeper waters and the design provided greater access to the halibut fishing ground while still allowing a buffer around the reef. At 15 km^2, it was 10 times the size of the reef complex. The closure was implemented in June 2004.

In relation to implementation, as with the other closed areas off Nova Scotia, DFO is responsible for enforcement of these closed areas and is employing monitoring tools described elsewhere in this report (e.g. overflights, VMS). While some infractions of the coral closures have been recorded, overall, there is relatively good compliance with these areas (B. Wood, pers. comm.)

Performance

As yet, there is no monitoring program by which the performance of these areas could be evaluated. Also, information was sparse prior to the implementation of the closures so there is no baseline to which recovery of the coral communities in the closed areas could be compared. However, one can expect that the coral conservation areas are highly beneficial to the coral communities.

Regarding the rest of the ecosystem, deep-water corals feed on live and dead particles (size < 1 cm) in the near bottom layer and thus represent an important link between the free - water masses and the bottom of the sea in areas rich in corals. The corals also provide shelter and food for a variety of organisms. Redfish have been observed associated with the deep sea coral in the Northeast conservation area (Mortensen et al 2005). It is thus conceivable that the coral is beneficial to the productivity of this species. Notwithstanding this, the same issues apply here as they do for the Gully MPA. The degree of conservation benefit of corals is dependent upon the relative percent of the coral community being protected. There is little information on the overall extent of the coral community so overall benefit cannot be stated. However, in the immediate area of the coral closures, there is likely benefit to the local ecosystem.

In summary, the key benefits of the coral conservation areas are:

- Long-term protection of the deep-water coral communities

- Protection and enhanced productivity of species (e.g. redfish) associated with coral communities
- Benefit to local ecosystem in immediate area of coral closure

EASTPORT PENINSULA MPAs, NEWFOUNDLAND

Background

The Eastport Peninsula is located in Bonavista Bay, off the Northeast coast of Newfoundland. A wide variety of marine species are found in the waters surrounding the Eastport Peninsula including capelin, herring, shrimp, Arctic cod, rock cod, scallop, mussels, crab, squid, lobster, sea urchins and whelk. The Eastport Peninsula has relied heavily on fishing for generations and although fishing activity has declined in recent years, it is still vitally important to the area. Of particular importance since the early twentieth century has been the lobster fishery.

During the early 1990s, lobster harvesters in the Eastport area recognized the serious decline in lobster stocks, attributed to increased lobster fishing pressures which had resulted from the groundfish closures. The Fisheries Resource Conservation Council (FRCC) recommended that harvesters take measures to increase egg production, reduce exploitation rates, improve stock structure, and minimize waste (FRCC 1995). It also recommended that local stakeholders and management authorities work together to develop a program best suited to their particular region. In response to the FRCC report, local harvesters formed the Eastport Peninsula Lobster Protection Committee (EPLPC) in 1995 with the primary aim being the implementation of a lobster conservation strategy for the Eastport Peninsula.

Based on initial success of measures such as monitoring to reduce illegal fishing and v-notching to protect egg-bearing females, in 1997, the EPLPC, under a Joint Project Agreement with DFO, established a 400-km^2 Eastport Peninsula Lobster Management Area (EPLMA). Within this management area, two prime lobster spawning and rearing habitats were closed to lobster harvesting under the *Fisheries Act*. The two closed areas, Round Island and Duck Islands, encompass an area of 2.1 km^2 (Figure 27). These waters were later closed to all commercial and recreational fishing activity, prohibiting the harvest of Atlantic cod, lumpfish, sea urchin, flounder and other species.

In 1999, the EPLPC approached DFO to establish an MPA under the newly proclaimed *Oceans Act* in the Eastport area. In October 2000, the Minister of Fisheries and Oceans identified the Eastport closed areas (Round Island and Duck Islands) as Areas of Interest (AOIs) for potential MPA designation.

