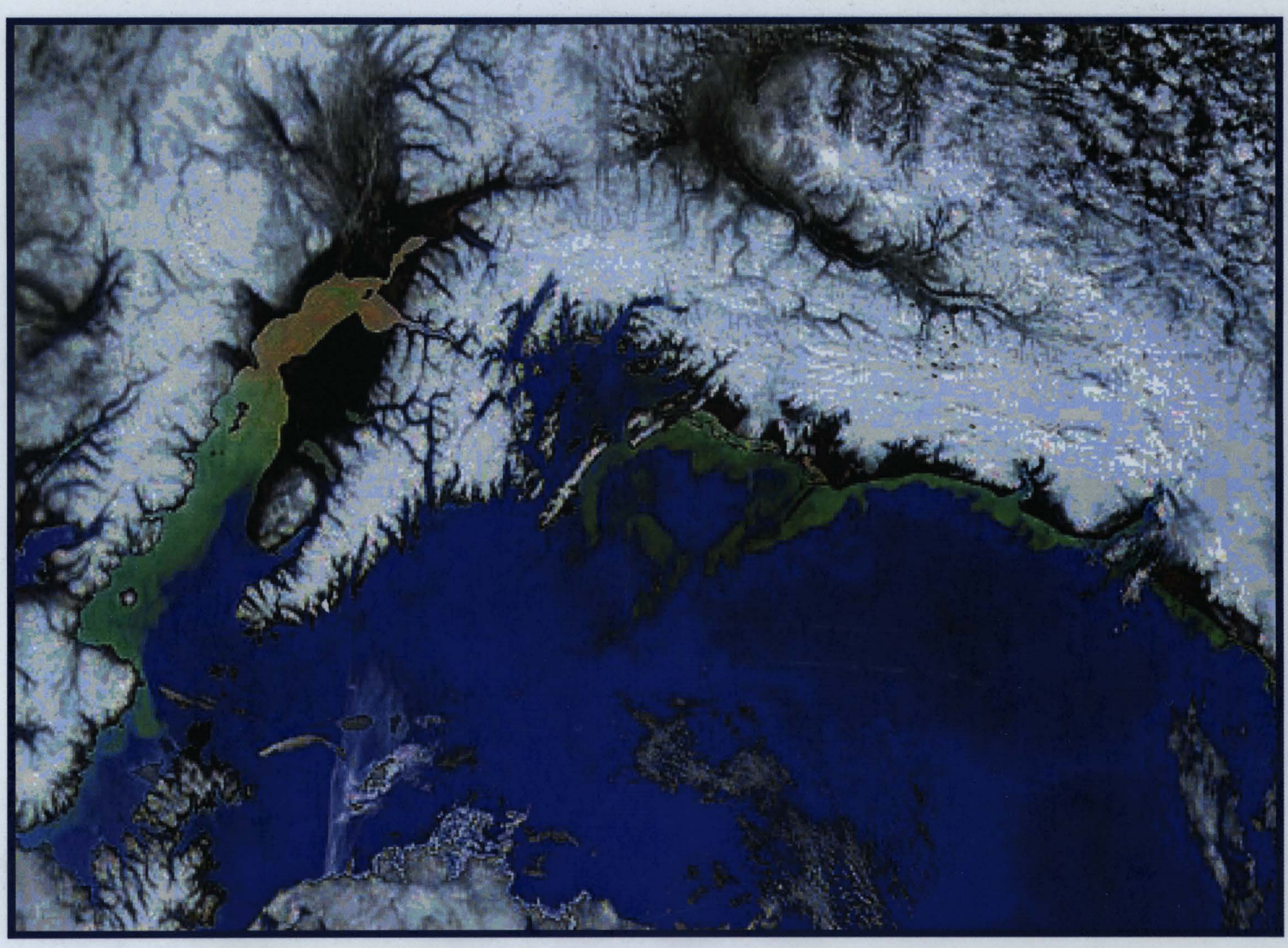
Gulf of Alaska Ecosystem Monitoring and Research Program (GEM)

Volume I
Strategic Plan for Monitoring and Research

Volume II
The Historical Legacy: Building Blocks for the Future

NRC Review Draft
August 31, 2001

Volumes I and II together should be referred to as the GEM Program Document



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Exxon Valdez Oil Spill Trustee Council
645 G Street, Suite 401
Anchorage, Alaska 99501
www.oilspill.state.ak.us
restoration@oilspill.state.ak.us
907-278-8012
800-478-7745, within Alaska
800-283-7745, outside Alaska

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The primary authors of the GEM Program Document are Molly McCammon, Phil Mundy, and Bob Spies Editors for the document were Molly McCammon, Phil Mundy, Bob Spies, and Judy Griffin

Credit goes to the following authors in Volume II Chapter 3 - Ted Cooney, Jim Bodkin, Anne Hollowed, Lloyd Lowry, Phil Mundy, Peter Olsson, Charles Peterson, Bob Spies, Alan Springer, Tom Weingartner, Chapter 4 - Phil Mundy and Bob Spies, Chapter 5 - Gretchen Oosterhout, Chapter 6 - Charles Falkenberg, Appendix B - Michael H Martin, Appendix C - Kerim Ayden, Appendix D - Joe Sullivan, Dede Bohn, Veronica Christman, and Sandra Schubert, Appendix E and A, Phil Mundy Cherri Womac has been instrumental in preparing the entire document

Many people made material or intellectual contributions to the GEM Program Document Because the number of contributors and advisors is so large, we apologize if we inadvertently left your name off this list

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OVERVIEW OF THE GEM DOCUMENT

The Gulf Ecosystem Monitoring (GEM) Program Document has been prepared in two volumes to more easily describe the basic monitoring and research program (Volume I) while providing access to the factual basis for the program (Volume II) Volume I explains the basic motivations for the program, information needs, and the strategies for meeting these information needs (see Table O 1 below) Volume II presents the factual basis for the program, including the detailed descriptions of two important components of the program (1) modeling and (2) data management and information transfer Table O 1 identifies the question addressed by each chapter and the products provided The Overview Figure, following the table, illustrates the structure of the GEM Program Document

Table O 1 Contents of the GEM Program Document

Chapter	Title & Question Addressed	Products
Volume I—Strategic Plan for Monitoring and Research		
1	Vision *Why do this and what do we hope to achieve?*	Mission and goals Program context
2	Human Uses and Activities *What are the human activities in the region and their potential impacts?*	Issues of concern to the Trustee Council and public
3	GEM Information Needs *What information do we need?*	Specific questions and information needs
4	Program Components and Strategies *How can we get the information we need?*	Key components and implementation strategies
5	Monitoring Plan & Research Agenda *What are we going to do to get the information, when will we do it, and with whom?*	Starting point for implementation process
6	Program Management *What are the processes and policies for monitoring and research?*	The Gulf Ecosystem Monitoring and Research Program
Volume II—The Historical Legacy Building Blocks for the Future		
1	Building on Lessons of the Past *What do other regional marine science programs have to teach us?*	Past experience Hypotheses and strategies
2	Lingering Effects of the Oil Spill *What does experience from the oil spill teach us?*	Past experience
3	Scientific Background *What is published that can help us?*	Current knowledge of the Gulf of Alaska General research questions

Table O.1 Contents of the GEM Program Document

Chapter	Title & Question Addressed	Products
4	Conceptual Foundation *How do we think the ecosystem works?*	Central hypothesis and question
5	Modeling *What is the role of modeling in GEM implementation?*	Modeling definitions and options for program implementation
6	Data Management and Information Transfer *What are the roles of data management and information transfer in GEM implementation?*	Data management and information transfer options for program implementation
A	Appendix A Acronyms and Web Links	
B	Appendix B Fish and Invertebrate Species from 1996 Trawl Survey of the Gulf of Alaska	
C	Appendix C North Pacific Models of the Alaska Fisheries Science Center and Selected Other Organizations	
D	Appendix D Gulf Ecosystem Monitoring and Research (GEM) Database	
E	Appendix E Glossary of Existing Agency Programs and Projects	

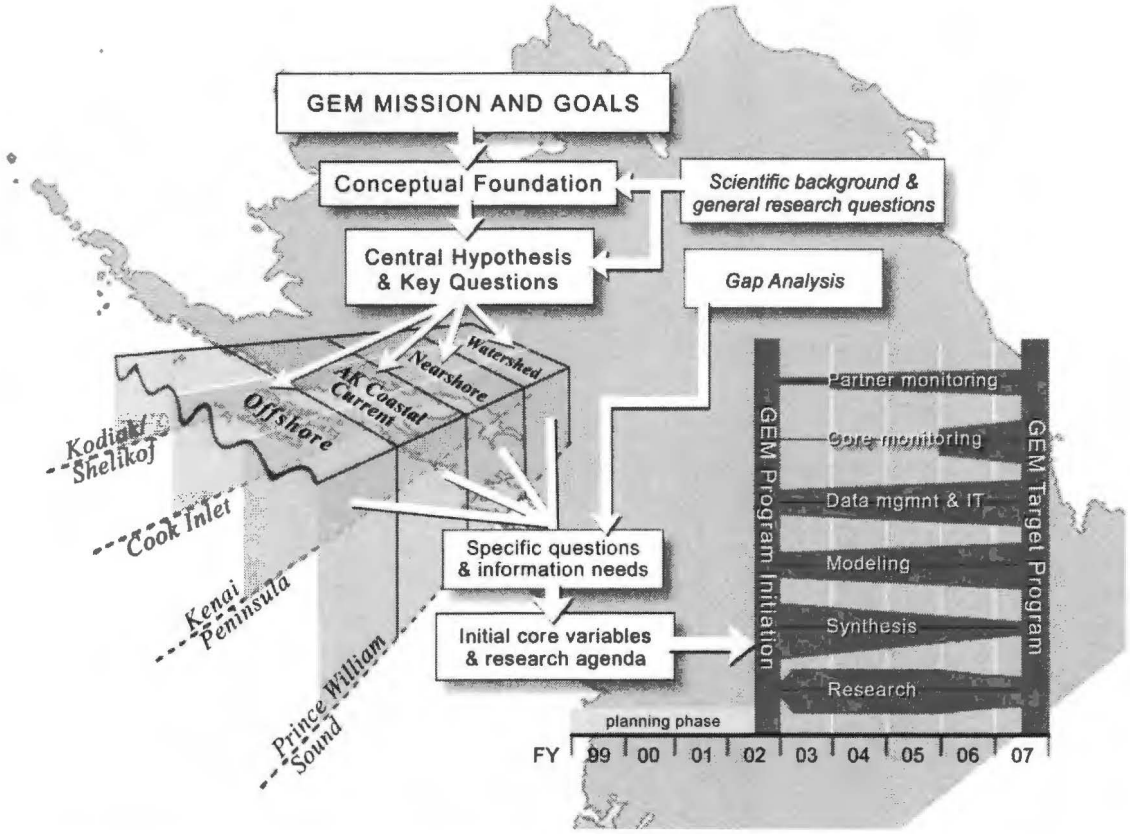

Figure O.1. An overview of the structure of the GEM Program Document showing the relation of key concepts to the habitat types and the schedule of implementation

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EXECUTIVE SUMMARY

This document provides the foundation for the Gulf Ecosystem Monitoring (GEM) program, a long-term research and monitoring effort in the northern Gulf of Alaska (GOA) The *Exxon Valdez* Oil Spill Trustee Council (Trustee Council) has endowed this program as a final legacy of its mission to restore the fish and wildlife resources injured by the 1989 *Exxon Valdez* oil spill (EVOS)

This document is composed of two volumes plus supporting materials

- Volume I explains the vision and motivations for the program, information needed to understand the GOA ecosystem, and the strategies and plan for answering the questions posed about how the system works Also described are the process and policies to further develop the program
- Volume II presents the historical legacy of the program, including lessons from the EVOS restoration program and other regional marine science programs The current scientific knowledge and current conceptual thinking of the GOA are described in detail

Together, the two volumes provide the overall framework for a program that includes an ongoing process of developing, reviewing, and implementing a monitoring and research plan Implementation is expected to begin in October 2002

Within the northern GOA (including Prince William Sound, Cook Inlet, Kodiak Island, and the Alaska Peninsula), offshore and nearshore marine, estuarine, freshwater, and terrestrial environments interact with geologic, climatic, oceanographic, and biologic processes to produce highly valued natural bounty and exceptional beauty The GOA provides habitat for diverse and abundant populations of fish and shellfish, marine mammals, and seabirds It is a major source of seafood for the entire nation, as well as for Alaska Natives, who rely on it for subsistence and cultural purposes The GOA is also a source of beauty and inspiration for those who love nature and part of the "lungs" of the planet for recycling of oxygen and carbon to and from the atmosphere As a result of both human influences and natural processes, these important attributes are continually changing

More than half of the state's 621,000 permanent residents live within the geographic area of the northern GOA and the nearby population center of the greater Anchorage area Most of the more than 1 million tourists that travel to the state each year visit this region The private-sector economy of Alaska depends heavily on extraction of natural resources from this region, including petroleum, fish and shellfish, minerals, and timber Crude oil and fuel tanker traffic, increasing tourism and recreational use, expanded road building, and growing commercial and sport fishing pressure are all human activities that could affect the

marine resources and ecosystem of the northern GOA In addition, recent evidence of persistent organic pollutants and heavy metals in fish and wildlife tissues in the GOA indicate that this region is not immune from worldwide concerns about potential effects of contaminants on marine organisms and on human consumers, particularly Alaska Native subsistence users

Populations of important marine resources in the northern GOA have undergone major changes, especially since the late 1970s Salmon catches of all species, especially sockeye, have remained near record levels for two decades, with annual catches significantly greater than those in the three decades ending in 1979 Shrimp and red king crab have fallen to extremely low levels in the GOA since 1980, in sharp contrast to the very high levels in the two prior decades Kodiak's red king crab fishery, once among the world's richest, has been completely closed since 1984 As shrimp and crab have declined, cod, pollock, and flatfish, such as arrowtooth flounder, have rapidly increased Some marine mammals associated with the GOA, such as sea lions, harbor seals, and over-wintering fur seals, have steadily declined since 1980 Other species, such as sea otters and elephant seals, have been on the rise for more than a decade Colonies of seabirds, such as black-legged kittiwakes, common murres, and cormorants, have shown declines since about 1980 in some coastal localities, such as PWS and central Cook Inlet, but not in others Overall, many species and populations associated with nearshore habitats in the GOA have declined since about 1977, whereas species and populations having access to offshore gulf habitats have generally increased

Understanding the sources of these changes, whether natural or influenced by human activities, requires a solid historical context This certainly has been the lesson of the 1989 *Exxon Valdez* oil spill, a large-scale ecological disaster, resulting in hundreds of millions of dollars invested in studies and restoration projects in the past decade From the knowledge and experience gained through this program, the Trustee Council has dedicated approximately $120 million to continue work on lingering oil-spill injury and to endow long-term monitoring and research in the world-renowned ecosystem of the northern GOA

The mission of the GEM program is "to sustain a healthy and biologically diverse marine ecosystem in the northern GOA and the human use of the marine resources in that ecosystem through greater understanding of how its productivity is influenced by natural changes and human activities "

GEM has five major programmatic goals These are to

1 DETECT Serve as a sentinel (early warning) system by detecting annual and long-term changes in the marine ecosystem, from coastal watersheds to the central gulf,

2 UNDERSTAND Identify causes of change in the marine ecosystem, including natural variation, human influences, and their interaction,

3 INFORM Provide integrated and synthesized information to the public, resource managers, industry, and policy makers in order for them to respond to changes in natural resources,

4 SOLVE Develop tools, technologies, and information that can help resource managers and regulators improve management of marine resources and address problems that may arise from human activities, and

5 PREDICT Develop the capacity to predict the status and trends of natural resources for use by resource managers and consumers

The annual earnings from a $120 million endowment will not be able to fund all that needs to be done to achieve the above goals Instead, the Trustee Council will focus a large part of its efforts on providing leadership in identifying monitoring and research gaps and priorities, synthesizing and interpreting results to form a "big picture" of the GOA ecosystem, encouraging efficiency and integration through leveraging of funds, coordination, and partnerships, and involving stakeholders in local stewardship by having them help guide and carry out parts of the program The GEM program must design its monitoring and research efforts to ensure their application to benefit conservation and management of marine resources

Recognizing that the gulf ecosystem under consideration is extremely complex, consisting of thousands of species, it also will not be possible for GEM to answer all, or even most, of the questions that could be posed about the GOA GEM instead will be focused, to a large extent, on key habitats and ecological processes in the system The four habitats—watersheds, intertidal and subtidal, Alaska Coastal Current, and offshore—will be used as tools around which to organize monitoring and research efforts Individual species may be used to answer questions and will be selected on the basis of ecological importance and their human relevance and ability to indicate ecosystem disturbance, as well as their importance for understanding the physical and biological bases for productivity In the end, GEM must be justified on what it can teach policy makers, resource managers, and the public about options for directing human behavior toward achieving sustainable resource management goals

The GEM program will continue to work with resource managers, stakeholders, the scientific community, and the public to refine a common set of priorities for research, monitoring, and protection in the northern GOA To do that, there must be a shared understanding of which marine resources of the northern GOA are valued and what stressors or potential threats could affect their overall health The GEM program will build a matrix of who is monitoring what, where, and when and identify gaps in monitoring those things that are important GEM will work toward filling in the important gaps

The monitoring program developed by the Trustee Council is intended to be the "flagship" of the GEM program and will be maintained even if funding levels

vary The monitoring program will incorporate these elements use of a key question for each habitat as a starting point for developing testable hypotheses, a proposed schedule and strategy for implementation, possible partners and partner activities, development of models to synthesize results, candidate core monitoring activities, and candidate core variables

The long-term monitoring element of GEM will be complemented by strategically chosen research projects These projects will follow up on lingering effects of the *Exxon Valdez* oil spill, explore questions and concerns that arise out of interpretation of the monitoring data, especially in trying to understand the causes of change, and provide key information and tools for management and conservation

The Trustee Council believes that encouraging local and community awareness and participation in research and monitoring enhances long-term stewardship of living marine resources Traditional and local knowledge can provide important observations and insights about changes in the status and health of marine resources and should be incorporated into GEM Citizen monitoring efforts are already under way in several communities in the GEM region and should be looked to for future collaboration

Independent peer review of the GEM program is essential for a high-caliber scientific program Participation in research and monitoring is expected to be completely open to competition All data must be archived, maintained, and readily accessible to other scientific users and the public In order for GEM to be successful, it will be necessary to integrate, synthesize, and interpret monitoring and research results to form and present a "big picture" of the status of and trends in the northern GOA ecosystem One approach is through the use of periodic "State of the Gulf" and "State of the North Pacific" workshops and reports Another is use of the GEM Web site The Trustee Council is committed to public input and outreach as vital components of the long-term GEM program

1. VISION FOR GEM IN THE NORTHERN GULF OF ALASKA

In This Chapter

- Origin of the GEM program
- Explanation of the mission identified for the program
- Identification of goals, geographic scope, and funding

1.1 Introduction

A program rooted in the science of a large-scale ecological disaster is uniquely suited to form the foundation for ecosystem-based management The knowledge and experience gained during 10 years of biological and physical studies in the aftermath of the *Exxon Valdez* oil spill (EVOS) confirmed that a solid historical context is essential to understand the sources of changes in valued natural resources Toward this end, in March 1999 the *Exxon Valdez* Oil Spill Trustee Council (Trustee Council) dedicated approximately $120 million for long-term monitoring and research in the northern Gulf of Alaska (GOA) The new fund will be in place by October 2002 and function as an endowment, with an annual program funded through investment earnings, after allowing for inflation-proofing and modest growth of the corpus

In making the decision to allocate these funds for a long-term program of monitoring and research, referred to herein as the Gulf Ecosystem Monitoring and Research (GEM) program, the Trustee Council explicitly recognized that complete recovery from the oil spill may not occur for decades and that through long-term observation and, as needed, restoration actions, the injured resources and services are most likely to be fully restored The Trustee Council further recognized that conservation and improved management of these resources and services would require substantial ongoing investment to improve understanding of the marine and coastal ecosystems that support the resources, as well as the people, of the spill region Improving the quality of information available to resource managers should result in improved resource management In addition, prudent use of the natural resources of the spill area without compromising their health and recovery requires increased knowledge of critical ecological information about the northern GOA This knowledge can only be provided through a long-term monitoring and research program that will span decades, if not centuries There are both immediate, short-

Prudent use of the natural resources of the spill area requires increased knowledge of critical ecological information about the northern GOA.

term needs to complete the understanding of the lingering effects of the oil spill and long-term needs to understand the sources of changes in valued natural resources

1.2 Mission

The original mission of the Trustee Council's Restoration Program, adopted in 1993, was to "efficiently restore the environment injured by the EVOS to a healthy, productive, world-renowned ecosystem, while taking into account the importance of the quality of life and the need for viable opportunities to establish and sustain a reasonable standard of living"

Consistent with this mission and with the ecosystem approach to restoration adopted by the Trustee Council in 1994, the mission of the GEM program is to

> ***Sustain a healthy and biologically diverse marine ecosystem in the northern Gulf of Alaska (GOA) and the human use of the marine resources in that ecosystem through greater understanding of how its productivity is influenced by natural changes and human activities.***

In pursuit of this mission, the GEM program will accomplish the following

- Sustain the necessary institutional infrastructure to provide scientific leadership in identifying research and monitoring gaps and priorities,
- Sponsor monitoring, research, and other projects that respond to these identified needs,
- Encourage efficiency in and integration of GOA monitoring and research activities through leveraging of funds and interagency coordination and partnerships, and
- Promote local stewardship by involving stakeholders and having them help guide and carry out parts of the GEM program

In adopting this mission, the Trustee Council acknowledges that, at times, sustaining a healthy ecosystem and ensuring sustainable human uses of the marine resources may be in conflict In those instances, the goal of achieving a healthy ecosystem will be paramount The Trustee Council also acknowledges that, at this time, clearly defined measures for assessing "ecosystem health" are lacking (NRC 2000) These measures will be incorporated into the program as they are developed

1.3 Goals

Five major goals have been identified as necessary to accomplish the GEM mission. Attaining all five, however, will require several decades. Two of these goals may be attainable within the early decades of operating the GEM program, given sufficient funding and collaboration with other partners.

1. **Detect.** Serve as a sentinel (early warning) system by detecting annual and long-term changes in the marine ecosystem, from coastal watersheds to the central gulf, and

2. **Understand:** Identify causes of change in the marine ecosystem, including natural variation, human influences, and their interaction.

Two other goals provide an essential piece of the foundation for a long-term program. Although these goals are likely to be fully realized only after the first decade of operating the GEM program, shorter-term accomplishments should be achieved sooner.

3. **Inform:** Provide integrated and synthesized information to the public, resource managers, industry and policy makers in order for them to respond to changes in natural resources, and

4. **Solve:** Develop tools, technologies and information that can help resource managers and regulators improve management of marine resources and address problems that may arise from human activities.

The fifth goal is inherently long-term and difficult to achieve, but of considerable potential value to resource users and managers. It serves more as a long-range beacon to guide the design of monitoring activities, than as a goal to be attained within the near term.

5. **Predict:** Develop the capacity to predict the status and trends of natural resources for use by resource managers and consumers.

During the process of learning how to detect and understand change in the northern GOA, resource managers and the concerned public should collect incremental dividends on their investment in GEM. Ultimately, however, the benefits will be maximized over the long run. To fully achieve its mission, GEM must provide information that enables resource-dependent people, such as subsistence users, recreationalists, and commercial fishers, to better cope with changes in marine resources. The data and information produced by GEM during its first decade may not totally solve problems for the public, commercial interests, resource managers, and policy makers faced with environmental change. Nonetheless, as information accumulates, the ability for GEM to provide problem-solving information and tools can and must increase.

