11.13.04

Exxon Valdez Oil Spill Trustee Council

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MEMORANDUM

TO: Trustee Council

FROM: Molly McCammon S Schubert for
Executive Director

RE: Proposed Revisions to Trustee Council's Procedures

DATE: June 6, 2002

As part of the transition to the GEM Program, we have undertaken a review of the Trustee Council's existing procedures and policies, and updated and revised them where necessary or in order to streamline the process. Our intent is to compile these into a single document or binder for ease of reference (until now, many of the individual procedures/policies have been separately bound or were lone documents in office files).

The Table of Contents below lists the existing procedures/policies. Those that have proposed revisions are attached to this memo for your review. I will brief the Trustee Council on the revisions at your June 14, 2002 meeting. The Council is tentatively scheduled to take action on the revisions at your July 9, 2002 meeting.

The proposed revisions have been reviewed by the Restoration Work Force. The draft Financial Procedures (III) have also been circulated to finance personnel at each Trustee agency. The Data Policy (IV) has also been circulated to the GEM Data Advisory Committee. If you would like copies of any of the procedures which are <u>not</u> attached, please let me know.

TABLE OF CONTENTS

<u>I. Introduction -- PROPOSED REVISION ATTACHED</u>
No substantive changes.

<u>II. General Operating Procedures -- PROPOSED REVISION ATTACHED</u>
Primary changes are related to organization of document.

III. Financial Procedures -- PROPOSED REVISION ATTACHED

Primary changes are:

- revising the GA formula to a flat rate of 9% on each project's total costs (current rate is 15% on personnel costs plus 7% on the first $250,000 of contractual costs plus 2% on contractual costs above $250,000);
- removing the requirement that expenditure of GA be in proportion to actual direct costs (we are proposing that a project be able to spend 100% of the budgeted GA even if less than 100% of the budgeted direct project funds are spent);
- allowing for bonuses to be paid from GA funds;
- reducing the maximum amount that may transferred between EVOS projects at an agency's discretion from $25,000 to $10,000;
- revising the process governing disposition of equipment at project's end (the current requirement that all EVOS equipment be made available at project's end for other EVOS projects would apply only to equipment with a purchase price of $5,000 or more--equipment costing less than $5,000 would be handled per existing agency disposal procedures; this new provision would apply to all equipment purchased under the restoration program including that purchased in previous years);
- referencing existing state and federal law regarding Trustee agencies' authority to issue grants; and
- adding language describing the Trustee Council's current policy on named contract recipients.

IV. Data Policy -- PROPOSED REVISION ATTACHED

This detailed policy statement would replace the Trustee Council's current policy, which is a general statement providing that any data resulting from any project to which the Council has contributed financially are in the public domain and must be available to the public.

V. Report Writing Procedures -- PROPOSED REVISION ATTACHED

Primary changes are:

- revising process for annual reports (beginning with annual reports due in FY 03 –which is most reports on projects funded FY 02 and beyond--requirement would shift to brief progress reports designed to allow determination of whether continued funding of the project is warranted; annual reports would be submitted on a brief electronic form; some annual reports may be reviewed in-house rather than by external peer reviewers; annual reports would be kept on file at the Trustee Council office but would not be housed at ARLIS);
- adding a distinct review procedure for GEM project final reports (peer review of lingering oil reports would continue to be handled by Dr. Bob Spies, the Chairman of the Lingering Oil Subcommittee; peer review of GEM reports would be handled by Dr. Phil Mundy, the Science Director); and
- requiring the report author to submit an electronic copy of the approved final report suitable for posting on the Council's web site (in addition to the currently required paper copies).

VI. TEK Protocols
Adopted 1996. No revisions proposed.

VII. Sample Destruction Policy
Summary, prepared by Craig Tillery, of settlement requirements regarding sample destruction. No revisions proposed.

VIII. Collections Policy
Adopted 1995. No revisions proposed.

IX. Supplementation Criteria
Adopted 1995. No revisions proposed.

X. Investment Policy
Adopted 2000. No revisions proposed.

XI. Habitat Protection Procedures
General guidance is contained in General Operating Procedures (II above). More detailed procedures may be needed following Trustee Council action on the pilot habitat grant, which is scheduled to expire September 30, 2002.

XII. Scientific Review Process (STAC, etc.)
Adopted 2002. No revisions proposed.

INTRODUCTION

1. *Purpose.* Define the Policies and Procedures of the *Exxon Valdez* Oil Spill Trustee Council (Trustee Council) and provide guidance regarding the authorities and responsibilities of entities that receive funds approved by the Trustee Council.

2. *Supersession.* These procedures supersede the Procedures adopted by the Trustee Council August 3, 2000 and August 29, 1996, the Operating Procedures adopted by the Trustee Council January 10, 1992, and the Financial Operating Procedures adopted by the Trustee Council September 21, 1992.

3. *Relationship.* The Procedures of the Trustee Council augment state and federal procedures. State and federal agencies receiving funds approved by the Trustee Council are responsible for ensuring that the procedures described in this document and the appropriate state or federal procedures are followed.

4. *Amendments.* These procedures may be modified by unanimous agreement of the Trustee Council.

5. *Authority.* The principles and processes stated herein are established pursuant to the Memorandum of Agreement and Consent Decree entered as settlement of United States of America v. State of Alaska, No. A91-081 Civil, U.S. District Court of Alaska. The Joint Trust Fund is comprised of all payments received in settlement of State of Alaska v. Exxon Corporation , el al., No. A91-083 CIV, and United States of America v. Exxon Corporation , el al., No. A91-082 CIV.

6. *Restoration Plan.* The *Exxon Valdez* Restoration Plan provides long-term guidance for restoring the resources and services injured by the 1989 *Exxon Valdez* oil spill. It contains policies for making restoration decisions and describes how restoration activities will be implemented. The Restoration Plan was adopted by the Trustees in November 1994 after completion of the Final Environmental Impact Statement. By unanimous consent, the Trustee Council may change the plan if the Trustee Council determines that the plan is no longer responsive to restoration needs.

II. General Operating Procedures

GENERAL OPERATING PROCEDURES

TRUSTEE COUNCIL

1. *Basic Governing Procedures*. The current edition of *Roberts Rules of Order* will govern the Trustee Council. All provisions of these rules of order will apply to Trustee Council deliberations unless the Trustee Council unanimously decides to proceed differently.

2. *Trustee Council Membership*. The following officials act on behalf of the public as trustees: the Attorney General of the State of Alaska; the Commissioner of the Alaska Department of Environmental Conservation; the Commissioner of the Alaska Department of Fish and Game; the Secretary of the United States Department of Agriculture; the Secretary of the United States Department of the Interior; and the Administrator of the National Oceanic and Atmospheric Administration, United States Department of Commerce. Each Trustee may designate a representative to serve on the Trustee Council. Any such designation shall be in writing and the designation shall be maintained in the official record. In the event a Trustee Council member is precluded from attending a meeting or must be excused during a meeting, an alternate may exercise voting privileges on behalf of the Trustee Council member. Alternates shall be designated in writing and the designation shall be maintained in the official record or an alternate may be identified at the meeting and so stated for the record.

3. *Quorum*. A quorum of two-thirds (2/3) of the total Trustee Council membership including at least two state members and two federal members shall be required to convene a meeting. All decisions shall be made by unanimous agreement of the six Trustee Council members, their designee or their alternate, except that a quorum may approve the agenda, take public testimony and adjourn a meeting.

4. *Chair*. The Trustee Council shall designate a chair to preside at each meeting. The chair may participate in discussion and debate at the meetings and shall vote on all questions before the Trustee Council.

5. *Trustee Council Action*. All matters before the Trustee Council which require a vote, make a recommendation, approve or disapprove an item, or otherwise render a decision shall require the unanimous agreement of the six Trustee Council members, their designee or their alternate. All actions by the Trustee Council shall be taken at duly convened meetings except as provided in Section 10, Emergency Action.

6. *Recusal*. In the event a Trustee Council member believes he or she must recuse himself or herself from voting, the Trustee Council member may request the decision be deferred until a designated alternate is available to vote.

7. *Meetings*. Meetings shall be held at times and locations determined by the Trustee Council. The Executive Director shall provide a proposed agenda and appropriate briefing

materials to the Trustee Council members in advance of the meeting. The final agenda for the meeting will be determined by the Trustee Council and shall include a reasonable opportunity for public comment.

8. *Executive Sessions*. Executive sessions shall be kept to a minimum and shall be used only for discussion of matters concerning confidential personnel issues, litigation or legal advice, habitat acquisition negotiations, confidential archaeological information, confidential fisheries information or other matters included under AS 37.14.430, AS 44.62.310 (c) or other applicable State or Federal laws.

9. *Minutes of Trustee Council Meetings*. All meetings shall be recorded electronically or by a court reporter, and said records shall, along with the written, approved meeting notes, constitute the official record of the Trustee Council's actions.

10. *Emergency Action*. In the event of an emergency requiring Trustee Council action before a meeting can be held in accordance with the procedures described herein, the Executive Director shall poll the Trustee Council and take action by unanimous agreement. Any decisions of the Trustee Council shall be reflected in the official record of the Trustee Council along with justification regarding the need to take emergency action. In addition, any emergency action taken shall be ratified at the next meeting of the Trustee Council.

ORGANIZATIONAL STRUCTURE

1. *General*. Pursuant to the agreement between the State of Alaska and the United States, the Trustee Council has created the position of Executive Director to manage the day-to-day administrative functions of the Trustee Council and the overall restoration program.

2. *Trustee Council Office*. Under supervision of the Executive Director, the Trustee Council Office is responsible for: (1) facilitating communication between the federal and state governments, the Trustee Council members, the Scientific and Technical Advisory Committee, and the Public Advisory Committee; (2) maintaining the official record of the Trustee Council's actions; (3) soliciting project proposals and administering the proposal process, including supporting the Scientific and Technical Advisory Committee and any additional subcommittees and working groups that are formed to advise on the scientific development of the program; (4) preparing and analyzing financial and project status information; (5) developing and implementing procedures to achieve the goals and objectives of the Trustee Council; (6) performing and/or overseeing special and ongoing projects; and (7) public outreach and public participation.

3. *Trustee Agencies*. Under supervision of the agency's Trustee Council member, each Trustee agency is responsible for administrative oversight of projects funded to or through their agencies. This oversight shall include (1) ensuring that the procedures described herein, and the appropriate state or federal procedures, are followed, including compliance with the National

Environmental Policy Act and (2) ensuring that projects funded meet their stated objectives and schedules, and are accomplished consistent with the funds authorized.

PROPOSAL SOLICITATION AND REVIEW

1. *Invitation.* At least annually the public, private sector, non-profit groups, and government agencies will be invited to submit proposals for funding based on identified restoration priorities and needs.

2. *Review.* Proposals received will be subject to independent scientific review, as well as policy, budget, and legal review. Based on these reviews, the Executive Director shall make a recommendation to the Trustee Council on which proposals should be funded.

3. *Public Review and Comment.* Prior to Trustee Council action, a reasonable period of time shall be provided for the public to review and comment on the project proposals.

4. *Approval.* After expiration of the period for public review and comment, the Trustee Council, in open session and with additional opportunity for public comment, shall review the Executive Director's recommendation on which proposals should be funded. The Trustee Council may make changes to the recommendation or include terms and conditions of funding as the Trustee Council deems appropriate. Upon unanimous approval, the recommendation shall be adopted by the Trustee Council.

PROJECT REPORTS

1. *Quarterly Project Status Reports.* Within thirty days following the end of each quarter, the investigator for each project approved by the Trustee Council shall submit a status report to the Executive Director. The report contents, format, and review procedures shall be determined by the Executive Director.

2. *Annual Project Reports.* Annually, the investigator for each continuing project approved by the Trustee Council shall submit a report to the Executive Director. A continuing project is one that was initiated with the expectation that it was multi-year. The report deadline, contents, format, and review procedures shall be determined by the Executive Director. A copy of each report shall be placed in the Trustee Council's official record.

3. *Final Project Reports.* Upon completion of each project approved by the Trustee Council, or a determination by the Trustee Council to no longer fund a project, the investigator shall submit a report to the Executive Director. The report deadline, contents and format, and review procedures shall be determined by the Executive Director. A copy of each report shall be placed in the Trustee Council's official record and at ARLIS (Alaska Resources Library & Information Services).

PROJECT DATA

1. Metadata and Data. During the course of the project and at its completion, the investigator shall submit metadata ("data about data") and project data according to Trustee Council approved data policies. The metadata and project data contents, format, and review procedures shall be determined by the Executive Director.

HABITAT PROTECTION AND ACQUISITION

1. *General.* Habitat Protection and Acquisition is an important means of restoring injured resources and the services that are dependent upon those resources. Habitat Protection and Acquisition may include the purchase of lands or interests in land such as conservation easements, mineral rights, or timber rights.

2. *Parcel Nomination.* Only those parcels nominated by a willing seller shall be considered for purchase. The Executive Director shall prepare and maintain written procedures regarding nomination of parcels.

3. *Parcel Evaluation.* Nominated parcels shall be evaluated based on their importance to the conservation and protection of marine and coastal resources, ecosystems, and habitats in order to aid in the overall recovery of, and to enhance the long-term health and viability of, those resources injured by the oil spill and the spill area ecosystem.

4. *Terms and Conditions.* By unanimous agreement of the six Trustees, their designee or their alternate, a resolution shall be adopted authorizing the purchase of land or ownership rights. The resolution shall set forth the terms and conditions appropriate for the identified parcel(s).

5. *Title and Management.* The title of any lands or ownership rights shall be specified in the resolution adopted by the Trustee Council. All land acquired shall be managed in accordance with the terms and conditions of the Trustee Council.

6. *Public Review and Comment.* Prior to final Trustee Council action, reasonable public notice shall be given and the public shall be provided an opportunity to comment.

7. *Application or Notification for Disbursement.* Upon certification from the Executive Director that the terms and conditions set forth in a resolution have been satisfied, the Alaska Department of Law and the United States Department of Justice shall be requested to provide notice to the United States District Court for the District of Alaska regarding the expenditure of funds. Concurrently, as appropriate, the Executive Director shall provide the custodian of the Investment Fund(s) with payment instructions.

PUBLIC PARTICIPATION

1. *General.* The Trustee Council recognizes that public participation in the restoration program is an integral part of the process. To that end, the public is invited to review, comment on and participate in the development and implementation of the restoration program.

2. *Exxon Valdez Oil Spill Public Advisory Committee.* By order of the District Court for the District of Alaska, the Public Advisory Committee is to advise the Trustees, appointed to administer the fund established in settlement of United States v. Exxon Corporation, Civil Action No. A91-082, and State of Alaska v. Exxon Corporation, Civil Action No. 091-083, both in the United States District Court for the District of Alaska, in all matters described in Paragraph V.A.1 of the MOA referenced above. The overall procedures for the Public Advisory Committee are contained in a Charter unanimously approved by the Trustee Council and signed by the Secretary of the United States Department of the Interior. The Public Advisory Committee consists of members recommended by the Trustee Council and appointed by the Secretary of the United States Department of the Interior.

3. *Public Notice.* Reasonable public notice shall be given for all meetings of the Trustee Council. The notice shall include, when possible, publication in one or more newspapers of general circulation in the following communities: Anchorage, Cordova, Homer, Juneau, Kenai, Kodiak, Seward, and Valdez and distribution of the public notice to radio stations broadcasting to these communities as well as Chenega Bay, Tatitlek, Whittier, Seldovia, Port Graham, Nanwalek, and Kodiak area villages. To the maximum extent possible, reasonable public notice shall also be provided to other communities within the spill area. The public notice shall identify the purpose of the meeting and include a reasonable opportunity for public comment.

4. *Access to Information.* Except where documents are confidential under state or federal law, the public shall have access to the official record of the Trustee Council's actions and information regarding proposed or completed projects or other activities funded by the Trustee Council.

III. Financial Procedures

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
FINANCIAL PROCEDURES

SETTLEMENT FUNDS

1. *Joint Trust Funds*. The Joint Trust Funds consist of all payments received or to be received by the United States and the State of Alaska pursuant to the Agreement and Consent Decree issued in United States v. Exxon Corporation, et al. (No. A91-082 CIV) and State of Alaska v. Exxon Corporation, et al. (No. A91-083 CIV), including any interest accrued thereon.

2. *Court Registry Investment System*. Pursuant to Court Order and in accordance with the Terms of the Memorandum of Agreement and Consent Decree, from December 1991 through October 5, 2000, the Joint Trust Funds were placed in an interest-bearing account in the Court Registry Investment System (CRIS) administered through the United States District Court for the Southern District of Texas. The CRIS established two accounts – the *Exxon Valdez* Oil Spill Settlement Account and the CRIS – *Exxon Valdez* Reserve Fund to receive and hold the Joint Trust Funds. Although the Joint Trust Funds were moved in October 2000 from the Court Registry System to the Alaska Department of Revenue, Division of Treasury, the Court Registry Investment System is still an investment option for the Trustee Council.

3. *Investment Fund(s)*. The Governments sought and obtained Congressional approval to expand options for investment of the settlement proceeds. Public Law 106-113, the Consolidated Appropriations Act, 2000, was enacted November 29, 1999. Section 350 of H.R. 3423, authorizes deposit of all or a portion of the Joint Trust Funds previously received, or to be received, by the Governments in the Natural Resource Damage Assessment and Restoration Fund or accounts outside the United States Treasury or both. See section on Investment Fund.

4. *CRIS Disbursement*. Upon joint application of counsel for the United States and the State of Alaska, the United States District Court for the District of Alaska orders the disbursement of funds for purposes consistent with the Memorandum of Agreement and Consent Decree. The joint application shall consist of legal documents required by the Court and documentation demonstrating the unanimous agreement of the Trustee Council. When appropriate, interest earned on the federal and state accounts and/or unobligated balances from prior years' Work Plans shall be subtracted from the disbursement.

5. *Investment Fund(s) Disbursement*. Upon unanimous approval of the Trustee Council, the Alaska Department of Law and the United States Department of Justice shall be requested to notify the United States District Court for the District of Alaska. The notification shall consist of legal documents required by the Court and documentation demonstrating the unanimous agreement of the Trustee Council. Concurrently, the Alaska Department of Law and the United States Department of Justice shall be requested to provide the custodian(s) of the Investment Fund(s) with payment instructions. When appropriate, interest earned on the federal and state

accounts and/or unobligated balances from prior years' authorizations shall be subtracted from the disbursement.

6. *Authority to Spend.* No obligations shall be incurred until such time as a Court Order is entered by the United States District Court for the District of Alaska or a notification is filed with the United States District Court for the District of Alaska and any terms and conditions placed on the funding by the Trustee Council have been met.

7. *Federal Account.* In accordance with federal law, funds required for federal project implementation are deposited in the Natural Resource Damage Assessment and Restoration (NRDA&R) Fund managed by the Department of the Interior.

8. *State Account.* In accordance with state law, funds required for state project implementation are deposited in the *Exxon Valdez* Oil Spill Settlement Fund.

INVESTMENT FUND

1. *General.* Under Public Law 106-113 (1999), some or all of the joint trust funds may be deposited in the Natural Resource Damage Assessment and Restoration Fund or accounts outside the United States Treasury, or both. Where the Trustee Council exercises this authority, it is responsible for the prudent investment of the settlement funds in income-producing obligations and other instruments or securities that have been determined by unanimous vote of the Trustee Council to have a high degree of reliability and security.

2. *Policies.* The Trustee Council shall adopt written investment policies to protect and manage an Investment Fund(s).

3. *Asset Allocation.* The Trustee Council recognizes that strategic asset allocation is the single most important policy decision affecting investment return and risk for an Investment Fund. At least annually, the Trustee Council shall evaluate its strategic asset allocation.

4. *Reporting.* Revenues and disbursements associated with the Investment Fund shall be reported to the Trustee Council on a monthly basis. Fees assessed by the Alaska Department of Revenue for the Investment Fund shall be paid on a quarterly basis.

PROJECT AUTHORIZATION

1. *General.* Authorization to expend personal services, travel, contractual, commodities, equipment and general administration funds shall be consistent with the project budgets approved by the Trustee Council.

2. *Fiscal Year.* Unless otherwise approved by the Trustee Council, the fiscal year begins on October 1 and ends on September 30. In the event the Trustee Council approves a project with a

different fiscal year, the fiscal year must be clearly stated in the approval motion. In the event the Trustee Council approves a capital project, the designation as a capital project must be clearly stated in the approval motion.

3. *Adjustments.* As long as an adjustment does not alter the underlying scope or objectives of the affected projects, agencies have the authority to move funds into or out of projects up to the cumulative amount of $10,000 or up to 10% of the authorized level of funding for each affected project, whichever is less. In addition, as long as an adjustment does not alter the underlying scope or objectives of the project, agencies are authorized to move, within a single project, budgeted funds between line items and may change detailed items of expenditure to accommodate circumstances encountered during budget implementation. Justification and supporting documentation as to the reason for all such adjustments (both between projects and line-items) shall be maintained by the agencies. All adjustments between projects shall be reported to the Executive Director in the Quarterly Financial Report. For further information regarding the Quarterly Report, refer to the Accounting section of these procedures.

4. *Revisions.* Trustee Council action is required to move amounts greater than that authorized in section 3 above. Trustee Council action is also required if the revision changes the scope or objectives of a project, establishes a new project, or terminates an approved project during the fiscal year. In the event the proposed revision changes the scope or objectives of a project, establishes a new project, or terminates an approved project during the fiscal year, the public shall be given a reasonable opportunity to review and comment on the proposed change prior to action of the Trustee Council.

PROJECT COSTS

1. *Direct Project Costs.* Direct costs are those costs that can be identified with or linked to a specific project.

2. *Indirect Project Costs.* Indirect costs are those that are incurred for common or joint projects and therefore cannot be identified readily and specifically with a project. In the case of governmental agencies, indirect costs are covered through a general administration formula. The appropriate indirect rate for contractors shall be approved on a case-by-case basis.

3. *General Administration Formula.* [PLEASE NOTE THIS SECTION IS STILL UNDER REVIEW AND OPEN FOR DISCUSSION.] The general administration formula is used to reimburse governmental agencies for indirect project costs incurred in implementing the restoration program. The general administration formula is nine percent of each project's direct costs. General administration funds may be spent at the agency's discretion provided they are spent on indirect costs incurred in implementing activities funded by the Trustee Council. Agencies are entitled to 100% of their budgeted general administration funds regardless of how much of their budgeted direct project funds have been expended.

4. *Unallowable Costs.* Restoration funds shall be used only for costs that directly benefit Trustee Council approved projects with the exception of reimbursement of general administration (i.e., indirect) costs that are calculated in accordance with the general administration formula.

5. *Bonuses.* Bonuses for personnel working on Trustee Council funded activities are allowable costs. Agencies shall follow their standard operating procedures in determining bonus awards. Bonuses shall be considered an indirect project cost and may be paid with General Administration funds.

ACCOUNTING

1. *General.* It is the responsibility of agency personnel and certifying officers to make certain that all actions are based on sound accounting and budgetary practices.

2. *Source Documentation.* Adequate justification and supporting documentation shall be maintained for each project.

3. *Appropriateness.* Expenditures charged to a project must be directly attributable to or allocated to the project benefiting from the activity. Salaries and benefits may be charged for the time an individual is working directly on a project, when supported by time sheets and when work performed by such individuals is necessary to the project.

4. *Reasonableness.* Costs attributable to a project must be necessary and reasonable to achieve the objectives of the project and be consistent with the policies and procedures governing other activities of the agency.

5. *Segregation.* Accounts must be properly designed and maintained to ensure that funds are expended in accordance with Trustee Council approval.

6. *Expended (Outlays).* The term expended shall be defined as the actual outlay of funds through the issuance of checks or warrants, the disbursement of cash, or the electronic transfer of funds. The term expenditure shall be defined as the act of expending.

7. *Obligations (Encumbrances).* The term obligations shall be defined as a commitment to acquire goods or services during the fiscal year, or to accommodate contracts where the length of time for completion of the service extends into the following fiscal year. An obligation is a commitment to pay and should not be considered an expenditure until the goods or services have been received and the invoice paid. Funds approved for contracts in which the length of time for completion of the service extends into the following fiscal year may be obligated at year end. To be valid, the length of time to complete the service should be identified in the Detailed Project Description and budget approved by the Trustee Council. As a general rule, agencies shall have

one year from the end of a project's approved fiscal year to satisfy all obligations.

8. *Reporting: Quarterly Financial Reports.* Within thirty days following the end of each quarter, agencies shall report expenditures and obligations recorded at the end of the quarter to the Executive Director. The report shall include the total amount authorized for each project, any revisions approved by the Trustee Council, any adjustments between projects, the total expended by project, and the total of any outstanding obligations by project.

9. *Reporting: Annual Financial Reports.* By January 31 of each year, agencies shall report to the Executive Director the total expended for each project, plus any valid obligations relating to the fiscal year just ended. The report shall reflect the total amount authorized by line-item, any revisions approved by the Trustee Council, any adjustments between projects, and any adjustments between line-items.

LAPSE

1. *General.* The unexpended and unobligated balance of a project shall lapse on September 30 of the fiscal year for which the project was approved. However, an undisclosed obligation may be established and/or paid during the Close-Out Period.

2. *Capital.* The unexpended balance of a capital project shall be carried forward for two subsequent fiscal years. At the end of the three year period, the unexpended and unobligated balance shall lapse. Trustee Council action is required to extend the project lapse date beyond the three year period.

3. *Close-Out Period.* During the months of October, November and December agencies may pay from prior year funds an expense that was undisclosed during the fiscal year just ended. In addition, agencies may establish obligations to accommodate an expense that was undisclosed during the fiscal year just ended. By January 31 of each year, agencies shall report to the Executive Director the total expended for each project, plus any valid obligations relating to the fiscal year just ended. For further information regarding the Annual Financial report, refer to the Accounting section of these procedures.

4. *Reimbursement for Prior Year Expenses.* Expenses discovered after the Close-Out Period (i.e., after December 31) may be charged to the subsequent year's project budget if the project has multiple years of funding and sufficient funds are available. In the event the agency determines that insufficient funds are available to charge the expense to the subsequent year's budget, or the expense relates to a completed project (i.e., there is no subsequent year's budget), authority to adjust a prior year Annual Financial Report is required. During the months of January through June, authority to adjust a prior year Annual Financial Report may be provided by the Executive Director. For expenses discovered after June, authority to adjust a prior year Annual Financial Report may be provided by the Trustee Council.

EQUIPMENT

1.*Title and Use*. Equipment shall be used for the project for which it was acquired. Items with an original per unit cost of under $5,000 shall belong to the acquiring agency. Items with an original per unit cost of $5,000 and over shall belong to the acquiring agency on behalf of the Trustee Council. At the end of a project that has equipment with an original per unit cost of $5,000 or more, the Executive Director shall determine if the equipment item shall be used for another Trustee Council project or if the item shall remain with the acquiring agency. If the equipment shall be used for another Trustee Council project administered by an agency other than the acquiring agency, the title for the equipment shall be transferred to the agency administering the new project. If the equipment shall remain with the acquiring agency, and it was purchased by a contractor, the agency may, at its discretion, transfer the title to the contractor. This section shall apply to all equipment purchased under the restoration program, for projects already in progress or completed as well as for projects funded in the future.

2. *Surplus*. Equipment that belongs to the acquiring agency shall be surplused in accordance with agency procedures.

4. *Inventory*. Property records shall be maintained in accordance with agency procedures.

5. *Repair, Maintenance and Safeguarding*. The repair, maintenance and safeguarding of equipment purchased with joint funds shall be accomplished in accordance with agency procedures.

6. *Disposal*. Equipment that ceases to function shall be disposed of in accordance with agency procedures.

7. *Reporting*. By December 31 of each year, agencies shall report all equipment with an original per unit cost of $5,000 or more to the Executive Director. The report shall include a description of the equipment (make and model), date the equipment was purchased, the purchase price, where the equipment is located and the condition of the equipment. The report shall also identify the project that is using the equipment.

CONTRACTS

1. *General*. Agencies shall ensure that contracts for professional and non-professional services are accomplished in accordance with the terms, conditions, and specifications of the project approved by the Trustee Council and in accordance with applicable Federal and State laws.

2. *Definitions*. Professional services means contracts for professional, technical, or consultant services that result in the production of a report or the completion of a task, and

includes analysis, evaluation, prediction, planning, or developing a recommendation. Non-professional services means contracts for services that are primarily manual in nature, and includes boat charters, printing, and other. Non-professional services contracts usually result in a service rather than a product or report.

3. *Named Recipient.* In the event the Trustee Council determines that, in order to carry out its mandate under the Memorandum of Agreement and Consent Decree, a particular person or entity should implement all or a portion of a project through a state Trustee agency, the Trustee Council may, by unanimous vote, name a contract recipient. The approval motion shall include the reason for selecting the contract recipient. If the contracting agency determines that an award to an entity different than that named by the Trustee Council would better serve the program, the basis of that determination shall be stated in writing to the Executive Director and forwarded to the Trustee Council for approval.

4. *Indirect Rates.* The appropriate indirect rate for contractors shall be determined on a project by project basis or through a memorandum of understanding with a contractor that provides for a consistent rate and methodology.

5. *Equipment.* Equipment purchased by the contractor shall remain the property of the contracting agency. See section on Equipment.

6. *Special Considerations.* All notes and other data developed by the contractor shall remain the sole property of the contracting agency.

GRANTS

1. *General.* Grants may be used as a procurement mechanism, but only to the extent they are permitted under existing state and federal laws. Federal Trustee agencies were given additional grant authority under Public Law 106-113 (1999).

AUDITS

1. *General.* The purpose of an audit is to ensure public trust and accountability regarding the use of settlement funds. An audit provides credibility to the information reported by or obtained from management by independently acquiring and evaluating the evidence.

2. *Definition.* The term audit includes both financial and performance audits.

3. *Readiness.* When an agency receives funding from the Trustee Council, the agency assumes certain responsibilities with respect to those funds. These include ensuring that source documentation is organized and available for review, internal controls are documented and individuals knowledgeable about the projects are available to answer questions.

Contracts. Contractors who receive funding for professional or non-professional services are not automatically subject to an annual audit. However, this does not preclude the Trustee Council or the agency from making a determination that an audit is required in addition to an agency's review of expenditure documentation and work produced by a contractor.

5. *State and Federal Audits*. Each Federal agency and the State of Alaska have audit functions. In the event an audit is performed on a Trustee Council funded activity, a copy of the audit shall be provided to the Executive Director.

6. *External Audits*. All external audits shall be conducted in accordance with Governmental Auditing Standards. In addition, the firm and the staff assigned to conduct the audit shall be independent of the Trustee Council, the funding agencies, the Alaska Department of Revenue, the Court Registry Investment System, Exxon Corporation, Exxon Shipping Company and Exxon Pipeline Company.

APPENDIX A: FEDERAL INTERNAL PROCEDURES

NATURAL RESOURCE DAMAGE ASSESSMENT AND RESTORATION FUND

1. *Segregation.* All principal and interest shall be accounted for separately by the Department of the Interior, Office of the Secretary. Each disbursement shall be assigned an appropriate account, sub-activity and/or project number when deposited to the aggregate Natural Resource Damage Assessment and Restoration Fund within the Federal Reserve Bank. Confirmation of the deposit shall be provided to the Treasury Department, which reconciles the deposit with the Federal Reserve Bank.

2. *Investments.* By law, the funds may only be invested in Treasury Securities and all ownership is maintained in the name of the Natural Resource Damage Assessment and Restoration Fund. Based on an estimate of cash flow requirements, the Department of the Interior, Office of the Secretary generates instructions for investment and forwards the instructions to the National Business Center. The National Business Center develops and submits an Investment Confirmation Letter that indicates which account investments are being purchased, the scheduled maturity dates and the investment type(s) to the Department of Treasury, which purchases the securities. At maturity, interest income is paid directly to the account.

3. *Reports.* Quarterly, the Department of the Interior shall report interest income to the Executive Director. In addition, all disbursements to the federal agencies shall be reported to the Executive Director. By March 31 of each year, the Department of Interior shall report to the Executive Director all lapsed funds returned to the Natural Resource Damage Assessment and Restoration Fund by the federal agencies.

AUTHORIZATION

1. *General.* Congress permanently appropriated funding approved by the Trustee Council in Section 207 of Public Law 102-227. However, all authorization is subject to compliance with any terms and conditions imposed by the Trustee Council.

2. *Budget and Reports.* Under Section 207, agencies are required to comply with directions published by the Federal Office of Management and Budget. This includes submitting a budget for the upcoming fiscal year and documentation associated with the current and prior fiscal year.

3. *Obligation Authority.* Prior to the obligation of any funds, agencies must first complete the allocation process required by their respective budget offices to establish codes for each project. The allocation process provides the authority, amount of funding and the guidance with which to obligate funds.

4. *Instructions for Transfer*. Federal agencies are required to submit an annual cash flow plan to the United States Department of the Interior, Office of the Secretary, Natural Resource Damage Assessment and Restoration Office, and instructions regarding the transfer of settlement funds. The instructions shall specify the purpose of the transfer, which account the funds are to be transferred to, and an estimate of cash flow requirements. Unless the transfer represents a one-time payment, the cash flow estimate shall be structured on a quarterly basis. Any change in cash flow requirements that occurs during the fiscal year shall be communicated to the United States Department of the Interior, Office of the Secretary, Natural Resource Damage Assessment and Restoration Office, in writing. A change is defined as a decrease in the cash flow requirement due to an unanticipated delay in a project or an increase in the cash flow requirement due to an unanticipated change in the schedule, or subsequent Trustee Council action.

5. *Fund Transfers*. The vehicle used for transfers is a SF1151, a non-expenditure transfer. The SF1151 is initiated, prepared, and approved by the Natural Resource Damage Assessment & Restoration Office, Office of the Secretary and then sent to Treasury where the funds are transferred within the Treasury system.

6. *Return of Unobligated Balances*. On March 15 of each year, federal agencies shall return to the Natural Resource Damage Assessment and Restoration Fund the unobligated balance for the fiscal year just ended. Concurrently, the agencies shall return any recovery of prior year obligations. Agencies are required to submit to the United States Department of the Interior, Office of the Secretary, Natural Resource Damage Assessment and Restoration Office, a report reflecting the total unobligated balance for the fiscal year just ended and the amount of funding recovered from prior year obligations. The report submitted shall also indicate the date the agency intends to return the funds. The vehicle used for transfers is a SF1151, non-expenditure transfer. The Department of the Interior shall report the total unobligated balance for the fiscal year just ended and the amount of funding recovered from prior year obligations to the Executive Director by March 31 of each year.

APPENDIX B: STATE INTERNAL PROCEDURES

EXXON VALDEZ OIL SPILL SETTLEMENT FUND

1. *Segregation.* All principal and interest shall be accounted for separately by the Alaska Department of Revenue, Division of Treasury. Each disbursement shall be deposited in a Department of Law sub-account, *Exxon Valdez* Oil Spill Settlement Fund. Confirmation of the deposit shall be provided by the bank to the Alaska Department of Revenue.

2. *Investments.* The Alaska Department of Revenue, Division of Treasury shall calculate the daily income amount and provide for daily compounding (including weekends and holidays). The income shall be credited to the fund and posted in the Alaska State Accounting System on a monthly basis.

3. *Reports.* The Alaska Department of Revenue, Division of Treasury shall report income earned to the Executive Director on a monthly basis.

AUTHORIZATION

1. *General.* Pursuant to Alaska Statute 37.14.405(a), a state agency may not expend money received from the trust unless the expenditure is in accordance with an appropriation made by law. However, prior to the expenditure of funds, Trustee Council approval must be obtained, the notice filed, any terms and conditions placed on the funding by the Trustee Council met, and the funds transferred from the Investment Fund to the *Exxon Valdez* Oil Spill Settlement Fund, if necessary.

2. *Budget and Reports.* To meet the requirements of Alaska Statute 37.14.415, agencies are required to comply with directions published by the State Office of Management and Budget, Division of Budget Review. Alaska Statute 37.14.415 states: The state trustees shall

(1) submit to the governor and the legislature by December 15 of each year a report setting out, for each object or purpose of expenditure, the amounts approved for expenditure from the trust during the preceding fiscal year and the amounts actually expended during the preceding fiscal year;

(2) prepare and submit, under AS 37.07, a budget for the next fiscal year setting out, for each object or purpose of expenditure, the Trustees' estimate of the amounts that are, during the next fiscal year, to be funded by the trust and expended by state agencies; and

(3) prepare and submit to the legislature, at the same time the budget for state agency expenditures is submitted under (2) of this section, a proposal setting out, for each object or purpose of expenditure, the trustees' estimate of the amounts that are to be funded by the trust in the next fiscal year and that are not included in the budget submitted under (2) of this section.

3. *Legislative Budget and Audit Committee.* Alaska Statute 37.14.405(b) allows agencies to meet the requirements of an appropriation conditioned on compliance with the program review

provisions of AS 37.07.080(h). In accordance with the procedures of the Alaska Office of Management and Budget (OMB), agencies are required to submit a request to OMB for transmittal to the Legislative Budget and Audit Committee.

4. *Expenditure Authority.* Authorization to receive and expend shall be recorded in the Alaska State Accounting System within the *Exxon Valdez* Oil Spill Settlement Fund. Following legislative action, OMB will record the authorization by approving an Authorized Budget Transaction (AB).

APPENDIX C: INVESTMENT FUND(S)

1. *General.* The Trustee Council, through appropriate state and/or federal agencies, may contract for investment, custodial or depository services on a discretionary or non-discretionary basis, with the State and Federal governments, or with independent investment management firms, banks, financial institutions or trust companies by designation through appointments, contracts or letters of authority.

2. *Segregation.* All principal and interest shall be accounted for separately by the custodian.

3. *Reports.* The custodian shall provide to the Executive Director financial reports on a monthly basis. The monthly report shall reflect all activity associated with the Investment Fund(s) including the date and amount of each transaction, any pending transactions, interest received, purchases, sales and other transactional data on a day-to-day basis. In addition, the custodian shall provide a monthly report which sets forth the opening balance in the Investment Fund(s), associated transactions and a reconciliation to the final balance. The investment manager shall provide to the Executive Director a suite of financial and performance reports on a monthly basis. The monthly financial report shall contain an asset appraisal which sets forth all of the assets held by the Investment Fund(s). The report shall provide detailed information such as cost and market value, current yield and percentage of each investment and sector. In addition, the investment manager shall provide monthly and cumulative performance reports. The performance reports shall include a comparison to the benchmarks approved by the Trustee Council.

4. *Investments.* By unanimous consent, the Trustee Council shall determine the strategic asset allocation and bands. The Executive Director shall have discretion to move assets among asset categories provided that such actions are consistent with movement of the actual asset allocation within the variability bands of the Trustee Council's strategic asset allocation policy. The Executive Director shall make the necessary adjustments to the initial target allocation within 30 calendar days. The Executive Director shall report any asset shifts at the next Trustee Council meeting. Such reports shall include a description of the rationale for the shift.

5. *Performance.* The Trustee Council shall identify benchmarks to evaluate Investment Fund(s) performance. Performance shall be evaluated relative to the identified benchmarks and also relative to an appropriate peer group of competitive alternatives. On a biannual basis, performance shall be presented to the Trustee Council.

6. *Fees.* No fees shall be assessed by the custodian except as approved in advance by the Trustee Council.

IV. Data Policy

The overall purpose of these policy statements is to facilitate full and open access to, and use of with confidence, both now and in the future, the data and information used in and results from the Gulf of Alaska Ecosystem Monitoring and Research Program (GEM).

The GEM Data Policy has the following objectives, to:

1. Make information from GEM projects available to other scientists and to the general public in a well documented and understood form.

2. Protect the citation right of investigators who collect data, develop models, or who apply models to generate significant new insight. The Trustee Council believes that description and interpretation of the results of research is the privilege and responsibility of those who collect data or develop and apply models. However, investigators must not unreasonably impede the exchange of information essential to comparative and interdisciplinary research, interpretation, and synthesis.

3. Ensure that data and samples are collected in a manner which will yield accuracy and precision sufficient for the objectives of each field program and sufficient for those comparisons and syntheses among programs which can be anticipated. It is fundamental to any research program that high-quality data be collected. While the primary responsibility for this always belongs to the Principal Investigator, GEM program administration must provide guidance, coordination and monitoring, particularly for situations where the data quality appropriate for an individual project is not the same as that required by an interdisciplinary program of large geographic and temporal extent.

4. Preserve all data collected under GEM funding (except that specifically exempted by GEM program administration) in an archive accessible to the scientific community in a timely manner. Data to be archived include GEM-funded compilations, analyses and syntheses of previously recorded data, even though the data themselves may be in the public domain. The archive and the means established for retrieving data it contains must foster both disciplinary and interdisciplinary data syntheses. A special goal of the GEM program is that the data collected ultimately yield generalizations at a larger scale ecosystem level. In order to accomplish this, it is important that both the data collected and the archival format allow comparisons among different field programs.

5. Preserve models developed with GEM funding in an archive accessible to the scientific community. The inputs and results of key numerical experiments employing models should also be archived, if they have been the basis for publications. The GEM program administration believes that inclusion of models in the GEM archive is necessary to realize maximal benefits from the considerable planned investment in modeling.

6. Encourage the voluntary release of data and other products of GEM-funded research by Principal Investigators at any time before the deadlines given in this document.

The policy has been developed in accordance with known current guidelines and/or standards for environmental data collection activities. In practice, the GEM Data Policy must comply with federal and state law and be consistent with that of sponsoring agencies. If any material differences exist between the GEM Data Policy and federal or state law, or policies of a sponsoring agency, the Principal Investigator must identify the differences to GEM program administration for resolution.

This policy supplements the Trustee Council's "*Procedures for State Agencies and Their Contractors for Destroying Documents or Physical Evidence Related to the Exxon Valdez Oil Spill.*"

To ensure that these policies will be followed for all GEM projects:

1. All Principal Investigators will agree to follow GEM data policies as a condition of receiving funding under the GEM program.
2. The Trustee Council Executive Director will be notified of any instances where GEM data policies are not being followed, and which cannot be resolved by the parties directly involved. The Trustee Council Executive Director will review the situation and recommend a course of action, which could include notification of parent agencies of principal investigators who have not complied with the GEM Data Policy and/or preclude funding for future projects.

Data Collection Policy

Upon receiving GEM funding, the principal investigator (PI) will be contacted by the GEM Data Systems Manager to establish a Data Management Plan (DMP), which will supplement information in the Detailed Project Description (DPD). This plan will include procedures to process, document and migrate all data to be collected to archives identified by the GEM Data Systems Manager. In addition, the GEM Data Systems Manager will collaborate with the PI(s) on data formats. To provide the opportunity for comparison with historical data, measurement techniques should be consistent with techniques used to collect the existing data unless there is significant scientific justification for change. When new techniques are adopted, methods for relating the new data to existing data should be developed.

Of particular interest are the following considerations, and each must be specifically addressed by the principal investigator in describing collection and analysis methodology:

1. Measurements to be made and the anticipated precision and accuracy of each measurement.
2. A description of the sampling equipment sufficient to permit an assessment of the anticipated raw-data quality. Typical descriptions will include where appropriate: navigation, timekeeping, sensor make and model, net opening and mesh size, rate of retrieval, mooring configuration, and similar information appropriate to the types of samples to be collected. Where the data collection equipment is well known or documented in generally available technical reports or the published literature, the need for documentation will be substantially reduced and may be satisfied by identifying the system or referring to the appropriate documentation.
3. A description of the analysis methodology sufficient to permit an assessment of the anticipated analyzed-data quality. Typical descriptions will include where appropriate: filter size and type, sample preservation technique, counting method, numerical algorithm, incubation procedure and similar details as appropriate to the measurements planned.
4. A discussion of the means by which the measurements to be taken could be compared with historical observations or with regions which are thought to have similar ecosystems. When the sampling method is critical to the interpretation and utilization of data type, a description of sampling methods used in the region or in similar regions during past experiments must be included. Where the planned sampling method differs from the previously used measurement technique, the principal investigator must either demonstrate that a quantitative comparison will be valid or provide justification for the change in technique.

Data Management Plans will be updated yearly for continuing projects, and for the year following completion of data acquisition until all data resulting from the project enters the archive. The

PI(s) responsible for collecting data funded by GEM must submit, and have approved, quality assurance and quality control (QA/QC) protocols as part of the DPD/DMP.

Data Processing Policy

The PI(s) responsible for collecting data on projects funded by GEM must apply approved QA/QC protocols to these data sets.

Within 60 days after data or sample collection is completed, a detailed inventory of measurements made or samples collected must be submitted to the GEM Data Systems Manager by the PI(s). This inventory will include the time and location of each measurement or sample, as well as the nature of the measurement or planned analyses of the sample.

Policy for Data Submission to the GEM Archive

Results of measurements which do not require time-consuming analyses, especially those which may provide basic environmental characterization needed by to other GEM investigators, should be submitted within six (6) months after the completion of data collection. The data categories to which this submission requirement applies will be specified in the DPD/DMP. All other measurements should be made within 12 months after field collection, or submitted with the final report for the project, whichever occurs first. Such measures will also be identified in the DPD/DMP. The PI(s) will advise the GEM Data Systems Manager if these schedules cannot be met.

Under no circumstances will a data file, data set, data layer, or database be accepted by or made available via the GEM archive without appropriate supporting metadata ("data about data"). Metadata usually include, but may not be limited to, location, time, units, accuracy, precision, method of measurement, method of sensor calibration and sensor calibration data, analyst or operator, and data processing methods. The metadata format will be compliant with the Federal Geographic Data Committee (FGDC) standards.

In coordination with the GEM Data Systems Manager, the PI(s) will include, at a minimum, the following information with each data set archived:

1. collection dates and times (Greenwich Mean Time [GMT]);
2. precise location (decimal degrees longitude and latitude, depth(s))
3. data collection methods;
4. data format (e.g., ASCII, Excel spreadsheet, ARC/INFO coverage, etc.);
5. data collection problems, data processing problems, bad data flags, data dropouts, and other quality control factors identified by the PI(s);
6. instrument descriptions and calibrations;
7. collection site descriptions and conditions; and
8. conditions for use and citation

Data sets may have specific additional guidelines; the PI(s) will accommodate whatever special considerations are necessary. Data information sheets designed by the GEM Data Systems Manager will help the PI(s) encapsulate this information and include it with the data when migrated to the GEM archive. The PI(s) will be required to submit metadata information to appropriate data clearinghouse(s) identified by the GEM Data Systems Manager.

The Federal Ocean Data Policy requires that appropriate ocean data and related information collected under federal funding be submitted to and archived by designated national data centers. Funding agencies, with assistance from the centers, identify the data and require their principal investigators to submit these data within specified time periods. GEM PI(s) will be required to submit their data sets to appropriate national data center(s) identified by the GEM Data Systems Manager.

Data Model Archive Policy

The GEM archive will also include selected data models developed with GEM funding, and products or results of modeling conducted with GEM support. Data models and/or model products will be chosen by the GEM Scientific-Technical Advisory Committee (STAC) for archiving if they are central to achieving the large-scale goals of a GEM study, and/or if they will be useful to a substantial group of PI's for GEM-funded projects.

If archiving of a data model and/or model products will be required, this will be specified in both the DPD/DMP and the funding award letter. Deadlines for submission and the length of the proprietary period will also be specified. Submission of other models and/or model products, not specified in the DPD/DMP, is encouraged if they are likely to be useful to other GEM investigators and the scientific community.

Archived computer models should include source code in a commonly used scientific language. Documentation, sufficient to allow use of the model by persons having the knowledge and abilities typical of numerical modelers, should also be submitted. Model products submitted must include sufficient explanation so that they can be understood by persons having knowledge and abilities typical of GEM investigators.

Data Dissemination Policy

Data collected in conjunction with GEM is considered public information.

Processed data and models will not be officially disseminated to the public for a period of two (2) years from the date of the data collection. The PI retains exclusive analysis and publication use of the data collected during the first year following data collection. After one year, data will be available to other GEM investigators. Two (2) years after data collection, the data will be made available to all other science users through the GEM archive. However, if the data are requested pursuant to the Freedom of Information Act or the Alaska Public Records Act, the Trustee Council is required to release any data which are transferred to the Trustee Council by the PI.

The PI may own a copyright on the publication of the processed data developed or bought under GEM funding. The *Exxon Valdez* Oil Spill Trustee Council reserves a royalty-free, nonexclusive, and irrevocable license to reproduce, publish, or otherwise use, and to authorize others to use, for GEM purposes, the copyright in any work developed under an award, or any rights of copyright purchased by an PI with GEM funding. Any such publication will include a notice identifying the award and recognizing the license rights of the GEM program under this clause. This paragraph will have no force and effect for the processed data not published by the PI.

GEM retains the right to analyze, synthesize and publish summaries of the data. The PI retains the right to be fully credited for having collected and processed the data. Following academic courtesy standards, the release of data to third parties will stipulate that the PI and the GEM project under which the data were collected will be fully acknowledged in any subsequent publications in which any part of the data is used. Manuscripts resulting from this GEM-supported research that are produced for publication in open literature, including refereed scientific journals, will acknowledge that the research was conducted under GEM funding.

Data Citation Policy

The PI retains the right to be fully credited for having collected and processed the data. Following academic courtesy standards, the PI and GEM project under which the data were collected will be fully acknowledged in any subsequent publications in which any part of this data set is used. Manuscripts resulting from this GEM-supported research and data collection effort that are produced for publication in open literature, including refereed scientific journals, will acknowledge that the research was conducted under GEM funding.

Persons who acquire data, models, or model products from the GEM data archive are responsible for communicating with the originating investigator(s). If a substantial use of the data is planned, collaboration and co-authorship with the originating PI(s) is expected for any resulting publications. However, originating PI(s) may not unreasonably impede use or publication of archived data, models, or model applications, provided that they receive due credit for their contribution.

Data Liability Policy

The data sets are only as good as the quality assurance and quality control (QA/QC) procedures applied to each project. The user bears all responsibility for its subsequent use or misuse in any further analyses or comparisons. The GEM program does not assume liability to the recipient or third persons, nor will the GEM program reimburse or indemnify the recipient for its liability due to any losses resulting in any way from the use of this data set.

V. Report Procedures

INTRODUCTION

These *Procedures for the Preparation and Distribution of Reports* provide instructions regarding the preparation, peer review, printing and distribution of final and annual reports for projects funded by the *Exxon Valdez* Oil Spill Trustee Council.

Unless otherwise specified by the Trustee Council Office, each project funded by the Trustee Council shall ultimately produce a *final* report subject to approval through the Trustee Council's peer review process. In the case of multi-year projects, an *annual* report shall also be prepared each year until the project is completed, at which time a final report shall be prepared. Annual reports may be peer reviewed. Subject to the approval of the Trustee Council Office, on a project-by-project basis, journal articles or manuscripts may be used to fulfill requirements for the preparation of final and annual reports (see below, page X).

These *Procedures for the Preparation and Distribution of Reports* update and supersede earlier versions of this document and should be read together with the report writing guidelines published by the *Journal of Wildlife Management* (Ratti, J. and L. Smith, 1998). (Appendix 1) To the extent that there are any inconsistencies between these *Procedures for the Preparation and Distribution of Reports* and the guidance provided by Ratti, J. and L. Smith (1998), the instructions provided in these *Procedures* shall be followed.

The primary changes in these *Procedures*, as compared to the previous version of this document, are a new format and review process for annual reports and the addition of review procedures for Gulf Ecosystem Monitoring and Research (GEM) project final reports (see page XX).

NOTE: For purposes of identification, GEM projects each have a six-digit project number preceded by the letter G (e.g., G-030204, G-042362). The letter G signifies GEM; the first two digits identify the fiscal year in which the phase of the project was authorized; and the last four digits provide a specific project identifier. Restoration projects each have a five or six-digit project number (e.g., 95225, 034520--those funded before FY 03 have five digits; those funded for FY 03 and after have six digits). The first two digits identify the fiscal year in which the phase of the project was authorized; the last three or four digits provide a specific project identifier. Natural Resource Damage Assessment (NRDA) projects are designated by alpha-numeric project numbers (e.g., MM6 for "Marine Mammal Study 6" or FS2 for "Fish/Shellfish Study 2"). For all projects, the number that appears on the cover of an annual report reflects the year in which the project work being described was conducted; the number that appears on the cover of a final report reflects the final year in which the project work was conducted.

FINAL REPORTS: NRDA, RESTORATION & GEM PROJECTS

Purpose. A final report for a project must be a comprehensive report addressing all the objectives identified over the course of the entire study. The final report shall address the original objectives of the study as identified in the approved Detailed Project Description and account for any changes in the objectives. Final NRDA reports shall be viewed as both the first and last word on the subject for the purpose of damage assessment under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and its amendments. The principal investigator for a project is responsible for the submission and production of a final report.

I. Preparation: NRDA, Restoration & GEM Project Final Reports

1. **Final Report Format** - Authors shall follow the format set out below to prepare final reports. Reports shall meet normal scientific standards of completeness and detail that shall permit an independent scientific reader to evaluate the reliability and validity of the methods, data and analyses.

   A. **Report Cover** – An example of a final report cover is provided. (Attachment A) A final report cover shall:

   - identify the report as either a[1]

     ✓ Natural Resources Damage Assessment final report,
     ✓ Restoration Project final report, or
     ✓ GEM Project final report;

   - provide the report title;

   - include the project identification number, using the project number for the final year in which the project work was *actually conducted* (i.e., not the data analysis/report writing or "closeout" year);

   - identify the author(s) with appropriate affiliation(s);

   - include the date (month and year) of publication; and

1 Include on the Cover Page and the Title Page the following uniform titles. For NRDA reports: *Exxon Valdez* Oil Spill State/Federal Natural Resource Damage Assessment Final Report. For Restoration Project final reports: *Exxon Valdez* Oil Spill Restoration Project Final Report. For GEM Project final reports: *Exxon Valdez* Oil Spill Gulf Ecosystem Monitoring and Research Project Final Report. See Attachment A.

