# 2 Developing an Ecosystem-based Approach for Ocean Management in the PICES Region

David Fluharty, Chris Harvey, Glen Jamieson, Xianshi Jin, Patricia Livingston, Mitsutaku Makino, Vladimir Radchenko and Chang-Ik Zhang

## 2.1 Introduction

This section is an effort to identify the efforts of PICES member countries in moving toward adoption of an EBM approach for fisheries and other sectors. Member countries were asked to confirm their commitments to, or incorporation of ecosystem-based management (EBM) actions or principles, into current fisheries and ocean management. As reported below, there is a wide range of effort in this regard, with considerable variation in approach and with respect to how comprehesive management actions turn out to be. The PICES Working Group on *Ecosystem-based Management Science and its Application to the North Pacific* (WG 19) regards these efforts as indicative of the progress toward EBM – especially with respect to fisheries from which we can compare experience and gain knowledge. None of the PICES member countries can be seen as fully implementing an ecosystem-based approach even for the fisheries sector, yet it is apparent that each member is seeking to employ and learn from the experience of implementing EBM. It is the hope of WG 19 that these experiences will be expanded upon and that as an EBM approach encompassing multiple sectors is developed among PICES countries, PICES will provide a significant focal point for documenting, synthesizing and comparing national experiences.

Since the industrial revolution, man's impact on the oceans has increased dramatically, this being especially true in recent years. In nearshore coastal areas, human population growth has led to increasing pollution and habitat modification. Fishing effects have become increasingly severe, with many, if not most, traditionally harvested populations now either fully exploited or over-fished (Garcia and Moreno, 2003). Thus far, management of these activities in the North Pacific has been primarily sector-focused. Fisheries, for example, have generally been managed in isolation of the effects of other influencing factors and have targeted commercially important species, without explicit consideration of non-commercial species and broader ecosystem impacts. There is an increasing international awareness of the cumulative impacts of sector-based activities on the ecosystem (Jennings and Kaiser, 1998; Kaiser and de Groot, 2000) and the need to take a more holistic or Ecosystem-Based Management approach (Anon., 1999; Link, 2002; Kabuta and Laane, 2003) to ensure the sustainability of marine ecosystems. Globally, there is an emerging paradigm shift in our approach to ocean management and usage (Sinclair and Valdimarsson, 2003) that is quite broad for which the term Ecosystem Approach to Management (EAM) applies.

The roots of this change can be found in the 1972 UN Conference on the Human Environment, and the 1992 UN Conference on Environment and Development (UNCED) in Rio, itself emanating from the 1973 UN Conference on the Law of the Sea which, in turn, resulted in the 1982 UN Convention on the Law of the Sea (UNCLOS). UNCED highlighted the need to consider resource management in a broader biological, socio-economic and institutional context. This led to follow-up conferences and conventions such as the 1993 Convention on Biological Diversity, the 1995 Agreement for the implementation of provisions of the UNCLOS relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stock Agreement), and the 1995 FAO Code of Conduct for Responsible Fisheries, to name a few. FAO has put in place International Plans of Action to meet UNCED objectives, progress against which was reviewed in Johannesburg at the RIO +10 meeting in August, 2002. At the World Summit on Sustainable Development (WSSD), governments obligated themselves to an ambitious time frame for implementing EBM in marine waters. Thus, there is a growing body of international agreements in support of EBM. (See Table 2.1.1 for some examples of the involvement of North Pacific nations.) In addition, the transboundary nature of marine resource use and management for fisheries, oil and gas, maritime transportation, and pollution control make it imperative that countries cooperate scientifically to observe and understand these activities and their interactions. In Table 2.1.2 we provide some examples of North Pacific multilateral regional agreements and bilateral agreements that recognize the transboundary nature of the ocean environment and cooperation needed to take the ecosystem into account.

The focus of this portion of the WG 19 report is to track the progress toward developing ecosystem approaches by PICES member countries in the North Pacific. The primary focus is on fisheries not only as one of the most common economically and socially beneficial uses of the North Pacific ecosystem, but one that may be a significant driver in ecosystem change. Scientific research that enables better understanding of the conditions affecting fishery management and the role of fisheries in an ecosystem is critical. Still, as is discussed herein, there are many other activities of importance to countries in the North Pacific and these, too, can become part of the forward looking evaluation of EAM.

**Table 2.1.1** Examples of international conventions to which PICES member countries are parties. Note that UNCED and WSSD were conferences, not conventions. However, these meetings did produce some important exhortatory documents that have helped popularize and give commitment to sustainable development concepts, including ecosystem-based management and integrated management. Those documents were Agenda 21 and the Johannesburg Plan of Implementation (JPOI). Both were negotiated and adopted by consensus by States, and represent outcomes of conferences.

| Convention | Canada | Japan | P.R. China | R. Korea | Russia | U.S.A. |
|---|---|---|---|---|---|---|
| UN Convention on the Law of the Sea (UNCLOS), 1982 | Signed 1982; ratified 2003 | x | Signed and ratified 1996 | x | Signed and ratified 1997 | Not signed |
| UN Conference on Environment and Development (UNCED), 1992 | x | x | x | x | x | – |
| UN Convention on Biodiversity, 1993 | x | x | x | x | x | x |
| Conservation and Management of Straddling Fish Stocks and Highly Migratory Species, 1995 [Implementation of UNCLOS] | x | x | x | x | x | – |
| Ramsar Convention, 1976 [wetlands] | Signed 1981 | x | x | x | x | x |
| World Summit on Sustainable Development (WSSD), 2005 | x | x | x | x | – | – |
| Code of Conduct for Responsible Fisheries, 1995 | x | x | x | x | x | – |
| Convention on International Trade in Endangered Species (CITES) | Signed July 1975 | x | x | x | x | – |
| IMO Convention for the Control and Management of Ballast Water and Sediments, 2004 | Signed but not yet ratified (as of 2008) | Not signed | – | – | – | – |

x = participant

**Table 2.1.2** Examples of North Pacific transboundary ecosystem approach to management (EAM) treaties.

| Treaty | Parties | Provisions |
|---|---|---|
| **Regional/ Multilateral** | | |
| Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea, February 11, 1994 | Japan, People's Republic of China, Poland, Republic of Korea, Russia, USA | Manages fishery in the international zone of the Bering Sea |
| Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean, February 11, 1992 | Canada, Japan, Republic of Korea, Russia, USA | Allows anadromous fisheries on the high seas |
| UN Moratorium on High Seas Driftnet Fishing, 1993 | UN Moratorium | Closes North Pacific high seas to drift net fisheries |
| Convention for a North Pacific Marine Science Organization (PICES), 1991 | Canada, Japan, People's Republic of China, Republic of Korea, Russia, USA | Establishes basis for broad scientific cooperation among signatory nations |
| Yellow Sea and East China Sea Fisheries Agreements | Japan, People's Republic of China, Republic of Korea | Allows fisheries in transboundary areas |
| **Bilateral** | | |
| Convention for the Preservation of the Halibut Fishery of the Northern Pacific Ocean, 1923 | Canada, USA | Conservation of Pacific halibut |
| Pacific Salmon Treaty, 1985 | Canada, USA | Conservation of Pacific salmonids |
| Memorandum On Four Islands Waters Agreement | Japan, Russia | Allows fisheries in the Russian zone by the Japanese fleet |
| Salmon/All Other Species–Commission on the Fisheries | Japan, Russia | Allows fisheries in each zone and fisheries under exchange agreement – joint research [5–6 cruises previously]; now mostly exchange of data due to strict border regulations |
| Amur River Fisheries | People's Republic of China, Russia | Allows Chinese fishing in Russian waters and Amur River considerations |
| Republic of Korea Fishing in Russian waters | Republic of Korea, Russia | Allows Republic of Korea fishing in Russian waters |
| Japan/Republic of Korea transboundary areas | Japan, Republic of Korea | Allows fisheries in transboundary areas |
| Joint oil and gas development zone | Japan, Republic of Korea | Operation assignment protocol |

In order to have a common language and definition of EBM/EAM, we developed a typology (Table 2.1.3) that served to discipline our Working Group's discourse on this topic. Further, we have elected to construct Country Profiles of efforts to implement EAM. The template for these profiles is in Appendix 2.

The reports provided by each country in the following sections demonstrate a high level of interest and a diversity of approaches. This diversity is seen positively as experimenting with the concept of EAM/EBM, consistent with each country's experience and circumstances. Through the efforts of WG 19, approaches being tried under particular circumstances are shown.

Although we have looked primarily at fisheries applications, we hope the approach discussed here will guide PICES in its further research and deliberations on EAM in the context of the new PICES scientific program, FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems).

### 2.1.1 Ecosystem-based Management/ Ecosystem Approach to Management Typology

It is useful to agree to a common typology of ecosystem approaches to management for purposes of discussion because it helps us more rigorously evaluate the progress toward EBM, or as its sometimes referred to, an Ecosystem Approach to Management (EAM). The typology found in Table 2.1.3 starts with recognition that even traditional management approaches that focus on single sectors or species, in the case of fisheries, do take considerable ecosystem information into account. The more factors and species that are taken into account in management decisions, the greater the progress toward EAM, *e.g.*, sectoral and ultimately integrated management in an ecosystem context.

### 2.1.2 Country Profiles

Country profiles have been constructed to provide background information of how each PICES member country has begun to recognize an EBM/EAM in its scientific research in support of management decisions and societal goals. We present the country reports in alphabetical order. Each report brings very interesting and valuable contributions to our learning about how EAM can be applied. Each country has attempted to respond to a systematic set of descriptors, listed below:

1. Definition of EAM objectives/purposes and goals
2. Agencies involved
3. Legislative mandates related to EAM.
4. Current implementation
5. Future implementation

For current and future work, we developed a template (Appendix 2) for assessing concrete progress toward developing and implementing EAM in fisheries, and provide illustrations by Canada of how it might be used. While there is some deviation from this format because of national experience and circumstances, this template serves well to organize each of the presentations.

**Table 2.1.3** Typology of ecosystem approaches to management.

| **EBM component** | **I. Traditional single factor management** | **II. Sectoral Management in an Ecosystem Context** | **III. Integrated Management in an Ecosystem Context** |
|---|---|---|---|
| Species | Considers only the factor or species being used | Considers prey, dependent predators and food supply, and impacts on ecosystem | Considers impacts of other activities on the status of the species being used and across the ecosystem |
| Physical habitats | Only considered if a surrogate for population parameters | Considers productive capacity and impacts of activity on the habitat | Accommodates spatial needs and habitat impacts of other activities |
| Environmental conditions | Not considered | Considers productivity regime and forcing | Considers direct and indirect effects |
| Biodiversity | Not considered | Considers impacts on species not being used directly | Considers status of communities and resilience of the community/system |
| Other components | Not considered | Considers other components as they affect the particular sector | Considers all components and all sectors and the interactions among them relative to agreed ecosystem management goals |

Describing and documenting EBM is a complex enterprise and one that does not fit into a single pattern. Each member country profile presented here addresses those components that are part of that country's approach to management. It is not expected that each component may necessarily be discussed in each profile. In fact, diversity in approaches is expected and adds to the potential for learning from alternative approaches. Critical to understanding the process of implementing EBM is that current efforts are seen as building blocks toward eventual fully implemented EBM.

### 2.1.3 References

Anon. 1999. Sustaining Marine Fisheries. Committee on Ecosystem Management for Sustainable Marine Fisheries. Oceans Studies Board, Commission on Geosciences, Environment, and Resources, NRC, National Academy of Sciences, 164 pp.

Garcia, S. and Moreno, I. 2003. Global overview of marine fisheries. pp. 1–24 *in* Responsible Fisheries in the Marine Ecosystem *edited by* M. Sinclair and G. Valdimarsson, FAO & CABI Publishing, 426 pp.

Jennings, S. and Kaiser, M.J. 1998. The effects of fishing on marine ecosystms. *Adv. Mar. Biol.* **34**: 201–352.

Kaiser, M.J. and de Groot, S.J. 2000. Effects of Fishing on Non-target Species and Habitats. Biological, Conservations and Socio-economic Issues. Blackwell Science, Oxford.

Kabuta, S.H. and Laane, R.W.P.M. 2003. Ecological performance indicators in the North Sea: Development and application. *Ocean Coast. Mgmt*. **46**: 277–297.

Link, J. 2002. What does ecosystem-based fisheries management mean? *Fisheries* **27**: 18–21.

Sinclair, M. and Valdimarsson, G. (Eds.). 2003. Responsible Fisheries in the Marine Ecosystem. FAO & CABI Publishing, 426 pp.

## 2.2 Canada

### 2.2.1 Objectives/Purposes, Goals and Legislative Mandates for Ecosystem-based Management

In Canada, the *Fisheries Act*, first enacted in 1857, has been to date, the prime legislative vehicle governing ocean usage, particularly fishing. It regulates the capture, holding and possession of all marine life, and makes unlawful the harmful alteration, disruption or destruction of fish habitat. While it is periodically revised (most recently in 1991), the focus of the *Act* has been the conservation and protection of commercially exploited species and their habitat. Similarly, the *Coastal Fisheries Protection Act* regulates the presence of foreign fishing vessels in Canadian fisheries waters and since 1977 there have been no unauthorised foreign vessels in Canadian Exclusive Economic Zones (EEZs) fisheries. Responding to both international legislative changes, as well as to concerns for the impacts of human activities on its marine ecosystems, Canada enacted the *Oceans Act* in 1997. This *Act* outlined a new approach to managing oceans and their resources, based on the premise that oceans must be managed as a collaborative effort among all stakeholders using the oceans, and that new management tools and approaches are required. While fishery management plans under the *Fisheries Act* continue to focus on target species, the *Oceans Act* has changed the legislative basis for management and now requires consideration of the impacts of all human activities on Canada's ecosystems in marine resource management plans.

While Canada's Department of Fisheries and Oceans (DFO; also referred to as Fisheries and Oceans Canada) had been active in addressing habitat impact issues (*e.g.*, oil and gas resource development in Atlantic Canada), the *Oceans Act* has provided a new tool in Canada's development of an EBM approach. As a consequence, since 1997 there have been a number of initiatives through which Canada's approach to EBM is beginning to emerge. In 2002, Canada's Oceans Strategy was published (Anon., 2002a), a key element of it being a nationally coordinated Integrated Management (IM) program in which interested stakeholders and regulators will work together to decide on how to best manage designated geographic areas (Anon., 2002b). In support of the IM program, DFO has established a national coordinating body, termed the Working Group on Ecosystem Objectives (WGEO), to facilitate the development of best practices for IM and oversee regional pilot projects designed to test implementation of the concepts. In 1998, a pilot project was established in DFO's Maritime Region to facilitate EBM in the Atlantic Ocean on the eastern Scotian Shelf, with a Strategic Planning Framework recently produced (Anon., 2003). Similarly, DFO's Pacific Region joined the Province of British Columbia in initiating the Central Coast Land and Coastal Resource Management Plan (CCLCRMP) process, and has established the pilot Central Coast Integrated Management (CCIM) project in another IM approach. The WGEO was instrumental in planning a national workshop (Jamieson *et al.* (2001), termed herein as the Sidney workshop) in 2001 to outline the objectives to guide EBM and, more recently, has initiated an exercise to define scientifically-based ecoregion boundaries within which ecosystem objectives (EOs) will be established. Human activities will be managed in Large Ocean Management Areas (LOMAs) in a manner that will allow the conceptual ecological objectives for the ecoregion a specific LOMA is in to be met.

### 2.2.2 Current Implementation

When the *Oceans Act* was proclaimed in 1997, there was little concept in Canada as to what IM actually meant in practical terms, not unlike the situation in other countries. Much of the dialogue had been at a higher policy level, with little linkage to implementation. Since then, there has been much discussion on implementation both in Canada and elsewhere, with various approaches starting to emerge (*e.g.*, Garcia and Staples, 2000; Pajak, 2000; Sainsbury and Sumaila, 2003). Here, we summarize the Canadian perspective on IM, based on our experiences with EBM in Canada (O'Boyle and Jamieson, 2006).

IM has been defined in Canada as "a commitment to planning and managing human activities in a comprehensive manner while considering all factors necessary for the conservation and sustainable use of marine resources and the shared use of ocean spaces" (Anon., 2002a). IM acknowledges the inter-relationships that exist among different uses and the environments they potentially affect (Anon., 2002b). It will thus involve many facets relating to both what activities are undertaken and to how these are undertaken when it is finally implemented.

It should be pointed out here that the *Oceans Act* refers to Marine Environmental Quality (MEQ) objectives, which are to be incorporated in IM plans to facilitate implementation of an ecosystem approach. MEQ objectives are functionally synonymous with the definition of operational objectives. Operational objectives are the strategies by which conceptual objectives are actually implemented. They make the link between conceptual and management control. Jamieson *et al.* (2001) considered that an operational objective consists of a verb (*e.g.*, maintain), a specific measurable indicator (*e.g.*, biomass from a population analysis), and a reference point (*e.g.*, 50,000 t for a specific species or stock), thus allowing an action statement for management (*e.g.*, maintain biomass of a given forage species greater than 50,000 t biomass). While others might differ on the details of what defines an operational objective (*e.g.*, FAO, 2003; Sainsbury and Sumaila, 2003), there is consensus on the need for indicators and reference points in operational objectives. In this PICES WG 19 report, we will use the terms 'conceptual' and 'operational', as they are more in line with usage in the literature.

How the conceptual and operational levels of objectives are linked is a critical issue. Jamieson *et al.* (2001) considered components and sub-components associated with the high-level conceptual objectives, thus creating a 'branched tree' of conceptual objectives. They stated, for example, that diversity and productivity are components of the 'conservation objective', and under diversity there are sub-components at the community, species and population level. For each component and sub-component, a conceptual sub-objective is stated (*e.g.*, for the diversity component, conserve population diversity so that it does not deviate outside the limits of natural variability). Jamieson *et al.* (2001) then provided example operational objectives (verb, indicator and reference point, as described above) linked to each conceptual objective. These were primarily included to indicate the intent of the associated conceptual objective.

Jamieson *et al.* (2001) translated each of the sub-objectives into operational objectives through a process termed 'unpacking', which involves breaking the objectives completed into their component parts (Table 2.2.1). Unpacking involves considering each conceptual objective associated with a component/ sub-component and determining whether or not a final operational objective can be stated. In other words, how best can a measurable indicator and reference point (see Appendix 3 for definitions) be associated with that sub-objective? This requires an understanding of what knowledge and information is available upon which indicators and reference points can be based. If this information is available, then the unpacking process stops and the final operational objective associated with that conceptual objective is considered defined. Otherwise, a further unpacking occurs which is again tested for it being a final operational objective. The unpacking stops when all conceptual objectives have been addressed. As mentioned above, Canada's Oceans Strategy (Anon., 2002b) refers to MEQ objectives. Both of these terms are synonymous with the operational objectives that would go in management plans.

**Table 2.2.1** Link between conceptual objectives and operational objectives (Anon., 2002b).

| **Conceptual objectives** | | **Operational objectives** |
|---|---|---|
| Objective | Maintain productivity | Consists of a verb, indicator and reference point |
| Sub-objective | Trophic transfers | |
| … | Forage species | |
| | Target escapement | |
| | (Maintain) biomass | Maintain biomass of forage species > 50,000 t |

With ‘maintenance of productivity’ as an example conceptual objective, beginning to unpack it creates the statements as maintaining trophic transfers and interactions within the foodweb. However, while this restatement is a more tractable concept than maintenance of productivity, it is still far from what managers can deal with practically. Therefore, the concept of ‘trophic transfers’ is further unpacked. This produces a more specific statement on the maintenance of forage species, and then, in turn, of target escapement. A point is finally reached where some component of the ecosystem is associated with a particular measure or indicator, and at this point, the objective can be termed ‘operational’.

Before IM can be implemented in Canada, concepts and approaches need to be tested in pilot-scale initiatives. Only through a nationally coordinated system of pilot studies would the challenges, opportunities and utility of different approaches be operationally evaluated for consideration in the development of a national approach. Such exercises would need to include:

- Synthesis, either through Delphic (see Appendix 3 definition) or more quantitative approaches, of all currently available information including socio-economic data,
- Practical experience in compiling ecosystem-level data and their utilization in ecosystem function measurements to allow comparison of experiences from different situations,
- Practical experience with regional ‘unpacking’ exercises to break down conceptual objectives to operational ones, and
- An assessment of the costs of conducting required ecosystem monitoring.

Since the Sidney workshop, many of the above recommendations have been or are in the process of being acted upon. Pilot IM projects have been established to test the concepts discussed at the workshop, including the unpacking exercises (*e.g.*, Jamieson *et al.*, 2003; O’Boyle and Keizer, 2003; Jamieson and McCorquodale, 2004) to test the efficacy of the objectives’ structure and the unpacking process reported above. These pilots involve consideration of how best to engage managers, clients and scientists in consultation and decision making. It will take time for results of these pilots to be realized and to determine how the concepts and approaches discussed by Jamieson *et al.* (2001) can be implemented over the long term.

Canada’s IM planning is at the heart of new, modern oceans governance and management. It is a comprehensive way of planning and managing human activities so that they do not conflict with one another and so that all factors are considered for the conservation and sustainable use of marine resources and shared use of oceans spaces. IM is:

- an open, collaborative and transparent process that is premised on an ecosystem approach;
- involves planning and management of natural systems rather than solely political or administrative arrangements;
- is founded on sound science that can provide the basis for the establishment of ecosystem management objectives.

Canada’s Oceans Strategy calls for the Minister of DFO to lead the development and implementation of plans for the IM of all activities affecting estuaries, and coastal and marine waters.

In the Oceans Action Plan (http://www.dfo-mpo.gc.ca/oceans-habitat/oceans/oap-pao/pdf/oap_e.pdf), DFO identified ecoregions nationally and named five priority LOMAs across the country in which it will coordinate IM efforts. In the Pacific Region, the priority area was the Queen Charlotte Basin, which is the Pacific Northern Shelf Ecoregion (see section 4.2, Figure 4.2.8). This area is also now referred to as the Pacific North Coast Integrated Management Area (PNCIMA), and includes the previously identified Central Coast Integrated Management Area (CCIMA). The earlier CCIMA work laid the foundation for later PNCIMA development.

In initial attempts to develop operation objectives from higher-lever conceptual objectives, referred to above, it was quickly realized that a solely top-down approach could not prioritize objectives, and so a combined top-down:bottom-up approach was developed. This involves the identification of Ecologically and Biologically Significant Areas (EBSAs; DFO, 2004; Clarke and Jamieson, 2006a,b), Ecologically Significant Species (ESSs; DFO, 2006), Depleted Species, and Degraded Areas, and through consideration and weighting of these data, first identifications of highest priority science-based conservation objectives (DFO, 2007) will be proposed. This latter process is currently on-going for PNCIMA, and is now beginning to be undertaken for the other parts of Canada’s Pacific Coast.

### 2.2.3 Future Implementation

Integrated Management is still in its initial stages in Canada. While progress has been made in some areas, much remains to be done. In the short term, Canada has stalled implementation of IM nationally – while the science process to develop appropriate conservation objectives has advanced, the complementary consultative process to develop appropriate socio-economic objectives has yet to commence, at least in Canada's Pacific Region. Jamieson *et al.* (2001) summarized three main recommended next steps to achieving IM in Canada, which are still relevant today:

*1. Objectives, Indicators and Reference Points*
There is a need to develop objectives for the other dimensions of sustainability (social, economic, and cultural) through workshops involving the appropriate experts. Whereas biology is relatively well circumscribed and objective, these other dimensions of sustainability tend to be driven by regional and local issues, and can be politically charged.

*2. Assessment Approaches*
A technical review of ecosystem assessment approaches is required, considering their performance and sensitivity through simulation exercises using existing and simulated data.

*3. Research Directions for the Future*
There is a continuing need for research to define indicators and reference points related to each objective, including consideration of their practicality, the extent to which measurements can separate real change from background variability, cost of measurement, *etc.* The direction of this research would greatly benefit from unpacking case study exercises to identify appropriate indicators and reference points for management, which would identify gaps in our knowledge to supply this information. This research needs to build on international initiatives such as the SCOR WG 119 workshop on *Quantitative Ecosystem Indicators for Fisheries Management* (Cury and Christensen, 2005).

Also, relatively little effort has been put into how one would use suites of indicators to meet the totality of objectives defined under operational resource management plans. Such an exercise has begun on the Eastern Scotian Shelf (O'Boyle *et al.*, 2005) where a number of ocean sectors – fishing, oil and gas exploration, transport, defence – utilize the area, typical of situations both in Canada and elsewhere in the world. A standardized operational framework for integrated management will thus be of global interest. The suite of national conceptual ecosystem-level objectives has been unpacked to a regional level for the Eastern Scotian Shelf Integrated Management (ESSIM) area to address biodiversity, productivity and habitat issues. Operational objectives, which identify an indicator and reference point associated with each conceptual objective, are being considered. Utilizing Canada's conceptual objectives unpacking protocol, individual ocean sector management plans and activities are beginning to be reviewed in a consistent manner to determine how they might be influenced by the conservation objectives for the area. Issues of spatial scale and cumulative impacts are beginning to be addressed, as required, and evaluated as to how progress against the suite of objectives could be reported.

Based on these experiences, it is suggested that the following sequential steps be required to effectively make the linkage between the high level, national objectives and operational objectives necessary for implementation of IM:

1. Identification of the conservation issues and threats relevant to the IM area,
2. Identification of the ecosystem science components (EBSAs, ESSs, Depleted Species and Degraded Areas) to be conserved, and the associated conservation objectives (Figs. 2.2.1 and 2.2.2),
3. Determination of the appropriate socio-economic (desirable) objectives (Figs. 2.2.1 and 2.2.2),
4. Definition of operational objectives for the IM area,
5. Definition of operational objectives for each ocean sector (fishing, oil and gas, transportation, *etc.*).

Once the operational objectives are available, monitoring programs can be designed to provide the indicators and reference points needed for assessment and decision making.

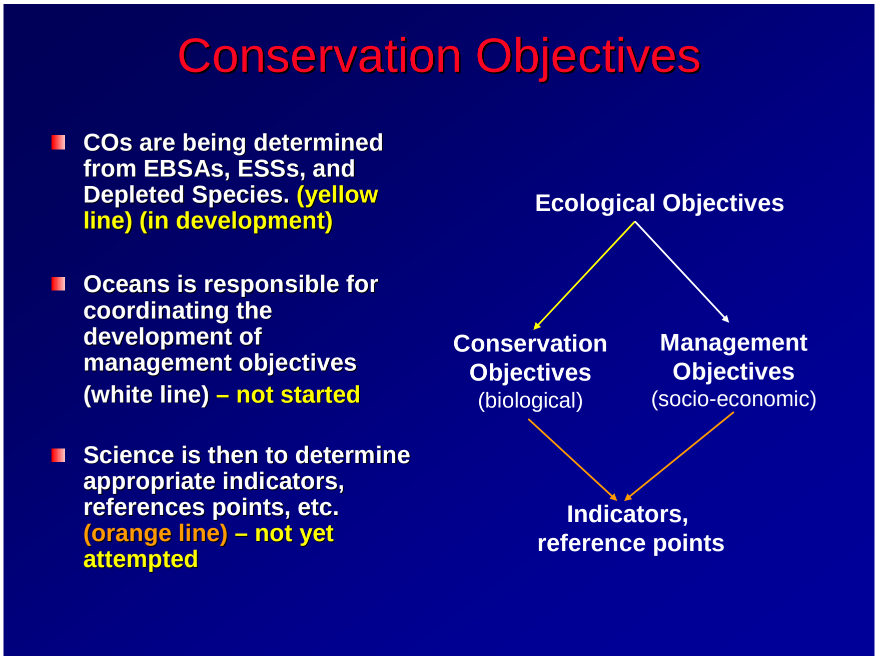


**Fig. 2.2.1** Sector processes leading to the the determination of both conservation and desirable thresholds.

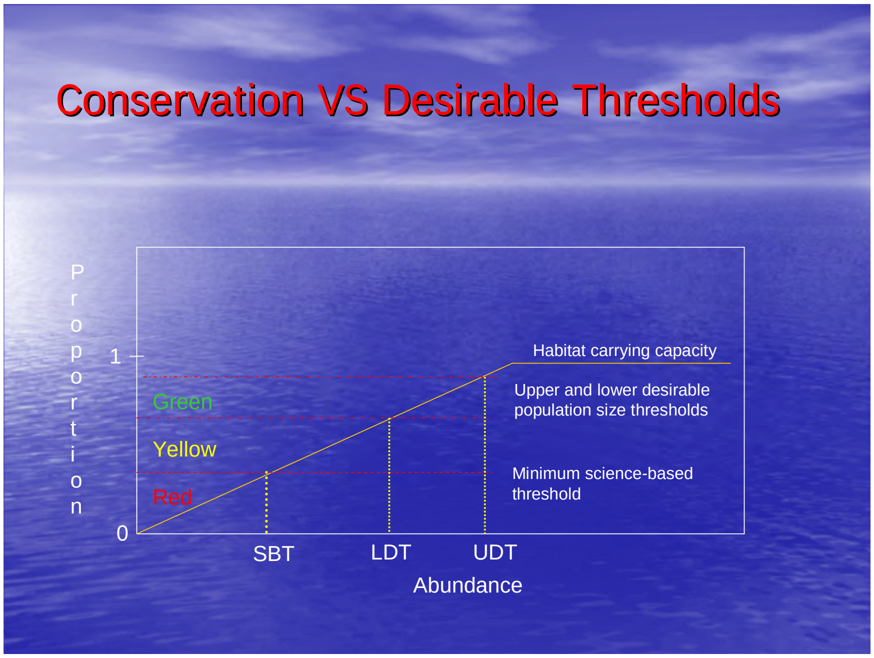


**Fig. 2.2.2** Conceptual relationship between minimum science-based threshold (conservation objectives) and desirable thresholds.

### 2.2.4 Canadian Template of Ocean Management Activities

#### Ecoregion

In 2004, DFO conducted a workshop (Powles *et al.*, 2004) to identify Canadian marine ecoregions to be used as a basis for integrated oceans management, using criteria that fell into three broad categories: geological properties, physical oceanographic properties and biological properties. The workshop resulted in the identification of 17 marine ecoregions for Canada's three oceans: four in the Pacific (see section 4.2, Figure 4.2.8), six in the Arctic and seven in the Atlantic. Here, we describe ocean management activities in the PNCIMA, a LOMA whose boundaries exactly match one of the identified Pacific ecoregions, the Pacific Northern Shelf (Fig. 4.2.8). Its characteristics are represented in the following:

1. *Geographic features:* It is bounded to the south by Brooks Peninsula and extends northward into U.S. Alaskan waters. A distinctive geological feature in this ecoregion is the shallow water area in Hecate Strait located between the Queen Charlotte Islands (officially renamed Hiada Gwai in 2009) and the mainland coast.

2. *Physical Oceanographic Properties:* The shallow water area east of the Queen Charlotte Islands results in a warm water front and strong mixing, and is considered to be a weak boundary within the ecoregion.

3. *Biological Properties:* The Northern Shelf is one of 17 ecoregions in the Canadian Pacific, Arctic and Atlantic oceans identified by experts within, and external to, DFO in 2004. Four ecoregions identified in the Pacific Region are the Strait of Georgia (part of the officially named Salish Sea (2010) that also includes Juan de Fuca Strait and Puget Sound), the Southern Shelf (West Coast of Vancouver Island), the Northern Shelf, and Offshore. The Southern Shelf extends from Brooks Peninsula on the northwest coast of Vancouver Island, south into U.S. waters. The Northern Shelf extends north from Brooks Peninsula into Alaskan waters. Many fish populations in the Northern Shelf area are managed separately from other populations of the same species. North Coast herring, several rockfish and flatfish species, and some other groundfish species, for example, are considered discrete populations based on biological traits, tagging studies which indicate minimal migration between geographic zones, and observed variation in trends in abundance indicators over time.

#### General Description of the Oceanographic and Biological Setting

The Pacific Northern Shelf is the continental shelf portion in the transition zone where the eastward-flowing trans-North Pacific Current divides into the southward flowing California Current and the northward-flowing Alaska Current. It is included in the description of the Gulf of Alaska in PICES (2004). Strong seasonality in storm intensity and frequency cause strong seasonality in coastal current forcing. During the winter, intense southeasterly alongshore winds support northward-flowing currents, while in the summer, the Eastern Pacific High Pressure system expands into the Gulf of Alaska and the associated, generally northwesterly winds create southward-flowing currents. Freshwater input varies seasonally with maximum discharge in the fall and minimum discharge in winter, when much of the precipitation is stored as snow. Water density in coastal waters is primarily driven by variations in salinity from freshwater input which, along with wind mixing, determines the onset and the strength of stratification in the spring and summer, with important implications for ocean productivity.

The Gulf of Alaska shelf is highly productive and supports a number of commercially important fisheries such as walleye pollock, salmon, Pacific halibut, other flatfish, Pacific herring, crab, and shrimp. The nearshore areas serve as important spawning grounds and as nursery grounds for juveniles of numerous demersal and pelagic species, including salmon, walleye pollock, Pacific cod, crab, and over 20 species of flatfishes.

#### Relevant Management Plan, Policy and Legislation

DFO is the Department within the government of Canada that is responsible for the management and safety of waters under federal jurisdiction. The Department mandate is largely focused on the conservation and allotment of quotas for saltwater fisheries on the Atlantic, Pacific and Arctic coasts of Canada. To address the need for conservation, DFO has an extensive science branch, with research institutes in various locations across the country.

Typically, the science branch provides evidence for the need of conservation of various species, which are then regulated by the Department. DFO maintains a large enforcement branch, with peace officers (known as Fishery Officers) used to combat poaching and foreign overfishing within Canada's EEZ. The Department is also responsible for several organizations, including the Canadian Coast Guard and the Canadian Hydrographic Service.