Given the size and complexity of the northern GOA ecosystem and the available funding, it will not be possible to meet these goals with only the data

collected by GEM Addressing the program goals will require achieving the following implementation goals

- **Lead** the way in integrating, synthesizing, and interpreting monitoring and research results to form and convey a "big picture" of the status of and trends in the GOA ecosystem,
- **Track** work of other entities relevant to understanding biological production in the GOA and **coordinate** GEM with those efforts,
- **Leverage** funds to augment ongoing monitoring work funded by other entities,
- **Involve** other government agencies, non-governmental organizations, stakeholders, policy makers, and the general public in a collaborative process to achieve the mission and goals of GEM,
- Increase **community involvement** and **local and traditional knowledge** in order to enhance long-term **stewardship** of living marine resources, and
- **Facilitate** application of GEM research and monitoring results to benefit conservation and management of marine resources

The substantial experience of the EVOS Restoration Program indicates that these six implementation goals are reasonable, necessary, and attainable

1.4 Geographic Scope

Consistent with the Restoration Plan, GEM program activities will occur within the area affected by the 1989 oil spill, which is generally the northern GOA, including Prince William Sound (PWS), Cook Inlet, Kodiak Island, and the Alaska Peninsula (Figure 1 1) Recognizing that the marine ecosystems affected by the oil spill do not have discrete boundaries, some monitoring and research activities may extend into adjacent areas of the northern GOA

The primary geographic focus of GEM will be the four habitat types that contain the ecosystems of the area affected by the oil spill, essentially the northern GOA These habitats are the watersheds, intertidal and subtidal, Alaska Coastal Current (ACC), and offshore (the continental shelf break and the Alaska Gyre) (Section 3 1 2)

Although GEM has a regional outlook, the waters of the GOA are connected to adjacent waters Waters from the shelf and basin of the GOA eventually enter the Bering Sea and the Arctic Ocean through the Bering Strait Waters from the west coast states (California, Oregon, and Washington), Canada and southern Alaska also feed into the northern GOA Consequently, the program will be of vital importance in understanding the downstream Bering Sea and Arctic Ocean ecosystems, as well as the upstream southern GOA In addition to the linkages provided by the movements of ocean waters, the GOA is linked to other regions by

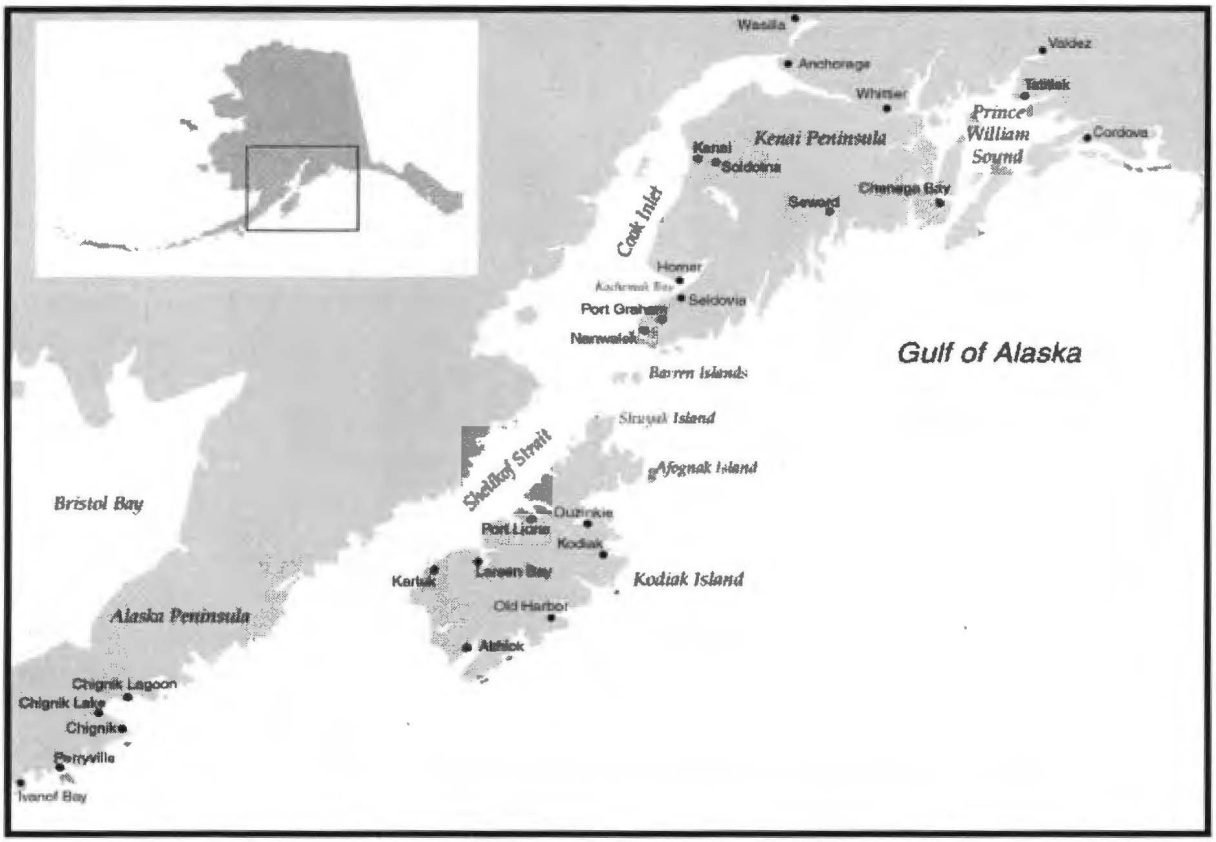

Figure 1.1 Map of the spill area showing the location of communities.

the many species of birds, fish, and mammals that also move through these regions. It is also becoming increasingly clear that environmental conditions in the GOA, such as levels of persistent organic pollutants, as well as the temperature of GOA waters, can originate many thousands of miles away.

Building on the lessons of the past from the oil spill damage assessment (Natural Resource Damage Assessment), the oil spill restoration program, and other efforts (see Volume II), monitoring will occur in localities within the habitat types best suited to answer the scientific questions posed in the GEM strategic plan (see Chapter 4, Volume I). Suitability of locales will be determined by scientific and policy criteria designed in accordance with the mission and goals of the Trustee Council.

1.5 Funding and Governance

The Trustee Council will fund the GEM program beginning in October 2002 with funds allocated for long-term monitoring and research, estimated to be approximately $120 million. The Trustee Council will manage these funds as an endowment, with the annual program funded by investment earnings after inflation-proofing, thus providing for a stable program through time. The Trustee Council may choose to fund a smaller program in the early years to allow the corpus of the fund to build. The Trustee Council's

long-term goal is to allow for additional deposits and donations to the fund from other sources to increase the corpus Achieving this goal might require changes in state or federal legislation and possibly a change in the court-approved settlement and will be pursued at a later time

Under existing law and court orders, three state and three federal trustees have been designated by the Governor of Alaska and the President of the United States to administer the restoration fund, which includes funding for GEM, and to restore the resources and services injured by the oil spill The State of Alaska trustees are the Commissioner of the Alaska Department of Environmental Conservation, the Commissioner of the Alaska Department of Fish and Game, and the Attorney General The federal trustees are the Secretary of the Interior, the Secretary of Agriculture, and the Administrator of the National Oceanic and Atmospheric Administration, U S Department of Commerce

The trustees established the Trustee Council to administer the restoration fund The state trustees serve directly on the Trustee Council The federal trustees each have appointed a representative in Alaska to serve on the Trustee Council They currently are the Alaska Director of the U S Fish and Wildlife Service (Department of the Interior), the Alaska Director of the National Marine Fisheries Service (National Oceanic and Atmospheric Administration), and the Supervisor of the Chugach National Forest (U S Department of Agriculture) All decisions by the Trustee Council are required to be unanimous

It is expected that the current Trustee Council will make policy and funding decisions for the GEM program It has been suggested that at some time in the future, a new board or oversight structure other than the Trustee Council be established to administer or guide the GEM fund It is also possible that an existing board, either under its current structure or with minor modifications, could take over management of the fund Use of a new governance structure, if justified, would require changes in law and the applicable court decrees Such changes would take considerable time and are not anticipated in the near future

1.6 References

NRC 2000 Ecological indicators for the nation National Academy Press Washington, D C

2. HUMAN USES AND ACTIVITIES IN THE NORTHERN GULF OF ALASKA

In This Chapter

- Discussion of the human impacts in the GOA
- Socioeconomic profiles
- Identification of human activities occurring

NOTE: This chapter is being reworked, and part or all of it will be included in the Scientific Background, Chapter 3, Volume II. This will provide better information to be used in developing specific questions and information needs, as begun in Chapter 3 (Volume I).

The growing population of Alaska and the existing and potentially greater human use of the resources of the northern GOA are important considerations for development of GEM To achieve the GEM mission of sustaining a healthy ecosystem, as well as sustaining human use of the marine resources of the GOA, it is essential to assess and understand the impacts that human activities may have on important fish and wildlife species, their habitat, and the northern GOA ecosystems overall

The economy of Alaska depends heavily on extraction of natural resources (primarily oil, fish, and shellfish, followed by timber and minerals) and on recreation and tourism In the northern GOA, commercial fishing, recreation and tourism (including sport fishing), oil and gas development, logging, roadbuilding and urbanization, marine transportation, and subsistence harvests are all activities that have the potential to affect fish and wildlife populations and habitat

Currently, the human impact on Alaska's marine ecosystems is relatively small, compared to impacts in most of the developed world Other regions are faced with marine dead zones caused by eutrophication (decline of a water body due to oxygen deficiency) from agriculture runoff (including pesticides), overfishing and depletion of fish stocks, serious industrial pollution, and degradation of important habitat such as coral reefs and coastlines Alaska is pristine in comparison Even here, however, natural resource managers have concerns about localized pollution, the potential impacts of some fisheries, extreme changes in some fish and wildlife populations, and the little known impacts of contaminants and global warming

Even in pristine Alaska natural resource managers are concerned about the impacts of pollution on marine ecosystems.

State and federal laws and permitting systems are designed to identify and mitigate the direct impacts of these activities Secondary and cumulative impacts are not as routinely assessed, however There is concern that local problems, if left unidentified or unmonitored, could grow into regional problems

Experience with the EVOS Restoration Program has demonstrated that, unless an impact is very large, it is often extremely difficult to isolate the human impact from the natural variability Because GEM will be a long-term program, however, it is important to assess the potential impacts of human activities on a regular basis to determine their influence on changes in the abundance and distribution of important resources

2.1 Socioeconomic Profile of the Northern Gulf of Alaska

About 71,000 full-time residents live within the area directly affected by the oil spill (Figure 1 1), and two to three times that number use the area seasonally for work and recreation The spill area population, combined with that of the nearby population centers of Anchorage and Wasilla, totals more than 60% of the state's 627,000 permanent residents When the resident population is combined with more than one million tourists who visit the state each year, it becomes clear that the natural resources of the northern GOA cannot be immune to the pressures associated with human uses and activities

2.1.1 Prince William Sound

PWS lies north of the GOA, south of the Chugach Mountain Range, west of the Copper River, and east of the Kenai Peninsula About 7,000 people live and make their living in this area The largest communities–Cordova, Valdez, and Whittier–are all coastal and predominantly non-Native, although Valdez and Cordova are home to Alaska Native village corporations and tribes Chenega Bay and Tatitlek are Alaska Native villages All five communities are accessible by air or water, and all have dock or harbor facilities In the north, the ports of Valdez and Whittier link the area to the state's main road system Whittier has train access, both passenger and cargo

The economic base of the five communities in PWS is heavily resource dependent The Cordova economy is based on commercial fishing, primarily for pink and red salmon As the terminus of the Trans-Alaska Pipeline System, Valdez is dependent on the oil industry, but commercial fishing and fish processing, government, and tourism also are important to the local economy Large oil tankers routinely traverse PWS and the northern GOA to and from the Port of Valdez In addition to working as oil industry employees, Whittier residents also work as government employees, longshoremen, commercial fishermen, and service providers to tourists The people of Chenega Bay and Tatitlek augment commercial fishing, aquaculture, and other cash-based activities with subsistence fishing, hunting, and gathering

2.1.2 Kenai Peninsula

The Kenai Peninsula, on the northwest margin of the GOA, separates Cook Inlet from PWS The central peninsula is connected to the main road system, only a few hours by car from the major population center of Anchorage Homer and Kenai have jet air access from Anchorage, and Seward has train access, both passenger and cargo Because of this road connection to Anchorage, the Kenai Peninsula is the fastest growing area in the northern GOA About 50,000 people live on the peninsula, with about two-thirds living near the cities of Kenai and Soldotna The economy of this area depends on the oil and gas industry, commercial fishing, and tourism This area was the site of the first major Alaska oil strike in 1957 and has been a center for oil and gas exploration and production since that time Seward is a seaport on the eastern Kenai Peninsula near the western entrance of PWS It is the southern terminus of the Alaska Railroad, which transports marine cargo and passengers to and from Anchorage

The southern Kenai Peninsula contains the cities of Homer and Seldovia and the Alaska Native villages of Nanwalek and Port Graham Homer, on the north side of Kachemak Bay, is the southern terminus of the state's main road system on the peninsula Seldovia, Nanwalek, and Port Graham, all located south of Kachemak Bay, are accessible only by air and sea Nanwalek and Port Graham depend largely on subsistence hunting and fishing and on village corporation enterprises, such as the salmon hatchery, cannery, and logging enterprise at Port Graham Homer is the economic and population hub of this part of the peninsula and depends on commercial fishing, tourism, and forest products

Tourism is an important and growing part of the Kenai Peninsula economy Marine sport fishing out of Seward and Homer is a major attraction for the tourist industry Cruise ships dock at the Seward harbor, and commercial vessels take passengers on tours of the nearby Kenai Fjords National Park The Kenai River and its tributary, the Russian River, are major sport fishing rivers, attracting tourists from Anchorage and all over the world

2.1.3 Kodiak Island Archipelago

The Kodiak Island archipelago lies to the west of the northern GOA This region includes the city of Kodiak and the six Alaska Native villages of Port Lions, Ouzinkie, Larsen Bay, Karluk, Old Harbor, and Akhiok About 14,000 people live in this region, although the population swells in the fishing season Communities on Kodiak Island are accessible by air and sea Approximately 140 miles of state roads connect communities on the east side of the island

The economy of the archipelago depends heavily on commercial fishing and seafood processing Kodiak is one of the world's major centers of seafood production and has long been among the largest ports in the nation for seafood volume or value of landings Village residents largely depend on subsistence hunting and fishing Kodiak Island also has a growing recreation and tourism

economy and is home to a commercial rocket-launch facility that held its first successful launch in 1999 The U S Coast Guard Station near Kodiak is a major employer

2.1.4 Alaska Peninsula

The Alaska Peninsula is on the western edge of the northern GOA Five communities on the south side of the Alaska Peninsula lie within the area affected by the EVOS Chignik, Chignik Lagoon, Chignik Lake, Ivanof Bay, and Perryville The population of the area is about 450 year-round residents, but doubles during the fishing season All five communities are accessible by air and sea The cash economy of the area depends on the success of the fishing fleets

Chignik and Chignik Lagoon serve as regional salmon-fishing centers, and Dutch Harbor, southwest of Perryville and outside the spill area, is a major center for crab and other marine fisheries In addition to salmon and salmon roe, fish processing plants in Chignik produce herring roe, halibut, cod, and crab About half the permanent population of these communities is Alaska Native Subsistence on fish and caribou is important to the people who live in Chignik and Chignik Lagoon

Chignik Lake, Ivanof Bay, and Perryville are predominantly Alaska Native villages and maintain a subsistence lifestyle, relying on salmon, trout, marine fish and shellfish, crab, clams, moose, caribou, and bear Commercial fishing provides cash income Many residents leave during summer months to fish from Chignik Lagoon or work at the fish processors in Chignik

2.1.5 Will add section on Anchorage Basin and how it affects other parts of region.

2.2 Description of Human Activities

2.2.1 Commercial Fishing

Commercial fishing is by far the predominant human activity in the northern GOA and is thought at this time to have the potential for the most significant impacts on the GOA ecosystem Within the GOA, the major commercial fisheries are salmon, Pacific herring, pollock, cod, halibut, and shellfish Tens of thousands of individuals participate in these fisheries

The period before the 1989 oil spill was a time of relative prosperity for many commercial fishermen Since 1989, these drastic changes have occurred in the commercial fishing industry

- Low prices have reduced the value of the pink and sockeye salmon fisheries
- Sharp declines in herring populations in PWS, possibly caused by disease related to the EVOS, have resulted in closures that have devastated the fishery

- The listing of the Steller sea lion under the federal Endangered Species Act has resulted in restrictions on groundfish fisheries
- In general, many GOA crab stocks have remained at low levels

A major ecological concern with all types of removals by fishing activities is the sustainability of fish stocks, which could be affected by directed fisheries or as a result of discarded bycatch in other fisheries and high seas interception This concern drives responsible fishery management The predominant fishery stocks historically fluctuate because of natural variability and climate cycles, and for that reason, harvest rates are set at sustainable fractions of the available biomass However, concern still exists that setting harvest rates without a complete understanding of those fluctuations could lead to unintentional overharvest, resulting in population declines that could take years to rebound

In addition, bycatch may have unintended consequences on non-targeted fish populations In many fisheries, observers monitor the bycatch In addition, bycatch is often only a small fraction of the overall mortality However, bycatch is not monitored in all fisheries, and may be significant in some

Another ecological concern with all types of fishing is the removal of marine nutrients (nitrates, phosphates, iron) that are key to sustaining the long-term productivity of watersheds (Finney et al 2000) Fishing for a dominant anadromous species such as salmon may lower the productive capacity of a watershed not only for salmon, but for a wide range of plants, fish, and mammals that are known to depend on marine nutrients When combined with the loss of nutrients associated with development of riparian (river and other waterfront) habitats and wetlands, the loss of marine nutrients may contribute to oligotrophy or "starvation" of the watershed Unfortunately, not enough monitoring data on marine nutrients in tributaries of the GOA are available to understand the degree to which oligotrophication is occurring

A third ecological concern with fishing is the potential for unintentional degradation of habitats and attendant losses of plant and animal species Sport-fishing activities in watersheds have substantially degraded some riparian habitats in Southcentral Alaska, resulting in lost vegetation, lost fish habitat, and siltation, and necessitating walkways and management restrictions Various types of marine fishing methods and gear, such as pots and bottom trawls (very large bag-shaped nets), also have the potential for degrading sea-bottom habitat and reducing populations of sedentary species such as corals and seaweeds

More information on how to define critical marine habitats is essential to balancing fishing opportunities and protection of habitat.

Protection has already been afforded to marine habitats in some sensitive areas by excluding gear types that are thought to be injurious to habitat For example most state waters are closed to bottom trawling In the eastern GOA, both state and

federal waters are now closed to trawling and dredging in part to protect coral habitats from possible trawling impacts There are numerous trawl-and-dredge closure areas near Kodiak Island, the Alaska Peninsula, and the Aleutian Islands But not all areas of the Bering Sea and GOA (especially those that have sandy and sediment bottom types) are vulnerable to trawling impacts Given the amount of marine habitats already subject to closure, more information on how to define critical marine habitats, a possible role for GEM, is essential to balancing fishing opportunities and protection of habitat

Commercial fishing also has the potential to affect other elements of the marine ecosystem, such as bird and marine mammal populations Effects result either directly, through entanglement in fishing nets or disturbance to haul-outs and rookeries, or indirectly, through impacts on food supplies Areas where marine mammals feed and that are adjacent to their haul-out areas have been closed to commercial fishing in parts of the Bering Sea, Aleutian Islands, and GOA A recent National Marine Fisheries Service (NMFS) Biological Opinion (NMFS 2000) concludes that lack of food is the reason why the endangered Steller sea lion is not recovering from serious declines in the GOA and Bering Sea On the basis of this opinion, NMFS has severely limited fixed-gear and trawl fishing for several groundfish species, a major food source for the Steller sea lion However, this opinion has been extremely controversial, and several independent teams of science reviewers have concluded that there is no evidence that sea lions are nutritionally limited and no evidence that fisheries are causing prey depletion

Salmon fisheries in the GOA are notable because hatcheries produce the majority of some salmon species in some areas and, in specific fisheries, the majority of salmon harvested Billions of juvenile salmon are released annually from hatcheries in three areas within the northern GOA Cook Inlet, Kodiak, and PWS Within this region, 56% of the salmon in the traditional commercial harvest were of hatchery origin in 1999 The percentage is higher if cost-recovery fisheries are also included In PWS in particular, hatchery production provides a majority of the pink and chum salmon harvested and a substantial fraction of the sockeye and coho salmon harvested In 1999, hatchery pink salmon contributed 84% of the number of pink salmon harvested by commercial fisheries in PWS

Information on the interactions between hatchery and wild fish appears to be essential to long-term fishery management programs.

Ecological concerns related to hatcheries include reduced production of wild fish because of competition between hatchery and wild salmon during all stages of the life cycle, loss of genetic diversity in wild salmon, and overharvest of wild salmon during harvest operations targeting hatchery salmon Information on the interactions between hatchery and wild fish in specific locations, as well as on the impact of salmon produced in hatcheries in both Asia and North America on food webs in the GOA, appears to be essential to long-term fishery management programs

2.2.2 Recreation and Tourism

Major recreational and tourist attractions within the spill area include Portage Glacier, Kenai Fjords National Park, Columbia Glacier, Kachemak Bay, and Katmai National Park World-class salmon fishing attracts residents and visitors alike to the Kenai River, the Russian River, and other rivers on the Kenai Peninsula Charter halibut fishing is an important and growing recreational activity, especially for Seward and Homer More than 500 vessels are active in this industry Camping, hiking, kayaking, hunting, and wildlife viewing attract visitors to the Kodiak National Wildlife Refuge, the Chugach National Forest, and numerous state and federal park units and refuges within the spill area

Growth of the Alaska population and increases in nonresident visitation to Alaska will increase the potential impacts of GOA resource use Between 1990 and 1998 alone, the number of nonresident visitors to Alaska increased from 900,000 to 1 35 million per year, averaging a 5% annual rate of increase during this period Cruise ship traffic to the state has been increasing by more than 10% a year, although the rate may be slowing somewhat

Increased tourism and recreational use could result in a variety of impacts on marine fish and wildlife and their habitats Sport fishing could contribute to localized depletion of fish stocks, as well as degradation of streambank habitat in watersheds Increased recreational boat traffic can disturb wildlife on their rookeries and haul-outs, as well as increase oil and gas residue in harbors and adjacent waters Cruise ships often carry more people than populate many Alaska towns, and cause concerns about their disposal of garbage and other waste, impacts on air quality, and potential for diesel fuel spills The growing use of jet skis for recreational use and their potential for disturbing nesting waterfowl has led the Alaska Department of Fish and Game (ADF&G) to ban jet ski use in Kachemak Bay Increased hiking and camping on coastal areas and riverbanks can lead to trampling, erosion, and related impacts on local water quality The Whittier road, opened in 2000, is expected to increase visitation to northwestern PWS, with potential impacts to shorelines, tidelands, and nearshore waters, as well as the fish and wildlife populations that rely on these habitats

2.2.3 Oil and Gas Development

The oil and gas industry is a major economic force in PWS and Cook Inlet Crude oil pumped from fields on the North Slope is transported by pipeline to Valdez, where it is loaded onto tankers and shipped to the lower 48 states and abroad Tankers traverse PWS on the journey south The number of tanker voyages from the Port of Valdez has declined from 640 in 1995 to 411 in 1999, because of the sharp reduction in North Slope crude oil production Any additional North Slope development could increase tanker traffic

Discovered in 1957, the Swanson River oilfield in the Kenai National Wildlife Refuge is the site of the first modern-day commercial oil development in Alaska

Much of the oil and gas development in the Cook Inlet area occurs on offshore platforms Underwater pipelines transport oil and gas to terminals on both sides of Cook Inlet Currently, all Cook Inlet production is delivered to a local refinery in Nikiski for processing

In April 1999, the State of Alaska offered for lease all available state-owned acreage (approximately 2 8 million acres) in its first Cook Inlet Areawide Oil and Gas Lease Sale As a result of the first sale, oil and gas leases have been issued on about 115,000 acres of land Sales in August 2000 and May 2001 resulted in the lease of about 205,000 acres of land Additional sales are proposed in 2002 and 2003 by the State of Alaska and the Minerals Management Service

The major concerns about oil and gas development include the potential for oil spills from vessel traffic, as happened during the 1989 EVOS, as well as small, chronic spills, pipeline corrosion and subsequent leaks, disposal of drilling wastes and potential impacts on water quality, and the introduction of exotic species from ballast waters

The State of Alaska issues leases and permits that stipulate site-specific and activity-specific mitigation measures The State also monitors exploration, development, and transportation activities on state land and waters The Minerals Management Service is responsible for comparable federal regulation of offshore development under the Outer Continental Shelf Act For activities within federal jurisdiction, the National Environmental Protection Act provides for analysis of environmental oil and gas development impacts All oil producers, shippers, and refineries are required to have approved contingency plans detailing response capabilities and specific response actions in the event of a spill In addition, the Oil Pollution Act of 1990 created regional citizens advisory groups to oversee oil and gas activities in PWS and Cook Inlet .