- include the following Office of Equal Employment Opportunity (OEO) and Americans with Disabilities Act (ADA) statement toward the *bottom of the page on the inside front cover* :

  The *Exxon Valdez* Oil Spill Trustee Council conducts all programs and activities free from discrimination, consistent with the Americans with Disabilities Act. This publication is available in alternative communication formats upon request. Please contact the Trustee Council Office to make any necessary arrangements. Any person who believes she or he has been discriminated against should write to: EVOS Trustee Council, 441 West 5th Avenue, Suite 500, Anchorage, Alaska 99501-2340; or O.E.O. U.S. Department of the Interior, Washington D.C. 20240. [NOTE: THIS LANGUAGE CURRENTLY UNDER REVIEW TO MAKE SURE IS CURRENT.]

- use quality cover stock and, to ensure consistent appearance, the color of the final report cover shall be as close as possible to the color of goldenrod provided in the example. (Attachment A)

B. **Title Page** - The Title Page of the report shall immediately follow the report cover page on white bond paper and be identical in terms of content and format to the front of the report cover page. (Attachment A)

C. **Study History, Abstract, Key Words, Project Data and Citation** - Following the Title Page, the report shall include, on not more than two pages: (1) a brief study history; (2) an abstract; (3) key words; (4) a brief description of data gathered during the project including its current location and a permanent contact; and (5) a recommended citation for the final report. (Attachment A)

- **Study History**. A brief study history shall include reference to all prior project numbers; changes in the title of the project or report over time; annual reports or other reports which contributed to the final report; and citation of publications that have preceded publication of the final report.

- **Abstract**. An abstract, with a maximum length of 200 words,[2] shall enable readers to quickly identify the basic content of the report, determine its relevance to their interests and thus decide whether to read the document in its entirety. If the final report consists of several chapters or manuscripts (see Use of Manuscripts for Report Writing below, page X), the abstract shall summarize the entire report. Do not use abbreviations or acronyms in the abstract.

2 A limit of 200 words is needed so that the abstract can be processed through the National Technical Information Service.

- **Key Words**. A short list of key words (up to 12 in alphabetical order) shall be provided. Include words from the title and others that identify: (1) common and scientific names of principal organisms, if any; (2) geographic area or region; (3) phenomena and entities studied (e.g., behavior, reproduction, etc.); (4) methods (only if the report describes a new or improved method); and (5) other words not covered above but useful for indexing.

- **Project Data**. A summary of the data collected during the project shall be provided in order to preserve the opportunity for other researchers and the public to access this data in the future. The summary shall: (1) *describe* the data; (2) indicate the *format* of the available data collections; (3) identify the *archive* in which the data have been stored or the *custodian* of the data (including contact name, organization, address, phone/fax, e-mail, and web address where data may be acquired); and (4) indicate any access limitations placed on the data. Limiting access requires pre-approval by the Trustee Council Office.

- **Citation**. A recommended citation for the final report shall be provided.

D. <u>Remainder of Report</u> - After the Study History, Abstract, Key Words, Project Data and Citation, the report shall continue as follows:

- **Table of Contents, including Lists of Tables, Figures and Appendices.**

- **Executive Summary**. The executive summary shall:

  ✓ consolidate principal points of the report in one place and provide enough detail for the reader to digest the significance of the report without having to read it in full;

  ✓ be written so that it can stand independently of the report (i.e., it must not refer to figures, tables or references contained elsewhere and all acronyms, uncommon symbols, and abbreviations must be spelled out);

  ✓ not exceed four single-spaced pages;

  ✓ concisely state the purpose, scope, methods, results and conclusions of the report; and

  ✓ be organized in the same manner as the report it summarizes.

- **Introduction**. The introduction shall:

  ✓ present first, with all possible clarity, the nature and scope of the problem investigated, including the general area in which field activities were conducted; and

  ✓ review pertinent literature, state the method(s) of investigation and briefly state principal results.

- **Objectives**. The statement of objectives shall be the same as the objectives identified in the final approved Detailed Project Description. If the objectives have changed, describe what has changed and why.

- **Methods**. The discussion of methods shall include a clear description of the study area. To the extent the methodology differs from that described in the Detailed Project Description, explain the reason for the deviation.

- **Results**. The presentation of results shall:

  ✓ provide an objective and clear presentation of the data collected; and

  ✓ in the case of damage assessment studies, present information in a manner that will make clear to the reader: (1) evidence of injury found, and (2) evidence that the injury found was or was not caused by the *Exxon Valdez* oil spill.

- **Discussion**. The discussion section shall:

  ✓ interpret the study results and explore the meaning and significance of the findings, including alternative interpretations of the results;

  ✓ discuss whether the study hypotheses were upheld or disproven;

  ✓ note where there are unanswered questions; and

  ✓ where appropriate, cite relevant findings from other *Exxon Valdez* oil spill restoration studies, including GEM studies, and published literature.

- **Conclusions**. This shall be a brief, clear statement of the conclusions that are apparent from the discussion. Major unanswered questions shall be identified.

- **Acknowledgments**

- **Literature Cited**

- **Other References**. If there is a need to list references other than the literature cited (for example, personal communications), these references shall be identified in this section.

2. **<u>Technical Format</u>** - The following guidelines shall help provide consistent formatting:

A. **<u>Word Processing Conventions</u>**

- **Standard Settings.**

Line

Line spacing:	single
Hyphenation:	off (i.e., do not hyphenate at right margin)
Justification:	left (i.e., do not right-justify margins)
Margins:	1 inch at top, bottom 1 inch left, right
Tabs:	every 0.5"
Widow Protection:	yes

Page

Page numbering:	bottom center
Header:	none

Font

Times:	12 point

Note: If Times is not available, some other serif font shall be used (e.g., Palatino, Bookman or New Century Schoolbook).

Literature Citations. In the Literature Cited section, start each citation with a hanging indent as shown below:

Byrd, G.V., D. Gibson, and D.L. Johnson. 1974. The birds of Adak Island, Alaska. Condor 76:288-300.

B. **<u>Other Conventions</u>**

- Use italics, rather than underlining, for Latin names and for *Exxon Valdez*.

- Use good quality white paper 8.5 x 11" (215 x 280mm) or metric size A4.

- Do <u>not</u> use dot matrix printers to print the report.

- When referring to the oil spill that occurred because the *Exxon Valdez* ran aground, use *Exxon Valdez* oil spill. After the first mention of the *Exxon Valdez* oil spill, refer to it simply as the spill.

- Clearly define any acronyms. Avoid the use of acronyms completely in the Abstract and Executive Summary.

- Use the terms "damages" and "injury" as defined by CERCLA regulations (see 43 CFR 11.14):

  "Damages" means the amount of money sought by the natural resource trustee as compensation for injury, destruction or loss of natural resources.

  "Injury" means a measurable adverse change, either long or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil. Injury encompasses the phrases "destruction" and "loss."

    "Destruction" means the total and irreversible loss of a natural resource.

    "Loss" means a measurable adverse reduction of a chemical or physical quality or viability of a natural resource.

3. **<u>Use of Manuscripts for Final Report Writing</u>** - The Trustee Council encourages principal investigators to publish the results of their work in peer-reviewed journals. Toward this end, manuscripts or journal articles may be used to help satisfy project final report writing requirements. Principal investigators shall contact the Science Director at the Trustee Council Office to request authority to use a manuscript(s) as the body of a final report.

   Because final reports are the primary and permanent record of how Trustee Council funds have been spent and what has been accomplished with those funds, it is necessary that these reports address all of the objectives for which the Trustee Council has provided funds.. If all of the project's objectives are completely described within one or more manuscripts being prepared for publication, then a copy of the manuscript(s) may be submitted as the entire body of the report. If a project's objectives are not all described completely within one or more manuscripts, the manuscript(s) may serve as a portion of the report.

   For example, if only two of five project objectives are addressed in a manuscript, the report shall include—in addition to the manuscript—information on the three objectives not covered in the manuscript. The two objectives covered by the manuscript shall be referenced in the report as appropriate (e.g., in the Methods and Results sections) and substantially integrated into the Discussion section, where there shall be an overall discussion of the project. In such cases, the combination of the manuscript and additional report material shall present an organized, integrated and complete account of project activities and results.

Please note that when a manuscript is used to fulfill report writing requirements, it must be in a form that can be duplicated freely. This may require obtaining a release of copyright restrictions.

In addition, every report, regardless of whether it is in the standard format or includes manuscripts, shall adhere to the formatting prescribed for the Report Cover, Title Page, Study History, Abstract, Key Words, Project Data and Citations (see above, Final Report Format, page X).

Investigators seeking to publish the results of Trustee Council sponsored projects shall include the following statement with all manuscripts:

> The research described in this paper was supported by the *Exxon Valdez* Oil Spill Trustee Council. However, the findings and conclusions presented by the author(s) are their own and do not necessarily reflect the views or position of the Trustee Council.

Investigators who publish the results of Trustee Council sponsored projects shall provide the Trustee Council Office (attn: Science Director) three (3) reprints of any published manuscript. The Trustee Council Office shall provide one of the reprints to Alaska Resource Library and Information Services (ARLIS).

4. **<u>Due Date</u>** - Final reports shall be *submitted for peer review by April 15 of the year following the fiscal year in which project work was completed* unless a different date is specified in the approved Detailed Project Description or contract. If this due date cannot be met, the principal investigator shall notify the Trustee Council Office in writing. With the approval of the Executive Director, an alternative final report due date may be identified.

<u>II. Review Process: NRDA & Restoration Final Reports</u>

See III below for review process for GEM final reports.

1. **<u>Submission of Draft Final Report for Peer Review</u>** - The principal investigator shall submit four (4) copies of the draft final report for peer review, as follows:

    ✓ three (3) copies of the draft final report to Dr. Robert Spies, the chairman of the Trustee Council's Lingering Oil Subcommittee;

✓ one (1) copy of the draft final report to the Trustee Council's Science Director.

Dr. Robert Spies Applied Marine Sciences 4749 Bennett Drive, Suite L Livermore, California 94550	phone: (925) 373-7142 fax: (925) 373-7834 spies@amarine.com
Science Director Trustee Council Office 441 W. 5th Ave., Suite 500 Anchorage, Alaska 99501	phone: (907) 278-8012 fax: (907) 276-7178 phil_mundy@oilspill.state.ak.us

2. **Final Report Peer Review and Acceptance Process** - Under the guidance of Dr. Spies, draft final reports are peer reviewed by one or more qualified reviewers who provide comments, identify questions and suggest revisions as appropriate.

   - Peer review comments shall be provided in writing by Dr. Spies to the principal investigator(s).

   - Final reports shall be revised by the principal investigator to address peer review comments and resubmitted for final acceptance, as follows:

     ✓ three (3) copies of the revised final report to Dr. Spies; and
     ✓ one (1) copy of the revised final report to the Science Director.

   Once the final report is accepted, Dr. Spies shall notify the principal investigator in writing and send a copy of the letter of acceptance to the Science Director.

3. **Final Report Review as to Form** - Once accepted by Dr. Spies, the principal investigator shall prepare the final report for publication.

   - Within 30 days of the date on which Dr. Spies accepts the final report, the principal investigator shall submit the first several pages of the approved final report to ARLIS for format review (i.e., Cover, Title Page, Study History, Abstract, Key Words, Project Data and Citation). These pages can be mailed, faxed, or e-mailed to ARLIS (attention: Carrie Holba):

Carrie Holba ARLIS 3150 C Street, Suite 100 Anchorage, AK 99503	phone (907) 272-7547 fax (907) 271-4742 carrie@arlis.org

- Within 15 days of receipt of the first several pages of the final report, ARLIS staff shall review it for compliance with the report format standards and notify the principal investigator in writing regarding any changes that need to be made.

- To be certain that format revisions are made correctly, the principal investigator shall fax a copy of the corrected version to ARLIS. The principal investigator shall not reproduce the report until format approval is confirmed in writing by ARLIS.

III. Review Process: GEM Final Reports

See II above for review process for NRDA and Restoration final reports.

1. **Submission of Draft Final Report for Peer Review** - The principal investigator shall submit three (3) paper copies of the draft final report and an electronic copy for peer review:

   ✓ three (3) copies of the draft final report to the Science Director; and
   ✓ one (1) electronic copy of the draft final report to the Science Director.

   (See address page XX.)

2. **Final Report Peer Review and Acceptance Process** - Under the guidance of the Science Director, draft final reports are peer reviewed by one or more qualified reviewers who provide comments, identify questions and suggest revisions as appropriate.

   - Peer review comments shall be provided in writing by the Science Director to the principal investigator(s).

   - Final reports shall be revised by the principal investigator to address peer review comments and resubmitted for final acceptance, as follows:

     ✓ three (3) copies of the revised final report to the Science Director; and
     ✓ one (1) electronic copy of the draft final report to the Science Director.

     Once the final report is accepted, the Science Director shall notify the principal investigator in writing.

3. **Final Report Review as to Form** - Once accepted by the Science Director, the principal investigator shall prepare the final report for publication.

- Within 30 days of the date on which the Science Director accepts the final report, the principal investigator shall submit the first several pages of the approved final report to ARLIS for format review (i.e., Cover, Title Page, Study History, Abstract, Key Words, Project Data and Citation). These pages can be mailed, faxed, or e-mailed to ARLIS (attention: Carrie Holba):

Carrie Holba	phone (907) 272-7547
ARLIS	fax (907) 271-4742
3150 C Street, Suite 100	carrie@arlis.org
Anchorage, AK 99503	

- Within 15 days of receipt of the first several pages of the final report, ARLIS staff shall review it for compliance with the report format standards and notify the principal investigator in writing regarding any changes that need to be made.

- To be certain that format revisions are made correctly, the principal investigator shall fax a copy of the corrected version to ARLIS. The principal investigator shall not reproduce the report until format approval is confirmed in writing by ARLIS.

IV. Printing and Distribution Process: NRDA, Restoration & GEM Project Final Reports

1. **Reproduction and Number of Copies** - Within 60 days of the date of the written confirmation from ARLIS indicating approval of the final report format, the principal investigator shall remove all references to "draft" from the report and produce final copies as follows:

   - **Two-sided Pages.** The body of the report shall be printed in two-sided format to reduce the space needed to store reports.

   - **Number of Copies: NRDA & Restoration Project Reports.** The principal investigator shall provide a total of 31 paper copies and one (1) electronic copy, as follows:

     ✓ two (2) bound copies of the approved final report to Dr. Spies;
     ✓ twenty-seven (27) bound copies and two (2) camera ready copies of the approved final report to ARLIS, which shall include a copy for the Science Director as well as a copy for the Trustee Council's official record. A camera-ready copy is an unbound copy of the report as it will appear in its final format, except that it is single-sided with blank pages inserted as appropriate; and [NOTE:

NUMBER OF COPIES NEEDED FOR LIBRARIES CURRENTLY BEING CONFIRMED.]

- ✓ one (1) electronic copy to the Science Director. The electronic copy may be submitted either as an Acrobat Portable Document Format (PDF) file or word processing document with all figures and tables imbedded. Acrobat PDF 4.0 or above file format shall be used, preferable in 'formatted text with graphics' (called "PDF normal" under Acrobat PDF 4.0) format. Minimally, "PDF searchable image" (called "PDF original image with hidden text" under Acrobat PDF 4.0) may be used if pre-approved by the Trustee Council Office. In either case, the PDF file shall not be secured or locked from future editing, or contain a digital signature from the principal investigator. Final reports shall be posted on the Trustee Council website at www.oilspill.state.ak.us

- **Number of Copies: GEM Project Reports.** The principal investigator shall provide a total of 29 paper copies and one (1) electronic copy, as follows:

  - ✓ twenty-seven (27) bound copies and two (2) camera ready copies of the approved final report to ARLIS, which shall include a copy for the Science Director as well as a copy for the Trustee Council's official record. A camera-ready copy is an unbound copy of the report as it will appear in its final format, except that it is single-sided with blank pages inserted as appropriate; and [NOTE: NUMBER OF COPIES NEEDED FOR LIBRARIES CURRENTLY BEING CONFIRMED.]
  - ✓ one (1) electronic copy to the Science Director. The electronic copy may be submitted either as an Acrobat Portable Document Format (PDF) file or word processing document with all figures and tables imbedded. Acrobat PDF 4.0 or above file format shall be used, preferable in 'formatted text with graphics' (called "PDF normal" under Acrobat PDF 4.0) format. Minimally, "PDF searchable image" (called "PDF original image with hidden text" under Acrobat PDF 4.0) may be used if pre-approved by the Trustee Council Office. In either case, the PDF file shall not be secured or locked from future editing, or contain a digital signature from the principal investigator. Final reports shall be posted on the Trustee Council website at www.oilspill.state.ak.us

2. **Binding** - Copies of final reports shall be bound using PERFECT binding. Smaller reports may be bound with black tape or comb binding. Very small reports may be bound with staples in three places along the spine, but only when other binding options are not available. Questions regarding binding shall be directed to ARLIS (attention: Carrie Holba; See address page XX).

3. **Distribution of Final Reports** - ARLIS shall distribute the bound and camera-ready copies of final reports to the appropriate individuals and libraries. (Attachment C)

ANNUAL REPORTS: RESTORATION & GEM PROJECTS

NOTE: This section was substantially revised in July 2002 and applies to all annual reports due after that date.

Purpose. In the case of multi-year projects, an *annual* report shall be prepared each year until the project is completed, at which time a final report shall be prepared. All NRDA annual reports have been completed, and so are not addressed in this section of the *Procedures*. The principal investigator for a project is responsible for the submission and production of an annual report.

I. Preparation of Annual Reports

1. Annual Report Format – Annual reports shall be brief documents (1-3 pages) that include the information listed below. An example of the annual report form, available for downloading from the Trustee Council's web site (www.oilspill.state.ak.us) or from the Trustee Council Office upon request, is provided. (Attachment B)

    - **Project Number and Title**
    - **Investigator's Name(s), Institution(s), and Contact Information**
    - **Period Covered by the Report and Date of the Report**
    - **Summary of Work Performed** – This section shall include a brief summary of work performed during the year, including results obtained to date and their relationship to the stated objectives of the project. Any current problems or unusual developments; any changes in objectives, methods or schedules; and any other significant information pertinent to the project shall also be described.
    - **Summary of Future Work to be Performed** – This brief summary shall describe work to be performed during the next year, if changed from the original proposal.
    - **Applications** – A list of publications, presentations, workshops, etc. undertaken during the year shall be provided, along with a description of data and/or information products developed during the year.
    - **Expenditures** – Expenditures shall describe actual expenditures for the reporting period and how they differ, if applicable, from budgeted expenditures. Any special problems and/or differences between actual and budgeted expenditures

shall be explained. A revised detailed budget for the next year shall be attached, if different from the amount requested in the original proposal; if the revision requests an increase in the amount approved by the Trustee Council, justification for the increase shall be provided.

- **Other Financial Support** – This section shall list any current or pending financial research support from other sources for each principal investigator.

- **Status of Data** – This section shall indicate whether project data have been submitted to the Trustee Council Office in accordance with the Trustee Council's data management policy and the data management plan for the project.

3. **Due Date** – Annual reports shall be *submitted by April 15 of each year during which a project receives funding*, with the exception of the final funding year in which a final report shall be prepared. The information in the annual reports shall be a key component in the Trustee Council's annual decision to continue funding a project. Failure to submit an annual report by April 15 of each year may result in withholding of remaining project funds, cancellation of the project, or denial of funding for future projects.

II. Review of Annual Reports

1. **Submission of Annual Report for Review** – The principal investigator shall electronically submit the annual report to the Trustee Council's Science Director at phil_mundy@oilspill.state.ak.us The electronic copy shall be submitted either as an Acrobat Portable Document Format (PDF) file or word processing document with any figures and tables imbedded. Acrobat PDF 4.0 or above file format shall be used, preferably in 'formatted text with graphics' (called "PDF normal" under Acrobat PDF 4.0) format. Minimally, "PDF searchable image" (called "PDF original image with hidden text" under Acrobat PDF 4.0) may be used if pre-approved by the Trustee Council Office. In either case, the PDF file shall not be secured or locked from future editing, or contain a digital signature from the principal investigator. In lieu of an electronic copy, a paper copy of the report may be mailed to the Trustee Council Office (see address page XX). Faxed reports are not allowed.

2. **Annual Report Review Process** – Annual reports shall be reviewed by the Science Director. Under the guidance of the Science Director, annual reports may also be reviewed by qualified outside peer reviewers. The review process shall be used to guide further work on the project and to determine whether continued funding of the project is warranted. Any written comments on annual reports shall be provided to the principal investigator and kept on file at the Trustee Council Office, available upon request.

III. Distribution of Annual Reports

Annual reports shall be kept on file as public documents at the Trustee Council Office, available upon request. Annual reports may also be posted on the Trustee Council's website.

ANNUAL PROJECT REPORT

All recipients of funds from the *Exxon Valdez* Oil Spill Trustee Council must submit an annual project report in the specified format. Failure to submit an annual report by April 15 of each year in which funding was received may result in withholding of remaining project funds, cancellation of the project, or denial of funding for future projects.

Project Title:

Project Number:

Project Amount:

PI Name:

Period Covered by this Report:

PI Institution:

Date:

PI Contact Info.:

Is continued funding requested?

Please provide the following information:

1. **A brief summary of work performed during the reporting period, including results obtained to date and their relationship to the stated objectives of the project. Also describe any current problems or unusual developments; any changes in objectives, methods or schedules; and any other significant information pertinent to the project.**

2. **A brief summary of work to be performed during the next year, if changed from the original proposal. Note in particular any proposed changes in objectives.**

3. **Applications:**
    a. **List publications, presentations, workshops, etc. during the reporting period**
    b. **Describe data and/or information products developed during the reporting period**

4. **Expenditures:**
    a. **Describe actual expenditures for the reporting period and how they differ, if applicable, from budgeted expenditures**
    b. **Explain any special problems and/or differences between actual and budgeted expenditures**
    c. **Attach a revised detailed budget for the next year, if different from the amount requested in the original proposal; if the revision requests an increase in the amount approved by the Trustee Council, provide a justification for the increase**

5. **Current and pending financial research support of principal investigators.**

Have project data been submitted to the Trustee Council Office in accordance with the data management policy and data management plan for the project?

PI Signature:

____

- Proposals are invited to conduct baseline research on diversity and distribution of marine organisms at one or more locations within the GEM area. Successful proposals will be those that choose research sites based on a number of criteria including: availability of historical data on site biology and physiology, proximity to other research areas, relative level of pristineness, long-term stability of the site, accessibility, and representativeness (in terms of biodiversity, GOA habitats, etc.). The GEM program is particularly interested in proposals that plan to use the coastal monitoring program being developed under the Census of Marine Life and the Diversitas Western Pacific and Asia (DIWPA) program. More information on these programs is available on the web at: http://www.coreocean.org/censhome.html (Census of Marine Life) or http://ecology.kyoto-u.ac.jp/%Egaku/diwpaindex.html (DIWPA protocol).

- Proposals are invited to pull together existing data from previous research conducted by agencies and partners. Investigators are referred to the results of April 2002 workshop *Detecting and Understanding Change in Intertidal/subtidal Environments: Planning for Habitat Mapping in the Gulf of Alaska* (available at www.oilspill.state.ak.us [NEED FULL CITE] for information on mapping and inventory priorities. Proposals in this category should specify the variables to be mapped, the mapping protocol, and the scale of the mapping effort. All mapping projects must include georeferenced data.

Intertidal/subtidal-specific synthesis proposals are not being solicited. Synthesis proposals that cut across habitat types and may include intertidal/subtidal are being solicited (see page XX).

Alaska Coastal Current (ACC)

Projects in the Alaska Coastal Current (ACC) habitat focus on developing collaboration between physical and biological scientists to decide how best to detect changes in annual and seasonal production and transfer of energy to higher trophic levels. The key question GEM seeks to answer with respect to the ACC 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?* A significant amount of work is already being conducted in this area under the auspices of the GLOBEC (Global Ocean Ecosystem Dynamics) and OCC (Ocean Carrying Capacity) programs. The Trustee Council is interested in identifying gaps in current research that provide opportunities for collaboration with research partners on questions of primary interest to GEM. These include variability in the current structure and dynamics [OF WHAT? SEEMS LIKE SOME WORDS ARE MISSING], nutrient supply, and selected populations and the processes affecting populations.

Phase I Proposals Recommended for Funding

- Underway in FY 02 and is recommended for continuation through the Phase I invitation: Project 02340 supports hydrographic station GAK1 and the accompanying retrospective analysis of the station's data record.

Phase II Invitation

- The Trustee Council is not soliciting for ACC proposals at this time, but will consider new innovative proposals in this area. Synthesis proposals that cut across habitat types and may include the ACC are being solicited (see page XX).

Offshore

Projects in the offshore habitat focus on the effect of the Alaska gyre on the natural variability in seasonal and annual productivity along the continental shelf and the ACC. The key question GEM seeks to answer with respect to the offshore habitat area is: *What are the relative roles of natural forces (such as changes in the strength of the ACC and Alaskan Stream, mixed layer depth of gyre, wind stress and downwelling) and human activities (such as pollution) in determining production of carbon and its shoreward transport?*

Phase I Proposals Recommended for Funding

- Underway in FY 02 and recommended for continuation through the Phase I invitation: Project 02614 is testing the ships-of-opportunity concept by installing a thermosalinograph and fluorometer on an oil tanker traveling between Valdez and Long Beach.
- Underway in FY 02: Project 02552 is gathering and analyzing data from the Hinchinbrook Entrance buoy; Project 02624 is installing a continuous plankton recorder on an oil tanker traveling between Valdez and Long Beach and on a second vessel along a Vancouver, B.C. to Kamchatka monitoring line; Project 02671 is developing logistics for a network of ships of opportunity in Kachemak Bay.

Phase II Invitation

- The Trustee Council is not soliciting for offshore proposals at this time, but will consider new innovative proposals in this area. Synthesis proposals that cut across habitat types and may include the offshore are being solicited (see page XX).

GA Analysis Based on FY 02 and FY 03 Proposed Phase I and Estimated Phase II Budgets

(dollars expressed in thousands)

Agency	Fy 02 Project Funding [a]	Current FY 02 GA [a]	FY 02 Project Management (inc. GA)	FY 02 Liaison Funding (inc. GA)	Total FY 02 Project Support	Proposed FY 03 Project Funding Phase I [abc]	Proposed 9% GA on FY 03 Project Funding Phase I [abc]	Proposed FY 03 Project Management (inc. GA)	Estimated FY 03 Project Support[d]	Approximate Months of Project Management
ADEC	31.7	2.3	10.2	23	35.5	0.0	0.0	0.0	0.0	
ADNR	125	8.8	8.6	19.8	37.2	198.1	17.8	10.0	45.7	1 month
ADFG	1691.5	126.8	60.6	17.5	204.9	825.2	74.3	50.0	198.5	6 - 7 months
USFS	31.5	1.7	8.7	20	30.4	0.0	0.0	0.0	0.0	
DOI	755.4	54.5	36.2	17.8	108.5	449.0	40.4	35.0	115.8	3 - 4 months
NOAA	1001.2	79	57.3	22.6	158.9	624.0	56.2	50.0	162.3	6 - 7 months
Total	**3636.3**	**273.1**	**181.6**	**120.7**	**575.4**	**2096.3**	**188.7**	**145.0**	**522.3**	

[a] (excludes projects 100,126, 250, 455, 550, & 630); GA on these projects for FY 03 is expected to total roughly 71.6 for ADFG, 8.6 for ADNR, and 2.3 for DOI

[b] Numbers not finalized per peer review revisions & admin reductions (some are placeholders) as revised budgets won't be due till July 8th

[c] These are estimated numbers for about 50% of the projects to be funded for FY 03

d Assumes each agency will receive in FY 03 Phase II direct project funding roughly what is recommended for Phase I; actual funding amounts for GA may be quite different

Capital projects negotiated GA rate depending on project

Revised 6/11/02

MEMORANDUM

State of Alaska
Department of Law

To:	EVOS Trustee Council Molly McCammon	Date:	June 12, 2002
		File No.:	N/A
		Tel No.:	269-5274
From:	Alex Swiderski Department of Law	Subject:	Sitkalidak Exchange

INTRODUCTION

In September 1998 the Trustee Council agreed to provide $73,500 for the State of Alaska and Old Harbor Native Corporation (OHNC) to pursue an equal value land exchange. Pursuant to the exchange the state would convey all of its holdings on Sitkalidak Island to OHNC and in return receive title to lands along the north shore of Kiliuda Bay. The council imposed a condition on funding the exchange that OHNC convey a conservation easement on Sitkalidak Island to the Fish and Wildlife Service or other entity.

The question before the Trustee Council is whether the conservation easement condition should be removed. The state and OHNC have reached the final steps in the land exchange and, but for the conservation easement, expect to complete the exchange prior to September of this year.

DISCUSSION

The idea for a conservation easement on Sitkalidak Island arose during the negotiations with OHNC for the sale of its lands on Kodiak to the U.S. Fish and Wildlife Service in 1995. The purchase agreement for that sale contained a clause providing that OHNC would convey a perpetual conservation easement on Sitkalidak Island to an appropriate entity. However, the parties disputed the meaning of the clause and whether the easement would be done with additional compensation. Little progress was made. The funding condition imposed by the Trustee Council was intended to motivate the parties to complete the conservation easement.

In a letter to the Trustee Council members dated February 25, 1999, OHNC agreed to negotiate in good faith for an enhanced easement on Sitkalidak Island. Following that letter the state initiated appraisals and other steps to undertake the exchange with the understanding that the easement needed to be completed. Eventually OHNC and the U.S. Fish and Wildlife Service tentatively agreed to a conservation easement that would prohibit development on Sitkalidak Island for ten years while the parties attempted to negotiate a permanent easement. The parties agreed that the Fish and

Wildlife Service would pay $100,000 per year (with funds other than EVOS civil settlement funds) for the easement.

The Fish and Wildlife Service has recently determined that it is not willing to proceed with the ten year easement and payment, although it is still interested in negotiating a permanent conservation easement with OHNC. The Fish and Wildlife Service has indicated to the state that it is supportive of the state proceeding with the land exchange without a requirement that the easement be completed as a condition of the exchange.

The exchange would benefit the state in that it would give title to shoreline lands adjacent to other state owned uplands, thus providing shoreline access to those uplands. The lands to be acquired by the state will be managed as wildlife habitat. The exchange would benefit OHNC by giving it title to virtually all of Sitkalidak Island where OHNC intends to concentrate its ecotourism and other economic development efforts. The exchange would consolidate the holdings of both parties.

MOTION

In the event that the Trustee Council decides to delete the requirement that the conservation easement on Sitkalidak Island be conveyed by OHNC, a motion to effect that decision would be as follows:

It is moved that the requirement that the Old Harbor Native Corporation convey a conservation easement on Sitkalidak Island to the United States Fish and Wildlife Service, imposed as a condition upon the funding provided for the Sitkalidak land exchange, be deleted.

cc: Regina Belt
Barry Roth
Maria Lisowski

ENTER HERE

A project of the North Pacific Universities Marine Mammal Research Consortium

University of Alaska

University of Washington

OREGON STATE UNIVERSITY

Oregon State University

Welcome to the Great Alaska Killer Whale Count!

19-21 July 2002 & February 2003

If you see a killer whale, we want to know about it!

Very little is understood about killer whales (*Orcinus orca*) in Alaska.

Knowing where people see killer whales is essential for directing future research efforts.

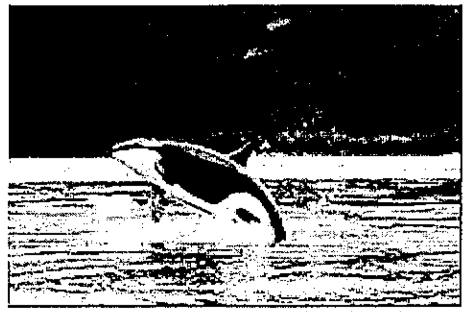

photo by Lance Barrett-Lennard and Kathy Heise

THIS IS WHERE WE NEED YOUR HELP!

For three days in July, 2002 and again in February, 2003 if you spend time on the water, we would like to know what you are *and* are not seeing.

Any information you can share with us will be kept confidential and will be very helpful to our research.

Thank you, and we look forward to hearing from you.

HOW YOU CAN HELP:

1. SIGN-UP

Submit your e-mail address & we will remind you of the survey date.

enter e-mail address:

Submit

2. READ OUR EXPLANATION

If you are on the water between **19-21 July 2002 & February 2003**, please fill in our short survey. If you do not see any whales, that is just as valuable information.

3. SPREAD THE WORD!

*cover photo by Lance Barrett-Lennard and Kathy Heise

Public comments on the Draft Update to Injured Resources

David Stutzer, Homer
David Janka, Cordova, Auklet Charter Services
Shelley Romer
Laura Litzky, Seattle, University of Washington, School of Aquatic and Fishery Sciences
Barbara Meyer, Homer
Greg Streveler, Gustavus
Mike Gracz, Homer
Susan Payne, Kodiak
Dena Matkin, Gustavus
Corrie Bosman, Sitka, Center for Biological Diversity
Jim Adams, Anchorage, National Wildlife Federation, Alaska office
Scott Sterling, Wasilla (formerly counsel for City of Cordova 1987-1993)
Lynn Highland, Anchorage

Molly McCammon

To: Cherri Womac

Subject: FW: Classification of species impacted by EVOS

keep in file for TC meeting in June.

-----Original Message-----
From: David Stutzer [mailto:dastutz@pobox.xyz.net]
Sent: Monday, May 06, 2002 9:52 PM
To: molly_mccammon@oilspill.state.ak.us
Cc: Craig Matkin
Subject: Classification of species impacted by EVOS

Molly McCammon
Executive Director, Exxon Valdez Trustee Council

Dear Ms. McCammon,

This letter concerns the recent reclassification of species impacted by the Exxon Valdez oil spill, in particular, killer whales and herring. I am very concerned that killer whales have been classified as recovered when the research shows that both the local pods and the transients are nowhere near their prespill population levels. Since there has been a recent increase in the resident AB pod, this group should be listed as recovering and the transient AT1 pod should be listed as not recovering. Herring were severely impacted by the oil spill and apparently, from documents produced by the Trustee Council, have not recovered to prespill levels and have not shown a strong age class since the spill. This would indicate a need for a classification of "non-recovering" for herring in PWS.

I would hope that science is what drives classifications of the species affected by the Exxon Valdez oil spill. These recent reclassifications seem arbitrary and unscientific. The facts seem to clearly indicate that at least herring and killer whales have not recovered from the oil spill. You are not doing anyone a service by trying to gloss over that fact. It is important to remind the public how pontentially dangerous our relationship with the oil industry can be.

Please classify herring and killer whales as I have suggested above and continue to have their populations monitored. Thank you.

David Stutzer
P.O. Box 2296
Homer, AK 99603

Cherri Womac

From: shelley romer [shelleyromer@hotmail.com]
Sent: Thursday, May 09, 2002 10:40 AM
To: restoration@oilspill.state.ak.us
Subject: Killer Whales

Dear Molly McCammon:

I am writing to express that I don't agree with the assessment of recovery status for killer whales and that I feel killer whale monitoring should continue. Killer whales are not "recovered." AB pod should be listed as "recovering." Acknowledgement should also be made for the lack of recovery of the AT1 group. The oil spill has demonstrated that long-term monitoring of killer whales is vital and productive. We would have had no idea of the spill effects on these whales had monitoring not been in place, nor would we have predicted the time involved in recovery. Herring should be listed as "non-recovering" to draw attention to repeated lack of recruitment of a strong age class in this severely reduced population. Herring are a cornerstone in the PWS marine ecosystem. I hope that this issue is not taken lightly and will be reconsidered as severe consequences in the marine ecosystem could result from hasty decision making. Thank you for your time.

Shelley Romer

Cherri Womac

From: Molly McCammon [molly_mccammon@oilspill.state.ak.us]
Sent: Wednesday, May 08, 2002 8:35 AM
To: Cherri Womac
Subject: FW: Draft Status of Injured Resources

add to injury comments.

-----Original Message-----
From: David Janka [mailto:info@auklet.com]
Sent: Tuesday, May 07, 2002 6:02 PM
To: molly_mccammon@oilspill.state.ak.us
Subject: Draft Status of Injured Resources

Hi Molly,

It was really nice to visit with you during your birding trip to Cordova.

I have been thinking about some of our conversations and want to pass a few thoughts along to you. Please add this to the public comments on your Draft Status of Injured Resources.

I guess I fall into the group that will never be able to say that the Sound has recovered from the Exxon spill. The practical/common sense reality is that it will never be the exact same as it was before the spill. The political reality will eventually say it has. The scientific will fall somewhere in between. Any amount of residual oil, any population that either by number or reproductive health is not the same as before the spill or any usage by subsistence, commercial or private users that continues to be altered or different because of the spill will mean it has not recovered. If nothing else was going on in the Sound; changes in weather, usage by humans, ocean/food web fluctuations, etc. it could return to exact pre-spill conditions, maybe. But the spill kicked some things one way and because it is an active and dynamic ecosystem certain things will never kick back to the same conditions.

Boating around the Sound before the spill one would regularly see a friendly, social pod of Killer Whales. AB Pod. It is rarely seen today. Some family members have taken up with another pod. Their numbers are still down and they do not have the same reproductive success as other pods. They are recovering but I find it insulting to call them recovered. Please consider listing them as recovering.

The spill mainly impacted wild stock pink salmon streams in the Sound and did no noticeable damage to hatchery fish. It has only been in the past few years that I have begun to see even a few pink salmon returning to some of the streams in the impacted area. These returns are very small. There used to be commercial openers for salmon around Knight Is. before the spill. These fisheries have not returned to a pre-spill regularity. Unlike Killer Whales, which have ongoing research to show their recovery as well as their continuing impact, there is no pink salmon monitoring taking place in the impacted wild stock streams. They are recovering but to call pink salmon recovered without any data to support it is poor science. Please consider keeping pink salmon listed as recovering until data shows otherwise.

On a trip out to Montague Island recently it was good to see what seemed to be a better herring spawn then the past few years. One year of slightly better spawning when predator impacts on eggs, larvae and adults is still to take place leaves the health of the population in question. There is no sign of their population being able to get above what the year-round predator needs are any time soon. It seems that they are not recovering but are possibly only stabilizing at a much lower population level as before the spill. Like the pink salmon many of the monitoring studies have been dropped for herring. I would suggest that you consider downgrading herring in PWS to not recovering or........herring, pink salmon as well as the AB pod could be given a Recovery Unknown classification which is defined as "limited data on life history or extent of injury; current research inconclusive or not complete." I think that is very true of the three. The extent of injury, actual oil on a whale, is not known for the AB pod. Current research on the herring and pink salmon is not complete. Along this line I would ask that you seriously consider adding the AT1 transient Killer Whale pod to the Recovery Unknown listing as well. All of the above criteria for listing them holds true.

I am curious about the Common loon and the 3 species of cormorants. Have there been any studies before, during or after the spill? It seems they would be better listed under Recovery Unknown because of the lack of information and study.

I have a few things that have been bothering me that don't fall into the Status of Injured Resources. Hope you don't mind my adding these thoughts and concerns.

I feel the impacts of intrusive science is approaching the residual impacts of the spill. I think this is true of some of the bird studies as well as ones for otters and seals. Now with large amounts of money for sea lion research they will be falling prey to similar harassment. Year after year you are chased, herded, netted and caged to be poked, prodded, examined, sampled, measured, operated on and transmitter implanted. You're then released and expected to act like nothing happened. The amount of money is very large for these kinds of projects and I am not sure the information gained is a very good value. I think there is a great deal still to be gained by basic, non-intrusive observations of behavior and interactions with human activities, clutch sizes, scat sampling and population surveys. When will there be a year that the birds and mammals in the spill impacted area and it's corresponding control areas be left alone?

I am appalled at how poorly run some of the projects at the Sea Life Center have gone with captured birds and animals. All but one of the land otters died and the one that was released died soon after. Ducks that were fed oil are now unable to be released into the wild. People at the Center where not properly trained in how to feed captive birds causing problems with projects as well as the well being of the birds. This is terrible science and I hope it is not continued especially through support from the Trustee Council.

Thank you for your time and consideration of my comments, suggestions and concerns.

Sincerely,
David P. Janka
Owner/Operator
Auklet Charter Services

Auklet Charter Services
Custom multi-day boat charters
throughout Prince William Sound.
David and Annette Janka
P.O. Box 498
Cordova, AK 99574-0498
voice/message: 907-424-3428
email: <info@auklet.com>
web: www.auklet.com

Cherri Womac

From: Laura Litzky [llitzky@u.washington.edu]

Sent: Thursday, May 09, 2002 11:03 AM

To: restoration@oilspill.state.ak.us

Subject: Trustee Council

To Whom It May Concern,

I am writing to express my disagreement with you recent assessments of killer whale and herring status. In particular:

1. Killer whales are not "recovered." AB pod should be listed as "recovering." Acknowledgement should also be made for the lack of recovery of the AT1 group.

2. The oil spill has demonstrated that long-term monitoring of killer whales is vital and productive. We would have had no idea of the spill effects on these whales had monitoring not been in place, nor would we have predicted the time involved in recovery.

3. Herring should be listed as "non-recovering" to draw attention to repeated lack of recruitment of a strong age class in this severely reduced population. Herring are a cornerstone in the PWS marine ecosystem.

Thank you,

Laura Litzky

><> ><> ><> ><> ><> ><> ><> ><> ><> ><> ><> <><
Laura Litzky
University of Washington
School of Aquatic and Fishery Sciences
Office: 260B Fishery Sciences
Mail: Box 355020, Seattle, WA 98195
Phone: (206)221-5453
FAX: (206)616-9012
email: llitzky@u.washington.edu

Cherri Womac

From: Molly McCammon [molly_mccammon@oilspill.state.ak.us]

Sent: Friday, May 10, 2002 8:15 AM

To: Grace Meyer

Subject: RE: orca whale status

thanks for your comments Grace. I'll be sure they get to the Trustee Council. Molly McCammon

-----Original Message-----
From: Grace Meyer [mailto:g.meyer@mindspring.com]
Sent: Friday, May 10, 2002 7:22 AM
To: molly_mccammon@oilspill.state.ak.us
Subject: orca whale status

To: Molly McCammon, Exec. Dir.

From: Barbara Meyer
PO Bx 1675
Homer, AK 99603

Dear Molly,

I'm actually out of state at the moment, visiting in CO and using email there, but I had heard before leaving AK about the changing status of orca whales on the recovery list from the oil spill, and it's very concerning to me. I am just an Alaskan citizen, not a scientist, but I have lived in Homer since 1985 and feel strongly about protecting the land/sea environment of our state. The oil spill deeply affected me, as it did everyone, and I want to do everything in my power to prevent it from happening again. To me, part of that effort comes in learning everything we can from the incident, especially over the decades. To be rushing (as I see it) to change the listing of orcas from "recovering" to "recovered" is really a dangerous thing to do, giving the wrong impression to the public, to scientists and environmentalists, and especially to the oil industry. I feel that long-term monitoring of orcas, herring, and many other species is going to show that recovery of PWS is still decades away, if indeed it ever happens. I'm especially dismayed when the organization pushing the re-classification is the very group that should be fighting it.

While I do understand the turnover to the GEM program, I'm worried that this re-classification of the whales may be more about the Council starting this new time with a clean slate. Alaskans need to keep the issue of marine ecosystem protection alive, and I believe the best way we can do that is to be slow and extremely thorough about research before saying the system is healthy once again. Please use your influence to list the orcas as recovering and herring as non-recovering until we all know much more than we do now. Please continue to fund long-term research and monitoring of these and other species devastated by the spill.

Thanks for your attention to this letter. my home email is babz@xyz.net, should you want to respond.

Sincerely, Barbara Meyer

Cherri Womac

From: Molly McCammon [molly_mccammon@oilspill.state.ak.us]
Sent: Monday, May 13, 2002 9:32 AM
To: Cherri Womac
Subject: FW: Sound Recovery List

-----Original Message-----
From: Greg Streveler [mailto:grigori@gustavus.ak.us]
Sent: Friday, May 10, 2002 3:05 PM
To: molly_mccammon@oilspill.state.ak.us
Subject: Sound Recovery List

Molly,

As a strong proponent of the good work your council has done over the years since the spill, I am mystified and disappointed over the recent decisions to gloss over the considerable difficulties still exhibited by orcas and herring. It seems very clear to me that these species still need attention, which they are less apt to receive if listed as proposed.

If there is the possibility of revisiting the designations for these species, I would strongly advocate that.

Sincerely,

Greg Streveler

Cherri Womac

From: Mike Gracz [anmbg@uaa.alaska.edu]
Sent: Monday, May 13, 2002 9:27 AM
To: restoration@oilspill.state.ak.us
Cc: GERALD TANDE; Craig O. Matkin
Subject: PWS "recovering"? taxa

Molly McCammon, Executive Director
***Exxon Valdez* Trustee Council,**

The most reliable data show that two killer whale groups, AT1 and AB are "not recovering" and "recovering", respectively, and not "recovered" as your proposed new classification suggests. AT1 hasn't seen an increase since it's dramatic post-spill drop; and AB is not near pre-spill numbers yet. Killer whales are long lived organisms which produce few offspring at relatively long intervals, taxa with this reproductive strategy (k selected) are sensitive to catastrophic disturbance, and recover slowly, if at all. K selected taxa also face the danger of a genetic bottleneck- where survivors of catastrophe retain insufficient genetic reserve to continue- so numbers alone fail to tell a complete recovery story- new recruits may lack fertility. An upgrade to "recovering" is appropriate for this killer whales as a whole.

When herring stocks again become commercially exploitable in the sound, then list that taxon as recovering. After ten years of successful harvest (or at least patterns mimicking other nearby stocks) then "recovered" seems appropriate. Please err on the side of caution when considering the fate of a complex ecosystem we do not not fully understand. Please help continue the necessary, though often unglamorous, work of monitoring the complete picture of recovery- and lack thereof.

Sincerely,

Mike Gracz

Molly McCammon, Executive Director
Exxon Valdez Trustee Council
441 West 5th Ave. Suite 500
Anchorage, AK 99501-2340

RECEIVED
MAY 14 2002
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

May 10, 2002

Dear Ms. McCammon,

The Exxon Valdez Trustee Council is in a unique situation to be able to maintain long standing research projects in the affected area of the Exxon oil spill. It has come to my attention that the Exxon Trustee Council is not interested in funding or maintaining the ongoing research of Craig Matkin and colleagues on the killer whale pods of Prince William Sound, the AB pod and AT1 group. I am writing you to please continue your involvement in this long-term study of these killer whale groups to see how long and under what factors these pods recover to their pre-spill population levels.

I have read information from Craig that shows how these groups have not recovered to their pre-spill population levels and continue to exhibit uncommon behavior from before the spill. This may hinge on their dependence on PWS herring, which also seems to be maintaining depressed recruitment since the spill.

We in the public are fortunate that Craig and the North Gulf Oceanic Society were monitoring the PWS killer whales before the spill because we have been able to see the effects on these killer whale communities. We have been fortunate that you have contributed to this research for some time, and I urge you to continue this funding to further enlighten us to the condition of PWS, to remind us of the oil spill effects, and let us know when these stocks are fully recovered to pre-spill levels. Please continue funding this project; what you gain in knowledge of these killer whale groups and thus the health of the PWS ecosystem is worth the price!

Sincerely,

Susan Payne

Susan Payne
PO Box 1903
Kodiak, AK 99615

Cherri Womac

From: Dena Matkin [denamatkin@hotmail.com]
Sent: Monday, May 27, 2002 4:46 PM
To: restoration@oilspill.state.ak.us
Subject: Recovery status of orca & herring in PWS

To Whom I Hope It Concerns:

I have studied killer whales in southeastern Alaska for the past 15 years, and am a former resident of Prince William Sound. I do not agree with your assessment of the recovery status of killer whales and herring in Prince William Sound. I am writing to recommend that killer whale AB Pod designation be changed to just barely "recovering" as current research has indicated the pod crashed from 36 to 22 (an unprecedented loss), now only up to 26 individuals. Also, you should recognize the AT group decline from 22 down to 9 individuals shows that it is "non-recovering."

Further, herring should be down-graded from "recovering" to "non-recovering." Trustee Council documents have indicated an unprecedented crash in herring in 1993, and that recovery has stalled due to a repeated lack of recruitment of a strong age class.

Please continue to fund long-term monitoring research on killer whales in Prince William Sound that also explores feeding habits, genetics, contaminant loads, acoustics and habitat needs. Thank you for your consideration to rethink these designations. You have the power to really help Prince William Sound. Please use it.

Sincerely,
Dena Matkin
Box 22
Gustavus, Alaska
99826

Center for Biological Diversity

Protecting endangered species and wild places through science, policy, education, and environmental law.

Molly McCammon, Executive Director
Exxon Valdez Oil Spill Trustee Council
441 West 5th Avenue, Suite 500
Anchorage, AK 99501-2340

June 7, 2002

Re: Comments on Draft Update of Injured Resources and Services

Dear Ms. McCammon:

These comments are submitted on behalf of the 7,500 members of the Center for Biological Diversity (The Center). The Center works on protection for endangered species and the habitat that supports them. For this reason we are particularly interested in the Trustee Council's findings in the Draft Update on Injured Resources and Services April 30, 2002 (Draft Update). The Draft Update serves an important role in educating the public of the overall health of the Prince William Sound ecosystem in the aftermath of the oil spill. For this reason, it is important to insure that any conclusions the Council makes regarding the status of the indicator species and habitats chosen for monitoring are not only accurate, but made with certainty. Where information is lacking or indeterminate, the Council has an obligation to proceed in a precautionary manner until it is conclusively demonstrated that a species has truly reached the point of recovery. Below are some of our particular concerns with the Draft Update.

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I. AB Pod of Killer Whales:

The Draft Update recommends moving the Prince William Sound AB pod of killer whales from the "not recovering" list to the "recovered" list. The AB pod is one of the eight resident killer whale pods found in Prince William Sound. Prior to 1989, the pod numbered 36 animals. Immediately following the oil spill seven members of the pod were found missing and later determined dead. These missing pod members included three adult females (leaving behind 2 young calves) and four juveniles (EVOS Restoration Notebook, 1997 at 8). By 1990, six additional whales from the AB pod were missing and presumed dead. This second loss included one mature female (who left behind one young calf), one mature male and four juveniles. All three of the orphaned calves died in the years following. From 1992-94 five additional adults from the AB pod were lost and presumed dead. At this time four new calves were born. Between 1996-98 two additional adults were lost, and five new calves were added (Status of Injured Resources, EVOS Report 1999). The rates of disappearance and mortality in the AB pod far exceed normal mortality rates of less than 1 percent per year. In comparison, in 1989 the AB pod had a 19.4 percent mortality rate and in 1990 the mortality rate increased to 20.7 percent (Restoration Notebook at 8). Mortality rates of the AB pod "far exceeded rates observed for other pods in British Columbia and Puget Sound over the last 30 years, and in the northern Gulf of Alaska over the last 18 years" (Draft Update at 17).

The initial definition of recovery adopted by the EVOS Council in its 1994 Restoration Plan states: "Full ecological recovery will have been achieved when the population of flora and fauna are again at former or pre-spill abundances, healthy and productive, and there is a full complement of age classes at the level that would have been present had the spill not occurred." The AB pod of killer whales clearly does not meet this definition of a recovered species. Prior to 1989, the pod had 36 members, this number dropped to a low of 22 in the early 1990's and now has increased to 26. The current population is a 27 percent decline in number of individuals from pre-spill state. Furthermore, it is fairly clear that the population is not healthy and productive as evidenced by the break away of a matrilineal group from the AB pod to join the AJ pod. This split-off is unprecedented for resident pods of PWS and other regions (Restoration Notebook at 9). Lastly, the loss of so many whales in the years following the spill has resulted in a different age and sex class than present prior to the spill's occurrence.

In 1999, the recovery objective for the AB pod was changed to: "the number of individuals in the pod stable or increasing **relative to the trends of other major resident pods in Prince William Sound.**" (EVOS Report 1999, emphasis added). The population of the other resident killer whale pods in Prince William Sound has increased consistently each year since 1987 at a rate close to 2 percent (Restoration Notebook at 6). In comparison, the AB pod has experienced a 27 percent decline in population since 1989 and although calf recruitment has occurred in the last five years, the pod still remains ten individuals short of its pre-spill number. Compared to the relative trends of other major resident pods in Prince William Sound the AB pod is clearly not recovered.

Frustratingly, the recovery objective set by the Council for the AB pod in the new Draft Update (April 2002) has **again lowered the standard.** The comparative language of the 1999 standard has been removed in favor of a much less stringent standard of recovery. "The pod will have recovered when the number of individuals in the pod is stable or increasing." On its face this standard is absurd. Under this standard, if only one whale is left in the pod and it remains year after year, the population would be deemed stable and therefore recovered!

Even if the Council should apply this new weaker standard, it does not lead to the conclusion that the AB pod has fully recovered. First, as discussed above the pod remains at 26 individuals, far less than the pre-spill number of 36. The part of the AB pod that split off to join the AJ pod has still not rejoined the AB membership. Lastly, the age and sex structure of the AB pod has undergone serious changes from its original pre-spill composition. Female killer whales do not reach sexual maturity until between 11 and 15 years of age and calves on average are born to a reproductive female only once every five years (Restoration Notebook at 6). Forty-three percent of all calves born are believed to die within their first year." The low birth rate coupled with the high mortality rate for calves; means that it will likely be a long-time, if ever, before the AB pod reaches its pre-spill size and can be considered "recovered"

While it is certainly good news that the AB pod has increased in size, we do not believe it is justifiable at this point to say that the pod has "recovered". The more appropriate listing would be to list the pod in a "recovering" state.