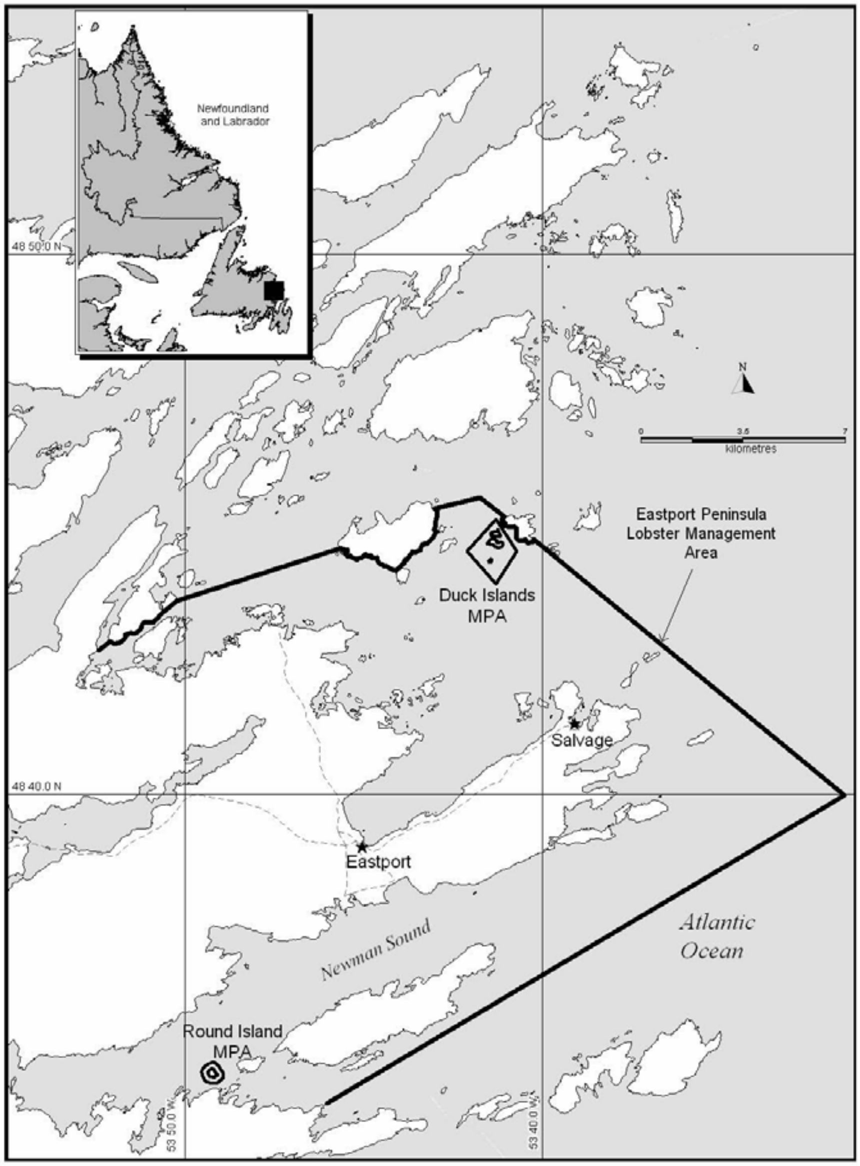


Figure 27. Eastport, Bonavista Bay, Newfoundland (Canada) showing Round Island and Duck Islands MPA boundaries and Eastport Peninsula Lobster Management Area Boundary (from Janes 2009)

Objectives

The Eastport Peninsula MPA management plan (DFO 2007d) describes the conservation objectives and associated management actions of the two MPAs, all designed to achieve a sustainable lobster population in the Eastport area and to protect areas used for lobster spawning, rearing and feeding. DFO is obliged to monitor and enforce regulations associated with these objectives. The two conservation objectives with associated short and long-term management actions are:

- To maintain a viable population of lobster through the conservation, protection, and sustainable use of resources and habitats
    - Short-term

        - Initiate larval drift and settlement studies of juvenile lobsters
        - Monitor average size of lobster inside and outside closed areas to develop a size fecundity relationship for the MPA comparative to outside the MPA
    - Long-term
        - Continue larval drift and settlement studies taking into account environmental factors that could influence distribution and settlement of juvenile lobster
        - Determine if there is a significant increase in average size of lobster inside the MPAs
        - Determine “an estimate” of egg production inside MPA
- To ensure the conservation and protection of threatened or endangered species
    - Short-term
        - Distribute public awareness packages to local fisherman on wolfish
        - Initiate observations of by-catch of wolffish outside the MPAs with particular interest paid to lobster fishing activities in close proximity to the MPA boundaries
    - Long-term
        - Determine population estimate of wolffish inside and outside closed areas

Thus the focus of these conservation objectives is the productivity of lobster in the Eastport Peninsula area. In relation to the biodiversity branch of the EAM objectives framework, the objective on wolffish is relevant as Spotted and Northern wolffish have been listed as threatened under the *Species at Risk Act*.

The management plan of the MPAs also outlines non-regulatory conservation objectives designed to support general marine conservation and the overarching goals of the MPAs steering committee. One of these non-regulatory conservation objectives states ‘to maintain and enhance the quality of the Eastport ecosystem’. While this is general, the regulations for the MPAs contain a general prohibition against the disturbance, damage, destruction, or removal of any living organism or any part of its habitat within the MPAs. In addition, the regulations prohibit activities including the depositing, discharging, or dumping of substances within the MPAs that result in the disturbance, damage, destruction, or removal of any living organism or any part of its habitat within the MPAs. All activities that do not violate the prohibitions, i.e. that do not disturb, damage, destroy or remove living marine organisms or their habitats, will be permitted in the MPAs. Thus, while no explicit objectives in relation to habitat are stated, habitat protection is a clear intent of these MPAs.

Design and Implementation

In 2002, a list of stakeholder groups interested in participating in the MPA initiative was developed. Meetings were held in Eastport, Gander, and St. John’s. These meetings and consultations provided an overview of the *Oceans Act* and the MPA Program, the history of the initiative, objectives of the proposed MPA, and plans for the future. Stakeholders were then invited to participate in the formation of a steering committee that would guide the ongoing evaluation of the proposed site as a potential MPA. The first steering committee meeting was held in March 2002. This committee was co-chaired by DFO and the EPLPC, and met approximately 3-4 times per year. The steering committee has remained intact upon designation of the MPAs and now functions as an advisory body for management of the MPAs (DFO 2007d).

A significant amount of federal, provincial and academic research had commenced in the Eastport area as a result of issues that were raised by the FRCC and the EPLPC. In addition, in November 2001, a biophysical overview of Eastport, Bonavista Bay was completed. A socio-economic overview of the Eastport Peninsula was also available which reviewed the regional and historical context of the Eastport Peninsula, human use and development of the area, and management issues. This work was included in the evaluation of the Eastport AOIs.

The regulations for the Eastport MPAs were developed based on input from the steering committee and consultations with local and regional stakeholders and governmental and non-governmental organizations since 1995. On October 11th, 2005, the Minister of Fisheries and Oceans Canada announced the designation of the Eastport MPAs, along with the Gilbert Bay MPA (Labrador) and the Basin Head MPA (Prince Edward Island). These MPAs were designated as part of the first phase of the Government of Canada's broader Oceans Action Plan, which was announced in May 2005.

As noted above, activities prohibited include the depositing, discharging, or dumping of substances within the year-round MPAs that result in the disturbance, damage, destruction, or removal of any living organism or any part of its habitat within the MPAs. All activities that do not violate these prohibitions, i.e. that do not disturb, damage, destroy or remove living marine organisms or their habitats, will be permitted.