2.2.4 Subsistence Harvest

Fifteen predominantly Alaska Native communities in the GEM region, with a total population of about 2,200 people, rely heavily on harvests of subsistence resources such as fish, shellfish, seals, deer, and waterfowl Subsistence harvests in 1998 varied among communities from 250 to 500 pounds per person, indicating strong dependence on subsistence resources Subsistence activities also support the culture and traditions of these communities Many families in other communities also rely on the subsistence resources of the spill area

Subsistence use is a form of resource exploitation and must be considered as a factor potentially affecting resource abundance and distribution It is monitored under state and federal authorities Subsistence harvest of marine mammals is probably of greatest concern because marine mammals are an important component of subsistence diets in the GEM region In addition, subsistence harvests are the only legal take of marine mammals, have no regulatory restrictions, and may affect species with small populations

2.2.5 Timber Harvest

No major timber operations are currently occurring in PWS, but logging continues on Afognak Island in the Kodiak archipelago and small-scale timber operations are planned for parts of the Kenai Peninsula Of the three major logging operators on Afognak Island, only Afognak Native Corporation is still logging in a major way, with 30 million board feet in 2000 and another 30 million board feet planned for 2001 Poor lumber markets, increased competition, and a dwindling timber supply have all led to decreased logging activities on Afognak Logging operations on Port Graham Corporation lands on the southern Kenai Peninsula have concluded, but some logging may take place on Native allotments near Port Graham On the Alaska Peninsula, Ninilchik Native Corporation and Cook Inlet Region Inc are preparing a major logging operation to begin in 2001 on the Crescent River, a major Cook Inlet salmon producer

The State of Alaska has a five-year Schedule of Timber Sales for the Kenai Peninsula and Kodiak area from 2000 through 2004 One significant factor affecting forest planning in the Kenai area is a major epidemic of the spruce bark beetle The proposed timber sales are designed to use dead and dying timber or to harvest timber with a high likelihood of infestation in the next few years During this 5-year period, the state plans to hold 31 timber sales on about 23,000 acres of state land on the Kenai Peninsula Harvest from these lands is estimated to be 115 million board feet of spruce and hemlock and 410,000 cubic board feet of birch, cottonwood, and aspen In 1999 in the Moose Pass area, one sale that totaled 153 acres occurred In December 2000, three tracts in the Ninilchik/Clam Gulch area, totaling 1,604 acres, were re-offered, however, no bids were received

Concerns about logging include water quality effects, long-term effects on the marine system of bark from log transfer facilities, and impacts on anadromous streams from siltation and habitat destruction The Alaska Department of Environmental Conservation (ADEC) reported that 24% of the water bodies on the state's list of polluted sites are due to some aspect of logging (ADEC 2000), (ADEC et al 2001) A significant issue related to logging is the increased access to previously remote lands provided by logging roads Logging operations on the Kenai Peninsula alone have added more than 3,000 miles of roads in the region This increased access has encouraged all-terrain vehicle use in sensitive habitats, such as the headwaters of salmon streams

2.2.6 Other Industrial Activity

Large spills like the EVOS are rare More common are smaller discharges of refined oil products, crude oil, and hazardous substances Small spills have been caused by a variety of industries, such as oil and gas, timber, fishing, and seafood processing industries, as well as small commercial establishments such as gas stations and dry cleaners

Under state law, the release of hazardous substances and oil must be reported to ADEC In 1998 and 1999, 1,325 spills were reported in the EVOS region, resulting in a total discharge of 218,000 gallons of refined oil products, crude oil and hazardous substances Although small spills were reported throughout the spill area, by far the largest number of spills (1,037) and greatest volume of discharge (198,000 gallons) occurred in the Cook Inlet region Most spills (87%) involved refined oil products, accounting for about 90% of the total volume discharged Only 6,000 gallons of crude oil were reported spilled in the region from 1998 to 1999 (ADEC 2001)

Figures reported to ADEC include spills onshore as well as discharges into the marine environment The effects of these small spills depend on such variable factors as the volume of the discharge, its toxicity and persistence in the environment, the time of year the spill occurred and the significance of the affected environment in the life history of species of concern

2.2.7 Road Building and Urbanization

Community growth and urbanization often go hand in hand with loss of water quality and fisheries habitat The greatest concentration of roads, subdivisions, and other aspects of increased urbanization affecting the GEM region are within the Municipality of Anchorage and on the west side of the Kenai Peninsula In 1999, the Kenai Peninsula Borough approved plats for 250 subdivisions Most of the subdivisions were small, but a few were 40 acres or more The borough recently initiated a road-permitting program that will address placement and design of new roads

Continued expansion of urban areas and resulting expansion of suburban zones inevitably degrade habitat Changes in land surfaces can change entire hydrologic systems and add to water pollution problems Urban growth leads to increasing disposal of human wastes Even treated wastes may lead to changes in species composition and productivity in watersheds, estuaries, and nearshore areas

Increased areas of impervious surfaces through new roads and subdivisions usually increase stormwater runoff Stormwater runoff is the largest single source of pollution in Alaska and is caused by runoff and erosion from pavement, parking lots and ditches, commercial and residential construction, and septic systems Thirty-eight percent of the sites on a 1998 state list of polluted water are affected by such community runoff The pollutants include chemicals, bacteria, and excess soil

Increased stormwater runoff tends to lower base flows in streams and increase peak flows Stream macroinvertebrates (large animals that lack backbones) and fish populations are sensitive to these changes As part of its stormwater discharge permit through ADEC, the Municipality of Anchorage is mapping the impervious surfaces within its area and studying the response of stream macroinvertebrates Under a U S Environmental Protection Agency (EPA) 319 grant from ADEC, the

U S States Department of Agriculture Cooperative Extension Service is also studying the effects of impervious surfaces A pilot project is planned for the Anchorage area, and if successful, the methodology may be applied to other areas in the future

Increased urbanization also results in filling wetlands, which play an important ecological role in filtration for water quality and stormwater protection The Municipality of Anchorage has a wetlands plan, with high- and low-value wetlands identified There is no plan delineating the extent of wetlands and analyzing their function and values for the rest of the region, however

Human access to streams usually leads to degradation of aquatic habitat.

Human access to streams increases as the number of miles of road increases Trampling of stream banks, changes in stream configuration created by culverting of roads, reduction in riparian zone vegetation, and a multitude of other problems created by road building and access lead to aquatic habitat degradation and loss of basic productivity Increased human access to small rivers and streams containing relatively large animals such as salmon and river otters also usually leads to loss of aquatic species through illegal taking, despite the best efforts of law enforcement Indeed, limitations in budgets usually lead resource management and protection agencies to focus scarce resources on sensitive areas during critical seasons, leaving degradation to take its course in less sensitive locations

2.2.8 Contaminants and Food Safety

The presence of industrial and agricultural contaminants in aquatic environments has resulted in worldwide concerns about potential effects on marine organisms and human consumers Polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and organochlorine pesticides, such as dichlorodiphenyltrichloroethane (DDT) and its derivatives, are distributed around the world in marine and coastal waters and in the rivers and watersheds that feed fresh water into these environments Such pollutants can be transported great distances by winds and ocean currents following their releases from industrial and agricultural sources, most of them far from Alaska In addition, mercury and other metals, such as inorganic arsenic, cadmium, and selenium, are naturally present in the environment at low concentrations, but man-made sources can contribute additional quantities to the environment

The remoteness of the northern GOA from centers of industry and human population might be expected to protect much of this region from deposition of environmental contaminants Nonetheless, there is limited evidence suggesting wide geographic distribution of persistent organochlorines (DDT, PCBs, and dichlorodiphenyldichloroethylene [DDE]), other organic pollutants and heavy metals in the Arctic, Subarctic, and areas adjacent to the GOA (Crane and Galasso 1999) For example, measurable amounts of organochlorines have been found in

precipitation and fishes of the Copper River Delta, a tributary of the GOA that forms the eastern boundary of PWS (Ewald et al 1998)

A variety of geophysical pathways bring these materials into the GOA, including ocean currents and prevailing winds In particular, the prevailing atmospheric circulation patterns transfer various materials as aerosols from Asia to the east across the North Pacific (Pahlow and Riebsell 2000) where they enter the marine environment in the form of rain or snow Some of these contaminants, such as PCBs and DDT, can bioaccumulate in living marine organisms For example, research sampling of transient killer whales that had eaten marine mammals in PWS indicated concentrations of PCBs and DDT derivatives that are many times higher than those concentrations found in fish-eating resident whales The sources of these contaminants are not specifically known It has been established, however, that these contaminants are passed from nursing female killer whales to their calves

There is also concern about the potential effects of contaminants on people, especially those who consume fish and shellfish, waterfowl, and marine mammals At higher levels of exposure, many of the chemicals noted above can cause adverse effects in people, such as the suppression of the immune system caused by PCBs

The State of Alaska does not monitor environmental pollutants in the marine environment or in marine organisms on a regular basis There is no ongoing program for sampling food safety in subsistence resources in coastal communities, although the oil spill provided the opportunity to sample subsistence resources for hydrocarbons in the affected areas from 1989 through 1994 Federal funding for a joint federal-state-Alaska Native initiative has been requested from Congress NOAA has annually measured chemicals in mollusks and sediments since 1984 The agency also has monitored chemical concentration in the livers of bottom-dwelling fish and in sediments at the sites of fish capture since 1984 The Prince William Sound Regional Citizens Advisory Council has measured hydrocarbon concentrations and sources within areas of PWS and the GOA This program focuses on sampling of intertidal mussels and nearby sediments

2.2.9 Global Warming

Although driven by forces outside the control of Alaska's natural resource managers, global warming is an essential consideration for development and implementation of the GEM program The earth's climate is predicted to change because human activities–the combustion of fossil fuels and increased agriculture, deforestation, landfills, industrial production, and mining–are altering the chemical composition of the atmosphere through the buildup of greenhouse gases These gases are primarily carbon dioxide, methane, and nitrous oxide Their heat-trapping property is undisputed, as is the fact that global temperatures are rising Observations collected during the last century suggest that the average land surface temperature has risen 0 45° to 0 6° C Precipitation has increased by about 1% over the world's continents in the last century, with high-latitude areas tending to see

more significant increases in rainfall and rising sea levels This increase is consistent with observations that indicate the northern GOA sea surface temperature has increased by 0 5° C since 1940, and that precipitation in Alaska (excluding the panhandle) increased 11% from 1950 through 1990

Increasing concentrations of greenhouse gases are likely to accelerate the rate of climate change The changes seen in the northern GOA and their relationship to other warming and cooling cycles in the North Pacific and the combined effects on global climate are important for understanding how humans affect biological production Some populations of fish and marine mammals that show longtime trends, up or down, or sharp rapid changes in abundance, are actively managed through harvest restraints The extent to which harvest restraints may be effective in establishing or altering trends in abundance of exploited species can only be understood within the context of climate change

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3. INFORMATION NEEDS

In This Chapter

- Summary of general information gaps in marine science
- Definition of a central question in terms of the four main habitat types integral to the GEM program
- Starting points for identifying information needs for each habitat type

3.1 Introduction

A number of current and historical monitoring and research projects and data sets in the GOA and adjacent waters will be of value in developing the GEM program These are summarized in Appendix D This chapter provides a "gap analysis" of information needed to answer the key questions of the conceptual foundation described in Chapter 4, Volume II The key questions are designed to promote better understanding of the origins and time-space scales of variability in marine production and fluctuations of key marine-related species in the GEM region The questions, and the information needed to answer them, are still very broad To provide a more meaningful gap analysis, the key questions have been further expanded into multiple specific questions for each of the four representative habitat types watersheds, intertidal-subtidal, Alaska Coastal Current (ACC), and offshore The specific questions are then followed by a description of the specific information needed to answer them Critical ecological processes are also suggested for each habitat type to provide further context for the specific questions and information needs Together, these information needs will form the starting point for developing specific hypotheses and designing the monitoring and research components necessary to test them as described in Chapter 5 (Volume I)

The reader is advised to consider the questions and information needs below as the starting points for the process of implementing the GEM plan All concepts for specific information needs are subject to further development through the scientific advisory process described in Chapter 6 (Volume I) The advisory process is expected to include workshops and other meetings to gather the advice of experts in science, public policy, management, and user group concerns Opportunities for data acquisition and partnerships are discussed in Chapter 5 (Volume I)

3.1.1 General Information Gaps in Marine Science

Relatively little information has been gathered in Alaska for species of plants and animals that are physically small and unsuitable for commerce and subsistence

(see Appendix D). Consequently, substantial information gaps still exist for the basic life histories and biology of broad assemblages of species and communities that are outside the realm of human trade. The rule of thumb is that the amount of scientific information available is inversely proportional to the remaining energy and biomass at each trophic level (Figure 3.1). An especially large gap exists for basic information on zooplankton species and benthic invertebrates that provide a vital link between primary producers and fish, birds, and mammals that constitute the higher trophic levels. Additionally, how natural forces and human activities control productivities of valued living marine resources is still poorly understood, although information on the natural forces of climate and physical oceanography is steadily increasing, primarily through satellite telemetry.

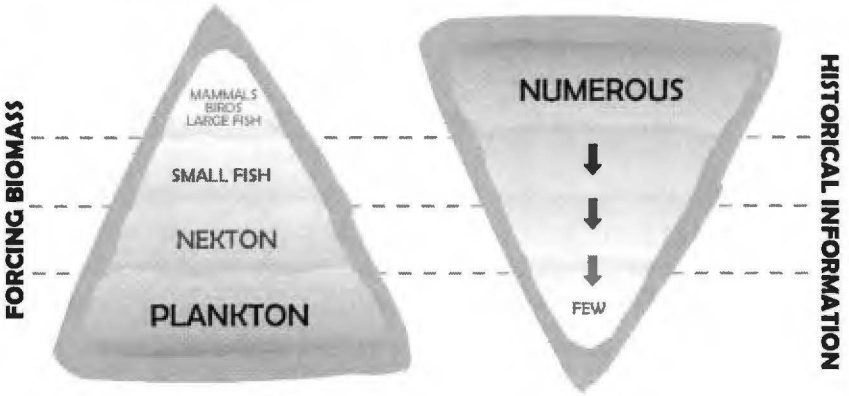

Figure 3.1 Comparison of forcing biomass and historical information.

The amount of historical scientific information available is inversely proportional to the forcing biomass (and energy) at each trophic level.

3.1.2 Filling Information Gaps for Representative Habitat Types

Filling information gaps requires answering questions on scales of time and space with respect to such phenomena of interest as predation, foraging, spawning, and population growth. Four habitat types, representative of the GEM region, are used to better organize the GEM program: watersheds, the intertidal and subtidal areas, the ACC, and the offshore areas (the continental shelf break and the Alaska Gyre). These habitats are composed of identifiable, although not rigid, collections of characteristic microhabitats, resident and migratory species, and physical features. The physical locations are described below:

- Watersheds—freshwater and terrestrial habitats from the mountains to the extent of a river's plume.
- Intertidal and subtidal areas—brackish and salt-water coastal habitats that extend offshore to the 20-m depth contour.

- ACC—a swift coastal current of lower salinities (25 to 31 psu) typically found within 35 km of the shore
- Offshore—the continental shelf break (between the 200-m and 1,000-m depth contour) and the Alaska Gyre in waters outside the 1,000-m depth contour

The four habitat types are used as a device around which to organize interdisciplinary monitoring and research activities that address GEM's central hypothesis (Chapter 4, Volume II) A central question that explores the hypothesis in relation to the Trustee Council's mission of determining the relative roles of natural forces and human activities is used to identify the information needs for evaluating the central hypothesis

> ***What are the relative roles of natural forces and human activities, as distant and local factors, in causing short-term and long-lasting changes in the biological communities that support birds, fish, shellfish, and mammals in the four key habitats of the GOA?***

The information needs of each habitat type are identified as the answers to the questions formed by adapting the central question to the specific circumstances posed by the habitat

To identify the information needed in each habitat type, the central question is adapted to the habitat's circumstances in the following sections Information needs are identified as the answers to specific forms of the central question for each habitat type

3.2 Watersheds

3.2.1 General Watershed Information Needs

The key question for watershed habitats is

> ***What are the relative roles of natural forces (such as climate) and human activities (such as habitat degradation and fishing) as distant and local factors, in causing short-term and long-lasting changes in marine-related biological production in watersheds?***

Long-term monitoring of marine-related productivity in watersheds is needed before the long-term effects of human activities and other natural forces on productivity can be fully understood Current monitoring activities and historical records make it possible to detect changes in productivity of prominent species within watersheds that are subject to relatively high levels of human activities, such as the Kenai River Understanding the causes of changes is not possible at this time, however, because a lack of basic measurements makes it nearly impossible to separate the effects of changes in marine productivity from the effects of other factors such as human activities and natural biological and geological forces Evidence of the significant role of marine nutrients in determining the productivity of watersheds is growing However, monitoring of these linkages in the northern

GOA is nonexistent to weak, based on the information gathering projects described in the database (see Appendix D) Measurements of certain kinds of human activities such as land development and fishing in some watersheds are available, but the actual impacts of these activities on production of natural resources are less certain Cumulative impacts such as accumulation of persistent contaminants may be of interest at some point in the future as they relate to control of plant and animal production

In addition, although there is substantial evidence of the potential role of the micronutrient iron in controlling marine productivity, the degree to which watersheds may be contributing iron to marine food webs in the GOA is not being measured The nature of flows of marine nutrients into watersheds, and the flow and distribution of freshwater micronutrients (such as iron) and carbon from the watersheds into the marine environments remain poorly understood in the GOA Filling watershed information gaps would address long-term questions about how the transport of marine nutrients, terrestrial micronutrients, carbon, and fresh water contribute to changes in productivity and community structure in watersheds and the marine environment and how human activities might affect these processes

3.2.2 Specific Watershed Questions and Information Needs

Three specific watershed (W) questions and the related information needs are presented below

W-1 What are levels of marine-related nutrients in watersheds and how do the annual inputs of marine nutrients vary?

Specific Information Needs Levels of nitrogen-stable isotopes in freshwater plants and animals, and feasibility of studying sources of precursors of reduced iron in watersheds with marine access

W-2 What is the annual variability in precipitation and runoff in Alaska watersheds bordering the northern GOA? (Same question applies to intertidal-subtidal and ACC habitats)

Specific Information Needs Annual precipitation and runoff for all watersheds flowing into the northern GOA In some cases, where data gaps exist, it may be possible to use marine salinity data to supplement precipitation and stream flow measures in estimating total freshwater run off from land to the GOA Input of the amount of fresh water entering the GOA from northern British Columbia and Southeast Alaska would also be needed to use marine salinity as a proxy for freshwater runoff

W-3 What are the levels of contaminants entering and leaving watersheds along marine-related pathways?

Specific Information Needs Levels of contaminants such as persistent organic pollutants (POPs) in anadromous species as adult immigrants and as juvenile emigrants of the watersheds

3.2.3 Watershed Processes

The watershed processes identified as of interest to the GEM program are those involved in linkages between terrestrial and marine variability, such as biogeochemical cycles

3.3 Intertidal and Subtidal

3.3.1 General Intertidal and Subtidal Information Needs

The key question for intertidal and subtidal habitats is

What are the relative roles of natural forces (such as currents and predation) and human activities (such as small-scale development and increased urbanization), as distant and local factors, in causing short-term and long-lasting changes in the community structure and dynamics of the intertidal and subtidal habitats?

Long-term monitoring is needed to identify how human activities can change the community structure of the intertidal and subtidal areas Current monitoring activities may make it possible to detect changes in community structure that are the result of a combination of human activities and natural forces in some localities, however, no program now produces the measurements sufficient to determine the extent to which such changes are due to human activities Evidence of the increasingly important role of human activities in changing the community structure of shallow nearshore environments is growing, however, monitoring that is structured to separate human and natural effects in areas of growing human impacts is sporadic Monitoring is needed to measure the natural variability of the intertidal and subtidal areas at places and times that support detection of the effects of human activities Simultaneous monitoring of currents and nutrients, bottom substrates, species composition, and other important natural forces in areas with differing degrees of chronic human activity is needed Filling intertidal and subtidal information gaps would begin to address the long-term questions of how human activities combine with natural forces to cause changes in productivity and community structure in intertidal and subtidal environments

3.3.2. Specific Intertidal and Subtidal Question and Information Needs

One specific intertidal and subtidal (I) question and several related information needs are presented below

I-1 What is the variability of selected plant and animal populations in the intertidal and subtidal zones?

Specific Information Needs

- Variability in numbers and diversity of fixed algae and invertebrates in several regions, such as PWS, Kachemak Bay, and Kodiak Island
- Relative availability of larval dispersal stages
- Measures of the cycling of carbon, nutrients, and contaminants in key species such as *Fucus*
- A detailed map of intertidal plant biomass during the growing season on a wide spatial scale
- Monitoring of clam populations
- Measurements of population processes of sea otters
- Identification and measurement of human impacts of concern

3.3.3 Intertidal and Subtidal Processes

Processes in the intertidal and subtidal habitat of interest to the GEM program relate to variability in community structure and plant biomass of selected populations and processes affecting populations

3.4 Alaska Coastal Current

3.4.1 General ACC Information Needs

The key question for ACC habitats is

What are the relative roles of natural forces (such as the variability in the strength, structure and dynamics of the ACC) and human activities (such as fishing and pollution) in causing local and distant changes in production of phytoplankton, zooplankton, birds, fish and mammals?

Long-term monitoring activities to detect seasonal changes in the ACC have permitted a general, large-scale understanding of circulation and lower trophic level productivity in the ACC, but current monitoring does not permit the changes in the ACC to be related to the changes in community structure or productivities in intertidal-subtidal areas and watersheds Long-term monitoring is needed to measure the natural seasonal and interannual variability of the ACC at locations that are likely to permit evaluation of these relationships Changes in annual production of some fish stocks are highly correlated with physical changes in the ACC, but ideas about the basis for these apparent relations cannot be evaluated from current monitoring activities Filling ACC information gaps would begin to address the long-term questions of how human activities combine with the transport of marine nutrients, terrestrial micronutrients, carbon, and fresh water to contribute to changes in productivity and community structure in watersheds and the marine environment

3.4.2 Specific ACC Questions and Information Needs

Seven specific ACC (A) questions and related information needs are presented below

A-1 What is the annual variability of strength, location and dynamics of the ACC?

Specific Information Needs Measurements of variability in temperature and salinity with depth, on time scales from days to multiple decades at locations sufficient to understand seasonal-scale variability and at localities sufficiently widely dispersed to understand large-scale structure, including intrusion into bays

A-2 What is the variability in the supply of deepwater nutrients to the photic zone of the ACC and their concentrations in that zone on time and space scales appropriate to understanding annual primary production?

