Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

C S A S | **S C C S**

Canadian Science Advisory Secretariat | **Secrétariat canadien de consultation scientifique**

Research Document 2004/076 | **Document de recherche 2004/076**

Not to be cited without
Permission of the authors *

Ne pas citer sans
autorisation des auteurs *

Operationalizing an Ecosystem Conservation Framework for the Eastern Scotian Shelf

Mise en oeuvre d'un cadre axé sur la conservation de l'écosystème pour l'est du plateau néo-écossais

R. O'Boyle, M. Sinclair, P. Keizer, K. Lee, D. Ricard, and P. Yeats

Fisheries and Oceans Canada
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2
OboyleR@mar.dfo-mpo.gc.ca

ISSN 1499-3848 (Printed / Imprimé)

Canada

ABSTRACT

Since Canada enacted the Oceans Act in 1997, there have been a number of initiatives in DFO to explore how best to manage Canada's three oceans. Principle amongst these has been the establishment of a national program on Integrated Management which involves pilot projects on each coast. The project on the east coast is being undertaken on the Eastern Scotian Shelf which a number of ocean industries utilize – for example, fishing, oil & gas exploration, transport, and the military. As part of this ESSIM pilot project, a framework has been developed to clarify how ecosystem-based management could be implemented. A suite of conceptual conservation objectives is first identified for the ESSIM area, based upon a set of national objectives which address biodiversity, productivity and habitat issues. The process whereby these conceptual objectives are made operational is then presented. Through this process, operational objectives, which identify an indicator and reference point, are stated for each conceptual objective. Utilizing this framework, ocean industry activities can be managed in a consistent manner to meet the conservation objectives for the ESSIM area. Issues of spatial scale and cumulative impacts are noted as required, and comment is made on how progress against the suite of objectives could be communicated.

RÉSUMÉ

Depuis que le Canada a adopté la *Loi sur les océans,* en 1997, diverses initiatives ont été prises au MPO pour déterminer quelle était la meilleure façon de gérer les trois océans du Canada. Une des plus importantes de ces initiatives a été la création d'un programme national de gestion intégrée, comprenant le lancement de projets pilotes sur chaque côte. Le projet pilote de la côte est se déroule dans l'est du plateau néo-écossais, région utilisée par diverses industries, comme la pêche, l'exploration pétrolière et gazière, le transport et la défense nationale. Dans le cadre de ce projet pilote de GIEPNE, un cadre a été élaboré pour clarifier les modalités de mise en œuvre éventuelle de la gestion axée sur l'écosystème. Dans un premier temps, on cerne un ensemble d'objectifs conceptuels de conservation pour la zone visée par la GIEPNE, en fonction d'objectifs nationaux concernant la biodiversité, la productivité et l'habitat. On décrit ensuite le processus suivi pour rendre concrets, ou opérationnels, ces objectifs conceptuels. Dans le cadre de ce processus, des objectifs opérationnels, assortis d'un indicateur et d'un point de référence, sont établis pour chaque objectif conceptuel. Ce cadre permet de gérer chacune des activités des industries qui oeuvrent dans le secteur océanique de manière cohérente en fonction des objectifs de conservation poursuivis dans par la GIEPNE. On note au besoin les considérations d'échelle spatiale et les effets cumulatifs et on formule des commentaires sur la façon de rendre compte des progrès accomplis dans la réalisation de l'ensemble des objectifs.

INTRODUCTION

Since Canada enacted the *Oceans Act* in 1997, there have been a number of initiatives through which DFO's approach to ocean management is starting to emerge. A nationally co-ordinated Integrated Management (IM) program (DFO. 2002a) was established which consists of regional pilot initiatives on the east and west coasts to provide test sites for implementation of IM. For instance, the Eastern Scotian Shelf Integrated Management (ESSIM) pilot was initiated in 1998. It is eventually intended that about 20 Large Ocean Management Areas (LOMAs) covering Canada's three oceans will be designated in each of which stakeholders and regulators would work together to decide how best to manage these areas to achieve both conservation and socio-economic objectives (DFO. 2002b). The status of the ESSIM pilot area (figure 1) as a LOMA is currently under review. While integrated management in the ESSIM area has not thus far included the coastal fringe, as the initiative develops, it is planned to expand IM into the inshore zone.

A key step towards implementation of IM was taken by DFO in 2001 when a national workshop (the 'Sidney' workshop reported in Jamieson et. al., 2001) was held to outline the conservation objectives necessary to guide IM of Canada's ocean ecosystems. Subsequent to the workshop, the regional pilots tested a number of the concepts discussed at the workshop to understand what they implied operationally.

In the spring of 2004, Maritimes Science Branch struck an ESSIM Science working group to consider the scientific requirements of integrated management on the Eastern Scotian Shelf, chief amongst these being the definition of indicators and references points for the various objectives of the initiative. It became evident that the activities of the working group would benefit from an overall ecosystem conservation framework to guide its discussion. This would outline the process whereby the ecosystem objectives are defined, how these objectives related to each other, how they could be achieved operationally and how progress on the objectives could be reported.

This contribution outlines an approach to the implementation of the ecosystem conservation aspects of IM on the Eastern Scotian Shelf based upon the experience of the authors as well as relevant international dialogue (Garcia and Staples, 2000a; Pajak, 2000; Sainsbury and Sumaila, 2003). It adopts the terminology of Jamieson et. al. (2001) in its description of an IM process. Throughout this contribution, conservation objectives based on the Sidney workshop are discussed. While these are based upon the literature as well as our own experience, they are illustrative and are not to be taken as specific proposals for the ESSIM initiative. They have not been sufficiently discussed with stakeholders and are not comprehensive. The main purpose of this contribution is to illustrate how all the conservation pieces of IM could fit into an overall planning framework. The detailed work of applying this framework in the ESSIM initiative is still to be undertaken and indeed is being considered by the ESSIM Science Working Group. From our experience, the establishment of objectives requires collaboration across all user groups in a highly interactive and iterative manner. Defining the framework is the essential first step. Applying it will be the most challenging part of the process.

INTEGRATED MANAGEMENT PLANNING

Planning Hierarchy

Integrated Management involves a number of linked activities (Figure 2) (Johnson (1999). Conceptual objectives are first developed to provide overall guidance to IM. These are based on input from the various ocean industries, non-government organizations, government agencies, science advice, etc. These objectives are to address all dimensions of sustainable development (environmental, social, economic, and institutional). Further discussion on the broader dimensions of integrated management in the ESSIM area is provided in the ESSIM Strategic Planning Framework (DFO 2003a), a public discussion paper distributed to the ESSIM Forum stakeholder community. In this paper, we will only be addressing the environmental dimension or conservation. The conceptual objectives are expressed as operational objectives, which state an action verb, indicator and reference point (Jamieson et. al, 2001) through an 'unpacking' process. While the conceptual objectives would apply to all ocean industries in a management area, the operational objectives would be specific and used to guide the management of activities of the ocean industries that are impacting the ecosystem. In some cases, this would be only one industry but in others, the cumulative impacts of a number of ocean industries might need to be addressed. A monitoring program is then designed and implemented for each indicator and a framework established for the assessment of the monitoring data. The assessment would be used to formulate advice to a management team on the success in meeting the operational and thus conceptual objectives.

Using this framework, IM of each LOMA in Canada would involve a set of nested planning activities, from an overarching IM plan at the top to industry-level 'plans' below (Figure 3). Note here that the term 'plan' is used in the broad sense to highlight the need for industry – based planning rather than implying that each ocean industry need draft a document specifically termed a 'plan'. The IM plan (e.g. for ESS) would outline the conceptual objectives and issues to be addressed by all ocean industry operating in that area. These conceptual objectives while specific to the IM area, would be derived from those stated in national policy (Jamieson et. al, 2001), thus providing national consistency for all IM plans in Canada. Regarding operational objectives, there are two possible uses of these at the IM Plan level. As stated above, operational objectives would be developed when ocean activities need to be managed. If a number of industries impact the same feature of the ecosystem, then the cumulative impacts of these activities would need to be managed. An operational objective to do this would have to be included at the IM Plan level to inform operational objectives at the ocean industry level. As will be seen below, there may be further need to address cumulative impacts within an ocean industry but these would be linked back to the IM Plan operational objective. The other use of operational objectives at the IM Plan level relates to the determination of the overall health of the ecosystem in the IM area. For ecosystem features where there is an operational objective to address cumulative impacts, this should suffice. For the features of the ecosystem where there are no cumulative impacts being assessed at the IM plan level, operational objectives would need to be developed that, while having no direct management implication, would be used to monitor the overall effectiveness of IM and ecosystem health. In this case, the term ‘operational’ refers to the need for DFO to monitor the identified ecosystem features.

Achievement of the objectives of IM would occur through management of each ocean industry’s activity. Each ocean industry would consider the operational objectives and regulations required to implement the intent of the broader IM plan. On the Eastern Scotian Shelf, separate industry discussion and planning would be required for at least fisheries, oil and gas, maritime transport and naval operations (Figure 3). As stated above, where cumulative impacts across ocean industries need to be taken into account, an operational objective could be stated at one level higher than the implicated industry (e.g. IM plan level) with the same operational objective stated for each impacting industry but adjusted to include an allocation of that industry’s impact. An illustration of this process is described below.

The fishery is one of the most complex industries operating in most IM areas in Canada. To facilitate the integrated management of this industry, industry-level planning would be required to inform the separate plans for each of the stock-specific fisheries (Figures 3 and 4). The fishery industry planning would reiterate the IM conceptual objectives and, where required, state operational objectives that would impact all stock plans (see below for examples). It would also state those operational objectives for which cumulative impacts across stock plans would need to be taken into account. Notwithstanding this, it is expected that these situations may be limited and that the stock plans would be the primary administrative vehicles for implementation of IM in the fishery.

Development of the Hierarchy

Reference above is made to the national conceptual objectives for conservation. These were developed at the Sidney workshop (Jamieson et. al., 2001) and have been accepted, with small modification, as national policy. The high level, conceptual objectives are:

- to conserve enough components (ecosystems, species, populations, etc.) so as to maintain the natural resilience of the ecosystem

- to conserve each component of the ecosystem so that it can play its historical role in the foodweb (i.e., not cause any component of the ecosystem to be altered to such an extent that it ceases to play its identified historical role in a higher order component)

- to conserve the physical and chemical properties of the ecosystem

These are to address the conservation of an ecosystem’s biodiversity, productivity and habitat. Under each of these objectives, sub-objectives are stated to address the various ecosystem components associated with biodiversity, productivity and habitat of an IM area. The Sidney workshop described a process termed 'unpacking' to link these national conceptual objectives to the operational objectives that would be placed in the IM and ocean industry plans. Guidelines on how to interpret the national conceptual objectives during the unpacking process in a consistent manner across DFO were developed in a February 2004 workshop (DFO, 2004). These operational objectives are equivalent to the Marine Environmental Quality (MEQ) objectives referred to in the Canada Oceans Strategy (DFO, 2002a). Jamieson et. al (2001) did not fully explore the details of the unpacking process but rather suggested that the approach be tested in the IM pilots on each coast. With this in mind, since the Sidney workshop, there have been projects on Canada's East and West Coasts exploring how best to unpack the national ecosystem objectives structure for implementation in the IM areas (Jamieson et. al., 2003; O'Boyle and Keizer, 2003).

Based on these experiences, it is suggested that the following sequential steps (Figure 5) are needed to make the linkage between the high level, national objectives and lower level, operational objectives necessary for implementation of the ecosystem conservation aspects of IM:

1. Identification of the conservation issues relevant to the IM area

2. Identification of the ecosystem components impacted

3. Identification of characteristic and conceptual objective associated with each ecosystem component

4. Determination of the appropriate ocean industries to implement the conceptual objective

5. Definition of operational objectives for the IM area

6. Definition of operational objectives for each ocean industry

One pass through this sequence is likely not enough. Once a set of operational objectives is stated, these need to be discussed with the stakeholders, NGOs, government managers and officials, scientists, the public and so on (IM community) to ensure that all issues have been addressed. Modifications can then be made to the objectives as appropriate. Thus, the process is very iterative with considerable consultation and stakeholder engagement.

Each of the above steps is elaborated below, focusing on the ESSIM area. As stated earlier, although much of the detail is based upon our experience with IM issues and regional unpacking exercises, the proposals are provided for illustrative purposes. The last section outlines a reporting structure which would facilitate communication on progress towards achieving the objectives at all levels of the planning hierarchy.

ECOSYSTEM CONSERVATION FRAMEWORK FOR THE EASTERN SCOTIAN SHELF

1. Identification of Conservation Issues Relevant to the Eastern Scotian Shelf

The first step towards developing objectives is identifying the relevant conservation issues for an IM area, without considering what the objective should be. In our experience, as objective setting tends to be a highly iterative process, we do not advocate simply asking the IM community to state the desired conceptual objectives for an IM area. It is first necessary to undertake significant dialogue and probing of what the motivating issue is before an objective can be stated. This should be done through some inclusive process (e.g. workshops) involving the whole IM community. At this stage, issues will likely be a mixture of human pressures, ecosystem states, management responses, etc. Subsequent steps will add increasing specificity and standardization of terminology; here it is important to state clearly in layman's terms, the issues that are important to everyone.