The *Fisheries Act*, passed in 1887 and last modified in 1985, is the main legislation under which marine resources have been managed. It is focused primarily on the management of commercial species, but does have some habitat conservation provisions. It prohibits the deposit of deleterious substances that would alter or degrade water quality, such that it would harm fish or fish habitat, into waters frequented by fish, such as oceans, rivers, lakes, creeks, and streams, or into storm drains that lead to such waters.

DFO, through the *Fisheries Act*, has authority over all marine animals and plants, but this *Act* does not allow for the establishment of marine protected areas (MPAs). Where MPAs have been established by other federal legislation (*e.g.*, *National Park Act*), fishing may still occur unless specifically closed by *Fisheries Act* regulation.

Provincial land in British Columbia is all land between 'headland to headland', and while this is accepted by the federal government, there is a difference of legal opinion as to what constitutes a headland. However, to date, this lack of clarification has not resulted in serious jurisdictional problems. Thus, in some nearshore waters, seafloor habitat is managed by the province but all marine animals present are managed federally by DFO. This means that in provincial MPAs, fishing may still occur, unless specifically closed there by *Fisheries Act* regulation.

Canada's *Oceans Act*, passed in 1997, states that "conservation, based on an ecosystem approach, is of fundamental importance to maintaining biological diversity and productivity in the marine environment". EBM is a guiding principle for implementing oceans management and preserving the health of oceans under Canada's Oceans Action Plan. EBM is the management of human activities so that ecosystems, their structure (*e.g.*, diversity of species), function (*e.g.*, productivity) and overall marine environmental quality are maintained. This ecosystem approach to oceans management recognizes that activities must be managed in consideration of the interrelationships between organisms, their habitats and the physical environment.

The *Oceans Act* calls for: 1) implementation of IM plans, 2) development of a national system of MPAs, and 3) establishment of MEQ guidelines, objectives and criteria. However, DFO is still determining how best to implement IM, and because the other two components are in reality a part of IM, progress in their implementation is also stalled. The PNCIMA is one of five pilot areas in Canada (the other four are in Atlantic Canada) where establishment of IM is currently being focused, and as of April 2009, only initial draft ecological objectives (EOs) in support of IM have been developed. EOs are determined from both science (conservation) objectives and socio-economic (desirable) objectives, as illustrated in Figure 2.2.1. The threshold relationship between conservation and desirable objectives is shown in Figure 2.2.2. Development of the draft EOs is ongoing and will be the culmination of a lengthy process which involves the completion of an Ecosystem Overview Assessment (EOA; Appendix 4) for the PNCIMA. The EOA is a technical document to provide IM partners and stakeholders with relevant information on marine and coastal ecosystems, including regional status and trends, an impact assessment and recommendations to management – based on the best science and knowledge available – in order to support IM planning and further decision making. The EOA contains two main parts:

1. A LOMA-scale ecosystem description that reports on ecosystem status and trends, and the basic information necessary to inventory key properties and components of ecosystems and describe ecosystem relationships and key elements. This part consists of different sections to report on influencing systems:
   a. geological systems (*e.g.*, sedimentology),
   b. oceanographic systems (*e.g.*, physical oceanography),
   c. biological systems (*e.g.*, flora and fauna).

2. Based on the above background information, the second part of the EOA document, "Assessment and Conclusions", provides managers with:
   a. an assessment that:
      i. reviews threats and human activities which have – or are suspected to have – significant impacts at the ecosystem scale;

ii. assesses and reports on the impacts of human activities on ecosystem structure and function, and overall marine environmental quality; and
iii. identifies ecologically and biologically significant areas (EBSAs) (Clarke and Jamieson, 2006a,b), ecologically significant species and community properties (ESSCPs), and Depleted Species and Degraded Areas;

b. recommendations for science managers to support planning and management actions in the IM area, *i.e.*, in terms of knowledge gaps identification, science research planning and the use of monitoring programs – be they existing or specifically designed – to effectively support oceans management in future.

**Overall Ecosystem-based Management Objective**

- *How will the objectives be achieved?*
- *What is the timeframe to implement objectives and meet goals?*

In 2002, DFO held a national workshop (Jamieson *et al.*, 2003) which identified national ecosystem-level objectives, with associated indicators and reference points, that could be used in managing ocean activities. Under the overarching objective of conservation of species and habitat, the workshop defined objectives related to biodiversity, productivity and the physical and chemical properties of the ecosystem. Under each of these, further nested components were defined, along with an unpacking process to link these conceptual objectives to those suitable for operational management (see Table 2.2.1). For each nested component, a suite of biological properties or characteristics was developed that further described the objective. Example indicators and reference points were also developed by operational objective, although further work on these at both a national and regional level was required. Assessment frameworks that evaluated progress against all objectives were discussed simultaneously and their potential uses investigated. A major achievement of the workshop was development, at a national level, of the concepts and terms related to EBM.

Two broad overarching general goals for EBM were accepted:

- the sustainability of human usage of environmental resources, and
- the conservation of species and habitats, including those other ecosystem components that may not be utilized by humans.

Discussion at the workshop was extensive and focused on objectives under the conservation goal; for more detail, refer to Jamieson *et al.* (2003). Initial conceptual objectives relating to biodiversity, productivity and the physical and chemical properties of the ecosystem were developed to:

1. conserve enough components (ecosystems, species, populations, *etc.*) so as to maintain the natural resilience of the ecosystem,
2. conserve each component of the ecosystem so that it can play its historic 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 historical role in a higher order component),
3. conserve the physical and chemical properties of the system.

The first conceptual objective, biodiversity, has the following nested components:

1. to maintain communities within bounds of natural variability,
2. to maintain species within bounds of natural variability,
3. to maintain populations within bounds of natural variability.

Current activities in relation to endangered and threatened species would be addressed under the species component, which thus provides a link to national and international species at risk acts, accords and legislation.

The second conceptual objective relates to the productivity of the ecosystem, with nested components being:

1. to maintain primary production within historic bounds of natural variability,
2. to maintain trophic structure so that individual species/stage can play their historical role in the foodweb,
3. to maintain mean generation times of populations within bounds of natural variability.

Current work under the *Fisheries Act* relates primarily to these three components.

The third conservation objective is intended to safe-guard the physical and chemical structures within which the ecosystem resides, with nested components being:

1. to conserve critical landscape and bottomscape features,
2. to conserve water column properties,
3. to conserve water quality,
4. to conserve biota quality.

Example indicators and reference points were also developed for some of these objectives. It is expected that specific situations within particular ecosystems, while starting from the same set of conceptual objectives, may produce different operational objectives through the unpacking exercise.

O'Boyle and Jamieson (2006) summarized a number of initiatives undertaken to explore the structure and function of this approach in Canada, in both the Atlantic and Pacific, since the 2001 Sidney workshop. These include not only the objectives of management, both at the conceptual and operational levels, but also issues relating to assessment, regulations and governance. They thus span the full complexity of what is termed IM.

O'Boyle and Jamieson (2006) also considered activities undertaken as part of management (functions) separate from the organization of how management is achieved (structures) (O'Boyle, 1993). Functions involve both goal setting (what one hopes to achieve, *i.e.*, objective definition) and control activities (how goals are achieved), the latter involving both regulation of human activity and the monitoring and assessment of the scale and nature of impacts. Structures include what it is that is being managed (*e.g.*, determination of ecosystem boundaries) and the organization of mandated management institutions (decision-makers and technical bodies). Much of their paper was focused on IM functions, particularly the determination of objectives, with some consideration of IM structure.

A number of lessons were learned (Jamieson *et al.*, 2003; O'Boyle and Keizer, 2003; DFO, 2004) from these exercises. Having an objectives tree that outlines the desired conceptual objectives and that formally links these to operational objectives used in everyday management forced consideration of why a particular indicator should be, or is being, measured. There was a tendency to use data availability to define the objective, rather than the converse. There will be occasions when documented scientific support for use of a particular indicator and reference point is not available. In these cases, expert judgement (Delphic approach) is appropriate.

O'Boyle and Jamieson's (2006) conclusions were that IM on Canada's East and West coasts is still in its initial stages. While progress has been made, development of IM will be a long-term, ongoing, adaptive process that will involve the testing of many alternative approaches to determine which approach works best and is most cost-effective. Incorporation of conceptual objectives for the dimensions of sustainability (social, economic and cultural), technical review of ecosystem monitoring approaches, and the continuing need for research on appropriate indicators and reference points are just some of the major IM challenges ahead. Progress to date has been substantial though, and the broad outline of what is required to implement IM is starting to emerge, as presented in the following.

## 1. Fishery Management

### - General approach to management for target and non-target species in fisheries

Canadian fishery management is still either species or gear-type focused. Management plans for target species, available for Canada's Pacific Coast as a whole, are listed in Table 2.2.2. Ecological objectives are just beginning to be incorporated into management plans. Non-target species are typically not specifically managed, although regulated area closures and catch limits exist in some management plans for some species/gear types to avoid incidental capture of some species (depleted species, or species that are targeted by another gear type) or damage to fragile species, such as sponges. Examples are regulated sponge reef closures and sub-area closures to address shellfish interception and shallow water habitat concerns in the groundfish trawl fishery (http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/plans10/Groundfish_2010_june28.pdf; appendix 8, section 5.1) and shrimp trawl fishery (http://www.dfo-mpo.gc.ca/Library/336240.pdf; section 1.13 and appendix 6).

- *How is the ecosystem taken into consideration when managing fisheries?*

Initial EOs in support of EBM have only been established since April 2007, and their incorporation into management plans is an on-going adaptive management process, with EOs being refined in both number and detail as a gradual shift to effective EBM is achieved. An example of their inclusion to date is shown in the shrimp trawl management plan

**Table 2.2.2** Canadian fishery management regulations by species, species group or gear type for Canada's Pacific Coast.

| | Fishery regulation | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **Closed season** | **Gear size limit** | **Area closure** | **TAC** | **IVQ** | **Species closure*** | **Minimum size limit** | **Minimum mesh size** | **Escape ring** | **Bycatch** |
| **Groundfish** | | | | | | | | | | |
| Trawl | x | x | x | x | x | x | – | x | – | Yes |
| Hook and line rockfish | x | – | x | x | x | – | x | – | – | Yes |
| Halibut | x | – | x | x | x | – | x | – | – | Yes |
| Sablefish | x | – | x | x | x | – | x | – | x | – |
| Hake | x | x | x | – | x | – | – | x | – | Yes |
| **Pelagics** | | | | | | | | | | |
| Roe herring | x | x | x | – | – | – | – | x | – | No |
| Roe on kelp | x | – | x | – | – | – | – | – | – | No |
| Food and bait herring | x | x | x | x | x | – | – | – | – | Yes |
| Sardine | x | x | x | x | – | – | – | – | – | Yes |
| **Invertebrates** | | | | | | | | | | |
| Intertidal clam | x | – | x | x | – | – | x | – | – | No |
| Crab | | – | x | – | – | – | x | – | x | Yes |
| Geoduck and horse clam | x | – | x | – | – | – | x | – | – | No |
| Euphausiid | x | – | x | x | – | – | – | – | – | Yes |
| Prawn and shrimp | x | – | x | – | – | x | x | – | x | Yes |
| Sea cucumber | x | – | x | – | x | – | – | – | – | No |
| Sea urchin | x | – | x | – | x | x | x | – | – | No |
| Shrimp trawl | x | x | x | – | – | x | – | – | – | Yes |
| Opal squid | x | x | x | – | – | – | – | – | – | Yes |
| Scallop trawl | x | x | x | x | – | – | x | – | – | Yes |
| Scallop dive | x | – | x | x | – | – | x | – | – | No |
| Octopus dive | x | – | x | – | – | – | x | – | – | No |
| **North Coast Salmon** | x | x | x | x | – | x | x | x | – | Yes |

*Species closure: fishery may be closed if bycatch of other species is excessive.
TAC = total allowable catch, IVQ = individual vessel quota

(http://www.dfo-mpo.gc.ca/Library/336240.pdf; section 8), which discusses Canada's efforts to date in identifying areas and species that require protection or other conservation measures.

- *How selective is the gear (e.g., bottom trawl, midwater trawl, purse seine, long line and trap, gillnet and other gear) for the target species?*

Selectivity for target species varies by gear type, as does the options available to minimize bycatch. Spatial and temporal closures to avoid bycatch are sometimes effective and design features of the gear can help minimize bycatch of either non-target species or undersirable sized individuals such as juveniles of target species. Groundfish trawl bycatchs have not been well analyzed, particularly with respect to their ecosystem impact implications but since 1996, every groundfish trawl vessel has been required to have an observer onboard to document bycatch by species and weight. Jamieson and Davies (2004) document both the nature and quantity of bycatch in the groundfish trawl fishery in PNCIMA. Bycatches for other fishing gears are not as well documented, as observers are typically not present, and data have not been analyzed in detail. An example of a selectivity device is in the shrimp trawl fishery management plan (http://www.dfo-mpo.gc.ca/Library/336240.pdf; appendix 1, section 6), which typically targets pink shrimp (*Pandalus borealis eous* and *P. jordani*). Voluntary plastic lattice panels are recommended to be installed in all otter trawl nets to reduce eulachon (*Thaleichtys pacificus*, an osmerid that currently has a reduced abundance) bycatch.

- *Does fishery gear target certain sizes or life-history stage(s)?*

Mesh sizes and trap escape rings regulations are, in some instances, used to target specific sizes and life-history stages by allowing the escape of undesired animals.

- *Is the fishery spatially concentrated?*
- *Is the fishery year-round?*

Because of the wide diversity in fisheries in PNCIMA, there is a whole range of fishing strategies being used for different species. Some species are year-round with a minimum size limit (*e.g.*, Dungeness crab); others are year-round with individual vessel quotas (IVQs), or have specific closed periods, and many have spatial restrictions, either as to where fishing can occur or to limit the amount of fishing activity (*e.g.*, number of vessels) that can occur in an area. Management plan features are summarized in Table 2.2.3.

- *Are certain geographic areas excluded from the fishery? Explain reason for the exclusion.*

In some cases, yes, for the following alternative reasons:

1. to avoid bycatch and/or to conserve biogenic habitat (*e.g.*, sponge reef closures),
2. to protect spawning stock and/or habitat and hopefully, to enhance recruitment (*e.g.*, rockfish conservation areas),
3. to protect communities in MPAs, which can be established for a variety of reasons (see Jamieson and Lessard, 2000).

- *Are there catch limits on non-target species?*

Not usually, but they do occur for some depleted species (*e.g.*, eulachon 'action levels', in shrimp trawl fisheries) when the species is normally fished by another gear type (*e.g.*, prawns (normally trapped) in a shrimp trawl fishery), or when different quotas exist for species caught by the same gear (*e.g.*, salmon species). When a certain biomass of eulachon (action level) is caught, the fishery may be closed. Likewise, no more than 100 prawns (all prawns caught must be retained) are allowed on a vessel while fishing. If prawn catch levels become too high, the area is closed to shrimp trawling.

- *Is the catch of non-target species recorded and accounted for?*

The groundfish trawl fishery has had 100% observe reporting of all bycatch since 1996. The shrimp trawl fishery requires estimates of bycatch to be provided for certain species. Other fisheries do not as of yet require bycatch reporting, which creates difficulties in the gathering of necessary inputs for EBFM.

- *What is the environmental variability (e.g., physical disturbance regime; El Niño, typhoon, changes in current strength) and how do species respond, if known?*

Periodic North Pacific regime shifts and El Niño events have an impact on the Pacific North Coast ecoregion. Water temperatures, in particular, may vary, which can impact some species. Migrating salmon seem to be particularly impacted, as in colder water periods, most salmon migrate to the Fraser

**Table 2.2.3** Canadian species with Pacific management plans (obtainable from http://www-ops2.pac.dfo-mpo.gc.ca/xnet/xIndex.cfm?pg=xnet_main_menu&expand=107).

| | |
|---|---|
| Groundfish | o Groundfish trawl<br>o Hook and line<br>o Halibut<br>o Sablefish |
| Pelagics and minor finfish | o Roe herring<br>o Spawn on kelp<br>o Food and bait herring<br>o Eulachon<br>o Sardine<br>o Albacore tuna |
| Shellfish | o Clam<br>o Crab<br>o Euphausiid<br>o Geoduck<br>o Octopus<br>o Prawn<br>o Scallop<br>o Sea cucumber<br>o Sea urchin<br>o Shrimp<br>o Squid |
| Salmon | o Salmon |

River from the outside of Vancouver Island, while in warmer water periods, most migrate through Johnstone Strait (see section 4.2, Figure 4.2.8) which, because of tidal mixing with deeper colder waters, is cooler. Because this region is also in the transition zone between many southern and northern species, ranges and relative abundance of different species may consequently vary. In El Niño years, for example, more southern species occur in abundance farther north (*e.g.*, hake in Queen Charlotte Sound). The relative copepod species proportions between southern and northern species can also change significantly.

- *What is the spatial distribution of the fishery compared to the distribution of the target species?*

With so many regional fisheries, this is difficult to answer. Many fisheries target mobile species when they are concentrated in abundance, such as spawning or feeding aggregations, or when they are concentrated by topography while migrating (*e.g.*, salmon in the confines of Johnstone Strait. With relatively sedentary nearshore invertebrate species like sea urchins, crabs and clams, fisheries occur where high abundances of these species occur, which are often dependent on substrate characteristics. Figure 2.2.3 shows the spatial distribution of commercial trawl effort in recent years for the northern British Columbia (BC) coast.

## 2. Management of Threatened or Protected Species and Communities

**- General approach to management of threatened or protected species and communities**

*Oceans Act*

Under the *Oceans Act*, the main deliverable for Phase I of the Ocean Action Plan (OAP) for the Pacific Region is the establishment of a LOMA planning process for the North and Central coasts called the Pacific North Coast Integrated Management Area (PNCIMA). PNCIMA will: 1) focus on addressing management needs and priorities related to multiple ocean uses, 2) be a collaborative planning and management process and 3) augment and consolidate decision making processes in the Queen Charlotte Basin.

The aim of the Plan is to augment and consolidate decision making processes and link sector planning and management to an overarching set of management objectives and targets. Regulatory authorities will continue to remain responsible and accountable for implementing management policies and measures within their mandates and jurisdictions. Rather than build an entirely separate process, the goal of the PNCIMA plan is to build references and linkages to existing management strategies and actions. DFO is currently preparing the background documentation required to inform this process. Part of this documentaion is the identification of EBSAs (DFO, 2004), ESSCPs (DFO, 2006), and Depleted Species and Degraded Areas which, as a first effort for PNCIMA, was completed for EBSAs (Clarke and Jamieson, 2006a,b). These will be used to determine conservation objectives (DFO, 2007).

*Species at Risk Act (SARA)*

The *Species at Risk Act* (SARA) was created to protect wildlife species from becoming extinct by: 1) providing for the recovery of species at risk due to human activity and 2) ensuring, through sound management, that species of special concern do not become endangered or threatened. The *Act* became law in June 2003. It includes prohibitions against

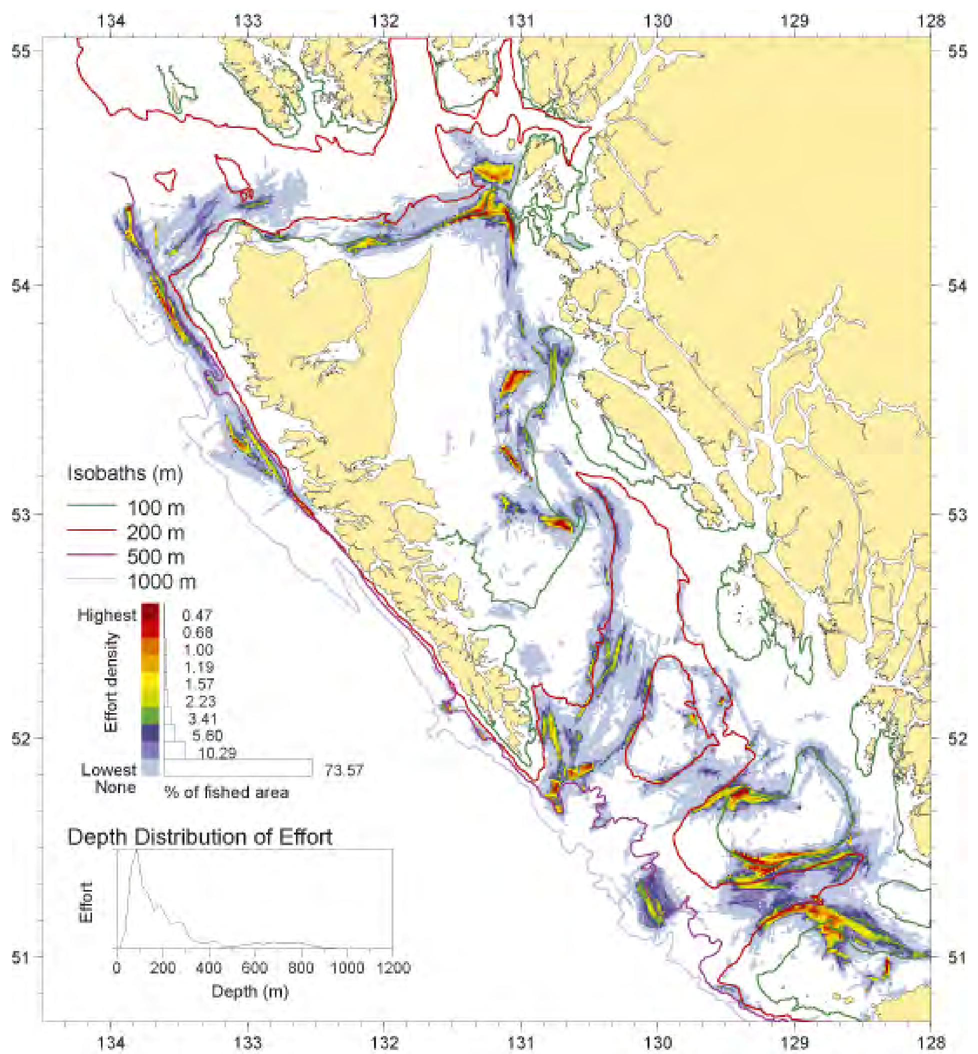


**Fig. 2.2.3** Spatial distribution of bottom trawl fishing effort on the BC Central Coast and around the Queen Charlotte Islands (Haida Gwai) from 1996–2004. Data were plotted using a 1 km$^2$ grid. Grids are colour coded by decile of the cumulative distribution, with the highest density coloured red and the lowest light blue. The histogram summarizes the percentage of the fished area covered by each decile. The line graph shows the depth distribution of effort (from Sinclair, 2007).

killing, harming, harassing, capturing or taking species at risk, and against destroying their critical habitats. Marine PNCIMA species listed at risk under SARA or other criteria can be found in Table 2.2.4. Recovery plans have been developed for many of the COSEWIC-listed species

*Protected Areas*

Protected areas in PNCIMA have been established under many different federal and provincial *Acts* (Jamieson and Lessard, 2000), and management plans have been written for only some of them. As indicated above, DFO manages all living marine animals, and management plan references for individual species or species groups are given in Table 2.2.3. There are presently no DFO *Oceans Act*-legislated MPAs in PNCIMA, so in the mpas legislated by other provincial or federal *Acts* in PNCIMA, two management plans are needed: one for substrate habitat by the appropriate agency that designated the mpa, and a DFO one for living resources. Many PNCIMA protected areas do not yet have specific management plans for either species or substrate. However, there is a plan to harmonize management objectives for mpas between the different agencies involved, but when this will be effected has yet to be determined.

- **General approach to designation (legal/ regulatory framework), management and recovery of threatened or protected species/ communities** [describe ecological properties of the species or groups that make them vulnerable and in need of protection.]

- *Is there legislation for designating species at risk?*
- *How are threatened species identified, and are there timeframes for developing recovery plans?*
- *Are recovery thresholds identified above which a species no longer needs legal protection?*

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC), an independent body of experts, was created in 1977 when the need for a single, official, scientifically sound, national classification of wildlife species at risk was recognized. COSEWIC has developed and periodically modified its operating procedures, the categories of risk and their definitions, and its assessment procedures to fine-tune its operations. COSEWIC's mandate currently considers vertebrates (mammals, birds, reptiles, amphibians and fishes), plants, molluscs, and arthropods. COSEWIC has the power to designate species on an emergency basis when there is a clear immediate danger of serious decline in the species population and/or range, or when such a decline is already in progress and will continue unless immediate corrective actions are taken, and when the delay involved with going through the normal process could contribute to the species' jeopardy.

The COSEWIC process is divided into three sequential steps, each of which has a tangible outcome. These are: 1) selection and prioritization of species requiring assessment – COSEWIC Candidate List and the Priority List; 2) compilation of available data, knowledge and information – COSEWIC status report; and 3) assessment of a species' risk of extinction or extirpation and subsequent designation – the record of COSEWIC assessment results. Species get on the SARA list by being designated 'at risk' by COSEWIC. The federal Cabinet then decides whether those species should get legal protection under the *Act*, following consultations with affected stakeholders and other groups (http://www.sararegistry.gc.ca/default_e.cfm). More details can be obtained at the COSEWIC website (http://www.cosewic.gc.ca/eng/sct0/assessment_process_e.cfm).

In Canada, the identification of recovery thresholds above which a species no longer needs legal protection is proving to be a non-trivial exercise. A national workshop was held on this topic (DFO, 2005), and a precautionary framework that has three zones for a population – healthy, cautious and critical – seems useful. It was determined that there are both strengths and weaknesses in placing a biologically-based recovery target at either the critical–cautious boundary or at the cautious–healthy boundary. There is, at present, no compelling scientific argument pointing to one position or the other, or to any specific position between them.

**Table 2.2.4** Status assessments of selected marine species in British Columbia.

| Group | Common Name | Scientific Name | Population | Status | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | SARA[1] | GS[2] | BCCDC[3] | IUCN[4] | COSEWIC[5] |
| Molluscs | Northern abalone | *Haliotis kamtschatkana* | – | 1 | x | R | – | TH |
| | Olympia oyster | *Ostrea conchaphila* | – | 1 | x | B | – | SC |
| Reptiles | Leatherback seaturtle | *Dermochelys coriacea* | – | 1 | 1 | R | – | EN |
| Mackerel sharks | White shark | *Carcharodon carcharias* | – | DD | 5 | x | Vu A1cd 2cd | DD |
| Basking sharks | Basking shark | *Cetorhinus maximus* | – | – | 2 | x | En A1ad | – |
| Cow sharks | Bluntnose sixgill shark | *Hexanchus griseus* | – | – | 3 | x | LR/nt | – |
| | Broadnose sevengill shark | *Notorynchus cepedianus* | – | – | 3 | x | DD | – |
| Hound sharks | Soupfin shark | *Galeorhinus galeus* | – | – | 3 | x | Vu A1bd | – |
| Skates | Sandpaper skate | *Bathyraja interrupta* | – | – | 3 | R | x | – |
| | Big skate | *Raja binoculata* | – | – | 3 | x | LR/nt | – |
| | Longnose skate | *R. rhina* | – | – | 3 | x | x | – |
| Ragfishes | Ragfish | *Icosteus aenigmaticus* | – | – | 3 | x | x | – |
| Sturgeon | Green sturgeon | *Acipenser medirostris* | – | 1 | 2 | R | – | SC |
| Rockfishes | Bocaccio | *Sebastes paucispinis* | – | 3 | 1 | x | CR A1abd+2d | TH |
| | Canary rockfish | *S. pinniger* | – | – | 3 | x | x | – |
| | Darkblotched rockfish | *S. crameri* | – | – | 3 | x | x | – |
| | Pacific ocean perch | *Sebastes alutus* | – | – | 3 | x | x | – |
| | Quillback rockfish | *S. maliger* | – | – | 3 | x | x | – |
| | Redbanded rockfish | *S. babcocki* | – | – | 3 | x | x | – |
| | Rougheye rockfish | *S. aleutianus* | – | – | 3 | x | x | – |
| | Shortraker rockfish | *S. borealis* | – | – | 3 | x | x | – |
| | Silvergray rockfish | *Sebastes brevispinis* | – | – | 3 | x | x | – |
| | Widow rockfish | *S. entomelas* | – | – | 3 | x | x | – |
| | Yelloweye rockfish | *S. ruberrimus* | – | – | 3 | x | x | – |
| | Yellowmouth rockfish | *S. reedi* | – | – | 3 | x | x | – |
| | Yellowtail rockfish | *S. flavidus* | – | – | 3 | x | x | – |
| | Longspine thornyhead | *Sebastolobus altivelis* | – | – | 3 | x | x | – |
| | Shortspine rhornyhead | *S. alascanus* | – | – | 3 | x | x | – |
| Osmerids | Eulachon | *Thaleichthys pacificus* | – | – | 2 | B | – | – |

**Table 2.2.4** Continued.

| Group | Common Name | Scientific Name | Population | Status | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | SARA[1] | GS[2] | BCCDC[3] | IUCN[4] | COSEWIC[5] |
| Salmon | Chinook | *Oncorhynchus tshawytscha* | Okanagan | ** | 4 | Y | – | TH |
| | Coho | *O. kisutch* | Interior Fraser | 2 | 4 | Y | – | EN |
| | Sockeye | *O. nerka* | Cultus | 2 | 4 | Y | – | EN |
| | | *O. nerka* | Sakinaw | 2 | 4 | Y | – | EN |
| Waterfowl | Western grebe | *Aechmophorus occidentalis* | – | – | 2 | R | – | – |
| Seabirds | Black-footed albatross | *Phoebastria nigripes* | – | – | 4 | Y | EN | – |
| | Laysan albatross | *P. immutabilis* | – | – | 5 | B | VU | – |
| | Short-tailed albatross | *P. albatrus* | – | 1 | 1 | R | VU | TH |
| | Northern Fulmar | *Fulmarus glacialis* | – | – | 4 | R | LC | – |
| | Pink-footed shearwater | *Puffinus creatopus* | – | 1 | 1 | R | VU | TH |
| | Flesh-footed shearwater | *P. carneipes* | – | – | 3 | B | – | – |
| | Black-vented shearwater | *P. opisthomelas* | – | – | 8 | A | VU | – |
| | Buller’s shearwater | *P. bulleri* | – | – | 3 | B | VU | – |
| | Manx shearwater | *P. puffinus* | – | – | x | A | – | – |
| | Double-crested cormorant | *Phalocrocorax auritus* | – | NAR | 3 | B | – | NAR |
| | Brandt’s cormorant | *P. penicillatus* | – | – | 2 | R | – | – |
| | Pelagic cormorant | *P. pelagicus pelagicus* | *pelagicus* subspecies | – | 4 | R | – | – |
| Shorebirds | Great blue heron | *Ardea herodias herodias* | *herodias* subspecies | – | 3 | B | – | – |
| | | *Ardea herodias fannini* | *fannini* subspecies | – | 3 | B | – | SC |
| | Wandering tattler | *Heteroscelus incanus* | – | – | 3 | B | – | – |
| | Short-billed dowitcher | *Limnodromus griseus* | – | – | 3 | B | – | – |
| Waterfowl | Canada goose | *Branta canadensis leucoparieia* | *leucopareia* subspecies | – | 4 | B | – | – |
| | | *B. canadensis occidentalis* | *occidentalis* subspecies | – | 4 | B | – | – |
| | Long-tailed duck | *Clangula hyemalis* | – | – | 3 | Y | – | – |
| | Surf scoter | *Melanitta perspicillata* | – | – | 3 | B | – | – |
| | Sandhill crane | *Grus canadensis tabida* | *tabida* subspecies | – | 3 | B | – | NAR |
| Raptors | Peregrine falcon | *Falco peregrinus anatum* | *anatum* subspecies | 1 | 3 | R | – | TH |
| | | *F. peregrinus pealei* | *pealei* subspecies | 1 | 3 | B | – | SC |

**Table 2.2.4** Continued.

| Group | Common Name | Scientific Name | Population | Status | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | SARA[1] | GS[2] | BCCDC[3] | IUCN[4] | COSEWIC[5] |
| Seabirds | Red-necked phalarope | *Phalaropus lobatus* | – | – | 3 | B | – | – |
| | California gull | *Larus californicus* | – | – | 3 | B | – | – |
| | Common murre | *Uria aalge* | – | – | 2 | R | – | CL |
| | Thick-billed murre | *U. lomvia* | – | – | 2 | R | – | CL |
| | Marbled murrelet | *Brachyramphus marmoratus* | – | 1 | 1 | R | VU | TH |
| | Ancient murrelet | *Synthliboramphus antiquus* | – | 1 | 3 | B | – | SC |
| | Xantus' murrelet | *S. hypoleucus* | – | – | 5 | A | VU | – |
| | Cassin's auklet | *Ptychoramphus aleuticus* | – | – | 3 | B | – | – |
| | Tufted puffin | *Fratercula cirrhata* | – | – | 3 | B | – | – |
| | Horned puffin | *F. corniculata* | – | – | 2 | R | – | – |
| Marine Mammals | Blue whale | *Balaenoptera musculus* | Pacific | 1 | 1 | B | – | EN |
| | Fin whale | *B. physalus* | Pacific | 1 | 1 | B | – | TH |
| | Sei whale | *B. borealis* | Pacific | 1 | 1 | B | – | EN |
| | Humpback whale | *Megaptera novaeangliae* | North Pacific | 1 | 4 | B | – | TH |
| | Grey whale | *Eschrichtius robustus* | NE Pacific | 1 | 3 | B | – | SC |
| | North Pacific right whale | *Eubalaena japonica* | | 1 | 1 | R | – | EN |
| | Killer whale | *Orcinus orca* | NE Pacific southern resident | 1 | 1 | R | – | EN |
| | | *Orcinus orca* | NE Pacific northern resident | 1 | 1 | R | – | TH |
| | | *Orcinus orca* | NE Pacific transient | 1 | 1 | R | – | TH |
| | | *Orcinus orca* | NE Pacific offshore | 1 | 1 | B | – | SC |
| | Harbour porpoise | *Phocoena phocoena* | Pacific Ocean | 1 | 3 | B | – | SC |
| | Steller sea lion | *Eumetopias jubatus* | | 1 | 3 | R | – | SC |
| | Northern fur seal | *Callorhinus ursinus* | | * | 1 | B | – | TH |
| | Sea otter | *Enhydra lutris* | | 1 | 1 | R | – | TH |

[1]**SARA**: *Species at Risk Act*. 1 = species on Schedule 1 legal list of wildlife species at risk; 2 = species not added to legal list; 3 = referred back to COSEWIC for further information or consideration; * COSEWIC status assessment not yet forwarded to the Minister; ** COSEWIC status assessment has been forwarded to the Minister of the Environment; a decision is pending.