Specific Information Needs Measurements of, or proportional to, macronutrients and micronutrients at appropriate spatial scales

A-3 What is the variability in chlorophyll a concentrations and phytoplankton species composition in the photic zone of the ACC on time and space scales appropriate to understanding annual primary production?

Specific Information Needs

- Chlorophyll a measurements
- Information on phytoplankton species composition

A-4 What is the variability of zooplankton biomass and species composition in the ACC on time and space scales appropriate to understanding annual primary and secondary production?

Specific Information Needs Information about zooplankton biomass and species composition

A-5 What is the variability in the availability of forage fish to higher trophic levels (birds, fish, mammals) in the ACC?

Specific Information Needs

- Analyses of the diets of selected higher-trophic-level organisms (birds, mammals, large predatory fish)
- Analyses of selected higher-trophic-level organisms (birds, mammals, large predatory fish) for fatty acid composition in relation to diet

A-6 What are the major factors affecting long-term changes in sea bird populations?

Specific Information Needs Annual colony and chick productivity counts of appropriate species in selected GOA colonies See also information needs for Question A-5 above

A-7 What are the major factors affecting long-term changes in harbor seal populations?

Specific Information Needs

- Annual surveys of molting population in selected GOA haul-outs
- Fatty acid profiles of individual animals and scat analysis surveys in selected GOA haul-outs

3.4.3 Alaska Coastal Current Processes

Processes in the ACC of interest to the GEM program relate to variability in the current structure and dynamics, nutrient supply, and selected populations and processes affecting populations

3.5 Offshore: The Outer Continental Shelf and Oceanic Waters

3.5.1 General Offshore Information Needs

The key question for offshore habitats is

What are the relative roles of natural forces (such as changes in the strength of the Alaska Current and Alaskan Stream, mixed layer depth of the gyre, wind stress and downwelling) and human activities (such as pollution) in determining production of carbon and its shoreward transport?

Long-term information gathering is needed on the effect of the Alaska gyre on the natural variability in seasonal and annual productivity of the continental shelf and ACC Past information gathering is sufficient to suggest that a strong relationship between gyre and inner waters has existed at times The gyre-continental shelf-ACC relationship appears to be based on movement of nutrients–detritus and plankton Current information gathering, however, does not provide the long-term data sets needed to detect changes in the gyre that may be related to changes in the ACC, intertidal and subtidal areas, or watersheds The same changes in annual production of certain fish stocks that are highly correlated with physical changes in the ACC also appear to be correlated with changes in the gyre, but ideas about the apparent relations between fish stocks, the ACC, and the gyre cannot be evaluated from current information gathering Filling information gaps on the gyre would begin to address the long-term questions of how oceanic productivities and processes in the GOA may contribute to changes in productivity and community structure in watersheds and the marine environment

3.5.2 Specific Offshore Questions and Information Needs

Five specific offshore (O) questions and related information needs are presented below:

O-1. What is the annual variability in the production of zooplankton in the offshore areas?

Specific Information Needs: Abundance of zooplankton on time and space scales appropriate to understanding annual production.

O-2. How are the supplies of inorganic nitrogen, phosphorus, silicon, and other nutrients essential for plant growth in the euphotic zone annually influenced by climate-driven physical mechanisms in the GOA?

Specific Information Needs: Measurements of inorganic nitrogen, phosphorus, silicon, and other nutrients on time and space scales appropriate to understanding annual variability.

O-3. What is the role of the Pacific High pressure system in determining the timing and duration of the movement of dense slope water onto and across the shelf to renew nutrients in the coastal bottom waters?

Specific Information Needs: Synoptic information on sea level pressure and horizontal and vertical structure of density and nutrients on the outer continental shelf and Alaska Gyre in relation to the ACC on appropriate time and space scales.

O-4. Is freshwater runoff a source of iron and silicon that is important to marine productivity in the offshore and adjacent marine waters?

Specific Information Needs: Levels of biologically available silicon and iron from offshore water in relation to the ACC on appropriate time and space scales.

O-5. Does iron limitation control the species and size distribution of the phytoplankton communities in the offshore areas?

Specific Information Needs: Levels of biologically available iron and species composition and size distribution of the phytoplankton communities from offshore water on appropriate time and space scales.

3.5.3 Offshore Processes

Processes of interest to the GEM program in the offshore habitat are variability in the strength and location of the Alaska Current and Alaskan Stream, gyre activity, and primary and secondary production.

4. PROGRAM COMPONENTS AND STRATEGIES

In This Chapter

- Relationships and functions of tools for implementing the GEM program
- Strategies for program implementation
- The ongoing role of gap analysis

4.1 Program Components

Synthesis, research, monitoring, modeling, and data management and information transfer are the tools to be used in implementing the GEM program These tools are common to most programs for assessing living marine resources (Myers et al 2000) For organizational purposes, retrospective analysis and process studies are treated as forms of research As a common toolset for monitoring and research, the components are closely related, and their functions sometimes overlap

4.1.1 Synthesis

The starting point for developing the GEM program is synthesis, because all good science ultimately involves synthesis In the words of biologist, E O Wilson (1998)

> *We are drowning in information while starving for wisdom The world henceforth will be run by synthesizers, people able to put together the right information, think critically about it, and make important choices wisely*

Synthesis builds on and updates the current understanding of the northern GOA It brings together existing data from any number of disciplines, times, and regions to evaluate different aspects of the GEM program's central hypothesis, key questions, and related ideas Synthesis has three broad uses First, it is used to provide direction for developing hypotheses to be tested and, combined with research and monitoring, to update and refine the conceptual foundation described in Chapter 4, Volume II Second, it is used as a tool–for example, in workshops, meetings, or publications–to inform stakeholders and the public about the developing understanding of the factors responsible for change in the marine environment And third, synthesis is used to solve resource management problems, by identifying new applications of existing information or by identifying opportunities to solve existing problems through collection of new information Synthesis is a logical place to begin the cycle of monitoring and research, but once used to initiate a project or component, it logically becomes a companion to research

For the purposes of the GEM program, synthesis is defined separately from research and from retrospective analysis, a form of research Synthesis differs from research in the requirement that synthesis be interdisciplinary or concerned with multiple habitat types, or both Synthesis is usually supported by various forms of retrospective analysis (discussed below) The results of synthesis and research are often used together to solve problems

4.1.2 Research

Research collects relatively short time series of observations to evaluate some specific aspect of the monitoring program or some testable hypothesis relating to the central hypothesis It may build on or use existing data and may also build models Testing current understandings through research provides the basis for making changes to the monitoring program and the associated components of modeling, data management and information transfer

Retrospective analysis is a specialized form of research that uses existing time series data to evaluate a testable hypothesis or other question of similar specificity relating to monitoring, often supported by statistical modeling Retrospective analysis contributes to building numerical models and to synthesis

Research, in the form of *process studies*, plays a vital role in moving beyond the correlative relationships that arise from the monitoring efforts to understand the underlying mechanisms Process studies develop information on the mechanisms through which energy and matter are transferred across varying scales of time and space This critical deeper understanding is essential to provide a framework and substance for the numerical modeling and synthesis Large-scale process studies may encompass ecosystem-level processes occurring across multiple trophic levels, water masses, and habitat types, whereas small-scale studies may deal with mechanisms as specific as the digestion rates of individual animals Processes such as predation, nutrient transport, and heat transfer are critical to understanding changes in living marine-related resources Process studies support model building by defining relationships among individuals and species and between phenomena such as primary production and physical forcing Process studies also contribute to other forms of research, such as retrospective analysis, and to synthesis

The short-term end point for GEM program synthesis and research is implementation of core monitoring activities that are refined as suggested by new information

The continuing roles for synthesis and research, as supported by modeling, are to promote understanding of the relationships among and within the broad habitat types of the ecosystems, plant and animal species, physical and chemical oceanographic processes, and climate in the GOA Continual refinement and testing of hypotheses, synthesis across geographic areas and species, and modeling of biological and physical processes are expected

4.1.3 Monitoring

Monitoring is the action of taking long-time series observations at times and places designed to test hypotheses based on current understandings Monitoring is essential to detecting and understanding change, because it provides the starting point for synthesis, various forms of research, modeling, and information transfer How often and where to sample are important aspects of detecting change, and, therefore, key considerations in the design of monitoring They must be appropriate to the hypotheses being analyzed

Monitoring in the GEM program will be organized into core monitoring and partnership monitoring Core monitoring is fully supported by the GEM program, partnership monitoring is partially supported

The end point for monitoring is a geographically distributed network gathering data on the state of the marine ecosystem These data are transformed into information for user groups by using synthesis, research, modeling, data management, and information transfer Monitoring will use spatially structured survey methods

4.1.4 Modeling

Modeling is used to make the relationships between the parts and processes of the ecosystem clear Models are tools for organizing data and telling a story and can be written in a variety of media as verbal, visual, statistical, or numerical models In the GEM program, the specific purposes of modeling are to help accomplish the following

- Inform, communicate, and provide common problem definition,
- Identify core variables and relationships,
- Set priorities,
- Improve and develop experimental (monitoring) designs, and
- Improve decision-making and risk assessment.

Modeling, monitoring, and data management strategies need to work in concert for each to be fully effective (Figure 4 1) Modeling is a pivotal link between monitoring and data management and information transfer on the one hand, and synthesis and research on the other Modeling feeds back information to the monitoring program in the form of recommendations on how the monitoring system can be made more effective Modeling also helps interpret data for the use of synthesis and research activities Current modeling efforts are considered in more detail in Chapter 5, Volume II The discussion below provides a brief introduction to definitions and strategies for modeling in the GEM program

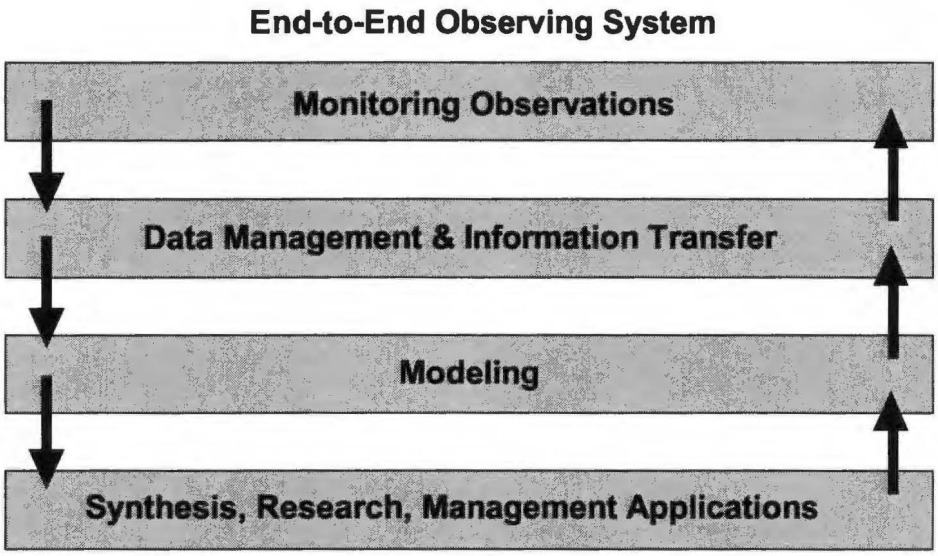

Figure 4.1 The End-to-End Observing System in which the monitoring observations are linked by data management and information transfer to end users, including modeling, synthesis, research, and management applications. (Adapted from Tom Malone [U.S. GOOS Steering Committee 2000]).

As defined for the purposes of the GEM program, a model may be expressed in verbal, visual, statistical, or numerical languages. Verbal models are also known as "qualitative" and "conceptual"; statistical models are also known as "correlative" and "stochastic"; and numerical models are also known as "deterministic" and "mechanistic." Note that "prediction," "simulation," and "analysis" are not types of models, but uses of models. For example, the use of any kind of statistical or numerical model to reproduce the behavior of a process, such as population growth, is known as a simulation (see Chapter 5, Volume II). The different media for models are explained below:

- Verbal models come in different degrees of precision, from low-precision, narrative explanations of how physical and biological factors combine to produce birds, fish, and mammals (such as in the conceptual foundation, Chapter 4, Volume II), to highly precise statements known as testable hypotheses.
- Visual models, such as Figure 4.2 of the conceptual foundation, are graphic images of verbal models.
- Statistical models and related mathematical techniques promote understanding of whether verbal models are worth considering further. By comparing combinations of measurements, such as fish growth rates at different water temperatures, statistical methods show the likelihood of relationships among phenomena, but not how or why they are related.

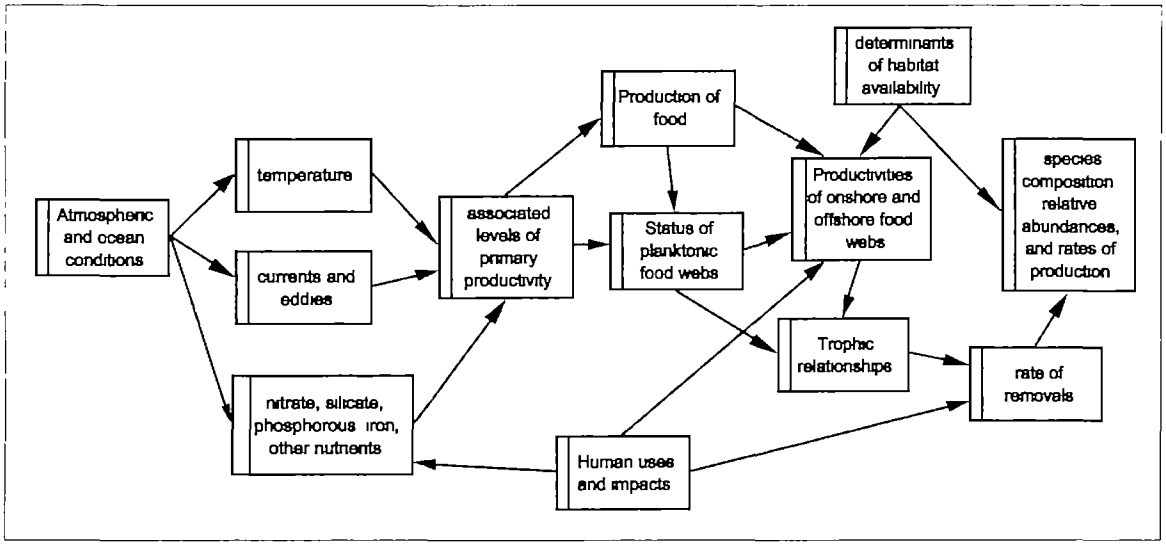

Figure 4 2 A visual model of the GEM conceptual foundation

- Numerical models are mathematical translations of verbal models describing how and why phenomena are related Numerical models often rely on established principles from physics, chemistry, and biology

All four types of models will be used in the GEM program In the near-term, however, models of biological phenomena are expected to be mostly verbal, visual, and statistical, whereas models of physical and chemical phenomena are likely to be primarily numerical, in addition to being verbal and statistical

Models are tools not only for understanding, but also, for predicting change Models organize and analyze monitoring observations of plants and animals, natural forces, and human activities With the use of the mathematics of modeling, short-term predictions can be made about how a particular aspect of the ecosystem works The ultimate demonstration of understanding a phenomenon, however, is longer-term prediction Covering the vast distance between current understanding of the productivity of living marine-related resources and predicting changes on longer time scales (weeks, months, and years) will require thousands of small steps in understanding This progression will necessarily take a long time Because of the time required, identifying the relationship between current understanding and probable changes in resource productivity is a reasonable goal for a long-term program such as GEM

The long-term modeling end points for monitoring, synthesis, and research in GEM are working biophysical models that make managers, policy makers, and resource users aware of changes in natural resources, help them understand the human and natural origins of these changes, and give them some idea of what to expect in the future

4.1.5 Data Management and Information Transfer

Data management and information transfer are the processes of acquiring in the field, receiving in the office, formatting, and storing data, providing quality control and assurance, developing and managing databases, and making the data understandable to users It includes the development of information products based on interpreted data and the delivery of these products, including user interfaces The short-term objective of data management and information transfer in the GEM program is to gain control of the data acquired with EVOS funds Many of these data are in danger of being lost as the passage of time leads to loss of project personnel and institutional memory

The long-term end point for GEM data management and information transfer is a system that manages the rapid and efficient flow of data and information based on core monitoring projects to end users, and that facilitates the flow of data and information between and among GEM partners and the user community

GEM data management is a program support function intended to accomplish the following

- Support cross-disciplinary integration of physical, biological, and traditional knowledge within a structured, decision-making framework,
- Support synthesis, research, and modeling that evaluate testable hypotheses on the roles of natural forces and human activities in controlling biological production, and
- Lay the groundwork for future use of distributed, Web-based analysis and management tools as the monitoring program becomes fully operational

By necessity, the data incorporated into the GEM program will derive from a variety of sources and formats, which will include retrospective data sets and traditional knowledge and may contain spatial and temporal components Synthesis and research will need to incorporate data not directly collected by the GEM program, such as satellite remote-sensing information and fishery catch data Incorporation of these data into regional models and decision-making systems will require tools for data ingestion and query, especially to facilitate modeling (see Figure 4 1) Because the output from the GEM program will be used by people from a wide variety of disciplines and backgrounds, the user interfaces must be easy to understand and accessible through a distributed network, such as the Internet

Data management and acquisition policies are essential to ensure the rapid transfer of information to end users Although the data must flow through the system as quickly as possible, quality control and assurance procedures and the prerogatives of scientists to publish interpretations of the data need to be respected One approach that may prove useful is the establishment of "peer reviewed" data

sets that allow the scientists involved to receive credit for their efforts in the publications of other scientists who may use the data

Information transfer products will depend on the nature of the monitoring and research activities (see Chapter 5, Volume I) that are yet to be chosen Possibilities for these products, based on the experience of other monitoring and research programs, are discussed in Chapter 6, Volume II, and could include models and measures relevant to determining the productivity of key species such as salmon

4.2 Strategies for Implementation

The scientific strategy of the GEM program uses a central hypothesis and key questions from the conceptual foundation to establish the initial direction for the program From this starting point, the GEM program follows a path of synthesis, research, and monitoring to detect, understand, and, eventually, predict changes in living marine-related resources of the GEM region As shown in the table below, the strategy calls for modeling and data management to closely support synthesis and research

The way to achieve prediction in the long term is to build a body of knowledge on how and why the productivity of living marine-related resources changes through time Synthesis is used to build and maintain a coherent and comprehensive understanding of the current state of knowledge Research tests current understandings Monitoring activities take long-time-series observations at times and places designed to test hypotheses based on current understandings And at all stages of the program, an ongoing gap analysis demonstrates when it is possible to take advantage of the work of others (Figure 4 3)

The basic sequence of activities for establishing the monitoring network is envisioned as follows

Synthesis → Research → Monitoring

Concurrent programs of modeling and data management would support the sequence of synthesis, research, and monitoring Table 4 1 illustrates this implementation strategy

The implementation strategy shown in Table 4 1 uses the basic components of the program in a series of three steps that lead gradually to the identification and establishment of a long-term monitoring program The first step is increased synthesis of existing information, continuing the process started in preparing the scientific background (Chapter 3, Volume II) and in conjunction with exploratory research projects that build on current synthesis The GEM program is now at this step, with ongoing synthesis and preliminary research expected to continue through Fiscal Year (FY) 2002 The initial synthesis activities, including modeling, would support identification and development of testable hypotheses Initial research activities would explore the feasibility of measuring candidate variables at various localities in the watershed, intertidal and subtidal, ACC, and offshore Initial synthesis in the intertidal and subtidal, ACC, and offshore areas would rely

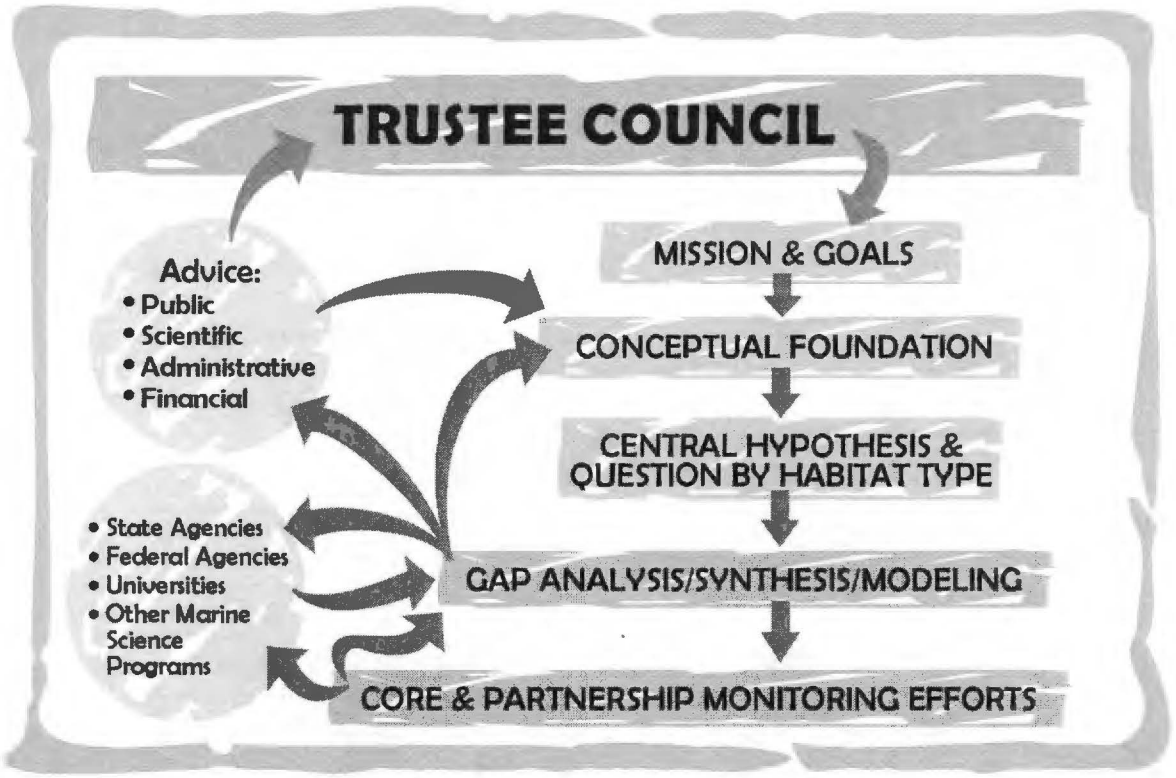

Figure 4.3 Selecting monitoring elements starts with the mission and goals established by the Trustee Council, as expressed in the conceptual foundation, which is regularly updated by new information from a variety of sources.

heavily on past and developing information from research and monitoring programs such as SEA, FOCI, OCC, and GLOBEC (see Appendix D). Synthesis in the watersheds would rely on past and ongoing monitoring and research under ADF&G, USFWS, USFS, and others.

The second step, to be initiated in FY 03, combines continuing synthesis with research that examines opportunities for core monitoring in PWS, the outer Kenai Peninsula, Lower Cook Inlet, Kodiak, and adjacent waters. All research projects are initiated for a fixed duration; however, some of these initial projects might be considered "pilot monitoring" projects that could be extended indefinitely if results of retrospective analyses, workshops, modeling studies, synthesis, and other preparatory research show continuation is warranted.