Pink Salmon:

The Draft Update also proposes moving pink salmon to the "recovered" species list. We are disturbed at both the changes in the definition of recovery and its application for pink salmon. In 1999, to meet the recovery objective a sequence of two years each of odd-and-even runs without differences in egg mortality was required (EVOS Report 1999). Because the Alaska Department of Fish and Game found the study too expensive to replicate for another four years, the Council has adopted a new recovery objective. This new objective is based solely on hydrocarbon exposure of embryos. "Pink salmon will be recovered when ongoing oil exposure is negligible." This standard does not meet overall recovery objectives discussed earlier for the sound adopted in 1994 and furthermore, appears rather arbitrary.

The Council has decided "it is highly unlikely that oil is now accumulating in pink salmon embryos and having any significant effects". Yet, the Council fails to present adequate evidence to support this conclusion. Field testing 6 streams for hydrocarbons in a one-year period does not make for a scientifically justifiable conclusion that all is well for the pink salmon. This is especially true given the fact other inter-tidal areas in the Sound continue to demonstrate high concentrations of hydrocarbons. The new recovery standard only takes into account one possible injury, exposure of embryos to oil, completely discounting other potential effects of oil. First, assuming that no on-going embryo exposure exists, this objective fails to account for all of the exposure and potential long-term impacts resulting from contact over the past 13 years. Second, the standard fails to take into account other potential adverse impacts from the oil such as impacts to out-migrant fry. It is clear that patches of oil still remain in inter-tidal areas (Draft Update at 25). Prince William Sound is notorious for its storms, of which even a moderate one can potentially release oil situated in the intertidal zone. This is the same area out-migrate fry pass through. The Council draws a blanket conclusion that since these areas are located outside salmon streams, that salmon will not be impacted. Lastly, the new recovery standard fails to take into account ecological changes in the Sound since the spill, including a different predator/prey field than previously existed and fails to address account possible long-term genetic mutations.

The Council's conclusion that pink salmon have fully recovered in the Sound has no scientific validity and no certainty. Instead it is based on speculative assumptions and optimistic thinking. In the face of this uncertainty the Council should act in a precautionary manner and not elevate pink salmon to the recovered list. If the Council does not have adequate information to assess impacts to the pink salmon, they should be moved into the "recovery unknown" category.

Pacific Herring:

Herring are an integral part of the Prince William Sound ecosystem and a key to the marine food web. A variety of marine mammals, birds, fish and invertebrates depend upon some lifestage of the herring for food. The Draft Update lists the pacific herring as a "recovering" species. It is clear that the Exxon Valdez oil spill had significant impacts to herring egg biomass, adult fish and overall population levels. The Draft Update proposes the herring as a "recovering" species, but there is no clear information to support this proposition. In 1993 the herring experienced an "unprecedented crash" when only 25 percent of expected adults returned. The recovery indicated by the increased biomass seen in 1997 and 1998 has stalled.

The Sound's herring population has yet to recruit a highly successful year class, a fundamental sign of the recovery of this species (Draft Update at 22). When a successful year class is recruited the Council could then cautiously claim the herring is **on the way** to recovery, but until that time the proper classification for the pacific herring is "not recovered". Since herring are the cornerstone of the Sound ecosystem, the Sound can not be truly recovered until the herring recover. By classifying the herring as a "recovering" species, the public is being misled to think the Sound has been restored to its pre-spill state. Herring should be down-listed to "not recovered" status.

AT-1 Group of Killer Whales:

While the AT-1 transient pod is not one of the populations that the Council chose to monitor over the years, it is clear that the pod is in serious decline. This genetically unique group lost nearly half its members immediately following the oil spill. In fact whales from the pod were seen surfacing in the oil slick next to the tanker immediately following the spill. Prior to 1984, 22 individuals were part of this unique group (Restoration Notebook at 6). Since 1990, 11 individuals have gone missing from the pod. No new calves have been recruited since the mid 1980's (1999 Status Report). Furthermore, one of the main food source for the pod, harbor seals, have declined 60 percent in the sound over the last two decades, adding further stress this declining population. Lastly, there are serious concerns regarding abnormally high (10 times greater than average) contaminant levels of individuals in the group. It is suspected that these high concentrations of DDT and PCB compounds may be correlated with the lack of calf recruitment.(Restoration Notebook at 10) The decline of the AT-1 transient pod is a clear indication that the Sound ecosystem has not returned to the healthy state it once was.

Conclusion: We respectfully request that the Council re-address its findings in the Draft Update for the AB pod of Killer Whale, pink salmon and herring. The Council needs to use indicator recovery objectives that accurately assess the species that are consistent with the overall recovery objectives set out in 1994. Furthermore, in the face of indeterminate information, the Council must not make conclusions based on optimism rather than reality. As a matter of public policy, the Council has a duty to accurately represent the ecological condition of the Sound and its inhabitants. Based on the Council's Draft Update, only 9 of the 25 species being monitored have reached "recovered status". The conclusion is clear-the overall health of the Sound has not recovered to its pre-oil spill state. Lastly, we strongly advocate for the continued funding for scientific research on the restoration and recovery of the sound. Long-term monitoring of the sound ecosystem is fundamental to determining changing conditions of the ecosystem into the future.

Thank you for considering these comments and please keep us informed.

Sincerely,

Corrie Bosman

Corric Bosman
Alaska Program Coordinator
Center for Biological Diversity

NATIONAL WILDLIFE FEDERATION®
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Alaska Office

June 5, 2002

RECEIVED
JUN 07 2002
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

Molly McCammon
Exxon Valdez Oil Spill Trustee Council
441 West 5th Ave, Suite 501
Anchorage, AK 99501-2340

Dear Ms. McCammon:

The National Wildlife Federation (NWF), the nation's largest education and conservation organization, and Eyak Preservation Council (EPC) urge the *Exxon Valdez* Oil Spill Trustee Council to alter its draft proposal to change the status of several monitored resources.

NWF and EPC appreciate the difficulty of determining whether a resource has recovered from the oil spill. Nonetheless, the spill had devastating impacts on resources, and the Trustee Council has appropriately elected to represent those impacts and the recovery from those impacts to the public through the injured resources status report. Having made that choice, the Council is obligated to ensure that its determinations are as accurate as possible, and also that they are conveyed to the public in an understandable form as accurately as possible.

Not all of the Trustee Council's proposed status changes meet these goals. Some decisions to upgrade the status of a resource are pervaded with a sense of impatience with the task at hand. The Trustee Council, it appears, is ready to move on to its larger ecosystem projects, such as GEM, leaving smaller monitoring tasks and questions about the status of individual species behind.

In several cases in this document, the Trustee Council has no new information about resources, or has information that is simply indeterminate. Nonetheless, the Council upgrades the resource based on the <u>assumption</u> that the Sound must be recovering. It goes without saying that if the Council does not have the information to upgrade a resource, it should not upgrade the resource. If the Council wishes to halt monitoring and does not have the information to declare a resource recovered, the Council should make use of the recovery unknown category.

In a few other cases, the Council's definitions of recovery do not match a conventional view of recovery, and therefore provide a confusing and potentially inaccurate message to the public. The Council's own definition of ecosystem recovery states that:

> full ecological recovery will have been achieved when the population of flora and fauna are again present at former or prespill abundances, healthy and productive, and there is a full complement of age classes at the level that would have been present had the spill not occurred. A recovered ecosystem provides the same functions and services as would have been provided had the spill not occurred.

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This definition is an appropriate benchmark, and the definitions of recovery for individual resources should be consistent with this definition. In other words, species should be present at prespill abundances, with a full complement of age classes at the level that would have been present had the spill not occurred. Some of the definitions, notably the definition for recovery of the AB pod, simply don't meet this common sense criteria.

With these ideas in mind, NWF and EPC have specific comments on four of the proposed changes.

Harlequin ducks: NWF and EPC disagree with the proposal to list harlequin ducks as recovering. This is one of the places the Trustee Council simply appears eager to "get on with it." There is a hodge podge of confusing data on the ducks, but there is no new data since the 1999 status report on injured species that suggests that harlequins are "recovering" now if they were not then. In fact, although the population of harlequins has been trending upward, in general the population has been growing much faster in unoiled portions of the Sound than in oiled portions of the Sound. This strongly suggests that ducks in the oiled portions of the Sound continue to be exposed to hydrocarbons that have an impact on their survival. In other words, not only have the ducks not recovered from the spill, they are still being actively injured by the spill.

NWF and EPC agree that the data is difficult to interpret. If the Trustee Council despairs of understanding whether harlequins have recovered, then the ducks should be placed in the recovery unknown category. At this point, however, a "not recovering" categorization continues to be appropriate.

AB pod of orcas: The difficulties of defining recovery are apparent in this category. It is possible that the oil spill changed the dynamics in Prince William Sound enough so that the AB pod will never return to its former size and structure. What is certain, however, is that the AB pod has been chosen to represent an oil spill injury, and that it is both structurally different and ten whales smaller (more than 25% smaller) than before the spill. In the minds of most people, that does not constitute recovery. Nor is it consistent with the larger definition of recovery for the Sound that states that flora and fauna will have returned to pre-spill levels.

If the Trustee Council feels too many uncertainties make it impossible to determine whether the and when the AB pod will have recovered, then the Trustee Council should make that clear, and place the AB pod in the "recovery unknown" category. However, a message to the public that the AB pod has recovered when, in fact, the AB pod has 10 fewer whales is misleading.

Pink salmon: In this case, the Trustee Council has no new data on pink salmon recovery. Although the 1999 definition of recovery was changed due to lack of data, there appears to be no data to support a determination that pink salmon meet the new definition of recovery either. If the Trustee Council does not have the data to make a determination, then salmon should be placed in the recovery unknown category.

Subtidal communities: There appears to be no new data on the health of subtidal communities. Despite this, the Trustee Council declares subtidal communities recovered based on "seven years of additional natural recovery." While time may heal all wounds, the Trustee Council has an obligation to rely on evidence rather than truisms when upgrading the status of a resource. If the Trustee Council feels that the status of the resource must be changed despite the absence of new evidence, then NWF and EPC suggest subtidal communities be listed, with a suitable explanation, in the "recovery unknown" category until additional data comes to light.

In addition to our comments on proposed changes, NWF and EPC propose that the Trustee Council downgrade herring's status from recovering to not recovering. Herring are not recovering. In the Council's own words, "in the last several years the recovery has stalled and the population has yet to recruit a highly successful year class, which is fundamental to the recovery of the species." Given herring's importance to the Sound ecosystem, it is essential that the Council provide an accurate representation of their situation in order to provide an accurate representation of the health of the Sound. In this case, that means downgrading the status of the species.

Finally, in keeping with the theme of accurately portraying the health of the Sound to the public, it is worth noting that even with the changes proposed by the Trustee Council, only 9 of the 26 monitored resources will have been designated as recovered. This makes a strong statement about the health of the Sound and the impacts of the spill, and NWF and EPC suggest that the Council lead with that information in its news releases on the revisions to most effectively convey it to the public.

Thank you for the opportunity to comment.

Sincerely,

Jim Adams

Jim Adams
Counsel
National Wildlife Federation-Alaska Office

Cherri Womac

From: Molly McCammon [molly_mccammon@oilspill.state.ak.us]
Sent: Thursday, June 13, 2002 8:22 AM
To: Cherri Womac
Subject: FW: Species Recovery - Public Comment

public comment.
-----Original Message-----
From: Scott Sterling [mailto:sasjmm@alaska.net]
Sent: Wednesday, June 12, 2002 6:30 PM
To: molly_mccammon@oilspill.state.ak.us
Subject: Species Recovery - Public Comment

Dear Molly: I am not an expert on animals nor the sea, nor oil spills. You could say that I had some direct personal and professional experience with the EVOS owing to my experience as counsel for the City of Cordova in 1987-1993, including a term as president of Prince William Sound RCAC. I suppose I know something about the impact of oil spills in general and EVOS in particular on people and community. With regard to the fauna and sea life affected by EVOS, however, I tend to put my faith in the effort of the trustees to adhere to an honest and scientific approach to the question of what is recovering, what is in doubt and what is in jeopardy. Regarding the pending proposal to reclassify the status of certain species according to rate and depth of recovery from the spill, I believe that the council should deem a species "recovered" if and only if the evidence of that status is all but incontrovertible. Taking a cautious approach does no harm, and gives us time to put right what we so badly put asunder. Thank you for considering my comments. Scott A. Sterling, 900 Susitna Drive, Wasilla, Alaska 99654.

Lynn Highland

om: Lynn Highland [lhighland@gci.net]

Sent: Thursday, June 13, 2002 12:51 PM

To: 'molly_mccammon@oilspill.state.ak.us'

Subject: official public comments

Regarding the proposal to upgrade the recovery status of 9 of the 25 monitored injured species and habitats resulting from the Exxon Valdez Oil Spill.

I am a licensed USCG captain and have been operating a boat in Western Prince William Sound since 1979.

While my observations have no scientific baseline data and are, therefore anecdotal, it seems obvious to people with a history of observing the Sound that those areas affected by the spill have not fully recovered.

- It is relatively easy to find residual oil.
- The Sea Otter population in the areas affected by the spill is a fraction of the pre spill level. Bainbridge Passage is a clear example.
- Killer Whales are seen much less frequently. Please reference Craig Matkin's work on the impact of the spill on the Orca population. The AT pod, which is genetically unique, may go extinct. Orcas were observed in the spilled oil and never seen again.

Thanks very much for the opportunity to provide input.

R. Lynn Highland
4650 Southpark Bluff Drive
horage, AK 99516
/-345-5035

Fr: Michelle Wilson Nordhoff
Re: Testimony to EVOS Trustee Council
Dt: Friday, June 14, 2002

These comments are on behalf of Alaska Center for the Environment regarding the DRAFT report Update on Injured Resources and Services related to the Exxon Valdez oil spill disaster.

We are uncertain as to what appears to be a recent change in recovery objectives for several key species, in addition to the immediacy to list species as 'recovered' when the scientific studies show otherwise or if they studies are still incomplete.

Furthermore, the Injured Resources list needs to reflect changes <u>not only</u> in recovery but also in non-recovery. Today we are asking that several resources be 'down listed' in classification.

(1) Lingering Oil in the Intertidal

To begin, we would like to highlight findings from the newly-released final report coming from Auke Bay Laboratory, the Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA titled **"Vertical Oil Distribution within the Intertidal Zone12 Years after the Exxon Valdez Oil Spill in Prince William Sound Alaska"** [draft final attached]. This study is important since previous reports have assumed low oil persistence in these areas.

<u>This groundbreaking study provides timely insight about the unexpected amount of oil—largely liquid oil matching the Exxon Valdez-- that remains in the productive lower intertidal areas.</u>

To quote: "the persistence and dominance of subsurface oil in the mid- and lower- intertidal ... is a <u>very surprising</u> result. The frequency of encounters was <u>more than expected</u>, and the trend of subsurface oil at lower tidal elevations was spread across all beach-oiling categories."

Furthermore, the report states:

"The prevalence of liquid subsurface oil in the mid- and lower-intertidal has important biological implications. The presence of oil provides a potential for bioavailability, and the potential is greatly increased when liquid oil is associated with the productive biological zone in the lower intertidal.

Mussels, clams, and other invertebrates may be exposed directly to the oil, and provide a source of oiled prey to predators. "

We are concerned about the continued instability and low productivity of the intertidal areas, particularly the lower and mid-intertidals. Since many invertebrates and their predators depend on varied age-classes of Fucus (or rockweed), their lack of recovery, the new evidence of extensive oil in the intertidal and the none recovery of clam populations on oiled and treated intertidal are grave concerns that demand further restoration.

The Conclusion states: "Our study viable source of contamination for those species that forage in the lower intertidal and continue to show evidence of protracted oil exposure."

This report has implications for most of the Council's monitored resources and services.

(2) Clams

We are particularly concerned about the lack of recovery of clams in western Prince William Sound. Sites that were examined in 97 – oiled and treated—were not showing any signs of recovery from pre-spill populations. We know some of the clams were still recovering from the Earthquake, but there is a difference from oiled and treated areas in the Sound, compared to sediments and shoreline areas that were not affected. According the main researcher for clams populations assessments (not contamination issues), Dennis Leese, their not seeing the recruitment events necessary and the balances are not stabilized.

There is no recovery of the clams on the beaches that were treated from the clean-up. The high-pressure hot water treatments basically "cooked" the clams—causing enormous mortality rates-- that were making them unable to re-establish themselves, reducing food sources for the predators that depend on them. Predators such as Otters and Sea Ducks.

We are also asking for CONTAMINATION studies on clams that are in these oiled areas.

From Auke Bay's new report, we are also concerned about the mussel beds in the intertidal areas. While many of the mussels have improved in rocky, cobble areas, ...

We feel that until the final report on Leese's study comes out, expected in January of 2004, the Clams must be listed as Not Recovered.

(3) Harlequin Ducks

We are concerned about the continued hydrocarbon exposure and possible effects on reproduction of female Harlequin Ducks since the oil spill.

Considering new evidence of unexpected intensity of liquid oil in the lower and mid-intertidal areas, prime foraging areas for Harlequins ducks, coupled with survey results which are still inconclusive and mixed, we ask that the Council take a precautionary approach and that Harlequins remain in the 'not recovered' category until further studies demonstrate the toxic exposure to hydrocarbons are no longer having effects.

<u>(4) AB Pod of Killer Whales</u>

The AB Pod were "the most commonly seen by tourists, fisherman, and other individuals who work and recreate in Prince William Sound... members of the AB pod were seen in and near oil slicks after the Exxon Valdez spill". ("Special Oil Spill Issue" ADF&G, July-Aug 1989, p. 29)

The AB pod has experienced a 27 percent decline in population since 1989 and although, fortunately, calf recruitment has occurred in the last five years, the pod still remains ten individuals short of its pre-spill number. Without reaching it's pre-spill population abundance and productivity, the AB pod is not recovered. While other pods are increasing at approx 2 percent annually since the spill, the AB pod is far from pre-spill levels.

We disagree with this proposed change recovery objective in this new Draft Update. The new standard states, "The pod will have recovered when the number of individuals in the pod is stable or increasing." So you are attempting to say, if the AB pod gives birth to one more calf, the pod is considered recovered?

We believe the AB pod must continue to be monitored and it is not suitable to change the definition of the recovery objective in light of their instability. We ask that the Killer Whales remain classified as 'recovering'.

(5) Pacific Herring

The Draft Update proposes the herring as a "recovering" species, but there is no clear information to support this proposition. We concur with the Center for Biological Diversity that when a successful year class is recruited the Council could then cautiously claim the herring is **on the way** to recovery, but until that time the proper classification for the pacific herring is "not recovered".

(6) **Sea otter**

We appreciate your acknowledgement of the non-recovery of Sea Otters in the most heavily oiled bays in the Western Sound. Bodkin's research on liver damage from chronic oil exposure, particularly research in northern Knight Island, is a great concern.

According to your prescribed recovery objective: "Sea otters will have recovered when the population in oiled areas returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway."

We would like the Council to add a phrase in the objective about sea otters ability to forage on non-contaminated food sources. We would also ask that the Council provide more public education about the state of Sea Otters non-recovery in Western Prince William Sound.

(7) **Black oystercatcher** –The draft report says "it is likely that the population of PWS is probably as large or larger than previous to the spill", yet the biological effect of exposure to contaminated mussels and other prey is still of concern to us. "Earlier studies with oiled mussel beds have demonstrated persistence of oil beneath the mussels, and contamination of the mussels (Carls et al., 2001)." Therefore we feel the Black Oystercatchers must cautiously remain in the 'recovering' category for further monitoring.

(8) Pink Salmon

We disagree with the new recovery objective for Pink Salmon: "Pink salmon will be recovered when ongoing oil exposure is negligible." We fail to understand how out-migrate fry are not being exposed to hydrocarbons that are remaining in the intertidal areas of the western Sound. The assumption that Pink Salmon –at any part of the life cycle—are not getting exposed to hydrocarbons is unsupported. When we have studies demonstrating that the smallest ppb of hydrocarbons can cause damage to the during early embryonic life stages and delayed reproductive impairments from chronic exposure to hydrocarbons (at low ppb), then we request more studies and public education from the Council regarding the damage to the reproductive DNA from hydrocarbon exposure in Pink Salmon.

In the face of this uncertainty the Council should act in a precautionary manner and not elevate pink salmon to the recovered list.

(9) Precautionary Principle

To conclude, it is imperative for the Trustee Council to err on the side of caution in proposing upgrades to the list of Injured Resources and Services resulting from the oil spill.

We urge the Trustee Council to refrain from altering the recovery objectives in such a way that does minimizes the recovery standards set in 1994 for the resources and services in the spill area. Also, we urge the use the Precautionary Principle, applying precautionary measures even if some cause-and-effect relationships are not fully established scientifically.

Lastly, we ask that the Trustee Council send a strong message to ExxonMobil that good environmental stewardship means holding to promises, such as agreements to pay for injuries and damages that were unanticipated at the time of the disaster.

DRAFT

Vertical Oil Distribution within the Intertidal Zone12 Years after the *Exxon Valdez* Oil Spill in Prince William Sound Alaska

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Abstract

In 2001, 12 years after the *Exxon Valdez* oil spill, we conducted a quantitative assessment of the vertical distribution of oil remaining on the beaches within Prince William Sound Alaska. Oil was found at 53 of the 91 sites surveyed. Surprisingly, most of the oil from the 4,249 quadrats evaluated was found in subsurface pits rather than at the surface, with 80% of the subsurface oil below the +3.3 m tidal elevation. This is a significant departure from random distribution with respect to tidal elevation. The amount of oil, lack of weathering in the subsurface oil from the lower zones, and the immediate proximity to biota give cause for concern for continued chronic exposure for species that live, prey, or spawn in the lower intertidal zones.

1 Introduction

The 1989 *Exxon Valdez* oil spill left 40%-45% of the more than 42,000 m^3 of oil initially released stranded on beaches within Prince William Sound (PWS), Alaska (Wolfe et al. 1994). The oil was deposited under high-energy wave conditions during an intense three-day storm that began three days following the incident. The vertical elevation range of the beached oil was constrained by the extent of tidal excursions during the storm, which was +0.2 m to +5 m above mean lower low water (MLLW).

Most of the beached oil dispersed back into the ocean during the three years following the incident. Dispersion was promoted by beach cleaning efforts in 1989 and 1990, and by high-energy waves generated by winter storms. Only 2% of the volume of oil spilled initially was estimated to remain on PWS beaches by the end of 1992 (Wolfe et al., 1994). Most of this oil was thought to be located in the upper intertidal, in the area of the "bath tub ring", where oil was so visually evident during the months just after the spill. Much of that oil was beneath an armouring layer of boulders or cobbles that protected oil from wave-dispersion (Neff et al. 1995, Gibeaut and Piper, 1998, Hayes and Michel 1998). The rate that the surface oil appeared to leave these beaches between 1989 and 1992 suggested that natural dispersive processes would remove the oil remaining to negligible levels within a few years.

We conducted a field study during summer 2001 to evaluate the amount of oil remaining on PWS beaches twelve years following the incident. This study was motivated in part by controversial reports of persistent oil. Visible surface oil was not evident for the most part, yet residents continued to complain of oil encounters, leading to a significant beach cleaning effort in 1997 and an unexpected finding of oil persistence (Brodersen et al. 1999). By the late 1990's, some studies were continuing to find recovery problems and evidence of continued oil exposure for sea ducks and sea otters (Bodkin et al., 2002, Esler et al., 2000a,b, Irons et al., 2000, Lance et al., 2001, and Trust et al., 2000). In summer 2001, we surveyed 91 sites in the spill zone within Prince William Sound and found oil at 53 of these sites. The geographical extent of the oiled area will be reported elsewhere (Short et al. in prep). This paper reports the vertical distribution of surface and subsurface oil at the 53 sites where oil was found.

2 Methods

Our study area is located in western PWS, an area that includes all the shoreline impacted by the oil spilled from the T/V *Exxon Valdez* (Figure 1). Our sampling focused on three categories of beaches as defined by the persistence of visually evident oil during surveys conducted from 1989 through 1993. These categories included discrete sections of beaches that were described as heavily (category I) or moderately (Category II) oiled at some time during the period 1990 to 1993, and beaches that were described as heavily oiled during 1989 but only light to no oil impact during subsequent years (Category III). Category III beaches were not expected to have significant amounts of oil, but surveys after 1989 were scant for this category. The total length of the discrete sections where oil was seen during these surveys was 116.6 km, which comprises lengths of 24.4 km, 49.1 km, and 43.1 km in Categories I, II, and III respectively.

2.1 Random Sampling of Beaches

Sections of beaches in each category were drawn by simple random sampling if 100 m in length, or by probability proportional to length (ppl), if less than 100 m. A total of 7.8 km of shoreline, comprising 91 distinct sections, was sampled with emphasis on category I where 5.2 km of cumulative shoreline was selected, and where most remaining oil was anticipated. The cumulative lengths selected from the other two categories were 1.9 km (II) and 0.69 km (III). Oil was found on 53 of the 91 distinct beach section sampled (see Figure 1 for a distribution of oiled sites), and we report here the distribution of this oil with respect to tidal elevation on these 53 beach sections.

2.2 Random Sampling within Beaches

The distributions of surface and subsurface oil on the beach sections selected for sampling were estimated by stratified random sampling (SRS) of the intertidal beach surface. The beach surface of a selected section between +1.8 m and +4.8 m above MLLW was partitioned into rectangular blocks by a number of equal-width alongshore columns and six 0.5 m vertical tidal elevation intervals. Each tidal elevation interval is considered as a distinct sampling stratum. These tidal elevations were sampled because previous surveys indicated oil was most persistent in the upper intertidal (Neff et al. 1995, Hayes and Michel 1999), and because lower exposure frequency made sampling in the lower intertidal less tractable.

The maximum beach section length, 100 m, was divided into eight columns, each 12.5 m wide, resulting in 48 blocks. Shorter beach sections were divided into fewer columns and blocks. Two 0.25 m^2 quadrats were randomly placed within each block, and each quadrat was evaluated for the presence of surface and of subsurface oil. A total of 4,249 random quadrats were drawn and evaluated for the presence of surface and subsurface oil on the 53 oiled beach sections. Only vertical cliffs were eliminated from the sampling protocols; bedrock quadrats were evaluated for surface oil, and counted as "no oil" for the subsurface sampling. Whenever subsurface patches of oil were discovered during random sampling, additional pits (about 3000) were excavated to delineate the patch sizes, including portions of patches that extended below the lowest tidal elevation of our sampling grid.

2.3 Determination of Oil in Sampling Quadrats

Oil visually evident within the uppermost 5 cm of a beach surface was considered surface oil. Surface oil included surface layers of asphalt (AP) or mousse (MS), rocks coated with oil films (CT), oil coated beach sediments (SOR), and tarballs (TB), as defined by Gibeaut and Piper (1998).

The presence of subsurface oil was evaluated by digging a test pit within each quadrat to a depth of 0.5 m or until boulders or bedrock was encountered, and examining the pit for visual and olfactory evidence of oil. Oil was usually detected visually from the evident sheens on the water that collected at the bottom, and confirmed by a characteristic smell. Subsurface oil was classified as oil film (OF), light, medium, or heavy oil residue (LOR, MOR, and HOR respectively), as defined by Gibeaut and Piper (1998).

Twelve samples typical of surface oil deposits and twelve samples typical of subsurface oil deposits were analyzed by gas chromatography-mass spectrometry at our laboratory to verify the origin of the oil (Short et al. 1996, Short and Heintz 1997).

2.4 Data Analysis

The significance of variation in the distribution of oil with respect to tidal elevation on the sampled beaches was evaluated by Chi-squared tests. Each of the 0.5 m tidal elevation intervals was considered as a class, giving 5 degrees of freedom for the test. This test was only applied when the expected frequencies within each class exceeded 5. Expected frequencies were calculated from the null hypothesis that oil distribution is independent of tidal elevation.

3 Results

Of the 53 beaches where oil was found, most of the oil was found in subsurface pits and chemical fingerprinting confirms the origin as from the *Exxon Valdez* oil spill. Surface oil seldom extended beyond a meter from any one quadrat; in contrast, there were many patches of subsurface oil that were extensive laterally, as in a zone, and extended below our sampling grid. Only 11% of quadrats that contained surface oil also contained subsurface oil. Category I beaches (those described as heavily oiled sometime during 1990-1993 surveys) had a higher frequency of oil encounters, both subsurface and surface oil, than either category II or III beaches (those beaches described as moderately oiled sometime during 1990-1993 surveys or heavily oiled in 1989 but not after). Further, the category I beaches had virtually all of the most heavily oil subsurface pits (HOR) in this survey of 2001.

3.1 Vertical distribution of surface and subsurface oil

Subsurface oil was encountered in 8.2% of the quadrats (Table 1), with over 80% below +3.3 m tidal elevation, an extremely significant departure from random distribution with respect to tidal elevation ($P < 0.001$). Subsurface oil was liquid, readily forming sheens or droplets of oil on water that collected in the bottom of the excavation pits.

Each of the subsurface oiling classifications showed similar trends of increasing frequency at lower tidal elevations when examined independently (Table 1). Each classification is most frequently encountered at tidal elevations below +3.3 m, and this trend is significant for the OF, LOR, and MOR classifications ($P < 0.005$, $P < 0.001$, and $P < 0.001$ respectively). The number of HOR quadrats is too small for a meaningful Chi-square test, but the trend is consistent with those of the other oil classifications.

Subsurface patches of oil discovered during our random sampling extended to tidal elevations that were below our sampling grid on 15 of the 53 oiled beaches. We confirmed that some of these patches extended to tidal elevations below 0 m., but we were not able to evaluate all the patches consistently because of coverage by tides during our visits at some beaches.

Surface oil was encountered in 5.3% of the quadrats (Table 1), with over 60% of these surface oil occurrences were within the tidal elevation interval 2.8 m - 4.3 m. The distribution of surface oiled quadrats with respect to tidal elevation (Table 1) was marginally significant ($0.05 < P < 0.10$), and surface oil was never found near the zero tide line. Surface oil was usually present as asphalt or as high-viscosity "mousse", in contrast to the liquid state in which subsurface oil was found.

3.2 Vertical Distribution of oil from different beach oil categories

The trends in the distributions of surface oil with respect to tidal elevation are different when the data from the beach sampling categories are combined than when analyzed separately. Surface oil on beaches described as heavily oiled sometime during the period 1990 through 1993 (i.e. category I) was encountered in 6.3% of the quadrats evaluated from sampling category I beaches, with 62% within the tidal elevation interval 2.8 m - 4.3 m (Fig. 2). This distribution of surface oiled quadrats with respect to tidal elevation is significantly different from a random distribution ($P < 0.05$), and is similar to results for the combined data from all three beach sampling categories because most of the sampling effort was directed at category I beaches. However, the distribution of surface oil on category II beaches (described as only moderately oiled during the period 1990 through 1993) was consistent with a random distribution with respect to tidal elevation ($P > 0.98$; Fig. 3).

In contrast, the trends in the distributions of subsurface oiling classifications are very similar regardless of whether the data are analyzed separately for each beach sampling category (I or II; Figs 2 and 3) or combined (Table 1). Each classification of subsurface oil was most often encountered at tidal elevations below +3.3 m, and this trend was significant whenever enough oiled quadrats were present to conduct the Chi-squared test ($P < 0.005$; compare Figs. 2 and 3) (except HOR on category II beaches, where only 1 quadrat was found). Data for sampling category III beaches are scant, but are consistent with these trends; all six oiled quadrats (MOR) found for this sampling category were below +2.8 m.

4 Discussion

The persistence and dominance of subsurface oil in the mid- and lower-intertidal as reported here is a very surprising result. The frequency of encounters was more than expected, and the trend of subsurface oil at lower tidal elevations was spread across all beach-oiling categories. The results were surprising because previous beach surveys by Owens (1991) argued that the adherence of oil to the beach is greatest in the upper intertidal of PWS because it is driest there, and this conjecture appears to have guided sampling for shoreline assessment surveys conducted from 1989 through 1993 (Neff et al. 1996, Gibeaut et al. 1998). Certainly the upper intertidal was impacted heavily in the early stages of the spill with the stranding of oil, creating the "bathtub ring" effect that impressed observers. Earlier surveys on the persistence of oil in PWS also seemed to implicitly assume that oil persistence was correlated with initial oiling intensity (Neff et al., 1996, Gibeaut et al., 1998, Hayes and Michel, 1999), and we also incorporated this assumption into our sampling design. In truth, probably all these surveys were "prejudiced" by the initial oiling, and certainly the priority of the initial surveys was slanted heavily toward the needs to clean up the surface oil. When surface oil was a dominant feature and problem, subsurface oil was not a priority, and little effort was spent to document the extent or intensity. Hence, searches for subsurface oil were conducted on beaches "...at locations where team members believed oil would most likely be found" (Owens, 1991).

We suspect that the subsurface oil we found below the upper-intertidal "bathtub ring" (+2.8 - +4.3 m above MLLW) had been there since the initial landfall of the oil, and was not the result of down-slope movement of oil over a period of several years, although down slope movement from the "bathtub ring" can not be ruled out. The uniform trend of increasing prevalence of subsurface oil at lower tidal elevations within our sampling grid regardless of oiling classification or of beach sampling category strongly suggests that subsurface oiling was widespread during the years immediately following the spill, and is not a consequence of unusual geomorphological conditions on a few beaches. Oil probably settled down into the beach substrate during low tides, and was partially lifted off the surface at higher tides. After repetition of many tides, significant oil quantities accumulated below the surface. Beach cleaning, particularly natural cleaning over the years would affect the top few inches, but has little impact at 20 cm depth and below. Down slope oil movement cannot be ruled out, and this process may also occur along with initial deposition in the lower intertidal.

Subsurface oil in the mid- and lower-intertidal might easily have been overlooked during previous surveys for several reasons, all related to the fact that the mid- and lower intertidal is covered by seawater more often than the upper-intertidal. Physical processes that promote oil dissolution, such as wave energy, have less impact below the beach surface. There is less time to survey and sample the beach at lower tidal elevations, and algae and kelp make traversing the lower intertidal more difficult. Without visual surface oil evident, there was little motivation to sample the lower intertidal in a systematic fashion.

The methods that were used to monitor the persistence of oil following the *Exxon Valdez* spill (cf. Owens, 1999) were developed and are routinely used to direct beach cleaning effort following catastrophic spills, and are practical and appropriate for that purpose. The most pressing priority following a spill is to limit damage; accurate measurement of oil remaining is rightfully a secondary priority. However, our study strongly suggests that the methods developed for directing clean-up operations, which must necessarily emphasize speed at some cost to accuracy, may have serious shortcomings for accurately measuring the extent or quantity of lingering subsurface oil.

In contrast with the distribution of subsurface oil, the distribution of surface oil with respect to tidal elevation we found in 2001 is consistent with impressions reported from prior surveys (Neff et al., 1995, Gibeaut et al., 1998, Hayes and Michel, 1999). Most of the remaining surface oil is in the "bathtub ring" where initial oiling was thought to be heaviest (Owens 1991), and there was no trend of increasing surface oil in the lower intertidal. This would also support the notion that there was no down slope movement of oil or there would be a trend with surface oil, where physical processes are much more active.

The presence of surface oil was a poor indicator of subsurface oil. The correlation we found between surface and subsurface oil (11%) is even lower than was reported in 1991 (about 33%; Neff et al., 1995). The use of surface oil to predict subsurface oil probably gets worse with time because physical factors such as wave energy will be more effective in the removal of surface oil compared to subsurface oil, particularly in the upper intertidal where wave energy exposure is more pronounced.

The prevalence of liquid subsurface oil in the mid- and lower-intertidal has important biological implications. The presence of oil provides a potential for bioavailability, and the potential is greatly increased when liquid oil is associated with the productive biological zone in the lower intertidal. Mussels, clams, and other invertebrates may be exposed directly to the oil, and provide a source of oiled prey to predators. Earlier studies with oiled mussel beds have demonstrated persistence of oil beneath the mussels, and contamination of the mussels (Carls et al., 2001). In recent years, recovery of some sea ducks and sea otters appears to be less in the heavily oiled areas (where we continue to find significant subsurface oil), and protracted exposure to xenobiotic chemicals such as PAH are indicated (Bodkin et al., 2002, Esler et al., 2000a,b,). These species all forage in the lower intertidal, and our study suggests that encounters with oiled prey or substrate may have been more frequent in those heavily oiled areas than has been recognized heretofore based on the previous reports of low oil persistence (Neff et al., 1995, Gibeaut et al., 1998, Hayes and Michel, 1999).

5 Conclusion

Subsurface oil was more frequently encountered than surface oil, and was surprising because it was found much lower in the intertidal than expected. Further, the subsurface oil was much less weathered than surface oil, was found in liquid form, and in close association with the productive biological zone in the lower intertidal. Our study provides a viable source of contamination for those species that forage in the lower intertidal and continue to show evidence of protracted oil exposure.

6 References

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Table 1. Vertical distribution of surface and subsurface oil for all beach categories combined (I, II, III). The number of quadrats evaluated and those with oil are broken down by each 0.5 m tidal elevation. Subsurface oil classifications given: OF = Oil Film; LOR, MOR and HOR = Light, Medium, and Heavy Oil Residue, respectively. Surface oiling categories include asphalt, mousse, oil coat, and tarballs.

Tide Height (m)	Total # of Quadrats Sampled	Number of Oiled Quadrats					
		All Oiling Classifications		Subsurface Oiling Classificatioins			
		Surface Oil	Subsurface Oil	OF	LOR	MOR	HOR
4.3-4.8	601	28	4	1	3	0	0
3.8-4.3	703	43	18	5	10	3	0
3.3-3.8	725	49	44	1	33	9	1
2.8-3.3	743	44	71	9	45	14	3
2.3-2.8	735	36	106	8	65	24	9
1.8-2.3	742	26	104	14	61	22	7
Totals:	4249	226	347	38	217	72	20

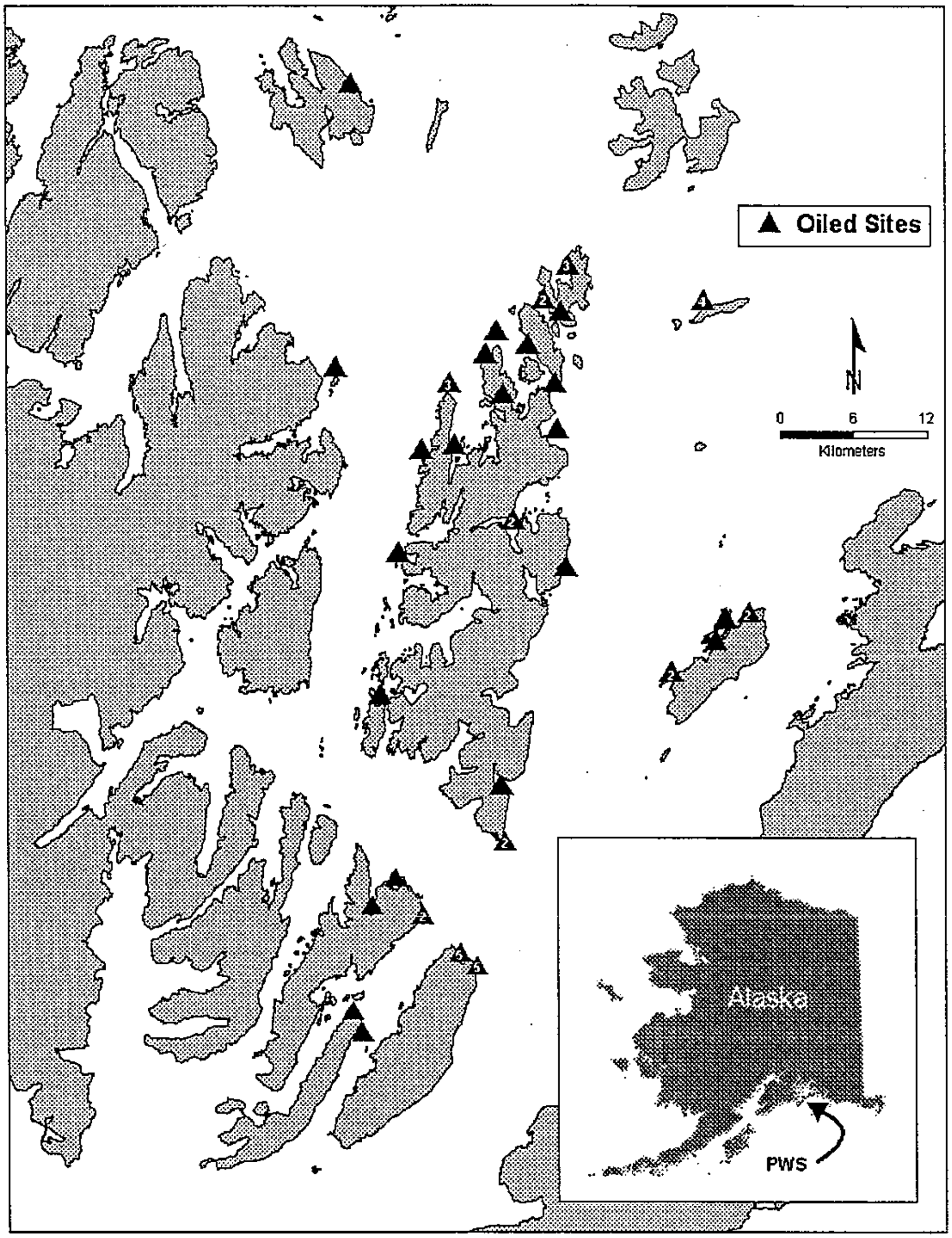

Figure 1. Location of 53 beaches where oil was discovered in summer 2001 in Prince William Sound, Alaska (see arrow) from the 1989 *Exxon Valdez* oil spill. Numbers inside symbols indicate the number of beach sites in close proximity to each other.

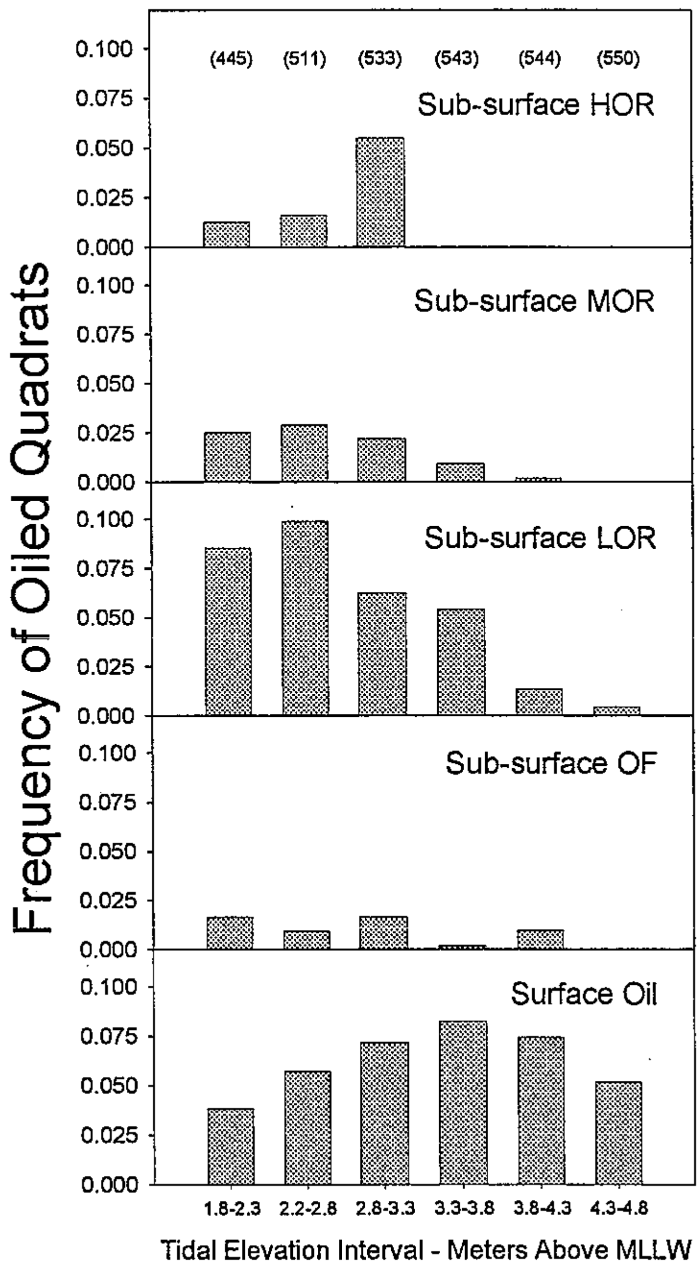

Figure 2. Category I: Vertical distribution of surface and subsurface oil at beaches (those beaches where oil was described as heavy sometime during 1990-1993). Tidal heights by meters above mean low low water. The number of quadrats sampled in each vertical zone for this category beach is given at the top of the frame. Subsurface oil is broken down by oiling classification (OF=oil film; LOR= lightly oiled; MOR = moderately oiled; HOR= heavily oiled).

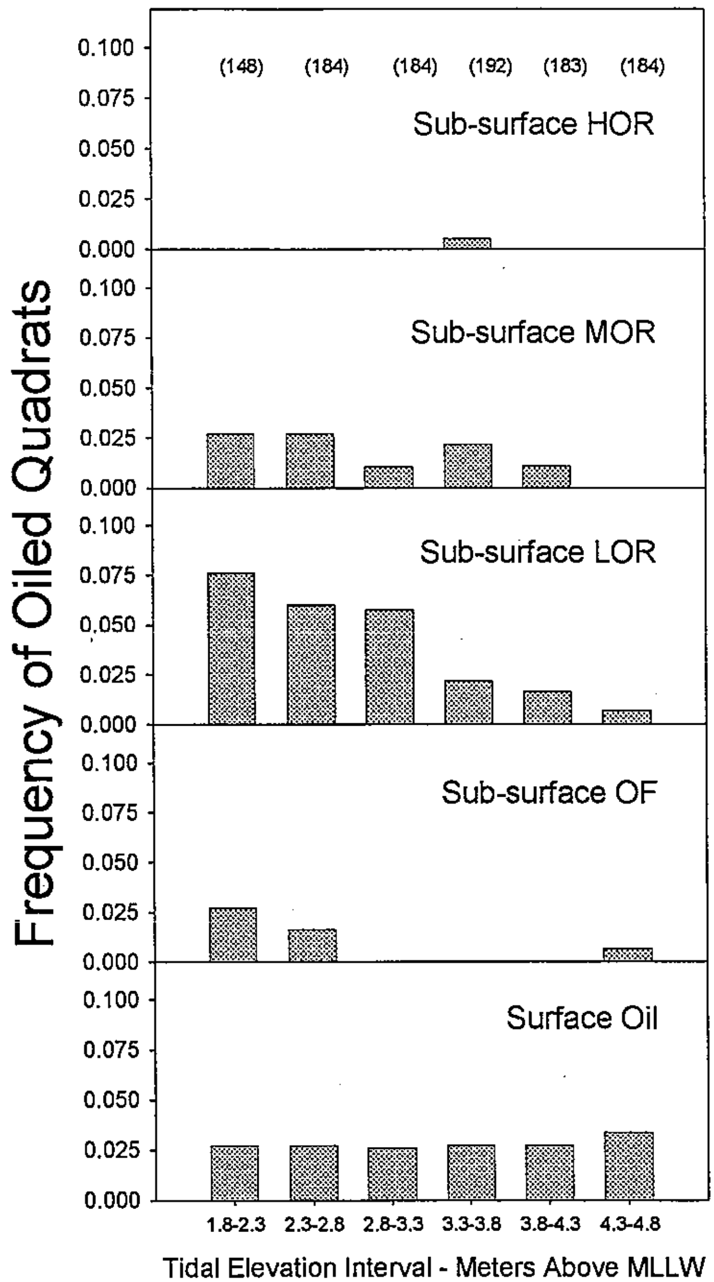

Figure 3. Category II: Vertical distribution of surface and subsurface oil at beaches (those beaches where oil was described as moderate sometime during 1990-1993). Tidal heights by meters above mean low low water. The number of quadrats sampled in each vertical zone for this category beach is given at the top of the frame. Subsurface oil is broken down by oiling classification (OF=oil film; LOR= lightly oiled; MOR = moderately oiled; HOR= heavily oiled).

Exxon Valdez Oil Spill (EVOS) Legacy: Shifting Paradigms in Oil Ecotoxicology[1]

Riki Ott, Ph.D., Charles Peterson, Ph.D., and Stanley Rice, Ph.D.[2]

Abstract. *Oil is much more toxic to coastal fish, birds, and mammals than previously predicted by short-term laboratory bioassay studies used during the 1970s and 1980s to develop a "paradigm" or model understanding of oil toxicity. Hundreds of comprehensive field assessments and lab studies conducted by government and academic researchers after the Exxon Valdez oil spill (EVOS) show that oil is persistent in important shoreline environments and causes long-term, population-level injury to coastal sealife. These 1990s studies frame a new oil toxicity paradigm, showing that risk evaluation or "ecotoxicity" models developed in the 1970s severely understate environmental damage from chronic oil pollution. Public policies based on the 1970s oil toxicity paradigm are not adequately protective of sealife. Policies guiding every phase of oil use from production to consumption and waste disposal need to be reevaluated in light of the 1990s oil toxicity paradigm.*

1970s Oil Toxicity Paradigm: History & Limitations

With the passage of the federal Clean Water Act in 1972, scientists developed standards to protect fish and wildlife in marine and fresh water environments from harmful levels of oil, among other chemicals. Scientists used short-term (usually 96-hour) laboratory "bioassays" as a way of exposing organisms to oil dissolved in the water column or the "water soluble fraction" (WSF) and then measuring the effects of this exposure (usually as mortality) to determine what levels of oil were harmful (*1*).

The oil toxicity paradigm[3] that emerged as a result of these bioassays (2) held that the primary compounds of concern in crude oil, which is composed of hundreds of different hydrocarbons, were the 1- and 2-ring aromatic hydrocarbons, which dissolve rapidly in water or air. Other larger aromatic hydrocarbons (3-5 rings) were more toxic, but they did not dissolve or mix into the water rapidly, and were not a factor in the short-term bioassays. The 1- and 2-ring aromatic hydrocarbons were quick in toxic action, but also short in duration – easily diminished by dilution, volatilization, and dispersal. Hence, the 1970s oil toxicity paradigm was based on *acute* toxicity, with toxic concentrations to fish and invertebrates in the low parts per million. There was some concern for long-term toxicity and safety factors were

[1] *Briefing Paper for Power Point presentation on www.alaskaforum.org*

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[3] *Note: in this paper, a "paradigm" is a theoretical framework created by scientists to explain a functional relationship in natural science. Paradigms are fluid, not static, models and they shift to accommodate new understanding as science advances. For example, a scientific paradigm once held that the world was flat, but we no longer believe this.*

suggested by guess work: for example, 1/100th of the acute toxicity *should* be safe.

What was Wrong with the 1970s Acute Toxicity Paradigm for Oil?

There are two basic problems with the acute toxicity model that evolved out of the 1970s – persistence and toxic mechanism. First, persistence of toxic compounds was not considered to be a problem. 1- and 2-ring aromatics do not persist in the natural environment, but their larger 3- , 4- , 5- ring cousins can. The larger compounds are not volatile, not soluble, but much more difficult to degrade. Second, the mechanism for toxicity is very different between the small and large aromatics. The 1- and 2-ring aromatics are toxic to membrane function and cause a "narcosis" type of toxicity. This acts quickly and leads to a variety of system failures. Fish, for example, loose equilibrium when exposed to 1-ring aromatics, there are function failures in gills and other organs, and the fish typically die within minutes of exposure.

In contrast, the mechanism of toxicity for larger compounds operates within the cell, where proteins and DNA can be directly affected. Embryos will suffer injury where cellular DNA is damaged and then replicated during embryonic growth, creating more cells with damaged DNA. Rather than causing an acute narcosis death, this damage affects "fitness" and results in a juvenile that is less capable of normal growth, avoiding predators, or capturing prey. In contrast to a direct narcosis death, this mechanism is more indirect (getting eaten, for example), but the result is still a loss in numbers of recruiting individuals. Populations slowly decline.

The limitations of the 1970s oil toxicity paradigm, based on acute toxicity, are such that it cannot be used to predict oil toxicity in an environment where oil may persist for some time (*1*). Acute bioassays were designed originally to measure potency of insecticides, not assess environmental safety to wildlife, where there are complex and long-term interactions among growth, body condition, maturation, diseases, reproduction, and predation.

Until now after results of EVOS studies have been compiled, resource and environmental managers only had available the 1970s oil toxicity paradigm to use to establish water quality standards and develop environmental risk models. A body of public policy (environmental laws) emerged, based on the 1970s paradigm, supposedly to protect aquatic and marine life from oil pollution.

1990s Oil Toxicity Paradigm & Supporting Studies

The 1970s oil toxicity paradigm failed to predict the long-term impacts of the EVOS, stemming from persistent oiling and subsequent bioavailability of oil in critical nearshore habitats (*1, 3*). As part of the Restoration Program undertaken by the federal and Alaska state governments, scientists designed comprehensive field and lab studies to explore and explain the population-level impacts that occurred, notably, in Prince William Sound, where nearly half of the oil from the *Exxon Valdez* had stranded on beaches (*4*). These studies and the resulting 400+ peer-reviewed papers frame the new 1990s oil toxicity paradigm. The persistence of substantial amounts of oil for more than a decade in biologically important, protected shoreline habitats, such as deltas of anadromous fish streams, mussel beds, and boulder-cobble shores (*1, 3*), was unanticipated and has induced the long-term exposures that underlie the new 1990s paradigm.