In relation to implementation, the Eastport MPAs Steering Committee has identified enforcement concerns with respect to poaching by users of the nearby Terra Nova National Park. DFO fishery officers in the area serve as the primary enforcement body and are complemented by other law enforcement personnel (or enforcement officers so designated by the Minister according to Section 39 of the *Oceans Act*) and community watch groups to ensure that the proposed management actions and regulations for the area are respected. There is an expectation by local residents that heightened enforcement within the MPAs will be effective in order to ensure compliance with the MPA regulations. Local fishers have already developed community-based, non-regulatory measures to promote compliance, including self-policing. Strong community support for the MPAs suggests that a community watch initiative, e.g. Stewards of Eastport, will complement the surveillance activities of the area. The surveillance activities will follow the outlined conservation objectives and will have a particular emphasis on American lobster and its habitat.

For the past several years, Fisheries and Oceans Canada's Oceans Division has entered into Service Level Agreements with the Conservation and Protection Division to increase patrols in the MPAs. These increased patrols appear to be working at deterring illegal activity. No charges have been laid in Eastport as a result of these patrols, which is a good sign of compliance.

<u>Performance</u>

Janes (2009) evaluated the effectiveness of the Eastport Peninsula MPAs by assessing differences in lobster population structure inside versus outside the MPA and examining changes over a decade, determining if there were differences in lobster carapace length between MPAs and adjacent outside areas and identifying any changes over time. Janes (2009) also assessed differences between proportion of ovigerous females inside and outside the MPAs in recent years and changes over time and assessed movement patterns of lobsters in and around the MPAs during 2004 - 2007. This evaluation built upon the findings of Rowe (2001; 2002) in which the first three years following protection from fishing pressure was examined at the Eastport sites. Although some changes were shown to occur early on, continued changes in larger sizes and higher proportions of berried females inside the MPAs were expected. A broadening of the population size structure inside the closed areas was also anticipated and some changes to the outside areas including adult spillover, following a decade of protection were predicted.

The study concluded that there were benefits to having these MPAs, but differences in trends were observed at each of the MPAs. In most instances, an increased occurrence of large lobsters, including large ovigerous females, was found inside the closed areas compared to adjacent commercially fished areas by 2004 and in some cases continued differences were seen between inside versus outside up to 2007 (Round Island females and Duck Islands males). Mean size of male lobsters inside both the Round and Duck Islands closed areas was larger than mean size of male lobsters in the adjacent commercially fished area; it increased from 1997 to 2004, and in most cases remained higher. Although significant differences were not detected until 2007, it appears that mean size of female lobsters inside the closed areas at Round Island had increased since 1997. The proportion of ovigerous lobsters was significantly higher inside both MPAs compared to the outside areas.

Collectively, the higher incidence of large lobsters, large ovigerous females and increased mean sizes indicated that after 10 years, these MPAs are likely encouraging higher reproductive potential compared to the adjacent commercially fished areas.

Regarding lobster movement, the majority of mobile lobsters did not cross the MPA boundary (exchange rate of 3%) and move long distances, suggesting that there is strong site fidelity at both the Eastport closed areas. It is therefore likely to take longer than 10 years for populations inside these MPAs to become dense enough to allow significant amounts of spillover of juveniles and adults to adjacent areas to occur.

Janes (2009) states that while it is difficult to determine the relative contribution of other conservation initiatives in the immediate area, the data suggest that MPAs are contributing to the enhancement of lobster populations both inside the MPAs and in the adjacent commercially fished areas. It is plausible that these MPAs will bring continued benefits to the outside areas through higher egg production and further adult spillover as the carrying capacity is reached in the years to come, although the amount of time this will take is difficult to predict. Ennis (2011) emphasizes that dispersal and recruitment processes for larval lobsters are complex and highly variable, with larval lobsters sometimes moving over relatively large areas. This makes it difficult to measure any increased recruitment of juvenile lobsters from the higher egg production that may occur in closed areas such as Eastport.

These observations are consistent with the broader literature on the benefits of MPAs. When the size of the MPA is large in relation to the resources involved, recovery within the MPA is expected. The extent of spillover benefits depends upon the growth rate of the population in the closed area and rate of exchange across the closed area boundary which appears to be low in this case.

In relation to the wolffish objective, the benefit of the MPA has still to be evaluated, although given the size of the resource in relation to the size of the two MPAs, the benefits are likely to be highly localized (DFO 2002b).

In relation to the habitat objectives, given the experience elsewhere, it is expected that given the prohibitions on fishing activity, benthic fauna will recover and over the longer term lead to localized increases in fish productivity.

In summary, the key benefits of the Eastport MPAs are:

- Likely higher productivity of lobster resources within the MPA with potential spillover of adolescent and adult lobster to adjacent areas in the long – term (10 years or more)
- Likely enhanced reproduction and contribution of lobster larvae to surrounding areas

- Localized protection of Spotted and Northern wolfish, which are listed under the *Species at Risk Act*
- Localized protection of benthic fauna leading to localized increases in fish productivity over the long-term

SYNTHESIS AND RECOMMENDATIONS

SYNTHESIS

Lubchenco et al. (2003) provides a synopsis of conclusions of a recent international workshop on changes occurring in marine reserves, based upon an analysis of over two decades of experience. While these are focused on marine reserves, which are permanently closed areas to all human uses, many of the conclusions are more broadly applicable.

It was concluded that marine reserves conserve both fisheries and biodiversity, although they must encompass the diversity of marine habitats in order to meet the goals of fisheries and biodiversity conservation. Reserves were considered the best way to protect resident species and provide heritage protection to important habitats but it was emphasized that reserves must be established and operated in the context of other management tools that are available. It was pointed out that reserves require a dedicated program to monitor and evaluate their impacts both within and outside their boundaries. Given this, reserves can provide a critical benchmark for the evaluation of threats to ocean ecosystems. The workshop considered that existing scientific information justifies the immediate application of fully protected marine reserves as a central management tool.