**Table 2.2.4** Continued.

[2]**GS**: General Status of Wildlife in Canada. 1 = At Risk: a formal, detailed risk assessment has been completed and determined to be at risk of extirpation or extinction. 2 = May Be At Risk: may be at risk of extirpation or extinction and are therefore a candidate for detailed risk assessment by COSEWIC, or provincial or territorial equivalents. 3 = Sensitive: not believed to be at risk of immediate extirpation or extinction but may require special attention or protection to prevent them from becoming at risk. 4 = Secure: not believed to belong in the other categories; includes some species that show a trend of decline in numbers in Canada but remain relatively widespread or abundant. 5 = Undetermined: insufficient data, information, or knowledge is available with which to reliably evaluate their general status. 6 = *Not Assessed:* known or believed to be present regularly in the geographic area in Canada to which the rank applies, but have not yet been assessed by the general status program. 7 = Exotic: moved beyond their natural range as a result of human activity. 8 = Accidental: occurring infrequently and unpredictably, outside their usual range.

[3]**BCCDC**: British Columbia Conservation Data Centre: Provincial list of species of conservation concern in British Columbia. R = Red List: indigenous species and subspecies that are extirpated, endangered or threatened in BC; B = Blue List: indigenous species and subspecies of special concern (formerly vulnerable) in BC; Y = Yellow List: species that are apparently secure and not at risk of extinction, may have Red or Blue listed subspecies. E = Exotic: Species that have been moved beyond their natural range as a result of human activity. Exotic species are also known as alien species, foreign species, introduced species, non indigenous species and non native species. Exotic species are excluded from the Red, Blue and Yellow lists. A = Accidental: Species occurring infrequently and unpredicatably, outside their usual range. Accidental species are excluded from the Red, Blue and Yellow list..

[4]**IUCN**: International Union for Conservation of Nature and Natural Resources: Red List of Threatened Species. EN = Endangered: A taxon is Endangered when the best available evidence indicates that it meets any of the criteria for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild; VU = Vulnerable: A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild' NT = Near Threatened: A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

[5]**COSEWIC**: Committee on the Status of Endangered Wildlife in Canada. EN = Endangered: facing imminent extirpation or extinction, T = Threatened: likely to become endangered if limiting factors are not reversed; SC = Special Concern: particularly sensitive to human activities or natural events but not endangered or threatened (formerly referred to as vulnerable), NAR = Not at Risk: evaluated and found to be not at risk, DD = Data Deficient: insufficient scientific information to support status designation.

## 3. Habitat Management

**- General approach to management of habitats**

The mandate of the Habitat Management Program in DFO is to: 1) protect and conserve fish habitat in support of Canada's coastal and inland fisheries resources, and 2) conduct environmental assessments under the *Canadian Environmental Assessment Act* before DFO makes a regulatory decision under the habitat provisions of the *Fisheries Act*.

The federal government has constitutional authority for seacoast and inland fisheries. Legislatively, it has exercised this authority through the *Fisheries Act*, one of the oldest acts in Canada. The *Fisheries Act* contains provisions to conserve and protect fish habitat (defined in subsection 34(1) of the *Fisheries Act* as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes") that sustain Canada's fisheries resources.

There are two types of habitat provisions in the *Fisheries Act*: habitat protection and pollution prevention. A key habitat protection provision is subsection 35(1). This section prohibits the harmful alteration, disruption or destruction (HADD) of fish habitat without an authorization from the Minister of DFO, or by regulation. Other habitat protection provisions include dealing with obstructions impeding the free passage of fish and with the minimum flow of water for fish.

Section 36 of the *Act* is the key pollution prevention provision. It prohibits the deposit of deleterious substances into waters frequented by fish unless authorized by regulation or by federal laws. The administration of section 36 has been assigned to the Minister of the Environment. However, the Minister of DFO is responsible to Parliament for all sections of the *Act*.

The national Habitat Management Plan (HMP) has responsibility for conducting environmental assessments under the *Canadian Environmental Assessment Act* prior to regulatory decisions being made by DFO under laws administered by the Department. This includes the issuance of authorizations of a HADD under section 35 of the *Fisheries Act*.

The Policy for the Management of Fish Habitat, tabled in Parliament in 1986, provides guidance for the administration of the habitat provisions of the *Fisheries Act* and a comprehensive framework for the management of Canada's fish habitat resource base in the context of sustainable development. It includes the overall objective of net gain for habitat for Canada's fisheries resources and outlines the three goals to reach this objective: fish habitat conservation, fish habitat restoration, and fish habitat development. It also includes a guiding principle of 'No net loss' (a working principle by which the Department strives to balance unavoidable habitat losses with habitat replacement on a project-by-project basis so that further reductions to Canada's fisheries resources due to habitat loss or damage may be prevented) which allows development to proceed where compensation of loss of fish habitat is acceptable.

- **General approach to management of habitats (including biological habitat such as corals, seagrass beds, *etc*., as well as physical habitat)** [describe ecological properties of the habitat that makes it significant.]

- *Are specific habitats designated for protection, and what legislation allows for the designation?*

The Policy for the Management of Fish Habitat protects fish habitats by administering the *Fisheries Act* and incorporating fish habitat protection requirements into land and water use activities and projects. Procedures for implementing the no net loss guiding principle are used as an integral part of the strategy to deal with proposed works and undertakings that could affect fisheries. DFO ensures a uniform and equitable level of compliance with statutes, regulations and policies, as necessary to manage and protect fish habitats in jurisdictions where the federal government manages fisheries. The *Fisheries Act* contains powers to deal with damage to fish habitat, destruction of fish, obstruction of fish passage, necessary flow requirements for fish, the screening of water intakes and the control of deleterious substances. Potential adverse effects on fish habitats are frequently avoided by modifying the plans, designs and operating procedures for projects and activities, and by incorporating mitigation and compensatory measures.

- *Are there monitoring and inventory activities in place?*

Proponents of an activity that might affect fish habitat may be asked to provide an assessment of the potential impact of existing or proposed works and undertakings on the fisheries resource. Usually such requests would apply to major projects (potentially having significant negative impacts on the habitats supporting Canada's important fisheries resources). Assessments include project-specific information on the resource in question, and supporting habitat and baseline fisheries information required to assess the potential impact of the proposed project. Costs of mitigating any anticipated damages, and for implementing compensation measures and facilities designed to avoid losses of fish habitat and reductions in the supply of fish, are the responsibility of proponents. DFO conducts detailed reviews, frequently and preferably as a participant in a provincial or federal environmental review process, of major proposed industrial undertakings that could potentially harm habitats supporting the fisheries resources.

- *Are there restoration plans or activities underway?*

DFO initiates projects and provides advice to other interested groups to restore and develop fish habitats, in support of the net gain (an increase in the productive capacity of habitats for selected fisheries brought about by determined government and public efforts to conserve, restore and develop habitats) objective. Under this strategy, habitats may be restored by rehabilitating streams; by eliminating or controlling exotic species, predators, parasites, and competitors; by removing man-made and storm-related physical barriers and other initiatives; and, in cooperation with Environment Canada, requiring the installation and operation of suitable waste treatment technology. Where it manages the fisheries directly, DFO will provide advice and guidance to community and conservation groups that wish to undertake habitat restoration and development projects; financial support also may be provided, depending on the availability of public funds for this purpose.

- **Evaluate the effectiveness of decisions taken and techniques used to conserve, restore and develop fish habitats**

1. Recognizing limitations in the ability to predict changes to fish habitats arising from proposed actions, the Department aims to monitor the effects, both during and, for a prescribed period, after development. In this way the effectiveness of departmentally prescribed conditions of approval, intended to maintain the productive capacity of fish habitats, would be evaluated and new knowledge acquired.
2. Proponents may be required to undertake follow-up monitoring studies on the effectiveness of habitat mitigation and compensation prescriptions as a condition of project approval by the Department, and subject to prior discussion and agreement with the proponent on the scope and schedule for monitoring.

- *Are there ecologically or biologically significant habitat types/areas that can be identified and are they given special protection, and are there standards (e.g., no activities allowed or just limitation of human activities in the habitat) for the level of protection?*

See "2. Management of Threatened or Protected Species and Communities" for the identification of EBSAs. These areas under IM are to be more closely managed and monitored to ensure the conservation of features identified as ecologically and biologically significant, but IM has yet to be established in Canada.

### 4. Community/Trophic Structure Management

- **General approach to management of food webs in general and of direct feeding interactions specifically**

- *Are the characteristics of the community altered by human activities (e.g., eutrophication, pollution, species introductions, sedimentation, altered coastal circulation, dredging and filling, altered hydrography of rivers, fishing, etc.)?*
- *Are management activities affecting food-webs or do existing food web perturbations constrain moving to a desired state?*
  - Does specific legislation address issues relevant to food webs?
  - Are there monitoring and inventory activities in place?
  - Are there restoration plans or activities underway?
  - Are there ecologically or biologically significant species interactions that can be identified and are they given special consideration, and are there

standards (*e.g.*, ballast water, coastal development, water quality) for the level of protection?

Although desirable "Community Properties" have been identified as something to conserve (DFO, 2006), the reality is that in Pacific Canada at least, the required data to evaluate what the current status of these properties is does not exist, and there are no programs underway that are currently collecting the required data for future assessment. However, since species in the higher trophic levels are often the ones that have been, or are being, most perturbed, the *Species at Risk Act* does address indirectly to some extent conservation of community/trophic structure.

## 5. Management of Contaminants and Pollutants

There are both federal and provincial approaches to the management of toxins and pollutants, in part depending on whether federal or provincial land or water is involved. Canadian Provinces have considerable authority, and are deemed to have control over most terrestrial land, freshwater and coastal seafloors (not the water column) between headlands.

### - General approach to management of contaminants and pollutants

Federal Legislation

*Canadian Environmental Protection Act (CEPA)*

The federal *Canadian Environmental Protection Act* (CEPA) of 1999 authorizes the Minister of the Environment and Minister of Health to investigate a wide variety of substances that may contaminate the environment and cause adverse effects on environmental or human health. The federal government is responsible for the management of risks to health and the environment posed by substances found to be toxic under CEPA. Under the federal Toxic Substances Management Policy, which is administered under CEPA, substances are considered toxic if they conform to the definition of a toxic substance as specified in CEPA. CEPA sets time limits for developing management strategies for substances found to be toxic under the *Act*. These strategies can include the preparation of regulations, pollution prevention plans, environmental emergency plans, environmental codes of practice, and environmental release guidelines. Once a substance has been determined to be CEPA-toxic, management strategies are developed with one of two possible objectives: 1) life-cycle management of the substance to prevent or minimize its release to the environment, or 2) virtual elimination of the substance from the environment. However, for CEPA-toxic substances which are also bioaccumulative, persistent and anthropogenic, the *Act* requires virtual elimination of that substance. CEPA does not regulate pesticides unless the active ingredient also has a non-pesticidal use and has been categorized as toxic under CEPA. The federal government policy for addressing toxic substsances is called the Toxic Substances Management Process.

Under the authority of CEPA, the Minister of the Environment can sign political commitments and agreements to address key issues of environmental protection and health. The Canadian Council of Ministers of the Environment (CCME), which includes federal, provincial and territorial environment ministers, has signed such an agreement, the Canada-Wide Accord on Environmental Harmonization and the Canada-Wide Environmental Standards Sub-Agreement. Under the framework of this agreement, the CCME develops Canada-wide Standards (CWSs) with the objective of establishing and achieving common environmental standards throughout Canada. CWSs can target specific substances or a number of sectors, sources, and substances. Action relating to the CWSs is taken by the jurisdiction deemed most appropriate. For many of the CWSs, action will be implemented by the provinces and territories. Where the federal government is identified as the most appropriate jurisdiction, regulations, codes of practice, or other preventive control instruments may be developed under CEPA.

For more information, refer to the following websites:

- Toxic Substances Management Process: (search in http://www.ec.gc.ca),
- List of CEPA-toxic substances (Schedule 1): http://www.ec.gc.ca/CEPARegistry/subs_list/Toxicupdate.cfm,
- Status of management strategies for CEPA-toxic substances: (search in http://www.ec.gc.ca),
- Existing regulations under CEPA: http://www.ec.gc.ca/CEPARegistry/regulations/default.cfm,
- Canada-wide Standards: http://www.ccme.ca/ourwork/environment.html?category_id=108.

*Fisheries Act*

While responsibility for the administration and enforcement for the *Fisheries Act* lies primarily with the federal Minister of Fisheries and Oceans, since 1978, the Minister of the Environment has had responsibility for the administration and enforcement of subsection 36(3) of the *Act*, which prohibits the deposit of substances that are deleterious to fish into a place where the substance may enter or does enter waters that are frequented by fish. Under this provision, the discharge of any quantity of a deleterious substance is prohibited, unless there is a regulation that permits that discharge. Under the *Fisheries Act*, any substance that may harm fish or alter fish habitat is considered deleterious. In addition, a number of sector-specific regulations under the *Fisheries Act* limit the release of toxic substances to the environment.

In addition, regulations for specific sources or industry sectors have been developed under the *Fisheries Act*. These include Pulp and Paper Effluent Regulations, Metal Mining Effluent Regulations, and Petroleum Refinery Liquid Effluent Regulations.

For additional information on the *Fisheries Act*, the general provisions of subsection 36(3), and the regulations pertaining to sector-specific releases of toxic substances, refer to http://www-heb.pac.dfo-mpo.gc.ca/water_quality/fish_and_pollution/fish_act_e.htm

*Pest Control Products Act (PCPA)*

The federal *Pest Control Products Act* (PCPA) is administered and enforced by the Pest Management Regulatory Agency (PMRA) for the Minister of Health. The PCPA regulates the use of substances that claim to have a pest control use and also substances such as formulants, adjuvants, and contaminants that are contained in pest control products. All compounds used for pesticidal purposes in Canada must be registered under the PCPA. Applications for pest control product registrations are reviewed by PMRA. In consultation with Environment Canada, PMRA considers science-based health, environmental, value and efficacy assessments for each pesticide prior to approving its use. Revisions to the PCPA have been completed and the revised PCPA came into force June 28, 2006. Under the revisions to the *Act*, PMRA will be able to provide to Environment Canada scientific studies and data that were submitted by chemical companies to support product registration. In BC, Environment Canada, in consultation with Fisheries and Oceans Canada, advises PMRA on regional concerns relating to unregistered pesticides and requests for emergency registrations.

For more information on the PCPA and the regulation of pesticides in Canada, refer to the PMRA website at http://www.pmra-arla.gc.ca/english/index-e.html. For an explanation of the recent revisions to the PCPA, refer to the PMRA website at http://www.pmra-arla.gc.ca/ english/legis/pcpa-e.html.

*Canadian Environmental Assessment Act (CEAA)*

This *Act* is administered by the Canadian Environmental Assessment Agency, which is accountable to Parliament through the Minister of the Environment. The CEAA specifies the responsibilities and procedures for conducting environmental assessments on projects conducted in Canada, which involve federal government decision making. The objective of the *Act* is to ensure that such projects do not cause significant adverse environment effects, by promoting a cooperative approach under which the federal and provincial governments review the potential impacts of these projects before decisions and actions are taken by the federal government. The process provides an opportunity for First Nations and public participation. The regulations under this *Act* identify the projects and classes of projects whose potential for causing adverse environmental impacts is considered sufficient to require an assessment under the CEAA. For more information on the CEAA, refer to http://www.ceaa-acee.gc.ca/013/index_e.htm.

*Migratory Birds Convention Act*

Section 35(1) of the *Migratory Birds Convention Act* prohibits the deposit of oil, oil wastes or any other substance harmful to migratory birds in any area frequented by migratory birds. Under this *Act* it is an offence to harm the habitat of migratory birds while the birds are in residence at the site. This includes the release of harmful substances (including pesticides) to areas frequented by them. For more information on the *Migratory Birds Convention Act*, search in http://www.ec.gc.ca.

*Fertilizers Act*

The *Fertilizers Act* is administered by Canadian Food Inspection Agency (CFIA). Fertilizers and supplements imported into or sold in Canada must be registered, packaged and labelled according to the requirements of this *Act*. In 1997, nonylphenol ethoxylates were banned as an active ingredient in soil supplements under the *Fertilizers Act.* For more information on the *Fertilizers Act*, refer to the CFIA website at http://www.inspection.gc.ca/english/ plaveg/ fereng/ferenge.shtml#actloi.

Federal Programs for Managing Municipal Wastewater Effluents

- In November 2003, the CCME agreed to develop a Canada-wide strategy for the management of municipal wastewater effluents (http://www.ccme.ca/ourwork/water.html?category_id=81). The strategy includes: 1) a harmonized regulatory framework, 2) coordinated science and research, and 3) an environmental risk management model.
- Environment Canada is developing a comprehensive federal strategy for municipal wastewater effluents, including addressing a number of substances found in municipal wastewater effluent that have been assessed as toxic under CEPA 1999. A contemplated long-term requirement of the federal stragegy is a regulation under the *Fisheries Act* which would include wastewater effluent standards equivalent in performance to conventional secondary treatment, with additional treatment where required.
- A CCME CWS on mercury for dental amalgam wastes was prepared in 2001. Through the collection and recycling of amalgam wastes and the use of advanced amalgam separator units at dental clinics, the amount of mercury discharged to sewer systems will be reduced. The intent of the CWS was to reduce environmental releases of dental amalgam in Canada by 95% by 2005, compared to releases in 2001.
- Under the Georgia Basin Action Plan (GBAP), Environment Canada, in cooperation with interested partners, is undertaking a projects to:
  - determine molecular level (genomic) toxicology of municipal wastewater effluents at receiving water concentrations to fish;
  - utilize in-house developed gene micro-arrays for salmonids to evaluate gene expression to either freshwater rainbow trout or seawater acclimated Pacific salmon. Effluents will be collected from the Greater Vancouver Regional District (GVRD) and Capital Regional District and adjusted to relevant receiving water concentrations in concert with District staff;
  - analyze select pharmaceuticals and fragrance compounds in-house and profile for molecular toxicity;
  - conduct sterol and select pharmaceutical chemistry on each effluent sample collected (~60 samples);
  - educate homeowners on the correct ways to care for their septic systems;
  - supporting technical and scientific conferences, such as the Annual BC Waste and Water Association Conference and Tradeshow.

For more information, refer to the following websites:

- CCME initiatives to reduce the release of contaminants in wastewater treatment plant effluent: http://www.ccme.ca/initiatives/water.html?category_id=81,
- CCME MOU with the Canadian Dental Association: http://www.ccme.ca/ourwork/water.html?category_id=118,
- Environment Canada programs to address municipal WWTP effluents: http://www.ec.gc.ca/etad/default.asp?lang=En&n=D5CE3A46-0,
- GBAP initiatives: http://www.ec.gc.ca/nature/default.asp?lang=En&n=B5519CB7-1.

Provincial Legislation

*Environmental Management Act (EMA)*

The BC Ministry of the Environement (BC MOE) is responsible for managing the release of wastes and other contaminants from the industrial and agricultural sectors, with the exception of waste discharges to the air in the GVRD which is under the jurisdiction of the GVRD. The pertinent provincial legislation is the *Environmental Management Act* (EMA), which controls the handling, disposal and release of wastes from industrial, provincial and municipal sources. The EMA was brought into force on July 8, 2004 and replaced the BC *Waste Management Act* (WMA).

Through a permitting system, the WMA had enabled allowable releases to be determined, based on scheduled standards (generally discharge volume, toxicity and chemical/compound concentration). Monitoring requirements in the permits depended on factors such as daily discharge rate and receiving environmental characteristics and, in some instances, receiving environment monitoring was required and was determined on a facility/site-specific basis.

Under the WMA, all discharges to the environment from industry, trades and businesses had to be authorized by the Ministry. However, the new EMA takes a risk-based approach in the authorization to discharge waste. Activities considered to be of medium to high-risk will require authorization to discharge waste. However, activities considered to be low risk will not require authorization to discharge, but will remain subject to the requirement that they not cause pollution. The BC MOE will prescribe industries/activities which require a waste discharge authorization through the EMA's Waste Discharge Regulation. Industries posing a high risk to the environment (such as mines and pulp mills) will require a valid authorization such as a permit or adherence to an existing regulation. Industries or activities considered to pose a modest risk to the environment will be required to adhere to province-wide codes of practice for that industry sector or activity. Operations will continue to require authorization through a permit, approval or regulation until accepted codes of practice have been established for that prescribed industry sector or activity. For more information on the *Environmental Management Act* refer to http://www.env.gov.bc.ca/epd/main/ema.htm.

*Integrated Pest Management Act (IPMA)*

The *Integrated Pest Management Act* (IPMA) replaced the *Pesticide Control Act* in 2004. Under this *Act*, the BC MOE addresses the application, storage, sale, transport and disposal of pesticides. The provincial integrated pesticide management program includes education and training programs, the licencing and certification of applicators and vendors, reviewing Pesticide Management Plans for managing pests, and the issuing of permits for the use of certain pesticides. For more information on the *Integrated Pest Management Act* and the provincial integrated pest management program, refer to http://www.env.gov.bc.ca/epd/ipmp/regs/index.htm.

*Mines Act*

The *Mines Act*, which is administered by the BC Ministry of Energy, Mines and Petroleum Resources, regulates the operation, health and safety of all BC mines. The regulations and orders under this *Act* prescribe most aspects of mine design and operation, like the stability of mine openings, dams and enclosures, and the prevention of pollution such as from acid rock drainage or acid mine drainage (AMD). Since 1969, this *Act* has required all mines to have bonds or letters of credit sufficient to ensure reclamation of mined lands. For more information on AMD, see http://www.focs.ca/reports/Catface_info_pkg/Acid%20Mine%20Drainage--FNEHIN.pdf.

## 6. Management of Aquaculture

A useful web site to review is the State-of-Knowledge Presentation for the Special Committee on Sustainable Aquaculture of the British Columbia Legislature at http://www.pac.dfo-mpo.gc.ca/science/aquaculture/sok-edc/aquamanage-gestionaqua-eng.htm.

The Strategic Plan objectives of 2005–2010 are to deliver programs that reflect the priorities of Canadians, in which aquaculture governance is a priority to achieve:
- healthy and productive aquatic ecosystems,
- sustainable fisheries and aquaculture.

General characteristics of aquaculture activities (*e.g.*, stocking or releasing of seed/fry/juveniles, production of individuals in contained environments) relative to the PNCIMA are:
- Finfish net pen culture of Atlantic salmon is primarily in the Broughton Archipelago; some sites are likely provincially licenced for sablefish but are not actively culturing this species yet;
- There are some test pilot shellfish aquaculture sites in First Nation territories;
- Very little shellfish culture in the PNCIMA (water is generally too cold);
- Shellfish culture of mussels (*Mytilus galloprovincialis*, *M. edulis*, *M. trossulus*), oysters (*Crassostrea gigas*), scallops (*Pactinopecten yessoensis*), and manila clam (*Venerupis philippensis*);
- The provincial government (Ministry of Agriculture and Lands) has authority to approve species cultured and licence requirements;
- Culture methodology is dependant on the species being cultured;
- Future cultures may include geoducks (*Panope abrupta*) and cockles (*Clinocardium*).

- *Do specific regulations address issues relevant to species selection, scale of the operation, spatial distribution, and environmental impact of activities?*

Species selection:
- is provincially regulated as part of the licence obtained; movement of species is regulated by the DFO introductions and transfer committee, and listed in the licence.

Scale of operation and spatial distribution:
- finfish are regulated by provincial and federal siting rules, provincial Finfish Aquaculture Waste Control Regulation, *Fisheries Act* Authorizations, including DEPOMOD modeling (modelling the deposition and biological effects of waste solids from marine cage farms), provincial land tenure requirements, and Transport Canada approval;
- shellfish are regulated by provincial management plan, conditions, siting and mitigation requirements within the Habitat Management Operational Statement or Letter of Advice, provincial land tenure requirements (some sites require Transport Canada approval).

Environmental impact:
- The provincial government requires monitoring of the benthic condition within the tenure under the provincial Finfish Aquaculture Waste Control Regulation. Under the provincial regulation, restocking cannot occur until near-field oxic conditions are demonstrated. This requirement limits the possibility for long-term habitat loss and cumulative effects. Fallowing is required prior to restocking in the event near-field anoxic conditions reported under the provinicial Finfish Aquaculture Waste Control Regulation. Site-specific differences have been observed with respect to benthic recovery and further research in this area is ongoing. For sites authorized by DFO, additional monitoring may be required on a site-specific basis.

- *Are there monitoring and inventory activities in place?*

Finfish
- Monitoring occurs for environmental effects (near-field monitoring is conducted by industry and far-field is conducted by DFO Science); auditing on-site management includes culture methods, species, *etc.* and is conducted by both the provincial and federal governments; on-site water quality monotoring, including dissolved oxygen levels, is conducted by industry; on-site feed monitoring is conducted by industry; on-site fish health is monitored by industry; escapes are reported to provincial and federal authorities – there is an Atlantic salmon watch program that monitors for Atlantics in natal systems; wild fish health is monitored by DFO/CFIA; sea lice abundance is monitored by industry and DFO Science; wild fish populations are monitored by DFO; CSSP (Canadian Shellfish Sanitation Program) monitoring is conduced by Environment Canada; research into contaminants and potential human health effects is conducted by Health Canada.
- Industry monitors for mortalities in their inventory.

Shellfish
- Government (federal and provincial) provides auditing regarding effectiveness of management approach.
- Culture of new species may require provision of baseline genetic information (*e.g.*, with geoducks).

- *Are there mitigation plans or activities underway?*

Finfish
- Extensive mitigation of harmful effects is required for the industry including meeting provincial environmental performance standards, contingency planning, provincial health plans, siting, best management practices, *etc.* The finfish industry is also required to provide habitat compensation when triggered.

Shellfish
- Conditions of licence, mitigation measures and siting are all used to minimize risk to wild fish and fish habitat.

- *Are there significant ecological and biological interactions that can be identified and are they given special consideration?*

Please see the State-of-Knowledge report, referenced above, for details.

Significance is evaluated on a site-specific basis and afforded appropriate management response based on the level of residual risk determined. The *Canadian Environmental Assessment Act* screening that is conducted for finfish aquaculture sites provides for a structured evaluation of the risks.

DFO management of ecological effects:

- Where an effect cannot be avoided through mitigation or design, those residual effects must be examined more closely to determine if they are negative (some effects can be positive or neutral);
- When a negative (or potentially negative due to uncertainty) residual effect remains, a risk management process is used to apply the appropriate management option.

**7. Management of Enhancement Activities (species and habitat)**

*Management objectives:* In 1977, backed by strong public support, DFO launched the Salmonid Enhancement Program (SEP) with the goal of stopping and reversing declines in salmon populations. It partnered with the BC MOE, which had responsibility for steelhead and cutthroat trout. As well, this government program set a new precedent as many British Columbia citizens became vital, hands-on partners in the effort. While DFO built major facilities (hatcheries and spawning channels), individuals and groups went to work cleaning up damaged streams and building small incubation boxes.

In a further effort to keep SEP in tune with local needs, the Community Economic Development Program (CEDP) was initiated in 1977/78, placing contracts with community-based groups to operate local enhancement projects.

Today, the scope of SEP is varied. Major hatcheries and spawning channels, on some of North America's greatest salmonid-producing rivers, incubate and release millions of juveniles each year. Slightly smaller, but effective, are the CEDP projects. Scientific research has contributed another technique: on Vancouver Island fertilization of lakes has greatly increased the production of sockeye salmon.

In some areas, SEP has turned to smaller technologies. Semi-natural spawning and rearing channels that require little or no ongoing staff or maintenance are producing fish in remote regions. Fish ladders and fishways provide access for spawners to areas once barren of salmonids. Volunteer projects have grown and matured. Besides leaving a legacy of improved habitat in many urban areas, these projects often produce salmonids from small, genetically-unique populations that might otherwise have vanished forever. In addition, every spring many neighbourhood creeks receive a few healthy fry that have been raised in a classroom by schoolchildren.

Not every project has been successful; many individual runs are still threatened by too many fishermen and too little habitat. However, in most rivers and streams, salmonids return every fall, as they have done for thousands of years.

The report "Pacific Salmon Hatcheries in British Columbia" summarizes salmon hatchery approaches (http://www.sehab.org/accomplishments/72-reports-recieved/162-pacific-salmon-hatcheries-in-british-columbia).

### 2.2.5 References

Anon. 2002a. Canada's Ocean Strategy. Fisheries and Oceans Canada. Oceans Directorate, Ottawa, ON.

Anon. 2002b. Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada. Fisheries and Oceans Canada. Oceans Directorate, Ottawa, ON.

Anon. 2003. A Strategic Planning Framework for the Eastern Scotian Shelf Ocean Management Plan. A Discussion Paper prepared for the ESSIM Forum. ESSIM Forum Secretariat. Oceans and Coastal Management Division. Maritimes Region, DFO.

Clarke, C.L. and Jamieson, G.S. 2006a. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: Phase I – Identification of Important Areas. 2678, 97 pp.

Clarke, C.L. and Jamieson, G.S. 2006b. Identification of Ecologically and Biologically Significant Areas for the Pacific North Coast Integrated Management Area: Phase II. 2686, 32 pp.

Cury, P.M., and Christensen, V. 2005. Quantitative ecosystem indicators for fisheries management. *ICES J. Mar. Sci.* **62**: 307–310.

DFO (Department of Fisheries and Oceans) 2004. Identification of Ecologically and Biologically Significant Areas. DFO Canadian Scientific Advisory Secretariat Ecosystem Status Report 2004/006, 15 pp.

DFO (Department of Fisheries and Oceans) 2005. A Framework for Developing Science Advice on Recovery Targets for Aquatic Species in the Context of the Species At Risk Act. CSAS Science Advisory Report 2005/054, 16 pp. (http://www.dfo-mpo.gc.ca/csas/Csas/status/2005/SAR-AS2005_054_e.pdf)

DFO (Department of Fisheries and Oceans) 2006. Development of Criteria to Identify Ecologically and Biologically Significant Species (EBSS) CSAS Proc. Ser. 2006/028, 45 pp.

DFO (Department of Fisheries and Oceans) 2007. Development of a Nationally Consistent Approach to Conservation Objectives. CSAS Proc. Ser. 2007/001, 18 pp.

FAO (Food and Agriculture Organization). 2003. Fisheries Management. The Ecosystem Approach to Fisheries. FAO Technical Guidelines for Responsible Fisheries. No. 4 (Suppl. 2), Rome, FAO, 113 pp.

Garcia, S.M. and Staples, D.J. 2000. 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.

Jamieson, G., Bauer, B. and Vandermeulen, H. 2003. Proceedings of the Central Coast Integrated Management Marine Environmental Quality Workshop, June 5–7, 2002, Parksville, BC. CSAS Proc. Ser. 2003/13.

Jamieson, G.S. and Lessard, J. 2000. Marine protected areas and fishery closures in British Columbia. *Can. Spec. Publ. Fish Aquat. Sci*. **131**: 414 pp.

Jamieson, G.S. and McCorquodale, B. 2004. Proceedings of the Central Coast Marine Environmental Quality Indicators Workshop. March 10-12, 2004, Parksville, BC. CSAS Proc. Ser. 2004/025: 50 pp.

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

Jamieson, G.S. and Davies, H. 2004. State of Knowledge of Marine Habitats of the Northern B.C. Coast in Oil and Gas Lease Areas. Canadian Science Advisory Secretariat Research Document 2004/009, 175 pp.

O'Boyle, R. 1993. Fisheries Management Organizations: A study of uncertainty. pp. 423–436 *in* Risk Evaluation and Biological Reference Points for Fisheries Management edited by S.J. Smith, J.J. Hunt, and D. Rivard,. *Can. Spec. Publ. Fish. Aquat. Sci.* **120**.

O'Boyle, R. and Jamieson, G. 2006. Observations on the implementation of ecosystem-based management: Experiences on Canada's east and west coasts. *Fish. Res.* **79**: 1–12

O'Boyle, R. and Keizer, P. 2003. Proceedings of Three Workshops to Investigate the Unpacking Process in Support of Ecosystem-based Management. CSAS Proc. Ser. 2003/004.

O'Boyle, R., Sinclair, M., Keizer, P., Lee, K., Ricard, D. and Yeats, P. 2005. Indicators for ecosystem-based management on the Scotian Shelf: bridging the gap between theory and practice. *ICES J. Mar. Sci.* **62**: 598–605.

Pajak, P. 2000. Sustainability, ecosystem management, and indicators: Thinking globally and acting locally in the 21st century. *Fisheries* **25**: 16–30.

PICES 2004. Marine Ecosystems of the North Pacific. PICES Special Publication 1, 280 pp. http://pices.int/publications/special_publications/NPESR/2005/File_9_pp_153_176.pdf#page=1

Powles, H., Vendette, V. and O'Boyle, B. 2004. Proceedings of the Canadian Marine Ecosystems Workshop. DFO CSAS Proc. Ser. 2004/016, 54 pp.

Sainsbury, K. and Sumaila, U.R. 2003. Incorporating ecosystem objectives into management of sustainable marine fisheries, including 'best practice' reference points and use of Marine Protected Areas. pp. 343–361 *in* Responsible Fisheries in the Marine Ecosystem *edited by* M. Sinclair and G. Vladimarsson, FAO and CABI Publ.