The 1990s oil toxicity paradigm holds that the compounds of concern are not the 1- and 2-ring aromatic hydrocarbons but 3-, 4- , 5-ring PAHs, or polycyclic aromatic hydrocarbons that were ignored in the 1970s paradigm. PAHs are persistent and bioavailable: PAHs are toxic during chronic exposure to early developmental life stages of herring and pink salmon at 0.4 to 1 part per *billion*, respectively, or levels 1,000 times lower than predicted by the 1970s paradigm (*5, 6*). A range of maladies was found in a variety of fish, birds, and mammals from field exposure to PAHs at levels of low parts per billion (ppb) (Table 1). Both direct and indirect effects were reported. In brief, these findings are as follows.

FISH. After the EVOS, weathered oil characterized by 3- , 4- , 5-ring PAHs was trapped in protected beach environments such as subsurface groundwater of anadromous fish streams for at least 4-8 years (*7*). PAHs were bioavailable to embryos and larvae of pink salmon as the PAHs were absorbed across the yolk membrane of eggs: prolonged exposures for months during incubation to levels as low as 1 ppb were found to be toxic (*6*). In addition to enhanced embryo mortality through chronic exposure to PAHs in weathered oil in groundwater (*8*), "sublethal" (not directly toxic) oil exposure led to population-level impacts. Evidence of higher rates of abnormal development and larval deformity in pink salmon and herring following oil exposure imply enhanced mortality (*5, 6*). Exposure of salmon fry to *Exxon Valdez* oil resulted in lower growth rates in 1989 and increased subsequent mortality through predation (*9, 10*). Finally, controlled laboratory studies of embryo development demonstrated reproductive impairment in the form of lower embryo survival of eggs from returning adult pink salmon that had been exposed to PAHs in weathered oil in streams during incubation as eggs and fry (*11*).

The 1990s paradigm of oil ecotoxicity to fishes incorporates both enhanced embryo mortality and delayed reproductive impacts of chronic exposure of embryos to persistent PAHs in weathered oil at low ppb concentrations, and it includes population-level consequences of sublethal impacts on growth of juvenile stages.

MARINE MAMMALS. Prior to the EVOS the widely accepted risk assessment model predicting population-level impacts to marine mammals and seabirds held that this wildlife had to be physically oiled and the resulting loss of insulation to fur or feathers led to hypothermia, drowning, and death. While the EVOS confirmed this model during the early weeks of the spill in that thousands of sea otters (*12*) and hundreds of thousands of seabirds (*13*) died from physical contact with oil, researchers also found that other processes caused previously unanticipated long-term population-level effects.

Smooth-skinned mammals–documented for harbor seals (*14*) and killer whales (*15*)–declined in abundance in 1989 in oiled areas of Prince William Sound. Brain lesions, evident in necropsies of seals implicate inhalation of toxic fumes, the 1- and 2-ring aromatics, and were considered to have caused mortality through observed behavioral disorientation, lethargy, and stress response (*16*). Killer whales in Prince

William Sound experienced unprecedented losses in the years following the spill. Early losses arose from direct toxic exposures, whereas long-term, delayed

Table 1. Evidence of Effects of Chronic Oil Pollution. Examples of species, life stage, connection to the intertidal zone, and lowest level of PAHs causing effect (in parts per billion). "Elevated P450 enzyme" indicates PAHs are bioavailable; further effects as noted. From Peterson (2001) and Rice et al. (2001).

Species	Life Stage	PAH s (ppb)	Connection to intertidal (Effect)
Pink salmon	Embryo	1 μg/g	Early development (death, genetic damage to 1st, 2nd generation)
Pink salmon	Juvenile	1 μg/g	Nursery (decreased growth & reduced marine survival)
Dolly Varden char	Juvenile, adult	low ppb	Forage (decreased growth for 1 yr)
Cut-throat trout	Juvenile, adult	low ppb	Forage (decreased growth for 2 yr)
Pacific herring	Egg, embryo	1 μg/g	Early development (death)
Black oystercatchers	Adult	low ppb	Nest (delayed recovery due to problems with rearing chicks)
Harlequin ducks	Adult	low ppb	Forage on mussels (depressed over winter survival of females, 9 yr)
Barrow's goldeneye	Adult	low ppb	Forage on mussels (depressed recovery, elevated P450 enzyme, 9 yr)
Cormorants, murres, black-legged kittiwake, pigeon guillemot (PG), loons, mergansers	Adult	low ppb	Forage on high lipid fish (delayed recovery for 9 yr (loons 5 yr); PG lower productivity of young, elevated P540 enzyme 9 yr)
Masked greenling	Adult	0.40 μg/g	Resident (elevated P450 enzyme up to 7 years post spill)
Sea otters	Juvenile	low ppb	Forage on mussels (high mortality for up to 3 yrs)
Sea otters	Adult	low ppb	Forage (high mortality of prime breeding age adults for 5 yr)
River otters	Adult	low ppb	Forage (expanded feeding territories, poor condition, elevated P450 enzyme

effects on survival, reproduction, and recruitment success were the indirect consequences of loss of parents and experienced older members, disrupting the social structure of the pods (*17*).

In addition to the thousands of early sea otters deaths caused by acute toxicity, long-term studies revealed processes inhibiting recovery of otters in heavily oiled areas. Intensive documentation of sea otter population dynamics for over a decade after the EVOS revealed a reduced population growth rate and increased death rate of prime-age and juvenile sea otters in oiled areas of Prince William Sound (*18*). Sea otters feed heavily on clams that they dig out of eelgrass beds and on mussels and crabs. Clams and mussels sequester (absorb and store in their bodies) oil hydrocarbons: sediment in eelgrass beds and under mussel beds remained contaminated with PAHs from *Exxon Valdez* oil, which remained bioavailable to sea otters through their shellfish diet (*19*).

The 1990s paradigm of oil ecotoxicity to marine mammals recognizes risk from inhalation of toxic fumes, behavioral interdependencies among social animals, and long-term exposure to oil through diet and residual weathered oil in sediments.

SEABIRDS. Guilds of seabirds that feed in nearshore habitats suffered greater initial declines, delayed declines, and delayed recovery compared to those that feed offshore (*20, 21*). In particular, species of seaduck that feed heavily on mussels such as Barrow's goldeneyes and harlequins showed no evidence of recovery through the 1998 survey (*22*) and continued exposure to PAHs, as evidenced by high levels of enzymes that metabolize or break down oil (*23*). For years after the EVOS, harlequins experienced high over-wintering mortality rates and continued population decline in oiled areas of Prince William Sound (*24*). Black oystercatchers, a shorebird that feeds heavily on mussels, also had reduced incidence of breeding, smaller eggs, and reduced growth of offspring in oiled areas in 1989 (*25*). Results of studies on seabirds imply that energetic costs of metabolizing oil ingested through diet are substantial and create sublethal effects on growth, body condition, and reproduction (*26*) with population-level impacts (*27*).

The 1990s paradigm of oil ecotoxicity to seabirds recognizes risk from long-term exposure to oil through diet and subsequent sublethal effects on reproduction, growth, and survival with population-level impacts.

INDIRECT EFFECTS. The current risk assessment models used for predicting population-level effects of oil pollution lack all indirect effects and treat species populations as independent of one another. Studies after the EVOS demonstrated two main types of indirect effects in communities of sealife associated with rocky shores: loss of critical habitat through loss of species that provide structural habitat and "trophic-level" (food web) interactions among species (*3*).

The macroalga *Fucus* provides critical habitat, a virtual seaweed forest, for a variety of marine invertebrates that serve as prey for seabirds and shorebirds, sea and land mammals, and young pelagic and benthic fish (*3*). Dramatic loss of *Fucus* in the intertidal zone by oiling and the pressurized hot water (*28*) wash inhibited recovery of both the *Fucus* itself, which depends upon recruits being protected from desiccation by the seaweed canopy

(29), and also the community of invertebrates that shelters under the seaweed (30). The subsequent sequence of community development and species succession extended over a decade as opportunistic species of fauna and flora were gradually replaced by single-aged stands of *Fucus*, which died in cycles, starting the whole process again (31).

In the Gulf of Alaska, large reductions in sea otter populations, not spill-related, have been shown to predictably reduce predation on sea urchins, which then can experience a population explosion and overgraze their kelp and macroalgal foods. The consequent loss of the kelp forests has dramatic negative impacts on the fish and invertebrate community that resides within the forest and subsequently on the seabirds and marine mammals that prey on these resources (32). The potential for such a trophic cascade existed in Prince William Sound after the EVOS, but it was not fully realized as only the initial phase of increased sizes of sea urchins was documented in oiled areas with depleted sea otter populations (19).

Another indirect trophic impact, however, was realized in Prince William Sound when populations of important species of forage fish crashed after the EVOS (33). Herring in particular are critically important to seabirds and marine mammals because of their high lipid (fat) content and surface schooling habits, making them nutritious and easy to capture (34). Several fish-eating seabirds, including murres, cormorants, mergansers, pigeon guillemots, and black legged kittiwakes (21), and marine mammals, such as harbor seals (14), have exhibited persistent reductions in abundance in oiled areas since the EVOS.

The 1990s paradigm of oil ecotoxicity recognizes risk of delayed recovery of apex consumers (seabirds and marine mammals) due to indirect, bottom-up trophic interactions of oil inducing prey limitation. It also recognizes that interspecific interactions will lead to a sequence of delayed indirect effects on rocky intertidal communities.

Public Policy Implications

In light of the recent research on chronic oil pollution, the current regulatory framework is grossly inadequate to protect marine life from chronic, non-point source discharges, especially along urbanized coastlines. The current regulatory framework is based on outdated risk assessment models (acute toxicity models based on narcosis) that fail to recognize (a) chronic direct population-level effects from persistent PAHs; (b) sublethal, indirect, and trophic-level effects of weathered oil; and (c) the importance of habitat quality in maintaining population structure (1, 3).

Streams and estuaries serve as critical habitat, a nursery, for vulnerable early developmental life stages of many species of fish and other sealife: these habitats also receive bulk chronic hydrocarbon discharges. Scientists estimate that the amount of highway runoff in the US to be about one quart of oil per person per year. This means that for every 50 million people the equivalent of an EVOS (or 11 million gallons as reported by Exxon) is dumped every year, year after year, into productive coastline habitats as urban run-off (1). Clearly, if sustainable coastal fish populations and other wildlife are to co-exist with industrialized societies, our focus needs to shift to the prevention, control, and restoration of these habitats from contamination–whether it is from acute spills or chronic non-point source pollution.

One place to start is with our federal water quality standards for PAHs, which are currently 300 ppb. Scientists now recognize a toxicity threshold of 1 ppb aqueous PAHs for habitats where fish eggs and larvae rear (*35*). Revisions to federal storm-water discharge regulations should be based on the 1990s oil toxicity paradigm (*1*), where chronic toxicity mechanisms are the concern not short-term narcosis.

Resource managers and oil spill response managers currently use outdated ecotoxicity models from the 1970s to assess only the short-term acute toxicity risks and damage from oil pollution and, in so doing, severely understate environmental impacts of chronic oil pollution (*1, 3*). The regulatory framework governing oil discharge from offshore drilling platforms, oil tankers, and oil facilities regulated by federal discharge permits needs to be re-examined in light of the 1990s oil toxicity paradigm. Policies governing natural resource damage assessment following oil spills also fail to reflect this new appreciation of impacts of long-term toxicity. For example, the Oil Pollution Act of 1990 has effectively eliminated long-term biological damage assessment and long-term monitoring in oil spills after the *Exxon Valdez.*

A precautionary approach to oil and gas development and use seems advisable in the face of mounting evidence that oil is far more persistent and deadly in protected nearshore habitats than previously recognized. Unless restrictive regulations of anthropogenic PAH sources are adopted to minimize the ubiquitous chronic oil pollution, public resources–land, water, fish, and sealife–will subsidize at great cost the environmental burden of our oil dependency.

Acknowledgements

This paper was built upon the work of countless numbers of scientists who contributed to evaluating impacts of the EVOS. Financial support for preparation of the paper came from the Packard Foundation through the Environmental Defense Fund Academic Minigrant Program to the Alaska Forum for Environmental Responsibility.

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Once it was a Paradise, then the
Exxon Valdez came
Prince William Sound changed forever
When the oil they failed to tame
The ugly goo spread far and wide
Broadcast by the storm and tide
It coated every living thing
Killing animal and stilling wing
Exxon says "It's all fine now
We'll stand up and take a bow"
But the ocean floor whispers "Untrue,
Untrue!"
In my secret places I live hidden, the goo"
For all your talk of recovery
We here await discovery
By the world of why we are bound
To call this place "The Silent Sound".

Judy Robertson – Spokane, Washington
May 2002

SUBMITTED BY: H. MAKARKA

6/18/02

<u>Esler comments on EVOSTC Update on Injured Resources and Services</u>

I have reviewed the draft updated recovery status for harlequin ducks. I recognize the difficulty of assimilating data sets, contrasting them with a recovery objective, and placing recovery status into a discrete category. Based on my own attempt at the process, I conclude that harlequin ducks should remain on the "not recovering" list rather than being upgraded to "recovering". Here's why:

I consider the recovery objective to be an appropriate target for harlequin ducks, and it highlights the important parameters that have been identified over the years as particularly relevant to population status and recovery. Many of the recovery objectives have not been met, which clearly indicates that recovery is not complete. Further, my interpretation is that most of the available data also do not indicate progress towards recovery, which leads to my conclusion that harlequin ducks are not yet ready for the "recovering" category.

Hydrocarbon exposure is still occurring. The NVP project identified exposure through March 1998, /423 studies have indicated exposure through at least November 2000, and NOAA studies found remaining, intertidal oil in summer 2001. Hence, we are not close to meeting the first recovery objective. What this means on a population-level is <u>the</u> remaining question (which /423 is addressing).

The survey data are indeed confusing. ADFG data from falls 95-97 indicated declining populations, which matched concurrent findings of hydrocarbon exposure and lowered adult female survival from NVP. USFWS winter data indicated increasing numbers of harlequins on oiled areas from 1989-98, which is good news and could be considered evidence of progress towards recovery. However, because the increasing trend was similar in unoiled areas, USFWS considered their results evidence of <u>lack</u> of recovery, under the assumption that the rate of increase on oiled areas should be higher than on unoiled for recovery to be occurring, after accounting for broad-scale changes in numbers unrelated to the EVOS. I've not seen the analysis with 1997 through 2000 data, but (based on the description in the recovery status update) those seem to indicate stable numbers on oiled areas (recovering?) but increasing numbers on unoiled (oiled area not recovering?). In sum, it seems like the second recovery objective (stable or increasing numbers) has been met, although interpretation with regard to recovery is a bit muddy. Dan Rosenberg's ADFG spring surveys might go a long way towards clearing up some of the confusion; I've not seen these recently, so I'm not sure what they would indicate.

Are demographic attributes similar between oiled and unoiled areas? Some of them certainly are. For example, ADFG findings of similar age ratios between oiled and unoiled areas suggest that recruitment is similar between areas. Dispersal is similar between areas and low overall (NVP and /423 studies). However, the NVP finding that adult female survival was lower in oiled areas than unoiled areas during 1995-98 is critically important, and indicated that, in fact, demographic attributes were not similar. Hence, based on the recovery objectives, recovery had not occurred and, in fact, there was continued injury and thus no progress towards recovery. Findings from /423 suggest a similar survival scenario during 2000-02. The /423 data set is not complete, nor powerful enough for final conclusions at this stage; however, there are hints that demographic differences may persist.

Finally, return to prespill densities is difficult to determine, given that few prespill winter data were available for harlequin ducks. However, as of 1997, winter densities in oiled areas were lower than would be expected given the habitat, suggesting that recovery had not fully occurred by this time. Again, recent data from ADFG may shed light on whether densities are increasing in the most heavily oiled areas.

Frankly, I'd love to see harlequin ducks in a position where they could be considered "recovering". I just don't see the data lining up solidly behind that conclusion. Harlequin ducks have provided an interesting case – a well-studied instance of a particularly sensitive species that has suffered long-term, chronic effects of environmental contamination. They are definitely an anomaly and I'd agree that most bird populations (including the similar Barrow's goldeneye) are recovering or recovered. However, I recommend that the anomalous situation of harlequin ducks be recognized and their status as "not recovering" maintained.

GEM REVISIONS

Gulf of Alaska **E**cosystem **M**onitoring and Research Program (GEM)

The GEM Program Document.

Review Draft – June 7, 2002

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GEM 2002 draft 6/7/2002

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* Notes: Most of Chapter 7 has been omitted from the paper copy because it is the same as GEM 2001 Volume II Chapter 3 (Scientific background) and Volume I Chapter 2 (Human Uses). Only the new section on economics from Chapter 7 has been included. The full version of chapter 7 is available on the web at www.oilspill.state.ak.us or call for a paper copy 800-478-7745.

Appendices are the same as in the GEM 2001 Document and have not been included in the paper copy. These are available on the web at www.oilspill.state.ak.us or call for a paper copy 800-478-7745.

ACKNOWLEDGMENTS

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: Chapter 7 - Ted Cooney, Jim Bodkin, Anne Hollowed, Lloyd Lowry, Phil Mundy, Peter Olsson, Charles Peterson, Bob Spies, Alan Springer, Tom Weingartner, Jim Richardson and Gregg Erickson; Chapter 8 - Gretchen Oosterhout; Chapter 9 - 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.

NRC Review committee. A special appreciation goes to the National Research Council's Committee to review the Gulf of Alaska Ecosystem Monitoring Program: Michael Roman, Chair, Don Bowen, Andria A. Elskus, John J. Goering, George Hunt, Seth Macinko, Donal Manahan, Brenda Norcross, J. Steven Picou, Thomas C. Royer, Jennifer Ruesink, and Karl Turekian. The committee was ably staffed by Chris Elfring, Dan Policansky and Ann Carlisle.

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.

The efforts of the following are gratefully acknowledged: Alisa Abookire, Ken Adams, Vera Alexander, Fred Allendorf, Paul Anderson, Peter Armato, Shannon Atkinson, Jim Ayres, Torie Baker, Kris Balliet, Hal Batchelder, Bill Bechtol, Catherine Berg, Brock Bernstein, Chris Blackburn, Jim Blackburn, John Blaha, Jim Bodkin, Dede Bohn, James Brady, Stephen Braund, Evelyn Brown, Patty Brown-Schwalenberg, Al Burch, Vern Byrd, Robin Carlson, Robert Clark, Dave Cobb, Ken Coyle, Ted Cooney, Seth Danielson, Tom Dean, Robert DeVelice, Jane DiCosimo, Gary Drew, Janet Duffy-Anderson, Doug Eggers, Dave Eslinger, Gary Fandrei, Bob Foy, Steve Frenzel, Carol Fries, Fritz Funk, Dan Gillikin, David Goldstein, Andy Gunther, Gary Gury, Ed Harrison, Bill Hauser, Robert Henrichs, Ken Holbrook, Anne Hollowed, Brett Huber, Gary Hufford, Charlie Hughey, Dan Hull, Joe Hunt, Henry Huntington, Steve Ignell, David Irons, Lisa Ka'aihue, Tom Kline, Gary Kompkoff, Jan Konigsberg, Gordon Kruse, Kathy Kuletz, Pat Lavin, Pat Livingston, Lloyd Lowry, Allen Macklin, Tom Malone, Suzanne Marcy, Michael H. Martin, Paul McCollum, Walter Meganack, Jr., Jennifer Nielsen, Gordon Nelson, Pat Norman, Phil North, Worth Nowlin, Peter Q. Olsson, Gretchen Oosterhout, Ted Otis, Paul Panamarioff, Kent Patrick-Riley, Charles Peterson, John Piatt, Josie Quintrell, Terry Reed, Bud Rice, Stanley Rice, Evan Richert, Monica Riedel, George Rose, Dave Roseneau, Susan Saupe, Andy Schmidt, Carl Schoch, Sandra Schubert, Marianne See, Stan Senner, Bob Shavelson, Hugh Short, Jeff Short, Claudia Slater, Bob Small, Alan Springer, Stacy Studebaker, Arliss Sturgulewski, Joe Sullivan, Kevin Summers, Gary Thomas, Glenn VanBlaricom, Shari Vaughan, Gale Vicki, Jia Wang, Sarah Ward, Tom Weingartner, Steve Weisberg, David Welch, Kent Wohl, Bruce Wright, Kate Wynne.

1. VISION

In This Chapter

- ➢ Origin of the GEM program
- ➢ Vision and mission identified for the program
- ➢ Goals, geographic scope, and funding
- ➢ Building on lessons of the past

1.1 Introduction

On March 24, 1989, the *T/V Exxon Valdez* ran aground on Bligh Reef in Prince William Sound, spilling almost 11 million gallons of North Slope crude oil. The event was the largest tanker spill in U.S. history, contaminating approximately 1,500 miles of Alaska's coastline, killing birds, mammals and fish, and disrupting the ecosystem in the path of the spreading oil. In 1991, Exxon Corporation agreed to pay the United States and the State of Alaska $900 million over 10 years to restore, replace, enhance, or acquire the equivalent of natural resources injured by the spill, and the reduced or lost human services they provide (United States of America and State of Alaska 1991). Under the court-approved terms of the settlement, the *Exxon Valdez* Oil Spill Trustee Council (Trustee Council) was formed to administer the restoration funds, and in 1994 the *Exxon Valdez* Oil Spill Restoration Plan was adopted to guide the development and implementation of a comprehensive, interdisciplinary recovery and rehabilitation program.

Thirteen years after the spill, total recovery has still not been achieved. Appendix B presents the current information regarding the recovery status of resources injured by the spill. There are still two main concerns about lingering effects of the spill. The first is the potential effect of pockets of residual oil in the environment. The second concern is the ability of population to fully recover by overcoming changes in the population dynamics resulting from the initial oil-related mortalities and the interaction of these effects with those of other kinds of changes and disturbances in the marine ecosystem.

The knowledge and experience gained during 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 Trustee Council dedicated approximately $120 million for long-term monitoring and ecosystem-based research in the northern Gulf of Alaska (GOA). This new program is called the GEM (the Gulf of Alaska Ecosystem Monitoring and Research) program. Funding for the GEM program comes from an endowment, with an annual program funded through investment earnings, after allowing for inflation-proofing and modest growth of the corpus.

A program rooted in the science of a large-scale ecological disaster is uniquely suited to form the foundation for ecosystem-based management. In making the decision to allocate these funds for a long-term program of monitoring and research, the Trustee Council explicitly recognized that complete recovery from the oil spill may not occur for decades and that full restoration of these resources will most likely be achieved through long-term observation and, as needed, restoration actions. 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.

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

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 the 1994 *Exxon Valdez* Oil Spill Restoration Plan, 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 plan, 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.

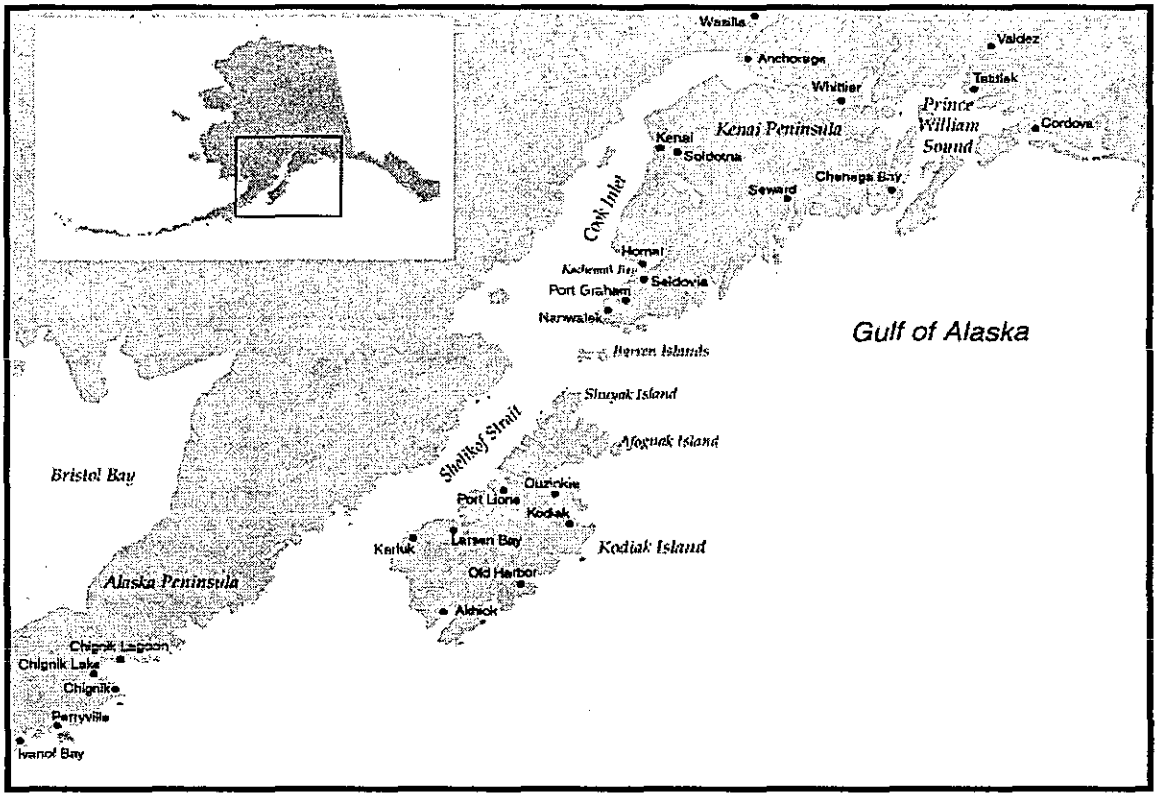

Figure 1.1 Map of the spill area showing the location of communities

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).

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 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.

The Trustee Council is aware of the trade-offs between the size of the area to be studied and the frequency and intensity of the monitoring and research that can be conducted there. In selecting core variables for long-term research and monitoring, the GEM Program will need to ensure that measurements are conducted at the spatial and temporal scales necessary to achieve the desired goals of the program. For this reason, much thought must be given to the selection of the variables and the identification of the subset of the northern GOA that can reasonably be monitored by a program the size of GEM. It is anticipated that partnering with other agencies and programs will help extend GEM's research area beyond that which GEM could fund on its own. However, a core GEM monitoring program should be able to stand on its own.

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 Building on Lessons of the Past

The GEM program is not the first attempt to look at large areas of Alaska's marine ecosystems from a broader perspective. The *Exxon Valdez* Oil Spill Restoration Program, as well as a number of other programs, provides valuable guidance. This section briefly describes some of these programs and their relevance to the development of GEM.

1.6.1 Alaska Regional Marine Research Plan (1993)

The *Alaska Regional Marine Research Plan* (ARMRP) (1993) is a marine science planning document with a broad geographic scope that was prepared under the U.S. Regional Marine Research Act of 1991. ARMRP goals express the scientific needs of the Alaska region as of 1992 and are still relevant to the GEM effort because they will accomplish the following:

Goals of other major programs are relevant to the GEM effort.

- Distinguish between natural and human-induced changes in marine ecosystems of the Alaska region;
- Distinguish between natural and human-induced changes in water quality of the Alaska region;
- Stimulate the development of a data gathering and sharing system that will serve scientists in the region from government, academia, and the private sector in dealing with water quality and ecosystem health issues; and
- Provide a forum for enhancing and maintaining broad discussion among the marine scientific community on the most direct and effective way to understand and address issues related to maintaining the health of the water quality and ecosystem health in the region.

1.6.2 Bering Sea Ecosystem Research Plan (1998)

The Bering Sea has received a good deal of attention because of concern about long-term declines in populations of high-profile species such as king and tanner crab, Steller sea lions, spectacled eiders, Steller's eiders, common murres, thick-billed murres, and red-legged and black-legged kittiwakes (DOI et al. 1998b). The

GEM mission is consistent with the vision of the federal-state regulatory agencies for the *Bering Sea Ecosystem Research Plan* (DOI et al. 1998a), which states: "We envision a productive, ecologically diverse Bering Sea ecosystem that will provide long-term, sustained benefits to local communities and the nation." The basic concepts of the GEM program are also consistent with the overarching hypotheses of the Bering Sea plan.

1.6.3 GLOBEC (1991 to Present)

The Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC) established the Global Ocean Ecosystem Dynamics (GLOBEC) program in late 1991. GLOBEC is the core project of the International Geosphere-Biosphere Programme responsible for understanding how global change will affect abundance, diversity, and productivity of marine populations. The program focuses on the regulatory control of zooplankton dynamics on the biomass of many fish and shellfish.

The GLOBEC Science Plan (U.S. GLOBEC 1997) describes an approach that uses a combination of field observations and modeling to concentrate on the middle and upper trophic levels of the ecosystem. The overarching concept is that marine and terrestrial ecosystems have close connections among energy flow, chemical cycling, and food web structure. GEM monitoring activities will be consistent with GLOBEC concepts.

1.6.4 Scientific Legacy of the *Exxon Valdez* Oil Spill (1989 to Present)

Ecological knowledge gained in the years following the 1989 *Exxon Valdez* Oil Spill (EVOS) forms a substantial portion of the foundation of the GEM program. In 1994 the *Exxon Valdez* Oil Spill Restoration Plan was adopted to guide the development and implementation of a comprehensive, interdisciplinary recovery and rehabilitation program. The recovery status of each affected resource is based to the extent possible on knowledge of the resource's role in the ecosystem. The scientific legacy of the *Exxon Valdez* Oil Spill Trustee Council (Trustee Council) creates the need to understand the causes of population trends in individual species of plants and animals through time and the need to distinguish human impacts from those of climate and interactions with related species.

The studies supported by the Trustee Council since 1989 include more than 1,600 damage assessment studies costing more than $100 million, as well as hundreds of restoration studies costing approximately $170 million. These studies have resulted in more than 500 peer-reviewed scientific publications, including numerous dissertations and theses. In addition, hundreds of peer-reviewed project reports are available through the Alaska Resources Library and Information Services (ARLIS) and state and university library systems. Many final reports are available in electronic format through the Trustee Council offices or ARLIS. A current electronic bibliography of scientific publications sponsored by the Trustee Council is available on its Web site (www.oilspill.state.ak.us) or on request to the

Trustee Council (EVROTCB 2002). A list of Trustee Council projects, as well as a complete list of final and annual project reports, also is available on the Web site or on request (EVROFAB 2002).

In addition to much specific information on the effects of oil on the plant and animal life in the spill area, the studies also provide a wealth of ecological information. Most prominent among the Trustee Council's studies are three ecosystem-scale projects, known by their acronyms: SEA, NVP, and APEX.

The Sound Ecosystem Assessment (SEA) is the largest of the three studies. Funded at $22 million for a seven-year period, SEA brought together a team of scientists from many different disciplines to understand the biological and physical factors responsible for producing herring and salmon in PWS. When completed, the data collected during SEA are expected to form the basis of numerical models capable of simulating the oceanographic processes that influence the survival and productivity of juvenile pink salmon and herring in PWS. SEA has already provided new insights into the critical factors that influence fisheries production, including ocean currents, nutrient levels, mixing of water masses, salinity, and temperatures. These observations have made it possible to model how physical factors influence production of plant and animal plankton, prey, and predators in the food web.

The Nearshore Vertebrate Predator (NVP) project is a six-year, $6.5 million study of factors limiting recovery of two fish-eating species, river otters and pigeon guillemots, and two invertebrate-eating species that inhabit nearshore areas, harlequin ducks and sea otters. The project looked at oil exposure, as well as natural factors such as food availability, as potential factors in the recovery of these indicator species, and has contributed to increased understanding of the linkages between terrestrial and marine ecosystems (see Chapter 7, Section 2).

The Alaska Predator Ecosystem Experiment (APEX) is an eight-year, $10.8 million study of ecological relations among seabirds and their prey species. The APEX project explored the critical connection between productivities of marine bird populations and forage fish species, in an attempt to understand how wide-ranging ecological changes might be related to fluctuating seabird populations. In addition, analyzing the food of marine birds shows promise in providing abundance estimates for key fish species, such as sand lance and herring.

The following topics also have been covered by other Trustee Council-funded studies and the results are available in published scientific literature:

- Physical and biological oceanography;
- Marine food web structure and dynamics;
- Predator-prey relationships among birds, fish, and mammals;
- The source and fate of carbon among species;

- Developmental changes in trophic level within species;
- Marine growth and survival of salmon;
- Intertidal community ecology; and
- Early life history and stock structure in herring.

Many studies have focused on key individual species injured by the oil spill, including pink and sockeye salmon, cutthroat trout, Pacific herring, black oystercatchers, river otters, harbor seals, mussels, and kelp.

One of the most extensive series of single-species investigations is the $14 million suite of pink salmon studies. These include monitoring the toxic effect of oil, conducting genetic studies related to survival, and supplementing select populations. Another extensive series of studies was done on Pacific herring. Roughly $6 million has been spent on the restoration of Pacific herring in addition to the funding for the herring component of SEA. Since the crash of 1993, the population has yet to recruit a highly successful post-spill year-class. Current investigative strategies are focused on the full range of causes of the crash, such as disease and ecological factors, including the effects of oceanographic processes on year-class strength and adult distribution and understanding stock structure.

More than $6 million has been spent on the restoration of marine mammals, primarily harbor seals, a major source of subsistence food in the diet of Native Alaskans in the northern GOA. Harbor seal populations were declining before the spill, took a big hit at the time of the spill event, and have continued to decline ever since, although the rate of decline seems to have slowed. Food availability is the major focus of current research, because disease and other factors have been ruled out as causes.

1.6.5 History of Trustee Council Commitment to Traditional Knowledge and Community Involvement

From 1995 –2001, the Trustee Council has provided almost $2 million to the Chugach Regional Resources Commission to facilitate the involvement of local communities in the oil spill restoration program. This included funding of facilitators in Alaska Native villages to promote community-based projects and involvement. The facilitators have been active participants in all the GEM planning workshops and meetings. This project has also included funding of the development of natural resource management plans in several villages, which tribal representatives believe are a necessary step before incorporating tribal concerns into the GEM program.

In 1994 the Trustee Council received its first call from a community resident to incorporate Traditional ecological Knowledge (TEK) of spill area residents into the restoration program. Two years later, the 1996 annual restoration workshop had TEK as its theme and led to a set of protocols for incorporating TEK into restoration projects developed by a committee of Alaska Natives and others and approved later that year by the Trustee Council. The Trustee Council has provided funds each year since 1995 toward the goal of incorporating TEK into the restoration program. Efforts have included:

- Developing a TEK handbook and reference guide for biologists documenting the sources of TEK in the spill area and incorporating it into a western science approach.
- Providing funds for CRRC to contract with TEK expert Henry Huntington. He has worked directly with Alaska Native elders and hunters as well as scientists to bridge the gap between these two different approaches to understanding the natural world. A result of this process is that several EVOS projects incorporate TEK directly into their data sets and results, including projects on community natural resource management, fish and seabird studies, and a series of films about Alutiiq culture (see examples below).
- Conducting two workshops to develop tribal management programs and bringing several scientists to spill area communities to share information.

Examples of projects incorporating TEK as a result of Trustee Council efforts include:

- Scientist Jody Seitz conducted an extensive project involving Traditional Ecological Knowledge. Researchers interviewed thirty-nine spill area community members to document the historical distribution of forage fish such as juvenile herring, sandlance, capelin, and eulachon. This information was mapped and provided to the Alaska Predator Ecosystem Experiment (APEX) and Sound Ecosystem Assessment (SEA) researchers. The results were extremely valuable because they could not have been obtained from other historical sources or from current data collection efforts.
- Scientist Dan Rosenberg solicited local participation from communities and conveyed results of his research on surf scoters, an important subsistence resource. The project idea came from local communities. Rosenberg worked with them throughout all stages of the project, from project design to writing the final report.
- The Trustee Council provided funding support to the Alaska Native Harbor Seal Commission, which uses Alaska Native hunters to conduct biosampling of harbor seal tissues using lab-approved techniques. In 1999, the commission reached an agreement with the National Marine Fisheries Service to co-manage harbor seal populations.
- Three videos have been produced with Trustee Council funds to provide the public information about Traditional Ecological Knowledge and concerns about subsistence use after the oil spill. The first two, *Alutiiq*

Pride: A Story of Subsistence and *Changing Tides in Tatitlek* describe subsistence methods, interview Alaska Native people who experienced the spill first hand, show actual subsistence hunts, and illustrate the importance of subsistence in Alutiiq culture. The third documents the communities of Chenega Bay and Ouzinkie in relation to the effects of the oil spill, residual oil in the spill region, and concerns about PSP, a natural toxin found in clams harvested for food. These videos were distributed at no charge to all schools in Alaska via their school districts, all spill area tribal councils, and any other library or school in the U.S. upon request.

The Trustee Council funded Elders/Youth Conferences in 1995 and 1998 that brought together Alaska Native elders, youth, other subsistence users, scientists, and managers to share ideas about subsistence issues and facilitate community involvement. The Trustee Council paid for four people from each of 20 spill area communities to attend each conference. Participants shared stories, voiced frustration, and asked scientists questions about subsistence issues. They also developed ideas for youth to get more involved through spirit camps, internships, and educational opportunities. These workshops facilitated collaboration between communities of the spill area, while concerns and ideas generated at the conference were reported to the Trustee Council.

Additional details on the Trustee Council's tribal and community involvement efforts are included in a March 4, 2002 report (Appendix B).

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2. INTRODUCTION TO THE CONCEPTUAL FOUNDATION, PROGRAM STRUCTURE, COMPONENTS AND STRATEGIES

In This Chapter

- Overview of GEM Program Structure
- Role of the Conceptual Foundation
- Components: Gap Analysis, Synthesis, Research, Monitoring, Modeling and Data Management
- Strategies: Traditional Knowledge and Community Involvement, Resource Management Applications and Use of Habitats for Organization

2.1 Program Structure

The overall structure of the GEM Program is built from the mission and goals, as defined by the Trustee Council, the conceptual foundation, as derived from current scientific information, and the standard components of a publicly oriented research and monitoring program (Figure 2.1). Specific strategies use the standard components, such as gap analysis and synthesis, to realize Trustee Council goals. The scope of the GEM Program and its mission and goals are represented by a broad, interdisciplinary conceptual foundation (see Chapter 5) that serves as a flexible framework for determining the type of monitoring and research activities that will be undertaken (see Chapter 3). The conceptual foundation is the product of syntheses of the latest scientific information, and an assessment of leading ecological hypotheses. It encapsulates the Trustee Council's understanding of how the GOA operates as an ecological system and how its biological resources, including highly valued populations of animals, are regulated. Key questions (hypotheses) emerge from a consideration of the conceptual foundation. These questions are further refined by assessing the information needed to evaluate them against information already available or currently being collected, through a process of gap analysis. 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 northern GOA (Figure 2.1). Modeling and data management are components which will closely support synthesis and research.

To further develop the program, the Trustee Council will use three major strategies: traditional knowledge and community involvement, emphasis on resource management applications, and organization by key habitats.

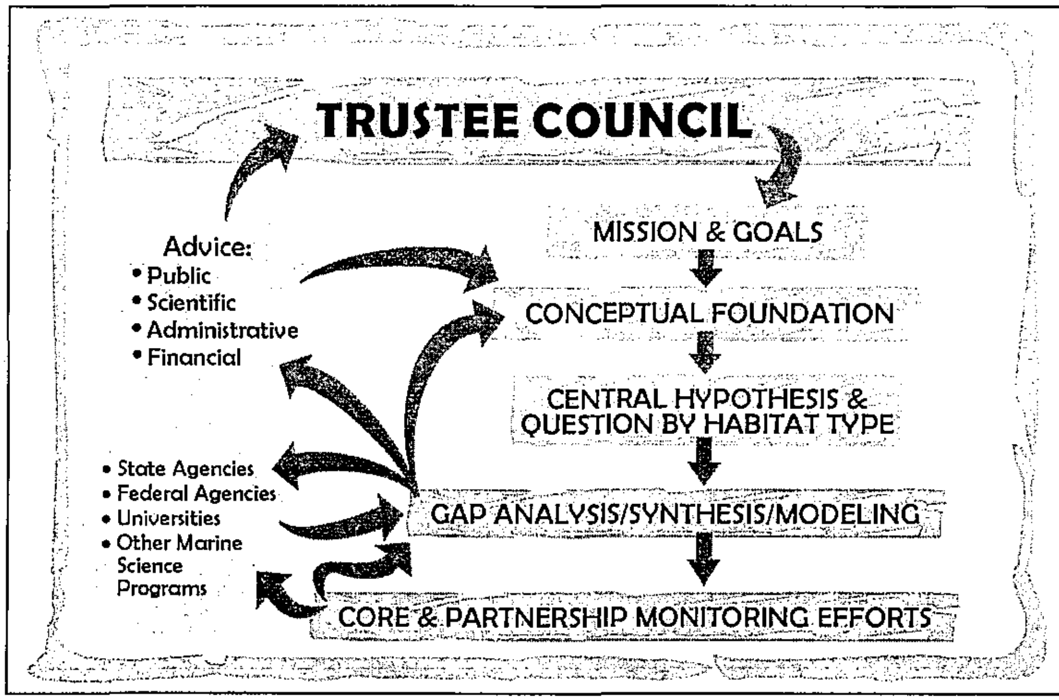

Figure 2.1. Selecting monitoring elements starts with the mission and goals established by the Trustee Council, as expressed in the conceptual foundation, which is regularly updated by new information from a variety of sources.

2.2 Introduction to the GEM Conceptual Foundation

The GEM conceptual foundation is summarized by a central hypothesis. The central hypothesis, as phrased by the NRC (2002, p. 27), states widely held beliefs about what drives changes in living marine-related resources in time and space:

The Gulf of Alaska, its surrounding watersheds, and human populations are an interconnected set of ecosystems that must be studied and monitored as an integrated whole. Within this interconnected set, at time scales of years to decades, climate and human impacts are the two most important driving forces in determining primary production and its transfer to upper trophic-level organisms of concern to humans.

Specific mechanisms that cause change are largely untested. However, current speculations, supported by limited observations, are that forcing by winds, precipitation, predation, currents, natural competitors for food and habitat, fisheries, and pollutants change living marine-related resources over different scales of time and space through alteration of critical properties of habitats and ecosystems (Figures 2.2 and 2.3).

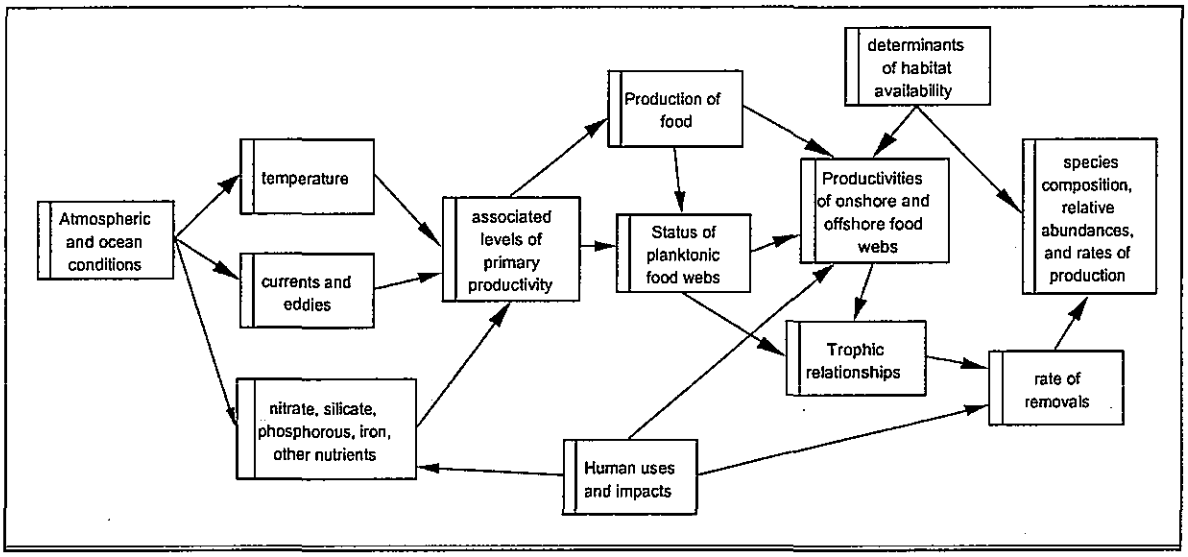

Figure 2.2 Relations among major parts of the GEM conceptual foundation.

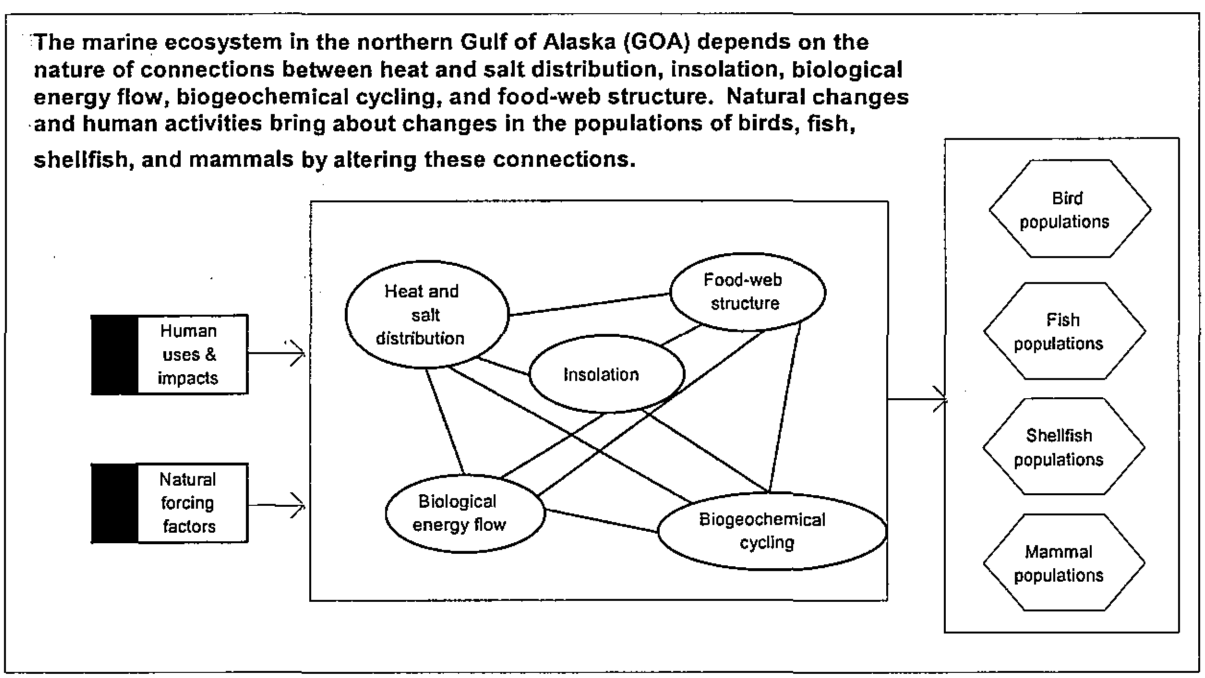

Figure 2.3 Possible connections among specific mechanisms and agents of change in living marine-related resources.

Because of the tremendous uncertainty about sources of long-term changes, the conceptual foundation does not provide a specific model (testable hypothesis) for ecosystem change. Rather, the GEM conceptual foundation is designed to be broad enough to serve as a tool to organize thinking and research over long time periods, to encompass ecosystem interconnections, and to link information from traditional knowledge and scientific disciplines. It takes into account both oceanic and terrestrial ecosystems and addresses the influence of climate and human activity in influencing biological productivity within these interconnected systems. By using this broad, scientifically grounded conceptual foundation, the GEM program will be able to adapt to changes in understanding ecosystem processes without having to sacrifice long-term research and monitoring goals (NRC 2002).

2.3 Program Components

Gap analysis, synthesis, research, monitoring, modeling, and data management and information transfer are the major components - or tools - of the GEM program. These are standard tools that are common to most programs for assessing living marine resources (Myers et al. 2000). These components are closely related, and their functions sometimes overlap (Figure 2.1).

2.3.1 Gap Analysis

In the process of starting the GEM program, key hypotheses about how the GOA ecosystem functions were evaluated and refined into a set of key questions for each of the primary habitat types in the GOA (Chapter 3). The major information gathering programs in the North Pacific (Appendix E) were reviewed to identify where these programs and projects are collecting data that could be used to answer the key questions, and where there were gaps in the information that would need to be filled by future research. This ongoing identification of information needs, or gap analysis, is an important part of the process of identifying the starting points for monitoring and research and continuing to refine the program as it progresses. This process will continue during implementation of the GEM program, with more general questions being replaced by increasingly specific questions as knowledge about the ecosystem increases.

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 four essential parts: a question, identification of information necessary to answer the question, a survey of relevant available information, and identification of gaps in the 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 seeks to identify what information is currently being collected that could help answer the question, and where gaps in the data exist. The data gaps become the priorities for focusing research and monitoring activities.

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 of effort or the possibility of failing to obtain needed data. In the short term, this database will provide information needed to select core monitoring variables and locations. In the longer term, the supporting database will become a valuable tool for resource managers, policy makers, other scientists, stakeholders, and the general public. As the GEM program moves from the general hypotheses 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.

2.3.2 Synthesis

A second 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 conceptual foundation, central hypotheses, 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 program structure and implementation plan. In this respect, synthesis is an ongoing evaluative process throughout the life of the GEM Program that will help to ensure that the program is meeting its goals and objectives. Second, synthesis is used as a tool to inform stakeholders and the public about the developing understanding of the factors responsible for change in the marine environment. This tool would be useful in workshops, meetings, or publications. And third, synthesis is used to help solve resource management problems, by identifying new applications of existing information or by identifying opportunities to solve existing problems by collecting 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 and an ongoing part of the overall program.

For the purposes of the GEM program, synthesis is distinguished separately from research and from retrospective analysis, a form of research. Unlike research, synthesis does not necessarily start from a specific hypothesis or question. Instead, synthesis takes an interdisciplinary approach to evaluating existing information or data to identify potential new applications and uses. As such, synthesis is a critical component in ensuring that cross-disciplinary and cross-habitat linkages and processes are adequately considered during research and monitoring. Synthesis may be supported by various forms of retrospective analysis (discussed below). The results of synthesis and research are often used together to solve problems.

2.3.3 Research

Research collects relatively short time series of observations to evaluate a testable hypothesis relating to the conceptual foundation or a specific aspect of the monitoring program. In the early stages of GEM program implementation, research will be critical in helping to identify the core variables around which the long-term monitoring activities will be developed. Research 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 questions 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 advance 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 northern GOA in accordance with the conceptual foundation. Continual refinement and testing of hypotheses, synthesis across geographic areas and species, and modeling of biological and physical processes are expected.

2.3.4 Monitoring

As defined for the purposes of the GEM program, monitoring is the action of collecting long-time series observations at fixed times and places and over multiple scales. At the level of data acquisition monitoring differs from research primarily in the length of time over which the measurements are taken, and the nature of methods and devices employed. Monitoring differs from research by employing methods and devices that are "tried and true," whereas research may use experimental devices or novel methods to acquire data.

The decision on what to monitor and where is based on the results of research and synthesis to identify core variables. The development of long time series of data is essential to detecting and understanding change in the ecosystem. When combined with research and modeling, monitoring can demonstrate how ecosystems change over time and in response to various inputs. As such, it provides a sound scientific basis for making management and other decisions affecting ecosystem resources. 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 in temporal and spatial scale to the hypotheses being analyzed.

Monitoring in the GEM program will be organized into core monitoring and partnership monitoring. Because of its critical importance to meeting the program's goals and objectives, core monitoring based on a set of core variables will be fully supported by the GEM program. Partnership monitoring is envisioned to extend the GEM core monitoring program by teaming with partners involved in research that is also relevant to the hypotheses that GEM will be testing. Partnership monitoring will be partially supported by leveraging GEM resources with the resources of the partner organization.

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

2.3.5 Modeling

Modeling is used to make the relationships between the parts and processes of the ecosystem clear, and as such, serve as a critical element in making connections between habitats and disciplines. 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;

- ③ Identify core variables and relationships;
- ③ Set priorities;
- ③ Improve and develop experimental (monitoring) designs;
- ③ Evaluate cross-habitat linkages and transfers; and
- ③ Improve decision-making and risk assessment.

Modeling, monitoring, and data management strategies need to work in concert for each to be fully effective (Figure 2.4). Modeling is a pivotal link

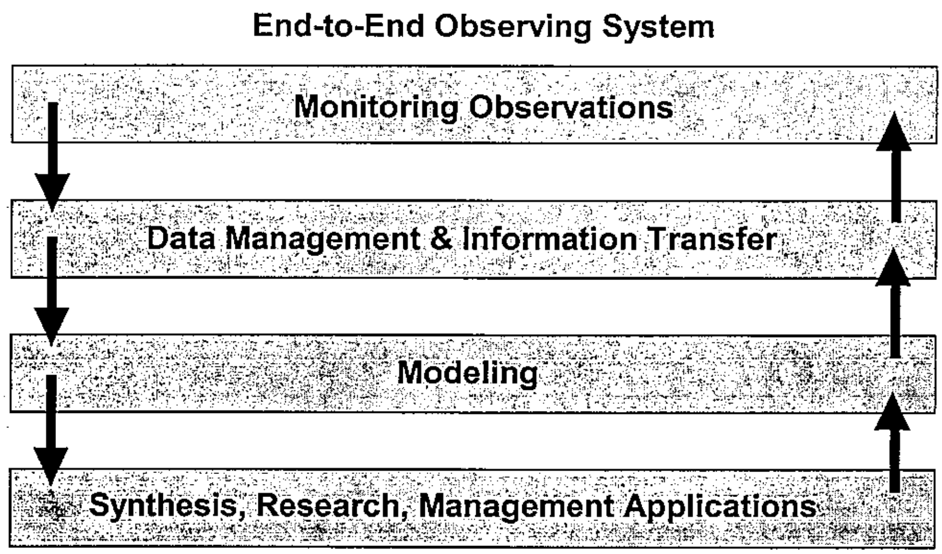

Figure 2.4 The End-to-End Observing System in which the monitoring observations are linked by data management and information transfer to end users, including modeling, synthesis, research, and management applications. (Adapted from Tom Malone [U.S. GOOS Steering Committee 2000]).