To the degree possible, the priority (e.g. high, medium, low) of addressing an issue should also be articulated. This will aid subsequent development of the operational objectives. This will not always be easy and no doubt perceived priorities will be different. For instance, one group might feel that there is an impact on them by the operations of another group. However, this initial step must at least circumscribe the main and peripheral issues and establish a set of issues that all stakeholders can agree to. Note that if the ocean managers and scientists feel that an issue has not been raised by stakeholders, this is the time for this group to raise this issue for the consideration of all stakeholders.

Coffen-Smout et al. (2001) developed a set of management issues for the ESSIM area (Table 1). While this is not a comprehensive list, it shows the breadth of issues that one needs to consider as part of IM on the Eastern Scotian Shelf and is the basis of the development of the objectives given in this paper.

Having defined the issues, it is then necessary to associate each of these with the appropriate part of the national conservation objectives hierarchy (Table 1). If benthic disturbance of coral communities is an issue for a number of ocean industries, it is important to associate this issue with the same national conceptual objective (here with the maintenance of community biodiversity) for all ocean industries. Sediment loadings might be associated with another objective. As will be seen below, this sorting of the issues according to the national objectives at an early stage of objectives' development will greatly aid consistency of the IM approach and facilitate consideration of cumulative impacts across industries.

2. Identification of Ecosystem Components Impacted

Once the conservation issues have been listed by national objective, it is then necessary to identify what components of the ecosystem in the IM area are implicated by each issue. Jamieson et. al. (2001) referred to components as being communities, species, populations, physical and chemical properties of the ecosystem, without being specific to any one IM area. Here, we more specifically identify the communities, species, populations, etc. that are impacted by human activity on the Eastern Scotian Shelf. The desire is to identify that part of the ecosystem that is closest to the human impact. As distance from the impact increases, the chance to meaningfully manage that impact decreases. As with the issues, the identification of these components should not get overly involved. The intent here is to add specificity to the issues that will ultimately allow articulation of conceptual and then operational objectives.

For the ESSIM area, the ecosystem components associated with the issues given in Table 1 are presented in Table 2. They span benthic communities throughout the area to the sound environment in the pelagic zone and thus represent a significant part of the overall ESS ecosystem.

3. Identification of Characteristic and Conceptual Objective Associated with each Ecosystem Component

The overarching national conservation objectives are not specific to any one IM area; it is necessary, through a process termed 'unpacking' (Jamieson et. al., 2001) to restate these national objectives in terms more specific to the identified issues and ecosystem components of the Eastern Scotian Shelf. As stated above, a national workshop (DFO, 2004) was held in February 2004 to provide guidelines on how to interpret the national objectives during the unpacking process. The unpacking process of Jamieson et. al (2001) continues to the point where an indicator and reference point of the operational objective can be identified. While this is the overall intent here, there are advantages to stating the conceptual objective in as specific terms as possible before identifying the operational objective. Identification of the indicator and reference point of the operational objective can involve highly technical discussion by the scientists involved in IM. These discussions need not involve the entire IM community, who should focus their discussion on the goals of IM – definition of the conceptual objectives. Stating the conceptual objective in as specific terms as possible at this stage will greatly facilitate later identification of the operational objective.

Having identified the ecosystem component being impacted in the previous step will facilitate development of the conceptual objective to conserve it. As we are only interested in defining the conceptual objective for the IM area in as specific terms as possible, this should be one step before the indicator and reference point can be identified. Later, the unpacking will continue to identify the indicator and reference point of the operational objective.

The unpacking of Jamieson et. al. (2001) used the identification of a measurable quantity, the indicator, as the stopping point for the unpacking. In a like manner, we might use the ecosystem component's *Characteristic* as a stopping point for the IM area conceptual objective. The *Characteristic* is a biological property of the ecosystem, separate from our ability to measure it (Jamieson, et. al (2001). For example, spatial distribution and recruitment are characteristics of a population. This is in contrast to age one numbers from a population model which would be a measurable quantity (indicator) of recruitment. During the unpacking of the national conceptual objective, there could be constant testing to determine the characteristic of the ecosystem component that deserves protection from the human impact. This would add clarity to the regional conceptual objective as well as assist later development of the operational objective. Explicit exploration of the use of the ecosystem component's *Characteristic* in the unpacking process has not yet been attempted but would be a useful feature to consider. In the illustrative ESSIM plans below, the *Characteristic* associated with each ecosystem component is identified for illustrative purposes.

In their conceptual objectives, Jamieson et. al. (2001) used terms such as maintain and conserve along with the ecosystem component. Other terms such as restore, minimize, etc could also be used. The exact terminology is not important as long as the IM community agrees to its meaning. This highlights the importance of articulating some sense of the desired long term state of the ecosystem component, even in general terms e.g. restore benthic community biodiversity to conditions present in the 1960s. This will influence later determination of the reference points in the operational objectives.

Table 3 presents an unpacked set of conceptual objectives, based upon our experience in a number of test unpacking exercises (O'Boyle and Keizer, 2003) for ESSIM. There are a number of significant features of these objectives:

- Human impacts on the benthic community are considered as being direct or indirect. The direct zone of influence (Figure 6) is considered to be a significant disturbance of the ecosystem component that cannot be avoided by the ocean industry activity, be it the area impacted by a fishing set, a well site, etc. These direct impacts are considered against the national objective on community biodiversity. This objective is intended to conserve the diversity of benthic communities, which implies conserving each community type making up the benthic community. Direct impacts on each community type would represent irreversible damage and would only be acceptable if the cumulative impacts of these activities were within specified limits. Thus, the cumulative area of these direct disturbances of each ecosystem community type needs to be carefully regulated. One means to do this is by applying limits to the total allowable area of disturbance of each benthic community type, dependent upon the vulnerability of that type to disturbance. Initial attempts have been made to categorize the vulnerability of benthic community types on the Scotian Shelf to human activity, using the Adversity / Stability Model of Southwood (1977, 1988) (Kostylev, pers com). These show promise on providing the necessary limits for management purposes.

- Indirect impacts occur beyond the direct zone of influence (Figure 6) and can result from dispersion of a deleterious material (e.g. contaminant) from a point source, such as an oil well. These impacts influence a number of components of the habitat, and thus are associated with the national conceptual objectives on the ecosystem's physical and chemical properties.

- A number of issues will impact species biodiversity. These include invasive species introductions and by-catch of non-target species in fisheries. These are associated with the national objective on species biodiversity. Also associated with this objective are all the species at risk issues.

- The characteristic of interest associated with the population biodiversity objective is the genetic diversity within fished populations. This implies that the elimination of spawning components should be prevented.

- A key feature of IM is the desire to utilize the ecosystem in a balanced manner. No one part of the ecosystem should be exploited to the detriment of another. This consideration is introduced into the ESSIM plan through the national objective on the maintenance of trophic structure. Here, two ecosystem components and associated characteristics are considered. The first addresses the importance that forage species such as krill, sand lance, etc. have on the food chain. The second addresses the need to exploit the food chain in a balanced manner. No one trophic level should be exploited beyond its productive capacity, as well as considering its role in the food chain.

- Traditional fisheries management has involved the maintenance of the recruitment and growth production of a population. This need is introduced into the ESSIM plan through the national objective on mean generation time.

- Disturbance of the sound environment can be introduced into the ESSIM plan through a number of different avenues. Deleterious levels of sound can impact species at risk, population productivity, food chain processes and so on. Given these many avenues, we decided to introduce all these impacts through the national objective on the ecosystem's physical properties. In this manner, the cumulative effects of these impacts can be more easily monitored.

The above points might seem self evident. However, the importance of clearly identifying at this early stage where in the conceptual objectives hierarchy the various issues are to be addressed cannot be over-emphasized. This is important to avoid confusion when considering cumulative effects of similar activities across ocean industries. It would not be appropriate to address the habitat impacts of bottom fishing under one objective and the habitat impacts of oil and gas exploration under another. This would confound efforts to address the cumulative impacts of these activities.

4. Determination of Appropriate Ocean Industries to Implement Conceptual Objectives

Once the conceptual objectives have been defined, to ensure their achievement, it is then necessary to determine for which industries within the IM area that operational objectives are required. This is essentially a threats analysis to identify the potential impacts of the activities of each industry on each ecosystem component.

It might be considered that the first step in the process (identification of conservation issues) has completed this threats analysis and thus this step is not required. While the first step will provide valuable information for this step, the task is incomplete. In the first step, one industry might raise issues regarding another industry. As well, issues might be raised that impact all industries. A sorting of the impacts by industry will not have been explicitly undertaken. In addition, there may be activities identified in the first step that occur outside the IM area which impact the ecosystem within the IM area. For instance, air and water pollution from adjacent areas might be impacting the IM area ecosystem. These may vary over time due to large scale oceanic and atmospheric processes such as the North Atlantic Oscillation, variation in the location of the Gulf Stream and so on. It may be very difficult to address these issues without management intervention at a higher level. Notwithstanding this, there is value is formally recognizing these impacts through the IM planning process and identifying what steps need to be undertaken to address them. At the very least, the impacts of these influences should be monitored. These issues are not pursued further and are only mentioned here to illustrate how the proposed IM planning structure can accommodate pressures on the IM area from outside its boundaries.

The initial threats analysis for the ESSIM area (Table 4) indicated that the conceptual objectives need to be achieved through operational objectives in an overall IM area plan, which may result in changes to existing industry specific plans. It was noted earlier that the cumulative impacts of industry activities would be addressed by identifying operational objectives in plans that govern the activities of the implicated industries. In the ESSIM area, this is a particular issue for achievement of the objectives on community biodiversity. It may be necessary to limit ocean industry activities according to specific benthic community types, through allocation of allowable impacts. Fisheries, oil and gas and military activities could be implicated. Under the fisheries plan, there may be the further need for stock plans to have assigned benthic community impact allocations. The cumulative impacts of the fishing industry on trophic structure is another area that the planning structure needs to take into account. This could be done through the inclusion of operational objectives both in the fishing industry plans and specific stock plans.

5. Definition of Operational Objectives for ESSIM Area

In this step, we define the operational objectives for the overall IM plan. As mentioned earlier, operational objectives at this level can have two purposes: 1) monitoring of progress towards all conceptual objectives and 2) control of human activity. In the first case, the action verb would be ‘monitor’ with no associated management action. It is operational in the sense of directing DFO to monitor overall IM performance. In the second case, the action verb might be ‘limit’, ‘restore’, etc, with an associated management action. Here, operational refers to required action to control some ocean industry activity.

There is a large literature on indicators and reference points for integrated management (see Rochet and Trenkel, 2003 for a review) and how these might be classified and used in management systems (e.g. the Pressure-State-Response classification, OECD, 1993; Garcia and Staples 2000b). The indicator can be either a state (e.g. biomass) or change of state (annual % change in biomass). The latter may be useful when the severity of the level of the indicator is very uncertain (i.e. take management actions that at least moves the state in the right direction). Reference points are typically stated as being limit (minimum level that should be avoided) and precautionary (level that signals proximity to limit reference point). For operational objectives with management actions, these reference points signal specific regulatory activities (e.g. reduction in fishing mortality when population spawning biomass reduces to a precautionary level (Figure 7) well in advance of reaching the limit RP, when fishing would be stopped). For operational objectives constructed to monitor ecosystem status, limit and precautionary reference points, while not signaling specific management actions, have value in quantifying the health of the ecosystem. To the degree possible, all operational objectives should state both limit and precautionary reference points. It will be seen below that for some objectives, the limit and precautionary reference points are the same. In these situations, any activity above the limit reference point would be considered undesirable.

The term 'covariate' has been suggested (Gavaris, pers com) to identify the variable associated with modifying the reference point of the indicator (e.g. spawning biomass for fishing mortality). This concept has great potential to allow inclusion in IM of observations on oceanographic and ecosystem properties that on the surface have little management applicability. The ocean climate has a large influence on ecosystem productivity and as such, information on changes in the environment can be used to modify the reference points of operational objectives.

Table 5 outlines potential operational objectives for the IM area drawn from relevant literature and experience to date with ecosystem objectives. The national conservation objective, ecosystem component, characteristic and conceptual objective linked to each of these is also provided. For each operational objective, the action verb, indicator, limit and precautionary reference points are stated as is the associated management action. Where a specific management action is required at the IM area level, the action verb is ‘Limit’, ‘Protect’, etc. The management action states what that action is and in which plan it is implemented. Most of the operational objectives are for ecosystem monitoring purposes and thus there is no management action at this level. Management actions to meet the conceptual objective occur within the relevant ocean industry plans, as determined in step 4 of the process. Notwithstanding this, the entire suite of operational objectives at the IM plan level would be used to monitor progress towards achievement of the ESSIM conceptual objectives.

The illustrative operational objectives presented in the table have associated potential management actions are to address cumulative impacts across all ocean industries and are concerned with the maintenance of community biodiversity. The first is designed to maintain the area of disturbance of each benthic community type within identified limits. It would do this by limiting the area (sq km) disturbed of each benthic community type within the limit and precautionary reference points. The exact area of allowable disturbance per benthic community type (the covariate) is yet to be determined. Once these are, there would be an allocation of the area of this disturbance to each of the industry plans. The other two operational objectives define the amount of area of coral and Gully benthic community that can be disturbed (zero in each case), this managed through a closed area (coral) and Marine Protected Area (the Gully), the coordinates of which would be recognized in impacting ocean industry plans.