Sinclair, A. 2007. Trends in Groundfish Bottom Trawl Fishing Activity in BC. CSAS Proc. Ser. 2007/001: 18 pp.

## 2.3 Japan

### 2.3.1 Ocean Management Activities Relative to Ecosystem-based Management

In Japan, fisheries management is conducted on a species-by-species basis. A national definition of EBM has not been established, but the Japanese *Law of the Preservation and Management of Marine Biological Resources* requires that the government should take inter-specific relationships as well as other biological or socio-economic factors into account when it decides the total allowable catches (TACs) of important fishery resources or total allowable effort (TAE) for certain fisheries. Thus, it is clear that we should take an ecosystem perspective into account. For that purpose, we are monitoring physical environmental factors and marine productivity along with the effects of fishery resource management (Table 2.3.1).

**1. Fishery Management**

**Coastal fisheries**

Fisheries resource management in Japan has been basically left to fishermen themselves who are licensed by either the national government or local government. Self-management or mutual regulation has been the traditional style in Japan's fisheries. However, in recent years Western-style fisheries management, that is, with management measures decided by the government on the basis of science and assigned to fishermen using a top-down style, has been also adopted in Japan, mostly for offshore fisheries.

In coastal fisheries especially, the self-management system by fishermen licensed by the government or local governments has been effective. Below, an example of a self-resource management system in a coastal area is shown, *i.e.*, the sand eel fishery in Ise Bay in the central part of Japan.

The sand eel is a cold current fish that has the unique characteristic of estivating in summer by digging into the sand, except in the northern part of Japan. The duration of estivation in Ise Bay is continuous from June to December. The sand eel spawns in winter after estivation. Fishermen are permitted to catch juvenile sand eels from March to May. They start catching from such a young stage because the market value is high in this stage. Sand eel mature one year after hatching and adult sand eel are caught in January and February. The core measures for self-management

**Table 2.3.1** Organization of fishery management bodies in Japan.

| Level | Organization | Function |
|---|---|---|
| National | Fishery Policy Council | The advisory body to the government for national level fishery coordination, design of national fisheries policy, *etc.* |
| Multi-jurisdictional | Regional Fisheries Coordinating Committees (RFCC) | Coordination of resource use and management of highly migratory species. It also addresses Resource Restoration Plans. |
| Prefectural | Area Coordinating Committees (ACC) | Mainly composed of democratically elected fishermen. Coordination is through the Fishery Ground Plan, Prefectural Fishery Coordinating Regulations, and Committee Directions. |
| Local | Local Fisheries Cooperative Associations (local FCA) | Composed of local fishermen. They establish operational regulations (FCA regulations) that stipulate gear restrictions, seasonal/area closures, *etc.* according to the local environment. |
| More specialized purpose | Fishery Management Organizations (FMO) | Autonomous body of fishermen. FMO rules are more detailed and stricter than the FCA regulations. It is composed of fishermen with the same gear or same target fisheries. |

of resources are:

1. Protect spawning fish through preservation of habitat during estivation,
2. Protect larvae and juveniles by establishing a closed season, and

Ensure the proper escapement of sand eels before estivation by closing the fishery.

Other appropriate self-management measures for target resources are carried out in many places around Japan, taking into account the life history of the species and the habitats on which they depend.

**Offshore fisheries**

Off-shore fisheries, such as purse seining, are also restricted in fishing effort by a Japanese license system that prohibits open access, except for small-scale line fishing. Besides these traditional regulations that still exist, fisheries management under a TAC approach has been conducted since 1997 for some fisheries resources in Japanese offshore waters.

Fishes managed by TACs in Japan are jack mackerel (*Trachurus japonicus*), Japanese common squid (*Todarodes pacificus*), saury (*Cololabis saira*), sardine (*Sardinops melanostictus*), chub mackerel (*Scomber japonicus*), spotted mackerel (*Scomber australasicus*), snow crab (*Chionoecetes opilio*), and walleye pollock (*Theragra chalcogramma*).

These species inhabit the pelagic warm current ecosystem around Japan. They spawn in the southern or middle part off Japan and migrate as far as the extent of the mixed water region, that is, to the area where the warm current (Kuroshio) and the cold current (Oyashio) mix. Biological reference points (BRPs) specific to each species are decided, based mainly on spawner–recruitment relationships in recent years and the allowable biological catch (ABC), which gives a scientific basis of the TAC which is calculated using the BRPs for each species. BRPs are set according to the level of each stock of fish. For fish stocks in a low level of abundance and which require recovery, the target stock level to recovery is determined and a BRP is set to achieve the level within a decided timeframe. For fish stocks in good condition, BRPs are usually set to ensure the current stock level.

Besides the TAC system, a TAE system has been employed since 2003. TAE is a management measure which sets an upper limit to the fishing effort allowed. Target species under this management system are both coastal and offshore species, *i.e.*, flathead flounder (*Hippogrossoides dubius*), sand eel (*Ammodytes personatus*), sharkskin flounder (*Clidoderma asperrimum*), Spanish mackerel (*Scomberomorus maculatus*), tiger puffer (*Takifugu rubripes*), small-mouthed sole (*Limanda herzensteini*), marbled sole (*L. yokohamae*), slippery (willowy) flounder (*Tanakius kitaharai*) and spear squid (*Loligo bleekeri*).

Resource Recovery Plans developed by the government have also been introduced for many coastal and offshore resources since 2002. As of 2006, 28 plans are being implemented in nearly all fishing regions of Japan. Those plans include measures such as:

1. reduction in fishing effort,
2. active cultivation of resources through release of larval and juvenile fish,
3. conservation of the fishing ground environment,
4. ecological properties of the species (*e.g.*, where it is on the r-K spectrum, *i.e.*, top predator, intermediate predator–prey, prey species).

The warm current ecosystem fish species described above, *i.e.*, jack mackerel, Japanese common squid, saury, sardine, chub mackerel and spotted mackerel feed mainly on zooplankton and are categorized in the same ecological niche, *i.e.*, as secondary consumers in the marine pelagic ecosystem. These fishes have experienced wide fluctuations in their stock size on decadal scales and are indicative of the phenomenon that a dominant species is periodically replaced by other species over time. Sequential replacement of dominant species has not been explained by bottom-up control, so the existence of inter-specific relationships among those species is suspected. By this we mean that there is a pathway of sequential replacement of dominant species, *e.g.*, 'usual' level of interannual recruitment variability leads to highly variable recruitment interannually which, in turn, leads to episodic recruitment and dominant species shift (Fig. 2.3.1).

The biomass of these fish stocks fluctuates widely in size on decadal scales. In the 1930s, sardine was dominant among these fishes. After sardine declined, Japanese common squid, saury and jack mackerel increased in abundance. After that, chub mackerel increased in abundance in the1960s. In the 1970s and 1980s, sardine increased remarkably again and decreased rapidly in the 1990s. Presently, saury, jack mackerel and Japanese common squid are again showing relatively high stock size levels.

It is thought that sardine stock size fluctuations, which were the most remarkable among those fishes, was mainly due to bottom-up controls in the ecosystem, accompanied by environmental changes such as a regime shift.

- *Planned management responses (control rules, recovery rules and targets)*

The target stock size and B(limit) are set in advance for sardine, chub mackerel, jack mackerel and walleye pollock. When the stock size of a certain stock falls short of its B(limit), F(fishing mortality coefficient) will be reduced linearly.

Target reference points for the following fishes in 2004 are (Table 2.3.2):

**Table 2.3.2** Target reference points for Japanese fish stocks in 2004.

| | |
|---|---|
| Jack mackerel | (Pacific stock): F(sus)*<br>(Tsushima Current stock): F(current) |
| Japanese common squid | (fall spawning stock): F(msy)<br>(winter spawning stock): F(sus)* |
| Saury | F(msy) |
| Sardine | (Pacific stock): F which recovers stock size up to 13,000 t in 2009<br>(Tsushima Current stock): B(ban)** |
| Chub mackerel | (Pacific stock): F which recovers spawning stock size up to 100,000 t in 2006<br>(Tsushima Current stock): 0.8F(current) |
| Spotted mackerel | (Tsushima Current stock): F(current) |

*F(sus) means F which sustains current stock sizes. F(current) means F which sustains current F (Fishing Mortality Coefficient), not current stock size.
**B(ban) is the stock size at which fishing should be stopped.

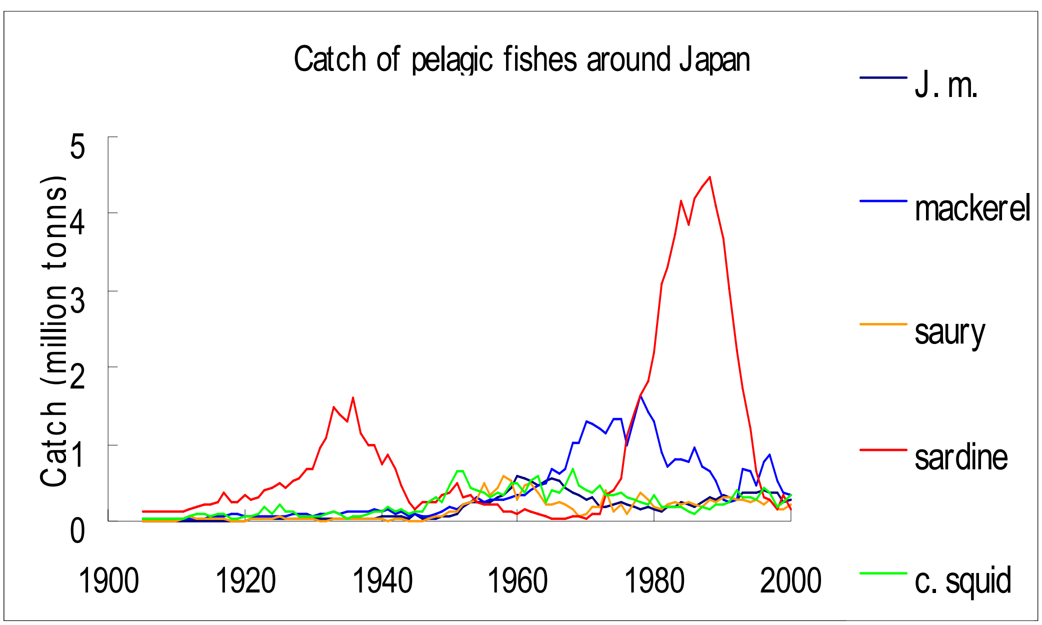


**Fig. 2.3.1** Sequential replacement of dominant fish stocks on decadal scales. J.m. = jack mackerel and c. squid = Japanese common squid.

Measures are taken for bycatch species which can be described using a general approach for a representative selection of species/groups. For groups which have a propensity to be caught in bycatch, *i.e.*, sea turtles and sea birds, we are investigating their biology and stock abundance and have developed devices to avoid bycatch and have adopted them in fisheries.

## 2. Management of Threatened or Protected Species and Communities

Our fishery control rule decides that the allowable biological catch (ABC) should be zero when the stock size falls short of its B(ban). At present, the stock size of the Tsushima Current stock of sardine was nearly equal to B(ban) which was decided on a biological analysis. So an ABC for this stock could not be described or set.

- *Ecological properties of the species or groups*

Sardine showed a remarkable fluctuation in catch on decadal scales. This may be due to a fluctuation in the mortality rate in early life stages, although the details of this process are not clear.

- *Level of natural variability*

The stock size could not be estimated precisely in recent years because the stock is too small. Judging from several indices, the stock size in recent years may be smaller by two orders of magnitude than that of 1980s.

- *Planned management responses (control rules, recovery rules and targets)*

The recovery plan for this stock is to prohibit catch and increase spawning stock biomass.

## 3. Habitat Management

A few examples are:

- preservation of habitat used during estivation by sand eels in Ise Bay (explained above),
- preparation of seaweed beds for spawning of sailfin sandfish in Akita Prefecture,
- placing blocks on the the seabed to protect young snow crab from trawl fishing in Kyoto Prefecture.

## 4. Community/Trophic Structure Management

Data here describe the approach to management of food webs, in general, and of direct feeding interactions (predator–prey relationships involving the target species), specifically.

This type of management has not been introduced into practice yet in Japan. However, we understand that we should be clarifying ecosystem structure and quantifying energy flows among ecosystem elements and culls from every trophic level to properly preserve the diversity of marine ecosystems. For direct feeding interactions (*e.g.*, predator–prey relationships) that directly involve the target or other highly valued species, we must particularly define these interactions.

## 5. Management of the Physical Environment (including Freshwater Discharge from Land)

In offshore ecoregions, influences from land for ecosystem conditions may be negligible, but we think fluctuations in the natural marine environment (the strength of the Aleutian Low, El Niño, *etc.*) are important factors influencing the status of offshore ecosystems. Therefore, we are monitoring general environmental factors over a long timeframe.

In contrast, we must consider many influences by human activities in coastal ecoregions. Local governments, as well as the central government, bear the responsibility for their environments and are responsible for managing the influence of human activities to sustain the environment within a desirable status range.

Generally speaking, environmental factors, such as the quality of water, have improved as compared with the conditions in the 1970s or 1980s, but enviornmental changes, *e.g.*, eutrophication, occurrence of red tides or oxygen deficient waters, all occur around Japan.

## 6. Management of Contaminants and Pollutants

The permissible amount of contaminants and pollutants is established by law and levels are monitored by environmental authorities.

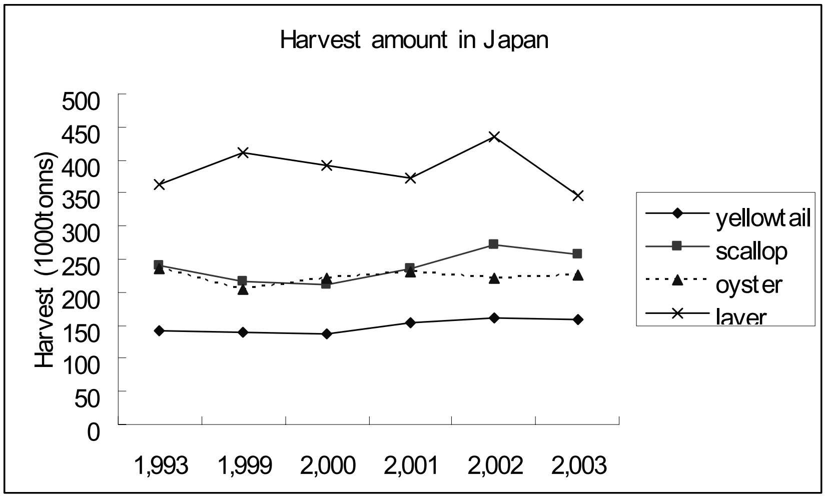


**Fig. 2.3.2** Levels of aquaculture harvest in Japan.

## 7. Management of Aquaculture

The major aquaculture species in Japan are scallops, oysters, yellowtail and laver (marine plants). Scallops are bivalves which occur in coastal areas of the Oyashio current region (cold water). Wild larvae are collected in the sea. Oysters are found all around Japan. Yellowtail is a piscivorous fish which hatches mainly in the East China Sea but is distributed all around Japan. Wild juveniles found under drifting seaweeds are the source of fish for their culture. Laver is a red algae which occurs in semi-closed coastal shallow seas.

**- Level of harvest variability**

Harvest levels of these species are relatively stable (Fig. 2.3.2).

## 8. Management of Enhancement Activities

**- General properties of enhancement activities (*e.g.*, stocking or releasing of fry/juveniles, constructing artificial reefs, making seaweed beds, *etc.*)**

The released fry/juveniles of chum salmon and scallops are numerically the most heavily stocked species in Japan. Other major species whose juveniles are released for stock enhancement are Japanese flounder (*Paralichthys olivaceus*), red sea bream (*Pagrosomus major*) and prawn (*Marsupenaeus japonicus*).

## 2.4 People's Republic of China

In China, coastal waters have mostly been fully or over-exploited by activities, including fishing and mariculture. High fishing intensity, increasing pollution and climate change have caused stock depletion of some commercially high-valued, large-sized species, and this, combined with environmental degradation, has brought attention to the loss of marine habitats and frequent outbreaks of toxic red tides. Mariculture also has adverse effects, including contamination of the coastal environment by fish wastes, pesticides, and antibiotics; spread of diseases; and escapement of non-native species. The Chinese government has recognized these problems and has promulgated several laws and regulations to prevent pollution, both directly in the sea and from land-based sources, and has zoned marine areas to include rational arrangements for the siting of mariculture areas and designation of marine protected areas.

For ecosystem-based management (EBM), a better understanding of ecosystems is essential. Food web dynamics and species interactions have been studied in China through the GLOBEC (Global Ocean Ecosystem Dynamics) programs in the Bohai Sea, Yellow Sea and East China Sea. Although scientific knowledge is still insufficient and the coastal zones, especially, were not well included, work has progressed. The effects on the ecosystem from releasing species need to be evaluated. In order for EBM to be understood by all people and to be more operational, socio-economic factors must be considered in the establishment of an integrated management system. All management agencies, not just those relevant to fisheries, should participate.

### 2.4.1 Agencies Involved in Ocean Management

In China, several government agencies are involved in regional governance of the Yellow Sea region and other marginal seas. The national government is the most important stakeholder in regional environmental governance in the ocean, and local governments' involvement is low. The State Oceanic Administration has been heavily involved in all ocean affairs, except for management of fishery resources and fisheries activities which are managed by the Ministry of Agriculture. The State Environmental Protection Administration is mostly involved in the control of land-based sources of coastal pollution and the Ministry of Communications is in charge of shipping and harbors. Therefore, several ministries have authorities for ocean issues.

The promulgation and enforcement of the Law of Fisheries of the People's Republic of China in 1986 is a milestone in the development of China's fisheries history. Since that time, Chinese fisheries have been in a period of rapid development. The Law of Fisheries prescribes the legal basis for a fishery development policy suited to China's conditions. This legislation has been important to the adjustment of fisheries activities, and to conservation and rational utilization of fishery resources, as fishery enforcement capability has been strengthened. The Law of Fisheries was amended in 2000, and a quota management approach was determined to be the way forward. In addition, the Law of Marine Environment Protection and Law of Sea Use Management were put into effect in 2000 and 2002, respectively.

However, due to the effects of global changes and increasing human activities, inshore fishery resources in Chinese coastal waters have mostly been fully or over-exploited. These fisheries highly depend on a market for small-sized, low-valued species. With the development of industrial fisheries and aquaculture near coastal populated areas, pollution and habitat degradation in the coastal waters is recognized as serious. In addition, the frequent occurrence of harmful algae blooms and introduction of non-native species through aquaculture and ballast water discharges are adversely affecting Chinese coastal waters and threaten the health of the ecosystem and its biodiversity.

For sustainable utilization of marine living resources and maintenance of biodiversity, EBM is necessary and it is a management target for Chinese ocean and fisheries policies in order to benefit the social economy. EBM of marine fisheries in China is, at the least, related to tasks under the jurisdiction of the Ministry of Agriculture (fisheries), State Oceanic Administration (oceanic affairs excluding fisheries), and State Environmental Protection Administration (pollution control). There is no single governmental agency designated to coordinate integrated EBM policies.

### 2.4.2 Fisheries Management Measures for Ecosystem-based Management

EBM is related to the management and the direct and indirect human activities which affect the ocean, particularly with respect to fisheries resources. The following are management measures for EBM.

1. *Output Control* – Based on the existence of high fishing pressures and many fishermen, a single species total allowable catch (TAC) is not practical to enforce at present.

2. *Fishing Measures* – China has established banned fishing areas for motorized trawlers in coastal waters, closed seasons and areas for major spawning grounds, licensing, minimum mesh sizes, and minimum landing size and limits on the percentage of bycatch for young fish. These regulations have been in effect since the 1950s.

3. *Catch Limits* – China has established a cap (limit) on total marine catches since 1999 (zero growth policy).

4. *Input Control* – In order to reduce fishing effort (and by inference, fishing mortality), the Chinese government has arranged payment of 270 million CNY each year since 2002 to subsidize the scrapping of old fishing boats and to encourage fishermen to change to alternative employment. The number of marine fishing boats is planned to be reduced from 222,000 boats in 2002 to less than 192,000 boats in 2010, with an average reduction of 3,750 boats each year. Meanwhile, the building of new fishing boats is strictly controlled.
5. *Summer Fishing Ban* – Since 1995, China has completely closed fishing in the Yellow, Bohai and East China seas for 2–3 months in the summer. In 1999, this ban was extended for 2.5 months in the region north of 35ºN, 3 months for south of 35ºN, and 2 months on the continental shelf of the South China Sea. These measures are effectively protecing spawners and juveniles, and catches and size of fish caught have observably improved.

6. *Mariculture* – Mariculture is being managed to achieve better distribution of siting relative to production and pollution control

7. *MPAs* – Ten marine protected areas were established in 2007. They are, so far, limited in distribution to coastal waters.

8. *Stock Rebuilding* – To enhance ecosystem health, stock enhancement has been in effect for more than 20 years. The main species are high-valued species, particularly penaeid shrimp (*Penaeus chinensis*) in the Bohai Sea, Yellow Sea and East China Sea since the mid-1980s. Other artificially hatched juvenile species, such as scallop, abalone and jellyfish are also released into coastal waters. Since the late 1980s, some artificially hatched juvenile fishes have been released, such as red sea bream (*Pagrosomus major*), marbled sole (*Pseudopleuronectes yokohamae*) and redlip mullet (*Liza haematocheila*). In recent years, juvenile large yellow croaker (*Pseudosciaena crocea*) have been released in the East China Sea to rebuild the depleted stock. Artificial reefs are being built in some coastal areas.

9. *Monitoring* – Parameters that are being monitored in China with respect to fisheries ecosystems are: 1) relative biomass, species composition, variation in mean length, trophic level of the catch, size-at-maturity, biophysical characteristics, long-term effects on the ecosystem of different fisheries management measures, 2) ecological effect of enhancement, 3) effectiveness of the complete summer ban on the conservation of juveniles, and 4) ecosystem benefits, and total economic benefit to society.

## 2.5 Republic of Korea

### 2.5.1 Ocean Management Activities Relative to Ecosystem-based Management

Elements of ecosystem-based management (EBM) may be 1) sustaining yields, 2) maintaining biodiversity, 3) protection from the effects of pollution and habitat degradation, and 4) maintaining or increasing socio-economic benefits. Based on these elements, initiatives in the spirit of EBM have been established in 14 *Acts* and 15 Presidential and Ministerial Orders. One of the major EBM initiatives in Korea is the *Basic Act of Ocean and Fisheries Development*, which describes the maintenance of biodiversity in marine ecosystems, and the protection and restoration of habitats for marine living resources.

Most of the Korean *Acts* in the context of EBM are focused more on the elements of the maintenance of biodiversity and protection from the effects of pollution and habitat degradation, rather than on sustainability of yields and provision of socio-economic benefits. The *Basic Act of the Land* also describes the conservation of the natural ecosystem, including mountains, rivers, lakes, estuaries, and oceans, and the mitigation and restoration of the ecosystem, based upon comprehensive EBM.

#### 1. Fishery Management

Korean fisheries have been managed by a variety of tools, such as input and output controls and technical measurements. Current initiatives of EBM in Korea include the establishment of precautionary total allowable catch (TAC)-based fishery management, closed fishing seasons/areas, fish size- and sex-controls, and fishing gear restrictions.

The general approach to retained species management in fisheries is the annual TAC-setting process under a precautionary TAC-based fishery management system. Recognition of uncertainty and its potential consequences have led to the adoption of a precautionary approach (PA) in many international agreements on fish stocks. The PA is focused on reducing the likelihood of fisheries having adverse impacts on marine resources and the host ecosystem.

Since 2000, Korean fisheries law has made provisions for the implementation of a TAC-based fishery management system in order to conserve and rationally manage fisheries resources in the Korean Exclusive Economic Zone (EEZ). A comprehensive monitoring and enforcement program has been developed for this management system. Ten species are currently managed under the Korean TAC-based fisheries management system: three species of pelagic fish (chub mackerel, jack mackerel, Pacific sardine); four species of shellfish (pen shell, hen cockle, spiny top shell, common squid); and three species of crabs (snow crab, red snow crab, blue crab). The annual stock assessment report is prepared by the stock assessment scientists of the National Fisheries Research and Development Institute (NFRDI) which sets the allowable biological catch (ABC) based on stock assessment models listed in the order of the quality and quantity of information required. Five tiers of information are used to estimate ABC (Zhang and Marasco, 2003). In tiers 1 to 3, reference points of management are suggested, that is, fishing mortalities (F) of $F_{35\%}$, $F_{40\%}$, and $F_{0.1.}$ In tiers 4 and 5, ABC is estimated from the fishery-dependent information, that is, time-series catch and effort data. The ABC recommendation from NFRDI is passed directly to the TAC Committee of the Ministry of Maritime Affairs and Fisheries (MOMAF) for the selection of TACs for target species and target fisheries by gears within the Korean EEZ, which are determined to be less than or equal to the ABCs estimated by stock assessment scientists.

Based on the *Fishery Act*, fishing seasons and fish size/weight limits are enacted for 41 species including Pacific cod, walleye pollock, and salmon. In Korea, fishing seasons for 24 species during their main spawning seasons are closed. Fish size or weight regulation is applied for 27 species, based on the 50% spawning length or weight of each species. Both fishing seasons and fish size or weight regulations are applied for 10 species, including Pacific cod. In July 2005, MOMAF added 31 species (19 fish, three crustacean, two shellfish, five seaweeds, and two cephalopods) to the list of fishing seasons and/or fish size or weight regulations. Catch of females of two crab species (snow crab and red snow crab) are not permitted.

Restrictions on some fishing gears are enacted, for instance, gillnets of more than two layers of netting are prohibited in Korean waters. The sizes of nets and meshes are restricted in 19 fisheries. Gear restrictions are set for 18 fisheries to conserve spawning and juvenile stocks and their habitats. The size of offshore and coastal fishing vessels is limited in terms of gross tonnage. The number of licenses for five kinds of aquaculture farming and set net fisheries is limited by fishing gear and area, and the duration of a license is limited to 10 years. Permission to fish is required for 13 kinds of offshore fishing gears, 16 kinds of coastal fishing gears, 10 kinds of deep-sea fishing gears, and two kinds of set net; and for seed production fisheries. Fishing using trawl, purse seine, gillnet, stow net, and dredge net for 12 species is not allowed in coastal areas year-round but permitted offshore, based on the distance of conventional fishing areas from land.

Zhang *et al.* (2009) recently developed a pragmatic ecosystem-based fisheries risk assessment method for Korean fisheries. This approach was developed to measure the risks associated with Korean fisheries relative to three different management objectives (sustainability, diversity, and habitat quality). For each objective, Zhang *et al.* (2009) assessed the risk of achieving an ecosystem goal by developing reference points for each indicator. Based on this information, the study developed pragmatic risk indices that were used to assess the status of a management unit. This assessment framework is expected to be used for implementing an EBM for Korean fisheries in the near future.

## 2. Management of Threatened Protected Species and Communities

When an animal species is categorized as an endangered species, the Minister of Food, Agriculture, Forest and Fisheries (MIFAFF) should take action to conserve the animal. The designation of endangered fisheries animals requires consideration of all of the following: 1) fisheries animals which are regulated by CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora), 2) endangered wild fauna and flora, specified by the *Natural Environment Conservation Act*, Article No. 2 Clauses 6 and 7, and 3) fish species which are valuable for protection scientifically, and which are requested for protection for research by research institutes that are endorsed by the Minister of MIFAFF. The Minister has to announce the designated fish species as a protected target species according to the above provisions (1) and (2), and should conduct proper steps to protect it.

## 3. Habitat Management

The habitats that are used by some or all of the life history stages of many species of fish are sometimes known, but the habitat utilization does not mean that the habitat is obligatory (*i.e.*, that the species must have the habitat to successfully carry out its whole life cycle). The mechanistic relationship between a fish species at a particular life history stage and the type of habitat it occupies should be known for most species and life history stages. It is most critical to understand the essential fish habitat inshore, where anthropogenic effects on habitat are likely to be most significant.

To ensure the opportunity for the propagation and conservation of fisheries resources, spawning and nursing areas are protected from fishing in Korea. Currently, a total of 10 areas in bays and estuaries (1,289 km$^2$ of land, 2,542 km$^2$ of shore) and 21 areas around lakes are regulated by *Acts*. To conserve biodiversity in wetlands, five areas (141 km$^2$) along the west coast and seven areas (44.48 km$^2$) around mountains, lakes and estuaries are designated and managed by *Acts*, and nine more areas along the coastline from the west coast to the south coast are scheduled to be designated in the near future.

The Korean government is currently developing a comprehensive ecosystem-based marine ranching program. This program is designed to carry out the enhancement and efficient management of fisheries resources, and thus requires an understanding of ecological interactions among major species with respect to predation, competition for prey species, effects of climate on fish ecology, interactions between fishes and their habitats, and the effects of fishing on fish stocks and their ecosystems. Based on the knowledge and such an understanding, fisheries management could avoid significant risks and potentially irreversible changes in marine ecosystems caused by fishing or marine ranching. The Tongyoung Marine Ranching Program has been conducted since 1998 as a pilot program for a comprehensive EBM in Korea. Currently the marine ranching programs are carried out in four other areas: in Gangwon, Taean, Jeonnnam, and Jeju.

## 4. Community/Trophic Structure Management

Recently, research projects for developing a management plan considering trophodynamic relationships in marine ecosystems were initiated in Korea. These are some marine ranching ecosystem management projects, such as Tongyoung, the Jeonnam Archipelago area, and three other marine ranching areas, which aim to understand the structure and function of an ecosystem using the Ecopath/Ecosim model. This kind of research is still at the beginning stages, and these projects will be gradually extended in Korea.

## 5. Management of Physical Environment (including Freshwater Discharge from Land)

Ecosystem monitoring in the East China Sea takes place where the construction of the Changjiang River dam has been conducted to understand how changes in freshwater discharge off the land can influence coastal and offshore fish populations and their ecosystem around the Korean Peninsula. The study area of this monitoring includes geophysical, chemical, and biological oceanographic characteristics and ecological modeling.

## 6. Management of Contaminants and Pollutants

Contaminants and pollutants have been managed by the *Basic Act of Environment Policy* (BAEP) since 1980. The management regions are categorized into river, pond and lake, and ocean. The management targets are based on eight standards measurements of the environment including pH, BOD, COD, DO, total nitrogen, and nine standards related to the protection of human health, including Cd, As, CN, Hg, and PCBs. The classification of river, pond and lake quality using five levels of freshwater quality, and as a system for the ocean using three levels of ocean water quality is monitored by an integrated coastal environment management system. For the preservation of a clean and safe ocean environment with systematic water-quality control, sea areas for special environmental management will be expanded from nine areas in 2000 to 30 areas in 2010. MIFAFF has tried to conserve coastal ecosystems by mapping estuaries and by providing necessary laws to create wetland conservation areas. NFRDI has continuously developed techniques to prevent or mitigate the effects of red tides. Moreover, NFRDI tries to make the ocean environment cleaner and safer by formulating a national contingency plan against oil spills, and by establishing a comprehensive marine traffic management network.

## 7. Management of Aquaculture

The total size of aquaculture areas is about 122 kilohectares (kha) and that of seaweed culture areas is 68 kha, accounting for 55.8% of the total area of aquaculture. Current cultured species number about 50, including seaweeds, flounder, rockfish, oysters, clams, shrimps, scallops, and abalone. Management activities of aquaculture are focused on the development of aquaculture species in order to meet the demand of the global fish market and sustainable production, and to follow the global market system, such as World Trade Organization/Doha Development Agenda (WTO/DDA) and Free Trade Agreement (FTA). Development of new aquaculture species is strictly banned and renewing the expired licenses of aquaculture is very limited.

## 8. Management of Enhancement Activities

In Korea, construction of artificial reefs is aimed at improving productivity of devastated fishing grounds by providing fish resources with habitats, and spawning and nursery grounds. Since 1971, 2,818 fishing grounds have been augmented, with artificial reefs covering a total area of 168 kha, requiring an investment of 550 billion Won, as of 2003. A total of 55% of the area with artificial reefs is utilized as fishing grounds and the other 45% is preserved for fisheries. In terms of construction area by sea region, the area off the East Coast of Korea accounts for 25.8%, off the West Coast, 19.4% and off the South Coast, 54.8%, *i.e.*, more than half of the artificial reefs were laid off the South Coast.

In Korea, construction projects for seaweed culture enhancement started in 2002. The project spent 3.49 billion Won from 2002 to 2004. In 2005, the Fisheries Resources Enhancement Center of NFRDI conducted a preliminary experiment in three provinces (Gangwon, Kyungbuk, Jeju) for three years, investing three billion Won each year to the seaweed bed project (Jeon, 2004).

Since 1998, NFRDI has developed seed production technology to release strong juveniles of rockfish and sea bream. Seed production has successfully enhanced fishery resources and increased the incomes of fishermen. In the early stages of seed production, national facilities took the lead to develop techniques, but private companies produce the seed currently. A total of 19 species, such as abalone, flatfish, sea bream and sea slug, are targets to be produced and a total of 203 million juveniles of all species have been stocked in the sea. A total of 19 million juveniles of horseshoe crab, carp, crucian carp and another seven species were stocked in inland waters (Jeon, 2004).

### 2.5.2 References

Jeon, I.G. 2004. Status and problems of stock enhancement. Symposium on the stock rebuilding in Korean waters. pp 95–123. NFRDI, Busan, Korea.

Zhang, C.I. and Marasco, R. 2003. New approaches in fishery assessment and management under the exclusive economic zone regime in Korea. *Am. Fish. Soc. Symp.* **38**: 685–693.

Zhang, C.I., Kim, S., Gunderson, D., Marasco, R., Lee, J.B., Park, H.W. and Lee, J.H. 2009. An ecosystem-based fisheries assessment approach for Korean fisheries. *Fish. Res.* **100**: 26–41.