The third step is full implementation of a long-term monitoring program. As identified by the preparatory synthesis, research, and modeling, each core monitoring activity would collect data on a number of core variables that support evaluation of testable hypotheses. Partners may fund additional measurements at the location of core monitoring activities. For example, with proper planning it is usually possible to add monitoring equipment to moorings without disrupting existing activities for data acquisition. It may also be advantageous for partners to

Table 4.1 Strategy for Implementing a Monitoring Network

Example of building a monitoring activity for the GEM program in 5 fiscal years through synthesis and research, supported by concurrent modeling and data management

	Monitoring Activity			
Fiscal Year	**Core**	**Partners**	**Model**	**Data Management**
2003	Synthesis Research	Monitor	Verbal(c)	Prototype
2004	Synthesis Research	Monitor Research	Statistical(c)	Coordination (c) Archiving(c)
2005	Research	Monitor Research	Statistical(c) Numerical prototype (p)	Coordination (c) Archiving (c) Distribution (p)
2006	Research Monitor	Monitor Research	Statistical(c) Numerical (p)	Coordination (c) Archiving (c) Distribution (p)
2007	Monitor Research	Monitor	Numerical (p)	Archiving (c) Distribution (p)

Notes

c = core (GEM program supported) activity

p = partnership (jointly supported) activity

incorporate core monitoring locations into their own transects and other surveys The actual number of core monitoring activities at full implementation at the end of FY 07 will depend on how much funding is available and the needs demonstrated by the results of retrospective analyses, workshops, modeling studies, synthesis, and other preparatory research

4.3 Gap Analysis: An Ongoing Strategy for Implementation

The identification of information needs, or gap analysis, is an important part of the process of identifying the starting points for monitoring and research (Chapter 5, Volume I) It will continue to be an important part of implementation In the process of starting the GEM program, the available information (Appendix D) was compared to the information relevant to answering the key questions (Chapter 4, Volume II) to see what information was missing (Chapter 3, Volume I) This process will continue during implementation, with more general questions being replaced by increasingly specific questions

It is important to have a clear understanding of how the nature of the question determines the nature and outcome of the gap analysis The gap analysis has three essential parts a question, identification of information necessary to answer the question, and a survey of relevant available information

The first part, the question, is fundamental to the gap analysis and defines the survey of all relevant information needed to answer it A general question calls for a general gap analysis, and a more detailed question calls for a more detailed gap analysis The gap analysis concludes with a comparison of the information needed to the information available

As the GEM program moves from general questions about what controls and connects biological production within and between habitats, and toward specific questions and testable hypotheses, the gap analysis will become highly specific Testable hypotheses will start to be developed during the second half of FY 02 More detailed gap analysis will be done when the process reaches the level of testable hypotheses, with highly specific questions, in FY 03

A continuing gap analysis, supported by a continuously updated database of current and historical information-gathering projects in the GOA and adjacent areas, is essential to implementing the GEM program This analysis will be key to finding new partners for monitoring activities, identifying new opportunities for research and synthesis, and providing increased opportunities for collaboration, without risking duplication

The immediate end point of the gap analysis strategy is a database that supports identifying information needs in the short term, as core monitoring variables and locations are selected In the longer term, the supporting database will become a valuable tool for resource managers, policy makers, other scientists, stakeholders, and the general public

4.4 Strategies for Developing Resource Management Applications

The GEM program is designed to increase and enhance the information managers and harvesters use to cope with changes in natural resources To accomplish this, GEM will acquire data suitable for use in resource management applications, ensure that data is converted into useful information in a timely manner, and invite research and synthesis projects that both involve and benefit natural resource management agencies

Salmon fishery management illustrates management concerns that are common to most natural resources The typical salmon fishery operates on a resource that depends on a variety of habitat types (freshwater, nearshore, and offshore) during the course of its life cycle (Figure 4 4) Management of the salmon fishery requires detecting and understanding the consequences for production of habitat management decisions (Box 1 9, Figure 4 4) throughout the salmon's life cycle GEM seeks to provide data relevant to answering specific questions about how a range of habitat types function to produce salmon and other species The cyclic nature of the salmon fishery in time and space makes it clear that biological production in one habitat type cannot be understood in isolation from production in the other habitat types in which the salmon completes its life cycle GEM

questions are directed at understanding not only specific mechanisms of production in representative habitat types, but the connections among habitat types.

The management applications actually achieved will depend on a variety of factors, including the participation of resource managers in the review and implementation of the GEM program.

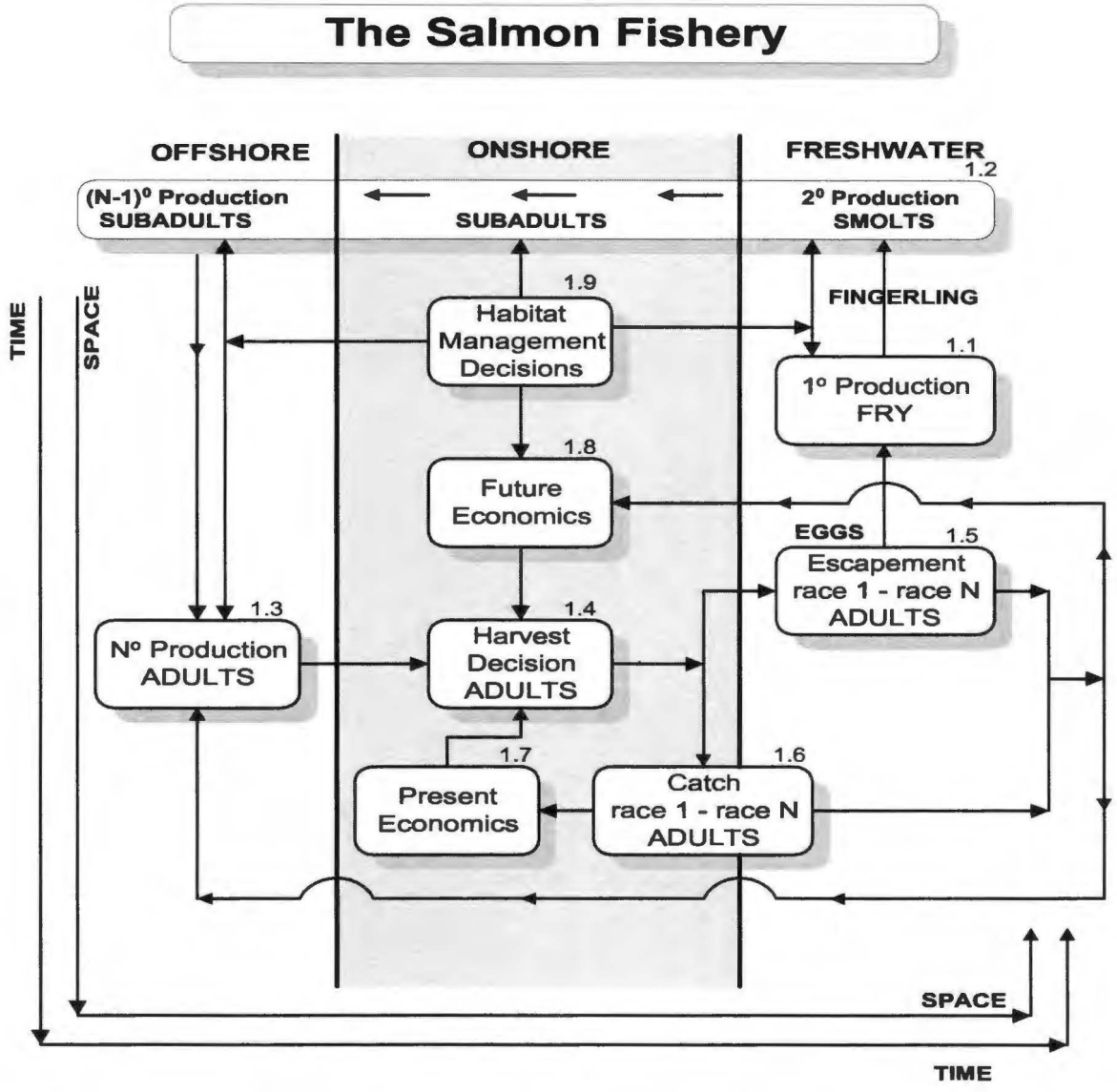

Figure 4.4. Diagram of the salmon fishery with life cycle stages, harvest, and habitat management decisions in geographic and temporal contexts (Mundy 1998).

4.5 References

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5. MONITORING PLAN AND RESEARCH AGENDA

In This Chapter

- Elements of the phased approach for developing a monitoring program
- Starting points for research

5.1 Introduction

The monitoring program developed by the Trustee Council is intended to be the "flagship" of the GEM program and will be maintained even if funding levels vary Synthesis, research, modeling, and data management will all be used to develop and refine monitoring activities A phased approach is envisioned during a 5-year period, from FY 03 to FY 07, and will incorporate these elements

- Use of the *key question* for each habitat as the starting point for performing the necessary synthesis and research for developing testable hypotheses
- A *proposed schedule and strategy for implementation,* FY 03 to FY 07, for core and partnership activities, models, and data management
- Lists of probable or *prospective partners* that are actively doing related monitoring or research in the broad habitat type
- Development of *models* as a way to synthesize monitoring and research results and transfer information to end users
- *Candidate (possible) core monitoring activities* recommended based on the conjunction of partnership opportunities and opportunities for measuring biological and physical quantities related to the key question and information gaps
- *Candidate (possible) core variables* recommended based on approaches suggested by the literature reviewed in the scientific background (Chapter 3, Volume II)

Following a discussion of data management, this chapter discusses the above monitoring program elements for each habitat type The key questions were introduced in Chapter 3 (Volume I)

5.2 Data Management

Because data management functions and products are generic to all habitat types, the suggested implementation strategy provided in this section is applicable to all four habitat types Core data management will be prototyped in

FY 03 as core synthesis and research projects are initiated and partnerships formed The first core function is to establish coordination among parties as soon as possible, but no later than FY 04, by such means as file transfer protocol (ftp) sites, Web sites, and e-mail lists As data from core and partnership research projects are produced, around FY 04, archiving of data will be essential to serve research needs A partnership system of data distribution will be designed to make information products readily available to partners and other user groups The ultimate goal for all broad habitat types will be an end-to-end system, in which a monitoring network provides data to models and other applications that provide services to a variety of end users, including the ongoing GEM synthesis, research, and modeling

5.3 Watersheds

5.3.1 Key Question

What are the relative roles of natural forces (such as climate) and human activities (such as fishing and increased urbanization) that result in habitat degradation, as distant and local factors, in causing short-term and long-lasting changes in marine-related biological production in watersheds?

5.3.2 Schedule

Development of watershed monitoring activity will be led by a core synthesis effort in FY 03, building on preparatory core research in FY 02 to establish an approach to measuring levels of marine influence in animals and plants of the watersheds Core synthesis will assist in developing hypotheses by about FY 04 that can be tested and refined by core research in FY 05 and FY 06 At least one core monitoring station will be initiated by FY 06, but may not be fully operational until FY 07

Table 5 1 presents the proposed schedule and strategy for implementation

5.3.3 Prospective Partners and Partner Activities

Partner activities in FY 03 are expected to be the supporting monitoring programs already in place, such as enumeration of animals and plants, water quality monitoring, existing hydrology models, including annual and seasonal runoff, and permitting of human activities such as resource harvests and land development Starting in FY 04, partners will be encouraged to assist in funding research to further site selection This activity will extend through FY 06, terminating after the monitoring stations are fully operational Because an analogous research program is underway at the Washington Department of Fish and Wildlife (WDFW), that agency may be willing to share information and the costs of process studies of mutual interest

Table 5 1 Proposed Implementation Strategy for Watershed Habitat

Fiscal Year	Monitoring Activity		Model	Data Management
	Core	Partners		
2003	Synthesis Research	Monitor	Verbal(c)	Prototype
2004	Synthesis Research	Monitor Research	Statistical(c)	Coordination (c) Archiving(c)
2005	Research	Monitor Research	Statistical(c) Numerical prototype (p)	Coordination (c) Archiving (c) Distribution (p)
2006	Research Monitor	Monitor Research	Statistical(c) Numerical (p)	Coordination (c) Archiving (c) Distribution (p)
2007	Monitor Research	Monitor	Numerical (p)	Archiving (c) Distribution (p)

Notes

c = core (GEM program supported) activity

p = partnership (jointly supported) activity

Prospective partners ADF&G, USFWS (Kenai Natural Wildlife Refuge [KNWR]), USGS, EPA, ADEC, USFS, Cook Inlet Keeper (CIK), Alaska Department of Natural Resources (ADNR), and Washington Department of Fish and Wildlife (WDFW)

Candidate core monitoring activities Kenai River watershed, Karluk River watershed

Candidate core variables Isotopes of nitrogen in aquatic and riparian plants and animals, precursors of reduced iron in water, and anadromous fish

5.3.4 Models

Models of the relationship between marine productivity and watershed productivity (Finney et al 2000) will likely be verbal as of FY 03 Statistical modeling to describe the strength of relations among variables and power analysis to guide sampling should start in FY 04, continuing through the evaluation of the initial monitoring station in FY 06 The end point of modeling will be a numerical model of the geochemistry of the core variable(s) in the watershed to the boundary of the intertidal and subtidal areas This model will be initiated in about FY 05 and operational (in some sense) by FY 07 It is recognized that a number of partner monitoring activities in addition to the core activity will be needed to create parameters for a numerical model If numerical modeling proves intractable, statistical modeling would be extended in the interim

5.3.5 Candidate Core Monitoring Activities

Candidate core monitoring activities will be chosen to build on existing long time series of data collected by prospective partners The Kenai and Karluk rivers are two likely candidates For the Kenai River watershed, three decades of data on adult salmon returns to the spawning grounds of the watershed can be used as

estimates of marine influence In addition, salmon catch data span more than five decades The proximity to Anchorage places the Kenai River watershed under heavy pressure from human activities and their associated impacts, many of which are documented by government regulators Multiple prospective partners have extensive programs in place to monitor vegetation, terrestrial animals, limnology, and other variables of potential relevance to the key question The Karluk River watershed is unique in having a published record of more than 300 years of changes in marine influence in general, and marine nitrogen in particular (Finney et al 2000) In addition, the prospective partners have collected more than eight decades of counts of salmon returns for the watershed

5.3.6 Candidate Core Variables

Isotopes of nitrogen in plants and animals and sources of reduced iron are candidates for core variables, based on work described in the scientific background under marine-terrestrial connections (Section 3 3, Volume II) and chemical oceanography (Section 3 5, Volume II) In watersheds of the GEM region, where nitrogen limits productivity, marine nitrogen in anadromous fish species, principally salmon, could be an important driver of watershed productivity Phosphorus and iron from salmon may also be important to watershed productivity, but direct measures of the origin of these elements are not available Indirect measures might be, for example, phosphorus or iron concentration per gram of fish times average fish weight times return number A decade of work on the role of iron in primary productivity in marine areas suggests that geophysical and biological processes in watersheds may contribute to marine productivity Processes in the watersheds may limit marine productivity by controlling the availability of precursors of reduced iron

5.4 Intertidal and Subtidal

5.4.1 Key Question

What are the relative roles of natural forces, such as currents and predation) and human activities (such as small-scale development and increased urbanization), as distant and local factors, in causing short-term and long lasting changes in the community structure and dynamics of the intertidal and subtidal habitats?

5.4.2 Schedule

Development of the intertidal and subtidal monitoring activities is expected to begin with a planning workshop in FY 02 and an intense core synthesis effort in FY 03 that involves extensive preparatory core research The inherently high variability of the community structure of the intertidal and subtidal habitat–and its vulnerability to the effects of predation and human degradation–may make it difficult to develop a design that can separate human activities from natural forces,

forestalling implementation of initial monitoring until FY 06 Core synthesis is planned to provide hypotheses by about FY 05 that can be tested and refined by core research in FY 06 and FY 07 The initial schedule calls for at least one core monitoring station to be initiated by FY 06, but it may not be fully operational until FY 07

Table 5 2 presents the proposed schedule and strategy for implementation

Table 5.2 Proposed Implementation Strategy for Intertidal and Subtidal Habitat

Fiscal Year	Monitoring Activity		Model	Data Management
	Core	Partners		
2003	Synthesis Research	Monitor	Verbal(c) Statistical(c)	Prototype Coordination (c)
2004	Synthesis Research	Monitor Research	Verbal(c) Statistical(c)	Coordination (c) Archiving(c)
2005	Research	Monitor Research	Verbal(c) Statistical(c)	Coordination (c) Archiving (c) Distribution (p)
2006	Research Monitor	Monitor Research	Statistical(c)	Coordination (c) Archiving (c) Distribution (p)
2007	Monitor Research	Monitor	Statistical(c) Numerical prototype (p)	Archiving (c) Distribution (p)

Notes

c = core (GEM program supported) activity

p = partnership (jointly supported) activity

Prospective partners ADF&G (Kachemak Bay National Estuarine Research Reserve [KBNERR]), NOAA (National Ocean Service) UAF, Cook Inlet Regional Citizens Advisory Council (CIRCAC), Prince William Sound Regional Citizens Advisory Council (PWSRCAC), USFS, EPA-ADEC (EMAP), Alyeska Pipeline Service Company

Candidate core monitoring activities Kachemak Bay (lower Cook Inlet), Green Island (PWS)

Candidate core variables substrate type and distribution, species composition and distribution, recruitment

5.4.3 Prospective Partner Activities

Partner activities in FY 03 will be the supporting monitoring programs already in place, such as monitoring of individual species for basic biology and contaminant loads, surveys of species composition and distribution, surveys of substrates, and measurements of physical oceanography (see Table 5 2) Starting in FY 04, partners will be encouraged to assist in funding research to further site selection These activities will extend through FY 06, terminating after the monitoring station is fully operational in FY 07

5.4.4 Models

Models of changes in community structure of the intertidal-subtidal areas in response to human activities and natural forcing are expected to be primarily verbal from FY 03 to FY 05 Statistical modeling, particularly power analysis to guide sampling, is expected to be operable as soon as FY 03, because of experience gained in the EVOS coastal habitat program and related damage assessment and restoration work Statistical modeling will continue through the evaluation of the initial monitoring station in FY 06 The end point of a numerical model to combine physical forcing and human activities for describing community structure is a very ambitious undertaking for a core activity within a 5-year time frame and may not be feasible at all without substantial partner support

5.4.5 Candidate Core Monitoring Activities

Candidates for core monitoring activities will be selected based on substantial partnering opportunities, chances for assessing human activities and impacts, and logistics Likely candidates are Kachemak Bay in Lower Cook Inlet and Green Island in PWS Kachemak Bay is close to the city of Homer and becoming a developed recreational destination In addition, the bay has the presence of coastal habitat assessment programs already in place within the Kachemak Bay National Estuarine Research Reserve (KBNERR), as well as nearby moorings taking oceanographic measurements The USFS has a long-term ecological monitoring site at Green Island, which is still seeing effects from the 1989 oil spill A new weather station is being installed nearby at Applegate Rocks, and additional oceanographic moorings in nearby Montague Strait are likely

5.4.6 Candidate Core Variables

Community structure in the intertidal and subtidal areas is determined by substrate type and amount, as well as by physical oceanographic features, such as wave action Species composition and distribution are fundamental to determining community structure, as is the recruitment rate of key species such as barnacles, mussels, and clams, depending on substrate

5.5 Alaska Coastal Current

5.5.1 Key Question

What are the relative roles of natural forces (such as the variability in the strength, structure, and dynamics of the ACC) and human activities (such as fishing and pollution) in causing local and distant changes in production of phytoplankton, zooplankton, birds, fish, and mammals?

5.5.2 Schedule

Development of ACC monitoring will require a period of synthesis and research that involves collaboration between physical and biological scientists to decide on how to best detect changes in annual and seasonal production and transfer of energy to higher trophic levels The determination of what physical-chemical processes are most important to measure for primary and secondary production will require a synthesis that combines existing physical and biological information and hypotheses Specific seasonal questions such as what controls the timing, duration, and magnitude of the spring bloom on the inner continental shelf need to be carefully cast as testable hypotheses before committing to long-term monitoring Having the SEA, APEX, GLOBEC Northeast Pacific National Estuary Program (NEP), FOCI, OCC, and NPAFC programs precede and parallel the GEM program is extremely fortuitous for development of this component The experience and lessons from these programs will be extremely beneficial in helping GEM build its core monitoring components For these reasons, development of ACC monitoring activity will begin with a core synthesis effort that is closely coordinated with the ongoing research and monitoring efforts mentioned above

Understanding how best to measure biological productivity and trophic transfer in the ACC will take longer to develop than the approach to physical measurements, which could be developed in a relatively short period of time The long-term observation program being carried out in PWS and across the shelf in the northern GOA under GLOBEC started in 1997 and will extend through 2004 Intense process studies are scheduled for 2001 and 2003 It will take some time to distill the large amount of information available from such studies and other programs to the point of recommending a full suite of core biological measurements for core GEM program monitoring in the ACC

Table 5 3 presents the proposed schedule and strategy for implementation

5.5.3 Prospective Partner Activities

NOAA's interest in the ACC continues to be high, as demonstrated through its participation in the GLOBEC and OCC programs and some continuing work in the FOCI program in Shelikof Strait It is almost certain that the GAK1 station and line, maintained and monitored by the University of Alaska and in place now for decades, will play a central role in future monitoring of the physical structure of the ACC based on temperature and salinity measures Recently added biological measures, including chlorophyll a, will likely be maintained and supplemented Other opportunities for partnerships include GLOBEC's more recently established stations from PWS across the continental shelf and one of the lines used in the FOCI program in the Shelikof Strait The USGS, which has an established set of seabird monitoring colonies spaced at about 500-km intervals around the GOA and into the Bering Sea, is another strong candidate for a partner Close coordination with methods of the colonial seabird program of the USFWS Alaska Maritime Refuge is envisioned to make seabird data consistent around the coast of Alaska

Table 5.3 Proposed Implementation Strategy for Alaska Coastal Current Habitat

Fiscal Year	Monitoring Activity		Model	Data Management
	Core	Partners		
2003	Synthesis Research	Monitor	Statistical(c) Numerical (p)	Coordination (c)
2004	Synthesis Research	Monitor Research	Statistical(c) Numerical (p)	Coordination (c) Archiving(c)
2005	Research	Monitor Research	Statistical(c) Numerical prototype (p)	Coordination (c) Archiving (c) Distribution (p)
2006	Research Monitor	Monitor Research	Statistical(c) Numerical (p)	Coordination (c) Archiving (c) Distribution (p)
2007	Monitor Research	Monitor	Numerical (p)	Archiving (c) Distribution (p)

Notes

c = core (GEM program supported) activity

p = partnership (jointly supported) activity

Prospective partners UAF (IMS, School of Fisheries and Ocean Sciences [SFOS]), U S Department of Interior (DOI) (National Park Service [NPS], USFWS, USGS), North Pacific Research Board (NPRB), NOAA (NMFS/National Ocean Service [NOS]), EPA-ADEC EMAP

Candidate core monitoring activities GAK1, Hinchinbrook Entrance, Montague Strait

Candidate core variables temperature, salinity, fluorescence, plankton, forage species

For measuring forage species variability, population abundance data from the ADF&G on Pacific herring in PWS and also for populations at Kodiak Island and in Kamishak Bay, although not complete, may be useful Starting in FY 04 and extending through FY 06, partners will be encouraged to assist in funding research to further site selection for monitoring the ACC

Plankton measurements (settled volume) are now being taken by potential partners at six hatcheries in PWS On the basis of past correlations of plankton-settled volume with annual pink salmon returns and decadal-scale herring abundance, these data could provide information about productivity of the ACC system of relevance to multiple species under certain conditions Extension of the "plankton watch" to hatcheries in other areas and local communities throughout the northern GOA may be a worthwhile and potentially economical way to maintain long-term data sets and archives of plankton Other opportunities to collect samples and analyze plankton communities may include cruises with net and hydroacoustic sampling, as well as satellite images Also of possible merit are the use of ships that offer opportunities, for example, the continuous plankton recorder is recommended to be deployed on oil tankers traveling from Valdez to Long Beach under EVOS sponsorship in FY 02 Certainly any satellite images of the sea surface that measure chlorophyll a concentrations provide very useful

synoptic pictures, even taking into account the limitations that cloud cover and lack of subsurface data present Decisions will be made with the guiding philosophy of collecting data of relatively low frequency in space and time so that decadal scale change can be resolved

Perhaps the largest challenge for the ACC habitat will be developing monitoring activities to measure variability in forage fish populations and associated predator populations Some options for exploration of partnerships for assessing forage fish abundance and associated phenomena include the following

- Larval surveys building on the databases and archived specimens from the FOCI program
- Use of forage fish occurrence in the stomachs of large fish collected in the sport fishery–or in some of the large fishery assessment programs conducted by NOAA and ADF&G–as an index of relative abundance (The Trustee Council sponsored a successful study of these occurrences of forage fish in the sport fishery for halibut out of Homer)
- Small mesh trawl surveys conducted by ADF&G around Kodiak Island and lower Cook Inlet to assess shrimp abundance (A large database from this program extends for some locations back to the 1960s for a large variety of species on the inner shelf)
- Aerial surveys with the use of conventional photography or other sorts of imaging (such as LIDAR) of shallow water aggregations of juveniles or adults
- Hydroacoustic sensors mounted on various ships of opportunity and fixed moorings
- Analysis of food items brought back to the nests of colonial seabirds (such as puffins) as an indication of the relative abundance of various forage fish species in particular areas
- Other net sampling programs that may be under way or contemplated

5.5.4 Models

Several hydrographic and circulation models have been or are being developed for the ACC (see also Chapter 5, Volume II, and Appendix C) A circulation model workshop is planned in FY 02 to consider approaches most likely to be useful to the GEM program Models of the relationship of marine planktonic production to water column structure were developed in the EVOS SEA program (Eslinger et al 2001) and are expected to eventually be further developed under the GEM program

The GLOBEC nutrient-phytoplankton-zooplankton (NPZ) 1-D and 3-D models are a suite of coupled biological-physical models concerned with the coastal region

of the GOA They address effects of concern to the GEM program in the ACC and offshore cross-shelf transport, upstream effects, local production, and conditions conducive to suitable juvenile salmon rearing habitat

Models of particular interest from the FOCI program are the 1-D and 3-D versions of the Shelikof NPZ models, and the GOA Walleye Pollock Stochastic Switch Model (SSM) (see Chapter 5, Volume II, and Appendix C) The Shelikof NPZ models are a set of coupled (biological and physical) models designed to examine hypotheses about pollock recruitment in the Shelikof Strait region The Pollock SSM is a numerical simulation of the process of pollock recruitment Of particular interest to the GEM program is the identification by the SSM of three specific agents of mortality wind mixing, ocean eddies, and random effects Ecopath models developed by Okey, Pauly, and others at the University of British Columbia are also of interest, especially for PWS, but also for the GOA continental shelf and slope (excluding fjord, estuarine, and intertidal areas) (see Appendix C)

5.5.5 Candidate Core Monitoring Activities

It appears that the physical oceanographers have developed a level of understanding about inner-shelf dynamics that will allow the GEM program to identify a core set of measurements, locations, and frequencies that address questions relevant to the GEM program A core monitoring activity based on the partnership at the GAK1 station is likely Others may be added in FY 04 to FY 07 as identified by synthesis and the results of other programs (GLOBEC and FOCI stations and moorings) and as funding allows Full core monitoring in the ACC may not be fully operational until FY 07

5.5.6 Candidate Core Variables

The key variables in measuring the productivity of the ACC are temperature, insolation, salinity, fluorescence, and abundance of key forage species, including fish and zooplankton

5.6 Offshore: Outer Continental Shelf and Oceanic Waters

5.6.1 Key Question

What are the relative roles of natural forces (such as changes in the strength of the Alaska Current and Alaskan Stream, mixed layer depth of the gyre, wind stress, and downwelling) and human activities (such as pollution) in determining production of carbon and its shoreward transport?