The operational objectives for the remainder of the biodiversity objectives all provide indicators and reference points designed to monitor progress towards achievement of conceptual objectives. Note that specific levels of the relevant ecosystem component's characteristic are not stated. For example, for species at risk, it is the number of species designated as endangered or threatened that is reported rather than the level of abundance of any one species in relation to a reference point. In this manner, the overall effectiveness of recovery efforts can be monitored. In a like manner, the operational objectives associated with the maintenance of generation time monitor the number of populations not achieving their growth and recruitment potential. Note that performance of these operational objectives is linked to those in the industry plans but not in a direct quantitative way. Aggregate yet simple indicators such as these have been used elsewhere to provide overviews of ecosystems (DFOb, 2003; Garcia and Moreno. 2003).

The operational objective associated with the maintenance of primary production, while having no explicit management action, infers the need for regulatory activities at a higher level to address the impacts of pollution.

The operational objectives related to trophic structure require highlighting as these imply monitoring of emergent properties of the Eastern Scotian Shelf ecosystem. Two operational objectives are suggested, one to monitor the biomass trophic spectrum (Gascuel et. al., 2004) by trophic level and the other to monitor processes along the food chain, using the Trophic Balance Index of Bundy et.. al., 2004. Management actions to address imbalances involve the fishing industry and would be handled in that plan. Here, the impact of those imbalances would be monitored. It should be noted that the research on indicators to monitor trophic processes is a rapidly developing field; those suggested here are based on recent advances. As the field develops, these indicators should obviously be updated as appropriate.

The majority of the operational objectives associated with the habitat objectives relate to monitoring the area where the concentration of some substance is above or below some acceptable level. As this implicates primarily one industry (oil and gas), management actions are included in that industry's plan. There are also instances where pollution sources from adjacent areas need to be considered. As with the impacts on primary productivity, higher level management actions may be required.

6. Definition of Operational Objectives for each Ocean Industry

The main vehicles for implementation of integrated management are the overarching IM plan and industry-based planning, examples of which are given for fisheries, stocks, oil and gas, transport and the military (Tables 6 - 10). The same format is used as for the IM area objectives. Here, however, there are no operational objectives purely for monitoring. All have associated management actions.

Fisheries Industry Plan (Table 6)

As per the threats analysis (Table 4), the fishing industry plan would include operational objectives to address community biodiversity and trophic structure. Regarding benthic community biodiversity, the IM plan would have allocated some area of allowable disturbance to the fishing industry (Fish [Area disturbed of each benthic community type]). This level of disturbance would then be allocated to the various stock plans in the fishery. To achieve this, the fishing industry may decide to use closed areas. This would be similar to the industry-wide coral closed area and Gully MPA.

Regarding trophic structure, the protection of forage species might imply a zero fishing mortality on a set of identified species with a license moratorium on fisheries for these species. Achieving the trophic balance objective is complicated. Species don't generally align well amongst trophic levels. To achieve a balance in removals along the food chain, it may be necessary to set overall catch limits for aggregates of species based on their trophic level. Once the overall catch is met, all fisheries for species in that aggregate would be halted.

Stock Plan e.g. Groundfish (Table 7)

The groundfish plan is provided as an example for how stock plans would fit into integrated management. Similar plans would be required for each of the stocks indicated in Figure 4. For groundfish, there would have to be considerable detail in this plan to address the different species (cod, haddock, flatfish, etc) covered by the plan. The example given here is based upon the current groundfish plan (DFO. 2002c) and enhanced to illustrate what additional ecosystem issues might need to be included.

The conceptual objectives on benthic community biodiversity would be met in a like manner to that presented for the fishing industry as a whole, except here specific allocations for benthic community disturbance would constrain fishing.

Operational objectives to meet the species biodiversity objectives would be met through by-catch limits and prohibitions on the catch of species at risk. The latter would be guided by a groundfish fishery-dependent allocation of the Potential Biological Removal (PBR) of a species at risk.

The population biodiversity objective would be met through the distribution of fishing mortality amongst population components through catch allocations to each component.

The trophic structure objectives would be met as per the IM plan stipulations and the mean generation time objective would be met through operational objectives to protect growth and recruitment production. There is a rich literature on the harvest control of fished populations. We have attempted here to rephrase the main controls currently being contemplated as an operational objective of IM. For instance, the operational objective to conserve growth production states the limitation of fishing mortality of the fully recruited age groups. Note that this objective is also intended to limit the exploitation of undersized fish. A number of management actions are implicated. The conservation of recruitment production focuses on the protection of spawning activity (first operational objective) and biomass (second operational objective). There is an added condition to the action for the first objective. It would not come into force unless spawning biomass was below some precautionary reference level (PARP). Fishing mortality on the fully recruited age groups would linearly decline from the PARP to the minimum acceptable level of biomass (Limit RP). This is illustrated in Figure 7.

Oil and Gas Industry (Table 8)

Conservation of biodiversity is achieved through three operational objectives, these similar to those presented in the groundfish plan, but with specific benthic disturbance allocations to this plan. This might, for instance, require limitations on the number of well sites allowable per benthic community type.

Similarly, for the conservation of species biodiversity, there may be a need for an allocation of the PBR, as was done in the groundfish plan. Management actions to achieve these limits would be developed as part of the environmental assessment process.

The majority of the operational objectives in this industry's plan concern the conservation of the IM area ecosystem's physical and chemical properties. The detrimental effects of concern are associated with the disposal the drilling muds and fluids and the conduct of seismic surveys. As this industry is the only one implicated in these issues, the operational objectives are identical to those stated in the IM plan but here the action verb is 'Limit' as opposed to 'Monitor' with regulatory measures identified through the environmental assessment process.

The development of indicators and reference points for operational objectives related to contaminants presents some interesting challenges. Chromium is a contaminant that exhibits a large degree of natural variability in the ecosystem. Anthropogenic sources of chromium additional to this natural variability include oil and gas sector drilling activities. At higher levels, it can be toxic to marine organisms, so the challenge is to distinguish the natural levels of chromium from those caused by human activities. On the Scotian Shelf, chromium is observed to vary naturally with aluminum (Figure 8). Thus this element can be used as a covariate of chromium to develop reference points for the operational objectives. Note here that the term covariate is different in principle to that used earlier although the same effect is achieved – modification of a reference point by another indicator. The regression between chromium and aluminum (using all data except the red squares as these data could be influenced by industrial activity) shows the natural variability in chromium. The yellow lines are various possible thresholds for precautionary Reference Points (PARP). The lowest one is a line parallel to the background regression line and is based upon the upper 95% confidence interval. It represents the minimum concentration of chromium that can be shown statistically to be above background. The next PARP is a two segment line, the first segment representing the threshold effect level (level above which effects are seen for the most sensitive species) and the second segment representing the above background concentration line, again based upon the upper 95% confidence interval. The third yellow line is another possible PARP and is the average of the threshold effects level and the Canadian Council of Ministers of the Environment (CCME) Probable Effects Level (the limit RP – red line above which biological effects would be expected).

An example of how this indicator / reference point system could be used was developed for the Scotian Shelf using the second PARP mentioned above (two segment line) and the CCME Probable Effects level as the limit RP (Figure 9). While there is a preponderance of observations in the Sable Island area, due to various oil and gas regulatory activities, no measurements on chromium concentrations above naturally occurring background were observed above the limit RP.

Maritime Transport Industry (Table 9)

Only two operational objectives are stated for the maritime transport industry, both related to biodiversity. The first is to address invasive species through the management of ballast water exchange and the second is to reduce interactions with bottlenose whale, an endangered species. In both cases, no impacting activities are permitted and thus the limit and precautionary reference points are the same.

Military (Naval) Operations (Table 10)

Four operational objectives are stated for naval operations, three relating to biodiversity and one to the sound environment. Again, these are similar to objectives stated in the other industry plans.

Cumulative Impacts

The hierarchy of planning (Figure 3) allows cumulative impacts across ocean industries to be addressed. To illustrate this property of the ecosystem conservation framework more clearly, the objectives related to the diversity of benthic communities have been extracted from Tables 5 – 10 and placed in Table 11. The conservation objective for the ecosystem component 'diversity of benthic community types' is to 'maintain area of disturbance within identified limits', as agreed by the stakeholder community. This objective is restated in all industry plans. For the IM area, based upon the vulnerability of various benthic community types to human activities, an overall allowable area of disturbance per benthic community type would be established, with X (TBD) and Y (TBD) as the LRP and the PaRP respectively. Note that 'benthic community type' is considered a covariate of the area disturbed reference point. The allowable area of disturbance is then partitioned among the ocean industries (e.g. Fish [Area disturbed]). The ocean industries then have to decide, through some consultative process, how their allocation would be distributed among their stakeholders. In the case of fisheries, there would have to be, for each stock plan, a part of the fisheries industry's allocation defined (e.g. Grd [Fish [Area disturbed]]). In the case of the Oil and Gas industry, as stated earlier, there may have to be limits to the number of wells situated within each benthic community type to ensure that the summed footprints of each well would be within the industry's allowable benthic community disturbance allocation.

This approach could be extended to the cumulative impacts of other ocean activities on other ecosystem components.

COMMUNICATION

Integrated management requires the collaboration of the entire stakeholder community, which is a very diverse group of people. It is therefore important to communicate progress towards meeting IM objectives in as clear and straightforward terms as possible. When only a few indicators are used to monitor management performance, as has been the case with traditional fisheries management, communication can be relatively straightforward. However, when management performance using a large suite of indicators is being considered, effective communication can be a challenge. Garcia and Staples (2000b) provide an overview of graphical methods that can be used to report on IM performance, making particularly reference to kite diagrams. The Traffic Light Methodology (TLM) (Caddy, 1999; Halliday et. al., 2001) has been used for fisheries assessments and has potential as a communications vehicle for Integrated Management. The TLM uses reference points to re-scale each indicator into a colour - good (green), concern (yellow) and bad (red). The green / yellow boundary can be associated with the precautionary reference point while that of the yellow / red associated with the limit reference point. This method was used to produce the first report on the state of the Eastern Scotian Shelf ecosystem (DFOb, 2003). While this report was produced prior to the Eastern Scotian Shelf ecosystem conservation framework discussed in this paper and thus was not intended to monitor management performance, it shows the possibilities of using the TLM to communicate the complex amount of information on indicators.

An illustration of an Eastern Scotian Shelf Ecosystem Status Report using the TLM is given in Figure 10. The first three columns state the national conservation objectives, IM area ecosystem component and its characteristic. The next eight columns report on the operational objectives in each plan. Each row of the table reports progress on a specific IM conceptual objective using the plan-specific operational objectives. The colour in each cell provides the status of the indicator using the limit and precautionary reference provided in Tables 5 – 10. It represents the degree of deviation from the reference point, which Sainsbury and Sumaila (2003) refer to as the Performance Measure. Interestingly, there are some situations e.g. community diversity operational objectives associated with corals and the Gully, where, since the LRP and the PaRP are the same, there will be no ‘yellow’ performance possible. It is either good or bad. It is important to keep in mind that the colours here are entirely illustrative and not based on actual interpretation of indicators and reference points. Cells with N/A indicate that an operational objective was not considered appropriate.

The column titled ‘IM Plan’ reports on the overall state of the Eastern Scotian Shelf ecosystem. It monitors the operational objectives for all IM conceptual objectives, regardless of ocean industry. In some cases, there may not be an operational objective in an industry linked to this column e.g. disease incidence under the conservation of the chemical properties objective. This illustrates that the framework can report on objectives that have no particular industry implication i.e. for monitoring purposes only. Indeed, as stated earlier, in many cases, the operational objectives in the IM Plan are not explicitly calculated from the operational objectives in the industry plans. In other cases, there is a direct link e.g. area of benthic community disturbance. Notwithstanding this, the IM plan operational objectives are functionally linked through the ecosystem’s processes to the impacts of industrial activities. Thus a problem identified at the IM plan level should be identifiable at the industry plan level. If not, this would indicate that further work is required on the operational objectives.

CONCLUDING REMARKS

The purpose of this paper is to present a methodology to elaborate an ecosystem objectives and indicators framework for the integrated management of the Eastern Scotian Shelf ecosystem. It links nationally defined conservation objectives at the conceptual level with operational objectives at the implementation level. In doing so, it draws together a number of concepts and definitions that have been discussed in Canada and elsewhere, showing how these fit into the overall IM planning framework. Much detailed work is now required, from dialogue with stakeholders, managers and scientists on the issues, ecosystem components and conservation objectives relevant to the Eastern Scotian Shelf IM area to the identification of indicators and reference points of the operational objectives. We consider that a useful first step in this process would be to document what is being currently achieved by each industry to address ecosystem objectives consistent with IM, as we suspect that there are a number of current activities that would fit well within this ecosystem conservation framework. Once this is completed, the stakeholder community could then review what additions to the framework are required through the complementary socio-economic and institutional objectives and indicators framework to ensure the long-term sustainability of the Eastern Scotian Shelf ecosystem.