## 2.6 Russia

### 2.6.1 Ecosystem-based Principles in Contemporary Fisheries Management in the Russian Far East

This paper consists of three parts. First, is a general characterization of contemporary Russian fisheries made with special attention given to the Russian Far East. The total allowable catch (TAC) setting system is briefly described and catch values for recent years are presented. Attention is also paid to legislation and problems derived from its implementation in fisheries management.

The second part deals with the ecosystem studies of marine biological resources. Using the recent literature review by Professor V. Shuntov *et al.* (2007), contemporary results and understandings of fishery stock dynamics are presented. These create a good basis for the current ecosystem-based principles in Russia.

The third part is devoted to fishery rules in the Far Eastern Basin, based on a new 2007 document. On one hand, this document is a fundamental basis for future developments in this field. On the other hand, it is also changeable like the famous "soft watches" painted by Salvador Dali. [Author's note: "Soft watches" – an allegory presented by Salvador Dali in his famous 1931 painting "The Persistence of Memory" to indicate that things may not be as rigid as usually assumed (Garcia and Charles, 2007).] Four significant changes were made in this code of rules in 2008 and more may be forthcoming.

### 2.6.2 Ecosystem Approaches to Management

First, it is necessary to characterize Russian fisheries and fishery management zones. Four Fisheries Management Region (FMR) patterns (gradually becoming more complex) were established in the former USSR in 1975, 1980, 1988 and 1989. Each of these patterns corresponded to the specific period in development of understandings about fishery management tasks. The first pattern (1975) corresponded to the time before the establishment of vast exclusive economic zones (EEZs) by coastal countries. The second and third patterns were established under the influence of the potential fisheries area limitation imposed by the newly formed EEZs. The most recent FMR pattern (1989) introduced further detailed elaboration (Fig. 2.6.1).

Actual removals of fisheries resources, *i.e.*, fishery harvest or catch, are influenced by a range of factors which are not always taken into account (*e.g.*, size of fishing fleet, control and enforcement of the regulations, industry investments, and markets for the commodities produced). Management is largely through effort control, and enforcement is in place. Additional data on the ecosystem, and to some extent, information on the impact of fisheries, is sometimes provided and occasionally fleet information is given as well (Hoydal, 2007).

Traditional fishing areas of the Soviet expeditionary fishery period at the end of 1980s were found in all the world's oceans. Russia was the biggest player in the global fisheries economy with an annual harvest of more than 11 million metric tons (mt). These indices are still in wide use now as a kind of target reference level when the national fisheries outlook is discussed. Even now, the biggest expectations for Russian fisheries still relate to the expeditionary fishery in open oceanic waters.

In reality, the Russian fishing fleet has retreated to Russia's own EEZ, yet the number of vessels has increased by 13.7% since 1990. At the same time, the grand total fisheries harvest by national fisheries has decreased by a factor of 3.5 times below the peak level in 1960. The main causes for these changes, besides the reduction of fishing in foreign waters, are higher fuel prices, the breaking up of fisheries ventures, and difficult business conditions, including the institution of administrative barriers and high transportation tariffs. These factors have resulted in the fishery harvest being largely exported, *i.e.*, redistributed from the domestic market in interior regions to the nearest foreign markets where higher prices are being paid. The services and repair base of the fishery fleet, material supplies, and banking facilities have followed the 'escaped' fleet that is delivering its catch in foreign markets; fishery ventures have also obtained their supplies and services in ports outside Russia. The annual average of Russia's consumption of fishery products has decreased from 22 kg per person to 10–12 kg.

Relatively few species contribute to the bulk of the total fishery harvest in the Russian Far East: in 1989–1990, walleye pollock contributed up to 2,930,000–3,120,000 mt; Japanese sardine, or iwashi, contributed up to 734,900–762,200 mt in 1989–1990.

Other important fish in the Russian Far East are Pacific herring (*Clupea pallasii*) and Pacific salmon (*Oncorhynchus* sp.), with pink salmon (*O. gorbuscha*) accounting for the biggest landing. In 2007, the Russian fishery harvest of pink salmon reached a level of 250,000 mt for the second time in recent history. Several other species have a regional significance: Commander squid (*Berryteuthis magister*) and Pacific saury for the oceanic waters, and Pacific cod (*Gadus macrocephalus*) and flatfish in the Bering Sea.

When walleye pollock catches decrease below the range 1,016,000–1,211,000 mt, the total fishery harvest on the Russian Far East shows a significant decrease (1,970,000–2,150,000 mt in 2006–2007). The significance of this is reflected in the analysis of fisheries gear in use. About 76.3% of the total fishery harvest was caught by trawls in 2005, with trawls the primary method used to catch walleye pollock. Beach seines and stationary traps are the main gears in the Pacific salmon fishery. Saury is caught using both liftnets and Dutch seines. Pot fisheries also account for landings by gear.

The contemporary legislative basis for Russian fisheries management was developed in 2003. Prior to this time, some temporary *Acts*, instructions, and guidelines were in force. Planning for fisheries development in the Russian Federation until 2020 and Procedure of Biological Resources Usage (approved by the Russian Government Resolution No. 704 of 20.11.2004 regarding quotas for aquatic biological resources) have established a basis of long-term (five-year) quota allocations between fishery ventures. The federal law on Fisheries and Water Biological Resources Conservation was signed on December 20, 2004. Its realization required 30 more legislative documents, including 15 governmental resolutions. Among other statements, this federal law strengthened the main principle of contemporary Russian fisheries management: annual TAC setting

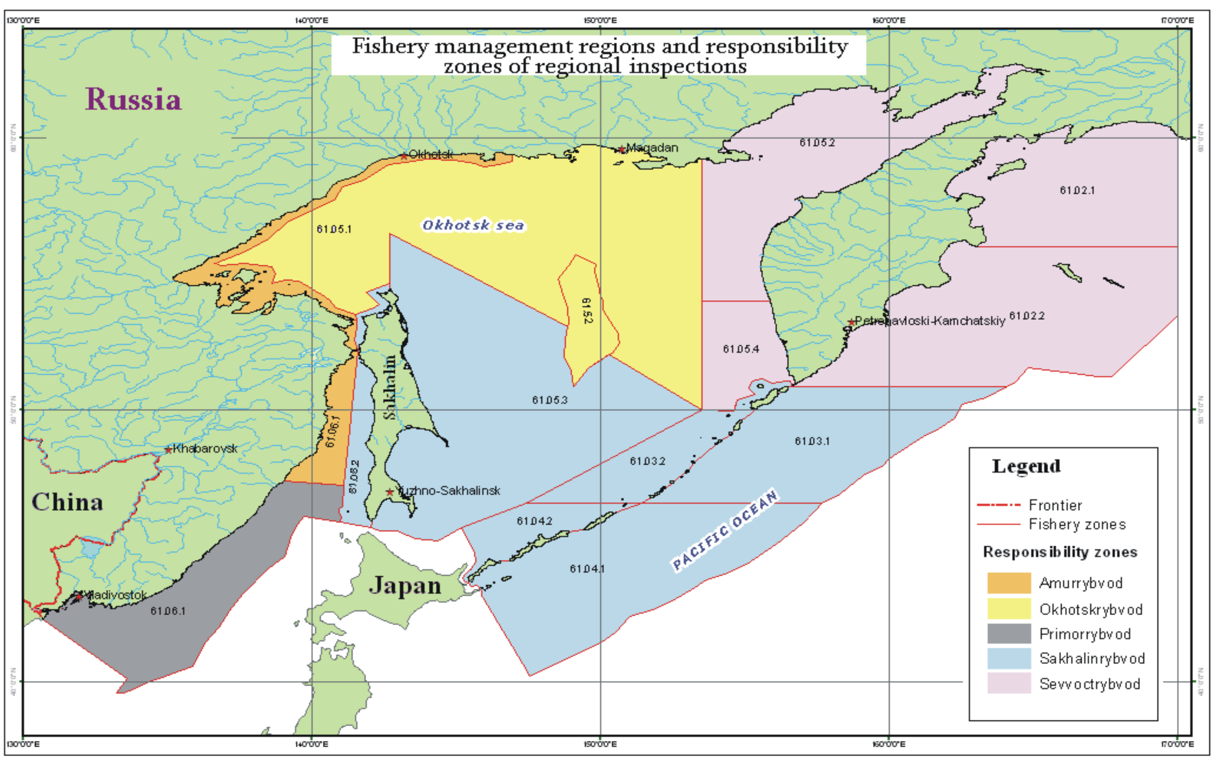


**Fig. 2.6.1** Fishery management regions and responsibility zones of regional inspections.

for target fisheries. However, there was neither emphasis in this law nor in the governmental resolution after its issue (No. 583 of September 26, 2005) that the TAC principle is obligatory for all marine biological resources, as it was in the documents previously enacted by the Duma. Then, the Russian federal agency on fisheries issued an order (No. 219 of October, 2, 2008) approving a list of water biological resources, which will be further managed by the TAC principle.

In summary:

- The legislative basis for the Russian Far East fisheries is still being reformed. The basic principles predicated on current statements about reforms are long-term quota allocations for fishery ventures, negotiation of administrative barriers, and strict poaching control.
- The annual TAC setting procedure has some benefits for fisheries, as it compelled fisheries managers to undertake a comprehensive review of all commercial species and stocks, *i.e.*, it:
  - ensured a unified approach and centralized management of all biological resources;
  - made preconditions for objective rules of quota allocations; and
  - cut down the number of users of marine biological resources which had become excessive and had led to deterioration of the most valuable fishery stocks.

  This allows the formation of new approaches for tax collection from biological resource usage instead of the previous procedure, *i.e.*, when fishery rights were being auctioned off. However, the aggressive development of the TAC setting and the TAC limitation approach also led to negative consequences, such as bycatch discard problems, deterioration of fishery statistics, and new obstacles to the optimization of fishery management. These were the main reasons to abolish TAC settings for all fisheries since 2009.

### 2.6.3 Ecosystem Studies

Russian fishery science has identified 374 fishery stocks in 11 fishery zones (note: three zones (61.06.1, 61.06.3 and 61.06.4; see Figure 2.6.1) are divided internally but are in fact managed as a single zone, thus giving the appearance of there being 14 zones) and sub-zones in the Far East, excluding the Chukchi Sea and freshwater. An annual TAC setting is executed for each of these stocks. The largest number of stocks (52) is in the Primorie fishery sub-zone, and the smallest (22) is in the Northern Kurils zone. The total average TAC for these regions was 3,207,500 mt for the 2003–2007 five-year period. The Sakhalin Research Institute of Fisheries and Oceanography (SakhNIRO) is responsible for a significant part of this area. Pelagic fish contribute to a large proportion of the total TAC as well as to the total harvest. In contrast, pelagic squid and kelp resources in the southernmost zones are probably being underestimated. Some resources of mysids, jellyfishes and tunicates occur but they are relatively small.

### 2.6.4 Science for Ecosystem Approach to Management

The summary below demonstrates the long-term forecast capability of fishery stock conditions as a result of ecosystem studies of biological resources. These forecasts are based on our understanding of element relationships with respect to ecosystem trophic structure: common species of pelagic and groundfish, benthos, and plankton. The main theses under consideration are briefly listed.

Russian fishery science has completed an inventory of the aquatic biological resources in the pelagic layer of the Far Eastern seas with publication of a series of “Atlases of nekton distribution” (Shuntov and Bocharov, 2003a, 2004a, 2005a, and 2006a) in the Far Eastern seas and adjacent Pacific waters, and volumes of quantitative data as references for these atlases named “Nekton distribution” in the same years (Shuntov and Bocharov, 2003b, 2004b, 2005b, and 2006b). The database for these eight volumes includes results of 22,200 trawl hauls during research cruises. This will be an important database for future comparative monitoring and consideration in the development of fishery management advice.

According to forecasts from the Pacific Research Institute of Fisheries and Oceanography (TINRO-Center), the fisheries harvest in the Far Eastern seas could reach 3.8 million mt by 2015. This is less than the historical high of 5 million mt of 1988 but about 1 million mt higher than the level of 2.48 million mt in 2009. Realization of this forecast depends on several factors:

- general socio-economical conditions in the Far Eastern region,

- fishery management improvement and optimization,
- scientific and technical assessment activities,
- demand for utilization of currently unfished and under-fished resources (*e.g.*, mesopelagic fish, pelagic squids, marine mammals, small bivalves, kelp, jellyfish),
- abundance dynamics of common pelagic fish (*e.g.*, walleye pollock, sardine, herring, Pacific salmon).

From the ecosystem study results, Shuntov *et al.* (1997) forecasted a decrease of total nekton biomass as well as biological and fishery productivity in the early 1990s, with further stabilization at a lower level in the first years of the present century. These predictions have been realized. Long-term dynamics of pelagic nekton distribution in the biostatistical areas in the Far Eastern seas resulted in a landing decrease in the first half of 1990s and then some recovery in most recent years, with the northeastern and eastern parts of Russian EEZ recently contributing the greatest amount of catch.

Biomass declines in the Far East are mostly attributable to decreases in pelagic fish. Pelagic squid abundance subesquently increased because of a reduction in both predation pressure and competition for food. Current high indices of pelagic squid abundance suggest that pelagic fish abundance is still far below the level of the 1980s.

Recent results, however, suggest future growth in abundance of other common commercial fishery species. The present understanding divides herring in the northern Sea of Okhotsk into two stocks. These stocks are generally fished under catch limits in two adjacent fishery zones, with notably different allowed catches. In recent years, some portion of the under-fished Gizhigin-Kamchatsky herring stock was allowed to be caught in the Northern Okhotsk zone, together with the Okhotsk herring stock. However, each stock did not respond similarly to fishery effort and now it is believed that the herring population in the northern Sea of Okhotsk has a more complicated structure, represented by three stocks instead two. This will require changes in fishery management.

Recent Pacific herring catch dynamics closely repeat the previous period of intensive fishing during the 1960s–1970s, despite different fishery gears and methods in those times. It is well known that Pacific herring resources undergo significant predation pressure, and that herring are sensitive to spawning conditions. Herring stocks respond to climate change, as evidenced during the mid-1970s after the well-recognized 1977 regime shift.

Walleye pollock in the Sea of Okhotsk demonstrate an expected spawning stock stabilization and gradual growth. Some peripheral regional spawning groupings of pollock show higher rates of abundance growth than the core stock in the western Kamchatka and northern Okhotsk fisheries areas. The TAC in the Eastern Sakhalin fishery sub-zone increased seven times during a relatively short period (2006–2008, from 5000 to 35,000 mt). It has continued to increase, with TAC of 50,000 mt in 2010 and 82,000 mt projected for 2011. Fisheries there are more intensive after the spawning period, which is promising in relation to a proposed division of pollock fishing into two seasons.

Pacific salmon marine life has been well studied by dozens of expeditions from 1990 to the present. Data now allow the TINRO-Center to construct an annual pattern of Pacific salmon residence in the Russian EEZ. The Sea of Okhotsk is the main forage ground for pink and chum salmon juveniles, while the Bering Sea is for larger salmon. In recent years, pink salmon catches reached new records for the period after the middle of the last century, even in the odd years. This may be, in part, because the success of pink salmon hatchery production has smoothed total annual salmon production by providing practically the same numbers of annual juvenile as from natural spawning. In any case, these data testify to recent good conditions for pink salmon survival during their marine stage.

Results of benthic TINRO-Center surveys suggest an interaction level between the benthic and pelagic ecosystems. A comparison of recent results with the estimates of benthos abundance in the 1970s–1980s does not reveal large differences. Shuntov (2001) considered that average benthos biomass varied among the Far Eastern shelf areas between 300–500 g $m^2$, and that the benthos biomass contained forage benthos for groundfish. Annual benthos consumption by groundfish was estimated to range from 30– 129 g $m^2$ in the various regions, including a part of the nekton-benthic species, so fish consumption of benthos appear to have a relatively minor influence on benthic biomass dynamics.

Food competition among groundfish does not, therefore, appear to reach a level where it could be a limiting factor for their abundance. Formation of groundfish year class strength occurs in the early ichthyoplanktonic stages when groundfish roe and larvae exist in the same habitat with the early stages of pelagic fish and bottom invertebrates, and with zooplankton, including predatory species. Another issue is that some groundfish species consume the juvenile stages of other commercially valuable species, *e.g.*, Pacific cod eat juvenile walleye pollock, shrimp and snow crabs. On the western Kamchatka shelf, such consumption was estimated at 100,000 mt of shrimp and 11,000 mt of snow crabs annually. That is higher than the TACs for these groups. Thus it seems to be sensible to keep the Pacific cod stock at the lower edge of its optimal size to prevent excessive predation upon other commercial fishery targets. A similar situation exists with the large sculpin species, snailfish, and skates, which are practically unfished now. Sculpins and skates were targeted but their fishery now has a low intensity due to low market prices. Snailfish are untargeted. Greater fishing for these lower unit value predators, with a subsequent lowering of their abundances, may thus help increase higher unit value fishery resources.

With respect to ecosystem studies, the following is observed:

- Most stocks of biological resources in the Far Eastern seas and adjacent Pacific waters remain in satisfactory and/or good condition. The resource base of the Russian fishery consists of numerous species and types of resources, some of which are under-utilized.
- The main factors affecting biological and fishery productivity of the Far Eastern seas are natural ones, *i.e.*, biotic and physical. Data from ecosystem status monitoring show a cyclic nature of many natural processes, with different (often hidden) periodicity. Regular monitoring is necessary.
- Consideration of global and large-scale physical factors may be insufficient for analysis of processes in marine populations and communities in individual seas and smaller areas. Local (provincial) conditions can affect them to a greater degree than global ones.

### 2.6.5 Fisheries Regulation

With respect to the fishery regulation procedure established by new legislative *Acts*, the Fisheries Rules for the Far Eastern Basin (hereinafter referred to as Fishery Rules) was signed on March 1, 2007. This document deals with all seven kinds of fishery target removals from the marine environment, *i.e.*, the commercial fisheries in the territorial waters, on the continental shelf, and in the EEZ.

The Fishery Rules have established 54 permanent and three seasonal area closures for commercial fisheries for all species: three closures are for trawls, one is for bottom gillnets, and others are for all gears for vessels whose total length is geater than 24 m. There are exceptions for shorter fishery vessels conducting coastal fisheries, and four which exempt Pacific salmon and kelp harvesting. There are additional area closures for some species: *e.g.*, nine for walleye pollock, two for holothurians, and one or two for each of the eight crab species. Many of these limitations protect marine mammals' rockeries and the forage grounds around them, as well as some valuable bottom biotopes which are protected from the negative influence of the bottom trawl fishery.

The Fishery Rules have established 44 seasonal fishery closures that deal with 20 species and groups of fishery targets. Most of the closed areas protect spawning and early development of commercial species. Other closures are efforts to restrict large-scale fisheries to the most profitable period (time with the highest catch per unit efforts) to reduce the total effects of a fleet presence on ecosystems. When a fishery quota is realized in the shortest time period, the fleet's environmental impact, because of its discards, noise and wastes on the marine ecosystem, also occurs over a shorter time.

The Fishery Rules have established 26 prohibitions and limitations that deal with fishing gears and method of catch, such as restriction in the crab fishery of any gear except specially equipped pots. These measures protect fishery stocks from overfishing and they may reduce the juvenile and non-target bycatch. These rules also prohibit the hunting of marine mammals, excluding seals, by nets, traps, seines, and rifles, and there is a requirement for vessels being used to have a winch, ropes, *etc.* to ensure the immediate extraction of killed animals from the water. Loss of marine mammal bodies in the sea is prohibited and is regarded as polluting. A minimal distance of beach traps from spawning rivers for Pacific salmon is also established.

The Fishery Rules have also established legal fishery size limitations for 85 fishery targets, including local populations of the same species. It is interesting that this section of Rules has an individual species focus, which is not implemented in TAC setting requirements and in fishery landing reporting. In the TAC setting procedure and fishery statistics, all small flatfish species are supposed to be grouped and reported together, irrespective of the actual species composition in the catch. However, the new Fishery Rules separate starry flounder, Alaska plaice, longhead dab, Sakhalin sole, and other species.

Permitted fishery bycatch regulated by TAC settings is limited to 2% in weight (excluding marine mammals, crabs, and shrimp), and to a maximum 8% in number for undersized individuals in all specialized fisheries. While this standard has also been called for in previous legislation, a new aspect is that the permitted bycatch of non-target species, for which TACs have not been established, is limited to 49% of total harvest weight. These non-target species include *e.g.*, mesopelagic fish, lumpsuckers, and poachers and usually are discarded. New limitations in the Fishery Rules serve as a conservation measure for these species and for fish communities as a whole. It prohibits a fishery by non-selective gears in areas where non-target species are spawning, overwintering or are otherwise aggregated.

Nevertheless, the TAC system based on single-stock approaches fails to account for interactions between different stocks caught together in the same fishery. Continuation of fisheries for one species may undermine conservation targets for another and lead to increased discarding. Mixed fishery considerations need to be included in setting annual TACs (Penas, 2007).

In summary:

- Different fishery regulation methods are widely applied in the fishery management in the Russian Far East. A TAC setting for all fishery targets and every fishery is not an optimal approach. This situation can hopefully be changed through prioritization of fishery regulation measures for different fishery types (*e.g.*, the trawl fishery on common pelagic fishes, coastal groundfish, *etc.*), and a transition from single-species management to multiple species-type regulations;
- Russian fishery science possesses comprehensive knowledge on fishery resources composition, stock abundance and dynamics. Permanent multipurpose monitoring is necessary to improve a long-term forecasting;
- Russian Far East fisheries currently possess all the preconditions for successful application of basic ecosystem-based principles.

### 2.6.6 References


Garcia, S.M. and Charles, A.T. 2007. Fishery systems and linkages: from clockworks to soft watches. *ICES J. Mar. Sci.* **64**: 580–587.

Hoydal, K. 2007. Viewpoint: the interface between scientific advice and fisheries management. *ICES J. Mar. Sci.* **64**: 846–850.

Penas, E. 2007. The fishery conservation policy of the European Union after 2002: towards long-term sustainability. *ICES J. Mar. Sci.* **64**: 588–595.

Shuntov, V.P. 2001. Biology of far-eastern seas of Russia. TINRO-Center, Vladivostok, Russia. 580 pp. (in Russian).

Shuntov, V.P., Radchenko, V.I., Dulepova, E.P. and Temnykh, O.S. 1997. Biological resources of Russian far-eastern economic zone: structure of pelagic and bottom communities, present state, and trends of perennial dynamics. *Izv. TINRO* **122**: 3–15 (in Russian).

Shuntov, V.P. and Bocharov, L.N. (Eds.) 2003a. Atlas of Nekton Species Quantitative Distribution in the Sea of Okhotsk. National Fish Resources, Moscow, Russia, 1031 pp. (in Russian).

Shuntov, V.P. and Bocharov, L.N. (Eds.) 2003b. Nekton of the Sea of Okhotsk: Tables on abundance, biomass and species ratio. TINRO-Center, Vladivostok, Russia, 643 pp. (in Russian).

Shuntov, V.P. and Bocharov, L.N. (Eds.) 2004a. Atlas of Nekton Species Quantitative Distribution in the North-western Part of the Sea of Japan. National Fish Resources, Moscow, Russia, 988 pp. (in Russian).

Shuntov, V.P. and Bocharov, L.N. (Eds.) 2004b. Nekton of the north-western part of the Sea of Japan: Tables on abundance, biomass and species ratio. TINRO-Center, Vladivostok, Russia, 225 pp. (in Russian).

Shuntov, V.P. and Bocharov, L.N. (Eds.) 2005a. Atlas of Nekton Species Quantitative Distribution in the North-western part of Pacific Ocean. National Fish Resources, Moscow, Russia, 1080 pp. (in Russian).

Shuntov, V.P. and Bocharov, L.N. (Eds.) 2005b. Nekton of the north-western part of Pacific Ocean: tables on abundance, biomass and species ratio. TINRO-Center, Vladivostok, Russia. 544 pp. (in Russian).

Shuntov, V.P. and Bocharov, L.N. (Eds.) 2006a. Atlas of Nekton Species Quantitative Distribution in the Western Bering Sea. National Fish Resources, Moscow, Russia, 1072 pp. (In Russian).

Shuntov, V.P. and Bocharov, L.N. (Eds.) 2006b. Nekton of the western part of the Bering Sea: tables on abundance, biomass and species ratio. TINRO-Center, Vladivostok, Russia, 415 pp. (in Russian).

Shuntov, V.P., Dulepova, E.P., Temnykh, O.S., Volkov, A.F., Naydenko, S.V., Chuchukalo, V.I. and Volvenko, I.V. 2007. Status of biological resources in relation to macro-ecosystems dynamics in the economic zone of the far-eastern seas of Russia. pp. 75–176 *in* Ecosystem Dynamics and Contemporary Problems of Conservation of Bioresource Potential of Seas of Russia. Dalnauka Publ. House, Vladivostok (in Russian).

## 2.7 United States of America

### 2.7.1 Definition of the Ecosystem Approach to Fisheries Management

The National Oceanic and Atmospheric Administration (NOAA), the primary ocean research agency of the U.S., has defined an ecosystem approach to fisheries management as one that is geographically specified, adaptive, takes account of ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse societal objectives. Implementation will need to be incremental and collaborative. Sissenwine and Murawski (2004) formally introduced this definition, and elaborated further on its components. The geographic specification should be scaled hierarchically according to the processes being studied or managed. The approach should account for several high-priority issues that have not traditionally been monitored in fishery management programs, namely bycatch and fishery interactions, indirect effects of harvest, and interactions between biotic and abiotic ecosystem components. Finally, this approach is ideally an inclusive, integrative process that accounts for the needs and interests of a diverse set of stakeholders throughout society, and helps those stakeholder groups to understand and anticipate both the costs and benefits of sustainable marine resource management.

### 2.7.2 Overview of Fisheries Management Implementation at the Federal Level

Management of fisheries in federal waters of the U.S. is governed by several federal *Acts* that extend protection to fish, seabirds, marine mammals, endangered species, and the coastal zone. Most significant is the *Magnuson-Stevens Fishery Conservation and Management Act* (MSFCMA) passed in 1976, amended in 1996 by the *Sustainable Fisheries Act* and again in 2007 (http://www.nmfs.noaa.gov/msa2007). Implementation of the requirements of the MSFCMA by the North Pacific Fishery Management Council (NPFMC) is aided by national standard guidelines (http://www.afsc.noaa.gov/refm/stocks/nsgfinal.pdf).

The MSFCMA explicitly provides for institution of key components of ecosystem-based fisheries management. It contains standards and provisions that relate maintaining or rebuilding the productivity and economic benefits of fisheries to broader suites of ecological interactions and ecosystem processes extending beyond single-species considerations. Some examples are described in the following paragraphs.

National Standard 9, added to the MSFCMA in 1996, states that “conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.” This standard gave rise to a federal plan for managing bycatch (http://www.nmfs.noaa.gov/bycatch.htm). The MSFCMA defines bycatch as “fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards…[but not] fish released alive under a recreational catch and release fishery management program.”

The MSFCMA calls for direct action to stop or reverse the continued loss of fish habitats. Congress mandated the identification of habitats essential to managed species and measures to conserve and enhance these habitats. The MSFCMA requires cooperation among NOAA, the councils, fishing participants, and federal and state agencies to protect, conserve, and enhance essential fish habitat (EFH) to the extent that is practicable. The amended MSFCMA requires NOAA to minimize damage to EFH from fishing practices, to the extent practicable. Federal agencies that authorize, fund, or conduct activities that “may adversely affect” EFH must work with NOAA to develop measures that minimize damage to EFH. Federal agencies proposing to dredge or fill habitats in or near EFH, for instance, must consult with NOAA to develop EFH conservation measures if the action may adversely affect EFH. While NOAA does not have veto authority over federal projects adversely affecting EFH, this mandate enables NOAA to provide guidance to federal action agencies on ways to tailor their projects to minimize harm to EFH. By requiring the consideration of impacts on EFH from both fishing and non-fishing activities, the MSFCMA ensures that NOAA takes a more holistic approach to fish habitat protection. Laws and regulations on EFH can be found at http://www.habitat.noaa.gov/protection/index.html.

The MSFCMA approach to management of food webs, in general, and of predator–prey relationships involving target species, has several facets. First, the MSFCMA defines optimum yield (OY) as the amount of fish that will provide the greatest overall benefit to the nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems. An OY is prescribed on the basis of the maximum sustainable yield (MSY) from the fishery, as reduced by any relevant economic, social, or ecological factor. Examples of ecological factors are given in the National Standard guidelines and include predator–prey or competitive interactions, and dependence of marine mammals and seabirds or endangered species on a stock of fish. Thus, fishery managers are given direction in modifying maximum biological yield targets to account for ecological factors such as predator–prey relationships.

An even broader piece of legislation than the MSFCMA is the *National Environmental Policy Act* (NEPA; http://ceq.hss.doe.gov). NEPA governs the actions of federal fisheries managers by requiring public officials to make decisions that are based on an understanding of environmental consequences, and take actions that protect, restore, and enhance the environment.

Another relevant piece of legislation is the *Marine Mammal Protection Act* (MMPA; see http://www.nmfs.noaa.gov/pr/laws/mmpa/text.htm). The MMPA establishes a federal responsibility to conserve marine mammals, with a goal of obtaining an optimum sustainable population of marine mammals within the carrying capacity of the habitat. If a fishery affects a marine mammal population, then the potential impacts of the fishery must be analyzed in an environmental assessment or environmental impact statement required by NEPA. No directed harvest may occur on any marine mammal, regardless of their population status. However, the MMPA allows for a limited incidental 'take' that must be less than the potential biological removal (PBR) rate, the maximum level of incidental mortality that still allows the species to attain its optimum sustainable population (http://www.nmfs.noaa.gov/prot_res/PR2/Fisheries_Interactions/TRT.htm). The MMPA further establishes management for cetaceans and pinnipeds (by NOAA) and sea otters (by the U.S. Fish and Wildlife Service) and requires regular stock assessments of all populations. Mammals whose population status is depleted receive protections that may include restrictions on fishing in their habitats or on fish species that they prey upon.

Legislation comparable to the MMPA has been passed for other species groups as well. The *Migratory Bird Treaty Act* (MBTA; http://laws.fws.gov/lawsdigest/migtrea.html), forbids the directed take of seabirds. The *Endangered Species Act* (ESA; http://www.nmfs.noaa.gov/pr/laws/esa/) provides protection for fish and wildlife species that are listed as threatened or endangered.

Other significant legislation deals with issues of water quality and coastal management. A major overarching piece of legislation is the *Coastal Zone Management Act* (CZMA; http://laws.fws.gov/lawsdigest/coaszon.html) which mandates that federally managed activities in coastal waters be consistent, to the maximum extent possible, with coastal zone management policies adopted by the states possessing the coastline. A wide range of local, state, and federal laws are in place that set standards for levels of point and non-point pollution (*e.g.*, http://www.ecy.wa.gov/programs/wq/nonpoint/index.html). Reflecting research which demonstrated that increased nutrient levels can lead to harmful algal blooms (HABs), Congress passed the *Harmful Algal Bloom and Hypoxia Research and Control Act* in 1998 (http://www.cop.noaa.gov/pubs/habhrca/1998_pl105-383.pdf), and amended and reauthorized it in 2004 (http://www.cop.noaa.gov/pubs/habhrca/2004_publ456.108.pdf). This *Act* created a coalition of federal agencies to assess the ecological and economic impacts of HABs, bloom-derived toxins, and bloom-related hypoxic conditions. Action plans have been developed for HAB species associated with fish kills, human shellfish consumption warnings, and marine mammal and seabird mortalities. Vessel-based dumping of materials into waters of the U.S. Exclusive Economic Zone (EEZ) is regulated under the *Marine Plastic Pollution Research and Control Act* (MARPOL) (http://www.csc.noaa.gov/opis/html/summary/mpprca.htm) and the *Marine Protection, Research, and Sanctuaries Act* (http://epw.senate.gov/mprsa72.pdf). The latter legislation, passed in 1972 and amended in 2000, includes regulatory language for dumping of dredge spoils which often contain contaminated sediments.

Below, we offer two case studies that illustrate the practice of U.S. ocean management under the laws listed above. We also outline some basic interactions between the federal government, regional fishery management councils, states, and other agencies, organizations and stakeholder groups. We offer two case studies from the U.S., in part, because the U.S. EEZ in the PICES region spans from the Eastern Pacific to the extreme north, and thus presents geographically and ecologically contrasting systems that are managed under a relatively common framework.

## 2.7.3 Case Study 1: Eastern Bering Sea

### Ocean Management Activities

Alaska ocean management activities occur in a large area encompassing southeast Alaska, Gulf of Alaska, Aleutian Islands, Eastern Bering Sea, and the Chukchi/Beaufort seas in the Arctic. The Eastern Bering Sea is a large focus for many of the ocean management activities. The Bering Sea is a semi-enclosed high-latitude sea with a deep basin (3,500 m), and shallow (<200 m) continental shelves. The broad shelf in the east contrasts with a narrow shelf in the west. In summer on the eastern shelf, coastal, middle, and outer domains can be distinguished by their hydrography and circulation patterns. The domains are separated by fronts that constrain cross-shelf exchange and are important locations for ecosystem interactions. There are large seasonal differences in solar radiation, wind forcing, and sea ice. The Bering Sea is connected to the North Pacific through the Aleutian archipelago and there is a shallow connection with the Arctic Ocean through the Bering Strait. The region can be considered as a continuation of the North Pacific subarctic gyre.

The region has high biological productivity that is strongly seasonal. Over 266 species in eight taxonomic classes of marine phytoplankton have been identified in the Bering Sea community. Rates of primary productivity up to 225 gC $m^{-2}$ $y^{-1}$ have been reported from the most productive areas. Zooplankton biomass production is strongly seasonal but varies regionally, with estimates up to 64 gC $m^{-2}$ $y^{-1}$ from the shelf edge to 4 gC $m^{-2}$ $y^{-1}$ for the coastal domain. The region includes more than 450 species of fish and invertebrates, of which about 25 are commercially important.