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.

As defined for the purposes of the GEM program (See also Chapter X), 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. 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.

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. A detailed discussion of the definitions and strategies for modeling in the GEM program is provided in Chapter 8.

2.3.6 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 (See also Chapter X). It includes the development of information products based on interpreted data and the delivery of these products, including user interfaces. The immediate objective of data management and information transfer is to insure that the data collected by projects under GEM are well documented, safely stored, and accessible to the public within a reasonable period of time after collection. An ongoing objective of data management and information transfer in the GEM program is to achieve to the extent possible the documentation, storage and public access for past data acquired with EVOS funds under the NRDA and Restoration programs of the Trustee Council.

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. 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 that are yet to be chosen. Possibilities for these products, based on the experience of other monitoring and research programs, are discussed in Chapter 9 and could include models and measures relevant to determining the productivity of key species such as salmon.

2.4 Strategies

2.4.1 Incorporating Traditional Knowledge and Community Involvement

Community involvement and the incorporation of traditional knowledge in the GEM program is critical to the program's long-term success. The significance of traditional knowledge is becoming increasingly recognized (IUCN 1986, Martinez 1994, Kimmer 2000) and can play a role in providing early warning signs of ecosystem change (Ford 2001). Local residents are expected to provide ecological knowledge that can be incorporated into established scientific models. They also can be a source of research questions which help ensure research that is relevant to both ecological and community needs. Community based monitoring efforts can efficiently collect essential data, and build local stewardship as well as long-term support for the GEM program.

The EVOS settlement requires meaningful public involvement in Trustee Council programs, including GEM, as well as a Public Advisory Committee. Residents of coastal communities have a direct interest in scientific and management decisions and activities concerning the fish and wildlife resources and environments on which they depend for their livelihoods and sustenance (Huntington 1992). The Trustee Council believes that encouraging local awareness and participation in research and monitoring enhances long-term stewardship of living marine resources.

Community involvement can occur in many ways. Several approaches have been tried in the EVOS restoration program and elsewhere in Alaska and other northern regions, and GEM will draw on these experiences to design specific processes for involving communities and their expertise (Brown-Schwalenberg et al. 1998, Huntington 2000, Fehr and Hurst 1996, Hansen 1994, Brooke 1993). One avenue is through active membership on the 20-member Public Advisory Committee, made up of representatives of communities and stakeholders, scientists and members of the general public. Another is through active participation of public members on various scientific subcommittees and work groups and during targeted workshops to help plan and guide the GEM Program as it develops. Other ways include having citizens, students and communities control local monitoring activities.

Traditional and local ecological knowledge can provide important observations and insights about changes in the status and health of marine resources (Huntington 1998). With Trustee Council funding, Alaska Native tribes in the GEM area are currently developing natural resource management plans that will help identify important resources and potential threats and be useful in designing local monitoring schemes that help answer key questions for the GEM program.

The Trustee Council has always listened closely to the views and interests of the people living in the spill-affected region, and responded to their concerns consistent with the legal restorations of the EVOS settlement funds. Under the terms of the settlement, restoration funds can only be used to respond to injuries to the public's natural resources - not injury to individuals or to communities. However, the communities have the well being of these resources at heart, and any program to provide for the long term health of the resources, has the benefit of providing for the long-term health of the local communities.

2.4.2 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 seek to 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.

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

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 2.5). Management of the salmon fishery requires detecting and understanding the consequences for production of habitat management decisions (Box 1.9, Figure 2.5) 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 degree to which resource managers are able to participate in the review and implementation of the GEM program.

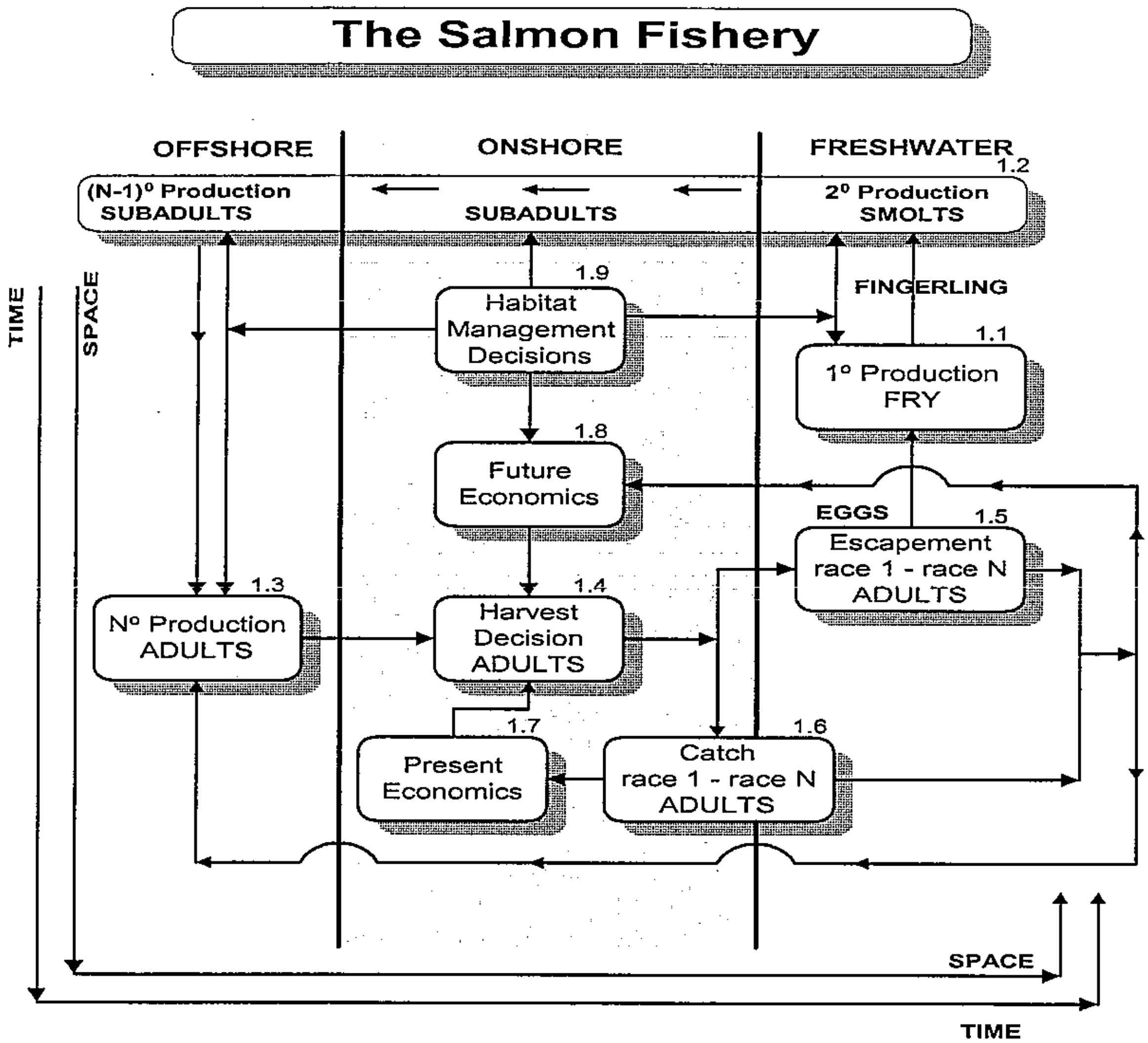

Figure 2.5. Diagram of the salmon fishery with life cycle stages, harvest, and habitat management decisions in geographic and temporal contexts (Mundy 1998).

2.4.3 Using Habitats for Organization

Four habitat types, representative of the entire GEM region, are used to better organize the GEM program: watersheds, the intertidal and subtidal areas, the Alaska Coastal Current (ACC), and the offshore areas (the continental shelf break and the Alaska Gyre). These habitats were selected as organizational units based on evaluation of hypotheses about how natural forces and human activities control biological productivity in the northern GOA (Chapters 6 and 7). The habitats are composed of identifiable, although not rigid, collections of characteristic microhabitats, resident and migratory species, and physical features. The physical, extent of the habitat types locations are described below:

The four habitat types are used as a device around which to organize interdisciplinary monitoring and research activities that address GEM's conceptual foundation.

- 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 conceptual foundation. The decision to use habitats as a mechanism for stratifying funds and allocating resources will require the GEM program to ensure that cross-habitat processes and transfers are not forgotten or ignored. Having an appreciation for the scales of time and space over which the processes responsible for biological production occur is essential for designing monitoring and research intended to detect and understand changes in the ecosystem. To understand the composition and extent of ecosystems, it is necessary to ask and answer questions about the distances and time associated with the variation in the biological and physical phenomena. As stated eloquently by Ricklefs (1990, p. 169), "Every phenomenon, regardless of its scale in space and time, includes finer scale processes and patterns and is embedded in a matrix of processes and patterns having larger dimensions."

Cross habitat linkages and processes will be incorporated into the GEM program in several ways that will be described in more detail in later chapters. The primary mechanisms for ensuring that cross-habitat issues are addressed will be through ongoing synthesis of research results and oversight by the Scientific and Technical Advisory Committee during program evaluation and funding decisions.

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3. THE CONCEPTUAL FOUNDATION IN PROGRAM IMPLEMENTATION

In This Chapter

- Building on the GEM Conceptual Foundation
- The Role of the Conceptual Foundation
- Central Hypotheses by Habitat Type
- Schedule for GEM Program Implementation

3.1 Building on the GEM Conceptual Foundation

Implementing the GEM Program is a process of building on the conceptual foundation. The scope of the GEM Program and its mission and goals require a broad, interdisciplinary conceptual foundation that provides a flexible framework around within which the program's synthesis, research, monitoring and modeling components will be applied. The GEM conceptual foundation is the product of synthesis and modeling, the latest scientific information, and an assessment of leading ecological hypotheses (Chapters 6 & 7). It encapsulates the Trustee Council's understanding of how the GOA operates as an ecological system and how its biological resources, including highly valued populations of animals, are regulated.

3.2 Role of the Conceptual Foundation

The conceptual foundation carries the information in the mission, goals, and historical record forward into the other GEM program elements and activities (Figure 3.1). It provides the framework for determining the type of research and monitoring activities that will be undertaken. From the conceptual foundation, key hypotheses are developed that lead to specific questions for guiding research. Through a process of gap analysis, synthesis, research and modeling, the key hypotheses and questions are further refined with input and involvement by partners, scientists and the community. Thus, the intellectual framework of the GEM program is a hierarchy composed of a conceptual foundation, central hypotheses related to habitat types, habitat-specific research questions, and ultimately, testable hypotheses based on the specific questions.

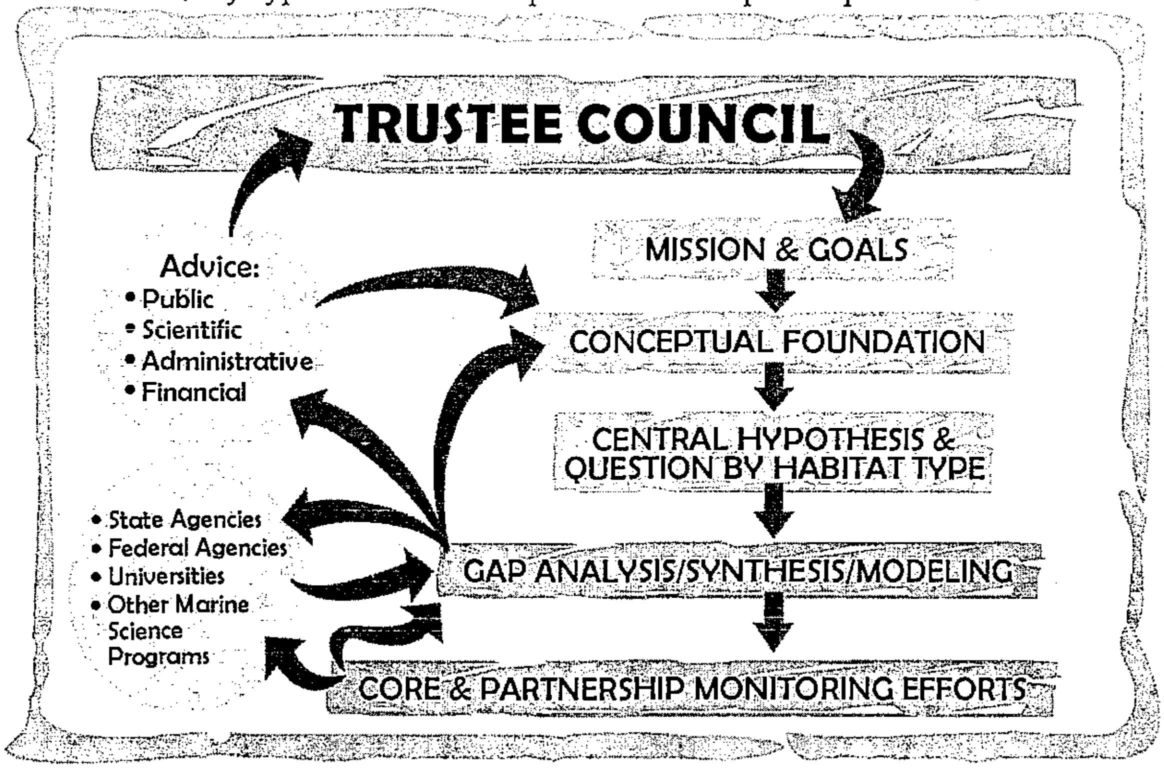

Figure 3.1 The process of selecting GEM monitoring efforts is a logical progression from the mission and goals, through the conceptual foundation, central hypotheses and questions, gap analysis, synthesis and modeling, as influenced by input from various sources.

The conceptual foundation focuses on how the marine ecosystem in the GOA works.

Through synthesis and further insight from ongoing programs, a conceptual model for the program may eventually be specified. If so, this model should be broad and robust enough to be tested by the monitoring and research program and then accepted, modified, or eventually rejected without rendering the underlying data streams irrelevant to constructing a clearer picture of ecosystem change.

3.3 Developing Key Hypotheses and Questions

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 were selected based on evaluation of hypotheses about how natural forces and human activities control biological productivity in the northern GOA (Chapters 6 and 7). The 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 conceptual foundation. The decision to use habitats as a mechanism for stratifying funds and allocating resources will require the GEM program to ensure that cross-habitat processes and transfers are not forgotten or ignored. Having an appreciation for the scales of time and space over which the processes responsible for biological production occur is essential for designing monitoring and research intended to detect and understand changes in the ecosystem. To understand the composition and extent of ecosystems, it is necessary to ask and answer questions about the distances and time associated with the variation in the biological and physical phenomena. As stated eloquently by Ricklefs (1990) (p. 169), "Every phenomenon, regardless of its scale in space and time, includes finer scale processes and patterns and is embedded in a matrix of processes and patterns having larger dimensions." Indeed, spatial and temporal scales are part of the definitions of physical and biological processes such as advection and growth. Taking account of spatial and temporal scales is critical to studying linkages between natural forces and biological responses (Francis et al. 1998).

Cross habitat linkages and processes will be incorporated into the GEM program in a several ways that will be described in more detail in later chapters. The primary mechanisms for ensuring cross-habitat issues will be through ongoing synthesis of research results and oversight by the Scientific and Technical Advisory Committee during program evaluation and funding decisions. It is also expected that modeling efforts will be regional in focus rather than habitat specific.

3.3.1 Key Hypotheses

Four habitat-specific key hypotheses, based on the conceptual foundation, form the core of the GEM monitoring plan. These hypotheses and are based on assumptions about how natural and anthropogenic factors influence ecosystem functioning within each of the habitat types, recognizing that different factors may be important in different habitats. The key hypotheses for each habitat type are:

Watersheds:

> *Natural forces (such as climate) and human activities (such as habitat degradation and fishing) serve as distant and local factors in causing short-term and long-lasting changes in marine-related biological production in watersheds.*

Intertidal and Subtidal:

> *Natural forces (such as currents and predation) and human activities (such as small-scale development and increased urbanization) serve as distant and local factors, in causing short-term and long-lasting changes in community structure and dynamics of the intertidal and subtidal habitats.*

Alaska Coastal Current (ACC):

> *Natural forces (such as the variability in the strength, structure and dynamics of the ACC) and human activities (such as fishing and pollution) cause local and distant changes in production of phytoplankton, zooplankton, birds, fish, and mammals.*

Offshore:

> *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) play significant roles in determining production of carbon and its shoreward transport.*

3.3.2 Key Research Questions

Before these hypotheses can be used to guide research, they need to be further refined into questions which can then be used to identify a core set of measurements for long-term monitoring. Information for developing these research questions comes from many sources, including analysis of ongoing and existing research results, evaluation of agency monitoring programs and activities, and input from a variety of interest groups including scientists, resource managers and the communities. One of the most valuable resources for identifying research questions is the legacy of scientific information and results from community involvement projects from the EVOS Restoration Program.

Using these resources, the following set of initial research questions has been developed. The questions are meant to capture some of the main uncertainties in how fluctuations in the northern GOA ecosystem influence the distribution and abundance of valued organisms. They do not attempt to capture the entire scope of potential monitoring and research projects, but rather they address discrete aspects of the conceptual foundation and are a starting point for identifying research activities. As knowledge of the ecosystem increases, through ongoing hypothesis testing, the research questions are expected to gain greater specificity and refinement.

<u>**Watershed Questions:**</u>

a. 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.

b. 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.

c. 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

Intertidal and Subtidal Question:

a. 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.

Alaska Coastal Current Questions:

a. 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.

b. 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.

c. 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.

d. 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.

e. 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.

f. 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.

g. 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.

<u>**Offshore Questions:**</u>

a. 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.

b. 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.

c. 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.

d. 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.

e. 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.

3.4 Program Implementation

The "flagship" of the GEM program will be a long-term monitoring program that will be maintained even if funding levels vary. Gap analysis, synthesis, research, and modeling will all be used to develop and refine monitoring activities. The core variables for monitoring will be determined from initial synthesis, research, modeling and community involvement.

To maintain the value of the long-term monitoring program, data collection and sampling protocols will remain as constant as possible over the life of the GEM Program. Therefore, it is critical that GEM thoroughly evaluate the choice of variables to monitor. This will be done by selecting targeted research projects in the early years of the program that will evaluate potential variables for inclusion in the long-term monitoring program. Research will be focused around the initial research questions identified above. In the initial years of the program, research projects will be selected through a solicitation process in which proposals for research will be requested. The request for proposals will be issued by the Trustee Council with recommendations from the Scientific and Technical Advisory Committee, the Public Advisory Committee and community involvement (See Chapter 4). As the GEM Program matures, requests for proposal may become increasingly targeted toward requests for specific research and monitoring projects and capabilities. To ensure that the program does not become isolated from innovative research that would be of great value, a portion of the available funds will be allocated to these types of projects. Workshops and subcommittees will be one of the most important mechanisms used to involve the public, including resource managers, communities and other stakeholders in selection of research and 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 *central hypothesis* for each habitat and the initial questions as the starting point for performing the necessary synthesis and research for identifying core variables for long-term monitoring as discussed in the preceding section. .
- 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 7).

The proposed schedule strategy for implementing GEM monitoring activities in the watershed, intertidal/subtidal, and ACC habitat areas is similar, but modeling and data management needs differ in each habitat. For offshore research, GEM will primarily be involved in partnering activities, since research offshore is already being undertaken by a number of other large-scale programs. As a result, the strategy and schedule for implementation is dependant on the implementation schedules for partner programs.

3.4.1 Watersheds

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 3.1 presents the proposed schedule and strategy for implementation.

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 3.1 Proposed Implementation Strategy for Watershed Habitat

	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

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

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.

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.

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.

3.4.2 Intertidal and Subtidal

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 3.2 presents the proposed schedule and strategy for implementation.

Table 3.2 Proposed Implementation Strategy for Intertidal and Subtidal Habitat

	Monitoring Activity			
Fiscal Year	**Core**	**Partners**	**Model**	**Data Management**
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

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 3.2). 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.

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.

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.

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.

3.4.3 Alaska Coastal Current

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 3.3 presents the proposed schedule and strategy for implementation.

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 3.3 Proposed Implementation Strategy for Alaska Coastal Current Habitat

	Monitoring Activity			
Fiscal Year	Core	Partners	Model	Data Management
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.

Models

Several hydrographic and circulation models have been or are being developed for the ACC (see also Chapter 8, and Appendix D). 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 8, and Appendix D). 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).

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.

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.

3.4.4 Offshore

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 3.4).

Table 3.4 Proposed Implementation Strategy for Offshore Habitat

	Monitoring Activity			
Fiscal Year	**Core**	**Partners**	**Model**	**Data Management**
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.

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.

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).

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.

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.

End Chapter 3

NOTE: PAGES 49 - 60 ARE NOT INCLUDED IN THIS DRAFT EDITION
06/07/2002

4. PROGRAM MANAGEMENT: ADMINISTRATION, PUBLIC & COMMUNITY ADVICE & INVOLVEMENT, SCIENTIFIC GUIDANCE, AND DATA POLICIES

In This Chapter

- Program administration
- Discussion of a reconstituted Public Advisory Committee to provide public advice and ways to provide for community involvement
- Description of the process for providing scientific advice, review and management
- Establishment of data management office and policies

4.1 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 Trustee Council Office (Figure 4.1). An executive director will oversee the financial, program management and administrative, 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, including the Scientific and Technical Advisory Committee, and from the public, including the Public Advisory Committee.

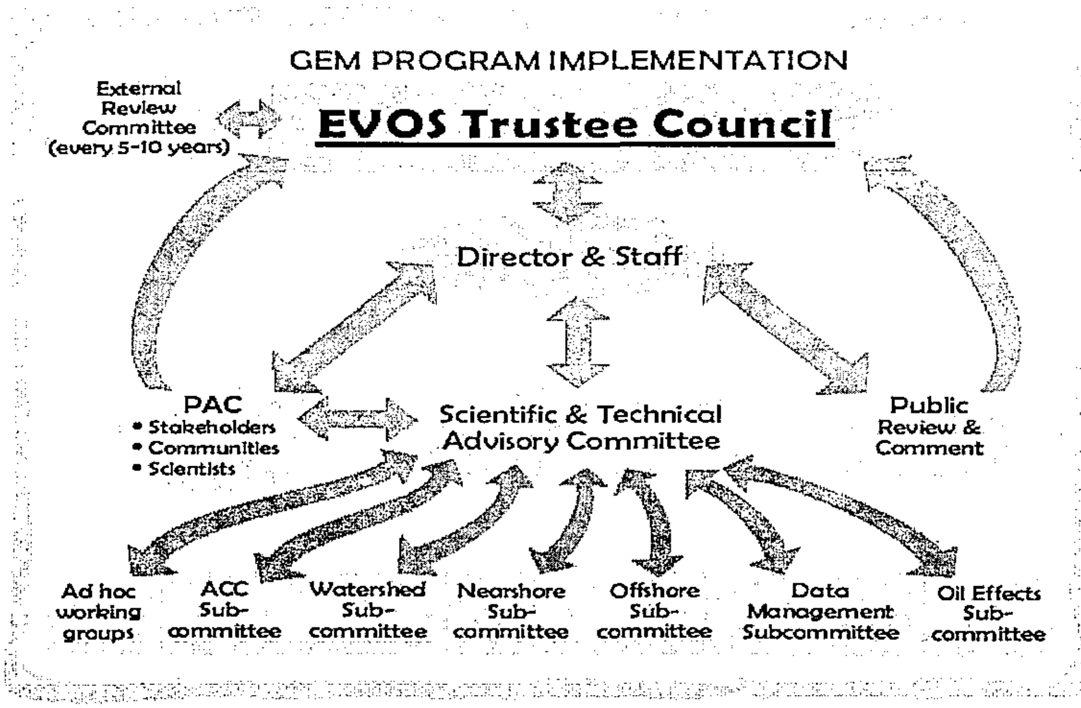

Figure 4.1. The organizational elements involved in GEM implementation. Modified in response to comments from the NRC, after GEM Program Document, Vol. I, Chapter 6, page 66.

4.1.1 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.

4.1.2 Proposal Development & Evaluation Process

The proposal development and evaluation process will have the following elements or steps, which are also shown in Figure 4.2. As implementation of the GEM program 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 and public 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, the public and others that proposals will be considered during a certain period of time.
- Proposals received in response to the *Invitation* will be circulated for technical peer review (see below). In addition, proposals will be reviewed by the STAC and appropriate subcommittees 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 strategies of the Trustee Council (see Chapter 1), 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.
- Comments from the PAC and the general public will be solicited. A reasonable period of time for public comment will be built into the review process.
- The executive director will present to the Trustee Council the recommendations of the STAC and PAC, a summary of any additional public comment, and additional recommendations if appropriate.
- The Trustee Council, after receiving advice from its public and scientific advisors and staff, will vote on which proposals to fund.

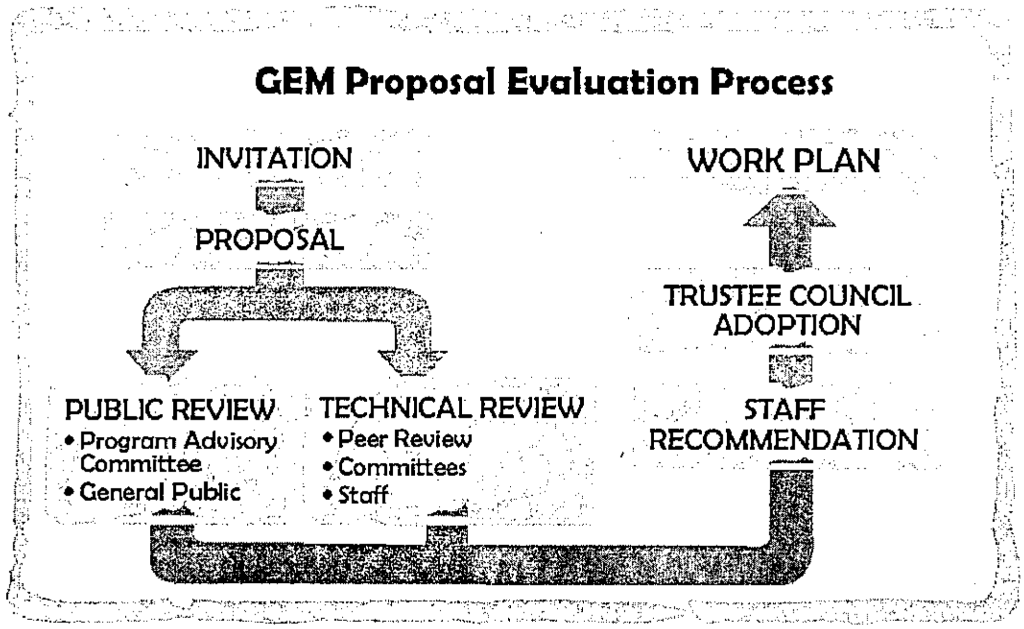

Figure 4.2 The GEM proposal evaluation process consists of seven basic elements in chronological order: the invitation, the proposal, public and technical review, staff recommendation, Trustee Council adoption, and the work plan.

4.1.3 Reports and Publications

Annual and final reports will be required for all projects, following established procedures. Annual reports will be reviewed by staff to ensure that investigators are making satisfactory progress toward project objectives. They may possibly be sent out for independent peer review in addition. 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 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.

4.1.4 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.

4.1.5 External Program Review

The Trustee Council is committed to review of the program by an outside entity, such as the National Research Council, at periodic intervals. This review will look at the program's structure and implementation to ensure that the GEM mission and goals are being achieved.

4.2 Public and Community Advice and Involvement

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.

The Trustee Council is committed to public input and public outreach as vital components of the long-term GEM program. Figure 4.1 illustrates the role of public participation in the GEM program.

4.2.1 Public Advisory Committee

The Public Advisory Group (PAG) in effect from 1991 - 2002 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 a new Public Advisory Committee (PAC) will be certified in September 2002. The PAC will consist of 20 members, representing at least 14 distinct public interests. The PAC meets at least twice a year to provide broad program and policy guidance to the Trustee Council and staff on the overall development and progress of the GEM program. The group will take an active role in setting priorities and ensuring that the overall program is responsive to public interests and needs.

4.2.2 Public Advice

The Public Advisory Committee is not the only source of public advice for the Trustee Council. Opportunities for public advice and comment are incorporated throughout the process. The Trustee Council is a public entity subject to the State of Alaska Open Meetings Act and corresponding federal laws. All meetings are public, noticed to the public, and include a formal public comment period. Newsletters, annual reports, public meetings in communities in the spill-affection region, and the Trustee Council's Web site (www.oilspill.state.ak.us) are all tools to promote and encourage public input and participation.

4.2.3 Public and Community Involvement

The Trustee Council is committed to incorporating public and community involvement in the GEM program at all levels. This means not just providing advice on proposals and policies, but involving communities early on in developing research hypotheses and questions and helping decide what variables to monitor and in what locations.

Developing a program that includes extensive community involvement will be a challenge, and will necessarily evolve over time. The Trustee Council is funding several planning projects in FY 2002-2003 to further develop ways to better incorporate local and community involvement in the GEM program.

Ongoing efforts include, but are not limited to, these elements:

- Community meetings where community members are asked to provide information on what issues and questions are most important to them.
- Public, stakeholder and community membership on the Public Advisory Committee. Expansion of the committee size to allow greater participation by communities and stakeholders.
- Community representation on all subcommittees and work groups used in developing and implementing the GEM program. Making funding available to encourage participation in subcommittees and work programs.
- Joint meetings between the Scientific and Technical Advisory Committee and the Public Advisory Committee to foster communication between scientific interests and community interests.
- Membership of at least one STAC member on the PAC.
- A proposal solicitation and review process that encourages community based proposals.
- The inclusion of community based monitoring programs and traditional knowledge in the GEM Program, especially in the watershed and intertidal/subtidal habitats.

4.3 Scientific Advice, Review & Management

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.

4.3.1 GEM Science Director

The GEM Program Science Director will work closely with other scientific advisory bodies, and will be the staff member tasked with overseeing implementation of the science program and informing interested communities of the program's results. The Science Director will work with a staff, currently composed of a Science Coordinator and a Data Manager, who will assist in overseeing implementation of research and monitoring activities, ensuring timely delivery and dissemination of research results, and maintaining the GEM database. The Science Director makes recommendations to the Executive Director and the Trustee Council on program implementation and development.

4.3.2 Scientific and Technical Advisory Committee (STAC)

The STAC is a standing committee that is expected to provide the primary scientific advice to the Executive Director on how well the collection of proposed monitoring and research projects (the work plan) and the GEM Program meet the mission and goals of the program and test the conceptual foundation.

The STAC has three primary functions:

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

2. Make recommendations to the Executive Director and GEM Science Director on preparation of the science program and implementation plans; proposal solicitation and peer review; and selection of research, monitoring, synthesis, modeling and other studies best suited to meeting the goals of the GEM program.

3. Provide support and oversight to subcommittees and ad hoc work groups (see below).

The STAC is composed of emeritus and senior scientists and others selected primarily for expertise and leadership in a field of study who serve for four-year renewable terms. At least one of the scientists serving on the STAC also serves on the PAC. In general, the STAC members are not be principal investigators for GEM projects. Institutional and professional affiliations are of interest in selecting members, because connections to other marine science programs are valuable for ensuring collaboration and coordination on GEM program implementation. The GEM Science Director is a co-chair and non-voting member of the STAC.

4.3.3 Subcommittees

Subcommittees would be standing committees organized to address specific aspects of the GEM program, to facilitate coordination among scientists, resource managers, and the communities, and to help the STAC provide leadership and oversight for the program.

The functions of the subcommittee(s) would be to:

- Recommend to the STAC testable hypotheses, items for invitation and peer reviewers;

- Identify and help guide implementation of core monitoring stations and variables that are relevant to the key questions and testable hypotheses;

- Advise on, or possibly convene special review panels or work groups about, aspects of the GEM program.

The subcommittees would be composed of scientists, resource managers, educators, and community members selected for knowledge, expertise or familiarity with the issue around which the subcommittee is created. For example, subcommittees could be developed around each of the broad habitat types (watersheds, intertidal and subtidal, ACC, and offshore), lingering oil effects, data management systems and information technology, modeling, monitoring or other GEM program areas. Subcommittee members could be principal investigators on current GEM funded projects. Institutional, professional, and other affiliations would also be of interest in selecting members to promote collaboration and cooperation.

4.3.4 Work Groups

Ad hoc work groups may be periodically formed to develop specific products as requested by the STAC 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.

4.3.5 Workshops

The STAC or subcommittees may recommend organizing workshops to provide input on core variables for monitoring, research activities, community involvement strategies, and other program elements. The GEM Program anticipates that workshops will play an important role in implementing the science program and disseminating the results of GEM research to resource managers and communities.

4.4 Data Management and Information Transfer

The Data Management Office will be an essential component of the GEM Program. The office will be headed by a Data Systems Manager who will evaluate continually the evolving information management needs of the GEM program, and identify and recommend cost-effective solutions to the Executive and Science directors. Over time the mix of in-house supporting staff and out-sourced tasking may vary, but there will be a long-term commitment to providing consistent and high quality data management support (data quality, archive, and analysis) to the GEM program. Staff in the Data Management Office will coordinate with other agencies in regard to data management and information transfer, manage computing resources, develop software programs, and maintain web sites in support of the GEM program. In addition, staff in the Data Management Office will be responsible for developing and ensuring compliance with data policies and procedures.

Data management and information transfer policies are an integral part of GEM program management. Clear and effective approaches for information gathering, archiving and dissemination are essential to the successful operation of a long-term ecosystem science project such as the GEM program. Because the GEM program is regional in geographic scope, with goals of cooperation, coordination, and integration with existing marine science programs, data management and information transfer 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 Geographic Data Committee (FGDC), GLOBEC, and the EPA's Environmental Monitoring and Assessment Program (EMAP), and other organizations will be considered for developing GEM data management and information transfer policies. (Options and procedures for data management and information transfer are considered in more detail in Chapter 9.)

The GEM data management and information transfer policies will incorporate the following broad elements:

1. A commitment to making data and models available in a well documented and understood form.
2. Full and open sharing of data and models at low cost, after verification and validation.
3. Timely availability of data and models.
4. Acceptance of and adherence to the data policies as a condition for participation in the GEM program and receipt of funding.
5. Adherence to data collection and storage standards.
6. Availability of data and models on the GEM public Web site, or through a national public archive.
7. Long-term archiving of all data and models in a designated storage facility.
8. Proper metadata, including identification of the origin of all data and models with a citation.

5. CONCEPTUAL FOUNDATION

In This Chapter

- Description of the Conceptual Foundation for the GOA
- Description of the Conceptual Foundation for the Habitat Types
- Description of Cross-Habitat Linkages and Regional Variations
- Description of the Central Hypothesis and Question Derived from the Conceptual Foundation by Habitat Type

5.1 Introduction

The conceptual foundation provides an overarching explanation, or verbal model, of how the GOA ecosystems produce biological resources. As such the conceptual foundation is not itself a testable hypothesis on the sources of change in ecosystems, but the origin of hypotheses, both general and testable. This chapter presents the narrative of the GEM conceptual foundation for the GOA, addresses cross-habitat connections and regional variability, adapts the narrative of the conceptual foundation to the four habitat types used by GEM, and develops a general hypothesis and research questions for the GOA and the habitat types based on the conceptual foundation.

The conceptual foundation focuses on how the marine ecosystem in the GOA works.

The general hypothesis and research questions for the GOA and the habitat types based on the conceptual foundation are those used in Chapter three to provide the initial starting points for GEM implementation. The answers to the questions based on the conceptual foundation are the objects of GEM monitoring and research.

5.2 The Conceptual Foundation

5.2.1 The GOA at a Glance

The conceptual foundation for the GOA ecosystem explains how its plant and animal populations are controlled through time. Specific citations to the scientific literature are omitted for the sake of brevity, however these may be found in the scientific synthesis of Chapter 7. Taking the watersheds and marine areas of the GOA together at a single glance, the importance of key geological features in shaping the natural physical and biological forces that control productivity is apparent (Figure 5.1). Note that features illustrated in Figure 5.1 are printed in bold in the following text. Natural forces are shaped by the surface topography of the Gulf. Storm tracks moving across the North Pacific from west to east can drive **Aleutian Low Pressure (ALP)** systems deep into the GOA until the

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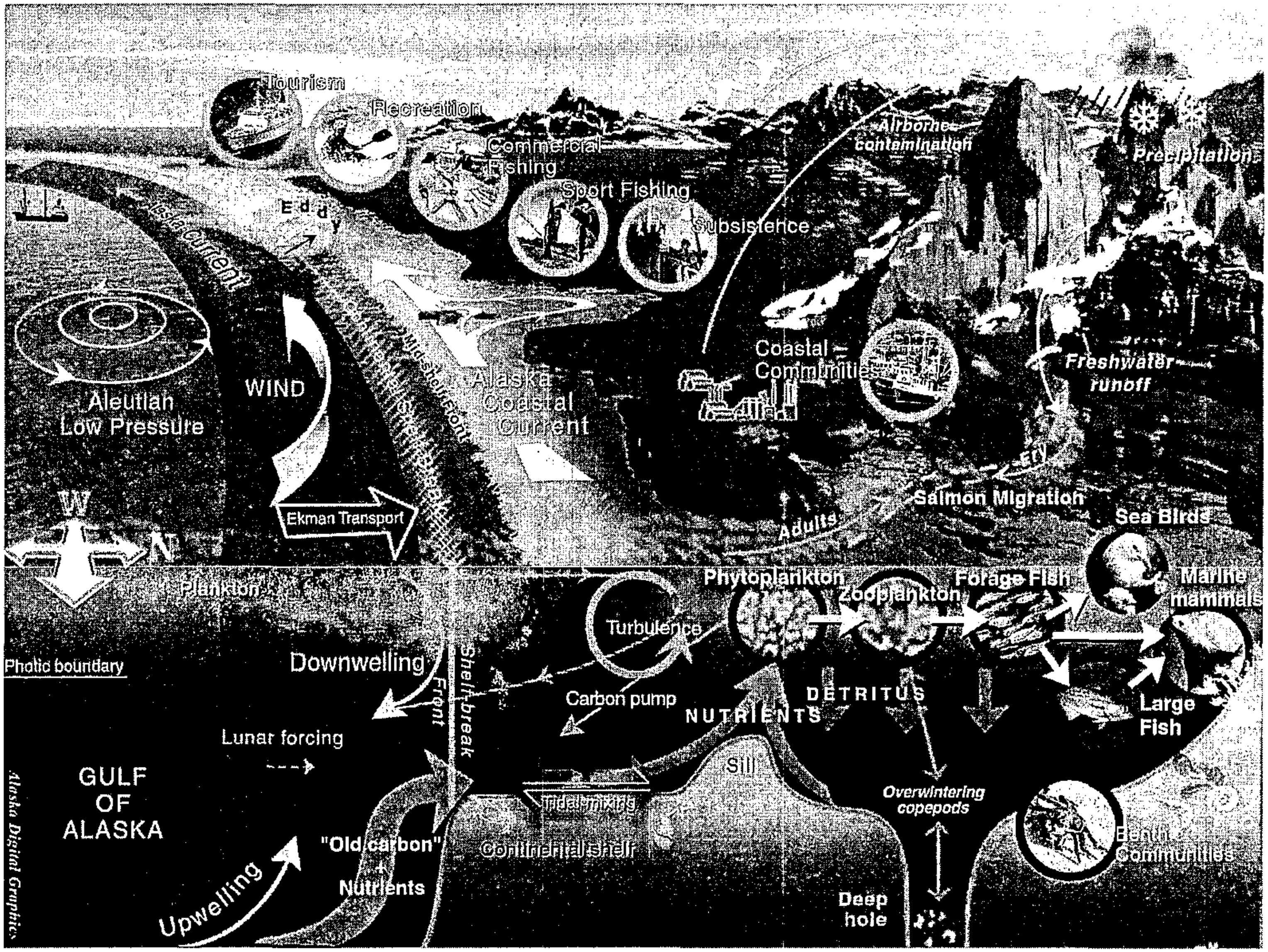

Figure 5.1 The physical and biological elements of the ecosystems of the northern GOA from the mountains surrounding the watersheds to the oceanic waters offshore.

encounter with **boundary mountains** causes the release of **precipitation** and **airborne contaminants**. **Freshwater runoff** strengthens the **Alaska Coastal Current** (ACC) even as it brings airborne and terrestrial pollutants into the **watersheds** and **food webs**.

Natural forces that control biological productivity are also shaped by the submarine topography (bathymetry) of the **continental shelf**. Deep waters **upwell** across the **continental shelf break**, subsequently being carried across the **photic boundary** into areas of photosynthetic activity by the motion of surface currents, (ACC; **Alaska Current [AC]**), **lunar forcing**, the motion of the earth, and **tidal mixing**. These deep waters carry **old carbon and nutrients** up into the food webs of the shelf and onshore areas. Where the deep waters encounter islands, seamounts and **sills**, the resulting currents may deform the boundaries of the frontal zones of the ACC (**mid-shelf front**) and AC (**shelf-break front**), creating **eddies** that entrain plankton and other plants and animals for long periods of time (Figure 5.1).

Natural physical forces control productivity by limiting the amount of food and availability of habitats. During the winter especially, the ALP produces **wind-driven** transport of surface marine waters (**Ekman transport**), bringing water onshore. Movement of water onshore creates **downwelling** that takes plankton and associated nutrients out of the photic zone. On the other hand, the wind may act to hold the nutrients dissolved in water and held in **detritus** in the photic zone in some areas, because wind also produces **turbulence** that mixes the surface water. Turbulent mixing causes nutrients to be retained in surface waters, and retention increases production of **phytoplankton**, the base of the food web in surface waters. Production of **zooplankton**, primary productivity, is the trophic connection (linkage) of phytoplankton to production of **forage fish**, which in turn links primary productivity to **seabirds, large fish, marine mammals**, and **benthic and intertidal communities** (Figure 5.1).

The biogeochemical cycle is an important collection of natural biological processes controlling the productivities of both marine and terrestrial environments. The mechanisms that move carbon from the surface to the deep waters, are known collectively as the **carbon pump.** Atmospheric carbon moves into seawater as carbon dioxide to be incorporated by phytoplankton during photosynthesis. Carbon also enters the sea as carbonates leached from the land by freshwater runoff, as plant debris, and as other biological input, such as immigrations of salmon (**salmon fry**) and other anadromous species. Carbon moves to benthic communities and to deep water as detritus and emigrant animals (**overwintering copepods** and migrating myctophids). Emigrant animals (**adult salmon** and other anadromous species) also move marine carbon (and phosphorous and nitrogen) into the watersheds (Figure 5.1).

As illustrated by the interactions of biological and physical components of the biogeochemical cycle, natural biological forces modify the effects of natural physical forces on birds, fish, and mammals. Because of biological-physical interactions, natural physical forces that cause changes in **primary productivity** do not necessarily cause proportional changes in populations of birds, fish, mammals, and benthic animals. For example, the effects of physical forces on the amount of food available from primary productivity are modified through other natural forces, such as **predation and competition** among individuals, collectively known as the **trophic linkages.** Populations that respond strongly to physical forcing of primary productivity on approximately the same time scales are termed "strongly coupled," and those that exhibit variable responses are termed "weakly coupled" with respect to those physical variables. Note that physical forcing changes not only the food available from primary productivity, but also the extent of habitats available for reproduction and feeding (Figure 5.1).

Human actions also serve to change the ways in which populations of plants and animals respond to the natural physical forces that affect the responses of reproduction, growth, and survival through limiting food and habitat. Human actions such as water withdrawals, sewage discharge, and development of **coastal communities** change productivity by altering habitat availability and trophic linkages. Fishing and other harvesting activities (**subsistence, sport, commercial**) affect death rates through removals. Other forms of human action are more subtle, but no less effective, controls on productivity. **Recreation and tourism** may alter growth and reproduction by disturbing rookeries and introducing pollutants. **Commercial marine transport** may alter productivity by introducing pollutants oil spills) and noxious species as competitors and predators (Figure 5.1).

In summary, the GOA and its watersheds are part of a larger oceanic ecosystem in which natural physical forces such as currents, upwelling, downwelling, precipitation and runoff, acting over large and small distances, play important roles in determining basic biological productivity. Natural physical forces respond primarily to seasonal shifts in the weather, and in particular to long-term changes in the intensity and location of the ALP system in winter. Increased upwelling offshore appears to increase inputs of nutrients to surface waters, which increases productivity of plankton. Increased winds appear to increase the transport of zooplankton shoreward toward and past the shelf-break. How often and how much offshore zooplankton sources contribute to coastal food webs depends on natural physical and biological forces such as predation, migration, currents and structure of the fronts, formation and stability of eddies, degree and extent of turbulence, and responses of plankton to short and long-term changes in temperature and salinity.

A wide range of human impacts interacts with natural biological and physical forces to change productivity and community structure in the GOA. Human activities have the most direct and obvious impacts at those sites in watersheds and intertidal areas where human populations are high. Nonetheless, some human activities affect populations of birds, fish, shellfish, and mammals far offshore, and also have impacts far from the sites of the actions. In short, human activities and natural forces together act over global to local scales to drive and shape marine and terrestrial life in the GOA and its tributary watersheds. Natural forces and human impacts, as exemplified by heat and salt distribution, insolation, biological energy flow, biogeochemical cycling and food web structure, fishery removals, pollutant inputs, and the relationships among them over time define the state of the marine ecosystem. Natural forces and human impacts bring about changes in populations of birds, fish, shellfish, and mammals by altering the relationships among these state variables that define the marine ecosystem.

5.2.2 Watersheds

Watersheds are linked by geochemical cycles and common climatic forcing to the marine ecosystem. Input of terrestrial carbon contributes to the carbon budget of the oceans. Likewise, marine contributions of nutrients appear to be important to growth of aquatic and terrestrial plants in watersheds.

5.2.2.1 Physical Forcing and Primary Production

Primary natural forces are precipitation and insolation. Watersheds depend on import of marine nutrients by anadromous fish and other animals. Therefore, maintenance of healthy salmon runs and populations of terrestrial animals that feed in the nearshore marine environment is key to healthy watershed ecosystems. Woody debris and vegetation from land are also imported to the marine environment, providing a carbon source and habitat for some species. The common effects of climate also link these two systems. Fresh water from coastal watersheds contributes huge amounts of fresh water to the GOA and makes possible the ACC–the single most dominant and integrating feature of the physical environment on the continental shelf.

5.2.2.2 Food, Habitat and Removals of Valued Species

Human activities in the watersheds that remove natural vegetation can result in soil erosion and its attendant effects on stream and coastal marine life. Fresh water can carry contaminants to the marine environment. Sources of these contaminants can be of local origin–sewage and septic wastes, industrial and military wastes, motor vehicles, and oil from spills–or imported from distant sources and carried across the Pacific Ocean by atmospheric processes.

5.2.3 Intertidal and Subtidal

The intertidal and subtidal–or nearshore–area is technically a part of the ACC regime in most places (the next habitat to be considered), except arguably in some embayments, such as the fjord systems in northern PWS. But, because of the importance and vulnerability of the intertidal and shallow subtidal areas and the dependence of so many valued species on nearshore habitat, it is treated here separately from the ACC.

5.2.3.1 Physical Forcing and Primary Production

The productivity of intertidal and subtidal marine communities depends on both fixed algae and some other vascular plants in shallow water, as well as free-floating phytoplankton. Nutrient supply to fixed plants is not well characterized, but presumably is controlled by oceanographic processes and seasonal cycles of water turnover on the inner shelf as well as some contributions from stream runoff. This process of nutrient supply is essentially the same as for nearshore phytoplankton. Ultimately, as mentioned in Section 3.5, Volume II, the run up of deepwater from the central GOA onto the shelf and some poorly characterized processes for cross-shelf transport of the nutrients are critical to growth of both fixed and floating nearshore algae. The nearshore waters can be depleted of nutrients during the growing season if the warm surface layers where primary productivity is drawing down nutrients is not mixed with deeper waters by wind and tidal action. Within-season variability in primary production, therefore, appears to depend on the previous late summer run up of deepwater onto the shelf, some poorly described cross-shelf transport processes, and within-growing season wind and tidal mixing.

Cloud cover also is likely to be very important in regulating the amount of solar energy reaching the ocean surface. Nearshore turbulence, which is the result of the prevailing climate and tidal action, promotes the growth of algae and phytoplankton. These plants are the food supplies for filter-feeding molluscs, such as clams and mussels, that are important sources of food for a variety of nearshore animals, such as sea otters and sea ducks. Climate also directly affects intertidal and subtidal animals through changes of temperature, water salinity, and ice formation. Ice formation is an important source of mortality and reduced growth of intertidal algae and some animal populations in some situations. It is suspected that bottom-up forcing through variability of primary production is an important influence on intertidal invertebrate communities on the scale of decades, but there are no long-term data sets to examine this supposition. If wave action is too intense, it can limit population growth; for example, waves during storms often throw large amounts of herring eggs (embryos) onto the beach where they die.

In addition to these natural factors, human activities in the intertidal and subtidal area, and human accidental releases of toxic materials have the potential to affect nearshore primary production. At the present time, it appears that the influences of natural forces on basin and regional scales in nearshore ecosystem productivity are overwhelming and that human influences are negligible, except in local areas (such as harbor contamination).

5.2.3.2 Food, Habitat and Removals of Valued Species

A large number of intertidal and subtidal animal populations respond to both bottom-up and top-down natural forcing as well as to human activities. Bottom-up forcing appears to have more documented effects on such populations as herring, pollock, shrimp, crab, salmon, and seabirds than have been documented for infaunal and attached intertidal animals. There are good examples of population controls by removals (top-down influences) and many of these relationships, such as that between sea urchins and sea otters, are cited in Section 3.7, Volume II.

Disease possibly influences some populations, such as *Viral Hemorrhagic Septicemia* virus effects on Pacific herring in PWS.

The intertidal and subtidal benthos is particularly vulnerable to human use through harvesting of various invertebrates, trampling, discharge of contaminants, road and home construction, and soil erosion. At the present time, impacts of such activities appear to be localized because of the dispersed nature of human activities along the vast coastline of the northern GOA. The nearshore sentinel populations may need to be monitored more closely, however, as Alaska's population and use of the nearshore zone expands in the future.

5.2.4 Alaska Coastal Current

As noted above, the domain of the ACC in many cases starts at the shoreline and extends out to a frontal area several tens of kilometers onto the continental shelf. The inshore boundary of this current system is not precisely defined in this subsection because the nearshore aspects of the ecosystem have been covered above.

5.2.4.1 Physical Forcing and Primary Production

Because the ACC is a buoyant, low-salinity, eastern, boundary current fed essentially by a line-source of fresh water along the length of the Alaska coastline, it offers a unique opportunity to study basin-scale physical forcing of biological production. Although one characteristic of the ACC is the draw-down of nutrients during the growing season to levels that are undetectable, the in-season variability is clearly driven by patterns in the aforementioned wind mixing, and is very significant. A promising model developed by Eslinger et al. (2001) is capable of tracking the in-season variability of plankton production based on the physical characteristics of the water column and the wind field. The extent to which patterns of seasonal wind mixing are the major contributors to longer-term variability in primary productivity is not clear. Tidal mixing likely contributes to variability, as do other potential mechanisms that transport deep-water nutrients into shallow waters; for example, late-summer relaxation of onshore Ekman transport and up-canyon currents.

Annual variability of nutrient supply likely has a great influence on long-term variability in primary production. For example, this influence would be consistent with the relationship between the Bakun upwelling index and pink salmon marine survival rates up to 1990 (see Section 3.6, Volume II) and the differences observed between the volumes of settled plankton in the 1980s and in the 1990s (Brown unpublished).

Another physical phenomenon that apparently affects biological production in the water column is eddies. Eddies have been documented in Shelikof Strait, for example, and greatly influence retention of larval pollock in a favorable environment (Bogard et al. 1994, Bailey et al. 1997). Beyond their study in the FOCI program, not much is known generally about eddies in the ACC and their biological influences. There are also eddies in Kachemak Bay, some of which are stratified at the surface by freshwater inputs that may similarly benefit pelagic species there and off Kayak Island, southeast of PWS. The southerly and easterly winds that predominate during most of the year drive offshore water inshore (via Ekman transport), carrying offshore planktonic organisms close to shore and providing potential sources of food for nearshore organisms, such as juvenile pink salmon.

Finally, the outer edge of the ACC often forms a front with the water masses seaward of it. This front is characterized by strong convergence of offshore and inshore water masses and significant downward water velocities. It appears at times to concentrate plankton, nekton, fish, and birds, and is probably an important site for trophic interactions.