REFERENCES

Bundy, A., L.P. Fanning, and K.T.C. Zwanenburg. 2004. Balancing Exploitation and Conservation of the Eastern Scotian Shelf Ecosystem. Abstract in International Symposium on Quantitative Ecosystem Indicators for Fisheries Management. 31 March – 3 April 2004, Paris, France.

Caddy, J. F. 1999. Deciding on precautionary management measures for a stock based on a suite of Limit Reference Points (LRPs) as a basis for a multi-LRP harvest law. NAFO Sci. Coun. Studies, 32: 55-68.

Coffen-Smout, S., R.G. Halliday, G. Herbert, T. Potter, and N. Witherspoon. 2001. Ocean Activities and Ecosystem Issues on the Eastern Scotian Shelf: An Assessment of Current Capabilities to Address Ecosystem Objectives. DFO Can. Sci. Advis. Sec. Res. Doc. Ser. 2001/095.

DFO. 2002a. Canada's Ocean Strategy. Fisheries and Oceans Canada. Oceans Directorate, Ottawa, Ontario. 30pp.

DFO. 2002b. Policy and Operational Framework for Integrated Management of Esturaine, Coastal and Marine Environments in Canada. Fisheries and Oceans Canada. Oceans Directorate, Ottawa, Ontario. 36pp.

DFO. 2002c. Groundfish Management Plan. Scotia-Fundy Fisheries Maritimes Region. April 1, 2002 - March 31, 2007. DFO Management Plan.

DFO, 2003a. A Strategic Planning Framework for the Eastern Scotian Shelf Ocean Management Plan: A Discussion Paper prepared for the ESSIM Forum (OCMD, 2003)

DFO. 2003b. State of the Eastern Scotian Shelf Ecosystem. DFO Can. Sci. Advis. Sec.Eco. Status Report. Ser. 2003/004.

DFO. 2004. Proceedings of the Ecosystem Objectives Guidelines Workshop: 24 – 26 February 2004. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/024.

Garcia, S., and I. Moreno. 2003. Global Overview of Marine Fisheries. P 1 -24. In Sinclair, M. and G. Vladimarsson. [ed] Responsible Fisheries in the Marine Ecosystem. FAO & CABI Publishing. 426pp.

Garcia, S.M., and D. Staples. 2000a. Sustainability Indicators in Marine Capture Fisheries: Introduction to the special issue. Mar. Freshwater Res. 51: 381-384.

Garcia, S.M., and D.J. Staples. 2000b. Sustainability Reference Systems and Indicators for Responsible Marine Capture Fisheries: a review of concepts and elements for a set of guidelines. Mar. Freshwater Res. 51: 385-426.

Gascuel, D., Y.M. Bozec, E. Chassot, A. Colomb, and M. Laurans. 2004. Trophic Spectra: A New Ecosystem Indicator. Theoretical Meaning and Practical Application. Abstract in International Symposium on Quantitative Ecosystem Indicators for Fisheries Management. 31 March – 3 April 2004, Paris, France.

Halliday, R.G., P.F. Fanning, and R.K. Mohn. 2001. Use of the Traffic Light Method in Fishery Management Planning. DFO Can. Sci. Advis. Sec. Res. Doc. Ser. 2001/108.

Jamieson, G, R. O’Boyle, J. Arbour, D. Cobb, S. Courtenay, R. Gregory, C. Levings, J. Munro, I. Perry, and H. Vandermeulen. 2001. Proceedings of the National Workshop on Objectives and Indicators For Ecosystem-based Management. Sidney, British Columbia, 27 February – 2 March 2001. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2001/09.

Jamieson, G, B. Bauer, and H. Vandermeulen. 2003. Proceedings of the Central Coast Integrated Management Marine Environmental Quality Workshop, June 5-7, 2002, Parksville, BC. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/13.

Johnson, B.L. 1999. The role of adaptive management as an operational approach for resource management agencies. Conservation Ecology 3(2): 8.

O'Boyle, R., and P. Keizer. 2003. Proceedings of Three Workshops to Investigate the Unpacking Process in Support of Ecosystem-based Management. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/04.

OECD. 1993. OECD Core Set of Indicators for Environmental Performance Reviews. A synthesis report by the Group on the State of the Environment. OECD Environmental Monographs. 93. 39 pp.

Pajak, P. 2000. Sustainability, Ecosystem Management, and Indicators: Thinking Globally and Acting Locally in the 21st Century. Fisheries. 25:16 - 30.

Rochet, M-J,, and V.M. Trenkel. 2003. Which Community Indicators can measure the Impact of Fishing? A Review and Proposals. Can. J. Fish. Aquat. Sci. 60: 86 – 99.

Sainsbury, K., and U. R. Sumaila. 2003. Incorporating Ecosystem Objectives into Management of Sustainable Marine Fisheries, Including 'Best Practice' Reference Points and Use of Marine Protected Areas. P. 343 - 361. In Sinclair, M. and G. Vladimarsson. [ed] Responsible Fisheries in the Marine Ecosystem. FAO & CABI Publishing. 426pp.

Southwood, T.R.E. 1977. Habitat, the templet for ecological strategies? J. Anim. Ecol., 46:337-365.

Southwood, T.R.E. 1988. Tactics, strategies and templets. Oikos 52: 3 - 18.

Table 1. Issues in the ESSIM area Associated with the National Conservation Objectives.

National Conservation Objective		Ocean Industries e.g. fisheries, oil & gas, transport, military	Other Stakeholders e.g. NGOs, Public	Regulatory Agencies e.g. DFO, EC, CFIA
To conserve enough components so as to maintain the natural resilience of the ecosystem	Maintain Community Biodiversity	Effects of activities on benthic communities (fishery: trawling; oil & gas: oil well pad; military: explosives)	Protection of fragile benthic communities e.g. coral communities in all areas and bottom communities in Gully	Distribution of impacts of human activities on the benthic communities
	Maintain Species Biodiversity	Interaction with Species at Risk (fishery: bycatch; oil & gas: drilling waste & seismic surveys; transport: shipping noise, ballast water, collisions; military: explosives)	Protection of high profile species at risk e.g. bottlenose whale, leatherback turtles	Recovery of all species at risk
	Maintain Population Biodiversity	Safeguard population spawning components		Genetic diversity of populations
To conserve each component of the ecosystem so that it can play its historical role in the foodweb	Maintain Primary Production	Oil & Gas: impact of produced water on primary production	Impact of pollution from all sources on primary production	Impact of pollution from all sources on primary production
	Maintain Trophic Structure	Fishery: balanced approach to harvesting across food chain	Impact of new fisheries on forage species e.g. krill	Balance in ocean uses
	Maintain Mean Generation Time of Populations	Fishery: exploitation of directed and non-directed species, oil & gas: drilling waste & seismic impacts	Oil discharges impacts on sea birds	Balance in ocean uses
To conserve the physical and chemical properties of the ecosystem	Conserve Ecosystem's Physical Properties: critical bottomscape	Oil & Gas: drilling mud disposal & contaminant degradation		Three dimensional structure of bottom
	Conserve Ecosystem's Physical Properties: water column properties	Fishery: noise; Oil & Gas: seismic noise impacts; transport: shipping noise impacts; military noise impacts	Overall amount of noise in environment	Overall amount of noise in environment
	Conserve Ecosystem's Chemical Properties: water quality	Fishery: ship-source pollution; oil & gas: well blowouts, produced water discharges, contaminant biodegradation & bioaccumulation; transport & military: ship source pollution	Overall amount of contamination of water	Overall amount of contamination of water
	Conserve Ecosystem's Chemical Properties: biota quality	Oil & gas: bioaccumulation; transport: bioaccumulation		Levels of contaminants in marine products

Table 2. Ecosystem Components in the ESSIM area Associated with National Conservation Objectives.

<table>
<tr><th colspan="2">National Conservation Objective</th><th>Ecosystem Component</th></tr>
<tr><td rowspan="3">To conserve enough components so as to maintain the natural resilience of the ecosystem</td><td>Maintain Community Biodiversity</td><td>• Benthic Community in ESS IM Area
• Coral Community in ESS IM area
• High diversity Benthic Community in Gully</td></tr>
<tr><td>Maintain Species Biodiversity</td><td>• All species in ESS IM area
• Species at risk in IM area i.e. Bottlenose whale, Leatherback Turtle, Cod</td></tr>
<tr><td>Maintain Population Biodiversity</td><td>• Populations under human pressure e.g. cod, flatfish, snow crab</td></tr>
<tr><td rowspan="3">To conserve each component of the ecosystem so that it can play its historical role in the foodweb</td><td>Maintain Primary Production</td><td>• Primary Producing species</td></tr>
<tr><td>Maintain Trophic Structure</td><td>• Forage Species
• Each Trophic level of ecosystem
• Food Chain</td></tr>
<tr><td>Maintain Mean Generation Time of Populations</td><td>• Fished populations in ESS IM area</td></tr>
<tr><td rowspan="4">To conserve the physical and chemical properties of the ecosystem</td><td>Conserve Ecosystem's Physical Properties – critical bottomscape</td><td>• Sediment layer</td></tr>
<tr><td>Conserve Ecosystem's Physical Properties – water column properties</td><td>• Sound Environment of Pelagic Zone in IM area</td></tr>
<tr><td>Conserve Ecosystem's Chemical Properties – water quality</td><td>• Pelagic zone of IM area</td></tr>
<tr><td>Conserve Ecosystem's Chemical Properties – biota quality</td><td>• All species in IM area</td></tr>
</table>

Table 3. Conceptual Conservation Objectives for Integrated Management on the Eastern Scotian Shelf.

A. Conservation Objectives Related to Biodiversity

<table>
<tr><th>National Conservation Objective</th><th>Ecosystem Component</th><th>Characteristic</th><th>Unpacking of Conservation Objectives</th></tr>
<tr><td rowspan="3">Maintain Community Biodiversity</td><td>Benthic Community Types in ESS IM Area</td><td>Distribution of each Benthic Community Type</td><td>• Protect Benthic Communities susceptible to disturbance
  • Prevent significant adverse alteration of each benthic community type
    • Maintain area of disturbance of each benthic community type within identified limits</td></tr>
<tr><td>Coral Community in ESSIM area</td><td>Distribution of Coral Community</td><td>• Protect Fragile Coral Communities in ESS IM area
  • Prevent significant adverse alteration of Coral Communities in Stone Fence area
    • Maintain area of disturbance of Coral Communities in Stone Fence area within identified limits</td></tr>
<tr><td>High diversity Benthic Community in Gully</td><td>Distribution of Gully Benthic Community</td><td>• Protect High Diversity Benthic Communities
  • Prevent significant adverse alteration of Benthic Communities in the Gully</td></tr>
<tr><td rowspan="3">Maintain Species Biodiversity</td><td rowspan="2">All species in ESS IM area</td><td>Number of Invasive species</td><td>• Protect Natural Communities from Invasive Introductions
  • Prevent significant adverse introduction of exotic species</td></tr>
<tr><td>Catch of Non-target Species</td><td>• Maintain Continued Existence of all Species
  • Minimize impact of fishing activity on non-target species i.e. bycatch
    • Minimize incidental mortality of fishing activity on non-target species i.e. bycatch</td></tr>
<tr><td>Species at risk in IM area e.g. Bottlenose whale, Leatherback Turtle, Cod</td><td>Abundance</td><td>• Restore Abundance of Species at Risk
  • Manage recovery of all species at risk e.g. Cod, Bottlenose Whale, Leatherback turtle</td></tr>
<tr><td>Maintain Population Biodiversity</td><td>Populations under human pressure e.g. cod, flatfish, snow crab</td><td>Genetic diversity within populations</td><td>• Maintain meta-population structures
  • Maintain Components of Populations impacted by human activity
    • Prevent elimination of spawning/breeding component by human activity</td></tr>
</table>

B. Conservation Objectives Related to Productivity

National Conservation Objective	Ecosystem Component	Characteristic	Unpacking of Conservation Objectives
Maintain Primary Production	Primary Producing species	Total Production	• Maintain productivity of primary producing species ◦ Maintain productivity of phytoplankton
Maintain Trophic Structure	Forage Species	Total Production	• Maintain the Production of Forage Species ◦ Protect forage species such as krill, sand lance, etc
	Each Trophic level of ecosystem	Total Production	• Maintain Productivity of Each Trophic Level (TL) ◦ Limit Biomass Removals from any Trophic Level with respect to Trophic Demands of next higher level and within trophic level productivity

Maintain Mean Generation Time of Populations	Fished populations in ESS IM area	Growth Production	• Maintain Growth Potential of populations impacted by human activity
			  ◦ Control death rate caused by human activity of mature adults at moderate levels
			    ▪ Allow immature individuals to grow to mature ages
			      ▪ Manage age/size composition of human impacts

		Recruitment Production	• Maintain Recruitment Production of populations impacted by human activity
			  ◦ Limit impact of human activity during spawning/breeding
			  ◦ Promote Rebuilding of populations impacted by human activity
			    ▪ At low biomass, reduce mortality rate caused by fishing activity of mature adults further

C. Conservation Objectives Related to the Physical and Chemical Properties of the Ecosystem

National Conservation Objective	Ecosystem Component	Characteristic	Unpacking of Conservation Objectives
Conserve the ecosystem's physical features, e.g. critical landscape and bottomscape and water column properties	Sediment layer	Surfical characteristics	• Prevent significant adverse alteration to natural variability of surficial sediment porosity, interstitial space, DO penetration beyond direct zone of impact
		Geochemical conditions	• Prevent significant adverse alteration to natural geochemical conditions (e.g. $S^{=}$, Eh, quality and quantity of organic matter, C_{org}:N) beyond direct zone of impact
		Microbial Community Production	• Prevent significant adverse alteration of conditions for natural microbial community function (e.g. benthic aerobic/anaerobic respiration) beyond direct zone of impact
		Contaminant Levels	• Prevent toxic chemical contamination of surficial sediments beyond direct zone of impact

	Sound Environment of Pelagic Zone	Sound Levels	• Protect sound environment of ESS for resident species
			  • Protect unique features of Gully for Bottlenose Whales
			    • Maintain noise levels in Gully within acceptable levels to protect Bottlenose Whales

Conserve the ecosystem's chemical features, e.g. water quality and biota quality.	Pelagic zone	Contaminant Levels	• Maintain levels of contaminants within levels at which biological effects are observed beyond beyond direct zone of impact
		Oxygen Levels	• Maintain bottom water dissolved oxygen at or above levels to support natural ecosystem functions beyond beyond direct zone of impact
	All species	Tissue contaminant levels	• Maintain health of wild organisms • Limit bioaccumulation of contaminants to within biologically acceptable levels
		Disease Incidence	• Limit disease impacts of ocean activities

Table 4. Ocean Industries in the ESSIM area Implicated in Achievement of Conservation Objectives.