### 1. Fishery Management

The groundfish fishery is managed by the North Pacific Fishery Management Council (NPFMC; http://www.fakr.noaa.gov/npfmc/) under the Bering Sea/Aleutian Islands Groundfish Fishery Management Plan (http://www.fakr.noaa.gov/npfmc/fmp/bsai/bsai.htm). Management of commercially important crabs is delegated to the State of Alaska. Alaska is also responsible for managing harvests of salmon, herring, and scallops.

**Alaska groundfish fisheries**

Federally-managed Alaska groundfish fisheries occur in the U.S. EEZ, primarily on the shelf and slope areas of the Gulf of Alaska (GOA) and Bering Sea and Aleutian Islands (BSAI). These fisheries are managed under two fishery management plans: the Bering Sea/Aleutian Islands Groundfish Fishery Management Plan (http://www.fakr.noaa.gov/npfmc/fmp/bsai/bsai.htm).

Acceptable biological catch (ABC) and total allowable catch (TAC) levels are prescribed for a number of species in the BSAI, although some may not necessarily be a target species of the groundfish fisheries. The environmental impact statement for the final specifications for the 2006–2007 fisheries on these species, which includes information on the biomass, ABC, overfishing levels, TAC levels, and the past year actual catch amounts can be found at http://www.fakr.noaa.gov/analyses/specs/06-07tacspecseafrfa_v4.pdf.

The following species/groups are actively managed in the BSAI region: walleye pollock, Pacific cod, yellowfin sole, Greenland turbot, arrowtooth flounder, rock sole, flathead sole, Alaska plaice, ‘other flatfish’ (mostly starry flounder, rex sole and butter sole.), sablefish, Pacific ocean perch, northern rockfish, shortraker and rougheye rockfish, other rockfish (two predominant species: light dusky rockfish and shortspine thornyheads), Atka mackerel, squid, and an ‘other species’ group (including sculpins, skates, sharks, and octopus).

Another essential aspect of the management program is the large Observer Program. Data provided by the

Observer Program is a critical element in the conservation and management of groundfish, other living marine resources, and their habitat. For example, these data are used for: 1) assessing the status of groundfish stocks; 2) setting groundfish quotas and monitoring them in season; 3) monitoring the bycatch of non-groundfish species in season; 4) assessing the effects of the groundfish fishery on other living marine resources and their habitat; and 5) assessing methods for improving the conservation and management of groundfish, other living marine resources and their habitat. The Observer Program also provides the industry with bycatch data it needs to make timely fishing decisions that decrease bycatch and increase productivity.

*Retained species*

The general approach to retained species management is the annual TAC-setting process and an at-sea Observer Program to monitor TAC. Stocks or stock complexes within the retained (or target) species category are part of this process. TACs are set by the NPFMC and are less than or equal to the ABCs set by stock assessment scientists which are, in turn, less than defined overfishing levels (OFLs). The following document summarizes the tier system for setting groundfish ABCs and includes life history parameters for the managed stocks in the BSAI region: http://www.fakr.noaa.gov/npfmc/summary_reports/bsstock.htm. Federal fishery scientists are, in general, responsible for deriving ABC and OFL estimates that are then reviewed by a panel of federal, state, and independent scientists who are on the Groundfish Plan Teams of the NPFMC. These ABCs and OFLs are then presented to the Council's Science and Statistical Committee for review. The SSC then makes the ABC and OFL recommendations to the NPFMC. Groundfish stock assessment documents each contain an ecosystem considerations section that outlines the ecosystem effects on the stock and the potential effects of that stock's fishery on the ecosystem. The ecosystem is also taken into account through the TAC setting process in which an Environmental Impact Statement (EIS) is prepared.

*Bycatch species*

There are several facets of bycatch management in Alaska groundfish fisheries, depending on the type of bycatch. One is the accounting of bycatch of target groundfish species that are discarded, and these amounts are included in total catch estimates of the target species. In 1998, an improved retention and utilization (IR/IU) amendment was approved that mandated the retention of pollock and cod in groundfish fisheries. No special consideration is being given to species biodiversity among the bycatch species although biodiversity measures that include target and nontarget species are under development.

For bycatch of non-target species, there is a special category called 'prohibited species' that is managed. In the Eastern Bering Sea (EBS), prohibited species include salmon, herring, crab, and halibut, and caps are placed on the amounts that can be caught by groundfish fisheries. In addition, there are many gear/area restrictions that have been made to provide further protection to these prohibited species, which are the target for non-groundfish fisheries and are managed by either the State of Alaska (salmon, herring, and crab) or an international commission (halibut). These agencies' management practices promote sustainable stocks and, in some cases, catch mortality in groundfish fisheries is accounted for in stock assessments of these prohibited species. A detailed history of the regulation of Alaska groundfish fisheries with regard to prohibited species can be found at http://www.fakr.noaa.gov/npfmc/sci_papers/MFR.pdf. There are many time/area closures, gear restrictions, and seasonal TAC apportionments designed to reduce bycatch of prohibited species. One benefit of individual fishing quota (IFQ) fisheries (sablefish) is the reduced catch of prohibited species. There is a detailed reporting and accounting system that includes at-sea observers who provide estimates of total catch and discard mortality for prohibited species in the groundfish fisheries to ensure that catches are not exceeded.

In some groundfish fisheries, particularly flatfish fisheries, the halibut cap is constraining and prevents the flatfish fisheries from achieving ABC. Groundfish fishery bycatch removals of these prohibited species do not significantly impact these stocks because groundfish fishery removals are much less than directed harvest amounts. Halibut and herring are in good condition, some crab stocks are considered overfished (although directed fishing may not have been the proximal reason for some crab stocks falling below their minimum stock size thresholds (MSSTs). Some western Alaska salmon stocks are depressed and the impact of bycatch removals are unknown for some stocks. In general, the detailed accounting and bycatch cap approach to management of these species is very successful at providing protection to this group, although these constrain the groundfish fishery and thus may not be optimal from an economic point of view.

Catch of a 'forage species' group is managed to prevent target fisheries from being initiated on those species, which include smelts, stichaeids, euphausiids, sandlance, sandfish, lanternfish, and gunnels. These species are generally species with fast turnover rates but are not well studied in the region. A maximum retention allowance (MRA) for each groundfish fishery is set at 2% of the total fishery catch for these species in aggregate. Commerce in these species is currently prohibited, except for the small amounts retained under the MRA rates and for artisanal or subsistence uses. Abundance estimates are not available for these species so their status is unknown. This group of fast turnover rate species is likely afforded sufficient protection by these maximum retainable bycatch limits that prevent target fisheries from starting on them.

Although species contained in the 'other species' category are included in the target species management description, above, because they are managed using ABCs derived from the target species tier system, the species in this category are not currently economically important in North Pacific groundfish fisheries, but were perceived to be ecologically important and of potential economic importance, as well. 'Other species' in the BSAI and GOA include sculpins, skates, sharks, squid and octopus (squid is catagorized as a separate group in the BSAI). Stock assessments are conducted and TACs are established for other species and separately for squid in the BSAI. Discussions are underway for improving the management of these groups through, for instance, improved detail in catch reporting.

A group of invertebrate species called HAPC (habitat areas of particular concern) biota has been defined. This group consists of living structural habitat species such as corals, sea pens/whips, sponges, and anemones. Some of these species, particularly deep water corals, are very long-lived and sensitive to fishing removals. Large areas of the Aleutian Islands have now been designated as off limits for bottom trawling.

Finally, there is a group of nonspecified species that are captured in the groundfish fisheries. These include a huge diversity of fish and invertebrate species. There is currently no management and only partial catch monitoring of species in this category, although retention of any nonspecified species is permitted. The complete lack of reporting requirements may be problematic. Research is ongoing to identify population trends in non-commercial species relative to fishing and climate. Species identification is very detailed for fish species in research surveys of the area but not very detailed for non-commercial invertebrates.

**2. Management of Threatened or Protected Species and Communities**

A number of threatened or endangered species or habitats for these species occur in Alaskan waters and these species are afforded protection under the ESA. The species include some marine mammals, seabirds, and fish. The full list is available at http://www.nmfs.noaa.gov/pr/pdfs/esa_factsheet.pdf. Other marine mammal species are also afforded protection under the MMPA. The general approach to fisheries management with respect to these species is the management of direct takes of species, utilization of take reduction devices, area closures to protect foraging habitat, and harvest rules that provide additional protection to key forage of some of these species.

With the exception of salmon, the majority of these species are long lived K-selected species with a variety of foraging strategies. There are difficulties in quantifying the level of natural variability in some of these stocks due to the past effects of direct harvest of mammals, and degradation of freshwater habitats of salmon, *etc.* that confound interpretation of species declines. However, there have been observations of large variability in species abundance trends over the last 30 years that has been partly linked to climate variation, particularly for salmon.

Fishery management restrictions that have been placed on Alaska groundfish fisheries because of ESA concerns are primarily for the protection of Steller sea lions and short-tailed albatross. Measures are in place to protect Steller sea lions in nearshore and critical habitat areas through fishing closures in certain areas and temporal–spatial distribution of the catch. Overall abundance of key Steller sea lion prey (walleye pollock, Atka mackerel, and Pacific cod) is regulated through a lower threshold harvest when spawning biomass reaches 20% of the projected unfished biomass ($B_{20\%}$), which is more conservative than is used in single-species harvest strategies for those stocks. The primary management concern for short-tailed albatross is direct take in fisheries and very low take limits have been set (four takes within two years) that will trigger consultation. In addition, seabird avoidance measures for fishing vessels have been mandated.

Understanding and data are limited to providing general indications of status and change – often with many different plausible interpretations. There is large uncertainty, particularly with regard to Steller sea lions, of the factors influencing the dynamics of this stock. Large amounts of research funding and efforts of independent panels of scientists are being spent to evaluate the reasons for the decline.

- Status of Steller sea lions and short-tailed albatross with respect to endangered listing reference point: these animals are still considered endangered.
- Status of the fishery interactions with these species with regard to direct take limits: interactions are below the direct take limits.
- Status of the fishery interactions with regard to the indirect effects of fishery removal of prey: enactment of biological opinion protection measures should remove any adverse modification of habitat or jeopardy of species existence due to fishing but this is uncertain due to the difficulty in quantitatively evaluating these indirect effects.

Direct take catch limits, gear modifications, and take reduction teams all provide good mechanisms for reducing direct takes of endangered and protected species. Take limits, such as PBR rates, vary relative to the status of the stock of concern and relate to the stock's productivity, and provide a sufficient trigger for management intervention The qualitative nature of determining the degree of protected species protection provided, due to area closures and prey species harvest control rules when indirect interactions are the concern, are problematic and uncertain. Considerable work needs to be done to determine more quantitative standards for reference points that ensure fisheries will not jeopardize the continued existence or adversely modify the critical habitat of listed species for these indirect interactions. However, detailed analysis of Steller sea lions and measures for their protection have been instituted through a Steller sea lion protection measures environmental impact statement (EIS) and a Biological Opinion. An open public process has been employed, including the use of a unique stakeholder constituent committee, to develop fishery management alternatives.

No consideration has been given to community biodiversity, except through protection of the individual pieces (individual community members). Development of biodiversity indices is ongoing though, typically, marine mammal and seabird communities are excluded from these because there is a lack of population abundance and trend information for many of the species.

## 3. Habitat Management

Habitat management for Alaska groundfish fisheries includes the consultation process mentioned above and the development of an Essential Fish Habitat Environmental Impact Statement (EFH EIS). In addition, habitat protection is provided by a variety of area closures and bottom trawling restrictions that have been put in place over the years (see summary Bering Sea habitat conservation measures at http://www.fakr.noaa.gov/npfmc/current_issues/BSHC/BSHC.htm). Habitat assessment reports were developed for EFH of all managed species in Alaska (http://www.fakr.noaa.gov/habitat/).

The BSAI and GOA groundfish management regions encompass a variety of habitat types. The EBS shelf consists primarily of sand, mixed sand and mud, and mud substrates and an outer continental shelf. The GOA has shallow, deep and slope areas that consists of soft (sand to gravel) or hard (pebble to rock) substrates. The Aleutian Islands region also consists of soft and hard substrates. Efforts are ongoing to better map the distribution of living organisms that provide structural habitat to fish, but the AI and GOA are known to have deep-water corals that are long-lived. Sponges also occur in all of these areas and are thought to be relatively long-lived, though present research is showing a range of recovery times. Other epifauna that could be impacted by fishing gear include sea pens/whips and anemones, and not much is known about the recovery rates of these organisms. Of the infauna in these regions, larger, longer-lived organisms include clams. Smaller, higher turnover-rate organisms such as polychaetes also occur throughout the regions but little effort has been expended in mapping these distributions after U.S. surveys conducted in the late 1970s and early 1980s, although bottom typing efforts are ongoing. Little is known of the natural levels of variability of these organisms although research is being conducted to compare densities and average sizes of organisms in trawled *versus* untrawled regions. A habitat impacts model has recently been developed to provide a quantitative basis for relating fishing intensity and habitat recovery in the process of evaluating fishing effects.

The main management response at this point is the requirement for federal agencies to consult with NOAA to see if that agency's actions may adversely effect EFH, and for NOAA to provide conservation recommendations if deemed necessary. For details on the consultation process, see http://www.nmfs.noaa.gov/sfa/reg_svcs/Council%20stuff/council%20orientation/2007/2007TrainingCD/TabT-EFH/EFH_factsheet.pdf.

Reference points being developed for evaluating habitat effects relate to a standard for determining "adverse effects on EFH" that are "more than minimal and not temporary". Temporary impacts are defined as those that are limited in duration and that allow the particular environment to recover without measurable impact. Minimal impacts are described as those that may result in relatively small changes in the affected environment and insignificant changes in ecological functions. In the EFH context, the terms 'environment' and 'function' refer to the features of the environment necessary for the life history requirements (spawning, breeding, feeding and growth to maturity) of the managed species and their function in providing that support. Presently, for managed Alaska groundfish, the standard for assessment is the stock's ability to remain above the minimum stock size threshold.

Assessment of the status of groundfish species relative to this threshold is presently being done in the EFH EIS and the Programmatic Alaska Groundfish EIS. It appears that groundfish stocks are above this threshold (for those in which MSST can be calculated, or else MSST is unknown). Although MSST is a quantitative standard, it cannot be defined for some stocks due to lack of data. Also, it provides only an indirect method of assessing the possible effects of habitat changes on a species' productivity. It seems there could be confounding factors, such as physical environmental regime shifts, that could make a species' production appear to be unchanged, while habitat degradation could be ongoing and not noticed until a regime shift occurred. Further research is required to quantitatively link habitat amount and condition with species production. The Sitka Pinnacles Marine Reserve was designated, in part, because of the high diversity of organisms in that region, so some consideration to diversity is being given in management. Also, the EFH EIS and Programmatic Groundfish EIS consider fishing effects on several types of diversity, including species diversity and structural habitat diversity. Fishing effects on structural living habitat and benthic communities are considered qualitatively in these EIS documents that are being prepared.

### 4. Community/Trophic Structure Management

#### - General approach to management of food webs

The MSFCMA allows the modification of a target species' biological yield estimates to be modified to an OY that takes into account the protection of marine ecosystems and that is prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factor. Examples of ecological factors are given in the National Standard guidelines and include predator–prey or competitive interactions, and dependence of marine mammals and birds or endangered species on a stock of fish. Thus, fishery managers are given direction in modifying maximum biological yield targets to account for ecological factors such as predator–prey relationships. In practice, an OY range is specified in the management of Alaskan groundfish. In the EBS, the maximum OY is capped at 2 million metric tons (mt) and has proved constraining on individual target fisheries. Guidelines indicate that OY should be a target reference point and not an absolute ceiling, but rather a desired result. The EBS OY cap was not derived from a specific food web concern but rather as a general way of buffering total removals in the system.

The Stock Assessment and Fishery Evaluation (SAFE) documents of the Alaskan groundfish fisheries includes an Ecosystem Considerations appendix that summarizes the best information available on the status and trends of various ecosystem components that are predators and prey of managed groundfish species, and includes the results of multispecies and ecosystem models of the region. Individual stock assessment reports now include a qualitative evaluation of the trends of predators and prey of the managed species. Some species, such as walleye pollock, are cannibalistic and stock assessment of those species implicitly includes consideration of the cannibalism via the stock-recruitment curve.

As mentioned in the "Bycatch species" subsection, the NPFMC has also designated a 'forage fish' category that consists of relative fast turnover rate forage species such as gunnels, bathylagids, gonostomatids, lanternfish, sandfish, sandlance, smelts, stichaeids, and euphausiids. A maximum retainable bycatch (MRB) rate for each groundfish fishery is set at 2% of the total fishery catch for these species in aggregate. Commerce in these species is currently prohibited except for the small amounts retained under the MRB rates and for artisanal or subsistence uses. Abundance estimates are not available for these species so their status is unknown.

Key forage species that are important prey of the endangered Steller sea lion and that are the target of commercial fishing in the region include walleye pollock, Pacific cod, and Atka mackerel. Steller sea lion protection measures are in place to protect Steller sea lion foraging in nearshore and critical habitat areas through fishing closures in certain areas. Overall abundance of key Steller sea lion prey (walleye pollock, Atka mackerel, and Pacific cod) is regulated through a lower threshold harvest when spawning biomass reaches 20% of the projected unfished biomass ($B_{20\%}$), which is more conservative than is used in single species harvest strategies for those stocks.

The direct feeding interactions that involve target species primarily revolve around middle trophic level species such as walleye pollock and Atka mackerel, which are targets of fisheries and are prey of other target groundfish species in the BSAI and GOA. Cannibalism by walleye pollock in the EBS is well documented and explains part of the density dependence in the spawner–recruit relationship of pollock. Single-species models of walleye pollock in the EBS and GOA have been developed which include predation by other species, including target groundfish. A multispecies virtual population analysis (MSVPA) model has also been developed for the EBS. It showed that most predation mortality on target species tends to occur in juveniles. The trophic level of the groundfish catch has also been estimated for the EBS, AI, and GOA and appears to be relatively high and stable (see p. 224 of the Ecosystem Considerations appendix of the SAFE report: http://www.afsc.noaa.gov/refm/docs/2002/ecochap.pdf).

Levels of natural variability in feeding interactions that involve target species are relatively high because of the variability in predator stock size and variability in the abundance of target species that serve as prey. MSVPA results from the EBS show that predation mortality of walleye pollock at age 1 can have relatively large interannual variability.

Aside from the Steller sea lion prey protection rules mentioned above ($B_{20\%}$ lower threshold for walleye pollock, Pacific cod, and Atka mackerel spawning biomass and closed areas in sea lion foraging areas), the forage species maximum retainable bycatch rules and stock assessment scientist considerations of qualitative trends in predator or prey abundance for their stock (which could be used to justify changes in ABC recommendations but which, so far, has not been used in that way), there are no other planned management responses.

The level of information available to parameterize models of groundfish predator–prey dynamics is relatively good – MSVPA, which has been developed for EBS and statistical catch at age models that include predators, has been developed for EBS and GOA pollock. There are still lots of uncertainties about seasonal feeding dynamics, spatial–temporal variability in predation, and the form of the functional feeding responses of groundfish.

Multispecies reference points have not been defined for this system, and for cannibalistic species such as walleye pollock and Pacific cod, such reference points may result in $F_{msy}$ estimates that are higher than in the single-species case. Walleye pollock, Pacific cod, and Atka mackerel are above the $B_{20\%}$ value established for Steller sea lions and MRBs of forage species have not been exceeded. The 2 million mt OY cap on total groundfish catch in the EBS is frequently reached and constrains the groundfish catch. For example, the sum of the recommended ABCs for BSAI groundfish in 2003 was 3.2 million mt, which is 1.3 million mt above the OY cap.

These reference points provide protection for endangered species that rely on target groundfish, prevent target fisheries from starting on some small pelagic fish stocks, and provide an overall cap on catch that is less than the sum of the individual ABCs. However, these do not provide explicitly for the needs of other predators in a particular year (*i.e.*, through predator set-asides). The OY cap constrains catch but does not explicitly constrain catch for a particular species, thus leading to ABC reductions based on economic considerations but not due to food web considerations.

The EBS food web in general has been described in Aydin *et al.* (2002) (http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-130.pdf) based on parameterization of an Ecopath model of the system. Similar models are being developed for the

GOA and AI. Ecosystem indicators are also under development, and the present state of indicators are reflected in the Ecosystem Considerations appendix of the SAFE report (http://www.afsc.noaa.gov/refm/docs/2002/ecochap.pdf). Most of these indicators reflect status and trends of environment, fishing pressure, and species abundance trends. Aggregate indicators reflecting various ecosystem-level measurements, including types of diversity are also being developed.

There is a fair amount of natural variability in the EBS, AI, and GOA food webs based on observations of species responses to climate variability. Although primary and secondary production are not regularly evaluated in these systems, there have been unusual phytoplankton blooms occurring in recent years, along with dramatic changes in non-target species abundance including fish, bird, and marine mammals.

There are no planned management responses to deal with the food web, except the inclusion of ecosystem information in the Ecosystem Considerations appendix of the SAFE report and the ongoing efforts to develop reference points that deal with the food web, in general. General thresholds for evaluating fishing effects on ecosystem attributes have been developed as part of the requirements under NEPA to evaluate ecological effects of human activities (Table 2.7.1). Environmental impact statements which evaluate fishing effects on these ecosystems are being prepared. Significance thresholds have been defined for food web effects of fishing on pelagic forage availability, spatial and temporal concentration of fishery on forage, removal of top predators and introduction of non-native species. Ecosystem-level thresholds dealing with fishing effects on energy redirection and removals have been defined along with thresholds for species diversity, functional diversity, and genetic diversity. Application of the thresholds require knowing either the natural levels of variability of a species or system attribute and the potential for fishing to bring that attribute either below a single species limit, such as MSST, or to bring a system attribute outside the range of natural variability. Since these thresholds are difficult to define quantitatively in practice, indicators are used to evaluate whether or not particular organisms, groups, or ecosystem attributes are changing in an undesirable direction (Table 2.7.1).

The level of information presently being used in this evaluation is mainly limited to providing general indications of status and change – often with many different plausible interpretations. No target reference points at the general ecosystem level are being used, with the exception of keeping the sum of the individual species ABC limits within an OY range. This range was originally set equal to 85% of the range of the summed species-specific MSYs in the BSAI, in part to insure that future harvests would be sustainable. Status of the food web relative to an ecosystem reference point is not known and heavy reliance is still placed on individual species status.

The strengths/limits of general food web reference points are that the OY range provides some general food web protection although this should be evaluated using ecosystem models that have been developed for these regions. It might be more appropriate to use OY constraints for trophic level groups (the forage fish MRBs could be thought of as an OY constraint for a trophic-level group though some central forage species, such as walleye pollock and Atka mackerel, might need to be included in an OY constraint that considers all mid-trophic level species). Single-species thresholds appear to provide ecosystem protection – by protecting the individual pieces, you protect the whole. However, there are many uncertainties about the effects of fishing on the food web as a whole, and the work developing ecosystem indicators and ecosystem models will be useful to evaluate the potential effects.

### 5. Management of Contaminants and Pollution

Fishery management in Alaska is primarily concerned with the effects of the physical environment on individual species production patterns because there is a great deal of evidence that climate influences are a strong driver of species recruitment in the region. Other agencies, such as the Environmental Protection Agency (EPA) and Alaska, have primary responsibility for water quality issues, and fishery impacts on water quality through dumping of fish processing offal or vessel-related pollution is monitored and evaluated by these entities. Individual permits are given to fish processing plants which are required to follow 'total maximum daily load' (TMDL) plans for impaired waters to attain water quality standards for Alaskan waters. TMDLs are specified individually to fish processing plants and depend partly on the characteristics of the receiving water basin with respect to water depth and exchange. See http://yosemite.epa.gov/R10/Homepage.NSF/webpage/Alaska's+Environment?opendocument for more details on environmental protection in Alaska.

**Table 2.7.1** Significance thresholds and indicators for determining fishery-induced effects on ecosystem characteristics in the Eastern Bering Sea (EBS).

| Issue | Effect | Significance threshold | Indicators |
|---|---|---|---|
| Predator–prey relationships | Pelagic forage availability | Fishery induced changes outside the natural level of abundance or variability for a prey species relative to predator demands | Population trends in pelagic forage biomass (quantitative: walleye pollock, Atka mackerel, catch/bycatch trends of forage species, squid and herring) |
| | Spatial and temporal concentration of fishery impact on forage | Fishery concentration levels high enough to impair the long-term viability of ecologically important, nonresource species such as marine mammals and birds | Degree of spatial–temporal concentration of fishery on walleye pollock, Atka mackerel, herring, squid and forage species (qualitative) |
| | Removal of top predators | Catch levels high enough to cause the biomass of one or more top level predator species to fall below minimum biologically acceptable limits | • Trophic level of the catch<br>• Sensitive top predator bycatch levels (quantitative: sharks, birds; qualitative: pinnipeds)<br>• Population status of top predator species (whales, pinnipeds, seabirds) relative to minimum biologically acceptable limits |
| | Introduction of nonnative species | Fishery vessel ballast water and hull fouling organism exchange levels high enough to cause viable introduction of one or more nonnative species/invasive species | Total catch levels |
| Energy flow and balance | Energy re-direction | Long-term changes in system biomass, respiration, production or energy cycling that are outside the range of natural variability due to fishery discarding and offal production practices | • Trends in discard and offal production levels (quantitative for discards)<br>• Scavenger population trends relative to discard and offal production levels (qualitative)<br>• Bottom gear effort (qualitative measure of unobserved gear mortality, particularly on bottom organisms) |
| | Energy removal | Long-term changes in system-level biomass, respiration, production or energy cycling that are outside the range of natural variability due to fishery removals of energy | Trends in total retained catch levels (quantitative) |
| Diversity | Species diversity | Catch removals high enough to cause the biomass of one or more species (target, non-target) to fall below or to be kept from recovering from levels below minimum biologically acceptable limits | • Population levels of target, non-target species relative to MSST or ESA listing thresholds, linked to fishing removals (qualitative)<br>• Bycatch amounts of sensitive (low potential population turnover rates) species that lack population estimates (quantitative: sharks, birds, HAPC biota)<br>• Number of ESA listed marine species<br>• Area closures |
| | Functional (trophic, structural habitat) diversity | Catch removals high enough to cause a change in functional diversity outside the range of natural variability observed for the system | • Guild diversity or size diversity changes linked to fishing removals (qualitative)<br>• Bottom gear effort (measure of benthic guild disturbance)<br>• HAPC biota bycatch |
| | Genetic diversity | Catch removals high enough to cause a loss or change in one or more genetic components of a stock that would cause the stock biomass to fall below minimum biologically acceptable limits | • Degree of fishing on spawning aggregations or larger fish (qualitative)<br>• Older age group abundances of target groundfish stocks |

MSST = minimum stock size threshold, ESA = *Endangered Species Act*, HAPC = habitat areas of particular concern

Environmental impact analyses of the effects of fishing on the environment also consider the effects of fishing on the physical environment through water pollution.

**6. Management of Aquaculture and Enhancement Activities**

The EPA regulates all aquaculture activities in Alaska. Alaska aquaculture activities mainly consist of hatchery operations for rearing and release of salmon smolts. Most salmon enhancement in Alaska is occurring outside of the GOA and is primarily focused on pink and chum salmon. There are 30 nonprofit hatcheries, two federal and two state hatcheries according to the latest Alaska Department Fish and Game (ADFG) salmon enhancement program report (http://www.sf.adfg.state.ak.us/FedAidPDFs/fmr07-04.pdf). Alaska's hatcheries are primarily for sport fishing enhancement while the nonprofit hatcheries are for commercial enhancement goals. ADFG geneticists, pathologists, and biologists review all projects before issuing a permit to operate a salmon ranching facility, transfer eggs or fish, or release any fish into Alaskan waters. Production levels are relatively stable at this time. EPA regulates hatchery operations by issuing permits to manage wastewater effluent (http://yosemite.epa.gov/R10/WATER.NSF/webpage/Current+NPDES+Permits+in+Alaska).

In Alaska, saltwater aquaculture or sea culture of organisms by a variety of means to maturation only includes the farming of aquatic plants and shellfish. Farming of finfish is prohibited. In 2006, there were 60 farms producing primarily oysters, with small numbers of clams and mussels being produced. Most of this is occurring outside of the EBS. Broodstock must be from state certified sources or else an application must be made to acquire broodstock from other sources. Regulation of the farming of these products is primarily to ensure food safety and quality and to ensure disease-free stock. A growing area classification must be completed before shellfish may be harvested for sale. Classification is a two-part process, the water quality survey and shoreline survey. The water quality survey consists of the collection of water samples that are taken from designated stations. The shoreline sanitary survey is a physical on-site evaluation of all actual and potential sources of pollution that may affect the growing area.

### 2.7.4 Case Study 2: U.S. Pacific Coast Groundfish

#### Ocean Management Activities

The federally-managed groundfish community off California, Oregon and Washington occurs on the shelf and slope areas in the U.S. EEZ. This area is located entirely within the California Current Large Marine Ecosystem. The fishery is managed by the Pacific Fishery Management Council (PFMC; http://www.pcouncil.org) under the Groundfish Fishery Management Plan (FMP; http://www.pcouncil.org/groundfish/), with catch levels proposed in the Groundfish EIS (http://www.pcouncil.org/groundfish/current-season-management/). In-season adjustments are often recommended by the PFMC and must then be approved by NOAA. Every two years, the PFMC and NOAA convene to update and adjust policies that are currently in place.

**1. Fishery Management**

The Pacific Coast groundfish fishery has limited entry, open access, recreational, and tribal components. Most take is allocated to the limited entry permit fishery, comprised of separately regulated trawl and fixed-gear fleets; most landings come from trawlers. The open access fishery cannot use trawl gear directed at groundfish harvest. Landings have recently been managed by cumulative trip limits and seasonal or annual quotas, although a transition to a catch-share system, known as 'rationalization,' is now underway (details available at http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/). The text below generally reflects management practices prior to rationalization.

The general approach to retained species management is the annual TAC-setting process and an Observer Program to monitor TAC. Stocks or stock complexes within the retained (target) species category are part of this process. TACs are set by the PFMC and are less than or equal to the ABCs set by stock assessment scientists, which are, in turn, less than defined OFLs. Alternative ABCs, OYs and TACs for the fishery are prescribed in Chapter 2 of the Groundfish EIS (http://www.pcouncil.org/groundfish/current-season-management/). The alternatives are offered because there are multiple goals of fishery management that may be at odds with one another; chief among these potentially conflicting goals is the desire to maximize the economic value of the fishery and the need to rebuild depleted stocks that co-occur with healthy target species. Federal fishery scientists are, in general, responsible for deriving ABC and OFL estimates that are reviewed by the Groundfish Management Team, a panel of federal, state, and tribal scientists. These ABCs and OFLs are presented to the Council's Science and Statistical Committee for review. The SSC then makes the ABC and OFL recommendations to the PFMC. The observer program (http://www.nwfsc.noaa.gov/research/divisions/fram/Observer/) provides targeted catch, bycatch, and discard data in addition to the logbook data maintained by fishing vessels, and also monitors changes in fishing behavior as vessels approach their limits for target species. Observer coverage in the Pacific Coast groundfish fleet is designed so that all limited entry trawling vessels are observed for a minimum of two consecutive months every two years. The exception is the at-sea hake fishery (vessels that catch hake and deliver them to at-sea processing vessels), which receives 100% observer coverage. Some additional observer effort focuses on fixed gear fisheries.

Routine (*i.e.*, on-going but regularly updated) restrictions on limited-entry fisheries are in place for several species, based on PFMC recommendations and on the classification of certain groundfish stocks as overfished. Principal among those restrictions is setting seasonal quotas and/or cumulative trip limits that may be geographically based. Routine restrictions are in place for all groundfish caught by open access or recreational fisheries. The PFMC can recommend, and NOAA can implement, management actions beyond the scope of the routine actions in order to address arising conservation or socio-economic concerns. Some notable examples are described below.

Time/space closures to some, or all, fishing gears can be enacted when certain species reach defined quotas in a season or year, or they may be established on a permanent basis. Recently there have been several large-scale closures throughout the EEZ. In June 2005, the PFMC voted to permanently close all EEZ waters deeper than 1280 m to bottom trawling, and closed seamounts to all bottom-contacting gears. Several times in recent years, the PFMC has temporarily closed bottom and midwater trawling on the continental shelf in regions referred to as Rockfish Conservation Areas (RCAs). These areas are large, complexly shaped polygons defined by many waypoints in order to cover the appropriate depth strata, which define preferred habitat for overfished rockfish species such as bocaccio, canary rockfish, darkblotched rockfish, and Pacific ocean perch. Other year-round closed areas that have been in place since the late 20th Century are the Cowcod Conservation Areas (CCAs) located off the coast of southern California, and the Yelloweye Rockfish Conservation Area (YRCA) located off the coast of Washington. The PFMC is currently exploring the use of electronic vessel monitoring systems (VMSs) to track the movement of fishing vessels through closed areas. Finally, there are dozens of much smaller marine reserves throughout the region, typically in coastal regions, with varying degrees of restrictions on fishing and other human activities.

A second management tool is restricted size of footropes on shelf trawls. Rollers on footropes may be no greater than 8 inches (20.3 cm) in diameter, which essentially prevents fishing in rocky habitats because of the high likelihood of gear damage (Hannah, 2003). Management believes that rocky habitats are critical for several life stages of groundfish, particularly rockfish, and that protecting these habitats by making them effectively untrawlable will improve rockfish rebuilding efforts.