5.6.2 Schedule

As with the ACC portion of the program, results of GLOBEC research need to be carefully considered before implementation of long-term monitoring in this broad habitat type This deliberate approach is reflected in the emphasis on synthesis for this habitat type in the early years of the proposed schedule and strategy for implementation (Table 5 4)

Table 5.4 Proposed Implementation Strategy for Offshore Habitat

Fiscal Year	Monitoring Activity		Model	Data Management
	Core	Partners		
2003	Synthesis	Monitor Research	Statistical(c)	Coordination (p)
2004	Synthesis	Monitor Research	Statistical(c)	Coordination (p) Archiving(p)
2005	Synthesis	Monitor Research	Statistical(c) Numerical prototype (p)	Coordination (p) Archiving (p) Distribution (p)
2006	Synthesis	Monitor?	Statistical(c) Numerical (p)	Coordination (p) Archiving (p) Distribution (p)
2007	Synthesis	Monitor?	Numerical (p)	Archiving (p) Distribution (p)

Notes

c = core (GEM program supported) activity

p = partnership (jointly supported) activity

Prospective partners NPRB, NOAA (NMFS/NOS), Canadian Department of Fisheries and Oceans (CDFO), Japan Fishery Agency

Candidate core monitoring activities GLOBEC stations, Valdez-Long Beach Line, and other ships of opportunity

Candidate core variables nutrients, detritus and plankton, temperature, and salinity

5.6.3 Prospective Partner Activities

Support of partners in existing monitoring projects may be necessary to obtain sufficient information for design of a monitoring program Because of the expense of initiating most offshore sampling programs, careful selection of partners and the use of long-term, low-frequency data gathering will be key strategies for understanding decadal-scale changes in this environment Current efforts to apply the continuous plankton recorder (CPR) technology on ships of opportunity in the GOA offer partnership opportunities Extension of existing ships of opportunity programs to include measurement of variables of interest to the GEM program is also a possibility

5.6.4 Models

The GLOBEC NPZ 1-D and 3-D models are discussed above in Section 5 5 4 A broader model addressing NPZ for the entire North Pacific is the North Pacific Ecosystem Model for Understanding Regional Oceanography (NEMURO), in which fluxes of nitrogen, silicon, and carbon will be tracked (see Appendix C)

5.6.5 Candidate Core Monitoring Activities

A reasonable oceanographic program in the ACC can probably be extended across the shelf break with the use of existing GLOBEC, FOCI, and OCC sampling stations, moorings, and transects The use of the Valdez-Long Beach line with oil tanker-mounted fluorescence and zooplankton sampling gear appears to be an attractive strategy for long-term, low frequency sampling over large spatial scales

5.6.6 Candidate Core Variables

Particularly crucial aspects of the offshore environment are physical processes and attendant biological responses at the shelf break and front (for example, extent of deep-water intrusion onto the shelf in the late summer and fall), the mixed layer depth in the Alaska Gyre in the spring-summer, and Ekman transport of offshore production onshore Measurements of basic variables are essential to understanding the role of these offshore aspects in affecting productivity of other habitats These variables include temperature, salinity, nutrients, detritus, and plankton

5.7 Starting Points for Research

The GEM program will use strategically chosen synthesis and research projects with relatively short-term goals to help develop the long-term monitoring component of GEM As starting points for selecting research in support of monitoring, four general areas of research are discussed, followed by a synopsis of past and current research conducted to aid the transition to GEM

5.7.1 General Areas of Research

Lingering Injury from the Oil Spill: Research specifically related to the effects of the EVOS may be needed in the first few years of the GEM program, but the need for this type of research is expected to diminish through time Types of research that may be conducted include exploring the continuing, low-level effects of hydrocarbon exposure on the survival and reproduction of fish and wildlife resources and the identification of pathways of such exposure General restoration projects that relate directly to restoration of oil spill injury may also be needed in some cases

Defining Testable Hypotheses· In many, or even in most, habitat types, sufficient information may not exist to define the testable hypotheses around which

monitoring projects can be designed In these and similar cases, synthesis and research will be needed to define testable hypotheses

Exploring Questions with or Generated by Monitoring Data: As the effects of EVOS fade and as GEM matures, research projects will increasingly arise from the results and needs to improve the long-term monitoring program Some of this research will involve special analyses and modeling of data obtained through the core monitoring program (including current and retrospective data) and/or partnership and independent monitoring efforts in the GOA

Management, Conservation, and Sensitive Areas and Seasons: GEM research will include projects designed to fill gaps in the information necessary to manage and conserve natural resources Examples of this type of research include improving techniques, tools, or technology for stock assessments of fisheries resources, gathering basic information on species' life histories, and stock identification of marine mammal, seabird, or fish populations GEM data may be applied to identify sensitive areas and seasons in the marine environment so that this information can be considered in the development of management and conservation strategies

5.7.2 Synopsis of GEM Transition Projects

Some of the past and current Trustee Council activities are particularly appropriate to serve as starting points for designing research in support of GEM (Table 5 5) Committees and work groups within each habitat type will use the results of these "GEM transition" projects (conducted in fiscal years 2000 to 2002) as starting points for developing testable hypotheses and synthesis and research recommendations

Note that GEM transition projects have been organized in Table 5 5 into categories that correspond to GEM program components synthesis (including workshops), research, and modeling (including aspects of data management and information transfer) Abstracts for each project are provided below If a project has been in operation a number of years, the abstract refers to the most recent activities of the project and its current status

210. This project links students in the area affected by the oil spill with research and monitoring projects funded by the Trustee Council The project involves students in the restoration process and provides these individuals the skills to participate in restoration now and in the future Youth conduct research overseen by principal investigators who have indicated interest in working with students Youth Area Watch fosters long-term commitment to the goals set out in the restoration plan and is a positive community investment in that process Participating communities in FY 02 will be Tatitlek, Chenega Bay, Cordova, Nanwalek, Port Graham, Seldovia, Seward, Valdez, Whittier, and Kodiak

Table 5.5 GEM Transition Activities, Fiscal Years 2000-2002
Listed with project number and titles of activities

Habitat Type	Synthesis and Workshops	Research	Modeling
Watershed	612 Kenai River Marine-Terrestrial Links (FY 02)	567 Contaminants monitoring (FY 00) 649 Reconstructing sockeye (FY 02) 667 Citizens' Environmental Monitoring Program (FY 02) 668 Water quality database (FY 02) [1]	391 Cook Inlet Information System (FY 00, 01) 455 Data system for GEM (FY 00)
Intertidal-Subtidal	374 Herring recommendations (FY 00) 395 Workshop on intertidal monitoring (FY 02)	210 Youth Area Watch (FY 00, 01, 02) 385 Kachemak Bay Monitoring (FY 01) 501 Seabird monitoring protocols (FY 00) 509 Harbor seal experimental design (FY 01) 510 Intertidal monitoring recommendations (FY 00) 538 Herring stock identification (FY 01, 02) 556 Mapping intertidal (FY 02) [1] 567 Contaminants monitoring (FY 00)	391 Cook Inlet Information System (FY 00, 01) 455 Data system for GEM (FY 00)
ACC	374 Herring recommendations (FY 00) 630 Workshop on modeling circulation (FY 02)	210 Youth Area Watch (FY 00, 01, 02) 340 GAK1 (FY 00, 01, 02) 404 Archival tag testing (FY 01, 02) 493 Sampling strategies for GOA trawl survey (FY 00) 501 Seabird monitoring protocols (FY 00) 538 Herring stock identification (FY 01, 02) 552 Exchange between PWS and GOA (FY 00, 01, 02)[1] 561 Community based forage fish sampling (FY 02) 567 Contaminants monitoring (FY 00) 584 Airborne remote sensing (FY 02) 614 Physical data from tankers (FY 02) 671 Ships of opportunity in Lower Cook Inlet (FY 02)	389 3-D Ocean state simulation modeling (FY 00, 01) 391 Cook Inlet Information System (FY 00, 01) 455 Data system for GEM (FY 00) 603 Ocean Circulation Modeling (FY 02)[1]
Offshore	630 Workshop on modeling circulation (FY 02)	567 Contaminants monitoring (FY 00) 614 Physical data from tankers (FY 02) 624 Ships of opportunity CPR (FY 02)	389 3-D Ocean state simulation modeling (FY 00, 01) 391 Cook Inlet Information System (FY 00, 01) 455 Data system for GEM (FY 00) 603 Ocean Circulation Modeling (FY 02)[1]

[1] Funding decision deferred to 12/01

340. Interannual variations in temperature, salinity, and their vertical distribution on the northern GOA shelf reflect environmental changes that might affect this marine ecosystem This variability needs to be quantified and understood based on extended time series such as the 30-year record at hydrographic station GAK1 near Seward This project maintains this time series and will continue to quantify the variability and understand the sources of variability It will also begin to document interannual variations in near-surface (upper 10 m) stratification and the timing of the spring bloom on the inner shelf The data and associated analyses are suggested as being an important component to the development of the GEM program

374 Much of the data already collected under EVOS funding on herring needs to be analyzed There are many components to herring research that need to be synthesized This project will evaluate all aspects of past research including, but not limited to, stock structure, year-class strength, and disease structure A workshop of herring researchers will be conducted to discuss ideas for additional herring research and monitoring The results of the workshop and writings will be analyzed to identify important questions that remain about herring and to decide which ones can and cannot be addressed Recommendations will be developed for priorities and research direction for herring in the future, which may serve as a basis for a science plan for herring

385. The increasing number of stresses on marine and estuarine ecosystems has challenged scientists and resource managers to find methods for determining temporal rates and spatial extents of ecological responses to changes in environmental conditions This project will provide the necessary matching funds for the Kachemak Bay National Estuarine Research Reserve to establish a monitoring program of oceanographic environmental attributes in Kachemak Bay Results of ongoing studies will then be able to link patterns of oceanographic changes to patterns of biodiversity in the marine and estuarine intertidal and subtidal habitats of Kachemak Bay

389. Using the observed data collected from 1995 to 1998 in PWS and the forcing of tide, coastal current inflow/outflow, freshwater discharge, and wind stress, a 3-D PWS model developed under the Sound Ecosystem Assessment (SEA, Project 320) will be used to produce continuous 4-year, 3-D fields of velocity, temperature, salinity, and mixing coefficients for resource managers, fishing industry, and biological applications In addition, the interannual variability of PWS ocean circulation, temperature, and salinity due to interannually variable atmospheric forcing will be studied This will allow identification of the key environmental parameters to be included in a long-term monitoring program to assist resource managers

391. The Cook Inlet Information Management/Monitoring System (CIIMMS) will provide a wide range of users the opportunity to share and access valuable information and data about the Cook Inlet watershed and Cook Inlet-related activities CIIMMS potential users include educators, scientists, students,

researchers, resource managers, private organizations, and individual citizens CIIMMS will provide an interactive Web site for the Cook Inlet community to efficiently and effectively contribute, identify, and access relevant information from a distributed network of providers

395 This project will produce a draft nearshore monitoring plan that provides a framework for future monitoring A preliminary draft plan will be developed by the principal investigators that includes consideration of existing programs in the Lower 48 (such as PICES and PISCO and Alaska (such as PWS and Cook Inlet Regional Citizens' Advisory commissions) This draft will then be reviewed by a panel of four to five independent experts in nearshore marine ecology representing various interests and disciplines A revised plan will be produced and presented to agencies, stakeholders, and other interest parties at a workshop held in conjunction with the EVOS Annual Workshop in January 2002

404. Archive tags with temperature and light-geolocation sensors will be monitored for post-smolt coho salmon in Cook Inlet Light/location relationships specific to the GOA developed under Project 00478 will be applied in this study of movement and migration paths for coho salmon during maturation in ocean environments in Cook Inlet Salmon for this study will be reared in captivity (at the ADF&G hatchery at Fort Richardson) to 1+ year of age (200 to 250 mm) and released in Cook Inlet as part of the department's Ship Creek sport-fishing hatchery release FY 01 includes pilot studies of tag retention, behavior, and growth for coho in captivity Ship Creek coho will be tagged mid-May A spring release experiment in the first year will be contingent on the successful implementation and retention of these tags Surveys for early jack recoveries will be done at the Ship Creek weir and among sport fishers Monitoring for adult tag recoveries will be done in the coho commercial fishery in Cook Inlet and the derby sport fishery on Ship Creek Archive tagged fish will be used to document coho salmon use of marine habitats, migration routes, contribution to the sport fishery, and hatchery/wild interactions for salmon in Cook Inlet

455. This project will report on the data system issues related to GEM, , the Trustee Council's long-term monitoring and research program In addition to the data collection effort, data delivery will prove to be a critical component of the success of GEM Therefore, the data system issues need to be part of the planning process This project will outline some of the key data and user issues and produce a report analyzing existing systems that deliver similar data In addition, strawman proposals will be developed for a range of data systems that could meet the needs of the GEM program

493. This project is an integrated study of mechanisms controlling changes in community structure in the GOA ecosystem The major goal for this fiscal year is to review the existing GOA small-mesh trawl survey database and develop a statistically based and cost-effective strategy for long-term sampling and future monitoring It is anticipated that any developed sampling scheme or strategy will then be employed in future monitoring survey designs Proper and consistent

sampling should lead to a more comprehensive understanding of biological-physical coupling and dynamics of the GOA ecosystem

501. Seabird populations will need to be monitored for many years to assess both recovery and ecological conditions affecting recovery Detailed studies of individual seabird colonies and marine ecosystems in the GOA have been conducted by the USGS and USFWS under the auspices of damage assessment and restoration programs of the Trustee Council Much has been learned about factors influencing seabird populations and their capacity to recover from the spill in the GOA As the restoration program moves toward long-term monitoring of populations, however, protocols and long-term monitoring strategies that focus on key parameters of interest and that are inexpensive, practical, and applicable over a large geographic area need to be developed

509. The production and survival of young harbor seals are critical to reversal of the long-term decline of seals in PWS, and to ultimate recovery of the population from damage due to the oil spill Significant inter-annual differences in diet and body condition of young seals were documented in 1997 to 1999 This project will obtain additional information on the population condition (such as diet and percent body fat) of pup, yearling, and sub-adult harbor seals, the age classes most likely to be limited by food availability Data obtained on harbor seal population condition from this project and from 1997 to 1999 will be compared with concurrent population abundance data to assess the status of harbor seals relative to carrying capacity, and subsequently derive more comprehensive and realistic expectations for population recovery

510. This project will examine the state of recovery of key habitats and representative injured species within the intertidal zone in PWS FY 00 will consist of a statistical comparison of the NOAA Hazmat and Coastal Habitat (primarily Project CH1A) data and identification of cost-effective measures for monitoring intertidal communities

538. This project will perform a comparative investigation of two promising stock identification techniques for Pacific herring--elemental analysis of otoliths and fatty acid profile analysis of select soft tissues Limited samples from Sitka Sound, PWS, Kamishak Bay, Kodiak Island, and Togiak will be collected and analyzed to determine if stock differences are detectable by each procedure, and at what scale Successful results from this pilot study should be followed up with future evaluations of the temporal and structural (sex, age, maturity) stability of these biomarkers

552. One of the least understood physical processes that influence the biological components of PWS is the exchange between the northern GOA and PWS This project will document the interannual variability in water mass exchange between the sound and the adjacent northern GOA at Hinchinbrook Entrance, and identify mechanisms governing this exchange The project will deploy an upward-looking ADCP (Acoustic Doppler Current Profiler) mooring in

Hinchinbrook Entrance to create time series of velocities spanning 3 years The mooring will be equipped with a CTD (conductivity temperature versus depth) to create a time series of deep temperature and salinity To identify the dominant factors that govern PWS/GOA exchange, the mooring velocity and deep temperature/salinity time series will be combined with meteorological and physical data collected under other research programs already in progress

556. Groups, individuals, and programs as diverse as natural resource agencies, local governments, researchers, conservation advocates in Cook Inlet and Kachemak Bay, and GEM can benefit from a comprehensive, high-resolution database of shoreline and nearshore habitats, and from information on the physical changes seen through time At present, no such detailed database or monitoring program exists within the GOA This project will use a method adopted along the US west coast to gather such habitat information in a cost-effective yet detailed manner The method relies on a nested hierarchical nearshore classification based on the physics of the environment to select replicate shore sites for monitoring algal and invertebrate diversity

561. This project is based on the recently completed 5-year pilot study, conducted as part of APEX (Alaska Predator Ecosystem Experiment, Project 163), that used stomach contents from sport-caught halibut to sample forage fish populations The project will monitor long-term trends in forage fish populations in several regions of the spill area during GEM The project will provide information to help assess and understand the types and levels of community participation that may be available for long-term forage fish monitoring studies Also, if project results are favorable, the information can be used to begin designing cost-effective, community-based forage fish monitoring studies to track long-term trends in capelin and sand lance stocks in the Kachemak Bay/lower Cook Inlet, Resurrection Bay, Kodiak Island, and PWS regions

567. This project will assess needs and priorities for monitoring environmental contaminants in the northern GOA, including the area directly affected by the oil spill It will evaluate information on water quality, marine species' sensitivities to pollutants, and contaminants that pose potentially adverse effects to the ecosystem and to human health Recommendations will specify priorities for monitoring of contaminants in order to track lingering oil spill injury, trends, and potential effects of pollutants

584. This project will evaluate airborne remote sensing tools for GEM, including a biological/ecological interpretation of the data collected The instrument package consists of (1) a pulsed LIDAR (Light Detection and Ranging) to map subsurface biological features day to a maximum of 50 m, (2) an infrared radiometer to map SST (sea surface temperature) day (similar to AVHRR, Advanced Very High Resolution Radiometer), (3) two three-chip digital video systems to map ocean color (chlorophyll), birds, mammals, surface fish schools, and ocean frontal structure, and (4) an infrared digital video to map birds and

mammals at night The project will use shipboard and buoy data for validation and interpretation of remote sensed data

603. This project will establish a 3-D ocean circulation model in the GOA to lay down a foundation for GEM in order to couple this model to a hydrological model and a biological model This model will cover the entire GOA, including PWS and Cook Inlet The horizontal resolution of this model is 4 by 2 minutes (about 3 7 km at 60° N This model will be forced by tides, the Alaska Current inflow/outflow, freshwater discharge, and wind stress derived from the National Center for Environmental Prediction

612. This project will provide matching funds for a coordinator to serve a multidisciplinary team of agency-supported scientists that is designing a study of marine and terrestrial nutrient cycling in the Kenai River watershed The oil spill curtailed commercial fishing on the river in 1989, causing changes in productivities of sockeye salmon and other species, in addition to allowing a massive input of marine nutrients borne by the unharvested salmon The watershed is also at some risk from anthropogenic activities, including habitat degradation, increased utilization, and invasive species Studies on watersheds of the Pacific Northwest suggest there may be cascading impacts when marine derived nutrients normally supplied by salmon carcasses are diverted from an ecosystem When nutrients normally supplied by salmon are withdrawn, productivity of the entire watershed is expected to be diminished

614. This project will use a thermosalinograph and fluorometer, to be installed on a crude oil tanker, to acquire continuous, long-term measurements of the near-surface temperature, salinity, and fluorescence fields along the tanker route between Valdez, Alaska, and Long Beach, California

624. This project presents the rationale for developing a plankton monitoring program for the GOA by using ships of opportunity Plankton are a critical link in the marine food chain whose dynamics are poorly understood, but respond rapidly and unambiguously to climate change and form the link between changes in the atmosphere and valuable upper trophic level populations, such as salmon, herring, shrimp, and groundfish The proposal reviews the evidence that many of the most valuable marine resources in the GOA are strongly influenced by changes in ocean climate Ships of opportunity are a cost effective platform for large-scale monitoring, and this project will build on recent experience gained with CPR (continuous plankton recorders) in the North Pacific to prepare for GEM

630. In FY 02, this project, which funds Trustee Council staff and the Chief Scientist to develop the GEM plan, will include a workshop on modeling circulation

649. This project will reconstruct the last 2,000 years of changes in sockeye salmon abundance in Eshamy Lake (PWS) and Upper Russian Lake (Kenai River watershed) by analyzing ^{15}N in lake sediments These new data will be synthesized

with ongoing studies at Karluk Lake (Kodiak Island) The research question is What is the normal variability in sockeye salmon populations in the GOA? This research will contribute to development of the GEM program by providing a historical perspective on current conditions and by developing new hypotheses about the climatic causes of population fluctuations in GOA salmon Work at Delight and Desire lakes on the outer Kenai Peninsula coast will also be conducted