A. Conservation Objectives Related to Biodiversity

National Conservation Objective	Ecosystem Component	Characteristic	IM Area Plan	Air Pollution from Adjacent Area	Water Pollution from Adjacent Area	Fishing Industry	Stock Plan e.g. Groundfish	Oil & Gas Industry	Transport Industry	Military
Maintain Community Biodiversity	Benthic Community Types in ESS IM Area	Distribution of each Benthic Community Type								
	Coral Community in ESSIM area	Distribution of Coral Community								
	High diversity Benthic Community in Gully	Distribution of Gully Benthic Community								
Maintain Species Biodiversity	All species in ESS IM area	Number of Invasive species								
		Catch of Non-target Species								
	Species at risk in IM area e.g. Bottlenose whale, Leatherback Turtle, Cod	Abundance								
Maintain Population Biodiversity	Populations under human pressure e.g. cod, flatfish, snow crab	Genetic diversity within populations								

B. Conservation Objectives Related to Productivity

National Conservation Objective	Ecosystem Component	Characteristic	IM Area Plan	Air Pollution from Adjacent Area	Water Pollution from Adjacent Area	Fishing Industry	Stock Plan e.g. Groundfish	Oil & Gas Industry	Transport Industry	Military
Maintain Primary Production	Primary Producing species	Total Production								
Maintain Trophic Structure	Forage Species	Total Production								
	Each Trophic level of ecosystem	Total Production								
Maintain Mean Generation Time of Populations	Fished populations in ESS IM area	Growth Production								
		Recruitment Production								

C. Conservation Objectives Related to the Physical and Chemical Properties of the Ecosystem

National Conservation Objective	Ecosystem Component	Characteristic	IM Area Plan	Air Pollution from Adjacent Area	Water Pollution from Adjacent Area	Fishing Industry	Stock Plan e.g. Groundfish	Oil & Gas Industry	Transport Industry	Military
Conserve the ecosystem's physical features, e.g. critical landscape and bottomscape and water column properties	Sediment layer	Surfical characteristics								
		Geochemical conditions								
		Microbial Community Production								
		Contamination Levels								
	Sound Environment of Pelagic Zone	Sound Levels								
Conserve the ecosystem's chemical features, e.g. water quality and biota quality.	Pelagic zone	Contaminant Levels								
		Oxygen Levels								
	All species	Tissue contaminant levels								
		Disease Incidence								

Table 5. Illustrative Operational Objectives for the Eastern Scotian Shelf IM Plan. TBD = To Be Determined

A. Conservation Objectives Related to Biodiversity

National Conservation Objective	**Ecosystem Component**	**Characteristic**	**Conservation Objectives**	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point)	**PotentialManagement Actions**
Maintain Community Biodiversity	Benthic Community Types in ESS IM Area	Distribution of each Benthic Community Type	Maintain area of disturbance of each benthic community type within identified limits	Limit Area (sq km) disturbed of each benthic community type X (TBD) Area disturbed; benthic community type Y (TBD)	Allocate area disturbed to Fisheries, Stock, & Oil & Gas industries; Implement through their plans
	Coral Community in ESSIM area	Distribution of Coral Community	Maintain area of disturbance of Coral Communities in Stone Fence area within identified limits	Limit Area (sq km) disturbed of Coral Community in Stone Fence Area 0; nil 0	Define Closed Area; Implement through Fishing, Stock, Oil & Gas and Military plans
	High diversity Benthic Community in Gully	Distribution of Gully Benthic Community	Prevent significant adverse alteration of Benthic Communities in the Gully	Limit Area (sq km) disturbed of Benthic Community in the Gully 0; nil 0	Define Marine Protected Area; Implement through Fishing, Stock, Oil & Gas and Military plans
Maintain Species Biodiversity	All species in ESS IM area	Number of Invasive species	Prevent significant adverse introduction of exotic species	Monitor Number of non-native species of total community Long-term average of indicator; nil Lower quartile of Long-term average	No Management Action
		Catch of Non-target Species	Minimize incidental mortality of fishing activity on non-target species i.e. bycatch	Monitor Bycatch (% weight) in all directed fisheries Long-term average of indicator; nil Lower quartile of Long-term average	No Management Action
	Species at risk in IM area e.g. Bottlenose whale, Leatherback Turtle, Cod	Abundance	Manage recovery of all species at risk e.g. Cod, Bottlenose Whale, Leatherback turtle	Monitor Number of SAR Species with COSEWIC designation of Endangered or Threatened Long-term average of indicator; nil Lower quartile of Long-term average	No Management Action
Maintain Population Biodiversity	Populations under human pressure e.g. cod, flatfish, snow crab	Genetic diversity within populations	Prevent elimination of spawning/breeding component by human activity	Monitor Number of meta populations considered not-viable Long-term average; nil Lower quartile of Long-term average	No Management Action

B. Conservation Objectives Related to Productivity

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	Operational Objective Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point)	Potential Management Actions
Maintain Primary Production	Primary Producing species	Total Production	Maintain productivity of phytoplankton	Monitor CPR Colour Index Lower quartile of 1961 - present average of Indicator; nil 1961 - present average of Indicator	No Management Action; Higher level management actions required to address Pollution from Adjacent Areas
Maintain Trophic Structure	Forage Species	Total Production	Protect forage species such as krill, sand lance, etc	Monitor Total Biomass of Forage Species Lower quartile of 1970 - present average of Indicator; nil 1970 - present average of Indicator	No Management Action
	Each Trophic level of ecosystem	Total Production	Limit Biomass Removals from any Trophic Level with respect to Trophic Demands of next higher level and within trophic level productivity	Monitor Biomass Trophic Spectrum by Trophic Level X (TBD); Trophic Level Y (TBD)	No Management Action
				Monitor Trophic Balance Index X (TBD) % of TBI; nil Y (TBD) % of TBI	No Management Action
Maintain Mean Generation Time of Populations	Fished populations in ESS IM area	Growth Production	Manage age/size composition of human impacts on fish populations	Monitor Number of populations not meeting growth potential 1970 - present average of Indicator; nil Lower quartile of 1970 - present average of Indicator	No Management Action
		Recruitment Production	At low biomass, reduce mortality rate caused by fishing activity of mature adults further	Monitor Number of populations not meeting recruitment potential 1970 - present average of Indicator; nil Lower quartile of 1970 - present average of Indicator	No Management Action

C. Conservation Objectives Related to the Physical and Chemical Properties of the Ecosystem

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point)	Potential Management Actions
Conserve the ecosystem's physical features, e.g. critical landscape and bottomscape and water column properties	Sediment layer	Surfical characteristics	Prevent significant adverse alteration to natural variability of surficial sediment porosity, interstitial space, DO penetration beyond direct zone of impact	Monitor Bottom area in which surficial sediment composition adversely altered X (TBD) ; nil Y (TBD)	No Management Action
		Geochemical conditions	Prevent significant adverse alteration to natural geochemical conditions (e.g. $S^{=}$, Eh, quality and quantity of organic matter, C_{org}:N) beyond direct zone of impact	Monitor Bottom area in which geochemical composition adversely altered X (TBD) ; nil Y (TBD)	No Management Action
		Microbial Community Production	Prevent significant adverse alteration of conditions for natural microbial community function (e.g. benthic aerobic/anaerobic respiration*)* beyond direct zone of impact	Monitor Bottom area in which microbial community adversely altered X (TBD) ; nil Y (TBD)	No Management Action
		Contaminant Levels	Prevent toxic chemical contamination of surficial sediments beyond direct zone of impact	Monitor Area where concentration of each contaminant in surficial sediment above acceptable level X (TBD) ; nil Y (TBD)	No Management Action
	Sound Environment of Pelagic Zone	Sound Levels	Maintain noise levels in Gully within acceptable levels to protect Bottlenose Whales	Monitor Hours during Bottlenose Whale season of Db of noise in Gully above acceptable level X (TBD) ; nil Y (TBD)	No Management Action
Conserve the ecosystem's chemical features, e.g. water quality and biota quality.	Pelagic zone	Contaminant Levels	Maintain levels of contaminants within levels at which biological effects are observed beyond beyond direct zone of impact	Monitor Area where concentration of each contaminant in water column above acceptable level X (TBD) ; nil Y (TBD)	No Management Action; Higher level management actions required to address Pollution from Adjacent Areas

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point)	Potential Management Actions
		Oxygen Levels	Maintain bottom water dissolved oxygen at or above levels to support natural ecosystem functions beyond beyond direct zone of impact	Monitor Area where Concentration of oxygen in water column below acceptable level X (TBD) ; nil Y (TBD)	No Management Action; Higher level management actions required to address Pollution from Adjacent Areas
	All species	Tissue contaminant levels	Limit bioaccumulation of contaminants to within biologically acceptable levels	Monitor % Total Biota with contaminants above acceptable level X (TBD) ; nil Y (TBD)	No Management Action; Higher level management actions required to address Pollution from Adjacent Areas
		Disease Incidence	Limit disease impacts of ocean activities	Monitor % Total Biota with disease above acceptable levels X (TBD) ; nil Y (TBD)	No Management Action; Higher level management actions required to address Pollution from Adjacent Areas

Table 6. Operational Objectives for the Eastern Scotian Shelf IM Fishing Industry. TBD = To Be Determined

National Conservation Objective	**Ecosystem Component**	**Characteristic**	**Conservation Objectives**	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point)	**Potential Management Actions**
Maintain Community Biodiversity	Benthic Community Types in ESS IM Area	Distribution of each Benthic Community Type	Maintain area of disturbance of each benthic community type within identified limits	Limit Fish [Area (sq km) disturbed of each benthic community type] 0; nil 0	Allocate Area disturbance to Stock Plans
	Coral Community in ESSIM area	Distribution of Coral Community	Maintain area of disturbance of Coral Communities in Stone Fence area within identified limits	Limit Area (sq km) disturbed of Coral Community 0; nil 0	Implement Coral Closed Area in Stock Plans
	High diversity Benthic Community in Gully	Distribution of Gully Benthic Community	Prevent significant adverse alteration of Benthic Communities in the Gully	Limit Area (sq km) disturbed of Benthic Community in the Gully 0; nil 0	Implement Gully Marine Protected Area in Stock Plans
Maintain Trophic Structure	Forage Species	Total Production	Protect forage species such as krill, sand lance, etc	Limit Fishing Mortality on Forage Species e.g. krill, sand lance 0; nil 0	No Fishing Licenses available for designated forage species
	Each Trophic level of ecosystem	Total Production	Limit Biomass Removals from any Trophic Level with respect to Trophic Demands of next higher level and within trophic level productivity	Limit Biomass Removal per Trophic Level X (TBD); nil Y (TBD)	Catch Allocations to Stock Plans

Table 7. Operational Objectives for the Eastern Scotian Shelf IM Stock Plans; e.g. Groundfish. TBD = To Be Determined