Another notable management tool was the recent buyback of trawl permits and vessels in the limited entry fishery. This federal legislation, implemented in 2003, was intended to reduce fishing effort on groundfish by roughly one third, and to increase financial stability among the fishing community. It ultimately funded the buyout of 92 vessels and 92 groundfish permits. This effort may be further augmented by a combined trawl permit buyback and marine protected area establishment proposed by The Nature Conservancy and the Environmental Defense Fund, non-governmental organizations that plan to purchase the permits for roughly half of the remaining trawlers in Central California and then establish marine reserves in the same areas to conserve sensitive benthic habitats, fish species, and related marine resources (see details in Appendix F of the Groundfish Essential Fish Habitat Environmental Impact Statement, available at http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/).

- **General approach to management for target and bycatch species**

Eighty-nine fish species are actively and specifically managed under the Pacific Coast Groundfish FMP: 62 species of rockfish (59 species of the genus *Sebastes*; shortspine and longspine thornyheads; California scorpionfish); 12 species of flatfish (arrowtooth and starry flounder; Pacific sanddab; butter, curlfin, Dover, English, flathead, petrale, rex, rock and sand sole); six roundfish (lingcod, cabezon, kelp greenling, Pacific cod, Pacific whiting (hake) and sablefish); one morid (finescale codling); one grenadier (Pacific rattail); and seven chondrichthyans (leopard and soupfin sharks; spiny dogfish; big, California and longnose skates; ratfish). However, the FMP states that any 'rockfish' (*i.e.*, a member of the family Scorpaenidae) is subject to management under the FMP. Pacific and California halibut are not managed under this FMP.

The dominant retained species are hake, rockfish, sablefish, and flatfish. Hake are potentially highly productive, with relatively short generation times (8 years) and high fecundity, but their production is constrained by stochastic recruitment success such that hake biomass is typically dominated by a few strong year classes. In general, rockfish (particularly large-bodied species) are slow to mature and have slow growth rates. Rockfish generation times are often measured in decades. They are live-bearing fish with very high fecundities, but survival of larvae is very poor and, in some species, episodic. Adult natural mortality rates are assumed to be low. These life history characteristics render rockfish susceptible to overfishing even at moderate rates of fishing mortality (Parker *et al.*, 2000). Sablefish have longer generation times than hake and episodic year class strength that appears strongly related to climate conditions. Flatfish vary broadly in terms of life span and size-specific fecundity.

Juvenile and adult hake eat mostly euphausiids, with larger adults also eating amphipods, squid, herring, smelt, crabs, and other fish, including juvenile hake. Juvenile hake are also eaten by lingcod and some rockfish while adults are eaten by sablefish, sharks, and marine mammals. Rockfish occupy a broad range of trophic roles owing to their species diversity, size diversity, and habitat diversity. Their diets range from gelatinous zooplankton to fish, with euphausiids being almost universally important. Larval, juvenile, and smaller adult rockfish provide food for other groundfish, albacore, marine mammals, sharks, and birds. Sablefish diets include fishes, cephalopods and benthic invertebrates. Young sablefish provide food for seabirds, fishes (including lingcod), and marine mammals. Juvenile and adult flatfish eat benthic invertebrates and fish, and are preyed upon by sharks, marine mammals, sablefish, and other flatfish. Some flatfish, such as English sole, inhabit estuaries at early ages, and are vulnerable to wading birds.

Population status of Pacific Coast groundfish is monitored through regular field surveys, using both fishery-independent trawl surveys and hydroacoustics. These surveys provide data on spatial distributions, habitat-specific abundances, and age structure of groundfish populations in trawlable habitats. NOAA scientists are attempting to improve monitoring of groundfish stocks in untrawlable habitats, but that is a relatively new research effort. Additionally, acoustic surveys concurrent with midwater trawl sets are done to monitor hake which inhabit midwater regions. Data from these surveys and from the fishery are incorporated into formal stock assessments; a compilation of SAFE documents for Pacific Coast groundfish from 2001 to the present is available at http://www.pcouncil.org/groundfish/. However, given the time required to conduct a stock assessment, the number of species in the FMP and the constant need to update assessments of key species, the number of species actually assessed is far less than the total number of species managed. For example, during the 2007–2008 biennium 23 species were assessed.

For the purposes of management, a species in this FMP is designated at 'precautionary status' if its spawning stock biomass (SSB) falls below 40% of the estimated unfished biomass. More drastically, a species is considered 'overfished' if its SSB is below 25% of the estimated unfished biomass. When fish are declared overfished, formal rebuilding plans are initiated; if SSB reaches 10% of initial, a zero catch policy is enacted. Rebuilding plans are currently in place for several overfished rockfish species; owing to the long generation times and low productivity of rockfish, target biomasses for some rockfish are not expected to be achieved for many decades.

Because several rockfish species have been declared overfished, and because their life history renders them especially sensitive to fishing mortality, fishing mortality target levels are being re-evaluated for rockfish. In the early 1990s, stock assessments of rockfish suggested that a fishing mortality ($F$) of $F_{35\%}$

would be sustainable; this was soon changed to $F_{40\%}$ (Clark, 2002). This indicates a fishing mortality that would reduce the spawning biomass per recruit (a proxy for lifetime egg production) to 40% of that in an unfished population. On subsequent analysis, this strategy was found to be unsustainable because of the low resiliency of rockfish to exploitation (Clark, 2002). More conservative $F$ levels are being considered and implemented in current OY determinations for rockfish. For example, recent draft stock assessments of vermilion rockfish (MacCall, 2005a), widow rockfish (He *et al.*, 2005), and bocaccio (MacCall, 2005b) are all using $F_{50\%}$ in their yield determinations.

Other species listed in FMP are considered either at target level, above target level, or have insufficient information to assess their populations. In cases where the abundance of species is based on either limited modeling ('data moderate' species) or solely on landed catch ('data poor' species), the PFMC may consider lowering the prescribed OY by 25% or 50%, respectively. A data-moderate OY reduction is under consideration for two flatfish (sanddabs and rex sole) that have not been assessed recently.

The bycatch mitigation plan (see http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/) goes into considerable detail about the species listed in both this section and the following "Threatened or Protected Species" section. It describes several alternative strategies for reducing the total bycatch and subsequent bycatch mortality in the groundfish fishery through changes in effort or catch limits. These alternatives have broad overlap with management strategies intended to optimize yield in the overall fishery while concurrently rebuilding stocks of depleted species, as drawn out in the Groundfish Environmental Impact Statement (http://www.pcouncil.org/groundfish/current-season-management/).

Many categories of bycatch species are recognized within the FMP, including overfished groundfish, highly migratory species (HMS), coastal pelagic species (CPS), prohibited species, and protected species. Incidentally caught overfished groundfish are often referred to as bycatch because they are rarely targeted, particularly those that have SSBs below the critical threshold of 10% of unfished biomass. Nonetheless, they are unavoidably caught in fisheries targeting more abundant groundfish. Although this bycatch is recognized as unavoidable, the PFMC and NOAA attempt to restrict it by setting low quotas for overfished species and monitoring those catches in season through the Observer Program. Meeting or exceeding those quotas may result in activation of a time/space closure such as an RCA.

HMS (tunas, billfishes, pelagic sharks) are mostly pelagic and are rarely caught in groundfish gears, and thus are not likely to be affected by groundfish management, unless perhaps by effort re-allocation related to groundfish permit buybacks or decreases in groundfishing opportunities.

CPS (*e.g.*, squid, sardine, anchovy, mackerel) are often caught in the hake fishery, which is a midwater trawl fishery, and in much lower numbers in groundfish gears associated with the bottom. Bycatch in the hake fishery can be large. For example, >80 mt of squid were caught in the 2001 at-sea hake fishery. The Pacifc Coast Groundfish FMP and EIS require that these species' status be considered in terms of impact. For that reason, take of these species is monitored, although any bycatch-related management decisions have to be made in conjunction with the CPS FMP, under which these species are managed. Current assessments indicate that biomasses of sardine and mackerel are increasing relative to other coastal pelagics, with both species being harvested at near-record levels. In contrast, squid population dynamics are highly variable and recruitment-driven. Sardine and anchovy population dynamics are strongly driven by interactions with climate regimes (Chavez *et al.*, 2003) as well as by fishing.

There is a special category of non-target bycatch species called 'prohibited species', meaning that they must be returned to the sea as quickly and safely as possible if brought on board. In the Pacific Coast Groundfish FMP, prohibited species include all Pacific salmon, Pacific halibut, and Dungeness crab (although Dungeness crab take is permitted in California waters, if done in accordance with California law). In addition, joint-venture operations (in which foreign processors receive fish caught in the U.S. EEZ) are prohibited from receiving salmon, Pacific halibut, Dungeness crab, and species outside of specific authorization or in excess of limits or quotas. Pacific salmon bycatch mostly occurs in the hake fishery, and specific fleet-wide bycatch rates have been established for Chinook salmon, which is the species most likely to overlap spatially and temporally with hake (the allowable rate has rarely been exceeded). These fish must be immediately returned; if retained, they are turned over to the state at which they are landed. Pacific halibut may only be kept if they are tagged, provided that the tag is returned to the International Pacific Halibut Commission (IPHC), the body that manages Pacific halibut. Bycatch of Pacific halibut that results in halibut mortality probably does not affect the overall status of the halibut population because halibut caught in Washington, Oregon, or California waters are likely at the southerly extent of the population and do not represent large numbers of the spawning stock biomass. However, fishing mortality of Pacific halibut incidentally caught by groundfish gear does count toward the total quotas established by the IPHC. Although this bycatch has been substantial on occasions, it is likely to have been curtailed in recent years by the establishment of RCAs which overlap with much of the Pacific halibut habitat off Washington, Oregon, and California. Dungeness crab are often taken in groundfishing gears, and all must be returned to the sea in Washington and Oregon. Despite this regulation, some mortality occurs, especially when the crabs are in the vulnerable soft-shell state following molting. Some RCA boundaries have been extended into shallower waters in molting seasons to minimize this impact. In California, some take of Dungeness crab is allowable in accordance with state regulations, which include size limits and a strict prohibition on the retention of female crabs.

Recently, the deep-sea coral communities of the continental slopes have attracted special attention with respect to groundfish fisheries. In slope regions, large footrope gear is permissible, and there is growing concern that these and other trawl gears will impact deep-sea coral communities, which are poorly studied. The impact of groundfish fishing on deep-sea coral communities remains unknown.

More generally, bottom trawling likely has a strong impact on substrates and associated organisms, especially benthos such as sponges, anemones, sea cucumbers, sea stars, sea pens, sea whips, and sea urchins, and benthopelagic organisms such as octopus. Little is known about the intensity or impact of trawl contact with benthic communities, although some generalizations can be hypothesized. For example, one might expect trawl impacts to be greater in relatively stable habitats that are not affected by strong current or wave action compared to more disturbance-prone habitats associated with higher wave energy. Also, there are some fishing grounds off California, Oregon, and Washington that are known to be regions of relatively high trawling intensity (NRC, 2002). However, the overall quantitative impacts of bottom trawls on these habitats remain unknown. As part of the evolution of the Essential Fish Habitat Environmental Impact Statement (EFH EIS) process, however, these issues will be addressed. Additionally, in the standard fishery-independent trawl surveys of groundfish abundance conducted annually by NOAA, biologists are now recording data on benthic invertebrates although these data are essentially limited to presence/absence of species.

Many other species are captured in groundfish fisheries, including some fish and invertebrate species with commercial value that are managed at state levels (*e.g.*, California halibut, shrimp, crab, sea cucumber), and others with recreational value (*e.g.*, California sheepshead, greenlings, ocean whitefish) or low human value (*e.g.*, eelpouts, midshipman, cat sharks). There is currently no management but some catch monitoring of species in this category, and retention of any nonspecified species is permitted. The impacts of different management alternatives on species such as shrimp, finfish, and other species not directly covered by the Groundfish FMP are discussed in the bycatch mitigation plan (available at http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/). Devising effective management measures to reduce bycatch will require additional economical and socio-cultural information.

**2. Management of Threatened or Protected Species and Communities**

In addition to the prohibited species noted in the previous section, there are several threatened and protected species in the EEZ off the Pacific Coast. These species fall under three overlapping categories (ESA-listed species, marine mammals, and seabirds), reflecting four mandates (the ESA, the MMPA, the MBTA, and Executive Order 13186, which gives further protection to migratory birds). Further protection for some of these species is outlined in the MSFCMA.

A number of threatened or endangered species or habitats for these groups occur in Pacific Coast EEZ waters, and these species are afforded protection under the ESA. Those species (and their ESA listing status) include: Pacific salmon (numerous threatened and endangered stocks in California, Oregon, Washington, and Idaho), sea turtles (endangered: leatherback; threatened: green, loggerhead, olive Ridley), seabirds (endangered: California least tern, California brown pelican, short-tail albatross; threatened: marbled murrelet), and marine mammals (endangered: blue whale, fin whale, humpback whale, North Pacific right whale, sperm whale; threatened: Steller sea lion, Guadalupe fur seal, sea otters in California). The listing status of some species, such as the southern resident killer whale (listed as ‘depleted’ under the MMPA), is the subject of some controversy. One mollusk, the white abalone, is endangered in this region, although it dwells in rocky, untrawlable habitat and is thus not likely to be directly affected by groundfish harvesting.

Take of Pacific salmon was discussed above in the section on bycatch; as prohibited species, Pacific salmon must be returned to the sea as quickly as practicable, regardless of their status under the ESA.

Interactions between sea turtles and groundfish gear or vessels are rare; most fishery-related sea turtle mortality appears to occur in gillnets (which are not used in groundfish harvest) or longlines (which are rarely used by the groundfish fleet in depths inhabited by sea turtles).

The Pacific Coast groundfish fishery is considered a low-risk fishery in the context of the MMPA. Direct incidental take of marine mammals by Pacific Coast groundfishing vessels has occurred in the hake fishery, but the take has been minimal. For example, between 1997 and 2001, by far the most frequently taken marine mammal was the Dall’s porpoise, but the average annual take by the entire hake fleet was 2.56 porpoises/year. Observer coverage from the remainder of the fishery indicates little direct take. For example, observer coverage of 30% of the limited entry fixed gear and 10% of the limited entry trawl fishery in fall 2001 to fall 2002 found a total take of 11 marine mammals, mostly California sea lions. The overall fishery is regarded as Category III under the MMPA, indicating a remote likelihood of mortality or injury related to fishing activity. The more likely impact of groundfish fishing is in changes to marine mammals’ food supply, whether by removal of their prey, alteration of the food webs in which they exist, or through provision of food via discard. These impacts, however, are not well known.

As with marine mammals, direct impacts of groundfishing on birds appear to be minimal, whereas indirect effects (*e.g.*, food web effects) are poorly studied. Observer data suggest that direct mortality of seabirds is very low. For example, observer coverage of 30% of the limited entry fixed gear and 10% of the limited entry trawl fishery in fall 2001 to fall 2002 found a total take of 5 birds. Most direct interaction appears to be birds scavenging offal on decks or discarded overboard, but there are little spatial or temporal data to quantify such interactions with birds and vessels.

Besides the ESA-listed seabirds mentioned previously, the U.S. Fish and Wildlife Service designated several birds as ‘species of special conservation concern.’ These include black-footed albatross, ashy storm petrel, gullbilled tern, elegant tern, arctic tern, black skimmer, and Xantus’s murrelet. Furthermore, migratory seabirds receive protection from the MBTA, an international treaty among Canada, Japan, Mexico, Russia, and the U.S. which forbids the killing, taking, or possessing of a migratory bird. EO 13186 mandates agencies to work with the Fish and Wildlife Service (FWS) to establish Terms of Understanding about the impact of human activities upon migratory birds; NOAA and the FWS are currently developing such Terms for migratory birds. Finally, the MSFCMA requires compliance among NOAA-enforced fisheries management actions and all legislation designed to protect seabirds.

### 3. Habitat Management

Essential fish habitat (EFH) for Pacific Coast groundfish is defined generally as the aquatic habitat necessary for groundfish production that supports both long-term sustainable fisheries and healthy ecosystems. To satisfy this description, EFH must be described for all life history stages of managed species. Pacific Coast groundfish species managed by the Pacific Coast Groundfish FMP occur throughout the EEZ and occupy diverse habitat types at all stages in their life histories. EFH for any one species may be large (*e.g.*, a species with pelagic eggs and larvae that are widely dispersed) or comparatively small (*e.g.*, nearshore rockfish which show strong affinities for a particular location or type of substrate).

EFH descriptions and management were originally incorporated into the Pacific Coast Groundfish FMP in Amendment 11 (available at http://www.pcouncil.org/groundfish/, but EFH designation and management were updated in 2006 with the adoption of Pacific Coast Groundfish FMP Amendment 19 (available at http://www.pcouncil.org/ groundfish/). This Amendment was a result of the process of developing a Groundfish Essential Fish Habitat Environmental Impact Statement (EFH EIS), which was finalized in late 2005 (http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/). Although EFH designation does not, by itself, confer protection upon a habitat, it does bring that habitat into the context of the EFH habitat management plan, which is intended to maintain or enhance habitats and their associated ecological and/or socio-economic benefits. The EFH EIS presents a framework for: 1) identifying groundfish EFH (waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity) and habitat areas of particular concern (HAPC; EFH that is especially important, sensitive, rare, or threatened by potential human activity); quantifying the 'habitat suitability probability' of potential groundfish habitat; 3) identifying strategies to minimize fishery-related impacts on EFH and HAPC; 4) conducting research and monitoring to evaluate the effectiveness of groundfish habitat management; and 5) identifying the ecological and socio-economic benefits and costs of implementation alternatives. The EFH EIS also describes the legislative basis for cooperative EFH management between the federal government, state governments, and tribal groups.

Habitat management for Pacific Coast groundfish fisheries has been done primarily through the standard federal consultation process. Specific cases in which action has been taken to minimize fishing impacts on EFH are limited to a few cases, although those cases are considerably important. A chief example is limiting bottom trawling to soft sediments; the mandatory small rollers on trawl footropes mean that vessels are unlikely to trawl around rocky bottoms due to potential gear damage. This means that rocky reef habitat, considered critical habitat for groundfish, is 'untrawlable', and is mostly fished by sport anglers or commercial longliners. Also, closing large areas to fishing is intended not just to lower fishing mortality, but also to protect habitat where fish species of concern (*e.g.*, yelloweye rockfish, cowcod) are found.

The standard consultation processes involved in identifying EFH, the modeling involved in the EFH EIS, and a general assessment of groundfish fishing impacts on marine habitats are data-intensive endeavors. Many programs exist for identifying and quantifying different habitat types in the Pacific Coast EEZ. At the federal level, these efforts include bottom mapping and related groundtruthing, using multibeam sonar equipment, echo sounders, and remote operated vehicles (ROVs) with cameras. Overlapping surveys are done to assess the physical and chemical characteristics of the water overlying different habitat types. More recently, NOAA biologists have begun efforts to assess the populations of groundfish in untrawlable habitats through use of ROVs and towed camera sleds, hook-and-line surveys, and mark-recapture studies. Such information will increase the accuracy of coastwide stock assessments.

Regarding empirical monitoring and research of human impacts on benthic habitats inhabited by groundfish, there are many human activities that have direct and indirect effects; these include fishing, dumping, dredging, oil and gas production, oil spills, water intake, cabling, pollution via runoff or wastewater discharge, coastal development, kelp harvesting, and introduction of non-indigenous species.

Fishing with bottom-contact gears, as described in the previous section, has numerous impacts on habitat (NRC, 2002), although they have not been well documented in this fishery (see Appendix C of the Groundfish EFH EIS, available at http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/). Bottom-contact gears can remove or damage benthic habitat-forming species, ranging from macrophytes to corals to invertebrates, as well as infaunal species that influence sediment stability by burrowing and water quality by filter feeding. It can also disrupt soft sediments through creating trawl scars that last anywhere from hours to years, depending on circulation patterns, sediment type, trawling speed, and trawl door size and weight; such areas can experience local areas of high sediment suspension and resettlement, nutrient release, and hypoxia (Kaiser *et al.*, 2002). Through repeated trawling of the same area, soft sediments can also become compacted. Other potential direct impacts on habitats include loss of gear, such as pots, traps, longlines or gillnets on hard substrates, which could result in 'ghost fishing' by those gears and local, habitat-specific increases in fish mortality until the gears biodegrade or are salvaged. Fishing vessel discards of unwanted bycatch or offal that sink to the bottom and decompose may result in localized hypoxia.

Direct and indirect impacts of the non-fishing human activities are described in Appendix C of the

Groundfish EFH EIS, available at http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/. Most of these descriptions are general, not specific to the U.S. Pacific Coast. These activities are regulated by established legislation (*e.g.*, the federal *Clean Water Act*, http://www.epa.gov/agriculture/lcwa.html) and by local, state and federal permitting processes, which often involve a full environmental impact statement. Specific impacts of these activities on groundfish habitats (and, by extension, groundfish ecology) have not been well documented, although it is likely that many of the activities occur in relatively nearshore habitats and thus have a low impact on continental shelf or slope species.

## 4. Community/Trophic Structure Management

### - General approach to management of food webs

At present, there is little empirical or modeling information on the extent to which food web interactions affect the population biology of Pacific Coast groundfish species, and hence the stock assessment models for these species remain essentially single-species models. In 2001, a panel of NOAA scientists compiled a Stock Assessment Improvement Plan (SAIP; http://www.st.nmfs.gov/st2/saip.html) to address ways to augment stock assessments through, among other things, incorporating food web interactions into population dynamics. A specific need cited in that document for Pacific Coast groundfish was to account for the role of increased pinniped abundance which could signal an increase in predation mortality on groundfish. Still other cases involving predation by groundfish on other groundfish have gained attention in the recent literature (*e.g.*, Mangel and Levin, 2005), and the PFMC has acknowledged the importance of food web interactions by banning the harvest of euphausiids (http://www.pcouncil.org/coastal-pelagic-species). This ban was enacted not because krill are overfished (in fact, they are not harvested at all), but precisely because they are a ‘fundamental food source’ for many marine species. The same document notes the possibility of extending this ban to other forage species. Thus, it is clear that food web interactions are considered important in managing this system.

Diets of many key Pacific Coast groundfish species have been studied quantitatively, including Pacific hake (Gotshall, 1969; Outram and Haegele, 1972; Livingston, 1983; Tanasichuk *et al.*, 1991; Buckley and Livingston, 1997; Grover *et al.*, 2002), sablefish (Laidig *et al.*, 1997), some shelf rockfish (Reilly *et al.*, 1992; Lee, 2002) and nearshore rockfish (Hallacher and Roberts, 1985; Hobson and Chess, 1988; Murie, 1995), arrowtooth flounder (Gotshall, 1969), and spiny dogfish (Tanasichuk *et al.*, 1991). Many of those studies evaluated diets over limited spatial and temporal scales. Diets of multispecies groundfish assemblages are summarized in some sources (*e.g.*, Quast, 1968; Lea *et al.*, 1999; Love *et al.*, 2002). Buckley *et al.* (1999) present quantitative, coastwide diet data from several size classes, seasons, and years for hake, sablefish, three flatfish, two thornyheads, and two grenadiers. Also, some prey (squid, euphausiids, and certain myctophids) are relatively ubiquitous and can thus be described as key to groundfish production. There is, however, a general scarcity of quantitative diet data that span large geographic ranges, multiple ontogenetic stages, seasons, or changes across climate regimes of different temporal scales.

Diets of several rockfish species off the Oregon coast have been inferred through analysis of stable isotope ratios (Bosley *et al.*, 2004). Tracer methods like stable isotope analysis are an attractive research avenue because they capture diet habits over a longer time scale than stomach analysis; they are not subject to some sources of bias in stomach analysis (*e.g.*, empty stomachs, stomach eversion, feeding while in the capture gear); and they provide information about the ultimate sources of production that support a species.

Our growing knowledge of diets will bring a better notion of bottom-up and top-down forces that structure groundfish populations and communities. The effects of bottom-up forces, such as the quality and quantity of prey on rockfish growth and reproductive fitness, have been shown both empirically (Lenarz *et al.*, 1995; VenTresca *et al.*, 1995) and with bioenergetics modeling (Harvey, 2005). Cases where poor spring and summer feeding conditions constrain female rockfish from storing enough lipids to produce a normal amount of larvae (Guillemot *et al.*, 1985; Lenarz *et al.*, 1995; VenTresca *et al.*, 1995) clearly link food web processes to rockfish population biology. Top-down forces, apart from fishing mortality, have been difficult to identify in groundfish communities, but some models argue for their importance and demonstrate their potential importance if overlooked. Mangel and

Levin (2005) developed alternative models of marine reserves intended to enhance a population of bocaccio rockfish. The efficacy of some marine reserves hinged on whether or not lingcod, which prey on young bocaccio, were included in the model. This was because lingcod, which have faster growth rates and shorter generation times, responded more rapidly to the cessation of fishing and quickly reached sizes and numbers capable of suppressing juvenile bocaccio through predation.

Bottom-up and top-down forces occur in concert, with varying degrees of impact, against a backdrop of environmental variability and fishery exploitation. Because of this complexity, scientists are using community-level or ecosystem-level modeling tools to simulate ecological dynamics. Field (2004) developed a model of the Northern California Current ecosystem using the Ecopath with Ecosim software (Christensen and Walters, 2004). The Ecopath mass-balance model was used to estimate, for example, linkage strengths in the food web, the effects of hake predation on different forage bases, the relative impacts of fishing and predation on groundfish stocks, and how the importance of thornyheads in sablefish diets has been overestimated (Field, 2004). The dynamic Ecosim model was used to estimate food web responses to fisheries and climate anomalies (upwelling, PDO). Among the inferences Field (2004) made concerning groundfish were: that hake compete for prey with Pacific salmon; that hake are a key source of mortality for pink shrimp; and that populations of longspine thornyheads, which are expected to decline due to fishing, may actually remain stable because their major predators, sablefish and shortspine thornyheads, have also been fished down.

Food web modeling may also help to demonstrate relationships between groundfish and other members of the community. Larval and juvenile groundfish are known to be important prey for seabirds (Sydeman *et al.*, 2001; Miller and Sydeman, 2004). Also, although the groundfish fishery has little impact on seabirds and marine mammals in terms of bycatch mortality (PFMC, 2004a), it likely influences their population in other ways: fisheries may deplete stocks of groundfish that apex predators depend on, whereas scavenging birds and mammals certainly feed on bycatch or offal that vessels discard.

Finally, it is noteworthy that there are relatively few specifics concerning food web dynamics in the FMP (PFMC, 2004a) or the fishery EIS (PFMC, 2004b). This does not indicate a lack of concern on the part of the PFMC – rather, it illustrates the difficulty in acquiring food web information and integrating it into an already complex system of population assessment and management. This underscores the strong potential of food web models: once user-friendly ecosystem-level food web models are available to decision-makers, the models can be used to synthesize available information and generate hypotheses or serve as guidelines toward determining the strength of food web interactions that ultimately may shape groundfish population dynamics. This, in turn, will lead to empirical studies designed to provide quantitative information for use in stock assessments.

## 5. Management of Physical Environment

The groundfish community occurs against a backdrop of physical conditions characterized by bottom topography and sediment type, bathymetric gradients, dynamic current structures at many spatial scales, chemical gradients, water temperatures, and climate. All of these factors can influence fish distribution.

The bottom habitat of the Pacific Coast EEZ is characterized by a fairly narrow continental shelf (rarely wider than 50 km) and a broader slope; most trawling for groundfish occurs on the shelf at depths up to about 500 m. Bottom types are typically sand, mud, gravel, boulders, rocky pinnacles, or exposed bedrock. Major geological features include capes and points (notably Point Conception and Cape Mendocino) and submarine features (notably Monterey Canyon, the Mendocino Escarpment, and Astoria Canyon) that often mark approximate boundaries for shifts in groundfish species composition. Species composition of groundfish communities is also linked to more basic physical gradients such as latitude and depth. For example, Williams and Ralston (2002) classified several distinct assemblages of rockfish based on latitude and depth, and Love *et al.* (2002) have found that rockfish species diversity increases from north to south along the North American coast. Estuaries provide habitat for juvenile life stages of some groundfish, including English sole and lingcod.

In terms of oceanography, the dominant feature of this region is the California Current, a large clockwise surface current that branches off the North Pacific Current in the region of Vancouver Island. It brings relatively cool water southward along the coast until roughly Point Conception, where it moves away from the coast. The California Current is strongest and closest to shore during the summer. The deeper, slower California Undercurrent runs northward along the Pacific Coast. Dynamics within the California Current, along with major wind events, can lead to the coastal upwelling of cold, nutrient-rich water which leads to increased primary production that can be propagated throughout the food web. Upwelling is often associated with areas that have submarine canyons. While upwelling is typically associated with episodes of high primary productivity, a recent large upwelling event introduced hypoxic water to waters off the northern U.S. Pacific Coast, causing large amounts of groundfish mortality and stress on other demersal and benthic communities (Grantham *et al.*, 2004). Many eddies and jets occur along the coast, often created or influenced by coastal geologic features such as capes and points. These localized current dynamics may be especially important to groundfish species whose larvae undergo a prolonged pelagic larval stage because current-driven dispersal and/or retention of larvae can have strong influence on recruitment. South of Point Conception is the Southern California Bight, dominated by a counterclockwise eddy of relatively warm water.

Much research in recent years has focused on the importance of climate variability on growth, survival, recruitment, and spatial distribution of groundfish. Variability ranges from changes in wind, temperature, and upwelling intensity on the scale of 1 to 2 years (El Niño Southern Oscillations (ENSOs) and La Niñas) to decadal-scale climate regime shifts (the Pacific Decadal Oscillation (PDO)). ENSOs have probably received the most attention, and their effects vary among different groundfish. For example, the warm waters and poor upwelling associated with an ENSO often create poor conditions for rockfish recruitment and have led to poor growth, reduced fecundity, and increased mortality among adult rockfish. Changes in temperature caused by ENSO events may also result in dramatic shifts in species composition of the groundfish prey community (Brodeur and Pearcy, 1992). In contrast, hake recruitment has been strong in years after ENSOs (Hollowed *et al.*, 2001). A shift from one PDO regime to another leads to differences in air pressure, oceanic circulation, and other key oceanic properties that affect primary production and consumer species composition (Francis *et al.*, 1998). Among rockfish off Southern California, the ‘cool’ PDO regime appears to be more favorable, as measured by larval abundance (Moser *et al.*, 2000). Pacific Coast groundfish may also be influenced by other sources of long-term variation: strong year classes for some groundfish have been associated with decadal-scale variation related to Aleutian Low pressure events in conjunction with ENSO events, rather than the timing of PDO regimes (Hollowed and Wooster, 1992, 1995). Sablefish year class strength off some regions of the Pacific Coast appears related more to factors such as seasonal Ekman transport and sea level than to adult abundance in a traditional stock-recruit relationship (Schirripa and Colbert, 2006).

Overall, despite the research dedicated to relationships between climate and groundfish, there has been little done to incorporate this research into management. Integrating climate variability into stock assessments, and understanding the relationships between climate and recruitment, are high priorities for Pacific Coast groundfish management.

### 6. Management of Contaminants and Pollution

There are many potential sources of contaminants and pollutants that can impact the ecosystems supporting Pacific Coast groundfish, and pollutants can take the form of toxic substances, discarded or lost materials such as plastics, or thermal discharges. Notable sources are point sources (rivers, sewage outfalls, power plants), non-point source runoff, atmospheric deposition of globally dispersed chemicals, oil spills, dumping, military activities, and shipping (via engine exhaust, materials lost overboard or dumped, or shipwrecks). Some human activities may also encourage production of natural toxins, such as those occurring in certain algal blooms. While other factors such as species introductions and sonar equipment have been described in similar terms (‘biological pollution’ and ‘noise pollution’, respectively), those factors will not be addressed in this section as they are probably more relevant to other ecosystems (*e.g.*, estuaries and intertidal habitats for species introductions) or communities (*e.g.*, marine mammals for sonar activity).

In the Pacific Coast region, there has been widespread addition of terrestrial nutrients from point sources and non-point runoff, and a wide range of local, state, and federal laws are in place that set standards for levels of point and non-point pollution (*e.g.*, http://www.ecy.wa.gov/water.html). Considerable research has been done on the effects of eutrophication on nearshore habitats, especially estuaries, bays, and seagrass beds. Little information is available on how eutrophication directly affects groundfish production, however. Similarly, it is well known that increased nutrient levels can lead to harmful algal blooms (HABs) on the U.S. Pacific Coast, including red tides, brown tides, and blooms of the diatom *Pseudo-nitzschia* that produce domoic acid, a toxin readily incorporated into marine food webs. However, there is little research directly connecting HABs with the ecology of groundfish.

In contrast, many anthropogenic contaminants and toxins have been found in tissues of groundfish on the U.S. Pacific Coast. These chemicals likely arrived in groundfish systems via point sources (rivers, outfalls, oil spills, urban centers, anti-fouling treatments) and non-point sources (terrestrial runoff, atmospheric deposition). They can then be taken up by direct absorption across gill membranes or indirectly via bioaccumulation through the food web, producing lethal and sublethal affects. Contaminants buried in marine sediments can also be resuspended by dredging activities. A large body of recent literature is devoted to levels of chlorinated hydrocarbons and heavy metals in groundfish tissues, not only around urban centers such as south Puget Sound (*e.g.*, Stein *et al.*, 1992; Johnson *et al.*, 1998; O'Neill and West, 2004) but also around relatively undeveloped areas such as the Farallone Islands (Sydeman and Jarman, 1998). Most of the impacts evaluated in these studies are sublethal, such as effects of exposure levels on enzyme levels or reproductive output. While guidelines for human consumption of groundfish have been set in many areas (*e.g.*, http://www.doh.wa.gov/ehp/oehas/fish/default.htm), and overall domestic release of organochlorines and heavy metals has been greatly reduced by legislation such as the *Clean Water Act* (http://www.epa.gov/agriculture/lcwa.html) and *Clean Air Act* (http://www.epa.gov/air/caa/), there have not been sweeping ecosystem management actions in specific response to contaminant levels in Pacific Coast groundfish. Recommendations on how to minimize contaminant impacts on groundfish were made in Amendment 11 of the FMP.