5.2.4.2 Food, Habitat and Removals of Valued Species

Many of the types of natural and human activities that affect the nearshore species apply also to the ACC. This similarity is due in part to the fact that many species cross between the nearshore environment and deeper waters. Bottom-up forcing appears to be of great importance, because areas of the ACC with high levels of chlorophyll a during the growing season and vigorous vertical mixing, such as Lower Cook Inlet, also support large populations of fish, seabirds and marine mammals. The ACC is the main domain of the GOA for the productive fisheries for both pelagic and benthic species. Consequently, human activities are potentially a quite large aspect of removals. Other possible human impacts include contaminants and long-term global warming.

5.2.5 Offshore: Alaska Current and the Subarctic Gyre

5.2.5.1 Physical Forcing and Primary Production

In the offshore areas of the Alaska Current and the subarctic gyre, forcing by winds associated with the ALP system has a profound effect on production and shoreward transport of plankton. Production and shoreward transport of plankton are determined by the following:

- Upwelling at the center of the subarctic gyre;
- Depth of the mixed layer (freshwater and solar energy input set up the mixed surface layer where primary production takes place);
- Possible upwelling of nutrients along the continental slope and at the shelf break where the shelf break front may direct upwelled water toward the surface; and
- Formation of eddies along the shelf break that may incubate plankton in a favorable environment for production and be mechanisms of exchange between offshore and shelf water masses. Individual eddies may persist for months and are therefore potentially important in any one growing season.

The contrasts in biological production and shoreward transport of plankton between intense and relaxed ALP conditions in the Alaska Current region and the subarctic gyre are profound. In periods with more negative atmospheric pressure that is keyed by the northeastern movement of the ALP into the GOA in winter, the following interrelated physical changes are observed:

- Acceleration of the cyclonic motion of the Alaska Current and subarctic gyre;
- Increased upwelling in the middle of the subarctic gyre (and possibly along the continental shelf);
- Entrainment of more of the west wind drift (southerly portion of the subarctic gyre) northward into the GOA, rather than into the California Current system;
- Warmer surface-water temperatures and increased precipitation and fresh water runoff from land;
- Freshening of the surface layer;
- Increased winds and Ekman transport; and
- Increased onshore downwelling.

These phenomena are thought to cause the following biological changes:

- The result of the shallower mixed surface layer is that the spring plankton production is likely higher (remember that nutrients may not be limiting in the subarctic gyre);
- Greater standing crops of zooplankton and nekton that have been observed are probably made possible by the higher productivity of the phytoplankton;
- More food is available for the fish that feed on plankton and nekton, such as salmon; and
- Salmon populations track mean atmospheric pressure for the wintertime sea surface on scales of decades.

In addition to the multi-decadal oscillations of atmospheric pressure, climate changes manifested in the northern GOA also include periodic El Niños and the long-term warming of the oceans. El Niños have been associated with successful recruitment of a series of groundfish species, such as pollock, as well as some die-off of seabirds. Because the El Niño phenomenon appears to be manifested solely in warming of the upper 200 m of the ocean, its biological effects are probably mediated through water stratification and its relationship to primary production and growth of larval fish.

5.2.5.2 Food, Habitat and Removals of Valued Species

The Alaska Current is centered over the shelf break, an area of high biological activity. The high concentrations of plankton observed at the shelf break, whether they result from accumulation of plankton originating further offshore, in situ production, or both, provide a rich resource for a variety of organisms and their predators. It is not clear that juvenile salmon feed in this regime, but adults of all species certainly do. Other prominent organisms include sablefish, myctophids (lantern fish), sea lions, some seabirds, and whales. Well-developed benthic communities exist on the outer shelf, shelf break, and continental slope, including commercially exploited populations of shrimp, crab, cod, halibut, and pollock. Some fishing activities, such as bottom trawling, have the potential to do habitat damage and possibly limit populations of animals associated with the sea bottom. Issues associated with the balance between production and removals of commercially important species are of the utmost societal importance in Alaska and further ecological information, modeling, and synthesis centered on the Alaska Current regime is necessary.

5.3 Cross-Habitat Connections, Regional Differences, Interacting Ecological Factors

In general, regional differences in populations of fishes, birds, and marine mammals in the northern GOA are well known, but the underlying interacting ecological factors that act across geographic locales and habitat types to give rise to these differences are not as well understood. In this section, some of the observed regional differences and some potential reasons underlying them are advanced. These explanations of regional differences are based on incomplete or piecemeal evidence, but this speculation is important because it may lead to further study and analysis and to new understanding. Comparative analysis of interacting factors, cross-habitat connections, in several regions may better clarify the role of various geographic features, physical forcing, and biological consequences in the northern GOA, as was emphasized in relation to seabirds (Section 3.9, Volume II). Because there is so much homogeneity in the ACC in particular, what happens in PWS, along the Kenai Peninsula, in outer and middle Cook Inlet, and in the Shelikof Strait may well represent four different field experiments in the same body of water.

One of the most prominent regional contrasts is the different levels of ecosystem productivity apparent in lower Cook Inlet and PWS. It is relatively clear from satellite measurements of surface-water chlorophyll a and the large populations of forage fishes, seabirds, and marine mammals that occur there that the Lower Cook Inlet area is extremely productive in the summer growing season relative to PWS. Satellite data for the sea surface temperatures indicate that cold deep water, which is presumably also rich in plant nutrients, is on the surface whenever images are available; in satellite images taken at the same times, PWS appears to have warmer surface water. The strong mixing that brings deeper water to the surface in this area is probably largely tidal in nature. Vigorous mixing is encouraged by:

- The local geography and oceanography, such as the large tide range;
- The large volume of water that is exchanged with each tidal cycle; and
- The narrow entrances to outer Cook Inlet relative to the area of Cook Inlet.

Another regional difference on a somewhat smaller scale occurs within Cook Inlet itself. In Cook Inlet, studies of forage fish abundance and seabird populations at Gull Island on the eastern side and Chisik Island on the western side provide an interesting contrast that strongly suggests physical forcing on seabird populations. At Gull Island, populations of all major seabirds have been increasing during the last 20 years, and at Chisik Island the opposite trend has occurred. This difference appears to be caused by marine-influenced conditions near Gull Island where the food web probably has much greater access to deep-water nutrient sources. At Chisik Island, however, the system is strongly influenced by nutrient-poor, silty freshwater runoff from the major glacial rivers of northern Cook Inlet, and only meager populations of forage fish exist within the range of most species. It appears that with a warmer climate and more runoff, the dynamic balance between fresher water coming down the western side of Cook Inlet and saltier offshore water entering Stevenson and Kennedy entrances has been shifted to make Chisik Island less productive and Gull Island more productive. Eddies, which have been known to exist for some time near Gull Island in Kachemak Bay, have recently been shown to provide a less-dense surface lens in which forage fish favorable to seabirds reside.

Another example of regional differences in geography and physical forcing shaping important differences in ecological production is the eddy system in Shelikof Strait. As mentioned above, this system has been extensively explored and modeled during the FOCI program. This eddy system retains larval pollock in relatively favorable conditions for growth and allows them to eventually contribute to the important pollock fishery in the northern Gulf.

The Trustee Council's SEA program, hatchery production records, and other studies, such as those carried out on kittiwake reproduction, have demonstrated important subregional ecological differences between northern and southern PWS as well as eastern and western PWS.

The pattern of some differences may have changed on a decadal scale. The following regional differences are apparent in PWS:

- Residence time of water in different portions of PWS, with longer residence time in the northern portions of the sound that have more restricted water circulation;
- Degree of incursion of the ACC into the sound, which appears to vary annually;

- ③ Glacial runoff, which is greater in the north and east; and
- ③ Extent of subtidal habitat, which is greater in the eastern portions of PWS.

5.4 Central Hypothesis and Questions by Habitat Type

5.4.1 Central Hypothesis

Natural forces and human activities working over global to local scales bring about short term and long lasting changes in the biological communities that support birds, fish, shellfish and mammals. Natural forces and human activities bring about change by altering relationships among defining characteristics of habitats and ecosystems such as heat and salt distribution, insolation, biological energy flow, freshwater flow, biogeochemical cycles, food web structure, fishery impacts, and pollutant levels.

The central hypothesis states widely held beliefs about what drives changes in living marine-related resources in time and space. Specific mechanisms that cause change are largely untested. However, current speculations, supported by limited observations, are that forcing by winds, precipitation, predation, currents, natural competitors for food and habitat, fisheries, and pollutants change living marine-related resources over different scales of time and space through alteration of critical properties of habitats and ecosystems (Figures 5.2 and 5.3).

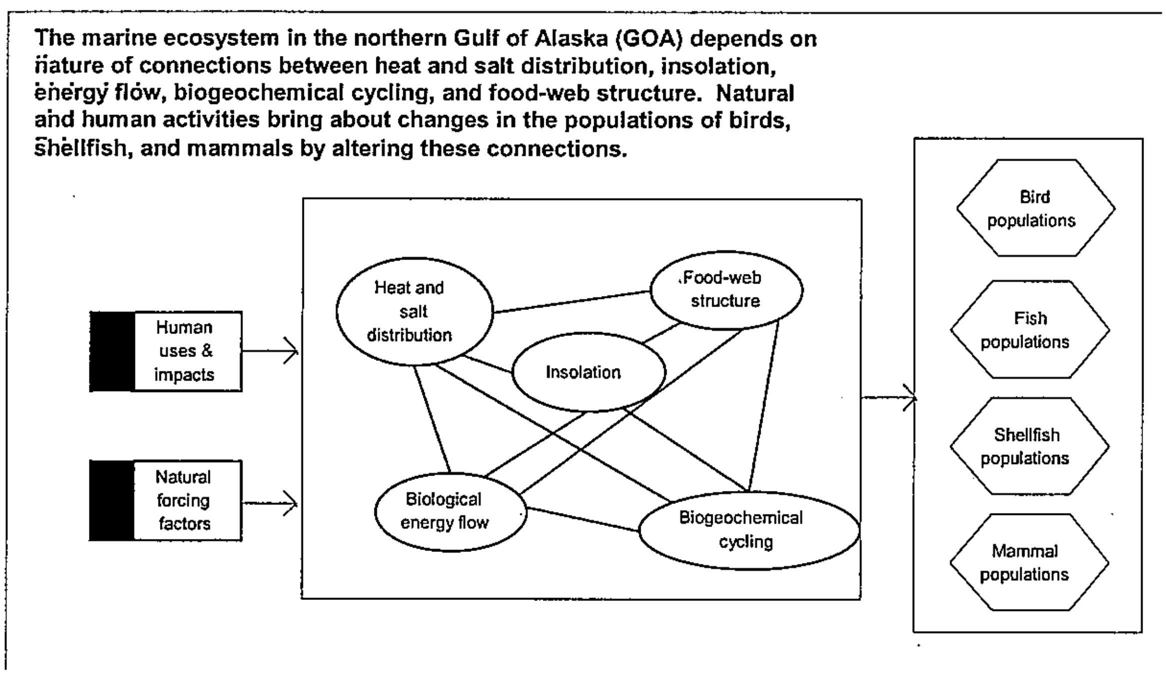

Figure 5.2 Relations among major parts of the GEM conceptual foundation.

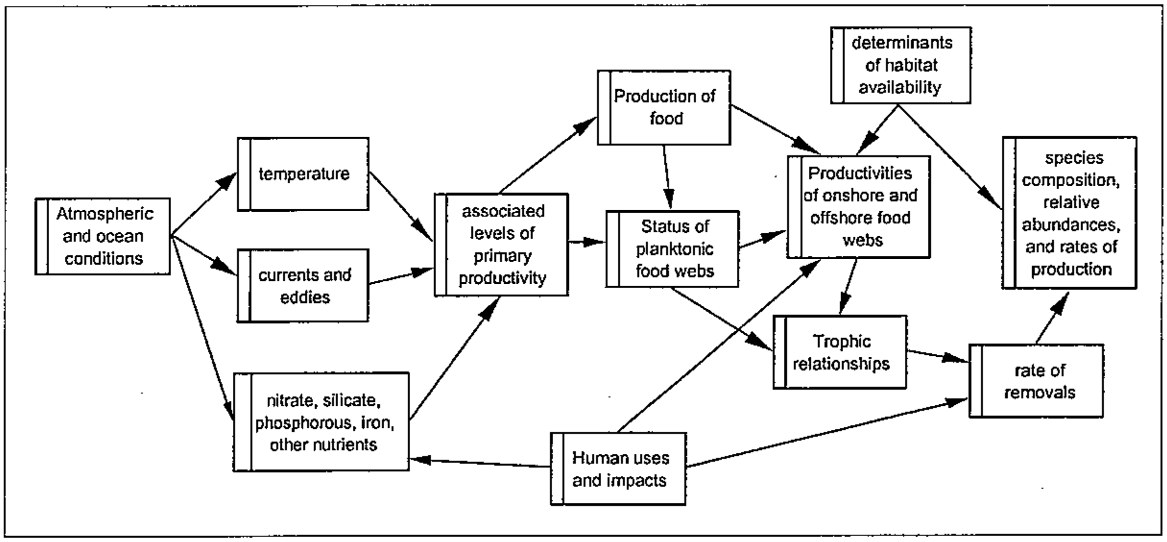

Figure 5.3 Possible connections among specific mechanisms and agents of change in living marine-related resources.

Having an appreciation for the scales of time and space over which the processes responsible for biological production occur is essential for designing monitoring and research intended to detect and understand changes in the ecosystem (Figure 5.4). To understand the composition and extent of ecosystems, it is necessary to ask and answer questions about the distances and time associated with the variation in the biological and physical phenomena. As stated eloquently by Ricklefs (1990) (p. 169), "Every phenomenon, regardless of its scale in space and time, includes finer scale processes and patterns and is embedded in a matrix of processes and patterns having larger dimensions." Indeed, spatial and temporal scales are part of the definitions of physical and biological processes such as advection and growth. Taking account of spatial and temporal scales is critical to studying linkages between natural forces and biological responses (Francis et al. 1998).

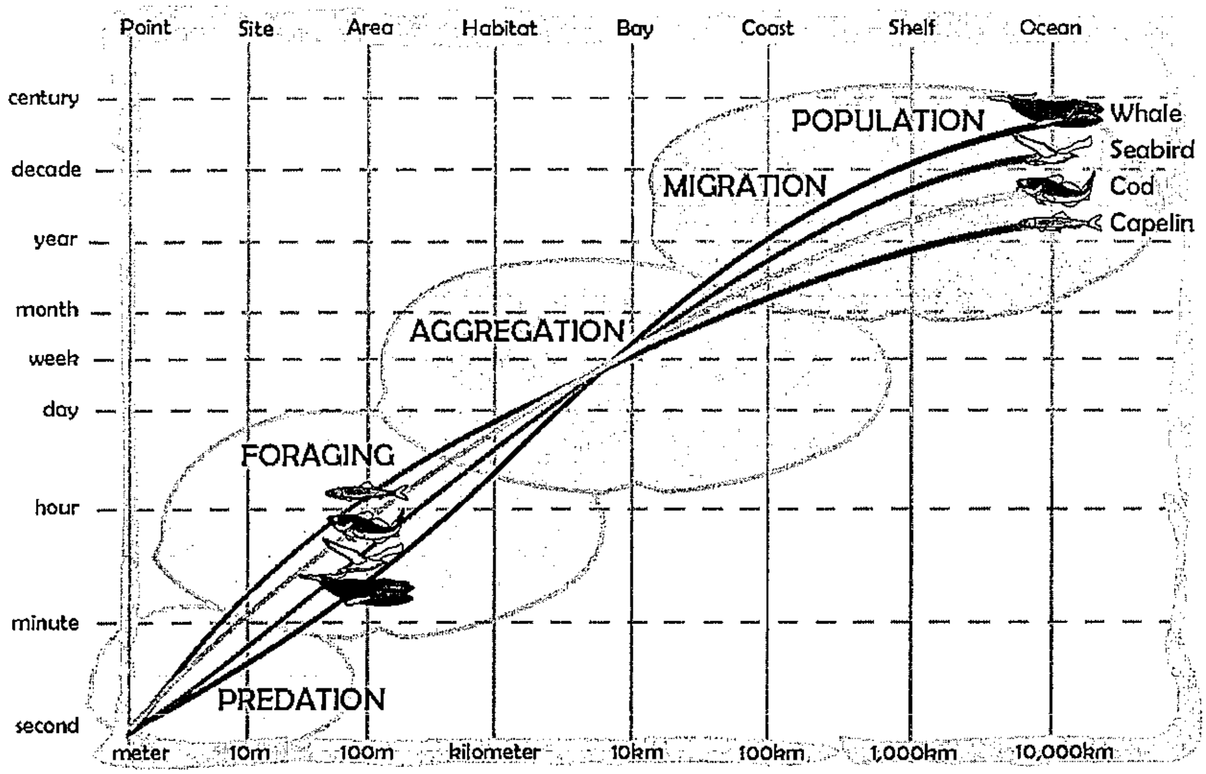

Figure 5.4 Scales of time and space corresponding to key elements and processes in ecosystems of the GOA. Illustration provided by John Piatt.

The central hypothesis is easily converted into a central question designed to explore the means by which natural forces and human activities drive biological responses over different scales of time and space:

> *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 following four habitat types, as formally defined in Chapter 3, Volume I, provide points of reference for studying the relations among species in spatially and ecologically separated habitats. The intent is to implement monitoring that can, in the long term, help understand the relationships between productivity or community structure of a habitat and the other three habitats. Thus, the central question can be specifically targeted to each of the habitats.

Watershed (see Chapter 3)

> *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?*

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 community structure and dynamics of the intertidal and subtidal habitats?

Alaska Coastal Current (see Chapter 3)

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?

Offshore (Outer Continental Shelf and Alaska Gyre) (see Chapter 3)

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?

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6. OVERVIEW OF THE SCIENTIFIC FOUNDATION

In This Chapter

- Leading hypotheses in marine ecosystems
- Leading hypotheses in marine ecosystems
- Ecological concepts by habitat

6.1 Introduction

GEM's mission, as defined in Chapter 1, 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 furthering this mission, it is necessary to have a strong, scientifically credible, conceptual foundation on which the long-term research and monitoring hypotheses and models for the program will be based. The scientific literature contains a number of specific hypotheses about how natural forces and human activities control biological productivity in marine ecosystems. This chapter presents an overview of the hypotheses and underlying principle ecological concepts that were used to guide the development of the conceptual foundation for the GEM program.

6.2 Some Leading Hypotheses

This section reviews leading hypotheses that explain changes in biological production as a result of natural and human activities.

6.2.1 Match-Mismatch Hypothesis

The essence of the match-mismatch hypothesis is:

- Populations of organisms are adapted to certain environmental conditions.

- When those conditions change rapidly, predator and prey populations may not track in the same way.
- As a result, transfer of energy into the higher levels of the food web is compromised.

This hypothesis has been proposed by Mackas to explain changes in production with the slow shift to earlier emergence of *Neocalanus* copepods at Ocean Station P in the last several decades (Mackas et al. 1998). The match-mismatch hypothesis was also invoked by Anderson and Piatt to explain ecological changes observed in a long time series of small-mesh trawl sampling around Kodiak Island and the Alaska Peninsula (Anderson and Piatt 1999).

6.2.2 Pelagic-Benthic Split

Eslinger et al. (2001) suggested that strong inshore blooms of spring phytoplankton that occur in conditions of strong stratification put more biological production into the benthic ecosystem, in contrast to weaker, but more prolonged blooms, that occur in cool and windy growing seasons. Under the latter conditions, it has been proposed that biological production is more efficiently used by the pelagic ecosystem and that relatively less of the production reaches the benthos. It is conceivable that during a series of years in which one condition is much more prevalent than the other, food might be reallocated between pelagic-feeding and benthic-feeding species and be reflected in changes in these populations. Strong year classes of particular long-lived species also might result from conditions of strong stratification causing more biological production or weaker blooms, leading to dominance of the system by certain suites of species.

6.2.3 Optimum Stability Window Hypothesis

Gargett (1997) proposed that there is a point in the range of water stability below which water is too easily mixed downward, resulting in less than maximum productivity, and above which the water is stratified to the extent that it resists wind mixing. Gargett proposed that the fluctuating differences in salmon production between the California Current and subarctic gyre domains are ultimately the result of these two systems being on different parts of this response curve at different times.

6.2.4 Physiological Performance and Limits Hypothesis

A number of explanations for long-term change more simply propose that the abundance of certain species, mainly fish, is a direct response to their physiological performance at different temperatures. Under this hypothesis, the changes in dominance of cod-like fishes and crustaceans that were seen in eastern Canada around 1990 and in the northern GOA around 1978 were initially a response to warm (ascendancy of gadids) or cold (ascendancy of crustaceans) water temperatures. In other words, the main agents of change are the direct effects of water temperatures acting on physiological functions of individuals, in addition to the combined effects of freshwater input, winds, and temperature on ecological processes.

6.2.5 Food Quality Hypothesis

The food quality hypothesis is also referred to as the junk food hypothesis. It attributes declines of many higher trophic-level organisms observed in the last several decades (harbor seals, sea lions, and many seabirds) to the predominance of suites of forage species that have low energy content (less lipid) than previous food sources (for example, gadids and flatfishes). Consistent with this hypothesis is evidence from the Trustee Council's APEX program, which showed that it takes about twice as much pollock as herring to raise a kittiwake chick to fledging during the nesting season (Piatt and Van Pelt 1998, Piatt 2000, Romano et al. 2000). With the relative rarity of capelin and sand lance in the diets of seabirds in PWS during the last several decades, it seems that many of the population declines might be at least partially attributable to the role of these fatty fish in seabird diets. The change in food sources has been advanced for marine mammal populations that have been in decline.

6.2.6 Fluctuating Inshore and Offshore Production Regimes Hypothesis

The GEM plan provides the first presentation of the model consisting of fluctuating inshore and offshore production regimes. Although this model is closely related to the Gargett hypothesis of an optimum stability window, it proposes that under the same set of atmospheric forcing conditions opposite production effects are seen inshore and offshore. Figures 6.1a-d illustrate some features of this model.

The model was developed from observations during the last several decades that populations of many seabirds, harbor seals, and sea lions, which forage mainly in inshore waters, have been declining while marine survival of salmon and high levels of offshore plankton and nekton suggested that offshore productivity was very high. It is proposed that the various manifestations of climate forcing have combined since about 1978 (positive Pacific Decadal Oscillation [PDO]) to make the ocean more productive offshore. Characteristics of the offshore ocean include more upwelling of deep nutrients and a mixed surface layer that is shallower and more productive. These same climatic conditions are proposed to have made the inshore areas of the GOA less productive. During the positive PDO, greater freshwater supply (precipitation on the ocean and terrestrial runoff) results in greater-than-optimal nearshore stratification. Also, during the positive PDO, greater winds cannot overcome the stratification during the growing season, but do inhibit the relaxation of downwelling. Therefore, fewer nutrients are supplied to the inshore regime from the annual run up of deep water onto the shelf. During a negative PDO, the opposite pattern in biological response results from a colder, less windy, and drier maritime climate.

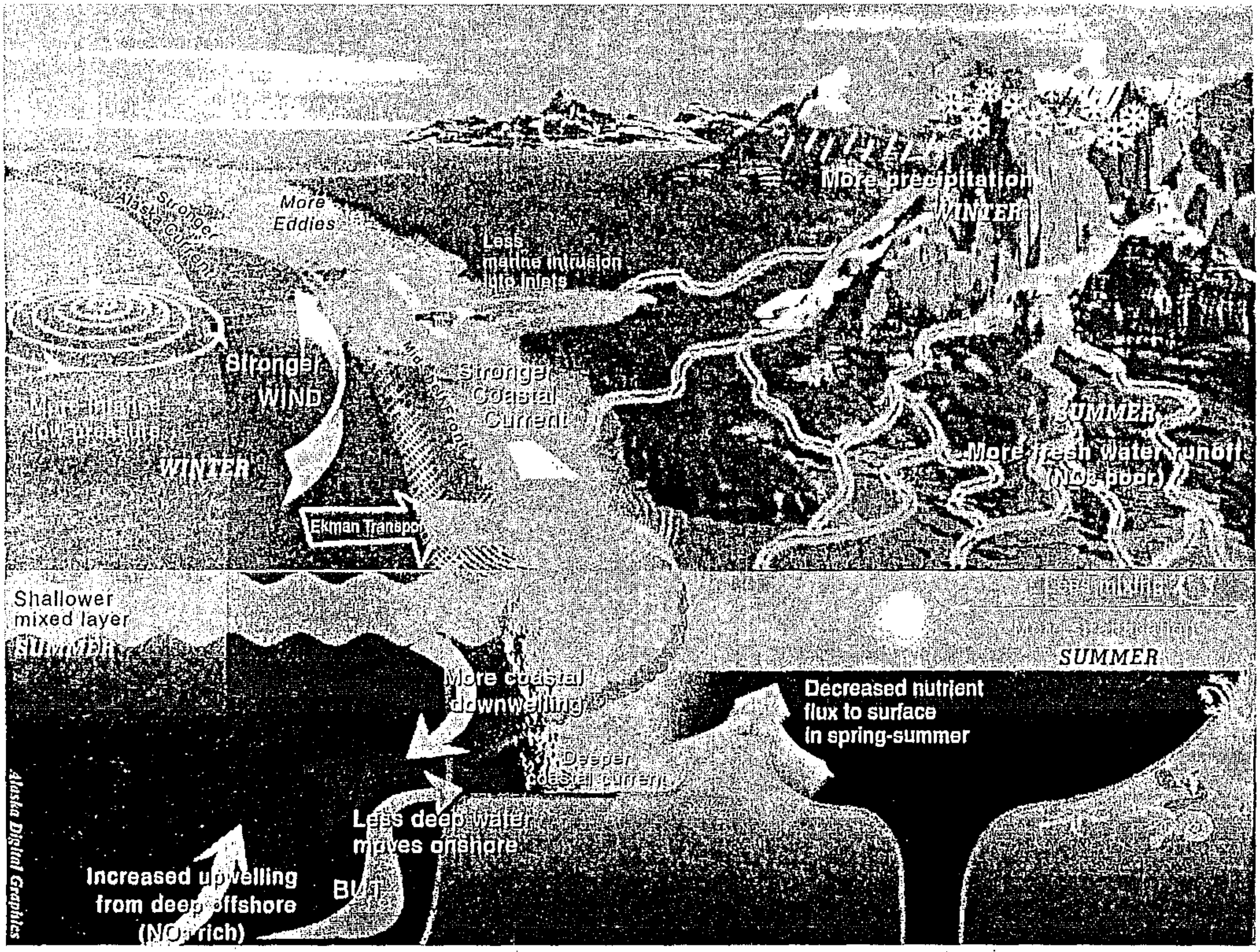


Figure 6.1a Schematic of proposed fluctuating inshore and offshore production regimes in the GOA showing relative changes: (a) in the physical processes during a positive PDO (strong wintertime low pressure), (b) the biological consequences of conditions in "a," (c) the physical changes in a negative PDO (weak wintertime low pressure) and (d) the biological consequences of conditions in "c."

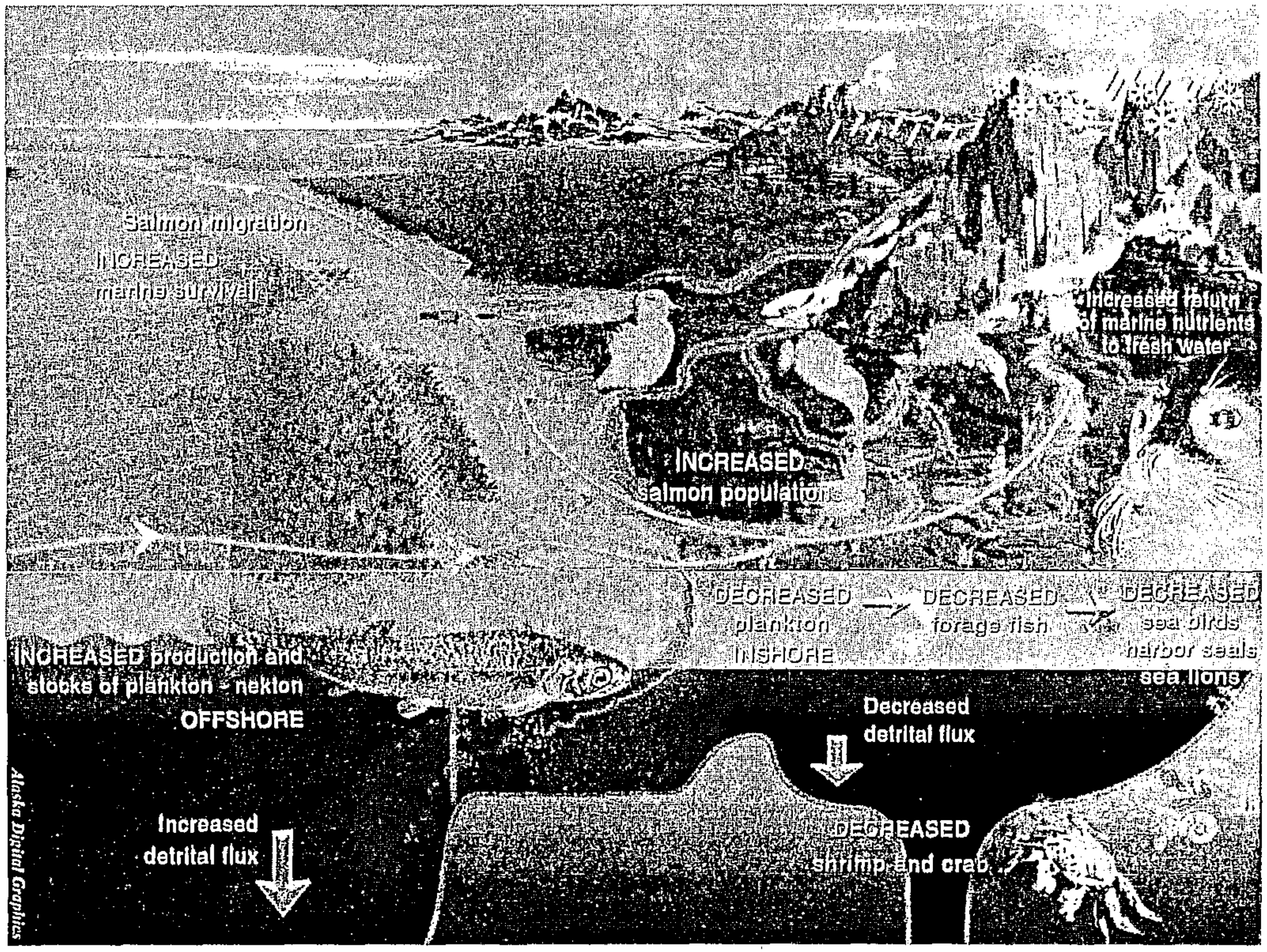


Figure 6.1b Schematic of proposed fluctuating inshore and offshore production regimes in the GOA showing relative changes: (a) in the physical processes during a positive PDO (strong wintertime low pressure), (b) the biological consequences of conditions in "a," (c) the physical changes in a negative PDO (weak wintertime low pressure) and (d) the biological consequences of conditions in "c."

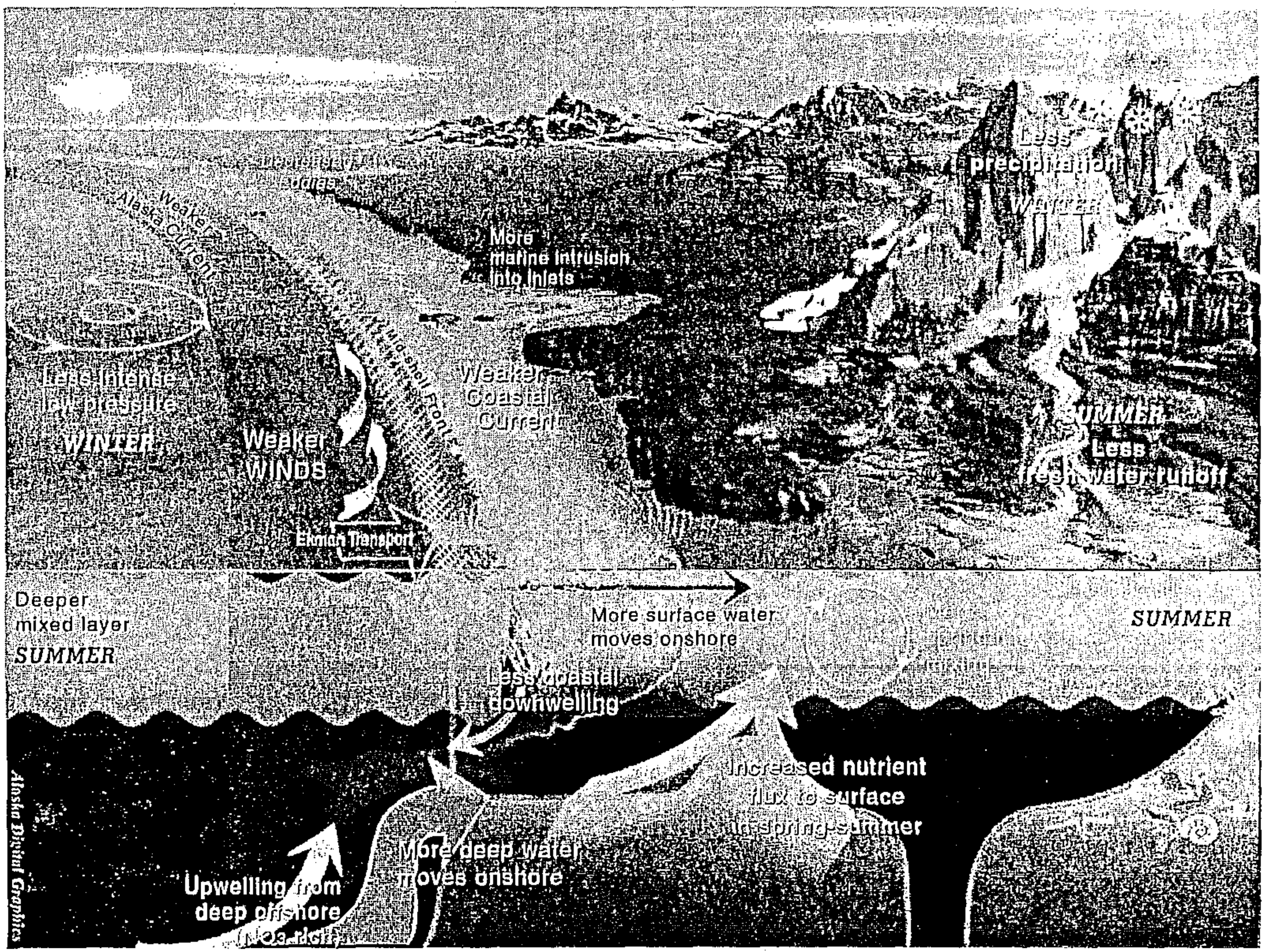


Figure 6.1c Schematic of proposed fluctuating inshore and offshore production regimes in the GOA showing relative changes: (a) in the physical processes during a positive PDO (strong wintertime low pressure), (b) the biological consequences of conditions in "a," (c) the physical changes in a negative PDO (weak wintertime low pressure) and (d) the biological consequences of conditions in "c."

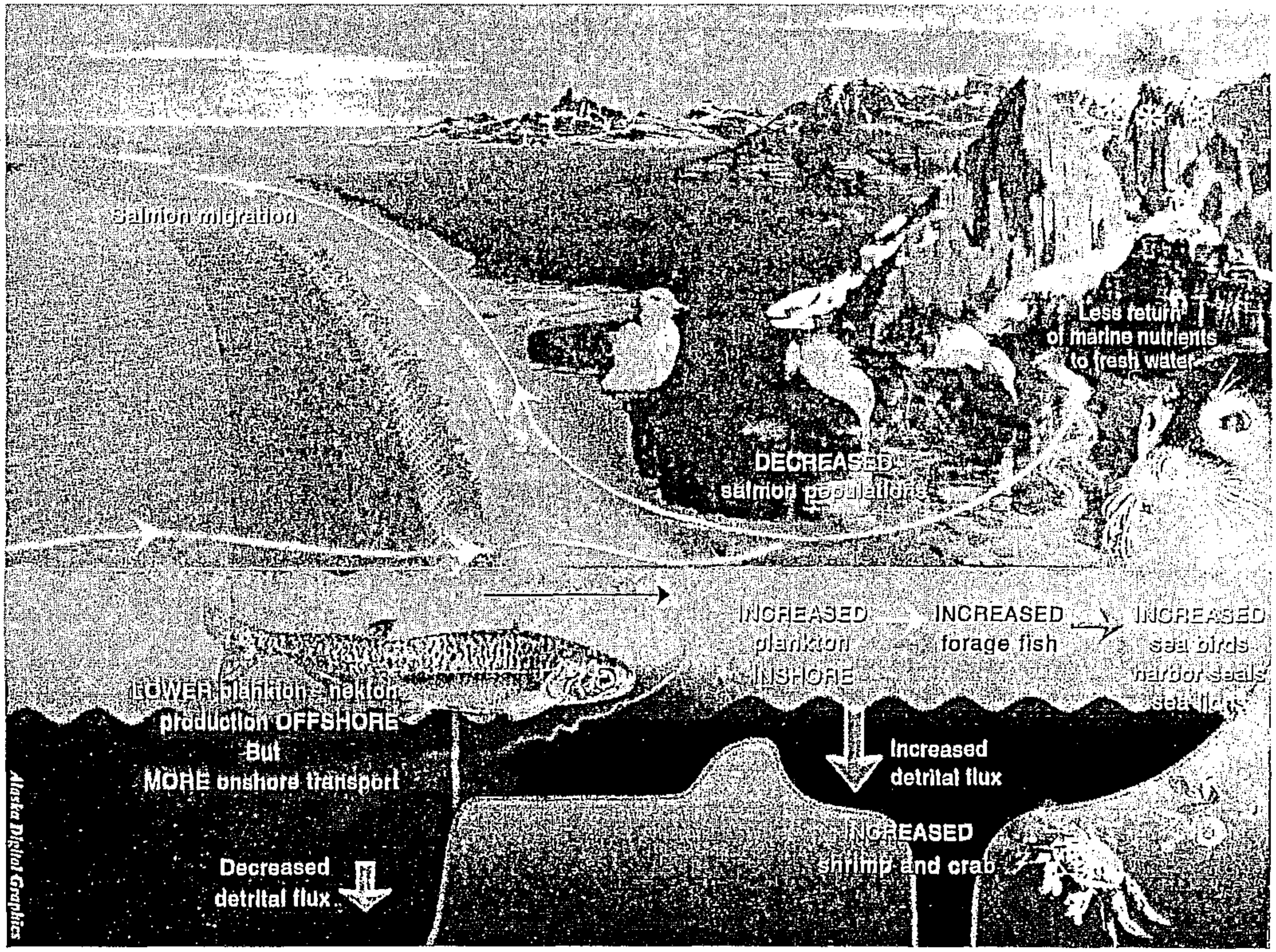


Figure 6.1d Schematic of proposed fluctuating inshore and offshore production regimes in the GOA showing relative changes: (a) in the physical processes during a positive PDO (strong wintertime low pressure), (b) the biological consequences of conditions in "a," (c) the physical changes in a negative PDO (weak wintertime low pressure) and (d) the biological consequences of conditions in "c."

6.2.7 Incremental Degradation Hypothesis

Marine environments around urbanized areas (such as Los Angeles, Puget Sound, Boston Harbor, San Francisco Bay, and New York Bight) and watershed systems (Columbia River Basin and San Joaquin River) have highly altered ecosystems that contain invasive exotic species, individuals impaired by contamination, and fish populations that have been highly altered by the combined effects of various human alterations. Although much of this degradation took place before policies for a sustainable natural environment were in place, it appears that this degradation occurred through a long period of time and as a result of the combined impacts of many different human activities. To this day, no regional programs track the combined impacts of all human activities.

6.3 Principal Ecological Concepts

Production at the base of the food web, primary productivity, is strongly influenced by physical forces, and ultimately determines ecosystem productivity. However, the abundance of any particular population within the food web depends on three things: immediate food supply (prey), removals (mortality), and habitat.

All animals and plants in the oceans ultimately rely on energy from the sun or, in some special cases, on chemical energy from within the earth. The amount of solar energy converted to living material determines the level of ecosystem production (total amount of living material and at what rate it is produced). As a rule of thumb, populations of individual species (such as salmon, herring and harbor seals) cannot exceed about 10% of the biomass of their prey populations (about the average conversion of prey to predator biomass). Therefore, the amount of energy that gets incorporated into living material and the processes that deliver this material as food and energy to each species are key factors influencing reproduction, growth and death in species of concern. Increases in prey, with other factors such as habitat being equal, generally allow populations to increase through growth and reproduction of individual members. At the same time, there are factors that lead to decreases in populations, loss of suitable habitat, decreases in growth, reproduction and immigration, and increases in the rate of removal (death and emigration) of individuals from the population. As a result, the combined effects of natural forces and human activities that determine food supply (bottom-up forces), habitat (bottom-up and top-down forces), and removals (top-down forces) determine the size of animal populations by controlling reproduction, growth, and death.

6.3.1 Physical Forcing and Primary Production

The vast majority of the energy that supports ecosystems in the GOA comes from capture, or fixation, of solar energy in the surface waters. How much of this energy is captured by plants in the ocean's surface layer and watersheds and passed on ultimately determines how much biomass and production occur at all levels in the ecosystem. Capture of solar energy by plants in the oceans and watersheds and the conversion of solar energy to living tissue (primary production) depends on several interacting forces and conditions that vary widely from place to place, season to season, and year to year as well as between decades. Needless to say, without a clear understanding of how these changes occur, it will not be possible to understand the most important aspects of ecological change in the GOA. The process of capturing solar energy is explained below.

First, in the ocean, primary production occurs only in the relatively shallow lit photic zone (a few hundred feet). In watersheds, cloud cover and shading play a larger role in variability of productivity. Second, plants that fix this energy, by using it to make simple sugars out of carbon dioxide and water, depend on nutrients which are absorbed by the plants as they grow and reproduce. Solar energy that is not captured by plants in the ocean warms the surface waters, making it less dense than the water beneath the photic zone, which causes layering of the water masses. A continuous supply of nutrients to the surface waters is necessary to maintain plant production. Likewise, terrestrial plants depend on nutrients carried from the ocean by anadromous fish. Because the deep water of the GOA is the main reservoir of nutrients for shallow waters, and apparently also an important source for watersheds, the processes that bring nutrients to the surface and into the watersheds are key to understanding primary, and, therefore, ecosystem productivity. Changes in nutrient supply on time scales of days to decades and spatial scales from kilometers to hundreds of kilometers have important impacts on primary production, generating perhaps as much as a thousand-fold difference in the amount of solar energy that is captured by the living ecosystem. Nutrient supply from the deep water is influenced by the properties of the shallower water above (mainly because of the decreasing density of the water toward the surface). Nutrient supply is also influenced by physical forces that can overcome the density differences between deep and shallow water--namely, wind acting on the water surface and tidal mixing. For watersheds, nutrient supply apparently depends strongly on biological transport of marine nitrogen by salmon, which die and release their nutrients in freshwater, as well as other sources (such as nitrogen fixers).

As demonstrated in the scientific background in Chapter 7, the knowledge of nutrient supply in the GOA, both how it occurs and how it may be changed on multi-year and multi-decadal scales, is very rudimentary. As the energy of the wind and tides mixes surface and deeper water, it not only brings nutrients to the surface layers, but also mixes algae that fix the solar energy down and out of the photic zone, which tends to decrease primary production. Therefore, other factors being equal, continuous high primary production in the spring-summer growing season is a balance between enough wind and tidal mixing to bring new nutrients to the surface, but not so much wind or tidal mixing that would send algal populations to deep water. The seasonal changes in downwelling, solar energy, and water stratification that set up the annual plankton bloom are described in Section 3.6, Volume II, of the scientific background. As noted in that section, however, it is not well understood how differences in physical forces from year to year and decade to decade change primary production many-fold in any particular place.

6.3.2 Food, Habitat, and Removals

Increases in immediate food supply (prey) will translate to population increase, all other factors being equal. The allocation of energy in each individual is key to growth of the population it belongs to. Food supply is converted into population biomass through growth and reproduction of individuals in specific favorable habitats. Therefore, factors in the habitat such as water temperature, distribution of prey, and contaminants that can influence the allocation of food energy to the following activities will influence the population size: chasing and capturing prey, maintaining body temperature (for homeotherms and other physiological processes), growth, and reproduction.

Removals are all the processes that result in loss of individuals from the population, or mortality. These processes include death from contamination, human harvest, predation, disease, and competition. For example, harvest of a large proportion of the largest and most fecund fish in a population will soon decrease the population, as will a virulent virus or the appearance of a voracious predator in large numbers.

Also included under the category of removals is any factor that negatively affects growth or reproductive rate of individuals, because such factors can decrease population size. Contaminants are considered potential removals because of the following possible effects:

- Causing damage that makes energy utilization less efficient and requires energy for repairs;
- Interfering with molecular receptors that are part of the regulatory machinery for energy allocation;
- Damaging immune systems that make disease more likely; and
- Outright killing of organisms at high concentrations.

Habitats in marine and freshwater environments are ultimately controlled by temperature and salinity, as modified by many other biological, physical and chemical factors. Basic physiological functions such as respiration and assimilation of nutrients from food occur only within certain boundaries of temperature and salinity. As stated in Section 4.3, a number of hypotheses on the origins of long-term change relate the abundance of certain aquatic species to their physiological performance in different temperatures. For example, changes in dominance of cod-like fishes and crustaceans in eastern Canada around 1990 and in the northern GOA around 1978 were explained as positive responses of gadids to increasingly warm temperatures. Using the same reasoning, the ascendancy of crustaceans such as shrimp in the GOA in the 1950s and 1960s, and in eastern Canada during the 1990s, have been attributed to cooling water temperatures.

On the basis of the first principles of physics, chemistry, and biology, temperature and salinity must be agents of change in biological resources through effects relating to physiological functions in individual plants and animals. Effects on individuals add to the combined effects of freshwater input, winds, and temperature on ecological processes. The preceding ecological concepts have been applied directly to the GOA ecosystems to show how the system and its plant and animal populations are controlled in the conceptual foundation, Chapter 5.

6.3.3 Trophic Structure

The principal trophic groups of the northern GOA are represented by the analysis of Okey and Pauly for PWS (Okey and Pauly 1998b). The upper trophic levels (3.5+) are dominated by large vertebrates, including toothed whales, harbor seals and sea lions, seabirds, sharks, and fish species that are large as adults (Table 6.1). Primary consumers on trophic levels between 1 (primary producers) and 3 (tertiary) include jellyfish, zooplankters (including larvae of crustaceans and fish), infauna, and meiofauna. The primary sources of food in the northern GOA are phytoplankton, macroalgae and eelgrass, and detritus. The species of the dominant biomass are macroalgae and eelgrass, followed closely by shallow and deep infauna, deep epibenthos, and herbivorous zooplankton. In terms of production per biomass (P/B), the dominant species groups are clearly the phytoplankton, followed by the herbivorous zooplankton. In terms of food consumption per biomass (Q/B), invertebrate-eating birds top the list, followed by small cetaceans and pinnipeds, and herbivorous zooplankton. Using this concept of the trophic structure of the northern GOA, data on the lower trophic levels (<3.5) are extremely important to detecting and understanding change in valued marine-related resources.

Table 6.1 Representative Trophic Groups of the Northern GOA Arranged in Descending Order by Trophic Level

Group name	Trophic Level	Biomass (t km^{-2} $year^{-1}$)	P/B (yr^{-1})	Q/B (yr^{-1})
Orcas	4.98	0.003	0.050	8.285
Sharks	4.81	0.700	0.100	2.100
Pacific halibut	4.59	0.677	0.320	1.730
Small cetaceans (porpoises)	4.52	0.015	0.150	29.200
Pinnipeds (harbor seal & sea lion)	4.45	0.066	0.060	25.550
Lingcod	4.33	0.077	0.580	3.300
Sablefish	4.29	0.293	0.566	6.420
Arrowtooth flounder adult	4.25	4.000	0.220	3.030
Adult salmon	4.17	1.034	6.476	13.000
Pacific cod	4.14	0.300	1.200	4.000

Table 6.1 Representative Trophic Groups of the Northern GOA Arranged in Descending Order by Trophic Level

Group name	Trophic Level	Biomass (t km^{-2} year^{-1})	P/B (yr^{-1})	Q/B (yr^{-1})
Arrowtooth flounder juvenile	4.01	0.855	0.220	3.030
Avian predators	3.89	0.002	5.000	36.500
Seabirds	3.78	0.011	7.800	150.60
Deep demersal fish (skates and flatfishes)	3.78	0.960	0.930	3.210
Pollock age 1+	3.76	7.480	0.707	2.559
Rockfish	3.74	1.016	0.170	3.440
Baleen whales	3.65	0.149	0.050	10.900
Salmon fry 0-12 cm	3.51	0.072	7.154	62.800
Nearshore demersal fish (greenling and sculpin)	3.35	4.200	1.000	4.240
Squid	3.26	3.000	3.000	15.000
Eulachon	3.25	0.371	2.000	18.000
Sea otters	3.23	0.045	0.130	117.000
Deep epibenthos	3.16	30.000	3.000	10.000
Capelin	3.11	0.367	3.500	18.000
Adult herring	3.10	2.810	0.540	18.000
Pollock age 0	3.07	0.110	2.340	16.180
Shallow large epibenthos	3.07	3.100	2.100	10.000
Invertebrate eating bird	3.07	0.005	0.200	450.500
Sandlance	3.06	0.595	2.000	18.000
Juvenile herring	3.03	13.406	0.729	18.000
Jellies	2.96	6.390	8.820	29.410
Deep small infauna	2.25	49.400	3.000	23.000
Near omni-zooplankton	2.25	0.103	7.900	26.333
Omni-zooplankton	2.25	24.635	11.060	22.130
Shallow small infauna	2.18	51.500	3.800	23.000
Meiofauna	2.11	**4.475**	4.500	22.500
Deep large infauna	2.10	28.350	0.600	23.000
Shallow small epibenthos	2.05	26.100	2.300	10.000
Shallow large infauna (clams, etc.)	2.00	12.500	0.600	23.000
Near herbi-zooplankton	2.00	0.136	27.000	90.000
Herbi-zooplankton	2.00	30.000	24.000	50.000
Near phytoplankton	1.00	**5.326**	190.000	0.000
Offshore phytoplankton	1.00	**10.672**	190.000	0.000
Macroalgae/eelgras	1.00	125.250	5.000	0.000
Inshore detritus	1.00	3.000	-	-
Offshore detritus	1.00	4.500	-	-

Table 6.1 Representative Trophic Groups of the Northern GOA Arranged in Descending Order by Trophic Level

Group name	Trophic Level	Biomass (t km^{-2} year^{-1})	P/B (yr^{-1})	Q/B (yr^{-1})

Notes: Bold values were calculated by the Ecopath software.

P/B is production per biomass. Q/B is food consumption per biomass.

Source: Table 74 (Okey and Pauly 1998a)

The GOA and its watersheds are part of a larger oceanic ecosystem in which natural physical forces such as currents, upwelling, downwelling, precipitation and runoff, acting over large and small distances, play important roles in determining basic biological productivity. Natural physical forces respond primarily to seasonal shifts in the weather, and in particular to long-term changes in the intensity and location of the ALP system in winter. Increased upwelling offshore appears to increase inputs of nutrients to surface waters, which increases productivity of plankton. Increased winds appear to increase the transport of zooplankton shoreward toward and past the shelf-break. How often and how much offshore zooplankton sources contribute to coastal food webs depends on natural physical and biological forces such as predation, migration, currents and structure of the fronts, formation and stability of eddies, degree and extent of turbulence, and responses of plankton to short and long-term changes in temperature and salinity.

A wide range of human impacts interacts with natural biological and physical forces to change productivity and community structure in the GOA. Human activities have the most direct and obvious impacts at those sites in watersheds and intertidal areas where human populations are high. Nonetheless, some human activities affect populations of birds, fish, shellfish, and mammals far offshore, and also have impacts far from the sites of the actions. In short, human activities and natural forces together act over global to local scales to drive and shape marine and terrestrial life in the GOA and its tributary watersheds. Natural forces and human impacts, as exemplified by heat and salt distribution, insolation, biological energy flow, biogeochemical cycling and food web structure, fishery removals, pollutant inputs, and the relationships among them over time define the state of the marine ecosystem. Natural forces and human impacts bring about changes in populations of birds, fish, shellfish, and mammals by altering the relationships among these state variables that define the marine ecosystem. This understanding of the mechanisms affecting change in the GOA provides the basis for developing a key hypothesis about the GOA ecosystem that will form the conceptual foundation around which the GEM program is focused.

Chapter 7 is the same as Chapter 3 in Volume II and Chapter 2 in Volume I, GEM 2001, with the exception of the materials included here.

7.15 Introduction to Economics of Human Uses and Activities in the Northern Gulf of Alaska

The GEM program focuses on the geologic, climatic, oceanographic, and biological processes of the Gulf of Alaska (GOA) marine and surrounding terrestrial environments. Human uses have likely affected the productivity of those environments from the beginning of the 4,000 or more years of human presence in the GOA region.

Trends since the 1989 oil spill suggest that the pace of change in human-caused effects may have accelerated. The spill itself changed attitudes toward acceptable risks of human-caused disruption, while economic trends have brought about more intense use of some resources and diminishing use of others. Understanding these trends will sharpen strategies for long-term monitoring and extend our understanding on how human uses may affect ecosystem productivity.

In the period before contact with Europeans, Kodiak, Prince William Sound, and most other areas affected by the oil spill were populated by Alu'utiq peoples, linguistically related to the Yupik Eskimos of the Bering Sea coast and the Aleut cultures of the western Alaska Peninsula and Aleutian Islands. All of these cultures were "ocean-facing," deriving most of their livelihood from the sea, with relatively little economic dependence on upland resources (Dumond, 1983).