National Conservation Objective	**Ecosystem Component**	**Characteristic**	**Conservation Objectives**	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point):	**Potential Management Actions**
Maintain Community Biodiversity	Benthic Community Types in ESS IM Area	Distribution of each Benthic Community Type	Maintain area of disturbance of each benthic community type within identified limits	Limit Grd [Fish [Area (sq km) disturbed of each benthic community type]] 0; nil 0	Closed Areas to Groundfish fishing
	Coral Community in ESSIM area	Distribution of Coral Community	Maintain area of disturbance of Coral Communities in Stone Fence area within identified limits	Limit Area (sq km) disturbed of Coral Community 0; nil 0	Coral Closed Area
	High diversity Benthic Community in Gully	Distribution of Gully Benthic Community	Prevent significant adverse alteration of Benthic Communities in the Gully	Limit Area (sq km) disturbed of Benthic Community in the Gully 0; nil 0	Gully Marine Protected Area
Maintain Species Biodiversity	All species in ESS IM area	Catch of Non-target Species	Minimize incidental mortality of fishing activity on non-target species i.e. bycatch	Limit Bycatch (% weight) of all non-target species 10%; nil 5%	By trip bycatch restrictions
	Species at risk in IM area e.g. Bottlenose whale, Leatherback Turtle, Cod	Abundance	Manage recovery of all species at risk e.g. Cod, Bottlenose Whale, Leatherback turtle	Limit Catch of each SAR species Grd [Potential Biological Removal]; SAR Y (TBD)	Close fishery if Catch of SAR species GE species LRP
Maintain Population Biodiversity	Populations under human pressure e.g. cod, flatfish, snow crab	Genetic diversity within populations	Prevent elimination of spawning/breeding component by human activity	Distribute Fishing Mortality on each population component X (TBD) ; nil Y (TBD)	Set Catch on each population component EQ X % of TAC
Maintain Trophic Structure	Forage Species	Total Production	Protect forage species such as krill, sand lance, etc	Limit Fishing Mortality on forage species (krill, sand lance, etc) X (TBD) ; nil Y (TBD)	Licence Restrictions on forage species fisheries

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point):	Potential Management Actions
	Each Trophic level of ecosystem	Total Production	Limit Biomass Removals from any Trophic Level with respect to Trophic Demands of next higher level and within trophic level productivity	Limit Biomass Removed by Grondfish Fishery Grd [X Biomass Removed]; Trophic Level Grd [Y Biomass Removed]	Close fishery if Biomass Removed by any TL GE LRP
Maintain Mean Generation Time of Populations	Fished populations in ESS IM area	Growth Production	Manage age/size composition of human impacts on fish populations	Limit Fully Recruited Fishing Mortality Fmsy; B, WAA, M, environment Y (TBD)	Total Allowable Catch (TAC) OT mesh GE 155 mm LL hook GE # 16 Landings EQ Catch (no discard of target species)
		Recruitment Production	At low biomass, reduce mortality rate caused by fishing activity of mature adults further	Limit Fishing Mortality on Spawners during Spawning Season 0; nil 0	Area / Season Closures
				When B below Bpa, Limit Fully Recruited Fishing Mortality 0 if B = Bmin; nil Fpa = Funct (Fully Recruited Fishing Mortality, B)	TAC by stock

Table 8. Operational Objectives for the Eastern Scotian Shelf IM Oil & Gas Industry. TBD = To Be Determined

A. Conservation Objectives Related to Biodiversity

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point):	Potential Management Actions
Maintain Community Biodiversity	Benthic Community Types in ESS IM Area	Distribution of each Benthic Community Type	Maintain area of disturbance of each benthic community type within identified limits	Limit OG [Area (sq km) disturbed of each benthic community type] 0; nil 0	Well limit per benthic community type
	Coral Community in ESSIM area	Distribution of Coral Community	Maintain area of disturbance of Coral Communities in Stone Fence area within identified limits	Limit Area (sq km) disturbed of Coral Community in Stone Fence Area 0; nil 0	Coral Area Closure
	High diversity Benthic Community in Gully	Distribution of Gully Benthic Community	Prevent significant adverse alteration of Benthic Communities in the Gully	Limit Area (sq km) disturbed of Benthic Community in the Gully 0; nil 0	Gully Marine Protected Area
Maintain Species Biodiversity	Species at risk in IM area e.g. Bottlenose whale, Leatherback Turtle, Cod	Abundance	Manage recovery of all species at risk e.g. Cod, Bottlenose Whale, Leatherback turtle	Limit Deaths of each SAR species OG [Potential Biological Removal]; SAR Y (TBD)	Mitigation in Environmental Assessments

B. Conservation Objectives Related to the Physical and Chemical Properties of the Ecosystem

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	Operational Objective Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point):	Potential Management Actions
Conserve the ecosystem's physical features, e.g. critical landscape and bottomscape and water column properties	Sediment layer	Surfical characteristics	Prevent significant adverse alteration to natural variability of surficial sediment porosity, interstitial space, DO penetration beyond direct zone of impact	Limit Bottom area in which surficial sediment composition adversely altered X (TBD); nil Y	Mitigation in Environmental Assessments
		Geochemical conditions	Prevent significant adverse alteration to natural geochemical conditions (e.g. $S^{=}$, Eh, quality and quantity of organic matter, C_{org}:N) beyond direct zone of impact	Limit Bottom area in which geochemical composition adversely altered X (TBD); nil Y	Mitigation in Environmental Assessments
		Microbial Community Production	Prevent significant adverse alteration of conditions for natural microbial community function (e.g. benthic aerobic/anaerobic respiration*)* beyond direct zone of impact	Limit Bottom area in which microbial community adversely altered X (TBD); nil Y	Mitigation in Environmental Assessments
		Contaminant Levels	Prevent toxic chemical contamination of surficial sediments beyond direct zone of impact	Limit Area where concentration of each contaminant in surficial sediment above acceptable level X (TBD); nil Y	Mitigation in Environmental Assessments
	Sound Environment of Pelagic Zone	Sound Levels	Maintain noise levels in Gully within acceptable levels to protect Bottlenose Whales	Limit Hours during Bottlenose Whale season of Db of noise in Gully above acceptable level 0; nil 0	MPA including buffer zone to ensure zero impact in MPA

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point):	Potential Management Actions
Conserve the ecosystem's chemical features, e.g. water quality and biota quality.	Pelagic zone	Contaminant Loadings	Maintain levels of contaminants within levels at which biological effects are observed beyond beyond direct zone of impact	Limit Area where concentration of each contaminant in water column above acceptable level X (TBD); nil Y	Mitigation in Environmental Assessments
		Oxygen Levels	Maintain bottom water dissolved oxygen at or above levels to support natural ecosystem functions beyond beyond direct zone of impact	Limit Area where Concentration of Oxygen in water column above acceptable level X (TBD); nil Y	Mitigation in Environmental Assessments
	All species	Tissue contaminant levels	Limit bioaccumulation of contaminants to within biologically acceptable levels	Limit Biota with contaminants above acceptable level X (TBD); nil Y	Mitigation in Environmental Assessments

Table 9. Operational Objectives for the Eastern Scotian Shelf IM Transport Industry

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	**Operational Objective** Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point):	Potential Management Actions
Maintain Species Biodiversity	All species in ESS IM area	Number of Invasive species	Prevent significant adverse introduction of exotic species	Limit Number of Occurrences of Bilge Pumping in IM area 0; nil 0	No bilge pumping in IM Area
	Species at risk in IM area e.g. Bottlenose whale, Leatherback Turtle, Cod	Abundance	Manage recovery of all species at risk e.g. Cod, Bottlenose Whale, Leatherback turtle	Limit Number of annual transits through Gully area during Bottlenose Whale season 0; nil 0	Coast Guard Notices during Bottlenose Whale season

Table 10. Operational Objectives for the Eastern Scotian Shelf IM Military (Naval) Operations

National Conservation Objective	Ecosystem Component	Characteristic	Conservation Objectives	Operational Objective Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point):	Potential Management Actions
Maintain Community Biodiversity	Coral Community in ESSIM area	Distribution of Coral Community	Maintain area of disturbance of Coral Communities in Stone Fence area within identified limits	Limit Annual number of military exercises in coral area 0; nil 0	No exercises permitted in Coral Closed Area
	High diversity Benthic Community in Gully	Distribution of Gully Benthic Community	Prevent significant adverse alteration of Benthic Communities in the Gully	Limit Annual number of military exercises in the Gully 0; nil 0	No exercises permitted in Gully MPA
Maintain Species Biodiversity	Species at risk in IM area e.g. Bottlenose whale, Leatherback Turtle, Cod	Abundance	Manage recovery of all species at risk e.g. Cod, Bottlenose Whale, Leatherback turtle	Limit Hours during Bottlenose Whale season of Db of noise in Gully above acceptable level 0; nil 0	MPA including buffer zone to ensure zero impact in MPA
Conserve the ecosystem's physical features, e.g. critical landscape and bottomscape and water column properties	Sound Environment of Pelagic Zone	Sound Levels	Maintain noise levels in Gully within acceptable levels to protect Bottlenose Whales	Limit Annual number of military exercises in the Gully 0; nil 0	MPA including buffer zone to ensure zero impact in MPA

Table 11. Illustration of Treatment of Cumulative Impacts under Integrated Management on the Eastern Scotian Shelf. TBD = To Be Determined

National Conservation Objective	Ecosystem Component	Conservation Objectives	Plan Level	Operational Objective Action: Indicator: LRP (Limit Reference Point); covariate: PaRP (Precautionary Reference Point):	Potential Management Actions
Maintain Community Biodiversity	Benthic Community Types in ESS IM Area	Maintain area of disturbance of each benthic community type within identified limits	ESSIM Area	Limit Area (sq km) disturbed of each benthic community type X (TBD) Area disturbed; benthic community type Y (TBD) Area disturbed	Allocate area disturbed to Fisheries, Stock, & Oil & Gas industries; Implement through their plans
			Fishing Industry	Limit Fish [Area (sq km) disturbed of each benthic community type] 0; nil 0	Allocate Area disturbance to Stock Plans
			Stock Plan e.g. Groundfish	Limit Grd [Fish [Area (sq km) disturbed of each benthic community type]] 0; nil 0	Closed Areas to Groundfish fishing
			Stock Plan e.g. Scallop	Limit Sca [Fish [Area (sq km) disturbed of each benthic community type]] 0; nil 0	Closed Areas to Scallop fishing
			Stock Plan e.g. Surf Clam	Limit Cla [Fish [Area (sq km) disturbed of each benthic community type]] 0; nil 0	Closed Areas to Surf Clam fishing
			Oil & Gas Industry	Limit OG [Area (sq km) disturbed of each benthic community type] 0; nil 0	Well limit per benthic community type

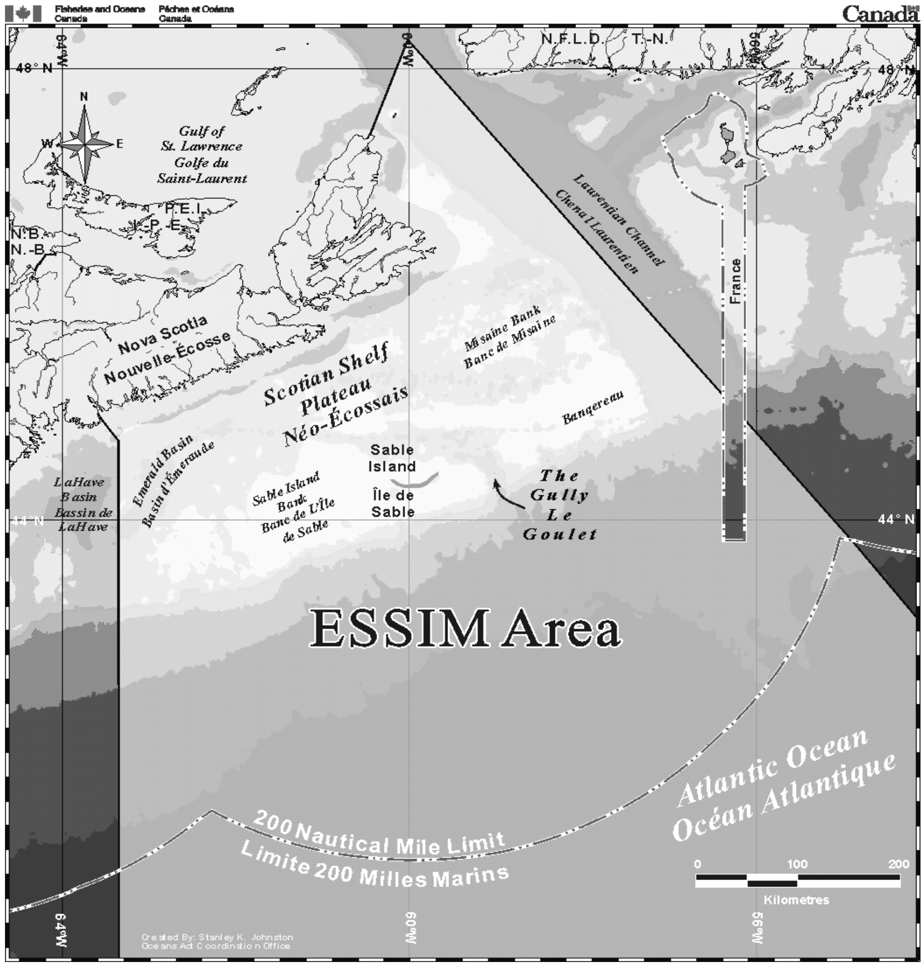

Figure 1. The Eastern Scotian Shelf Integrated Management Pilot Area.