Lubchenco et al. (2003) go on to summarize the main ecological effects that have been observed both inside and outside the boundaries of marine reserves. Regarding ecological changes inside reserves, long-lasting and often rapid increases in the abundance, diversity and productivity of marine organisms have been observed, these due to decreased mortality, decreased habitat destruction and to indirect ecosystem effects. Fully protected marine reserves in particular are concluded to reduce the probability of extinction for marine species resident within them. Although increased reserve size results in increased benefits, even small reserves were seen to have positive effects. Full protection (which usually requires adequate enforcement, industry compliance and public involvement) is critical to achieve the full range of benefits afforded by marine reserves. Lubchenco et al. (2003) consider that marine reserves, from which all human impacts are excluded, afford more benefits than areas in which some human impacts are permitted. Regarding benefits of marine reserves to outside areas, in the few studies that have examined spillover effects, the size and abundance of exploited species is observed to increase in these areas, this often through population replenishment via larval export. Finally, regarding networks of reserves, there is increasing evidence that these buffer against the vagaries of environmental variability and provide significantly greater protection for marine communities than a single reserve. However, for a network to be effective, it needs to span large geographic distances and encompass a substantial area to protect against catastrophes and provide a stable platform for the long-term persistence of marine communities.

In addition to the benefits of MPAs stated above, they also provide a reference against which to evaluate the impacts of human activities in similar areas not afforded protection. MPAs provide a means to monitor diversity and productivity changes following disturbance from human (or other) impacts. Such references can be formally incorporated into the management system as a means to monitor its overall performance.

While these conclusions are general, it is useful to keep them in mind when considering the experience of the seven case studies described above. Table 1 provides a synopsis of the main design features, objectives and benefits of each of these. Regarding the design features, all except the haddock closure on Browns Bank, are year-round. The range of human activities either excluded or permitted by each area varies markedly. As would be expected, these are strongly dependent on the objectives of each area. Fisheries closures tend to be focused on the gears (e.g. groundfish bottom trawls, lobster traps) being regulated. MPAs are broader in their scope of excluded activities. The Gully MPA and the Coral Conservation Closure both employ zoning which stipulates different restricted activities within subzones of the area. Formal evaluations of the performance of some areas has not been undertaken, so the observations made in this regard are based upon both published studies as well expected benefits seen elsewhere. Overall, benefits relevant to the stated objectives of each area are conditioned by the percent of the overall ecosystem component being protected by the area. Notwithstanding this, many of these areas have benefits there were not envisaged when they were initially designed. These range from the protection of bottom habitat to broader beneficial effects throughout the ecosystem. Again, these effects are generally conditional on the size of the closed area relative to that of the local ecosystem and the spectrum of activities being regulated. However, as noted by Lubchenco et al. (2003), although increased reserve size results in increased benefits, even small reserves can have positive effects.

It is useful to evaluate the benefits, both primary and collateral, of each area using the EAM objectives framework provided in the first section. This allows a comprehensive evaluation of the benefits of each area across the full suite of EAM objectives, regardless of initial intent of each area and will highlight the collateral benefits of these areas for the rest of the ecosystem. This evaluation is summarized in Table 2. For each case study (column), the degree to which an EAM objective (row) is likely to be achieved is indicated by the shading of the cell – dark shading for good progress toward objective and light shading for limited progress towards the objective. While qualitative and based upon the author’s judgment, the table is useful on providing an overview of the performance of the seven case studies. The elements of this table are elaborated on below the table.

An evaluation of the negative impacts, either observed or potential, of each area was not undertaken. As noted under some of the case studies, the imposition of fishery closed areas has often had the negative effect of displacing fishing effort elsewhere with the consequence of no reduction in the overall exploitation rate on a stock and possible negative impacts on bottom habitat. These negative impacts are difficult to predict and are highly dependent upon the broader management of the regulated activities. Thus, to evaluate these negative effects, one would need to evaluate the effectiveness of the broader management system, which is beyond the scope of this study. This highlights that MPAs are one tool of many within a management system and that they need to be designed and implemented as such.

Table 1. Synopsis of seven MPA and fishery closure design, objectives and benefits

MPA	Temporal Extent	Excluded Activities	Permitted Activities	Objectives	Benefits relevant to Objectives	Collateral Benefits
Groundfish Closures US GOM	Year-round	All gear capable of retaining groundfish (trawls, gillnets, hook gear, and scallop dredges)	Lobster traps and mid-water trawls for small pelagic species	Reduction of exploitation rates of Georges Bank cod, haddock and yellowtail	Some reduction of fishing mortality on groundfish in the absence of quotas, particularly protection of juvenile haddock	Protection of sea scallop resulting in enhanced production; some benefits to community biodiversity; some benefits for protection of bottom habitat
Haddock Closure Browns Bank	Seasonal (March – mid- June)	All gear capable of retaining groundfish (trawls, gillnets, hook gear, and scallop dredges)	All other gear (e.g. lobster traps except in LFA 40)	Reduction of exploitation rate of Browns Bank haddock to low level; spreading of catch throughout year	Not effective in reducing Browns Bank haddock exploitation rates; protection of 4X cod and haddock spawners during spawning season	Due to seasonal nature of closure, additional benefits for habitat and ecosystem likely limited
Haddock Closure Emerald Bank	Year-round	All groundfishing	All other gear (e.g. lobster traps, scallop dredges)	Protection of juvenile 4VW haddock	Limited evidence that closure has been beneficial to overall haddock stock productivity (due to confounding growth declines)	Increases on abundance of non-target species in closed area, indicating broader beneficial effects throughout ecosystem; inferential evidence that expected benthic habitat improvements have improved juvenile haddock survival

Lobster Closure LFA 40	Year-round	Fixed lobster gear	Fixed and mobile groundfish gear and scallop dredges	Protection of mature female lobster; input control for inshore fleet; buffer zone between inshore and offshore fleets	In comparison to distributional range of early life and mature stages of lobster, likely only partial protection of stock from fishing pressure	There may be benefits in relation to protection of endangered species such as Right Whales and Leatherback turtles but these remain to be confirmed
Gully MPA	Year-round	Zone 1: all fishing	Zone 2 & 3: halibut, tuna, shark and swordfish fishing	Maintenance of productivity of Gully ecosystem; protection of natural biodiversity of Gully; protection of physical structure of Gully and its physical and chemical properties	Some protection of juveniles of 4TVW haddock stock; protection of marine turtles, bottlenose whales and other marine mammals to extent that they use Gully; protection of benthic fauna in Gully with expectation of increases in abundance of long-lived species with low turnover rates and growth of shelter forming epifauna (e.g., corals)	Protection of wide spectrum of ecosystem components
Coral Conservation Closures Scotian Shelf	Year-round	Restricted fisheries zone: bottom – contacting gear	Limited fisheries zone: groundfishing using longline & handline with observer present	Minimization of impacts from human activities on coral communities; protection of and, where necessary, restoration of important coral habitats	Long-term protection of the deep-water coral communities	Protection and enhanced productivity of species (e.g. redfish) associated with coral communities; benefit to local ecosystem in immediate area of coral closure