667. This project will analyze 5 years of past data from Cook Inlet Keeper's Citizens' Environmental Monitoring Program, the first consistent, credible, and coordinated community-based water quality monitoring program in Alaska Keeper's stream ecologist will determine if sampling frequency, methods, parameters, and site selection are effective at meeting the monitoring objectives of detecting significant changes in water quality through time The results will assist Cook Inlet Partners (Kenai Watershed Forum, Anchorage Waterways Council, Wasilla Soil and Water Conservation District) in refining their community monitoring efforts and may lead to future community-based monitoring programs

668. The project partners have come together to form a database committee to create a consistent data management system in which all citizens groups and agencies can equally share, report, and review their water quality and habitat data The committee's objective is to make data more accessible and more useful to decision makers, stakeholders, resource managers, and the public The committee will uplink a shared interactive database on the Internet, where it can be viewed and queried with GIS watershed maps, photographs, and graphs so that it is user-friendly, educational, and meaningful Access to these data will help facilitate a better understanding about threats to, and solutions for, water quality and habitat

671. Cook Inlet Keeper and the Kachemak Bay Research Reserve will organize a network database of local community volunteers for the purpose of collecting oceanographic data from regional ships of opportunity An outreach program will be undertaken to identify and construct a database of private and commercial vessels making frequent trips in the Kachemak Bay, lower Cook Inlet, and GOA regions A thermosalinograph, installed on a vessel at the Kachemak Bay Research Reserve, will be used to clarify regions for future data collection These data will also be correlated with existing stationary sensors and volunteer-monitoring projects to expand spatial and temporal knowledge of water quality and mixing patterns and their relationship to the dispersal of larvae and pollutants in the region

5.8 References

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6. PROGRAM MANAGEMENT: PUBLIC ADVICE, SCIENTIFIC GUIDANCE, AND DATA POLICIES

In This Chapter

- Discussion of a reconstituted Program Advisory Committee to provide public advice
- Description of the process for inviting, reviewing, approving, and adopting projects
- Preliminary descriptions of the processes for getting advice from experts and the public
- Preliminary data management and information transfer policies

6.1 Public Advice

The importance of public participation in the Trustee Council process, as well as establishment of a public advisory group to advise the trustees, was specifically recognized in the *Exxon Valdez* settlement and is an integral part of the agreement between the state and federal governments Figure 6 1 illustrates the role of public participation in the GEM program

The existing Public Advisory Group (PAG) has 17 members representing 12 interest groups and the public at large, as well as two ex-officio members from the Alaska Legislature The charter for this group must be renewed in January 2003 At that time, it would be appropriate to change the makeup of the PAG to include the participation of additional interests Preliminary input from the current PAG and from some of the community facilitators representing tribal interests calls for a reconstituted Program Advisory Committee (PAC), representing a broad range of stakeholder interests and communities and including a number of scientists with broad vision and stature

One possible scenario is a group of 20, with five scientists and 15 community and stakeholder representatives A decision would need to be made on whether specific seats would be formally designated This group would meet at least twice a year and provide broad program and policy guidance to the Trustee Council and staff on the overall development and progress of the GEM program The group would take an active role in setting priorities and ensuring that the overall program is responsive to public interests and needs

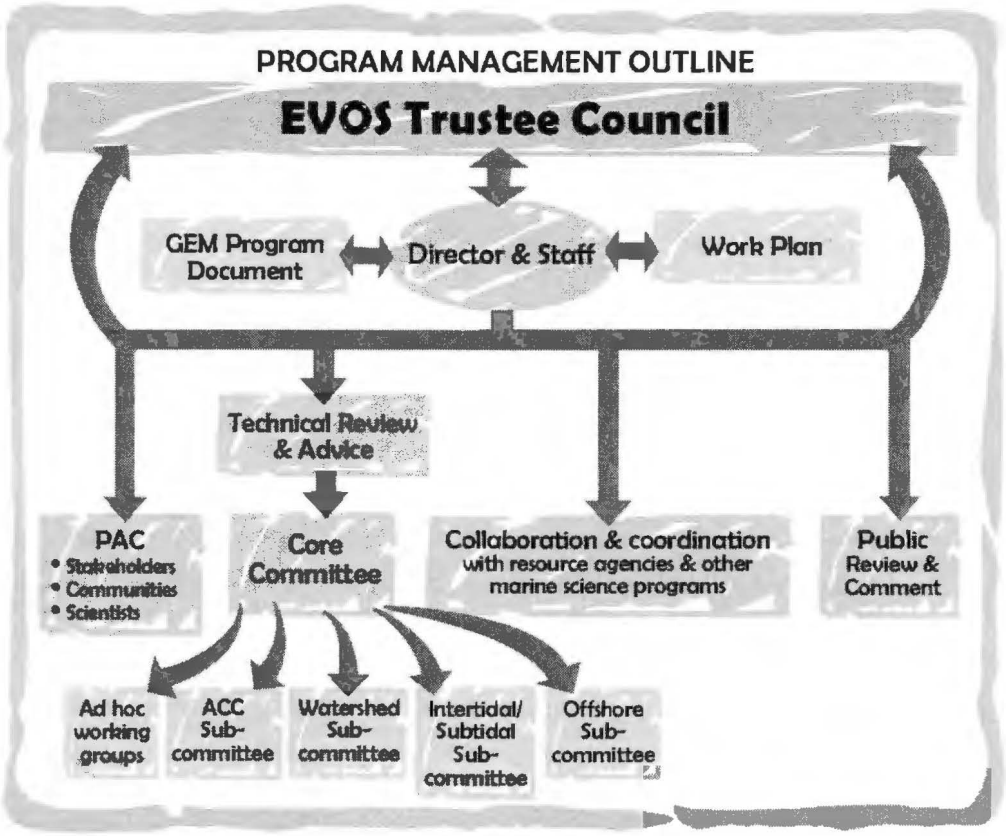

Figure 6.1 The flow of information to the Trustee Council in GEM program management comes from the director and a staff, the Public Advisory Committee (PAC), and the public at large. The director and staff link the Trustee Council to information from technical review and advice and with other marine resource programs.

6.2 Program Management and Administration

The administration and management of the GEM program must be cost-efficient, have a high degree of scientific credibility, and provide for public access and accountability.

The GEM program will be administered by a core professional staff that is not directly affiliated with any particular agency, institution, or program, as is currently the case with the management of the *Exxon Valdez* Oil Spill Restoration Office (Figure 6.1). An executive director will oversee the financial, program management and administration, scientific, and public involvement aspects of the program. The executive director and staff, while housed for administrative purposes in a single government agency, will work under a cooperative agreement for all six trustees. The Trustee Council and staff will actively solicit advice on science and policy matters, including review of monitoring and research activities, from experts and from the public, including the PAC.

6.2.1 Proposal Evaluation Process

The basic work plan process will have the following elements or steps, which are also shown in Figure 6 2 As implementation of GEM begins, however, these steps may be modified as efficiencies and improvements are found

- A "State of the Gulf" workshop will be held periodically, at which the current status of the health of the GOA ecosystem will be assessed Project investigators, peer reviewers, resource managers, stakeholders, and the public will be invited to this meeting, at which research and monitoring results will be presented and discussed In some years, this workshop will be replaced by or augmented with a process of consultations and workshops with various committees and work groups of science advisors to evaluate and affirm or revise priorities

- An *Invitation to Submit Proposals,* which will specify the types of proposals that are priorities for consideration to implement the mission and goals of the GEM program, will be issued periodically Research proposals are envisioned to be of finite duration and have short-term goals (for example, 2 to 5 years) Monitoring projects will be evaluated and renewed on longer time scales (such as once every 5 years) The *Invitation(s)* will be the vehicle for notifying the scientific community and others that proposals will be considered during a certain period of time

- Proposals received in response to the *Invitation* will be circulated for peer review (see below) Peer review comments and recommendations will be summarized by staff and provide a basis for a preliminary recommendation by the executive director Proposals will be reviewed for their ability to contribute to the information-gathering needs of the central hypothesis and questions, and also for how they contribute to meeting the programmatic goals and policies of the Trustee Council (see Chapter 1, Volume I), such as promoting community involvement, developing resource management applications, and leveraging funds from other sources Past performance of principal investigators will be assessed Staff will also review all budgets In addition, the comments from the PAC and the general public will be solicited

- The executive director will develop a recommendation on each proposal based on the peer review, staff review, and public and scientific advice

- A reasonable period of time for public comment will be built into the proposal review process, including review by the PAC

- The Trustee Council, after receiving advice from its public and scientific advisors and staff, will vote on which proposals to fund

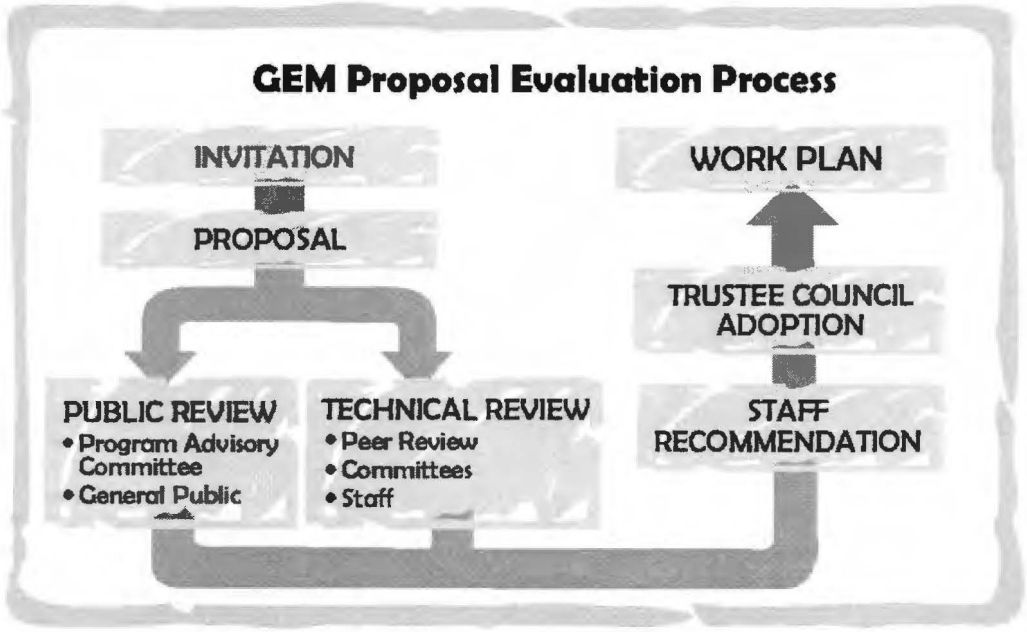

Figure 6.2 The GEM proposal evaluation process consists of seven basic elements in chronological order: the invitation, the proposal, public and technical review, staff recommendation, Trustee Council adoption, and the work plan.

6.2.2 The Work Plan

A Work Plan will document the current activities that implement the program. As projects for monitoring and research are approved by the Trustee Council, they will become part of the Work Plan. The Trustee Council may be asked to adopt a new Work Plan each year or they may be asked to adopt new groups of projects into the Work Plan on a periodic basis.

6.2.3 Reports and Publications

Final reports will be required for all monitoring and research projects and will be reviewed to evaluate whether the investigators are making satisfactory progress toward project objectives. Selected annual reports may be required and possibly sent for peer review. All final reports will be subject to independent peer review, and comments from the independent peer reviewers must be addressed in the final versions of final reports. All annual and final reports will be archived at the Alaska Resources Library and Information Service (ARLIS).

Publications in the peer-reviewed literature will be expected of program participants.

6.2.4 Peer Review

Each project, as well as some annual and all final reports, will be peer-reviewed by appropriate experts identified by staff who, as a rule, are not also conducting projects funded by the Trustee Council. The peer review may be either paid or

volunteer, whichever is most expeditious and appropriate The external peer review process will provide a rigorous critique of the scientific merits of all monitoring and research proposals and selected reports Review functions may be carried out in writing, by telephone and occasionally on site or in person

Special review panels may be convened from time to time to evaluate and make recommendations about aspects of the GEM program At other times, special panels may meet with project investigators and others to fully explore particular topics, problems, or projects Periodic review by an outside entity, such as the National Research Council, may be appropriate

6.3 Guidance on GEM Program Development and Implementation

In addition to peer review and public review and advice, a committee and work group approach will be used to guide GEM program development and implementation This approach may include a core committee, subcommittees, and work groups

6.3.1 Core Committee

The core committee would have four purposes

1 Provide leadership in identifying and developing testable hypotheses relevant to the central questions of the GEM plan, consistent with the mission, goals and policies of the Trustee Council

2 Support habitat subcommittees and ad hoc work groups (see below) in identifying and helping implement core variables and core monitoring stations

3 Help identify and recommend syntheses, models, process studies, and other research activities for the *Invitation to Submit Proposals*

4 Assist staff in identifying peer reviewers and possibly participate in the peer review

The core committee would be composed of emeritus and senior scientists and others selected primarily for expertise and leadership in a field of study The scientists serving on the PAC would also serve on the core committee, as would the chairs of each of the habitat subcommittees (see below) In general, the core committee members would not be principal investigators for GEM projects Institutional and professional affiliations would also be of interest in selecting members, because connections to other marine science programs will be valuable for ensuring collaboration and coordination on GEM program implementation

6.3.2 Subcommittees

Subcommittees would be organized around the four broad habitat types watershed, intertidal and subtidal, ACC Current, and offshore (Outer continental

shelf and Alaska gyre) The chairs of each subcommittee would serve on the core committee

The purposes of the subcommittees would be to

- Recommend to the core committee testable hypotheses, items for invitation and peer reviewers in their broad habitat type,
- Identify and help guide implementation of core monitoring stations and variables that are relevant to the key questions and testable hypotheses, and
- Possibly conduct peer review on proposals and reports in their broad habitat type

The subcommittee would be composed of scientists, resource managers, and other experts selected primarily for disciplinary expertise and familiarity with the broad habitat type (watersheds, intertidal and subtidal, ACC, and offshore) Institutional and professional affiliations would also be of interest in selecting members to promote collaboration and cooperation

6.3.3 Work Groups

Ad hoc work groups may be periodically formed to develop specific products as requested by the core committee and subcommittees Work groups could also be charged with solving a particular problem in a finite amount of time, such as the proper location of an oceanographic mooring

6.4 Data Management and Information Transfer Policies

Data management and information transfer policies are an integral part of GEM program management Clear and effective approaches to gathering information and making it widely available in understandable formats are essential to the successful operation of the GEM program Because the program is a regional program with goals of cooperation, coordination, and integration with existing marine science programs, data policies are to be compatible with, and similar to, existing norms for state, federal, and nongovernmental marine science programs Whenever possible, existing norms will be adapted or adopted for use by the Trustee Council Standards adopted by the Federal Geospatial Data Committee (FGDC), GLOBEC, and the EPA's Environmental Monitoring and Assessment Program will be used as starting points for developing GEM data policies (Options and procedures for data management and information transfer are considered in more detail in Chapter 6, Volume II)

From the fundamental premises stated here, data policies will evolve to support GEM projects as they are implemented (see Chapter 5, Volume I) In the GEM program working definitions, "data" are basic observations on the state of the system, and "information" is data processed to be both understandable and of immediate use to specialists and the public

The GEM data policies incorporate 10 broad elements

1 A commitment to the maintenance and long-term availability of data

2 Full and open sharing of data at low cost, after verification and validation

3 Timely availability of data, depending on the type of data Some data will be available almost immediately, other data may be available within 24 months

4 Availability of data on the GEM public Web site

5 Identification of the origin of all data with a citation

6 Adherence to data collection and storage standards

7 Provision of citations to the GEM Bibliography

8 Encouragement of active participation in the GEM Web site for all participants

9 Long-term archiving of all data in a designated storage facility

10 Acceptance of and adherence to the data policies as a condition for participation in the GEM program and receipt of funding

APPENDIX A. ACRONYMS AND WEB LINKS

Note Not all of these acronyms and Web links are referenced in the GEM Program document Many are included for general reference purposes

ABC Acceptable Biological Catch
ABWC Alaska Beluga Whale Committee
ABSC (USGS) Alaska Biological Science Center (Biological Resources Division, U S Geological Survey)
http //www absc usgs gov/research/seabird&foragefish/index html
AC Alaska Current
ACC Alaska Coastal Current
ACCE Atlantic Climate and Circulation Experiment
ACIA Arctic Climate Impact Assessment
http //www acia uaf edu
http //www iarc uaf edu/structure_of_IARC html
ACDP Acoustic Doppler Current Profilers
ACT Alliance for Coastal Technologies
ADCED Alaska Department of Community and Economic Development
ADEC Alaska Department of Environmental Conservation
ADEOS-II Advanced Earth Observing Satellite-II
ADFG Alaska Department of Fish and Game
Division of Commercial Fisheries http //www cf adfg state ak us/cf_home htm
Division of Habitat http //www state ak us/adfg/habitat/hab_home htm
Division of Subsistence
http //www state ak us/local/akpages/FISH GAME/subsist/subhome htm
Division of Subsistence Whiskers Database
http //www state ak us/local/akpages/FISH GAME/subsist/subhome htm
Division of Sport Fish
http //www state ak us/local/akpages/FISH GAME/sportf/sf_home htm
ADHSS Alaska Department of Health & Social Services
ADNR Alaska Department of Natural Resources http //www dnr state ak us/
Division of Parks and Outdoor Recreation http //www dnr state ak us/parks
Division of Mining, Land and Water http //www dnr state ak us/mlw
ADOT Alaska Department of Transportation
AEPS Arctic Environmental Protection Strategy
http //arcticcircle uconn edu/NatResources/aeps html
AEWC Alaska Eskimo Whaling Commission
AFSC Alaska Fisheries Science Center (NOAA/NMFS)
http //www afsc noaa gov/generalinfo htm
AIS Archival Information System

AMAP Arctic Monitoring and Assessment Programme
http //www amap no
AMHS Alaska Marine Highway System
AMMC : Aleut Marine Mammal Commission
AMMTAP Alaska Marine Mammals Tissue Archival Project
AMNWR Alaska Maritime National Wildlife Refuge
AMOS Advanced Modelling and Observing System
AMSR Advance Microwave Scanning Radiometer
ANHSC Alaska Native Harbor Seal Commission
APEX Alaska Predator Ecosystem Experiment
ARC Atlantic Reference Center
ARCUS Arctic Research Consortium of the United States
http //www arcus org
ARGO Array for Real-time Geostrophic Oceanography
ARGO OPN ARGO Ocean Profiling Network
http //www argo ucsd edu
ARIES Australian Resource Information and Environment Satellite
ARLIS Alaska Resources Library and Information Service
ARMRB Alaska Regional Marine Research Board
ARMRP Alaska Regional Marine Research Plan
ARPA Arctic Research and Policy Act (1984)
ASLC Alaska SeaLife Center
http //www alaskasealife org/
ASP Amnesiac Shellfish Poisoning
ASTF Alaska Science and Technology Foundation
http //www astf org
ATSDR Agency for Toxic Substances and Disease Registry
ATV All Terrain Vehicle
AUV Autonomous Underwater Vehicle
AVHRR Advanced Very High Resolution Radiometer
AVSP Alaska Visitor Statistics Program
AWC Anchorage Waterway Council
http //www anchwaterwayscouncil org
AWQ Division of Air and Water Quality, ADEC
BAHC Biospheric Aspects of the Hydrological Cycle (IGBP)
BASS Task Team Basin Scale Studies Task Team (PICES)
BBMMC Bristol Bay Marine Mammal Council
BBNA Bristol Bay Native Association
BCIS Biodiversity Conservation Information System
BDY Beach Dynamics
BIO Biological Oceanography Committee (PICES)
BOOS Baltic Operational Oceanographic System
BRD Biological Resources Division
CAAB Codes for Australian Aquatic Biota
CACGP Commission on Atmospheric Chemistry and Global Pollution

CalCOFI California Co-operative Fisheries Investigation program
CAOS Co-ordinated Adriatic Observing System
CARIACO Carbon Retention in a Colored Ocean Program
CARICOMP Caribbean Coastal Marine Productivity
CBMP Chesapeake Bay Monitoring Program
CCAMLR Commission for the Conservation of Antarctic Marine Living Resources
http //www ccamlr org
CCC Cod and Climate Change (ICES/GLOBEC)
CCCC Climate Change and Carrying Capacity (PICES/GLOBEC)
CCF One hundred cubic feet
CCS California Current System
http //globec oce orst edu/groups/nep/index html
CDFO Canadian Department of Fisheries and Oceans
CDOM Coloured Dissolved Organic Matter
CDQ Community Development Quota
CEMP CCAMLR Ecosystem Monitoring Program
http //www ccamlr org/English/e_scientific_committee/e_ecosystem_monitoring/e_ecosys_monitoring_intro htm
CENR Committee on Environment and Natural Resources
CEOS Committee on Earth Observation Satellites
CGOA Coastal Gulf of Alaska
http //globec oce orst edu/groups/nep/index html
C-GOOS Coastal Panel of GOOS
CHL Chlorophyll
CHM Clearing-House Mechanism of the Convention on Biological Diversity
CIFAR Cooperative Institute for Arctic Research
http //www cifar uaf edu
http //www cifar uaf edu/fisheries html
CIIMMS Cook Inlet Information Management and Monitoring System
http //www dnr state ak us/ssd/ciimms/ciimms_sum2 html
CIK Cook Inlet Keepers
CIMI Computer Interchange of Museum Information
CIRCAC Cook Inlet Regional Citizens Advisory Council
CISNet Coastal Intensive Site Network
CLEMAN Check List of European Marine Mollusca
CLIC Climate and Cryosphere
CLIVAR Climate Variability and Predictability Program
C-MAN Coastal Marine Automated Network
CMED/GMNET Consortium for Marine and Estuarine Disease/Gulf of Mexico Network
CMI (MMS) Coastal Marine Institute
CMM Commission for Marine Meteorology (of WMO)
CNES Centre National d'Etudes Spatiales (France)
COADS Comprehensive Ocean-Atmosphere Data Set
http //www cdc noaa gov/coads
CODAR Coastal Radar

COLORS COastal region LOng-term measurements for colour Remote Sensing development and validation
COMBINE COoperative Monitoring in the Baltic Marine Environment
CoML Census of Marine Life
http //core ssc erc msstate edu/censhome html
CONNS Coastal Observing Network for the Near Shore
COOP Coastal Ocean Observation Panel
CoOP (NSF) Coastal Ocean Processes
COP Coastal Ocean Program
CORE Consortium for Oceanographic Research and Education
http //core ssc erc msstate edu/corehmpg1 html
COSESPO Coastal Observing System for the Eastern South Pacific Ocean
COTS Commercial off the shelf software
CPR Advisory Panel on Continuous Plankton Recorder Survey in the North Pacific (PICES)
CPTEC Center for Weather Forecasts and Climate Studies (Brasil)
CRIS Court Registry Investment System
CRP Comprehensive Rationalization Program
CSCOR Center for Sponsored Coastal Ocean Research
CSIRO Commonwealth Scientific and Industrial Research Organization
CTD Conductivity temperature versus depth
CTW Coastal Trapped Waves
CVOA Catcher Vessel Operational Area
CZCS Coastal Zone Colour Scanner
DARPA Defense Advanced Research Projects Agency
DBCP Data Buoy Cooperation Panel
DBMS Database Management System
DDE Dichlorodiphenyldichloroethylene
DDT Dichlorodiphenyltrichloroethane
DEOS Deep Earth Observatories on the Seafloor
DFO Department of Fisheries and Oceans, Canada
DMS Dimethylsulphide
DNMI Norwegian Meteorological Institute (Det norske meteorologiske institutt)
DO Dissolved Oxygen
DOC U S Department of Commerce
DoD U S Department of Defense
DODS Distributed Oceanographic Data System
http //www unidata ucar edu/packages/dods/
http //dods gso uri edu/
DOE U S Department of Energy
DOI U S Department of the Interior
DON QUIJOTE Data Observing Network for the QuIJOTe
EA/RIR Environmental Assessment/Regulatory Impact Review
EASy Environmental Analysis System
EC European Community
ECDIS Electronic Chart and Display Information Systems