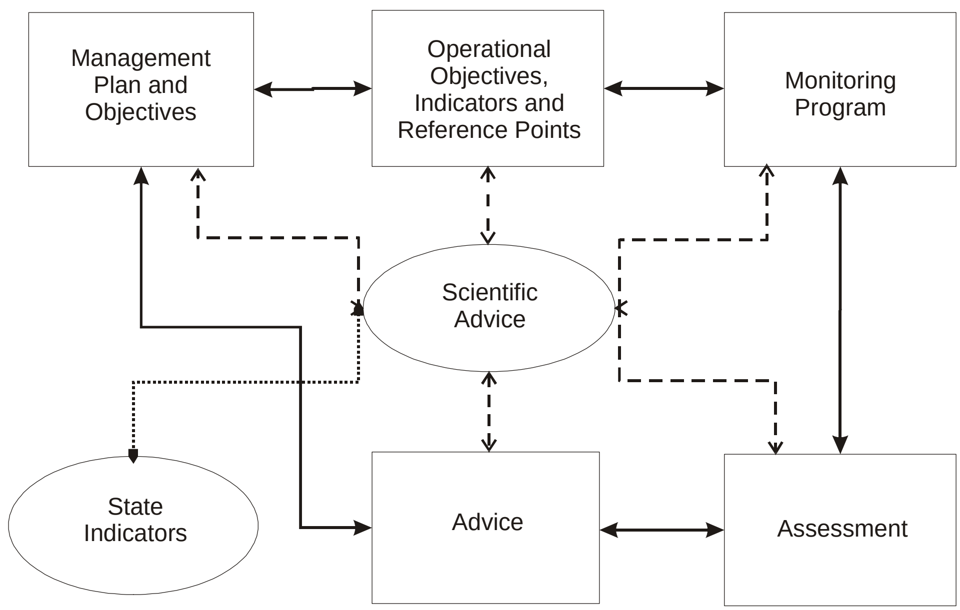

Figure 2. Flowchart of Integrated Management. Solid lines indicate processing of information. Dashed lines indicate interactions and the dotted line the collection of ancillary information. (Figure based on descriptions of adaptive management such as Johnson (1999).)

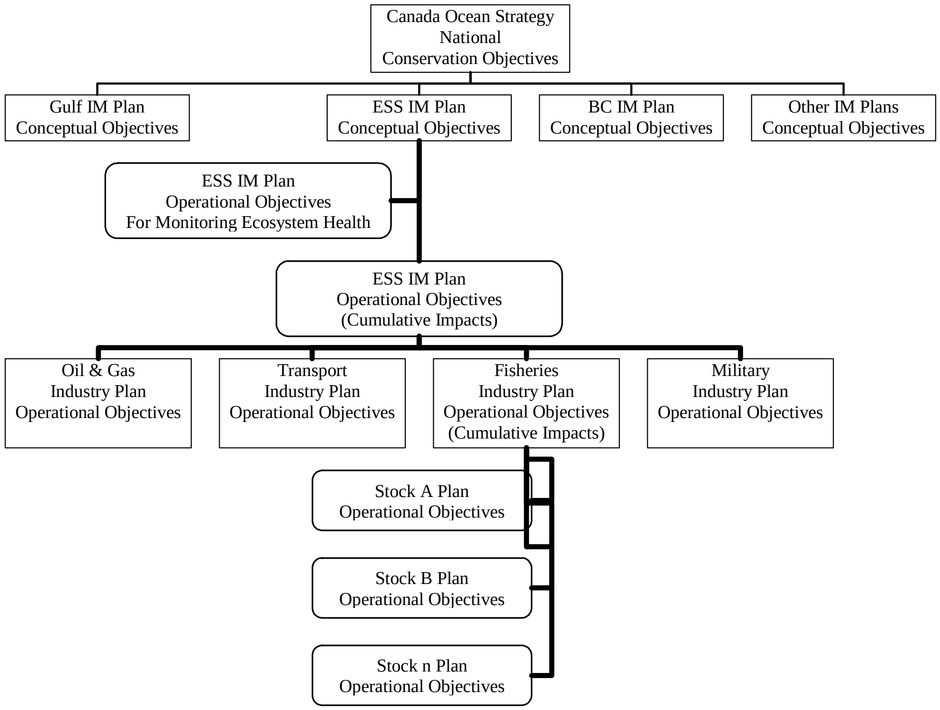

Figure 3. The set of nested IM Planning Activities for each of Canada's Large Ocean Management Areas.

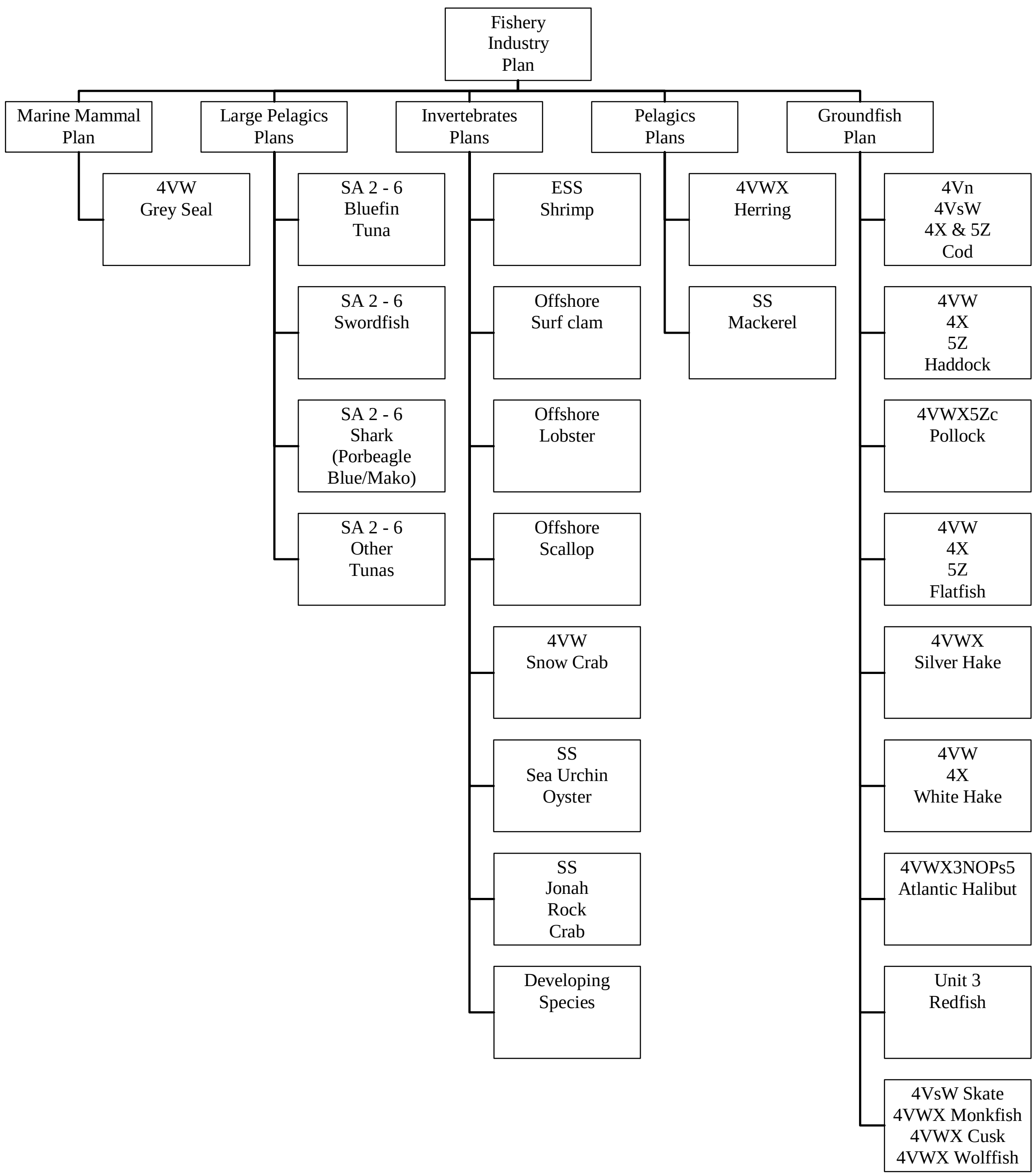

Figure 4. Fishery Industry Plans of the Eastern Scotian Shelf IM Area.

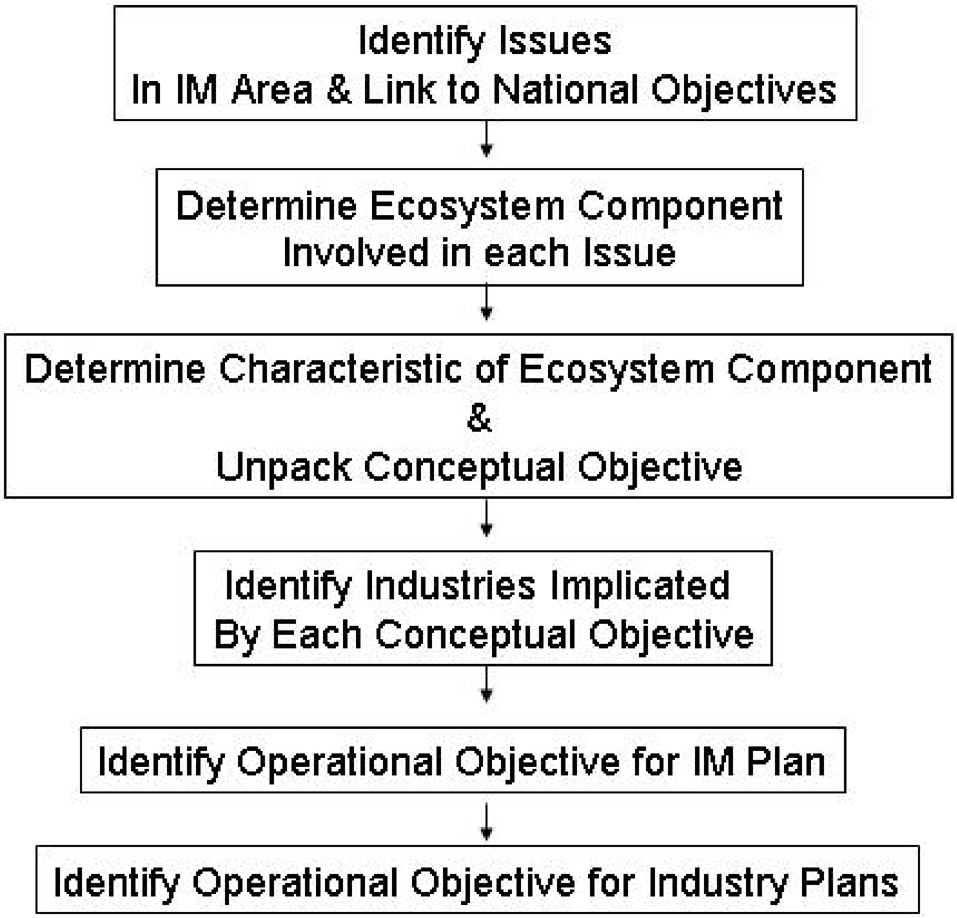

Figure 5. Steps to make the link between High-Level Conceptual Objectives and Low-Level Operational Objectives of Integrated Management.

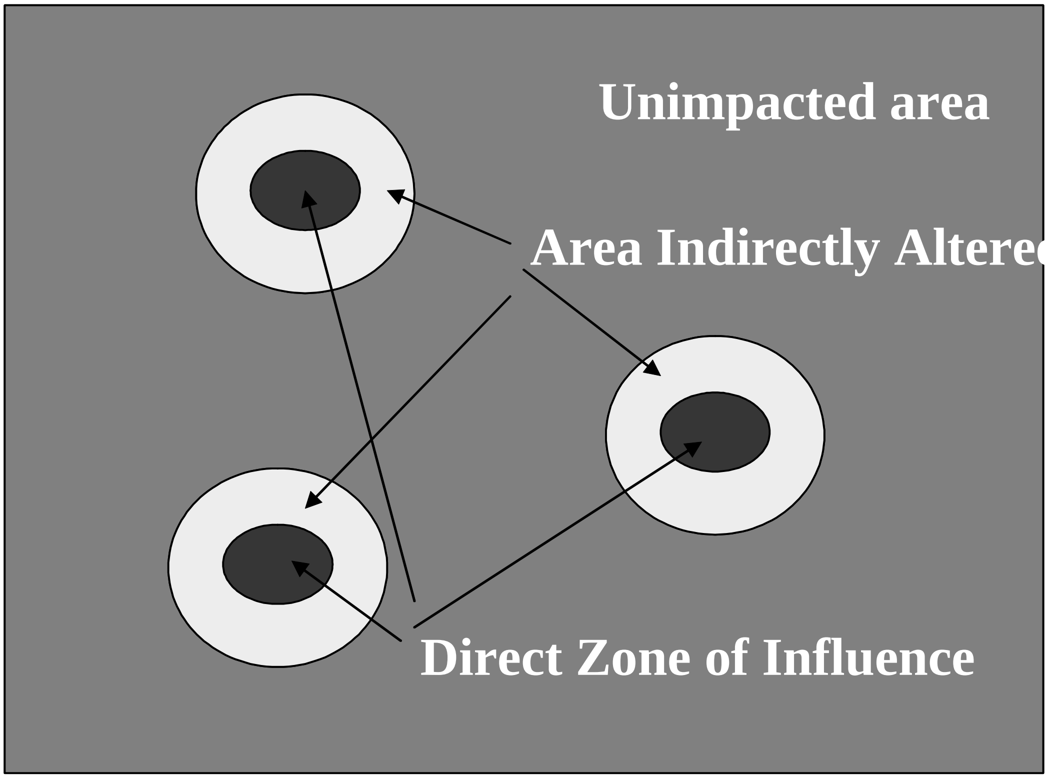

Figure 6. The Management of Cumulative Impacts on Benthic Communities: Directly Impacted Areas (Red) would be summed and Impacts kept below a percent disturbance by benthic community type; these zones are surrounded by areas Indirectly impacted (Yellow) which would be minimized through mitigation measures identified during environmental assessment process