Eastport Peninsula MPAs	Year-round	Depositing, discharging, or dumping of substances that result in disturbance, damage, destruction, or removal of any living organism or any part of its habitat	Any activity that does not disturb, damage, destroy or remove living marine organisms or their habitats	Maintenance of a viable population of lobster through conservation, protection, and sustainable use of resources and habitats; conservation and protection of threatened or endangered species (i.e. wolfish)	Likely higher productivity of lobster resources within MPA with potential spillover of adolescent and adult lobster to adjacent areas in the long – term; likely enhanced reproduction and contribution of lobster larvae to surrounding areas; localized protection of wolfish; localized protection of benthic fauna leading to localized increases in fish productivity over long-term	Protection of spectrum of ecosystem components, with focus on those relevant to lobster and endangered / threatened species

Table 2. Overview of performance of seven case studies in relation to EAM objectives; cell shading indicates degree of progress towards EAM objective – dark shading implies good progress, light shading some progress and no shading where an MPA or fishery closure was considered not relevant to the EAM objective

Conservation Objectives of Ecosystem Approach to Management		Groundfish Closures US Gulf of Maine Area	Haddock Closure Browns Bank	Haddock Closure Emerald Western	Lobster Closure LFA 40	Gully MPA	Coral Conservation Closures Scotian Shelf	Eastport Peninsula MPAs
Biodiversity	Community Level							
	Species Level							
	Population Level							
Productivity	Target Species							
	Food Chain Dynamics							
Habitat	Benthos							

Biodiversity

Regarding the benefits of MPAs for biodiversity, these need to be considered at the community, species and population level.

Improvements in community biodiversity were either observed or are expected in a number of the case studies, this primarily due to the recovery of benthic epifauna. This is particularly true of the US Gulf of Maine Area groundfish and Emerald / Western haddock closures. For the Gully, coral closures and the Eastport MPA, it is too early to state categorically whether or not community biodiversity will improve but based upon experience elsewhere, this is likely. Babcock et al. (2010) consider that while the direct benefits of MPAs on a target species are likely to occur within five or so years, the indirect benefits will ripple through the rest of the ecosystem and likely not be apparent until 13 or so years after implementation of an MPA. There is only partial progress towards this objective in most closures as these typically cover only part of the distributional range of the benthic habitat. The US Gulf of Maine Area closures are judged to have made more progress in this regard given its spatial extent. The haddock and lobster closures on Browns Bank do not perform well in relation to this objective given that they are only partial closures targeted at particular fisheries. While community biodiversity is expected to improve through the coral conservation areas, these effects will likely be localized to these areas in the short-term but may ripple throughout the broader ecosystem community in the longer term, as noted above for the other closures.

At the species level, the MPA performance was evaluated in relation to protection of highly depleted species e.g. those relevant to Canada's *Species at Risk Act*. In this regard, the Browns Bank lobster closure, the Gully and Eastport MPA are noteworthy. In the case of the latter two, the MPAs were designed with *SARA* species in mind. In the case of the lobster closure, it may have benefits for the protection of Right Whales. Only in the case of the Gully is performance rated high, this given the extent of protection afforded to Bottlenose Whale.

At the population level, MPA performance was evaluated in relation to the protection of population spawning components. It is plausible that the four fishery closures have afforded some protection to population biodiversity but this is neither proven nor certain. It could be argued that the loss of the 4VsW cod spring spawning component could have been avoided if there had been a groundfish spawning closure in place on the Eastern Scotian Shelf since the 1970s.

Overall, when considering the performance of MPAs in relation to the biodiversity objectives of EAM, there are some benefits consistent with the international literature (e.g. Lubchenco et al. 2003) but these are tempered by the amount of protection afforded to the ecosystem by each MPA. When MPAs cover a large part of the ecosystem, benefits can be expected to be significant. This is also true when MPAs are designed to protect specific ecosystem components (i.e. corals and SARA species). Otherwise, benefits will be either modest or limited, although even small areas can have some benefits.

Productivity

Regarding the benefits of MPAs for productivity, these need to be considered for both target species of exploitation and food chain dynamics.

The most benefits of MPAs for target species of the seven case studies were observed for the US Gulf of Maine Area groundfish closures, this primarily due to the reduction in Georges Bank haddock exploitation. It is important to note however, that these closures were implemented specifically to control groundfish harvest rates given the inability of US management at the time to impose more direct quota controls. Benefits were also seen for the 4VW haddock stock and lobster in the Eastport Peninsula of the closed areas. In both cases, monitoring shows that population productivity has improved, although in the case of 4VW haddock, it was more equivocal than in Eastport. Increases in haddock recruitment occurred at a time when quotas were being reduced and thus the potential benefits of this management action are confounded with the imposition of the closure. However, here as in the case of Georges Bank, the protection afforded to juvenile haddock benthic habitat may have been important to the survivorship of this sensitive life history stage and may have been an important factor in the rebuilding of these stocks. The benefits to target species of the other closures is likely limited given the spatial extent of the closures in relation to the distributional range of the target species, most closures covering only a small fraction of the stocks' area.