The cultural and economic values of these communities appear to have been very stable. The central place of marine mammal and fish resources in the Alu'utiq subsistence economies profoundly influenced the social organization of pre-contact societies and shaped their spiritual and cultural values. In the face of environmental variability, rituals and other cultural observances focused on assuring predictable marine resource abundance. Failure of a prime resource such as a salmon run could threaten the extinction of an entire community.

While the Alu'utiq had highly developed technologies for exploiting fishery resources with minimum expenditures of time and labor, strongly conservative values and attitudes toward environmental change and resource use tended to limit overharvesting. Property rights to resources such as salmon streams or sea otter hunting areas were vested in clans and villages, who were responsible for stewardship of the resource and its spiritual embodiments (Cooley, 1963). Elements of these values remain strong in some GOA communities.

Notwithstanding the high value attributed to environmental stability and sustainability, human activity was a significant factor in pre-contact changes in resource abundance in other parts of the Pacific littoral (Jackson, et al, 2001), and human-caused effects might have extended to the salmon resources exploited by the Alu'utiq. A clearer example is the extirpation of sea otter from the interior waters of Prince William Sound before the arrival of Europeans in the middle of the 18th century (Lensink, C, 1964; Simenstad, C. A., et al, 1978).

The hundred years following contact brought an end to the relative cultural and economic stability. European traders and fur hunters possessed weapons technologies and an organizational infrastructure that allowed them to quickly dominate the small, fragmented Alu'utiq communities. Europeans also brought upland-facing cultural attitudes that reflected diminished concern for the sustainability and stability of ocean resources. Whatever constraints against overexploitation may have been afforded by the sophisticated system of property rights and clan-based institutional systems, all were quickly brushed aside. For resources that attracted European commercial attention, the results were invariably disastrous.

The sea otter was the first resource to attract commercial attention. Though the trade in pelts was fabulously profitable at the outset, the resource base that made the trade possible quickly shrunk in the face of unremitting harvest pressure to supply Asian and European markets. By the time of the transfer of Alaska to the United States, only remnant populations remained (Rogers, 1992).

Improved transportation and food preservation technologies in the late 19th century opened the region's salmon resource to markets thousands to tens of thousands of kilometers distant. Canned salmon production grew from 1.3 million cases in 1900 to a peak of 8.5 million in 1936, and then collapsed from overexploitation to 1.6 million cases in 1959, the year Alaska became a state. Not until the late 1970s did the institutional development of entry limitations make it possible to meet the biological requirements of sustained salmon harvests without dissipating most of the potential economic gains in excess costs.

Despite its long and rich history of human occupation and use, the GOA marine environment remains relatively unsullied, at least in the popular understanding. As is described in section 3.2, the closing years of the 20th century saw significant declines in commercial fishing, marine transportation of oil, and logging. Subsistence use of GOA resources partially rebounded after the oil spill, while tourism and recreational uses of the GOA resources and environment grew.

Many of the benefits of the GOA environment are largely non-market, non-use, existence values with heavy emphasis on the future: future existence of endangered populations of wild salmon stocks, future protection of charismatic megafauna such as sea otters, and the global marine commons are examples (Brown, 2000). Contingent valuation studies conducted in 1990 provided an immediate post-spill benchmark of the economic existence value of GOA resources directly affected by the oil spill (NOAA, 1993). No follow-up work has been done to confirm subsequent changes in GOA existence values. Other economic studies, however, suggest that the public continues to assign high values to the existence of healthy environments, and apply increasingly sophisticated and stringent criteria for evaluating environmental health, particularly in relation to environments viewed as relatively pristine (Whitehead, et al, 1999). The GEM mission of sustaining a healthy ecosystem and its focus on long-term monitoring has been shaped by the need for a long-term understanding of how the human activity shapes the environment, and the need to be able to distinguish between human- and non-human-caused environmental change.

7.15.1 Socioeconomic Profile of the Region

The bulk of the land area draining into the spill-affected parts of the GOA is found in five boroughs (a county-level governmental unit unique to Alaska), a portion of a sixth borough, and one unorganized census area. Just under 400,000 people, 63 percent of Alaska's population, live in this physiographic GOA region. Two to three times that number use the area seasonally for work and recreation. An estimated 700,000 tourists visit the region each year.

The GOA region has grown rapidly throughout the 20th century, but that growth has recently decelerated. During the 1990s, population grew by 19 percent and non-agricultural jobs by 26 percent, the slowest decadal rates since the 1930s (Williams, 2000).

Most growth has occurred in three urbanized areas: Anchorage, the bedroom communities of the southern Matanuska and Susitna valleys, and the urbanized west-central Kenai Peninsula around the cities of Kenai and Soldotna. In the remainder of the region, including almost all the areas immediately impacted by the spill, growth has been slower. Table 3.2-1 shows how boundaries of the overall region and the subregion directly affected by the spill are defined. During the 1990s, population in the directly-affected subregion grew by 7 percent, less than half as fast as the GOA region as a whole. The 2000 census found 35,470 people residing in the directly affected subregion (U.S. Bureau of the Census, 2001).

Migration to and from the GOA region as a whole has been highly volatile. High wages and low unemployment in Alaska relative to the Pacific Northwest have generally stimulated net inmigration to the region, while the reverse condition has led to a net population exodus. Over the last half century in Alaska and the Pacific Northwest, economic cycles have tended to be out of phase, amplifying the migratory swings.

Demographic data for the 1989-99 interval and preliminary information for 1999-00 suggest that the 1990s were the first decade since the 1930s in which Alaska newcomers to failed to replace all of those who left. The GOA region is likely to have experienced similar net outmigration over the decade of the 1990s (Williams, 2002).

The major reason for the recent net outmigration was the attraction created by the fast-growing economy in the Pacific Northwest and the rest of the nation, and the relatively torpid rate of economic growth in Alaska.

Over the long term, net migration has been less important to Alaska population growth than the state's chronic excess of births over deaths. Average annual net migration in the 20 years between 1979 and 1999 was +1487 persons, while the average excess of births over deaths during the same period was +8928 (Williams, 2000).

This persistent excess has been a consequence of three longstanding features of the state's demographics—fertility rates well above the national averages in all racial groups, an unusually large percentage of residents of child-bearing age, and an unusually small share of the population in the older age groups where natural mortality is highest.

Table 9.2-1

Borough or Census Area	Portion Include in:	
	GOA Economic Region	Oil Spill Subregion
Anchorage Borough	All	None
Aleutians East Borough	All	None

Kenai Peninsula Borough	All	South and southeast portion: Homer, Seldovia, Port Graham, and Seward census subarea.
Kodiak Borough	All	All
Lake and Peninsula Borough	Southern portion only: Chignik, Chignik Lagoon, Chignik Lake, Ivanof Bay & Perryville.	Southern portion only: Chignik, Chignik Lagoon, Chignik Lake, Ivanof Bay & Perryville.
Matanuska-Susitna Borough	All	None
Valdez-Cordova Census Area	All	Prince William Sound and Cordova census subareas

As is described in sections following, commercial fishing, marine transportation of oil, and the wood products industries in the GOA region have all declined, while tourism and recreation-related industries have grown. Money transfers to households have also grown, most notably from the state's permanent fund dividend, an annual payment to all residents from earnings on the state's $25-billion oil-money savings account (U.S. Bureau of Economic Analysis, 2002). Continuation of these trends would suggest a continuation of slow economic and population growth.

The fundamentals of Alaska's economy are likely to remain rooted for some time in the state's natural resources. As world population grows, the demand for access to the scenic beauty and open spaces of the state is likely to increase as well. Beyond the economic effects of increased tourism, the intangible quality of Alaska as a place of wilderness, beauty and a special way of life will continue to attract migrants to the last frontier, increasing pressures of human uses and activities on the GOA environment.

7.15.1.1 Prince William Sound-Southeast Kenai

The Prince William Sound-Southeast Kenai (PSW-SEK) region is a coastal belt extending from the mouth of the Copper River on the east, in an arc around Prince William Sound, southwest along the GOA coast, and around the southern tip of the Kenai Peninsula to just past Port Graham and Nanwalek. It includes numerous offshore islands. The region is mountainous throughout, and three of its four largest communities are located at the heads of deep fiords. All of the PSW-SEK region is within the Chugach or Kenai mountains, and the region's boundaries are roughly the same as those of the Chugach Regional Native Corporation. Most of its land area is in or adjacent to the Chugach National Forest.

Between 1990 to 2000, the population of the PSW-SEK region grew less than 6 percent, well below the rates in the GOA region as a whole or the state. In 2000, 12,211 people lived in PSW-SEK, 88 percent of whom live in seven communities. The three largest communities—Cordova (population 2,454), greater Seward (3,430), and Valdez (4,036)—are predominantly non-Native, although Valdez and Cordova are home to Alaska Native village corporations and tribes. Of the five other communities, Chenega Bay (86), Port Graham (171), Nanwalek (177), and Tatitlek (107) are Alaska Native villages, and Whittier (182) is mostly non-Native (U.S. Bureau of the Census, 2001).

Of the seven communities, only Valdez, Whittier and Seward have highway access to the state's main road system. Whittier and Seward have Alaska Railroad passenger and freight service. Cordova, Valdez, Whittier, Tatitlek, Chenaga Bay and Seward are served by the Alaska Marine Highway System. Except for Valdez, all of the communities grew during the 1990s, although at rates well below the average of the state or GOA region. The population of Valdez declined by 1 percent.

The economic base of the seven communities in PSW-SEK is almost entirely resource dependent (Fried and Windisch-Cole, 1999a). The Cordova economy is based on commercial fishing, primarily for pink and red salmon. Recent declines in the value of landings have been a hardship to the community, and to the Prince William Sound Aquaculture organization that operates hatcheries in the Sound. Some biologists have expressed concern that the 600 million or more smolt that hatcheries annually released into the Sound and adjacent waters have had a deleterious effect on wild salmon.

In recent years formerly important herring fisheries have been closed due to inadequate stocks. Cordova has recently benefited from an increase in small-scale tourism, and some cruise ships have visited the port, but the community remains in economic distress.

Valdez, as the terminus of the trans-Alaska pipeline, is dependent on the oil industry, but did not suffer seriously from the downsizing that occurred in the industry during the 1990s. This is due to additional labor required in Valdez to implement safety and pollution prevention measures adopted in the wake of the 1989 spill. The state's official oil production forecast suggests that crude shipments will roughly maintain their current level over the next decade (see section 3.3.3).

Notwithstanding its dependence on oil, the Valdez economy is more diversified than any other community in PWS. Valdez has deployed revenue from its large oil-related tax base in ways designed to simulate economic diversification. The city invested $48 million in cargo and port facilities in an attempt to become the major entry port for cargoes headed to the Alaska Interior. The scheme has yielded some success. Other investments in seafood processing have also resulted in additional jobs, but their cost-effectiveness in terms of economic development remains uncertain.

The major growth industry in Valdez is tourism and recreation. The number of fishing charter boats operating out of the local small boat harbor doubled between 1997 and 1999, and cruise ship visits have become an important part of the summer economy. As cruise ship operators redeploy vessels away from foreign waters, the number of visits is expected to increase. Although population declined slightly in the 1990s, jobs do not appear to have experienced a similar decline (Alaska Department of Labor, 2001).

Seward, more than any other community in the GOA region has transitioned from an economic dependence on fluctuating seafood and timber markets to a visitor and recreation-based economy. Most economic growth since 1990 has been driven by the visitor industry, with employment in trade, services and transportation growing at a 5.9 percent annual rate. The community has capitalized on its road and railroad access to market itself as the major jumping-off point for visits to the Kenai Fiords National Park and Alaska Maritime National Wildlife Refuge. Seward's Alaska SeaLife Center has created another visitor attraction. More than 260,000 cruise ship passengers disembarked at Seward in 2000 (Goldsmith and Martin, 2001).

Commercial fishing has trended downward in importance throughout the 1990s, but it remains a significant part of the Seward economy. The state prison located nearby and other government facilities, including the park headquarters, are also important year-round employers. Although a major sawmill was opened in 1993, it never became competitive, and has remained closed since 1994.

Although its growing dependence on the seasonal visitor industry has been a concern, in the 1990s Seward developed a diverse and dynamic economy: "Over the last decade, it has successfully exploited its location beyond people's expectations." (Fried and Windisch-Cole, 1999b)

Whittier depends on transportation and visitor-related businesses. The other four small communities in the PWS-SWK region augment commercial fishing, logging, aquaculture, and other cash-based activities with subsistence fishing, hunting, and gathering.

7.15.1.2 Western Kenai Peninsula Borough

The western Kenai Peninsula (WKP) region encompasses all the drainages to the northwest of the crest of the Kenai Mountains excepting those at the southern tip of the peninsula around Port Graham and Nanwalek. In addition, it includes the relatively sparsely populated area on the west side of Cook Inlet.

In terms of its physiography the area faces Cook Inlet (Barnes, 1958); its economy has been closely linked since the 1960s with the oil and gas developments in the Inlet and on the nearby uplands.

The WKP region is connected to the Alaska's main road system, and is only a few hours by car from Anchorage, the state's largest metropolitan area. Homer and Kenai have scheduled air service from Anchorage.

The region grew 23 percent in the 1990s, making it second only to the Matanuska-Susitna Borough as the fastest growing area in the greater GOA region (Williams, 2000). In addition to oil and gas, the WKP economy depends on commercial fishing, sports fishing and other outdoor recreation. About 46,500 people live in the WKP region, with over two-thirds living in or near the cities of Kenai and Soldotna. Soldotna is the headquarters of the Kenai Peninsula Borough and the borough school district, the fourth and first-largest employers in the borough. Government at all levels accounts for 23 percent of the non-agricultural jobs in the borough, slightly less than the 26 percent statewide (Fried and Windisch-Cole, 1999b).

The southern Kenai Peninsula contains Seldovia (286 persons) and Homer (3946). Homer, on the north side of Kachemak Bay, lies at the southern terminus of the state's main road system, and has been popularized in the colorful writings of author Tom Bodet as "the end of the road."

Homer has attracted a significant number of retirees. According to the 2000 census, 10.1 percent of Homer residents are older than 64, the highest percentage of any community in the state. The percentage of over-64 residents in the borough as a whole is 7.3 percent, the highest in the GOA region. The statewide percentage over 64 is 5.7 percent (Williams, 2000).

7.15.1.3 Kodiak Island Borough

The Kodiak Island Borough occupies the Kodiak Archipelago west of the GOA, and a largely uninhabited strip of the Alaska Peninsula coastline across the stormy Shelikof Strait. The borough population in 2000 was 13,913, of which 64 percent (8864) lived in Kodiak city, the adjacent Coast Guard station, or on the road system nearby. The borough population grew 6 percent between 1990 and 2000, about one-third as fast as growth in the GOA region as a whole (U.S. Bureau of the Census, 2001).

There are six outlying communities, the Alaska Native villages of Port Lions, Ouzinkie, Larsen Bay, Karluk, Old Harbor, and Akhiok, none of which have road connections to each other or Kodiak city.

The region's only scheduled jet service is to the City of Kodiak municipal airport, co-located at the U.S. Coast Guard air station. The state's Alaska Marine Highway System serves Kodiak city and Port Lions. Other communities depend exclusively on air taxis or unscheduled private vessels for access.

The economy of the archipelago depends heavily on commercial fishing and seafood processing, and the borough's population swells in the fishing season (Alaska Department of Labor, 1999). 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 and 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 state-owned commercial rocket-launch facility that held its first successful launch in 1999. The U.S. Coast Guard Station, with 1,840 permanent residents, is a major employer.

7.15.1.4 Alaska Peninsula

The Alaska Peninsula is on the western edge of the northern GOA, and encompasses the Aleutians East Borough and the southern part of the Lake and Peninsula Borough. The total population of the region is 3,153. Sand Point, with 952 residents, and King Cove, with 792, are the largest communities (U.S. Bureau of the Census, 2001). The cash economy of the area depends on the success of the fishing fleets.

Five smaller communities on the south side of the Alaska Peninsula lie within the area directly affected by the *Exxon Valdez* oil spill: Chignik, Chignik Lagoon, Chignik Lake, Ivanof Bay, and Perryville. The population of this area is 456, but may double during the fishing season. All five of these oiled communities are in the Lake and Peninsula Borough, and are served by scheduled air taxi service. Chignik is also served by the Alaska Marine Highway ferries on a seasonal basis.

Sand Point, Chignik, Chignik Lagoon, and King Cove serve as regional salmon-fishing centers. 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.

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 or work for fish processors elsewhere in the region.

7.15.1.5 Anchorage/Mat-Su Urban Area

Anchorage, located at the head of Cook Inlet, and the Matanuska-Susitna Borough just to the north of Anchorage, constitute the economic, financial and industrial capital of the state. Although outsiders often conceive of Alaska as sparsely populated, the state is also highly urban, and becoming more so. In 2000, 51 percent of the Alaska's population lived in the Anchorage/Mat-Su metropolitan area, up from 48 percent a decade earlier. Between 1990 and 2000, Anchorage/Mat-Su added 53,584 residents, more than the 2000 population of Juneau and Ketchikan combined, the state's third and fourth largest urban areas (U.S. Bureau of the Census, 2001). Although Anchorage/Mat-Su is situated outside the oil spill subregion, its geographic proximity suggest that growth there will—as it has in the past—produce environmental impacts in the area directly affected by the EVOS. This is likely to be particularly true where the surface transportation connections already exist, as they do to Seward, Whittier, and Valdez.

No economic development is likely to occur anywhere in the state without links to Anchorage. It serves as headquarters for the state's major financial institutions, its oil companies, its major media outlets, its largest labor unions, religious organizations, and most of its federal military and civilian government bureaucracy. The Anchorage airport is the major funnel through which the largest part of the state's visitor traffic passes, and through which a significant share of its seafood harvest is exported.

Many Anchorage/Mat-Su residents work in other parts of the state, especially construction workers, oil workers and fishermen (Fried, 2000). These workers provide Anchorage with a direct source of income earned in other parts of the state. As the most diversified economy in the state, Anchorage is better positioned than any other community in the state to maintain growth in the face of economic hard-times.

7.16 Economics of Human Use Activities in the Northern Gulf of Alaska

> "*At first glance, Prince William Sound presents an aspect of pristine and untrammeled wilderness, and this is one of her major delights. Anchored in a secluded cove or ascending a trackless ridge, it is easy to imagine oneself as the first explorer. Yet, a closer examination of the shoreline quickly reveals subtle signs of former habitation. Decayed, sawed off stumps line the shores – witness to former hand-logging operations. The logs were used for cabins, firewood, fishtraps, cannery pilings, mining timbers, railroad ties, fox farm pens and even ship building. If one rummages around the moss, alder and devils club along the shores, virtually every bay reveals the rotted foundations of some old cabin or fox pen. Abandoned, frail human structures do not last long in this damp climate and under such heavy winter snow-loads. And perhaps this is as it should be.*"
>
> *from Cruising Guide to Prince William Sound Alaska, Jim and Nancy Lethcoe*

This quote from a book about sailing in Prince William Sound is a fitting introduction to a section on human use activities in the northern Gulf of Alaska. At least a portion of the public has a perception that, prior to the *Exxon Valdez* oil spill, the region had little human impact. To the contrary, there has been a succession of different types of human habitation and economic activities in the northern Gulf of Alaska. Many of these activities had a high level of impact on both the environment and other users and residents of the region.

The earliest inhabitants to the region came from nomadic Asian explorers crossing the Bering Land Bridge and spreading southward. The dates of first human occupation in Prince William Sound is not known, but radio carbon dating estimates use as far back as 205 AD.

Beginning in the 1700s, the Northern Gulf of Alaska was utilized by a succession of explorers and developers. Russian and English fur traders in the 1700s were followed by development of fish canneries in the late 1880's. The first fox farms were developed in 1894 at Seal Island. Mining activity in the region also developed in the latter part of the 1890s. In 1897, Klondike gold was discovered, opening up the region as a gateway to Alaska's interior. Mining began in northern Gulf of Alaska in 1896. For example, the communities of Ellamar and Latouche were built to develop copper mines. The Kennicott copper mine was developed around 1905 and resulted in the Valdez to Copper River and Northwestern Railway in 1911.

Mining and fox farming gradually declined and military activity during World War II, added a new type of activity to the region. Whittier remained an active military port until 1960. Commercial fisheries were developed and expanded in the 1950s, 1960s and 1970s. The late 1970s were dominated by development of the trans-Alaska pipeline and the terminal at Valdez. The 1980s and 1990s have shown a large expansion in recreation and tourism.

7.16.1 Commercial Fishing

Since the Exxon Valdez oil spill in 1989, commercial fishing in northern Gulf of Alaska has undergone dramatic changes as a result of changes in salmon markets for salmon, declining abundance of other fisheries stocks, institutional changes associated with "rationalization," harvest limitations designed to protect endangered species, and other factors.

Communities within the GEM region have varying levels of dependence on commercial fishing. The communities most dependent on commercial fishing are Cordova, Kodiak (and the outlying six villages within Kodiak Island Borough), Chignik, Chignik Lagoon, Sand Point and King Cove. Commercial fishing is an important but less dominant economic sector in the road accessible communities of Valdez, Whittier, Seward and Homer.

7.16.1.1 Salmon

Commercial fishing for pink, sockeye, sockeye, chum, coho and Chinook salmon has long been a mainstay of the northern Gulf of Alaska commercial fishing. Salmon are harvested by seine, drift gillnet and set gillnet gear. Pink salmon is the dominant species in PWS, contributing over 80 percent of total salmon landings by volume and contributing the largest share of ex-vessel value. In Cook Inlet, Kodiak and the Alaska Peninsula, sockeye is by far the dominant species.

PWS exhibits a pattern of odd-even run strength for pink salmon that persists even with the influence of hatchery production. The very low catch levels in 1992 and 1993 were due to closures associated with the *Exxon Valdez* oil spill. Harvests since then have increased, but unlike most other Alaska fisheries are now highly dependent on hatchery returns.

Non-profit hatcheries have operated in Prince William Sound since the mid 1970's. The Prince William Sound Aquaculture Association (PSWAC) began operations in 1976, and operates five hatcheries: the W.F. Noerenberg, Armin F. Koernig, Cannery Creek, Main Bay and Gulkana facilities. The Valdez Fisheries Development Association has operated the Solomon Gulch hatchery since 1979 (Kron, 1993). Much smaller, salmon enhancement programs operate in Cook Inlet and Kodiak.

Returns of both wild and hatchery salmon fluctuate greatly from year to year. During the period 1960-1976 when the pink salmon fishery was supported wholly by wild stocks, the average pink salmon catch in Prince William Sound was 3.3 million fish (Eggers et. al. 1991). The pink salmon harvest during this period fluctuated from 0.1 to 7.3 million fish. Since hatchery releases were begun, the average pink salmon catch has been 19.7 million.

In 2001, 76 percent of the total pink salmon return was harvested by PWSAC to cover costs of hatchery operations . In 2002, the percentage was reduced to 54 percent in an attempt to make more of the salmon resource available to commercial fishermen. PWSAC has significant long-term financial obligations, with over $30 million in state loans outstanding.

Salmon prices and market demand for salmon produced in northern Gulf of Alaska as well as other parts of Alaska are at relatively depressed levels. The primary reason for the market trend has been a huge increase in world production of salmon. Alaskan salmon face both price and quality competition from salmon originating in Chile, Norway, Canada and other farmed salmon-producing countries.

7.16.1.12 **Herring**

Herring are harvested predominantly for sac roe to be exported to foreign markets. Quotas are established for each discrete stock. Herring fisheries in the region are currently at low levels. In the 2000 season, Prince William and Cook Inlet were both closed, due to low abundance. Limited herring fisheries occurred in Kodiak and the Alaska Peninsula.

Two causes have been hypothesized for the collapse of Prince William Sound herring: 1) residual effects from the Exxon Valdez oil spill and 2) stress from simultaneous high abundance of herring and pink salmon in Prince William Sound.

7.16.1.13 **Shellfish**

Most of the shellfish fisheries in the GEM region are closed to commercial fishing due to inadequate stocks. Within the PWS, no crab harvests have been permitted for several years, and there is no evidence of recovery. The decline of Prince William Sound crab is thought to be associated with the growth of the sea otter population, which preys heavily on shellfish (Trowbridge, 1995).

Kodiak has a small fishery for Dungeness crab and there are miscellaneous fisheries for PWS scallops, Cook Inlet scallops, Cook Inlet hard shell clams and Kodiak sea cucumbers that offer a limited opportunity for fishermen.

7.16.1.4 **Groundfish**

Gulf of Alaska groundfish catches have ranged from a low of 135,400 metric tons in 1978 to a high of 352,800 metric tons in 1984. The 2001 groundfish harvest was 181,400 metric tons (NPFMC, 2001). Pollock has been the dominant species in the overall catch, followed by Pacific cod and sablefish. Groundfish abundance in the Gulf of Alaska has been relatively stable, rising slowly since the mid

1980s. The estimated long-term annual yield for Gulf of Alaska groundfish is about 450 thousand metric tons. The recent five- year average yield has been about 230 thousand tons per year. The wide disparity between the potential and recent yield is because of fishing restrictions by the North Pacific Fishery Management Council to reduce incidental catches of Pacific halibut. A major portion of the Gulf of Alaska groundfish biomass consists of arrowtooth flounder with little or no current commercial value. A National Marine Fisheries Service trawl survey conducted in 1989 estimated that arrowtooth flounder made up the greatest proportion of total biomass at every site except Central Basin and Port Wells (NPFMC 2001).

The North Pacific Fishery Management Council manages Gulf of Alaska groundfish . However, separate state-waters allocations of Prince William Sound pollock and Pacific cod are deducted from the federal-waters allowable catch. The Pacific cod state-waters allocation is Gulf-wide, but a specific Prince William Sound pollock quota has been established since 1995. The Sound's pollock harvest has averaged 1,800 metric tons since 1995. This harvest occurs mostly during the winter months and is processed in Cordova and Seward.

7.16.1.5 **Halibut**

Pacific halibut is found from the Bering Sea to Oregon, but the center of abundance is in the Gulf of Alaska. Stock assessment research and management advice is provided by the International Pacific Halibut Commission.

Approximately half of the Alaska commercial harvest of halibut comes from the Central Gulf of Alaska. Halibut harvested in the central and western Gulf are delivered to the ports of Cordova, Seward, Valdez and Whittier.

7.16.1.6 **Future Resource Outlook and Issues for Commercial Fisheries**

Commercial fisheries in the GEM area have been in a state of dynamic flux for the past several years. Among the ongoing issues affecting commercial fishers are the following:

Environmental and oceanographic conditions. Ocean survival is a key factor in regulating the magnitude of returning salmon and the level of harvest. Since the 1970's, the ocean environment has been favorable off Alaska, and salmon runs increased. However, there are indications that North Pacific circulation patterns may be shifting away from conditions favorable for Alaska salmon production (Mantua et. al. 1997). If the warm water regime off Alaska reverses to a cold regime, natural salmon production will decrease throughout Alaska to levels observed in the 1960's. Hatchery production and other salmon enhancement efforts may aid in maintaining harvests if natural production declines, but the outlook remains uncertain.

Resource and Legal Issues. Actions taken under the endangered species act (ESA) as a result of depressed levels of Steller sea lions has created economic hardship for commercial groundfish fishers from several of the communities, particularly Kodiak, King Cove and Sand Point. The North Pacific Fishery Management Council (NPFMC) is developing regulations for the 2002 season after completion of a number of studies. National Marine Fisheries Service developed a biological opinion that pointed to commercial fishing as one of the factors in declining numbers of Steller sea lions. Regulations designed to protect the species by limiting groundfish fishing will likely be in place by early 2002. The status of harbor seals and sea otters is also uncertain, and ESA actions in relation to these species could create additional difficulties for fishers and communities.

Gulf Alaska pollock and cod stocks are likely to decrease over the next several years, while most other Gulf of Alaska groundfish remain stable.

Regulatory Actions. The NPFMC is considering a groundfish "rationalization" program for the Gulf of Alaska groundfish fisheries. A similar program covering Bering Sea fisheries established individual fisheries quotas (IFQs), and made other major changes to fisheries management. The fishing interests in the GEM region will be profoundly affected by the decisions of the NPFMC on these issues.

Since its implementation several years ago, the NPFMC IFQ share system has spread halibut and sablefish landings over a longer period, with the consequence that the fresh market has largely displaced frozen production. Road-accessible Homer is now the largest halibut landing port on the West Coast, with over 10 million pounds per year. Most of the halibut landed there are placed in iced totes and delivered to processing and distribution companies in the Pacific Northwest via refrigerated van.

Commercial Fishing Summary

Reasons for monitoring: Many commercial fisheries in the GEM region are at very depressed levels or are currently closed. Interactions with protected species or species that have a subsistence priority may create new problems for commercial fishing in the future.

Type of impacts: Commercial fishing activities create resource conflicts and impact other user groups through gear loss and discard, oil and fuel spills and resource competition.

Who is monitoring: ADF&G is the primary agency for monitoring commercial fishing effort and harvest in state waters. The National Marine Fisheries Service has primary responsibility for monitoring fishing effort and harvest in offshore marine waters (three miles offshore to 200 miles offshore). The International Pacific Halibut Commission has primary responsibility for monitoring effort and harvest for halibut.

Regulatory Authority: Alaska Board of Fisheries has regulatory authority for fisheries that occur in state waters. The North Pacific Fishery Management Council (NPFMC) has regulatory authority for fisheries that occur in offshore marine waters. Recommendations from the NPFMC require action by the Secretary of Commerce to become law.

7.16.2 Recreation/Tourism

Recreation and tourism is the fastest growing economic activity and human use in the GEM region, but incomplete data leave many uncertainties regarding the characteristics of use and rates of growth.

7.16.2.1 Commercial Recreation on Excursion Vessels

Commercial excursion boat operators operating out of Valdez, Whittier, Seward, Homer and, to a lesser extent, Kodiak provide sightseeing trips to visitors. This group is comprised of several large companies that take most of the passengers, with smaller companies providing services to a much smaller sector of the market. According to a 1990 survey of excursion boat passengers visiting the Kenai Fjords National Park, most boat passengers (77 percent) were from other states (72 percent) or other countries (5 percent) (Kenai Fjords National Park, 1990). The 5-year data series includes only passengers traveling into Kenai Fjords National Park, and excludes excursion boat passengers that stay within Resurrection Bay. This limited data series is shown in Table 3.3-1 below.

Table 9.3-1

Kenai Fjords Excursion Boat Passengers	
1996	71,243
1997	67,934
1998	81,538
1999	93,266
2000	86,963
2001	85,047

Source: Kenai Fjords Visitation Report, Mike Tetreau, personal communication.

Excursion boat visitation appears to have declined slightly in 2000 and 2001, but this may reflect a trend toward more Resurrection Bay, trips as excursion operators attempted to accommodate the demand for shorter trips typically sought by cruise ship passengers. As limited as the Kenai Fjords' data may be, it is superior to the situation for other areas in the GEM region, where data is completely lacking.

7.16.2.2 Trends in Sport Fishing Effort

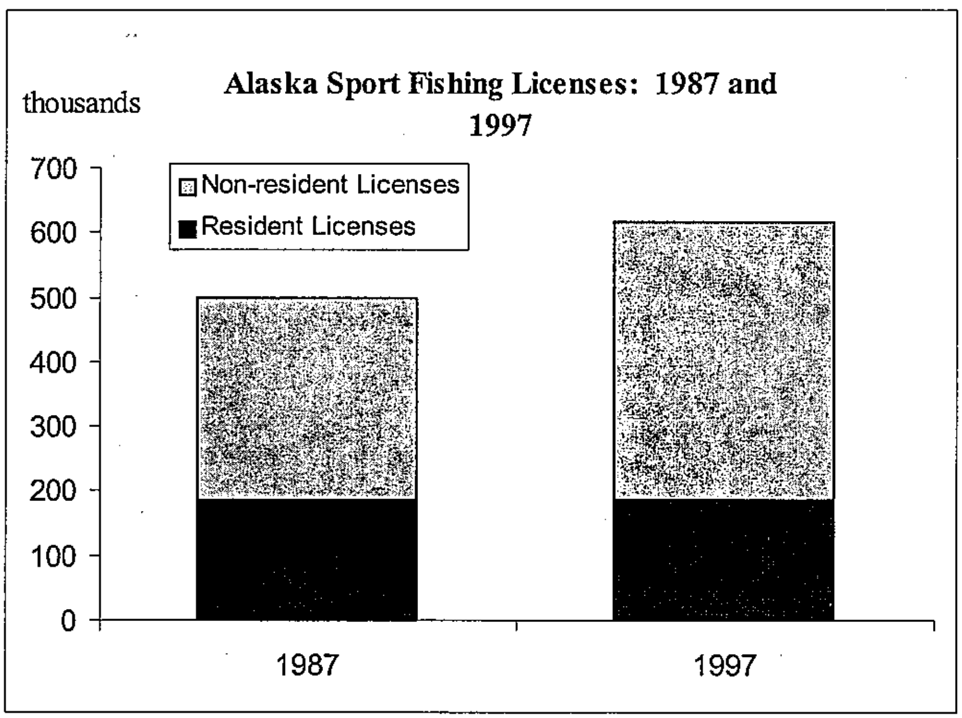
Data on sport fishing effort is also limited. ADF&G data shows the use of private boats for fishing out of Seward and Valdez from increased steadily from 1988 through 1995 and then dropped sharply in 1996 and have increased slowly since that time (ADF&G, various years). Because ADF&G changed the way these data were compiled for the years after 1995, they are of only limited usefulness long-term trend analysis.

Overall sport fishing effort within the GEM region is centered on the road-accessible areas. Cordova, Seward and Homer are the most popular ports for marine fishing. Whittier and Kodiak are less popular ports for marine fishing. Freshwater angling is concentrated along the road-accessible areas of Cook Inlet and the Susitna River watershed. The number of resident sport anglers in Southcentral Alaska has been on a slightly decreasing trend since 1992, but the total number of anglers has increased due to the growth in the numbers of non-resident anglers. Non-resident licenses sold in Alaska increased 46 percent between 1987 and 1997 (see Figure 3.3-1). The Alaska Department of Fish & Game has a study underway to investigate the reasons for the declining number of resident anglers, but that study is not yet complete (ADF&G, various years).

7.16.2.3 Cruise ships

Cruise ships dock at five ports in the GEM region: Anchorage, Homer, Seward, Valdez and Whittier. Seward dominates in cruise ship dockings Cruiseship patrons typically take passage on either a north bound or southbound run, choosing to fly to or from Anchorage on the reverse leg of their trip. Seward has the important features of proximity to the Kenai Fjords National Park as well as the ease of combining a rail or scenic bus ride segment. Seward also offers considerable time savings for cruise ships traveling to or from the Pacific northwest, compared with travel to Anchorage. Cruise ship docking in Seward can offer passengers a one-week turnaround schedule via return air.

Figure 9.3-1

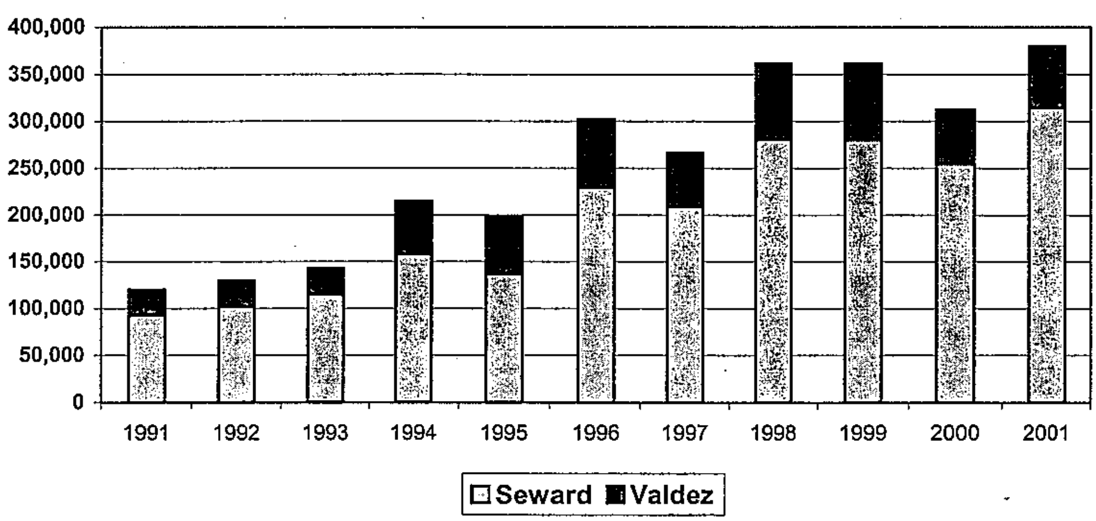


The growth of cruise ship use of the GEM region has been well documented (Figure 3.3-2). The data likely underestimates the growth in passengers because the size of cruise ships vessels have grown substantially over this period as well (McDowell, 1999).

Cruise ship visitors have non-consumptive users of resources within the northern Gulf of Alaska as they move from port to port, but may become consumptive users when in port. Short-duration sport fishing trips are a popular activity for passengers while in port. Recreation and tourist user, including cruise ship users, can be compatible or incompatible with other uses and groups of users, based on their characteristic of use. For example, cruise ship passengers are probably not affected by seeing groups of boaters or kayakers. However, boaters and kayakers may have their experience adversely affected by too many contacts with cruise ships.

One well known issue for impacts of cruise ships is air and water pollution. Cruise ships also affect other user groups by their presence in the northern Gulf of Alaska, and in some areas by competing with local residents for sport fish harvests. In July 2001, Alaska enacted a law to regulate cruise ship and ferry wastewater discharges in marine waters. The new law sets discharge limits for greywater (sink, shower and galley water) and blackwater (treated sewage) for fecal coliform and suspended solids. It limits discharge to areas at least one mile offshore and requires vessels to be moving at least six knots during discharge. Sampling of discharges is required, and the Alaska Department of Environmental Conservation (ADEC) has independent authority to perform additional sampling. Finally, the new law requires improved record keeping and reporting of vessel disposal of wastewater, hazardous waste and garbage.

Figure 3.3-2
Cruise Ship Visitors to Seward and Valdez 1991 through 2001



Source: Seward Chamber of Commerce and Valdez Chamber of Commerce, 1997-2001. McDowell Group, 1001-1997.

Seward will continue to be the major Southcentral port for cruise ship passengers to embark and disembark. Valdez anticipates a sharp decline in cruise ship passengers in 2002 due to the Holland America ending its port calls in that community. The cruise ship visitation in Valdez in 2002 is anticipated to be around 26 cruise ship down from 45 in 2001 (Valdez Convention & Visitors bureau, personal communication).

7.16.2.3 Recreation/Tourism Issues

Sport fishing within the GEM region has created localized environmental damage in some areas by concentrated activity in fragile areas. The Alaska Department of Fish & Game completed an evaluation of these impacts along the Kenai River (ADF&G, 1994).

The Chugach National Forest is currently completing an analysis of remote recreation carrying capacity in areas around Prince William Sound that may provide information on use impacts and appropriate levels of use. The Alaska Department of Parks completed an analysis of carrying capacity for the Kenai River in 1991 which identified areas of the river where crowding was diminishing user satisfaction for fishing and other recreational experiences (Alaska State Parks, 1993).

In October 2001, The North Pacific Fishery Management Council recommended an individual fisheries quota (IFQ) program for commercial charter operators fishing for halibut. Requiring new charter operators to purchase halibut shares to take out sport charters, may tend to shift sports fishing effort toward currently non-limited species, such as Pacific cod, long cod and rockfish, creating localized depletions and potential resource concerns. If commercial halibut charter prices increase as a result of the IFQ program, use of the resource by non-charter private boats may increase in reaction. Impacts on the resource base could be significant.

Some residents of Prince William Sound communities expressed concern with a potential huge flood of new recreational users to the region as a result of completion of the Whittier tunnel. The tunnel opened on June 7, 2000 and had a total of 88 thousand vehicles for the remainder of that year. In 2001, the Whittier tunnel vehicle traffic totaled 85,772 through December 17th (Gordon Burton, personal communication). The initial level of traffic through the Whittier tunnel is much lower than anticipated by the Alaska Department of Transportation and Public Facilities. Local residents speculate that the use tolls imposed after the first year of operation have discouraged users.

Recreation/Tourism Summary

Reasons for monitoring: immediate impacts of high use levels on habitat as well as localized depletion of fisheries resources. Although recreational users may impact other user groups, but areas of conflict are largely unstudied.

Type of impacts: potential for resource depletion, damage to fragile habitat, competition among user groups, water quality degradation from discharges and spills.
Agencies managing for a subsistence priority can create impacts on other user groups utilizing resources within the GEM region.

Who is monitoring: ADF&G is the primary agency for monitoring sport fish effort and harvest. The U.S. Forest Service monitors uses within Chugach National Forest. The National Park Service monitors use levels within the Kenai Fjords National Park.

Regulatory Authority: the Alaska Board of Fisheries and Board of Game have regulatory authority over sport fishing and hunting within state lands and waters.

The North Pacific Fishery Management Council has made a recommendation for new regulations dealing with halibut charter vessels.

The U.S. Coast Guard has enforcement authority for vessel operations in marine waters.

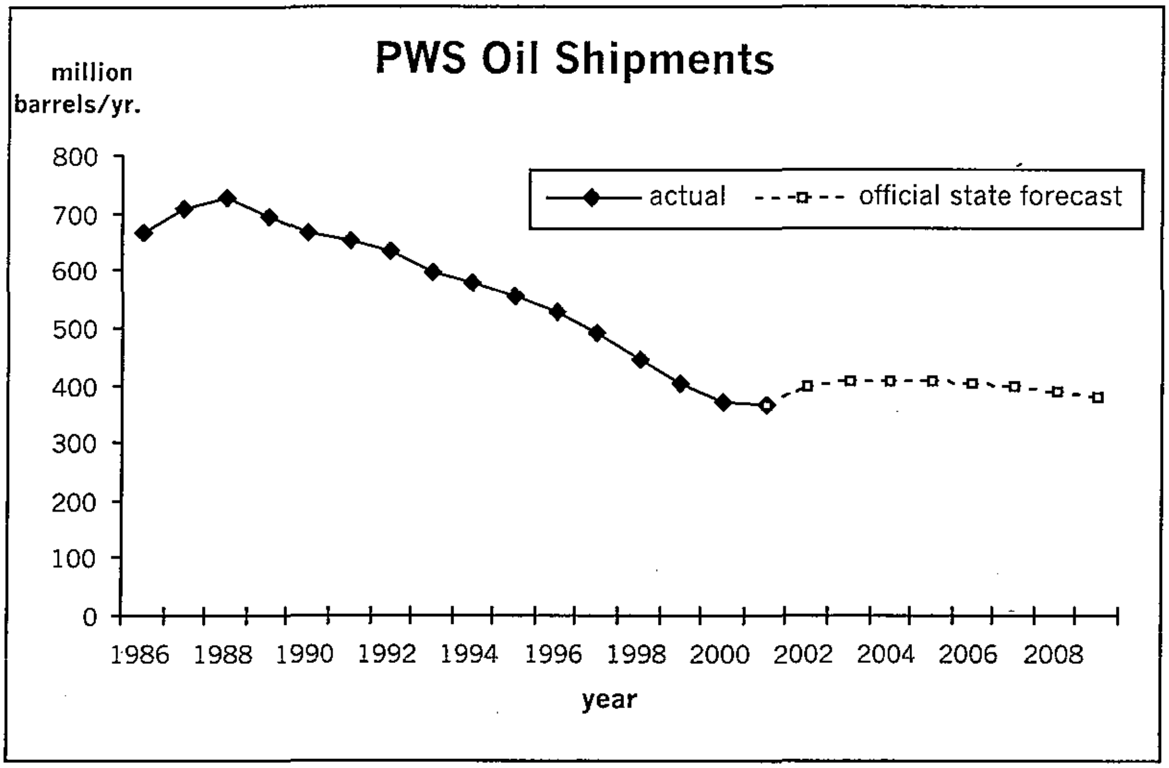
7.16.3 Oil and Gas Development

The oil and gas industry is a major economic force in Prince William Sound (PWS) and Cook Inlet. Crude oil from the Alaska North Slope is transported by pipeline to Valdez, where it is loaded onto tankers and shipped to the lower 48 states, abroad, and to a refinery on Cook Inlet, near Kenai. Whatever their destination, tankers carrying this oil traverse PWS and the GOA on their journey (Fried and Windisch-Cole, 1999).

The number of tanker voyages from the Port of Valdez has declined from 640 in 1995, to 411 in 1999, partly from a 4 percent increase in the average load per vessel, but mostly as the result of reduced North Slope production (Alaska Dept. of Environmental Conservation, 2000).

Annual shipments through PWS peaked at 705 million barrels in 1988, and have declined in every year since. Shipments in 2001 are estimated at 366 million barrels, almost exactly one-half of what they were at the peak. The annual rate of change in shipments has varied from -10 percent in 1998-99, when oil prices were low, to -1 percent last year (2000-01), when prices were high. The state of Alaska's official oil production forecast issued in December 2001 predicts that North Slope production will increase 9 percent in 2002, and then remain relatively constant through 2009 (see Figure 3.4-1). The forecasters acknowledge, however, that unexpected excursions in oil prices could shift the trajectory up or down (Alaska Dept. of Revenue, 2001).

Figure 3.4-1



Commercialization of North Slope natural gas reserves—estimated at more than 90 trillion cubic feet—could cause PWS tanker traffic to increase. Under one concept, proposed more than 30 years ago and still popular in Alaska, a gas pipeline would be built parallel to the oil line, terminating at a liquefied natural gas (LNG) facility near Valdez. LNG from the plant would be exported in specially built tankships to the Far East, Mexico, or the U.S. West Coast. A similar, but much smaller LNG plant has operated in Cook Inlet since 1966 .

A separate gas-to-liquid (GTL) commercialization proposal would transform the gas to methanol liquid or a chemically related product that would be shipped to Valdez in the existing trans-Alaska oil pipeline (Alaska Highway Natural Gas Policy Council, 2001).

Three recent studies, sponsored separately by the North Slope gas owners, the state, and an independent energy consulting firm, concluded that the GTL and LNG proposals (including a pipeline project terminating at an LNG plant in northern Cook Inlet) are likely to be less feasible than alternatives in which the gas is shipped by pipeline through Canada to markets in the lower 48. Volumes of gas to be shipped under the various commercialization proposals range up to 2.2 trillion cubic feet per year, equivalent in energy content to roughly 350 million barrels of oil (Purvin & Gertz, 2000). In most applications, substitution of gas for oil reduces greenhouse gas emissions by about 15 percent. No project for commercializing North Slope gas has yet attracted commitments for the $7 billion to $20 billion in investment expected to be required.

Megaprojects do not have an exclusive franchise on potential petroleum developments in the GOA area. The first producing oil wells in Alaska were at Katalla, southeast of Cordova. Small-scale production continued there from 1902, until destruction of the local refinery by fire in 1933. The Chugach Alaska Corporation, owner of much of the Katalla oil and gas acreage, believes that modern technology may make the Katalla oil resource economical to redevelop (Chugach Alaska Corporation, 2001).

Modern oil development in Alaska began in 1957 in the Cook Inlet basin, with discovery of oil at the Swanson River field in the Kenai National Wildlife Refuge. In 2001, the basin produced 11 million barrels of oil, about 3 percent of the volume coming from the North Slope (Alaska Oil and Gas Conservation Commission, 2001).

Most of the oil and much of the natural gas produce from the Cook Inlet comes from offshore platforms. Underwater pipelines transport oil and gas to terminals on both sides of Cook Inlet. Much of Cook Inlet oil production is delivered to a local refinery in Nikiski, north of Kenai, for processing.

State forecasters expect oil production from the Cook Inlet basin over the next several years to increase, reaching 15 million barrels per year in state fiscal year 2003-04. An aggressive state leasing program initiated in 1999, together with planned increases in federal offshore lease offerings could stimulate additional new production thereafter (Alaska Dept. of Revenue, 2001).

Much of the new exploration in Cook Inlet, however, has been targeted toward natural gas. Cook Inlet gas has provided low cost energy to the Anchorage metropolitan area since 1962, and since the late 1960s has provided energy and feedstock to an LNG plant and a large fertilizer manufacturing facility at Nikiski. The bulk of the region's electricity comes from gas-fired generation.

In recent years Cook Inlet gas sales have ranged close to a quarter trillion cubic feet. The region's utilities and major industrial users believe that additional discoveries or imports from the North Slope will be needed in the next decade to sustain current industrial gas uses and meet the growing demand for utility gas and electric generation (Dept. of Natural Resources, 2002).

Major concerns about oil and gas development in the GOA region include the potential for oil spills from vessel traffic, as happened during the 1987 T/S *Glacier Bay* spill in Cook Inlet and the 1989 EVOS. 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 are other major concerns. Only six thousand gallons of crude oil were reported spilled in the region from 1998 to 1999 (ADEC 2001).

Oil producers, shippers, and refiners are required to have contingency plans detailing response capabilities and specific response actions in the event of a spill. In addition, the Oil Pollution Act of 1990 authorized regional citizens advisory groups in PWS and Cook Inlet to oversee oil and gas activities. These groups, along with state and federal agencies, maintain oversight of oil industry operations in their respective regions.

7.16.4 Subsistence

Subsistence is an important traditional activity practiced by residents of northern Gulf of Alaska communities to provide food and cultural enrichment. In addition to the cultural aspects of subsistence production, its economic importance comes from import substitution. Rural residents are able to rely on wild foods rather than food imported into the region. Dependence on subsistence production is typically higher in remote areas and lower near centers of population, although there are exceptions to this general trend.

Understanding of subsistence patterns and consumption largely relies on focused household surveys conducted by the Alaska Department of Fish and Game (ADF&G) Subsistence Division. ADF&G's analysis and monitoring of subsistence focus on subsistence production, consumption, sharing patterns and species of concern. Subsistence studies are typically conducted at irregular intervals, often oriented towards a specific management issues or need, such as the *Exxon Valdez* spill. The household studies provide a cross-sectional profile of use patterns at a particular time. Due to the focus on oil spill impacts and the availability of funding, there have been several subsistence studies conducted in communities across the GEM region over the past 10 years, providing a wealth of data and information. The declining frequency of subsistence studies suggests that future changes in use patterns within northern Gulf of Alaska communities may not be as well documented.

ADF&G researchers have developed village contacts that will allow accurate tracking of subsistence harvests of salmon, seals, sea lions, marine mammals and halibut. It is more difficult for ADF&G to track subsistence harvests of marine invertebrates and marine fish, so there is a much lower level of confidence in estimated use levels for these species.

In a recent report funded jointly by the Minerals Management Service (MMS) and ADF&G, researchers analyzed subsistence patterns for communities within the area affected by the *Exxon Valdez* spill (Fall et al., 2001). The communities analyzed were Chenega Bay, Cordova, Tatitlek, Valdez, Kenai, Nanwalek, Port Graham, Seldovia, Akhiok, Karluk, Kodiak City, Larsen Bay, Old Harbor, Ouzinkie, Port Lions, Chignik, Chignik Lagoon, Chignik Lake, Ivanof Bay and Perryville.

The study tracked wild food harvests measured in pounds per capita before and after the *Exxon Valdez* spill, producing the following findings:

- Subsistence production averages over 300 pounds per person per year throughout the region. In predominantly Native communities, subsistence production averages 352 pounds annually per person. In Cordova, subsistence production averages 200 pounds per person annually and in Kodiak it averages 148 pounds per person.
- Subsistence production utilizes nearly 17 different types of resources per household (see Fall et al 2001, Table V-6).
- The studies show a very high participation rate in subsistence harvests and use particularly in predominantly Native communities where 99 percent of residents used subsistence resources.
- Subsistence production is often distributed through an extensive network of sharing. In predominantly Native communities, 87.5 percent of households received resources and 78.3 percent of household gave away resources.
- Following the Exxon Valdez spill, there was an immediate decline of over 50 percent in subsistence harvests (Fall et al 2001, Table VII-1). Equally important as the decline in production was the reduction in range of resources utilized. At first the reduction was due to fear or oil contamination, and later due to scarcity of resources.
- The impacts of the oil spill caused a disruption in sharing and teaching of children and a temporary increase in the year following the spill in household income associated with spill cleanup activities.

- In the years from 1990 to the present, there has been a gradual rebound in subsistence production from the EVOS communities. But, communities in Prince William Sound have been slower to rebound than areas outside the Sound.
- Since the EVOS, several communities have increased their dependence on fish and reduced their dependence on marine mammals and shellfish.

In addition to ADF&G's Subsistence Division and the Federal Subsistence Board, others monitoring subsistence uses and harvests of certain species include the Alaska Board of Fisheries and the North Pacific Fishery Management Council. The Council recently completed an analysis of impacts relating to subsistence halibut and has recommended new regulations for that species.

The National Marine Fisheries Service (NMFS) follows the status of the beluga whale population, and funds operation of the Alaska Beluga Committee. The Committee has attempted to understand beluga whale subsistence harvests through an informal network of contacts. The Cook Inlet Marine Mammal Council, comprised of Cook Inlet beluga whale subsistence hunters, works independently of the Alaska Beluga Committee to focus on beluga whales in Cook Inlet.

The Alaska Native Harbor Seal Commission partners with ADF&G's Division of Subsistence in a harvest assessment project to interview hunters and collect data on subsistence harvest of seals. This effort is currently funded by the National Marine Fisheries Service. The U.S. Fish & Wildlife has a program to monitor harvests of sea otters. USF&W also monitors waterfowl.