EC/IP Executive Committee / Implementation Panel for CCCC (PICES)
ECMWF European Center for Medium Range Weather Forecasting
ECOHAB (NSF) Ecology of Harmful Algal Blooms
EDY Estuarine Dynamics
EEZ Exclusive Economic Zone
EEZ(A) European Economic Zone (Area)
EFH Essential Fish Habitat
EGB (NSF) Environmental Geochemistry and Biogeochemistry
EIOA European Oceanographic Industry Association
ELOISE European Land-Ocean Interaction Studies
EMAP Environmental Monitoring and Assessment Program
http //www epa gov emap/
http //yosemite epa gov/r10/oea nsf/1887fc8b0c8f2aee8825648f00528583/f7a660b35e5d96df882568790053fc10?OpenDocument
ENSO El Niño Southern Oscillation
EOSDIS EOS Data and Information System
http //spsosun gsfc nasa gov/NewEOSDIS_Over html
EPA U S Environmental Protection Agency
ERMS European Register of Marine Species
ERS-1 European Remote Sensing satellite-1
ERS-2 European Remote Sensing satallite-2
ESH (NSF) Marine Aspects of Earth System History
ESIP Earth Science Information Partners Federation
ESP Eastern South Pacific
ESRI Environmental Systems Research Institute
ArcIMS system http //www esri com/software/arcims/index html
ETL tools Extraction, Transformation, and Loading tools
EU European Union
EUMETSAT European Organization for the Exploitation of Meteorological Satellites
EuroGOOS European GOOS
EuroHAB European Harmful Algae Bloom
EVOS Exxon Valdez Oil Spill http //www oilspill state ak us/
Bibliography http //www oilspill state ak us/Biblio/biblio htm
Final and Annual Reports http //www oilspill state ak us/reports/clusters htm
F & A Finance and Administration Committee (PICES)
FCCC Framework Convention on Climate Change
Federal Geographic Data Committee metadata requirements
http //www fgdc gov/metadata/metadata html
Federal Subsistence Fishery Monitoring Program, Federal Subsistence Management Program
http //www r7 fws gov/asm/home html
FGDC Federal Geographic Data Committee
FIS Fishery Science Committee (PICES)
Fishbase, FishGopher, FishNet searchable fish databases managed by multiple organizations
FMP Fishery Management Plan

FOCI Fisheries Oceanography Investigations
http //rho pmel noaa gov/card/long/home_page html
F-R Fundraising Committee (PICES)
FY Fiscal Year
GAIM Global Analysis, Interpretation and Modelling (IGBP)
GAK Gulf of Alaska
GAP Gap Analysis Program
GARP Genetic Algorithm for Rule-set Production
GBIF Global Biodiversity Information Facility
GC Governing Council (PICES)
GCM Global Climate Model
GCN Global Core Network
GCOS Global Climate Observing System
http //193 135 216 2/web/gcos/pub/dim_v1_1 html
GCRMN Global Coral Reef Monitoring Network
GCTE Global Change and Terrestrial Ecosystems (IGBP)
GEF Global Environmental Facility
GEM Gulf Ecosystem Monitoring
GEO Global Eulerian Observations
GEOHAB Global Ecology of Harmful Algal Blooms
GHL Guideline Harvest Level
GIPME Global Investigation of Pollution in the Marine Environment
GIS Geographic Information System
GIWA Global International Water Assessment
GLI Global Imager
GLOBE Global Learning and Observations to Benefit the Environment
http //www globe gov
GLOBEC Global Ocean Ecosystem Dynamics
http //cbl umces edu/fogarty/usglobec/
GLOBEC NEP GLOBEC Northeast Pacific
http //globec oce orst edu/groups/nep/index html
GLORIA Geological Long-Range Inclined Asdic
GLOSS Global Sea-Level Observing System
GMBIS Gulf of Marine Biogeographic Information System
GNP Gross National Product
GOA Gulf of Alaska
GODAE Global Ocean Data Assimilation Experiment
GOES Geostationary Operational Environmental Satellite
GOOS Global Ocean Observing System
http //www gos udel edu
GPA/LBA Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities
GPO GOOS Project Office
GPS Global Positioning System
GSC GOOS Steering Committee

GTOS Global Terrestrial Observing System
GTS Global Telecommunications System
GUI Graphical User Interface
HAB harmful algal bloom
http //www redtide whoi edu/hab
HABSOS Harmful Algal Bloom Observing System
http //www habhrca noaa gov
HAPC Habitat Areas of Particular Concern
HELCOM Helsinki Commission-Baltic Marine Environment Protection Commission
HMAP History of Marine Animal Populations
HMS Hydrometeorological Service
HNLC high nitrate, low chlorophyll waters
HOTO Health of the Oceans
HPLC High Performance Liquid Chromatography
IABIN Inter-American Biodiversity Information Network
IAI Inter-American Institute
IARC International Arctic Research Center, University of Alaska
http //www iarc uaf edu/
IARPC Interagency Arctic Research Policy Committee
http //www nsf gov/od/opp/arctic/iarpc/start htm
IBOY International Biodiversity Observation Year
IBQ Individual Bycatch Quota
ICAM Integrated Coastal Area Management/ Integrated Coastal Area Management Programme
ICES International Council for the Exploration of the Sea
ICLARM International Center for Living Aquatic Resources Management
ICM Integrated Coastal Management
ICSU International Council for Science
ICZN International Code of Zoological Nomenclature
IFEP Iron Fertilization Experiment Panel (PICES)
IFQ Individual Fishing Quota
IGAC International Global Atmospheric Chemistry Project (IGBP/CACGP)
IGBP International Geosphere-Biosphere Programme
http //www igbp kva se/
IGBP-DIS Data and Information System (IGBP)
I-GOOS IOC-WMO-UNEP Committee for the Global Ocean Observing System
IGOS (NASA) Integrated Global Observing System
IGOSS Integrated Global Ocean Services System
IGS International GPS Service for Geodynamics
IGU International Geographic Union
IHDP International Human Dimensions Programme on Global Environmental Change
IIP International Ice Patrol
I-LTER International LTER
IMS Institute of Marine Science, University of Alaska
InfoBOOS BOOS Information System

INPFC International North Pacific Fisheries Commission
http //www npafc org/inpfc/inpfc html
IOC Intergovernmental Oceanographic Commission (of UNESCO)
http //ioc unesco org/iyo/
IOCCG International Ocean-Color Coordinating Group
IODE International Oceanographic Data and Information Exchange
http //ioc unesco org/iode/index htm
IOOS Integrated Ocean Observing System
http //core ssc erc msstate edu/oceanobs html
IPCC Intergovernmental Panel on Climate Change
IPHAB Intergovernmental Panel on HABs
IPHC International Pacific Halibut Commission
http //www iphc washington edu/)
IPSFC International Pacific Salmon Fishing Commission
IRFA Initial Regulatory Flexibility Analysis
IRIU Improved Retention/Improved Utilization
ITAC Initial Total Allowable Catch
ITIS Integrated Taxonomic Information System
ITSU IOC Tsunami Warning System in the Pacific
IUCN The World Conservation Union
Japanese ADEOS-2 satellite http //seawinds jpl nasa gov
JCOMM Joint Technical Commission for Oceanography and Marine Meteorology
JDBC Java Database Connectivity
JDIMP Joint Data and Information Management Panel
JGOFS (NSF) Joint Global Ocean Flux Study
http //ads smr uib no/jgofs/jgofs htm
KBRR Kachemak Bay Research Reserve
Kachemak Bay Ecological Characterization study
http //www state ak us/adfg/habitat/geninfo/nerr/kbec/index htm
KRSA Kenai River Sportfishing Association
LAMP Local Area Management Plan
LATEX Louisiana-Texas shelf study
LEO Long-term Ecosystem Observatory
LEO-15 Long-term Ecosystem Observatory at 15-m depth
LExEn (NSF) Life in Extreme Environments
LIDAR Light Detection and Ranging
List of oceanographic data servers http //gcmd gsfc nasa gov/pointers/ocean html
LLP License Limitation Program
LMR Living Marine Resources
LOICZ Land-Ocean Interactions in Coastal Zone
LTER Long-term Ecological Research (NSF) http //lternet edu/
LTOP Long-Term Observation Program
http //globec oce orst edu/groups/nep/index html
LUCC Land Use/Cover Change (IGBP/IHDP)
MABNET Man and the Biosphere Network

MARBID Marine Biodiversity Database
MARGINS (NSF) Continental Margins
MarLIN Marine Laboratories Information Network
MAROB Marine Observation
MAST Marine Science and Technology
MBARI Monterey Bay Aquarium Research Institute
http //www mbari org/about/
MBF One thousand board feet
MBMAP Advisory Panel on Marine Birds and Mammals (PICES)
MBNMS Monterey Bay National Marine Sanctuary
http //bonita mbnms nos noaa gov/research/mb_workshop/index html
MEHRL Marine Environmental Health Research Laboratory
http //www cofc edu/~grice/mehrl
MEL Master Environmental Library
http //www-mel nrlmry navy mil/
MEQ Marine Environmental Quality Committee (PICES)
MERIS Medium Resolution Imaging Spectrometer
MetOp Meteorological Operational
MFS Mediterranean Forecasting System
MMPA Marine Mammal Protection Act
MMRC The North Pacific Universities Marine Mammal Research Consortium
consortium@zoology ubc ca
MMS Minerals Management Service
MMS OCSES Outer Continental Shelf Environmental Studies
MODEL Conceptual / Theoretical and Modeling Studies Task Team (PICES)
MODIS Moderate Resolution Imaging Spectroradiometer
MONITOR Monitor Task Team (PICES)
MOOS Ocean Observing System of the Monterey Bay Aquarium Research Institute
http //www mbari org/default htm
MOS Modular Optoelectronic Scanner
MPA Marine Protected Areas (DOC/DOI)
http //www mpa gov
MRB Maximum Retainable Bycatch
MSFCMA Magnuson-Stevens Fishery Conservation and Management Act
MSY Maximum Sustainable Yield
mt Metric tons
NA Northern Adriatic
NABIN North American Biodiversity Information Network
NABIS National Aquatic Biodiversity Information Strategy
NAML National Association of Marine Laboratories
NAO North Atlantic Oscillation
NASA National Aeronautics and Space Administration
NASA/AMSR Advance Microwave Scanning Radiometer
http //wwwghcc msfc nasa gov/AMSR/
Earth Science Enterprise http //www earth nasa gov

NASA/GRACE Gravity Recovery and Climate Experiment
http //essp gsfc nasa gov/esspmissions html
NASA/NASDA Tropical Rainfall Measurement Mission
http //ltpwww gsfc nasa gov/MODIS/MODIS html
NASA/Salinity and Sea Ice Working Group
http //www esr org/lagerloef/ssiwg/ssiwgrep1 v2 html
NASA/SeaWiFS http //seawifs gsfc nasa gov
Naval Oceanographic Office
http //128 160 23 51/noframe/select products htm
NAWQA National Water Quality Assessment Program
NCAR National Center for Atmospheric Research
NCDC National Climate Data Center
http //www ncdc noaa gov/
NCEP National Centers for Environmental Protection
NDBC National Data Buoy Center
NDVI Normalized Difference Vegetation Index
NEAR-GOOS North East Asian GOOS
NEMO Naval Earth Map Observer
NEODAT Inter-Institutional Database of Fish Biodiversity in the Neotrophics
NEP National Estuarary Program
NERR National Estuarine Research Reserve
NESDIS National Environmental Satellite, Data, and Information Service
NGO Non-governmental organization
NGOA Northern Gulf of Alaska
NIST National Institute of Standards and Technology
http //www nist gov/
NIWA National Institute of Water and Atmosphere Research
NMFS National Marine Fisheries Service
http //www nmfs gov/
NMMHSRP National Marine Mammal Health and Stranding Response Program
http //www nmfs gov/prot_res/overview/mmhealth html
NMML National Marine Mammal Laboratory
http //nmml afsc noaa gov/AlaskaEcosystems/sslhome/FILEINFO htm
NOAA National Oceanic and Atmospheric Administration
NOAA HAZMAT Hazardous Materials Program
NOAA NOS National Ocean Service
NODC National Oceanographic Data Center
http //www nodc noaa gov
NOLS National Outdoor Leadership School
NOPP (NASA) National Ocean Partnership Program
http //core ssc erc msstate edu/NOPPpg1 html
NOPPO National Oceanographic Partnership Program Office
NORLC National Ocean Research Leadership Council
NORPAC North Pacific, an informally organized group of scientists responsible for collating and publishing much of the oceanographic data collected in the North Pacific Ocean during

the period of approximately 1930 to 1965 These data were published in several volumes by the University of California Press This data set is collectively known as the NORPAC data

NOS National Ocean Service
http //www nos noaa gov/

NPAFC North Pacific Anadromous Fish Commission
http //www npafc org
http //www pac dfo-mpo gc ca/sci/pbs/pages/NPAFC htm

NPDES National Pollution Discharge Elimination System

NPFMC North Pacific Fishery Management Council

NPO North Pacific Oscillation

NPOESS National Polar-Orbiting Environmental Satellite System

NPS National Park Service

NRC National Research Council

NRT Near Real Time

NS&T National Status and Trends Program
http //ccmaserver nos noaa gov/NSandT/New_NSandT html

NSF National Science Foundation

NSIPP (NASA) Seasonal-to-Interannual Prediction Program

NURP (NOAA) National Undersea Research Program

NVODS National Virtual Ocean Data System http //nvods org/

NVP Nearshore Vertebrate Predator project

NWP numerical weather prediction

NWS National Weather Service
http //www nws noaa gov/

OAR Office of Oceanic and Atmospheric Research (NOAA)
http //oar noaa gov/

OBIS Ocean Biogeographical Information System
www coml org

OCC Ocean Carrying Capacity

OCSEAP Outer Continental Shelf Environmental Assessment Program

OCTS Ocean Color and Temperature Scanner

OE (NOAA OAR) Office of Ocean Exploration
http //oceanpanel nos noaa gov/

OECD Organization for Economic Co-operation and Development

OFP Ocean Flux Program

OMB Office of Management and Budget

OOPC Ocean Observations Panel for Climate

OOSDP Ocean Observing System Development Panel

OPA 90 Oil Pollution Act of 1990
http //www pwssc-osri org/docs/opa90 html

OPR Office of Protected Resources
http //www nmfs gov/prot_res/prot_res html

ORAP Ocean Research Advisory Panel

ORNL Oak Ridge National Laboratory
Mercury http //beija-flor ornl gov Iba/

OSNLR Ocean Science in Relation to Non-Living Resources
OSPARCOM Convention for the Protection of the Marine Environment of the North-east Atlantic
OSRI Prince William Sound Oil Spill Recovery Institute
http //www pwssc-osri org/mission/mission fr html
OSSE Observation System Simulation Experiments
OSTP Office of Science and Technology Policy
OY Optimum yield
PAG Public Advisory Group
PAGES Past Global Change (IGBP)
PAH Polyaromatic hydrocarbons
PAR Phosynthetically Available Radiation
PC Publication Committee (PICES)
PCAST President's Committee of Advisors on Science and Technology
PCB Polychlorinated biphenyls
PCC Pollock Conservation Cooperative
PDO Pacific Decadal Oscillation
PICES Data Bases http //pices ios bc ca/data/weblist/weblist htm
PICES North Pacific Marine Science Organization (not an acronym)
http //pices ios bc ca/
PICES Technical Committee on Data Exchange http //pices ios bc ca/data/dataf htm
PIRATA Pilot Research Array in the Tropical Atlantic
PISCO Partnership for the Interdisciplinary Study of Coastal Oceans
http //www piscoweb org/
PMEL Pacific Marine Environmental Laboratory
http //www pmel noaa gov/
PMEL Bering Sea and North Pacific Ocean Theme Page www pmel noaa gov/bering
POC Physical Oceanography and Climate Committee (PICES)
POLDER Polarization and Directionality of the Earth's Reflectances
POM Princeton Ocean Model
PORTS Physical Oceanographic Real-Time System
PORTS/VTS PORTS/Vessel Traffic Services
POST Pacific Ocean Salmon Tracking Project
PRODAS Prototype Ocean Data Analysis System
PROFC Programa Regional de Oceanografia Fisica y Clima
PSC Pacific Salmon Commission
http //www psc org/Index htm
PSMFC Pacific States Marine Fisheries Commission
http //www psmfc org/
PSMFC Regional Mark Processing Center
http //www rmis org/index html
PSP Paralytic Shellfish Poisoning
PST Pacific Salmon Treaty
PWS Prince William Sound
PWSAC PWS Aquaculture Corporation http //www ctcak net/~pwsac/

PWSRCAC PWS Regional Citizens Advisory Council
PWSSC Prince William Sound Science Center
http //www pwssc-osri org/
QAQC Quality Assurance and Quality Control
QC quality control
QUIJOTE Quickly Integrated Joint Observing Team
R&D Research and Development
RACE Resource Assessment and Community Ecology
RAMS Regional Atmospheric Modeling System
RCAC Regional Citizens Advisory Council
RCRA Resource Conservation and Recovery Act
RDP Ribosomal Database Project
REX Regional Experiments Task Team (PICES)
RIDGE (NSF) Ridge Interdisciplinary Global Experiments
RLDC Responsible Local Data Center
RLDC Responsible Local Data Center
RMI Remote Method Invocation
RNODC Responsible National Oceanographic Data Center
RSN RedSur Network
S1 Session 1 - Science Board Symposium on Subarctic gyre processes and their interaction with coastal and transition zones physical and biological relationships and ecosystem impacts (PICES)
S2 Session 2 - BIO Topic Session on Prey consumption by higher trophic level predators in PICES regions implications for ecosystem studies (PICES)
S3 Session 3 - Joint BIO / CCCC Topic Session on Recent progress in zooplankton ecology study in PICES regions (PICES)
S4 Session 4 - FIS Topic Session on Short life-span squid and fish as keystone species in North Pacific marine ecosystems (PICES)
S5 Session 5 - POC Topic Session on Large-scale circulation in the North Pacific (PICES)
S6 Session 6 - Joint POC / BIO Topic Session on North Pacific carbon cycling and ecosystem dynamics (PICES)
S7 Session 7 - CCCC Topic Session on Recent findings and comparisons of GLOBEC and GLOBEC-like programs in the North Pacific (PICES)
S8 Session 8 - MEQ Topic Session on Environmental assessment of Vancouver Harbour results of an international workshop (PICES)
S9 Session 9 - MEQ Topic Session on Science and technology for environmentally sustainable mariculture in coastal areas (PICES)
SAFE Stock Assessment and Fishery Evaluation Document
SAR Synthetic Aperture Radar
SB Science Board (PICES)
SBIA (NSF) Shelf-basin Interactions in the Arctic
SCAMIT Southern California Association of Marine Invertebrate Taxonomists
SC(-IGBP) Scientific Committee for the IGBP
SCICEX (NSF) Science Ice Exercise
SCOPE Scientific Committee on Problems of the Environment

SCOR Scientific Committee on Oceanic Research
SCS South China Sea
SEA Sound Ecosystem Assessment
SEARCH Study of Environmental Arctic Change
SEAS Shipboard Environmental Data Acquisition System
SeaWIFS Sea-viewing Wide Field-of-view Sensor
SEI Special Events Imager
SEPOA Southeast Pacific Ocean Array
SFOS School of Fisheries and Ocean Sciences
SG Sea Grant
http //www nsgo seagrant org/
SGI State of the Gulf Index
SHEBA (NSF) Surface Heat Budget of the Arctic Ocean
SIMBIOS Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies
SIMoN Sanctuary Integrated Monitoring Network
http //www mbnms nos noaa gov/Research/simon/simon htm
SLFMR Scanning Low Frequency Microwave Radiometers
SO-GLOBEC Southern Ocean Programme (GLOBEC)
SOIREE Southern Ocean iron release experiment
http //katipo niwa cri nz/~hadfield/gust/iron
SOLAS International Convention for Safety of Life at Sea
SPACC Small Pelagic Fish and Climate Change (GLOBEC)
Specimen Banking Project
http //www nwfsc noaa gov/pubs/tm/tm16/tm16 htm
SQuID Structured Query and Information Delivery
SSC Scientific and Statistical Committee
SSE (NOAA) Sustainable Seas Expedition
SSF Storm Surge Forecast System
SSH Sea Surface Height
SSM/I Special Sensor Microwave/Imager
SSS Sea Surface Salinity
SST Sea Surface Temperature
STAMP Seabird Tissue Archival Monitoring Project
START Global Change System for Analysis, Research and Training (IGBP)
STD Salinity Temperature Depth recorder
STORET System (EPA)
http //www epa gov/owow/STORET
SWAO South Western Atlantic Ocean
TAC Total Allowable Catch
TAO Tropical Atmosphere Ocean (buoy array)
http //www pmel noaa gov/toga0tao/review98/data html
TASC Transatlantic Study of Calanus finmarchicus (EU)
TCODE Technical Committee on Data Exchange (PICES)
TCP Tropical Cyclone Programme

TEMA Training, Education and Mutural Assistance (IOC)
TOGA Tropical Ocean and Global Atmosphere
TOPEX/Poseiden http //topex-www jpl nasa gov
T/P TOPEX/Poseidon
UAA University of Alaska, Anchorage
UAF University of Alaska, Fairbanks
UN United Nations
UNCED The United Nations Conference on Environment and Development
UNCLOS United National Convention on the Law of the Sea (Montego Bay, 1982)
UNEP United Nations Environmental Programme
UNESCO United Nations Educational, Scientific and Cultural Organization
http //ioc unesco org/iocweb/
UNFCCC United Nations Framework Convention on Climate Change
USARC U S Arctic Research Commission
USCG U S Coast Guard
USDA U S Department of Agriculture
USDHHS U S Department of Health and Human Services
http //www os dhhs gov/
USFS U S Forest Service
USGCRP (NASA) U S Global Climate Research Program
US GLOBEC (NSF) U S Global Ocean Ecosystem Dynamics
http //cbl umces edu/fogarty/usglobec/
USGS U S Geological Survey
http //www usgs gov/
USNO U S Naval Observatory
http //www usno navy mil/
VBA Vessel Bycatch Accounting
VENTS (NOAA) Vents Program
VIP Vessel Incentive Program
VOS Volunteer Observing Ships
W1 Workshop 1 - MONITOR Workshop on Progress in monitoring the North Pacific (PICES)
W2 Workshop 2 - REX Workshop on Trends in herring populations and trophodynamics (PICES)
W3 Workshop 3 - MODEL Workshop on Strategies for coupling higher and lower trophic level marine ecosystem models (PICES)
W4 Workshop 4 - BASS Workshop of Development of a conceptual model of the Subarctic Pacific basin ecosystem(s) (PICES)
W5 Workshop 5 - IFEP Planning Workshop on Designing the iron fertilization experiment in the Subarctic Pacific (PICES)
W6 Workshop 6 - (BIO / MBMAP) - The basis for estimating the abundance of marine birds and mammals, and the impact of their predation on other organisms (PICES)
W7 Workshop 7 - CO2 Data Synthesis Symposium (PICES)
WAM Wave Model
WCRP World Climate Research Program (ICSU/IOC/WMO)
WES Waterways Experimental Station

WESTPAC IOC Sub-Commission for the Western Pacific
WG Working Group (PICES)
WHOI Woods Hole Oceanographic Institution
WMO World Meteorological Organization
WMS Open GIS Consortium's Web Mapping Server
http //www opengis org/techno/specs/01-047r2 pdf
WOCE (NSF) World Ocean Circulation Experiment (WCRP)
http //www soc soton ac uk/OTHERS/woceipo/ipo html
http //www cms udel edu woce/
WODC World Oceanographic Data Center
WOOD World-wide Oceans Optics Database
WWW World Weather Watch
XBT expendable bathythermograph
XCDT expendable conductivity, depth and salinity devices