Regarding the benefits of the MPAs to food chain dynamics, benefits within each area are expected although, as noted by Babcock et al. (2010), these will take a number of years to become evident. Benefits to the ecosystem outside the closed areas are expected to be either modest or limited, given the size of these areas in relation to the size of the overall ecosystems. Further, benefits to the rest of the ecosystem due to closed areas will be difficult to distinguish from those due to other management action such as quota reductions.

These observations on productivity are consistent with the international literature (e.g. Halpern 2003; Hastings and Botsford 2003; Link et al. 2005; Lubchenco et al. 2003; NAS 2001). Benefits to productivity are a function of the relative size of the MPA to the ecosystem component (e.g. fish stock or coral bed) in question and the rate of exchange of the ecosystem component across the MPA boundaries (e.g. high in the case of a fish stock and low in the case of a coral bed). These exchange rates can differ not only by species but also by life history stage within a species. When a large fraction of the resource is protected, large benefits are expected. This is also true when a large percentage of the habitat important to an ecosystem component's productivity is protected (e.g. gravel epibenthos for juvenile haddock). When exchange rates across an MPA boundary are low, then the benefits accrue inside the MPA and less so outside. When exchange rates are high, causing high spillover, there can be benefits both inside and outside the closed area but this depends upon the control of human impacts on the spillover outside the closed area. For example, when the US Gulf of Maine Area closures were implemented in 1994, as noted above, US fisheries managers could not impose quotas to control exploitation on any one stock. Consequently, fishing fleets could have moved from Georges Bank to exploit stocks (e.g. cod) in the Gulf of Maine Area outside the closures, with resultant increases in fishing mortality on these stocks. Thus, when closed areas are employed, it is essential that the level of overall human impact be taken into consideration as the displacement of these impacts can negate any positive benefits of spillover from a closed area.

Habitat

The closed areas were evaluated primarily in relation to their protection of benthic habitat. In this regard, most MPAs either performed well or are expected to, based upon experience elsewhere. In the case of the coral conservation closures, benefits to the coral communities are expected to be high, given that these closures were designed to protect them. As with the other objectives, however, the level of benefit is conditional on the fraction of the total benthic habitat protected. Notwithstanding this, the experience of the Georges Bank and Emerald / Western Bank closures is relevant. Both closed areas may be protecting a high percentage of the habitat important to juvenile haddock habitat, which would then produce benefits for the whole stock, both inside and outside the closed area. Thus, it may not be important to have a large closed area to protect all benthic habitat but rather to have one that is designed to cover that habitat important to the ecosystem component (e.g. fish stock) in question.

There is a corollary to these effects. Many species prefer some habitats (e.g. gravel lag for sea scallops). Preventing access to these areas will be strongly resisted by the fishing fleets and also could result in proportionally more damage to unprotected benthic habitat by the displaced fishing effort. An alternate approach is to permit fishing specifically in those areas where the preferred habitat of commercially important species, such as scallop, is known to reside. DFO (2006c) describes such an approach in which benthic habitat mapping was used to locate areas where scallop would preferentially be found. By directing fishing effort to these areas, the scallop fleet was able to lower its operating costs. As well, the overall damage of the benthic habitat caused by the fleet was reduced.

RECOMMENDATIONS

The above synthesis highlights the benefits of MPAs. These benefits are tightly linked to their design and implementation (monitoring and enforcement). A poorly designed and implemented MPA may not accrue conservation benefits and indeed could be counterproductive. On the other hand, there are compelling arguments to be made for designing and implementing MPAs based on current best knowledge and practices, where objectives are derived from first principles as currently understood. Design and implementation that allow for an iterative approach, one that can incorporate new knowledge as it becomes available are to be favoured over those which never get off the ground because of "insufficient knowledge," or less than perfect design.

One can increase the chances of an MPA achieving its objectives by taking into consideration the wide array of competing issues in a systematic manner during the initial design phase. O'Boyle et al. (2005) outlines an approach which, being exemplary of experience elsewhere (e.g. Rosenberg et al. 2009), provides the steps that should be followed when implementing an EAM. More recently, Smith et al. (2007) outlines a broader planning framework which includes EAM as well as another important component of planning and management - Management Strategy Evaluation (MSE). Whereas EAM is focused on the objectives to be achieved, MSE is focused on how best to achieve those objectives. These frameworks are generally recognized and used within the ocean management community and are consistent with the approach used in recent reviews of MPA implementation (e.g, NAS 2001). The EAM and MSE frameworks were thus used here to guide formulation of the following recommendations on MPA implementation in the ESSIM area.

MPA Objectives in the Context of an EAM

The ESSIM strategic plan (DFO 2007a) outlines the broad objectives of EAM on the Eastern Scotian Shelf, the conservation elements of which build upon the DFO national ecosystem objectives hierarchy (DFO 2004b) noted earlier.

It is first necessary to state the issues associated with each conservation objective. This implies identifying what ecosystem components (e.g. deepsea coral) are to be considered and the threats to these. Much of this work has already been done through the efforts of the ESSIM initiative.

The next step is to identify those issues which should be a priority of management. Which issues present the most risk to the conservation of the ecosystem components under consideration? Over the past decade, a number of methods have become available that can assist in this prioritization process. Smith et al. (2007) outline a three step process composed of an initial scoping phase, an intermediate semi-quantitative screening phase and a final full quantitative phase, each with a specific suite of risk management tools. For instance, the Productivity Susceptibility Analysis (PSA) of Hobday et al. (2007), which is being considered in a number of ocean resource management issues (e.g. Lenfest 2009) is the main risk management tool of the intermediate phase. While not formally part of the Smith et al. (2007) framework, Fletcher (2005) describes an approach which engages managers, scientists and stakeholders in identifying the main issues in EAM and an assessment of the risks that they pose. It is a semi-quantitative approach to the prioritization of risk management. A number of fully quantitative tools exist. Those specific to spatial planning include MARXAN (Leslie et al. 2003) and more recently, the Swept Area Seabed Impact (SASI) model (NEFMC 2009). These procedures are very data and computationally intensive and are best applied when evaluating high risk issues.