Oil and petroleum spills are a major problem on the U.S. Pacific Coast, owing to extensive oil production on the continental shelf in California waters, and the large amount of oil that is shipped through areas subject to strong storms and characterized by rocky coasts or shoals. While coastwide programs are in place to coordinate response to spills (*e.g.*, www.oilspilltaskforce.org/index.htm), they remain essentially inevitable: whereas the global trend has been one of fewer major spills in recent decades, the number of yearly oil or petroleum spills >37,850 L in the California Current region has been relatively unchanged from 1978–1999 (Mearns *et al.*, 2001). Over 150 spills of this magnitude occurred on the U.S. Pacific Coast in this period (the vast majority in California), and many more small spills also occurred; the dispersal characteristics of these spills vary considerably (Mearns *et al.*, 2001). Oil and petroleum spills can have lethal or sublethal effects on groundfish (Marty *et al.*, 2002) and the species that they depend on for prey or habitat. Species that feed on groundfish (sea birds, marine mammals) are also adversely affected, as are fisheries that typically close while clean-up activities are occurring. Oil spill dispersant chemicals are, themselves, potentially toxic to some fish and to other species that provide biogenic habitat or prey, although often less so than the oil that they are used to disperse (Singer *et al.*, 1995). Regarding management responses and recovery rules concerning oil and petroleum spills, it seems likely that species groups other than groundfish will dictate the course and pace of decision making, particularly because many of the species most obviously affected by oil spills are also federally protected species, such as marine mammals and seabirds, or are targets of surface-oriented fisheries, such as salmon and herring.

Debris, garbage, and dredge spoil have been dumped regularly at sea in the U.S. Pacific Coast region, as evidenced by a survey that found debris on 14% of the seafloor between 10 and 200 m off Southern California (Moore and Allen, 2000). The debris in that study was patchy and occurred at low density. It was comprised mostly of fishing gear, plastics, metal, glass, and miscellaneous items. Debris on the sea floor may be the result of intentional actions (*e.g.*, dumping, littering, military exercises) or accident (*e.g.*, loss of fishing gear, shipwrecks, loss of cargo in inclement weather, discharge of debris in stormwater). Dredge spoil dumping may also introduce some debris in addition to large loads of sediment.

Overall, the impacts of non-fishing activities, including pollution and contaminant production, on groundfish in this region are very poorly studied, and thus there are no reliable measures of target levels for management responses, nor have risk assessments and mitigation plans been developed.

## 7. Management of Aquaculture

Currently, there is little or no aquaculture for groundfish species in the U.S. Pacific Coast EEZ. However, pen rearing of groundfish to market size is certainly feasible, and captive breeding of some groundfish species, notably lingcod, sablefish, and brown rockfish, is being studied in the U.S. at the Northwest Fisheries Science Center (NWFSC, NOAA, Seattle; http://www.nwfsc.noaa.gov/research/divisions/reutd/marineenhance.cfm and www.nwfsc.noaa.gov/publications/issuepapers/pdfs/reut6203.pdf). Extensive aquaculture of at least one rockfish species, *Sebastes schlegeli*, occurs in Asia, underscoring the feasibility of groundfish culture.

Wild groundfish may be affected by regional aquaculture activities that produce non-groundfish species. For example, oyster and other bivalve culture in coastal regions may affect groundfish by providing habitat, affecting prey abundance, or by altering water quality. Whether such effects would be positive or negative has not been established experimentally owing to the difficulty of conducting controlled field studies in such areas. Salmon net pen aquaculture has been linked to many localized environmental problems, including eutrophication, hypoxia, and disease introduction; Kent *et al.* (1998) found that groundfish near a salmon net pen were infected with viral and bacterial infections previously only seen in pen-reared salmon. Further studies assessing links between groundfish ecology and non-groundfish aquaculture practices would be valuable.

Aquaculture has changed the global fish market because fresh, domesticated finfish and shellfish are now available in large quantities at all times of the year. These resources are cheaper to produce than wild finfish and shellfish, which has driven seafood prices down. To remain competitive, groundfish managers, harvesters and processors have attempted to allocate harvest more evenly over the course of a calendar year (*e.g.*, Chapter 7 of the 2009–2010 Groundfish EIS, avaliable at http://www.pcouncil.org/groundfish/current-season-management/). How this temporal allocation of fishing mortality will affect groundfish ecology is unclear, as is the impact of changing price structures caused by global aquaculture.

## 8. Management of Enhancement Activities

As referred to in the "Management of Aquaculture" section, researchers at the NWFSC have undertaken captive breeding studies for lingcod, sablefish, and many rockfish species. This research covers topics such as physiology, nutrition, pathology, developmental biology, and optimal conditions for rearing larvae, with a long-term goal of large-scale culturing (see http://www.nwfsc.noaa.gov/research/divisions/reutd/marineenhance.cfm and http://www.nwfsc.noaa.gov/publications/issuepapers/pdfs/reut6203.pdf).

As of this writing, there have been no artificially reared larval or juvenile groundfish releases (akin to the release of hatchery-reared Pacific salmon smolts) into Pacific Coast waters of the U.S. As captive breeding methods at the NWFSC are developed and refined, subsequent research (as listed in the issue paper cited above) will shift to:

- establishing captive broodstocks of marine species to provide offspring for research;
- determining appropriate conditions for using hormonal and environmental manipulation to stimulate and synchronize spawning;
- developing egg incubation, larval culture, and juvenile rearing technologies;
- developing environmentally-sound aquaculture techniques, feed and health-management practices for rearing juveniles to maturity and spawning;
- developing rearing technologies that are both cost-effective and environmentally friendly; and
- investigating the genetic and ecological effects of released fish on wild populations.

Longer-term groundfish enhancement efforts noted in the issue paper include:

- establishing and maintaining captive broodstocks for future research;
- raising sablefish and rockfish broodstocks under photoperiods that have been shifted to provide offspring out of season (doubling the amount of research that can be done on critical larval stages);
- training state biologists, tribal members and entrepreneurs in large-scale rearing technologies;
- conducting stock-enhancement aquaculture trials in cooperation with state and tribal fisheries agencies.

Despite the groundfish stock enhancement research focus described above, there are no plans for artificial groundfish propagation listed in the current FMP or the groundfishing EIS.

Another means of groundfish enhancement is creating or restoring habitat that promotes groundfish production. Groundfish, such as rockfish, clearly aggregate around artificial substrates such as oil and gas platforms off the California coast, and there is considerable support from multiple public sectors to preserve decommissioned platforms as artificial reefs although more research is needed as to the suitability of oil platforms as productive groundfish habitat (Helvey, 2002). Restoration of large kelp species, which form dense stands that provide habitat for nearshore groundfish and valuable recruitment substrate and nursery habitat for juveniles of many inshore and offshore species, has been undertaken in many areas. For example, in Southern California waters, the California Coastkeeper Alliance and NOAA have a project in which laboratory-reared kelp sporophytes are transplanted to reefs in the wild (see details at http://www.cacoastkeeper.org/). The transplants are monitored regularly, and potential grazers, such as sea urchins, are relocated to preserve kelp growth. Other researchers have used plastic kelp blades which act as a mechanical defense for living kelp against sea urchins in Southern California waters (Vasquez and McPeak, 1998).

As with any project designed to increase groundfish abundance, responses to habitat enhancement will be difficult to monitor because of the long generation times and unpredictable recruitment success of many groundfish species. The inherent difficulty in observing and enumerating these species in non-trawlable habitats adds further complication.

### 2.7.5 References


Aydin, K.Y., Lapko, V.V., Radchenko, V.I., and Livingston, P.A. 2002. A comparison of the eastern Bering and western Bering Sea shelf and slope ecosystems through the use of mass-balance food web models. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-AFSC-130.

Bosley, K.L., Lavelle, J.W., Brodeur, R.D., Wakefield, W.W., Emmett, R.L., Baker, E.T. and Rehmke, K.M. 2004. Biological and physical processes in and around Astoria submarine Canyon, Oregon, USA. *J. Mar. Systems* **50**: 21–37.

Brodeur, R.D. and Pearcy, W.G. 1992. Effects of environmental variability on trophic interactions and food web structure in a pelagic upwelling ecosystem. *Mar. Ecol. Prog. Ser.* **84**: 101–112.

Buckley, T.W. and Livingston, P.A. 1997. Geographic variation in the diet of Pacific hake, with a note on cannibalism. *Cal. Coop. Ocean. Fish. Invest. Rep.* **38**: 53–62.

Buckley, T.W., Tyler, G.E., Smith, D.M. and Livingston, P.A. 1999. Food habits of some commercially important groundfish off the coasts of California, Oregon, Washington, and British Columbia. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-AFSC-102.

Chavez, F.P., Ryan, J., Lluch-Cota, S.E. and Niquen, C.M. 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. Science **299**: 217–221.

Christensen, V. and Walters, C.J. 2004. Ecopath with Ecosim: methods, capabilities and limitations. *Ecol. Modell.* **172**: 109–139.

Clark, W.G. 2002. $F_{35\%}$ revisited ten years later. *N. Am. J. Fish. Mgmt.* **22**: 251–257.

Field, J.C. 2004. Application of ecosystem-based fishery management approaches in the Northern California Current. Ph.D. dissertation, University of Washington, Seattle, WA.

Francis, R.C., Hare, S.R., Hollowed, A.B. and Wooster, W.S. 1998. Effects of interdecadal climate variability on oceanic ecosystems of the NE Pacific. *Fish. Oceanogr.* **7**: 1–21.

Gotshall, D.W. 1969. Stomach contents of Pacific hake and arrowtooth flounder from northern California. *Cal. Fish Game* **55**: 75–82.

Grantham, B.A., Chan, F., Nielsen, K.J., Fox, D.S., Barth, J.A., Huyer, A., Lubchenco, J. and Menge, B.A. 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific. *Nature* **429**: 749–754.

Grover, J.J., Buckley, T.W. and Woodbury, D. 2002. Effects of the 1997–1998 El Niño on early-juvenile Pacific hake *Merluccius productus*: age, growth, abundance, and diet in coastal nursery habitats. *Mar. Ecol. Prog. Ser*. **240**: 235–247.

Guillemot, P.J., Larson, R.J. and Lenarz, W.H. 1985. Seasonal cycles of fat and gonad volume in five species of northern California rockfish (Scorpaenidae: *Sebastes*). *Fish. Bull.* **83**: 299–311.

Hallacher, L.E. and Roberts, D.A. 1985. Differential utilization of space and food by the inshore rockfishes (Scorpaenidae: *Sebastes*) of Carmel Bay, California. *Environ. Biol. Fishes* **12**: 91–110.

Hannah, R.W. 2003. Spatial changes in trawl fishing effort in response to footrope diameter restrictions in the U.S. West Coast bottom trawl fishery. *N. Am. J. Fish. Mgmt.* **23**: 693–702.

Harvey, C.J. 2005. Effects of El Niño events on energy demand and egg production of rockfish (Scorpaenidae: *Sebastes*): a bioenergetics approach. *Fish. Bull*. **103**: 71–83.

He, X., Pearson, D.E., Dick, E.J., Field, J.C., Ralston, S. and MacCall, A. 2005. Status of the widow rockfish resource in 2005. NOAA-NMFS-SWFSC, Santa Cruz, CA.

Helvey, M. 2002. Are southern California oil and gas platforms essential fish habitat? *ICES J. Mar. Sci.* **59**: S266–S271.

Hobson, E.S. and Chess, J.R. 1988. Trophic relations of the blue rockfish, *Sebastes mystinus*, in a coastal upwelling system off northern California. *Fish. Bull.* **86**: 715–743.

Hollowed, A.B. and Wooster, W.S. 1992. Variability of winter ocean conditions and strong year classes of Northeast Pacific groundfish. *ICES Mar. Sci. Symp*. **195**: 433–444.

Hollowed, A.B. and Wooster, W.S. 1995. Decadal scale variations in the Eastern Subarctic Pacific: 2. Response of Northeast Pacific fish stocks. *Can. Spec. Pub. Fish. Aquat. Sci*. **121**: 373–385.

Hollowed, A.B., Hare, S.R. and Wooster, W.S. 2001. Pacific Basin climate variability and patterns of Northeast Pacific marine fish production. *Prog. Oceanogr*. **49**: 257–282.

Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S. and Poiner, I.R. 2002. Modification of marine habitats by trawling activities: prognosis and solutions. *Fish and Fisheries* **3**: 114–136.

Kent, M.L., Traxler, G.S., Kieser, D., Richard, J., Dawe, S.C., Shaw, R.W., Prosperi-Porta, G., Ketcheson, J. and Evelyn, T.P.T. 1998. Survey of salmonid pathogens in ocean-caught fishes in British Columbia, Canada. *J. Aquat. Animal Health* **10**: 211–219.

Laidig, T.E., Adams, P.B. and Samiere, W.M. 1997. Feeding habits of sablefish, *Anoplopoma fimbria*, off the coasts of Oregon and California. pp. 65–79 *in* Biology and Management of Sablefish, *Anoplopoma fimbria, edited by* M. Wilkins and M. Saunders, U.S. Dept. of Commerce, NOAA Tech. Rep. NMFS 130.

Lea, R.N., McAllister, R.D. and VenTresca, D.A. 1999. Biological aspects of nearshore rockfishes of the genus *Sebastes* from Central California with notes on ecologically related sport fishes. *Calif. Dept. Fish Game Fish Bull*. **177**: 1–112.

Lee, Y.-W. 2002. Oceanographic effects on the dynamics of food habits and growth condition of some groundfish species of the Pacific Northwest. Ph.D. dissertation, Oregon State University, Corvallis, OR.

Lenarz, W.H., VenTresca, D.A., Graham, W.M., Schwing, F.B. and Chavez, F. 1995. Explorations of El Niño events and associated biological population dynamics off central California. *Calif. Coop. Oceanic Fish. Invest. Rep.* **36**: 106–119.

Livingston, P.A. 1983. Food habits of Pacific whiting, *Merluccius productus*, off the west coast of North America. *Fish. Bull.* **81**: 629-636.

Love, M.S., Yoklavich, M. and Thorsteinson, L. 2002. The Rockfishes of the Northeast Pacific. University of California Press, Berkeley, CA.

MacCall, A. 2005a. Status of vermilion rockfish in southern and northern California. NOAA-NMFS-SWFSC, Santa Cruz, CA.

MacCall, A. 2005b. Status of bocaccio off California in 2005. NOAA-NMFS-SWFSC, Santa Cruz, CA.

Mangel, M. and Levin, P.S. 2005. Regime shifts, phase shifts and paradigm shifts: Making community ecology the basic science for fisheries. *Phil. Trans. Roy. Soc. London B* **360**: 95–105.

Marty, G.D., Hoffman, A., Okihiro, M.S., Hepler, K. and Hanes, D. 2002. Retrospective analysis: bile hydrocarbons and histopathology of demersal rockfish in Prince William Sound, Alaska, after the Exxon Valdez oil spill. *Mar. Envir. Res*. **56**: 569–584.

Mearns, A., Watabayashi, G. and Lankford, J. 2001. Dispersing oil near shore in the California Current region. *Cal. Coop. Oceanic Fish. Invest. Rep.* **42**: 97–109.

Miller, A.K. and Sydeman, W.J. 2004. Rockfish response to low-frequency ocean climate change as revealed by the diet of a marine bird over multiple time scales. *Mar. Ecol. Prog. Ser.* **281**: 207–216.

Moore, S.L. and Allen, M.J. 2000. Distribution of anthropogenic and natural debris on the mainland shelf of the Southern California Bight. *Mar. Pollut. Bull.* **40**: 83-88.

Moser, H.G., Charter, R.L., Watson, W., Ambrose, D.A., Butler, J.L., Charter, S.R. and Sandknop, E.M. 2000. Abundance and distribution of rockfish (*Sebastes*) larvae in the southern California Bight in relation to environmental conditions and fishery exploitation. *Cal. Coop. Oceanic Fish. Invest. Rep.* **41**: 132–147.

Murie, D.J. 1995. Comparative feeding ecology of two sympatric rockfish congeners, *Sebastes caurinus* (copper rockfish) and *S. maliger* (quillback rockfish). *Mar. Biol*. **124**: 341–353.

NRC (National Research Council). 2002. Effects of Trawling and Dredging on Seafloor Habitat. National Academy Press, Washington, DC.

O'Neill, S.M. and West, J. 2004. PCB accumulation in marine and anadromous fishes of the Puget Sound and Strait of Georgia. *In* 2003 Georgia Basin/Puget Sound Research Conference Proceedings *edited by* T.W. Droscher and D.A. Fraser, Puget Sound Action Team, Olympia, WA.

Outram, D.N. and Haegele, C. 1972. Food of Pacific hake (*Merluccius productus*) on an offshore bank southwest of Vancouver Island, British Columbia. *J. Fish. Res. Bd. Can*. **29**: 1792–1795.

Parker, S.J., Berkeley, S.A., Golden, J.T., Gunderson, D.R., Heifetz, J., Hixon, M.A., Larson, R., Leaman, B.M., Love, M.S., Musick, J.A., O'Connell, V.M., Ralston, S., Weeks, H.J. and Yoklavich, M.M. 2000. Management of Pacific rockfish. *Fisheries* **25**: 22–29.

PFMC (Pacific Fishery Management Council). 2004a. Pacific coast groundfish fishery management plan for the California, Oregon and Washington groundfish fishery as amended through Amendment 17. PFMC, Portland, OR.

PFMC (Pacific Fishery Management Council). 2004b. Acceptable biological catch and optimum yield specification and management measures for the 2004 Pacific coast groundfish fishery. Final environmental impact statement and regulatory analyses. PFMC, Portland, OR.

Quast, J.C. 1968. Observations on the food of the kelp-bed fishes. *Calif. Dept. Fish Game Fish Bull*. **139**: 109–142.

Reilly, C.A., Wyllie Echeverria, T. and Ralston, S. 1992. Interannual variation and overlap in the diets of pelagic juvenile rockfish (Genus: *Sebastes*) off central California. *Fish. Bull.* **90**: 505–515.

Schirripa, M.J. and Colbert, J.J. 2006. Interannual changes in sablefish (*Anoplopoma fimbria*) recruitment in relation to oceanographic conditions within the California Current System. *Fish. Oceanogr*. **15**: 25–36

Singer, M.M., George, S., Jacobson, S., Lee, I., Weetman, L.L., Tjeerdema, R.S. and Sowby, M.L. 1995. Acute toxicity of the oil dispersant Corexit 9554 to marine organisms. *Ecotox. Env. Safety* **32**: 81–86.

Sissenwine, M. and Murawski, S. 2004. Moving beyond intelligent tinkering: Advancing an Ecosystem Approach to Fisheries. *Mar. Ecol. Prog. Ser.* **274**: 291–295.

Stein, J.E., Collier, T.K., Reichert, W.L., Casillas, E., Hom, T. and Varanasi, U. 1992. Bioindicators of contaminant exposure and sublethal effects: studies with benthic fish in Puget Sound, Washington. *Envir. Toxicol. Chem.* **11**: 701–714.

Sydeman, W.J. and Jarman, W.M. 1998. Trace metals in seabirds, Steller sea lion, and forage fish and zooplankton from central California. *Mar. Pollut. Bull.* **36**: 828–832.

Sydeman, W.J., Hester, M.M., Thayer, J.A., Gress, F., Martin, P. and Buffa, J. 2001. Climate change, reproductive performance and diet composition of marine birds in the southern California Current system, 1969–1997. *Prog. Oceanogr.* **49**: 309–329.

Tanasichuk, R.W., Ware, D.M., Shaw, W. and MacFarlane, G.W. 1991. Variation in diet, daily ration, and feeding periodicity of Pacific hake (*Merluccius productus*) and spiny dogfish (*Squalus acanthias*) off the lower west coast of Vancouver Island. *Can. J. Fish. Aquat. Sci.* **48**: 2118–2128.

Vasquez, J.A. and McPeak, R.H. 1998. A new tool for kelp restoration. *Calif. Fish Game* **84**: 149–158.

VenTresca, D.A., Parrish, R.H., Houk, J.L., Gingras, M.L., Short, S.D. and Crane, N.L. 1995. El Niño effects on the somatic and reproductive condition of blue rockfish, *Sebastes mystinus*. *Cal. Coop. Oceanic Fish. Invest. Rep.* **36**: 167–174.

Williams, E.H. and Ralston, S. 2002. Distribution and co-occurrence of rockfishes (family: Sebastidae) over trawlable shelf and slope habitats of California and southern Oregon. *Fish. Bull.* **100**: 836–855.

## 2.8 Progress Toward Ecosystem Approaches to Management – Fisheries

To various degrees, the country profiles discussed above have responded to the explicit request to identify the extent to which fisheries management in each country is developing an EAM. This responds to part of the charge to WG 19. In addition, there has been attention to broader questions of how an EAM can be implemented across sectors. As a means of documenting the ability of countries to implement EAM, WG 19 devised a template (Appendix 2) to allow reporting of progress towards EAM. In the experience so far from Canada and the U.S., we are in the early stages of implementing an EAM for fisheries.

WG 19 explored various ways to identify how a country may take on a full-scale EAM (Table 2.8.1). In the Working Group approach, this would require that additional sectoral approaches to EAM be considered and that eventually an integrated approach to ocean management across all sectors be made.

WG 19 members from each country reviewed the list of EBM components in the Fisheries Management Sector matrix (Table 2.8.1); only Canada and the U.S. reported on progress in their respective country in using each of those components under each management category. The scoring system used is given below, followed by an example of a completed matrix for Canada and the U.S. (Table 2.8.2):

1. Use this component sometimes or a little
2. Use this component a moderate amount
3. Use this tool frequently or a lot

**Table 2.8.1** Fisheries management sector – Conceptual matrix.

| **EBM component [management tool]** | **I. Traditional resource management** | **II. Single-sector EBM fisheries** | **III. Integrated multisector EBM** |
|---|---|---|---|
| Define ecosystem boundaries | Defined by fishing areas | Defined by management around ecosystem boundaries | Area-based management using ecosystem principles |
| Stock assessments | Single species stock assessments | Single species stock assessments with consideration of ecological interactions | Fishing assessed relative to other activities and ecosystem services |
| Harvest level | MSY is the management target for key species | Harvests consider other ecosystem variables (*e.g.*, biodiversity, habitat, *etc.*) | Considers non-fishery and fishery interactions (cumulative effects) |
| Cap on total ecosystem removal | Sum of all captures (including bycatch) | Examine effect of total captures on total fishery production | Examines cumulative capture effects on ecosystem |
| Specific protection of prey species | Prey species are not considered except as a target species | Managed use of prey species relative to impacts on other fish species | Prey considered for their roles in food webs |
| Use of ecosystem information from monitoring in management;<br>a) physical data and<br>b) biological data | a) generally not considered<br>b) fishery-dependent data or single-species fishery-independent data | Used to manage fisheries in an ecological context | Used to manage all impacts on the ecosystem |
| Species capture accounting (logbooks, observers, VMS) | Focus on target species only | Focus on all exploited species (including discards and bycatch) | Focus on all species, *e.g.*, biogenic habitat, turtles, mammals, birds |

**Table 2.8.1** Continued.

| **EBM component [management tool]** | **I. Traditional resource management** | **II. Single-sector EBM fisheries** | **III. Integrated multisector EBM** |
|---|---|---|---|
| Bycatch/discard management | Seldom done | Bycatch and discard controls on exploited species, *e.g.*, selective gears, closed area | Bycatch and discard management of all species, *e.g.*, selective gears, closed area |
| Seasonal closures | Focus on single species, *e.g.*, for reducing gear conflicts, protection of spawning populations | Focus on exploited species | Management of all species |
| Area closures | Focus on single species, *e.g.*, for limiting gear conflicts, protection of spawning areas and habitat | Focus on  exploited species | Management of all species |
| Protect vulnerable and rare species | Not generally considered | Focus on exploited species, *e.g.*, depleted species management | Management of all species and processes, *e.g.*, biogenic habitat, availability of prey |
| Endangered or threatened species [Species at Risk] | Not important unless required by law | Specific measures taken to mitigate impacts of fisheries | Specific measures to mitigate impacts on all species at risk from human activities |
| Management plans | Single-species based management | EBFM, based on species complexes, multiple species interactions and habitat | IEM, *e.g.*, using suite of available management tools across sectors |
| Environmental impact assessment (EIA) of management activities | As required by law | As required by law with emphasis on fishing impacts in ecological context | EIA applied to multiple sectors as required by law |
| Vessel [Location] Monitoring Systems | Limited use for fishing | More extensive use across fleets for fishery monitoring | Monitoring of all vessel activity/safety, *etc.* |
| Limited fishing effort | Minimal application for fishing – primarily for economic considerations | Improves fisheries management for ecological reasons | Effort limitation to mitigate impacts on all species at risk from human activities |
| Habitat protection | Relatively little consideration, except as an obstacle (gear hazard) and protection of single-species spawning and nursery grounds | Protect habitat for ecological reasons to improve fisheries or reduce damage from fisheries | Protect habitat relative to cumulative impacts of all sectors |
| Biodiversity [species, population, genetic] management | Not generally considered, except to ensure availability of the targeted species or stocks | Consider ecological effects of fishing on community structure and function | Consider cumulative impacts on ecosystem structure and function from all sectors |
| Cultural heritage preservation (*e.g.*, historical or subsistence fishing, recreational fishing) | Generally not considered by traditional fishery management | Considered in ecological fisheries management as a legacy value | Considered as a component of cumulative effects by all sectors |
| Species enhancement | Single-species population rebuilding and enhancement | Enhancement of species in ecological and genetic contexts (habitat, trophic structure, *etc.*) | Ecosystem enhancement and/or restoration; integration of enhancement across sectors |

EBM = Ecosystem-based management, MSY = Maximum sustainable yield, VMS = vessel monitoring system, EBFM = Ecosystem-based fisheries management, EIM = Integrated ecosystem management, EIA = Environmental impact assessment

**Table 2.8.2** Ecosystem approach to management (EAM) fisheries mangement sector matrix examples for Canada and the U.S.

| | I. Traditional resource management | | II. Single-sector EBM fisheries | | III. Integrated multisector EBM | |
|---|---|---|---|---|---|---|
| **EBM component** | **Canada** | **U.S.A.** | **Canada** | **U.S.A.** | **Canada** | **U.S.A.** |
| Define ecosystem boundaries | 3 | 3 | 2 | 2 | – | – |
| Stock assessments | 3 | 3 | 1 | 2 | – | – |
| Harvest level | 3 | 3 (MSY as limit) | 1 | 1 | – | 1 |
| Cap on total ecosystem removal | 3 | 2 | – | – | – | – |
| Specific protection of prey species | 3 | 3 | 1 | 2 | | 1 |
| Use of ecosystem information from monitoring in management; | | | | | | |
| a) physical data | 3 | 2 | 1 | 3 | – | – |
| b) biological data | 3 | 3 | 1 | 3 | – | – |
| Species capture accounting (logbooks, observers, VMS) | 3 | – | 2 | 3 | – | 2 |
| Bycatch/discard management | 3 | – | 2 | 3 | – | 2 |
| Seasonal closures | 3 | 3 | – | 2 | – | 1 |
| Area closures | 3 | 3 | – | 2 | – | 1 |
| Protect vulnerable and rare species | – | – | 2 | 3 | – | 2 |
| Endangered or threatened species [Species at Risk] | – | – | – | 2 | 3 | 2 |
| Management plans | 3 | – | 1 | 3 | – | 1 |
| EIA of management activities | – | – | 2 | 3 | – | 2 |
| [Location] VMS | 3 | 3 | – | 2 | – | – |
| Limited fishing effort | 3 | 3 | – | 1 | – | – |
| Habitat protection | 3 | – | 1 | 3 | – | 1 |
| Biodiversity [species, population, genetic] management | 3 | 3 | – | – | – | – |
| Cultural heritage preservation (*e.g.*, historical or subsistence fishing, recreational fishing) | 3 | 2 | – | 2 | – | – |
| Species enhancement | 3 | 3 | – | – | – | – |

VMS = Vessel Monitoring System, EIA = Environmental impact assessment, MSY = maximum sustainable yield

At present there is considerable discussion about which approach to management should be used and what would be the differences between approaches. Table 2.8.3 builds off the fisheries oriented conceptual matrix (Table 2.8.1) and the examples of how it could be used to guage progress toward an ecosystem approach to fisheries management (Table 2.8.2). In Table 2.8.3 we explore how an ecosystem approach could be implemented across multiple sectors in integrated multisector ecosystem-based management. An integrated multisector approach clearly requires taking into account different uses and evaluating trade-offs among uses, including higher priorities for protecting habitat, biodiversity and aesthetic values.

Similar approaches could be developed for other key sectors of economic and management significance, *e.g.*, aquaculture, wildlife, shipping, and energy in the North Pacific in the coming years, as appropriate.

**Table 2.8.3** Progress measurement actions in ecosystem approaches in ocean management (from single sector toward integrated multisector management for fisheries as conceptualized in Table 2.1.3).

| EBM Component | I. Traditional resource management | II. Single-sector EBM fisheries | III. Integrated multisector EBM |
|---|---|---|---|
| Define ecosystem | Define fishing areas | Define management around ecosystem boundaries | Space based zoning using ecosystem principles |
| Harvest rates | At or above MSY | Conservative – below MSY | Subject to ecosystem context |
| Cap on total removals | Best practice is sum of MSY of target species | Examine effect of total removals on ecosystem [including bycatch and harvest effects] | Examine cumulative impacts on ecosystem |
| Stock assessments | Single species stock assessments | Single species stock assessments with ecosystem interactions factored in | Fishing assessed relative to other activities and ecosystem services |
| Protection of prey species | Prey species target of fishing or otherwise not considered | Limited use of prey species relative to other fish species management, *e.g.*, ban on industrial harvests | Prey considered for its contribution to food webs for all species |
| Use of ecosystem information,<br>Physical<br>Biological | Not considered | Use to understand the ecosystem relative to fisheries | Use to understand the ecosystem relative to all activities |
| Catch accounting | Accuracy – low? | Accuracy high, *e.g.*, observers | Only one of metrics relevant to ecosystem |
| Bycatch/discard accounting | Seldom done – estimated | Accuracy high, *e.g.*, with observers [fish, marine mammals, seabirds, other | Only one of metrics relevant to ecosystem |
| Closed areas [broad definition of MPAs] | Sometimes for reducing gear conflicts, protect nursery areas | Significant use to protect fish and habitats utilized by fish | Significant use to protect key features, vulnerable species |
| Protect vulnerable and rare species | Not important | Important in context of fisheries | Important to protect key features, vulnerable species |
| Endangered or threatened species [Species at risk] | Not important unless required by law | Specific measures taken to mitigate impacts of fisheries | Specific measures to mitigate impacts of human activities |
| Management plans | Single species | Species complexes, multiple species interactions | Ocean zoning and plans |
| Environmental assessment | As required by law | As required by law with emphasis on fishing in ecosystem context | EA applied to multiple sectors |
| Use of VMS | Not likely | As a way of monitoring fishing behavior | Monitoring a vessel activity / safety, *etc.* |
| Limiting fishing effort | Minimal – primarily economic consideration | Effort limitation improves management for ecosystem concerns and to limit ecosystem impact | Balance of marine uses for sustaining ecosystem health |
| Habitat | Relatively little consideration except as objective hazard | Protect habitat relative to feedback in fisheries [minimum] protect habitat from damage from fisheries | Protect habitat relative to cumulative impacts of all sectors |
| Biodiversity | Ignore biodiversity effects in fished populations – deny impacts | Consider ecosystem effects on biodiversity [species, population, genetic – ecosystem structure from fishing | Consider ecosystem effects on biodiversity [species, population, genetic – ecosystem structure from all sectors |
| Natural heritage/ preservation | Seen as threat to fishing – unnecessary | Should be considered in fisheries management – legacy value | Should be considered as part of mix of cumulative effects of all sectors |

## 2.9 Relevant National Marine Ecosystem Monitoring Approaches

An initial term of reference for WG 19 was to describe relevant national marine ecosystem monitoring approaches and plans and types of models for predicting human and environmental influences on ecosystems. Key information gaps and research and implementation challenges were to be identified. Working Group members informally reported on national monitoring efforts at the first two working group meetings. However, after reviewing the nature of the work already completed as part of the PICES/Census of Marine Life/IPRC Workshop on "*Impact of Climate Variability on Observation and Prediction of Ecosystem and Biodiversity Changes in the North Pacific*" (Alexander *et al.*, 2001) on summarizing national monitoring and modeling efforts, this term of reference was deemed to be a duplication of that effort. WG 19 focused instead on linking monitoring efforts to our third term of reference on indicators. In the section on Ecosystem Indicators that follows, member countries focused on reporting on the availability of monitoring information that could be used to report on ecosystem status through key indicators identified by the Working Group. The following is a summary provided by WG 19 of the key considerations of monitoring with respect to implementing ecosystem approaches to management which requires developing a monitoring and reporting system that provides information on ecosystem status, threats, and success of management efforts relative to stated management objectives.

- A common set of indicators is proposed for PICES member countries to monitor ecosystem status with respect to fisheries impacts.
- Monitoring systems in place at the present time are sufficient for calculating many of these indicators of ecosystem status and change.
- Enhancements to the monitoring system are needed in all member countries to measure habitat, size-based indicators, benthic invertebrates, and total fishery removals.
- Predicting future ecosystem conditions will require advancement of a variety of models that incorporate human and climate factors.
- Further work is needed to define a broader set of human impact indicators outside of the fisheries context, including socio-economic.
- Understanding and communicating the main drivers of change in each region will be important.

### 2.9.1 Reference

Alexander, V., Bychkov, A.S., Livingston, P. and McKinnell, S.M. (Eds.) 2001. Proceedings of the PICES/CoML/IPRC Workshop on "Impact of Climate Variability on Observation and Prediction of Ecosystem and Biodiversity Changes in the North Pacific". PICES Sci. Rep. No. 18, 210 pp.