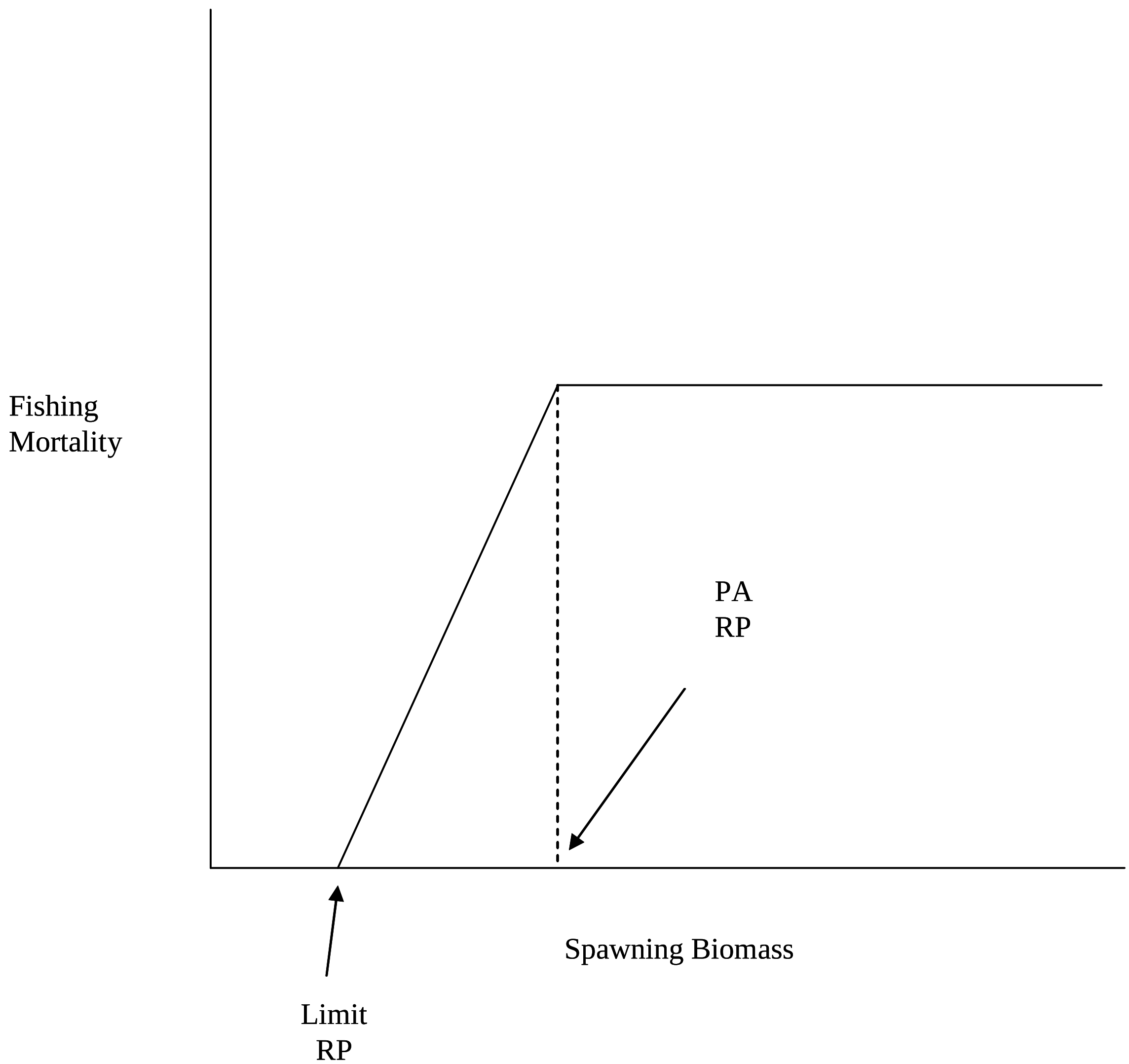

Figure 7. Relationship between the indicator, Fishing Mortality (F), and its Covariate, Spawning Biomass, used to modify the F Reference Point.

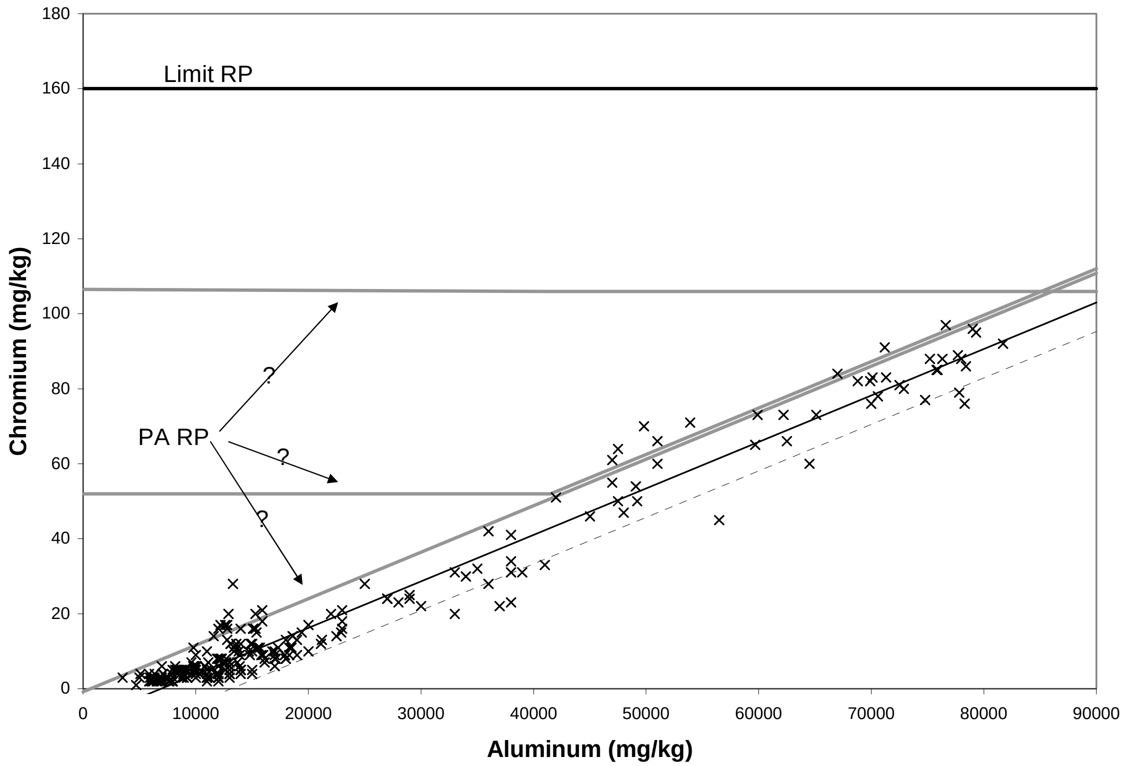

Figure 8. Aluminum Covariate of Chromium Limit (black line) and various Precautionary Approach Reference Points (grey lines) for the Scotian Shelf, the Limit RP is based upon the CCME Probable Effects Level.

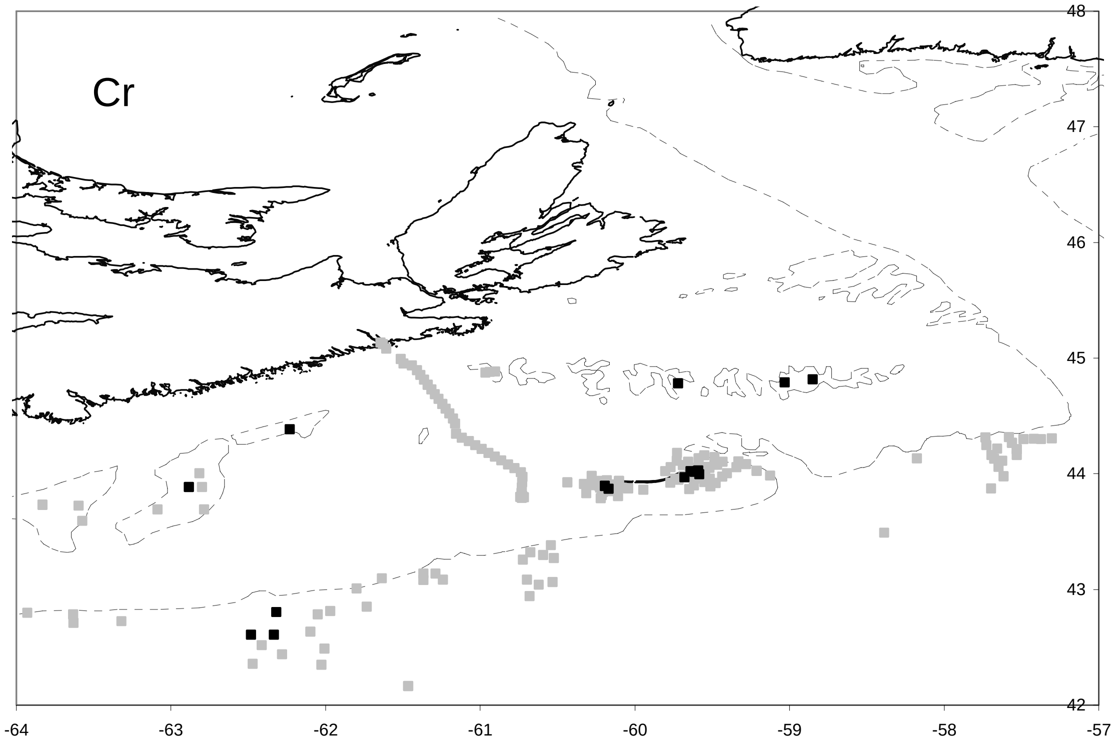

Figure 9. Distribution of Chromium from Industrial Activities on the Scotian Shelf showing sample locations colour coded as per Figure 8. Locations shown in grey have concentrations <PARP, those in black >PARP but < Limit RP. No samples are >Limit RP.

National Conservation Objective	Ecosystem Component	Characteristic	IM Plan	Air Pollution from Adjacent Area	Water Pollution from Adjacent Area	Fisheries	Stock Plan e.g. Groundfish	Oil & Gas	Transport	Military
	Benthic Community Types	Distribution of each Community Type		N/A	N/A				N/A	N/A
Maintain Community Diversity	Coral Community in Stone Fence Area	Distribution of Coral Community		N/A	N/A				N/A	
	Gully Benthic Community	Distribution of Gully Community		N/A	N/A				N/A	
	All Species in ESSIM area	Number of Invasive Species		N/A	N/A	N/A	N/A	N/A		N/A
Maintain Species Diversity		Catch of Non-Target Species		N/A	N/A			N/A	N/A	N/A
	Species at Risk	Abundance		N/A	N/A	N/A				
Maintain Population Diversity	Populations under human Pressure	Genetic Diversity		N/A	N/A	N/A		N/A	N/A	N/A
Maintain Primary Production	Primary Producing Species	Total Production				N/A	N/A	N/A	N/A	N/A
	Forage Species	Total Production		N/A	N/A			N/A	N/A	N/A
Maintain Trophic Structure	Each Trophic Level of Ecosystem	Total Production		N/A	N/A			N/A	N/A	N/A
		Total Production		N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Fished Populations	Growth Production		N/A	N/A	N/A		N/A	N/A	N/A
Maintain Mean Generation Time		Recriutment Production		N/A	N/A	N/A		N/A	N/A	N/A
		Recriutment Production	N/A	N/A	N/A	N/A		N/A	N/A	N/A
		Surficial Characteristics		N/A	N/A	N/A	N/A		N/A	N/A
	Sediment Layer	Geochemical Conditions		N/A	N/A	N/A	N/A		N/A	N/A
Conserve ESS Physical Properties		Microbial Community Production		N/A	N/A	N/A	N/A		N/A	N/A
		Comtaminant levels		N/A	N/A	N/A	N/A		N/A	N/A
	Sound Environment	Sound Levels		N/A	N/A	N/A	N/A		N/A	
	Pelagic Zone	Contaminant Levels				N/A	N/A		N/A	N/A
		Oxygen Levels		N/A		N/A	N/A		N/A	N/A
Conserve ESS Chemical Properties	All Species in ESSIM area	Tissue Contaminant levels		N/A		N/A	N/A		N/A	N/A
		Disease Incidence		N/A	N/A	N/A	N/A	N/A	N/A	N/A

Figure 10. An Illustration of an Ecosystem Status Report for the Eastern Scotian Shelf IM Area using the Traffic Light Method. (light grey = yellow; medium grey = green; dark grey = red)