All these tools provide a means to objectively evaluate the risks confronting ecosystem components and thus allow identification of those impacts which are important to address. Some of these tools are already being used in ESSIM (e.g. MARXAN). Notwithstanding this, there is value to exploring semi-quantitative approaches, particularly that of Fletcher (2005), to identify and prioritize those issues that pose the most risk to sensitive ecosystem components in proposed areas of protection. The results of this exercise could then be further explored using both MARXAN and SASI. MARXAN allows for exploration of different area configurations to meet stated objectives while SASI allows description of the spatial impacts of various fishing gears. For instance, the Habitat Committee of the New England Fisheries Management Council is using SASI to evaluate the potential impacts of a wide range of fishing gear on benthic habitat in the Northeast region and offers opportunities for Canada / US collaboration. It is recommended that this tool, in addition to MARXAN, be explored for application in ESSIM. Overall, it is prudent to employ a diversity of tools and approaches in the design of MPAs.

The result of these risk assessment explorations is a suite of conceptual objectives, linked to the ESSIM conservation objectives, which specify which ecosystem components (e.g. benthic and fish species) are to be considered in management, what in general is its desired future state (e.g. recovery to 1980s conditions) and what threats need to be managed (e.g. bottom fishing).

Implementation of MPAs

The implementation of MPAs requires consideration of each component of Management Strategy Evaluation (MSE). A comprehensive description of MSE and its components (Figure 28) is provided by McAllister et al. (1999).

The first component to consider is the state of **knowledge of the ecosystem components** under consideration. MPAs, to be effective, require particular knowledge of the migration and movements of organisms inside and outside of their boundaries. Spillover has increasingly been observed to be due to larval drift, particularly for sessile species. In this context, Gaines et al. (2003) highlights the need for knowledge of ocean currents in and around closed areas to fully evaluate the implications of spillover processes for the ecosystem outside closed areas. Fortunately, the physical oceanography of the Scotian Shelf is well described with development of 3-D models like the Finite Volume Community Ocean Model (FVCOM - http://fvcom.smast.umassd.edu/FVCOM/index.html). On the other hand, the state of knowledge of the migration and movements of commercial and non-commercial species is not as advanced although through efforts such as the Ocean Tracking Network, considerable progress is being made. Still lacking, however, are spatial models which allow evaluation of the impact of the movement and migration rates of species across

MPA boundaries (Gerber el al. 2003). To the degree possible, development of models that describe the spatial movements of ecosystem components is recommended for the ESSIM area.

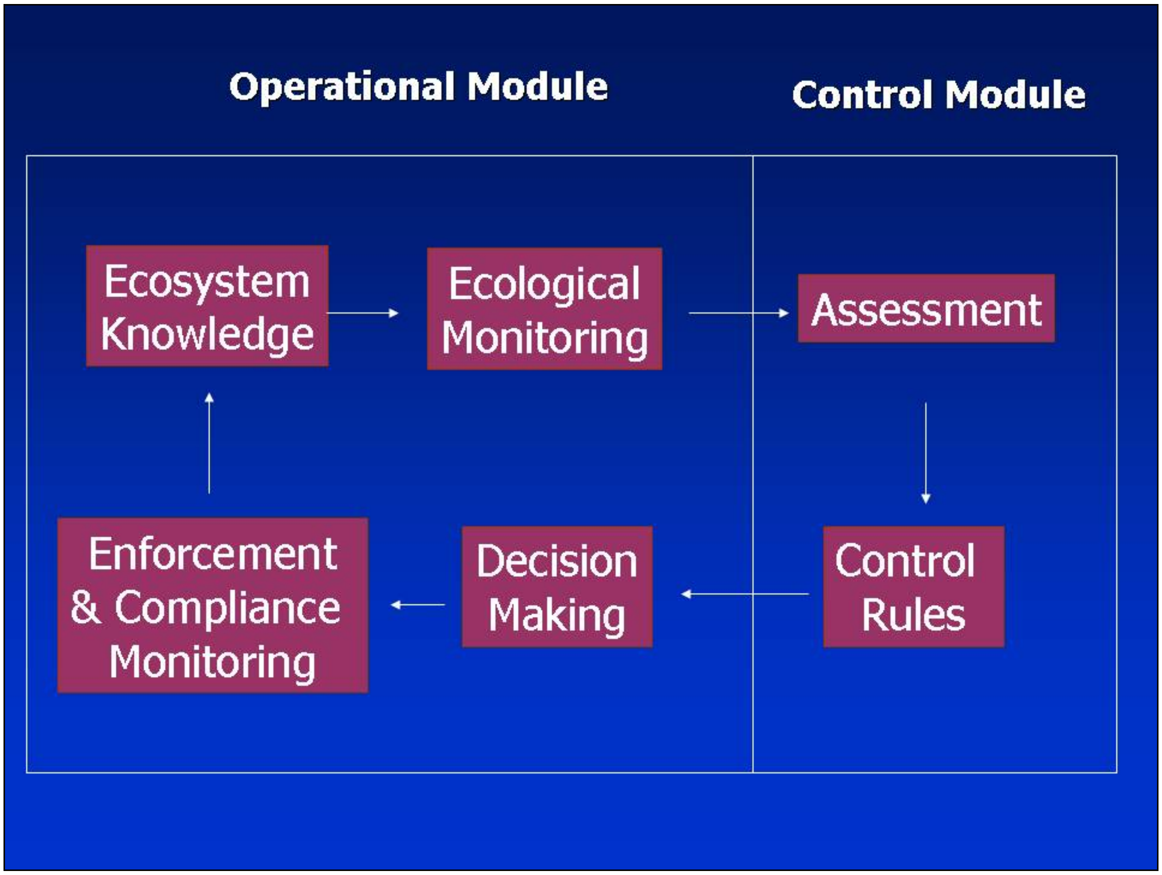


Figure 28. Components of Management Strategy Evaluation (from McAllister et al. 1999)

The state of knowledge on species – habitat associations needs to be considered. The value of this is highlighted by the gravel - juvenile haddock association observed on Georges Bank. Similar associations no doubt exist on the Scotian Shelf. It would be useful to summarize the species - habitat associations known on the Scotian Shelf, the spatial distribution of identified habitats and what the potential implications of damage to these habitats on population productivity.

Ecological monitoring is the second component of the MSE framework. This involves outlining what surveys and sampling are required to evaluate the performance of the MPA. It is important to note that a monitoring program has been developed for the Gully (DFO 2010b). Many of the elements of this plan are likely applicable to any new MPAs to be considered in the future. An important aspect of this is the monitoring of fishery impacts. Gavaris et al. (2005) noted the need to consider fishery vessel tracks at fine spatial scales in order to properly evaluate habitat impacts. VMS provides a valuable tool in this regard. Murawski et al. (2005) point out the benefits of using VMS data to monitor the impacts of fishing fleets around the closed areas in the Gulf of Maine Area. This is only one potential component of a comprehensive monitoring plan. It is recommended that a monitoring plan be formulated before establishment of future MPAs which outlines the monitoring activities that would be used to evaluate performance of the MPA in relation to the EAM objectives. It would also be useful to include monitoring of ecosystem components that might be expected to enjoy collateral benefits of the MPA. It is further recommended that monitoring be undertaken as stipulated by this plan before implementation of any new MPAs in order to provide baseline information for future assessments.

The third component of MSE is **assessment**, which in this case consists of defining those indicators and associated reference points necessary to evaluate performance of an MPA against the suite of ecosystem objectives. For the productivity objectives of commercially targeted species, the fishery stock assessments are adequate. The Recovery Potential Assessments are also appropriate for depleted (e.g. SARA) species. On the other hand, the evaluation of progress towards the biodiversity and habitat objectives needs careful consideration to identify which indicators are most appropriate to assess. This may require modeling of potential species – habitat linkages. This will have to be evaluated on a case by case basis.

The schedule of assessment of the response of the ecosystem to MPAs needs to be considered. This will need to take into account the time scale of expected changes. Assessment of the state of the habitat in and around an MPA will likely not need to be on the same schedule as that for fishery stock assessment. On the other hand, annual assessment of the rate of human impacts on the habitat would likely be required. It is therefore recommended that the components of the assessment of the performance of any new MPAs be defined in advance of its implementation.

The next two components of an MSE are the **control rules and decision – making** needed to achieve the desired objectives. Taken together, these represent the evaluation of the management strategy for use of the MPA. This is arguably the most important components of the MSE for new MPAs. They involve deciding whether or not an MPA is the right tool to achieve the conservation objectives associated with the high risk issues and if so, what are to be its boundaries. It may be that an MPA is not the best tool to address all issues. Part of the DFO regulatory process for establishing new MPAs is a Regulatory Impact Analysis, where a suite of management tools are evaluated against costs and benefits, and the suitability of an MPA as one of these management tools becomes apparent. Some objectives may be better achieved through other management approaches (e.g. bycatch regulations). Consistent with experience elsewhere, new MPAs need to be considered as complementary to other management tools. This exercise will no doubt highlight issues that other approaches can't address and vice versa.

Regarding boundaries of future MPAs, either alone or part of a network, it will be necessary to consider different boundary proposals and how each of these relates to the spatial distribution of ecosystem components at risk from human impacts. Information on the rate of movement and/or migration of these ecosystem components across the proposed MPA boundaries is thus required. In the short term, educated guesses on these rates can be made based on knowledge of life history and experience elsewhere. These initial estimates would then be updated as knowledge grows. It would be valuable to construct spatial models that allow evaluation of the potential costs and benefits of different MPA boundary options although it is recognized that this will be difficult. Existing modeling approaches (e.g. SASI and MARXAN) may be adapted to this purpose. It is the author's experience that the modeling process itself leads to new insights on complicated resource management issues such as this.

An important consideration of MPA boundaries is how best to update these as new information becomes available. It is possible that with experience, the need to adjust existing MPA's boundaries will be required. During the MPA design stage, the conditions which would both initiate this update process and how this would be undertaken should be stipulated. This is an issue that should be considered during the assessment of the MPA performance.

The last component of an MSE includes **enforcement and compliance monitoring**. During the drafting of this report, while it was evident that compliance with the MPAs considered in the case studies was generally felt to be high, there were few if any documented reports that provide an indication of compliance with the closed areas in relation to other management tools. Halliday (1988) noted that some of the perceived benefits of closed areas are their relatively low enforcement cost and relatively high stakeholder acceptance. It would be useful to verify this and to report, on an on-going basis, relative compliance with new MPAs compared to other management tools.

When considering the requirements of each component of an MSE for new MPAs, it will become evident that these are interlinked. The indicators defined in the assessment component are dependent upon information provided through the monitoring component. The capacity to evaluate the management strategies is dependent upon knowledge of migrations and movements of biota. Thus, the exercise is iterative and it will take a few passes through all components to finalize. Nonetheless, it is recommended that this approach be considered to ensure that all aspects of future MPAs and fishery closures be investigated so that their conservation benefits are fully realized.

CONCLUDING REMARKS

Both Marine Protected Areas and fishery closures offer promise in providing a means to achieve conservation objectives across the suite of issues facing an ecosystem approach to management. Benefits have been observed and are expected for ecosystem biodiversity and productivity as well as habitat protection. The scale and extent of these benefits is dependent upon the scale and extent of the ecosystem components being considered. Closures are most suited for sessile organisms and those that are in well defined localized regions. The benefits are less clear when MPAs are being considered for the protection of highly mobile organisms and / or those that cover a large distributional range. However, even in these cases, there may be life history stages which are localized enough, the protection of which would provide population-scale benefits. When creating closures, it is thus necessary to clearly state what ecosystem components are being considered for protection by new MPAs and evaluate the costs and benefits of management through a Management Strategy Evaluation. This will ensure that all closures are implemented within the appropriate context of the rest of resource management system, thus optimizing their utility in an Ecosystem Approach to Management.

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