ADF&G's subsistence division has been working to coordinate and report on the various monitoring efforts. However, their efforts have been funded through special research funding, such as EVOS. Future funding for ADF&G's subsistence division to continue coordination of subsistence monitoring as well as periodic household surveys within northern Gulf of Alaska communities is uncertain.

The impact of subsistence harvests on injured resources, particularly marine mammals, has not been determined. In some cases, it may become necessary to address the impact of subsistence on recovery, as was necessary for Cook Inlet Beluga whales. The Alaska Department of Fish & Game and National Marine Fisheries Service are working cooperatively to combine research efforts on harbor seals. The results of this research program may improve understanding of the status of the harbor seal resource and reasons for population declines within the northern Gulf of Alaska. However, the program will not address the effects of subsistence harvests on this resource.

7.16.4.1 Current and Potential Future Issues, Subsistence

Subsistence activities and production are related to many factors, such as population growth within villages and communities and changes in abundance and distribution of fish and wildlife resources. The criminal settlement subsistence restoration program utilizing money from the *Exxon Valdez* settlement has funded 32 projects totaling $5.6 million in support of subsistence (Fall et. al. 2001). These included fish enhancement projects, development of subsistence infrastructure, cultural education and mariculture. The *Exxon Valdez* Trustee Council Habitat Protection Program has protected over 700 thousand acres within the northern Gulf of Alaska through outright purchase or conservation easements. This program ensures that the lands protected will remain part of the productive ecosystem, thus aiding support of the resource base for subsistence production.

Increasing use within Prince William Sound for boaters, fishers, hunters and other recreational users may affect future subsistence opportunities through direct competition or the indirect effects of increased traffic in areas where subsistence harvests occur. In 1995, Stephen R. Braund & Associates (SRB&A) evaluated the impact of completion of the Whittier tunnel on subsistence uses within six communities: Chenega Bay, Tatitlek, Cordova, Whittier, Hope and Cooper Landing (SRB&A., 1995).

Subsistence users from the Gulf of Alaska communities identified increased boat traffic within Prince William Sound and the potential increased direct competition for fish and wildlife resources from increased numbers of visitors as their greatest concerns related to the opening of the Whittier tunnel (SRB&A, 1995). Use of the Whittier tunnel has been much lower than forecast, but the overall trend in increasing recreation in the region may create conflicts with subsistence activities.

Recent changes in subsistence regulation and management may affect other user groups, including sport and commercial fishers, hunters and others.

Some future issues may include:

- Definitions of federally-recognized subsistence users could greatly increase the number of subsistence users from outside the region. For example, the Federal Subsistence Board currently plans to allow all recognized subsistence users from anywhere in Alaska to participate in subsistence harvests on the Kenai Peninsula. The Board earlier moved to restrict subsistence salmon fishing within the Copper River watershed to those living in the region.
- The Federal Subsistence Board has received proposals to extend its jurisdiction to include marine waters and species.
- In two decisions in Southeast Alaska, the Federal Subsistence Board has preemptively closed state fisheries in fresh water to make sure that there would be enough fish for subsistence in federal harvest areas. During the 2001 fishing season, the Federal Subsistence Board preemptively closed all the state fisheries: commercial sport, sport and state subsistence operating within federal waters within both the Kuskokwim and Yukon drainages to ensure that the federal subsistence users would have access to salmon resources.
- In a recent decision, the Federal Subsistence Board increased the limits for subsistence harvests in the Copper River by fish wheels, with no upper limit on king salmon. If the subsistence harvest of king salmon is substantially increased in Copper River fisheries, sport and commercial users could face restrictions.
- The North Pacific Fishery Management Council (NPFMC) took final action in April 2002 to define subsistence halibut fishing in Alaskan waters. Subsistence management actions include a limit on the number of hooks, a 30-fish annual limit , a system to permit temporary transfer of subsistence rights, and a gear stacking allowance for multiple subsistence fishers on a single vessel.
- The decline of the beluga whale in Cook Inlet provides an example of a resource problem alleged to be caused by subsistence harvests. Under the Marine Mammal Protection Act, state

and federal agencies were unable to take any action to address the declining resource until the population reached the point where it could be classified as depleted under the Endangered Species Act. If the beluga whales fail to recover, many commercial activities within Cook Inlet could face restriction.

Subsistence Summary

Reasons for monitoring: subsistence uses have not yet recovered and are a priority use under state and federal law.

Type of impacts: subsistence harvests of recovering species have the potential for causing at least localized depletion of some species.
Agencies managing for a subsistence priority can create impacts on other user groups utilizing resources within the GEM region.

Who is monitoring: ADF&G is the primary agency for monitoring subsistence uses and harvests.

Regulatory Authority: The U.S. Fish and Wildlife Federal Subsistence Board has regulatory and allocation authority within federal lands in Alaska.
The Alaska Board of Fisheries and Board of Game have regulatory authority over subsistence within state lands and waters.
The North Pacific Fishery Management Council has made a recommendation for new regulations dealing with subsistence halibut.
Federal laws, such as the Marine Mammal Protection Act and the Migratory Bird Act regulate subsistence uses in both state and federal waters.

7.16.5 Timber and Forest Products

Ancestors of the Alu'utiq peoples who occupied most of the GOA area are believed to have migrated into the region from treeless areas to the west and north. In the late 18th century, at the time of the first contacts with Europeans, the Alu'utiq made relatively little use of timber resources except for heat (Dumond, 1983).

Many small logging and sawmill operations grew up in the 19th century to support local fish processing and mining operations. In the early 20th century, most of the sawlog timber resources of the Prince William Sound area, the Kenai Peninsula and the Kodiak Archipelago came under the control of the U.S. Forest Service. In addition to local fish processing and mining, GOA forests also supplied railroad ties and timber for bridges to the Alaska Railroad and the Copper River & Northwestern Railway.

Throughout most of the 20th century, the timber industry remained small. From 1910 through 1986, total commercial harvests from government land in the GOA region averaged less than 4 million board feet (MMBF) per year, and never exceeded 12 MMBF per year. As part of policy to encourage timber-based manufacturing within the forest and nearby communities, the Forest Service largely prohibited the export from Alaska of unprocessed timber (Rogers, 1962). Until 1987, there were essentially no forest product exports from the region to anywhere outside Alaska.

That all changed in the 1980s, when regional and village Native corporations established under ANCSA began receiving lands selected by them in accordance with the Act. For the first time in the history of the GOA region, significant timber resources moved under the control of private, profit-seeking corporations. Most of the high-quality timber has since been logged in an effort to monetize the timber assets as rapidly as possible. Harvest from the region grew from less than 10 MMBF in 1986, to a peak of about 235 MMBF in 1995, and then quickly declined (USDA, 2000b). Although a major sawmill was opened in Seward in 1993, it never became competitive, and has remained closed since 1994. Almost all of the private timber was exported from the state, most being sold abroad as unprocessed logs (Fried and Windisch-Cole, 1999).

Since 1996, a dwindling timber supply of high-quality timber and a depressed world market for softwood have caused a dramatic decline in harvest from the GOA region. No major timber operations are currently operating in PWS. Some logging continues in the Kodiak Archipelago and small-scale timber operations are planned for parts of the Kenai Peninsula. Improving market conditions and rising softwood prices could significantly increase the market for significant volumes of currently marginal timber, especially on Afognak Island.

A significant factor affecting forest planning in the GOA area is a major spruce bark beetle infestation. A series of timber sales of beetle-damaged stands on state land have been proposed (USDA, 2000a). Harvest from the state's proposed sales would encompass an estimated 115 MMBF over a maximum of five years, but adverse market conditions have cause commercial interest in the offerings to wane, and some recent sales have received no bids . In 2000 the state offered almost 12 MMBF, but the amount cut was less than 3 MMBF(ADNR, 2000).

Concerns about logging include long-term effects on the marine ecosystem of bark detritus at log transfer sites, impacts on anadromous streams from siltation and upland habitat destruction. ADEC reported that 24 percent of the water bodies on the state's list of polluted sites are due to some aspect of logging (ADEC, 2000). 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.

Timber and Forest Products

Reasons for monitoring: Immediate impacts of logging on anadromous fish and riparian habitat. Point source impacts of wood processing facilities on air and water quality. Long-term habitat and water quality degradation from past logging and past pollution of uplands and marine sediments.

Type of impacts: erosion, wide swings in water temperature, loss of habitat, changes in carbon cycle, increased human pressure due to access. Industrial air and water quality impacts from wood processing.

Who is monitoring: U.S. Forest Service on federal land, ADNR on state and private land. ADF&G monitors impacts on economically important sport, commercial and subsistence species. ADEC and EPA monitors effects of bark deposition on marine environment. EPA and ADEC monitor point source industrial effects on air and water quality.

Regulatory Authority: State and federal laws have established regulatory authority over most aspects of logging and wood processing. Federal laws include the Clean Water Act, the Endangered Species Act, Wilderness Act, Federal Land Planning and Management Act, National Forest Management Act, Forest and Rangeland Renewable Resources Planning Act and others; state authorities in Alaska Statutes, include Title 16 (Fish and Game), Title 47 (Environmental Conservation), and the Forest Practices Act.

7.16.6 Urbanization and Road Building

Urban areas within the GEM region are likely to continue to grow from natural population growth, inmigration from smaller communities within Alaska and from outside the state. Increasing urbanization diminishes some basic environmental qualities, even when development is planned and regulated with care. Along with greater numbers and density of residents, comes additional air pollution, water pollution, utilization of lands for solid waste disposal, increased levels of noise and other effects. Continued expansion of urban areas and increasing density of development of suburban zones inevitably degrade the habitat. Changes in land surfaces can change entire hydrologic systems and also water pollution problems. Urban growth leads to increasing disposal of human waste. Anchorage, the largest center of population in the state only completes primary treatment for sewage effluent piped into Cook Inlet. The City received a 301 (H) waver to allow primary sewage treatment only, whereas almost all metropolitan communities in the country are required to complete secondary treatment. The inherent turbidity of Cook Inlet water was a significant factor in EPA's grant of the waver.

Treated waste or street runoff may lead to changes in species composition and productivity of watersheds within the region. A 1998 study of the Kenai River showed a decreased diversity of benthic invertebrates in areas of the river below storm drain outfalls (Litchfield, 1999). What was important in this study was the discovery that even though the benthic invertebrate community was still in place, certain species were missing from the surveyed areas. Based on this study, it appears as if some key indicator species could be utilized to measure at least some of the effects of storm runoff pollution.

Diminished environmental quality from increased population density is not limited strictly to urban areas. As population density increases in previously rural areas—for example along the Kenai River—there has been a documented loss of environmental quality. In 1994, ADF&G published as study evaluating the cumulative impacts of development and human uses on fish habitat in the Kenai River (Liepitz, 1994). Factors diminishing water quality include wetlands loss, point source pollution from outhouses or faulty septic systems and household spills of oils and other contaminants.

The Alaska Department of Environmental Conservation is responsible for monitoring and regulation of state water, however, due to staff and funding limitations the agency is does attempt to track down and resolve household or small commercial violations. The U.S. Geological Service operates a National Water-Quality Assessment (NAWQA) program tracking water quality and non-point pollution sources in urban watersheds. The goals of the NAWQA Program are to (1) describe current water-quality conditions for a large part of the nation's freshwater streams and aquifers, (2) describe how water quality is changing over time, and (3) improve our understanding of the primary natural and human factors affecting water quality. The Cook Inlet Basin is part of the NAWQA program. The study will provide increased understanding of water quality in the streams and ground water of the Cook Inlet Basin and identify factors that influence water quality.

Roads are an important factor in habitat damage and water quality degradation. A 2001 study (Western Native Trout Campaign, 2001) evaluated the relationship between public land roadless areas and existing native trout populations in western states. This report evaluates the diminished status of wild trout and the habitat damage associated with development of road systems. The report concludes that roadless areas are essential to persistence and rebuilding of native salmonid populations.

Within the GEM region, roadbuilding and urbanization is of most concern within the Cook Inlet area. There are no agencies monitoring or evaluating the effects of roads on habitat and water quality within this area.

Urbanization and Road Building

Reasons for monitoring: Direct impacts to fish and wildlife species. Immediate losses of wetlands and water quality.

Type of impacts: erosion, wide swings in water temperature, loss of habitat, changes in carbon cycle, increased human pressure due to access. Industrial air and water quality impacts from wood processing.

Who is monitoring: The Municipality of Anchorage has a wetlands plan but has little on-going involvement. The Alaska Department of Fish and Game and private research groups (such as the Western Native Trout Campaign cited) study the cumulative effects of roadbuilding and development. The USGS NAWQA program monitors water quality within the Cook Inlet Basin.

Regulatory Authority: ADF&G has Title 16 authority over anadromous fish water bodies. The Alaska Department of Environmental Conservation and the U.S. EPA have regulatory authority over water quality. The Army Corps of Engineers has regulatory authority over development on wetlands.

7.16.7 Other Industrial Activity

Large oil spills like the *Exxon Valdez* oil spill are rare occurrences. More common are smaller discharges of refined oil products, crude oil and a variety of hazardous substances. Small spills, however, occur frequently in the commercial fishing industry, in the petroleum industry, in the timber industry and a wide variety of commercial establishments such as gas stations and dry cleaners. One of the worst spills near the Kenai was due to repeated discharges dumping of dry cleaning fluid over many years a short distance from the Soldotna Bridge (ADEC – River Terrace spill).

Under state law, the release of hazardous substances and oil must be reported to the Alaska Department of Environmental Conservation (ADEC). Table 3.3-2 shows the number of spills by area for the year 2000. Spills of refined oil account highest number of largest volume of spills. In 1998 and 1999, 1,325 spills were reported in the GEM 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 GEM region, the largest number of spills (1,037) and the greatest volume of discharge (198,000 gallons) occurred in the Cook Inlet region. Most spills (87 percent) involved refined oil products, accounting for about 90 percent of the total volume discharged. Only 6,000 gallons of crude oil were reported spilled in the GEM region during 1998 and 1999. (ADEC, 2001).

Spills 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.

Table 9.3-2: Spills Reported within the GEM Region in 2000

	total number of spills	total gallons spilled
Cook Inlet:		
hazardous substances	16	1,942
refined oil products	82	2,940
crude oil	3	22
Kodiak:		
hazardous substances	2	6
refined oil products	11	1,047
crude oil	0	0
Prince William Sound:		
hazardous substances	5	44
refined oil products	18	1,545
crude oil	0	0

Source: ADEC, 2002

Other Industrial Activity

Reasons for monitoring: Direct contamination of water quality. Danger of loss to fish and wildlife.

Type of impacts: erosion, wide swings in water temperature, loss of habitat, changes in carbon cycle, increased human pressure due to access. Industrial air and water quality impacts from wood processing.

Who is monitoring: The Alaska Department of Environmental Conservation, and the U.S. Environmental Protection Agency.

Regulatory Authority: The Alaska Department of Environmental Conservation and the U.S. EPA have regulatory authority over water quality.

7.16.8 Contaminants and Food Safety

The presence of industrial and agricultural contaminants in aquatic environments has generated worldwide concerns about potential effects on marine organisms and human consumers. The remoteness of the northern GOA from centers of industry and human population does not necessarily offer protection. Industrial and agricultural contaminants can be transported great distances by atmospheric and marine mechanisms, and evidence of persistent organochlorines (DDT), polychlorinated biphenyls (PCBs), dichlorodiphenyldichloroethylene (DDE), other organic pollutants, and heavy metals has been found 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).

In the case of mercury and other metals, such as inorganic arsenic, cadmium, and selenium, low concentrations of the contaminants may be present in the natural environment, with industrial and agricultural sources contributing additional quantities. In many other cases there is no known local or regional environmental, industrial or agricultural source of the contaminant.

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.

Contaminants and Food Safety

Reasons for monitoring: The presence of industrial and agricultural contaminants is concentrated in fish and wildlife species. This can cause mortality in affected fish and wildlife as well as danger to humans consuming contaminated fish and wildlife.

Type of impacts: Persistence within the environment and spread to fish, wildlife and humans.

Who is monitoring: NOAA monitors chemicals in mollusks, sediments and bottom-dwelling groundfish.

Regulatory Authority: The U.S. EPA has regulatory authority over contaminants in aquatic environments.

7.16.9 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, nitrous oxide and chlorofluorocarbons. 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 percent 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 Southeast Alaska) increased 11 percent 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.

A rise in sea level is one of the anticipated changes from global warming, leading to flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater intrusion into fresh water wells and increased costs for maintenance and/or replacement of roads causeways and bridges (EPA, 1998). Among other impacts, in increase in ocean level may have profound impacts on salmon production. The loss of estuarine wetlands from the 1964 earthquake resulted in major losses of pink salmon habitat in Prince William Sound.

Global warming may also have a negative effect on use of water resources throughout Alaska by leading to earlier and more concentrated spring runoff periods. There could be detrimental effects on forests within the GEM region, for species that are adapted to a cooler temperature regime.

Global Warming

Reasons for monitoring: Direct contamination of water quality. Danger of loss to fish and wildlife.

Type of impacts: flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater intrusion into fresh water wells, increase in public costs for maintenance and replacement of roads and bridges

Who is monitoring: U.S. Environmental Protection Agency.

Regulatory Authority: U.S. EPA has regulatory authority over activities that add to global warming.

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Williams, Gregory J. Personal communication. 2002.

Admin Record
11.13.04

EVOS Trustee Council Meeting

June 14, 2002

Exxon Valdez Oil Spill Trustee Council

441 W. 5th Ave., Suite 500 • Anchorage, Alaska 99501-2340 • 907/278-8012 • fax 907/276-7178

AGENDA
EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
TELECONFERENCE MEETING
June 14, 2002 10:00 a.m.
441 West 5th Ave., Suite 500, ANCHORAGE

DRAFT - Revised 6/6/02

Trustee Council Members:

CRAIG TILLERY
Assistant Attorney General
State of Alaska

MICHELE BROWN
Commissioner
Alaska Department of
Environmental Conservation

DRUE PEARCE
Senior Advisor to the Secretary
for Alaskan Affairs
U.S. Department of the Interior

DAVE GIBBONS
Forest Supervisor
Forest Service Alaska Region
U.S. Department of Agriculture

JAMES W. BALSIGER
Administrator, Alaska Region
National Marine Fisheries Service

FRANK RUE
Commissioner, Alaska
Department of Fish & Game

Teleconferenced in Anchorage, Restoration Office, 441 W 5th Ave, Suite 500
_________ State Chair

1. Call to Order - 10:00 a.m.
   - Approval of Agenda*
   - Approval of Meeting Notes*
     April 18, 2002

2. Executive Director's report

3. Public comment and hearing on Injured Resources and Services Update
   10:15 a.m.

4. Old Harbor Land Exchange*

5. Revised operating and report procedures - briefing
   -including a new data policy

6. GEM - briefing on NRC report and proposed revisions - 12:00 p.m.
   -Mike Roman, Chair, NRC Review Committee
   -Molly McCammon and Phil Mundy

7. Revisions to draft PAC Charter*

8. FY 03 Draft Invitation - Phase II - briefing

9. Solicitation for Subcommittee and PAC nominations

Adjourn - 2:00 p.m.

* Indicates tentative action items.

MEETING NOTES
APRIL 18, 2002

DRAFT

Exxon Valdez Oil Spill Trustee Council

441 W. 5th Ave., Suite 500 • Anchorage, Alaska 99501-2340 • 907/278-8012 • fax 907/276-7178

TRUSTEE COUNCIL MEETING NOTES

Anchorage, Alaska
April 18, 2002

By Molly McCammon
Executive Director

Trustee Council Members Present:

*Dave Gibbons, USFS
Drue Pearce, DOI
James Balsiger, NMFS
Frank Rue, ADF&G
Michele Brown, ADEC
Craig Tillery, ADOL

* Chair
In Anchorage: Gibbons and Tillery
By teleconference: Pearce, Balsiger, Rue, and Brown

Meeting convened at 2:32 p.m., April 18, 2002, in Anchorage.

1. Approval of the Agenda

APPROVED MOTION: Approved the April 18, 2002 agenda
Amended by adding FY 02 Work Plan Modifications
Projects 02556/02681 and 02423 (Attachment A).

Motion by Tillery, second by Brown.

2. Approval of Meeting Notes

APPROVED MOTION: Approved February 25, 2002 meeting notes
(Attachment B).

Motion by Brown, second by Tillery.

Public comment period began at 2:50 p.m.

Public comments received by two individuals from Anchorage and two people by teleconference.

Public comment period closed at 3:38 p.m.

3. FY 02 Work Plan Modifications

APPROVED MOTION: Approved the following modifications to the FY 02 Work Plan:

Project 02052: Approved a motion to approve an additional $86,400.

Motion by Balsiger, second by Rue.

Project 02423: Approved a motion to approve an additional $24,300 to contract with the Alaska SeaLife Center for the purposes described in the 4/15/02 memo from Shannon Atkinson. (Attachment C).

Motion by Rue, second by Brown.

Project 02556: Approve a motion to approve $62,200 to ADF&G, contingent on receipt of a memo acknowledging that the funds are for mapping only, with no commitment at this time by the GEM Program to future nearshore monitoring, and receipt of the final report for Project 01385.

Motion by Rue, second by Balsiger.

Project 02613: Approved a motion to approve $80,000 to ADF&G for a contract with Coastal & Oceans Resources Inc., for ShoreZone Mapping in Prince William Sound.

Motion by Balsiger, second by Rue.

Project 02619: Approved a motion to approve $70,000 to ADF&G for a contract with the University of Alaska for low resolution mapping in the Kodiak region.

Motion by Balsiger, second by Rue.

4. PAG Charter:

APPROVED MOTION: Approved a motion to adopt the attached draft charter for the *Exxon Valdez* Oil Spill Program Advisory Committee (dated 2-26-02). (Attachment D)

Motion by Tillery, second by Brown.

5. STAC:

APPROVED MOTION: Approved the nominees listed in the memo from Henry Huntington dated April 11, 2002 (Attachment E) for the Scientific and Technical Advisory Committee.

Motion by Pearce, second by Balsiger.

6. Injured Resources and Services:

Briefing by Bob Spies, discussion and recommendation by the Trustee Council to improve the explanations in the subtidal, common loon, and pink salmon sections regarding their categorization status. A copy of the report with the revised language will be circulated to the Trustee Council for review prior to being distributed for public review.

Meeting adjourned 5:15 p.m.

Motion by Rue, second by Tillery.

INVESTMENT REPORT

Exxon Valdez Oil Spill Trustee Council

441 W. 5th Ave., Suite 500 • Anchorage, Alaska 99501-2340 • 907/278-8012 • fax 907/276-7178

MEMORANDUM

TO: Trustee Council

THROUGH: Molly McCammon
Executive Director

Debbie Hennigh

FROM: Debbie Hennigh
Special Assistant

DATE: June 4, 2002

RE: April Investment Reports

Included are the Department of Revenue's reports as of April 30, 2002:

- Statement of Invested Assets,
- Statement of Investment Income and Changes in Invested Assets,
- Asset Allocation Policy with Actual Investment Holdings, and
- Performance Measurement.

Also attached are the following graphs for the period of activity ending April 30, 2002:

- Investment Fund Assets, and
- Earnings (Loss).

Also included are graphs of each investment pool's activity for October 2000 through April 2002, the entire investment fund/benchmark, and each individual pool/benchmark for April 2002.

Attachments

cc: Investment Working Group

STATE OF ALASKA
DEPARTMENT OF REVENUE
TREASURY DIVISION

Exxon Valdez Oil Spill Investment Fund

STATEMENT OF INVESTED ASSETS

April 30, 2002 and 2001

Investments (at fair value)	2002	2001
Cash and cash equivalents		
Short-term Fixed Income Pool	$ 182,303	$ 76,903
Marketable debt and equity securities		
Broad Market Fixed Income Pool	73,194,533	60,905,590
Non-retirement Domestic Equity Pool	77,248,523	49,828,183
SOA International Equity Pool	32,474,957	21,593,395
Total invested assets	$ 183,100,316	$ 132,404,070

STATE OF ALASKA
DEPARTMENT OF REVENUE
TREASURY DIVISION

Exxon Valdez Oil Spill Investment Fund

STATEMENT OF INVESTMENT INCOME
AND CHANGES IN INVESTED ASSETS

For the period ended April 30, 2002

	CURRENT MONTH	FEDERAL YEAR TO DATE
Investment Income		
Cash and cash equivalents		
Short-term Fixed Income Pool	$ 413	$ 3,016
Marketable debt and equity securities		
Non-pooled investments		
Broad Market Fixed Income Pool	1,222,759	1,131,907
Non-retirement Domestic Equity Pool	(4,281,267)	4,957,942
SOA International Equity Pool	245,337	2,615,076
Commission Recapture	29	15,819
Total income from marketable debt and equity securities	(2,813,142)	8,720,743
Total investment income (loss)	(2,812,729)	8,723,759
Total invested assets, beginning of period	185,940,069	174,451,698
Net contributions (withdrawals)	(27,024.21)	(75,140)
Total invested assets, end of period	$ 183,100,316	$ 183,100,316

Exxon Valdez Oil Spill Investment Fund
Period Ending April 30, 2002

	Mkt Value ($M)	Monthly Return	3 Mo. Return	Calendar YTD	Federal Fiscal YTD*	Inception to Date**
AY02 EVOS Investment Fund	**183,100**	**-1.51**	**0.42**	**-0.65**	**5.00**	-2.61
EVOS Investment Fund Index		***-1.22***	***0.46***	***-0.62***	***5.32***	*-4.86*
Short-term Fixed Income Pool	182	0.20	0.39	0.56	1.26	*4.44*
91 day T-Bill		*0.16*	*0.44*	*0.59*	*1.23*	*4.08*
Broad Market Fixed Income Pool	73,195	1.69	0.82	1.49	1.55	*9.15*
Lehman Brothers Aggregate Index		*1.94*	*1.22*	*2.04*	*2.08*	*9.47*
Non-Retirement Domestic Equity Pool	77,248	-5.25	-3.13	-4.34	6.86	*-13.84*
Russell 3000 Index		*-5.25*	*-3.11*	*-4.33*	*6.92*	*-15.12*
SOA International Equity Pool	32,475	0.76	8.88	3.90	8.82	*-11.74*
Morgan Stanley Capital Intl. (EAFE)		*0.66*	*6.85*	*1.17*	*8.23*	*-14.39*

Source: State Street Bank, Insight.

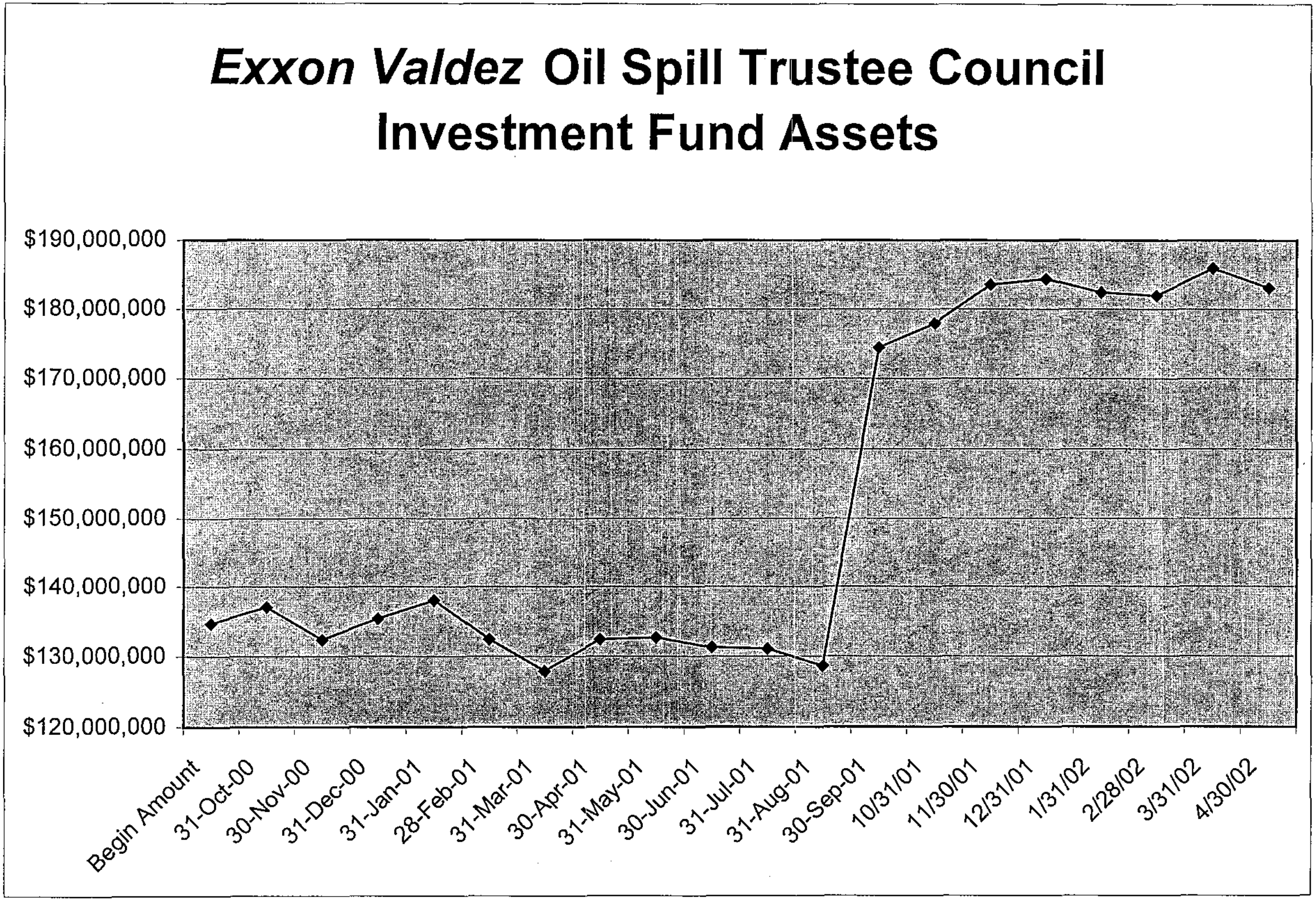
* Federal Fiscal YTD indicates a term beginning October 1, 2001 to current period ending.
** Inception Date: October 31, 2000

STATE OF ALASKA
DEPARTMENT OF REVENUE - TREASURY DIVISION

Exxon Valdez Oil Spill Investment Fund
Asset Allocation Policy (effective 4/24/00) with Actual Investment Holdings as of April 30, 2002

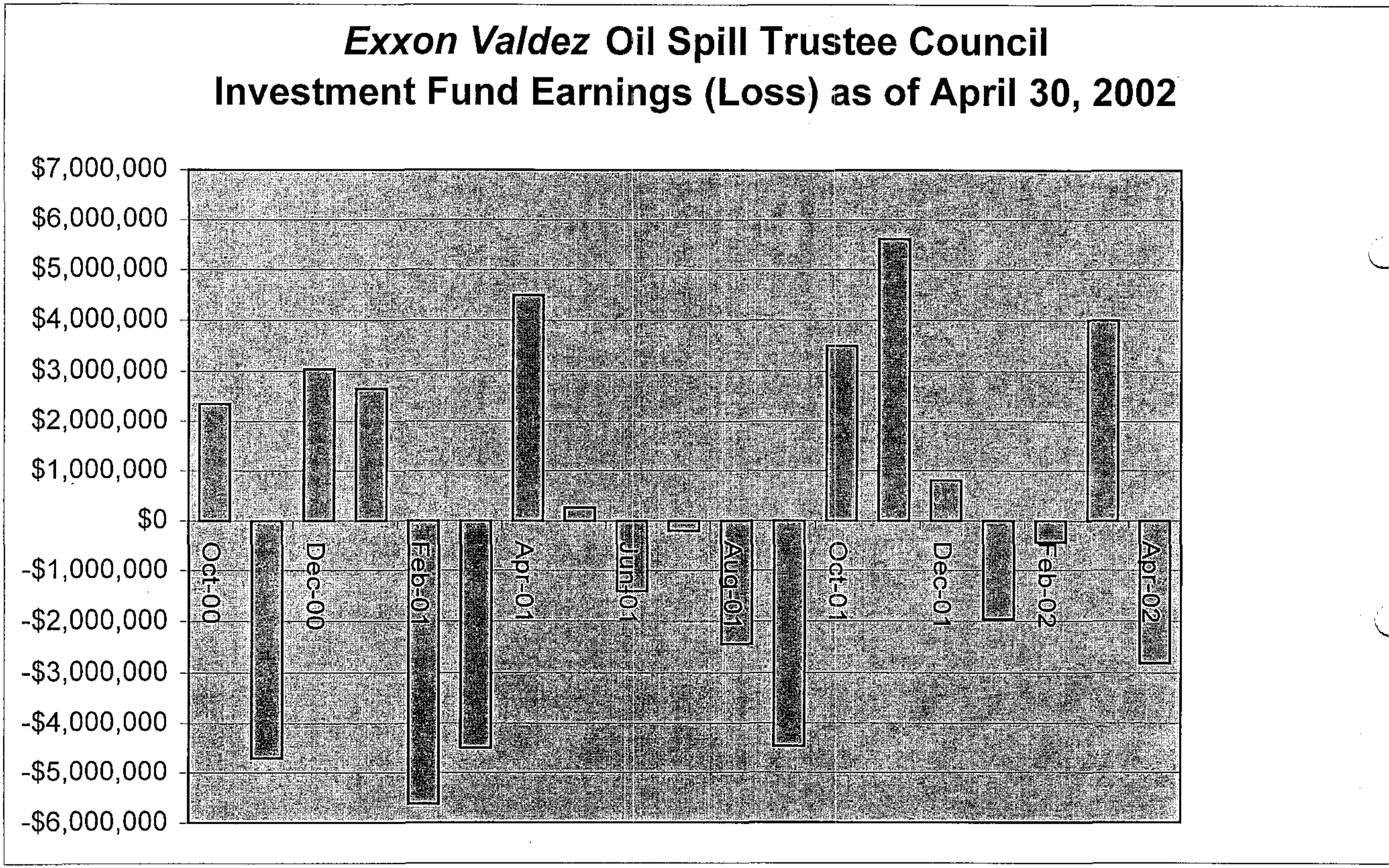
	Asset Allocation		Fair value	Current Allocation	Variance
	Policy	Range			
Cash and cash equivalents					
Short-term Fixed Income Pool	0.00%		181,889.60	0.10%	-0.10%
Total cash and cash equivalents	**0.00%**		**181,889.60**	**0.10%**	**-0.10%**
Marketable debt and equity securities					
Broad Market Fixed Income Pool	42.00%	35% - 49%	73,194,533.47	39.98%	2.02%
Non-retirement Domestic Equity Pool	41.00%	34% - 48%	77,248,523.09	42.19%	-1.19%
SOA International Equity Pool	17.00%	12% - 22%	32,474,956.63	17.74%	-0.74%
Total marketable debt securities	**100.00%**		**182,918,013.19**	**99.90%**	**0.10%**
Total holdings	**100.00%**		**183,099,902.79**	**100.00%**	**0.00%**
Short-term Fixed Income Pool Interest Receivable			413.38		
Total Invested Assets at Fair Value			**183,100,316.17**		

Prepared by Treasury Division
Printed: 5/7/02 at 10:37 AM
Filename: EVOS_0402 policy



Note: September's amount reflects addition of Exxon's last payment of $66,113,500

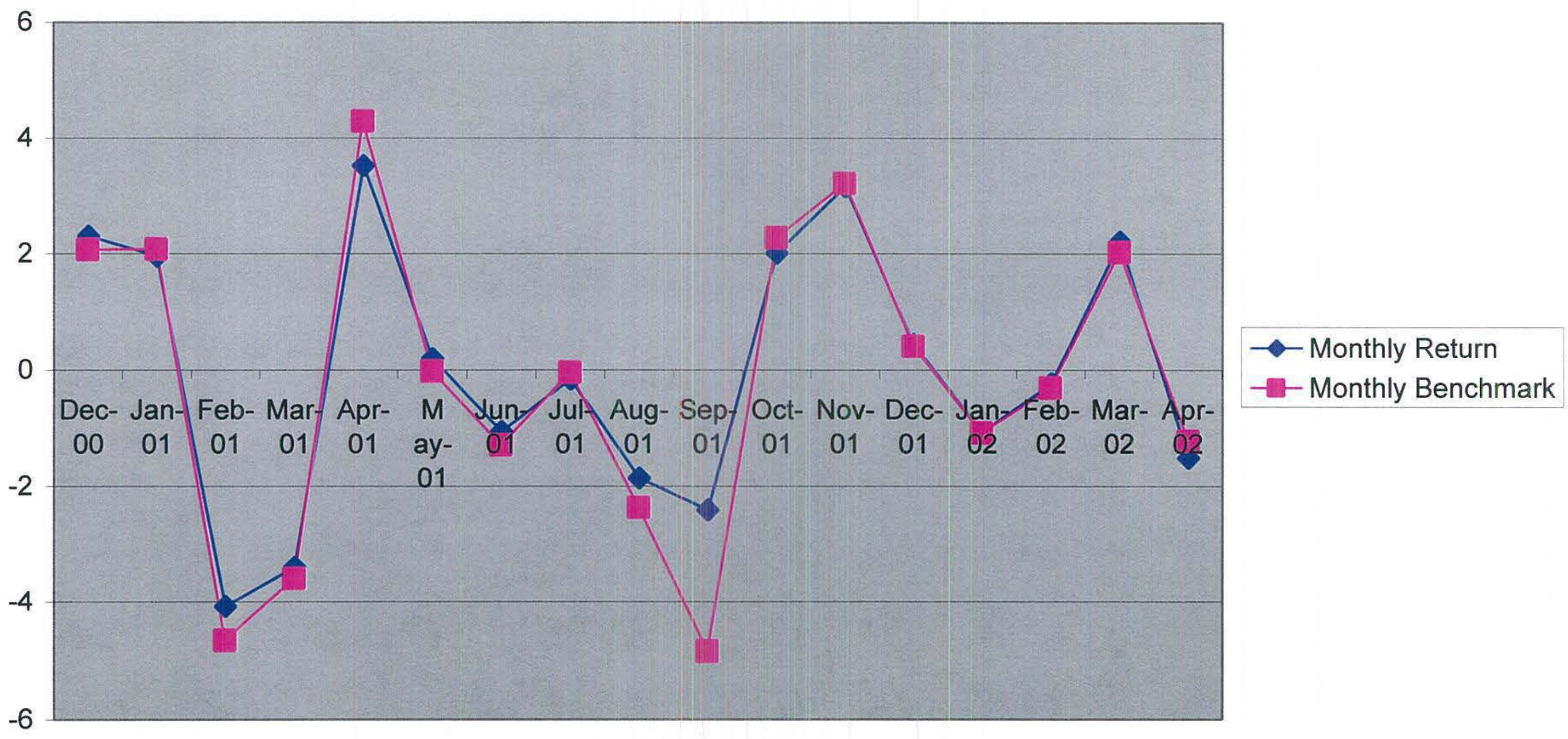
EVOS Investment Fund Earnings (Losses)				
	SFY 01	SFY 02	Total	
31-Oct-00	$2,503,034			
30-Nov-00	-$4,794,990			
31-Dec-00	$3,042,417			
31-Jan-01	$2,652,034			
28-Feb-01	-$5,626,092			
31-Mar-01	-$4,499,192			
30-Apr-01	$4,497,983			
31-May-01	$267,233			
30-Jun-01	-$1,412,478			
31-Jul-01		-$203,007		
31-Aug-01		-$2,442,542		
30-Sep-01		-$4,465,637		
31-Oct-01		$3,499,297		
30-Nov-01		$5,613,492		
31-Dec-01		$811,775		
31-Jan-02		-$1,964,261		
28-Feb-02		-$432,974		
31-Mar-02		$4,009,240		
30-Apr-02		-$2,812,729		
Total Earnings/Losses	**-$3,370,051**	**$1,612,654**	**-$1,757,397**	



Exxon Valdez Oil Spill Trustee Council
Investment Fund Earnings (Loss) as of April 30, 2002
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
-$1,000,000
-$2,000,000
-$3,000,000
-$4,000,000
-$5,000,000
-$6,000,000
Oct-00
Dec-00
Feb-01
Apr-01
Jun-01
Aug-01
Oct-01
Dec-01
Feb-02
Apr-02

EVOS Investment Fund - EVOS Index																	
NOTE: The increase in assets from August 2001 to September 2001 is due to Exxon's last payment and not earnings.																	
	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
Monthly Return	2.3	1.96	-4.08	-3.4	3.52	0.2	-1.06	-0.15	-1.86	-2.41	2.01	3.15	0.44	-1.07	-0.24	2.2	-1.51
Monthly Benchmark	2.07	2.08	-4.66	-3.6	4.29	-0.02	-1.29	-0.04	-2.37	-4.85	2.27	3.21	0.41	-1.08	-0.31	2.02	-1.22
Market Value ($M)	135,397	138,049	132,423	127,924	132,404	132,671	131,259	131,056	128,613	174,452	177,950	183,565	184,376	182,412	181,931	185,940	183,100

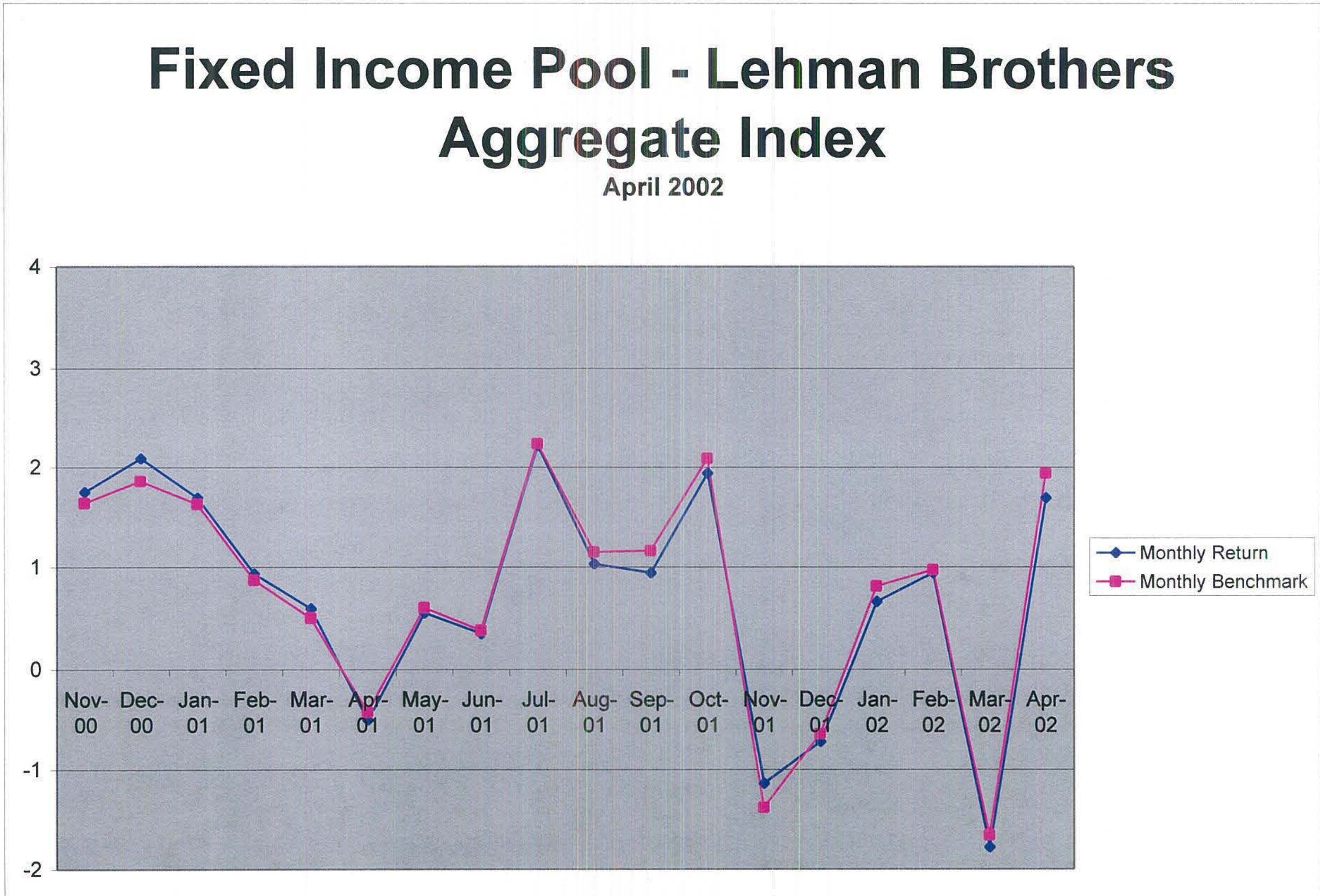
EVOS INVESTMENT FUND - EVOS INDEX



Fixed Income Pool - Lehman Brothers Aggregate Index

NOTE: The increase in assets from August 2001 to September 2001 is due to Exxon's last payment and not earnings.

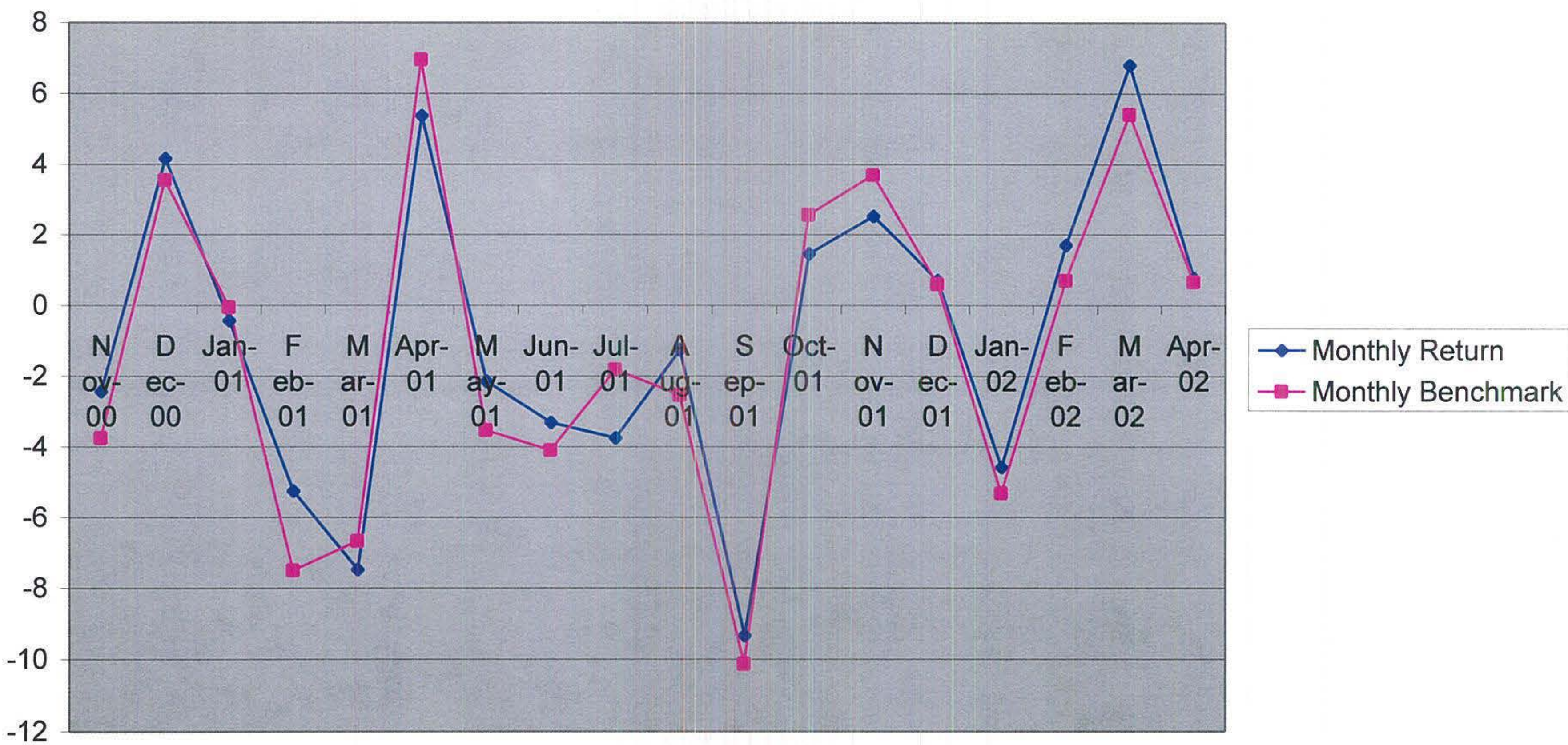
	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
Monthly Return	1.75	2.09	1.69	0.93	0.59	-0.5	0.55	0.35	2.22	1.03	0.94	1.94	-1.14	-0.72	0.66	0.94	-1.78	1.69
Monthly Benchmark	1.64	1.86	1.63	0.87	0.5	-0.42	0.6	0.38	2.24	1.15	1.16	2.09	-1.38	-0.64	0.81	0.97	-1.66	1.94
Market Value (in $M)	58,073	59,289	60,291	60,853	61,210	60,906	61,238	61,458	62,822	63,483	72,063	73,460	72,621	72,108	72,587	73,276	71,972	73,195


Fixed Income Pool - Lehman Brothers Aggregate Index
April 2002
4
3
2
1
0
-1
-2
Nov-00
Dec-00
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Jan-02
Feb-02
Mar-02
Apr-02
Monthly Return
Monthly Benchmark

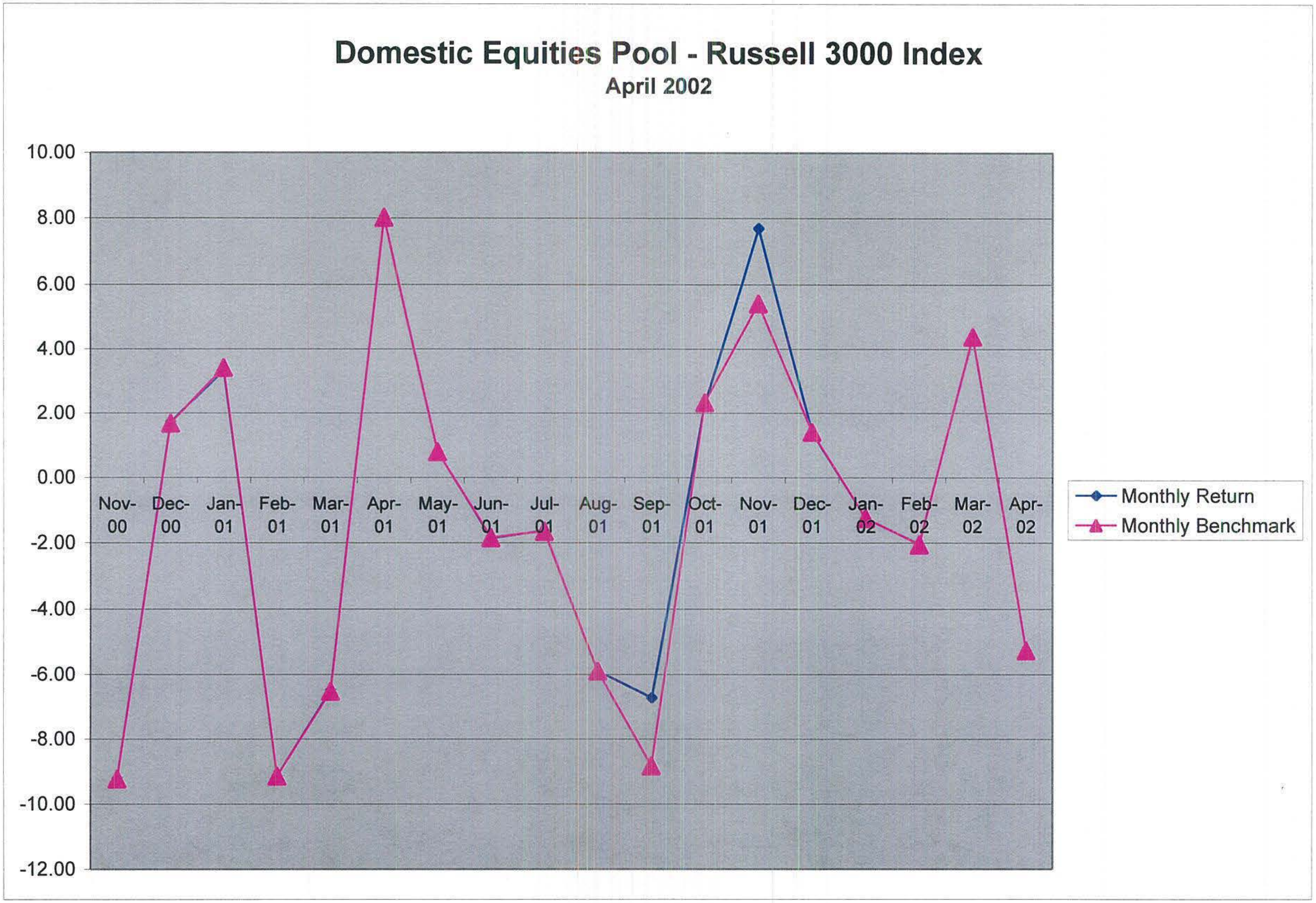
International Equities Pool - Morgan Stanley Capital Intl (EAFE)																		
NOTE: The increase in assets from August 2001 to September 2001 is due to Exxon's last payment and not earnings.																		
	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
Monthly Return	-2.43	4.16	-0.44	-5.25	-7.47	5.37	-2.15	-3.31	-3.75	-1.26	-9.33	1.45	2.52	0.7	-4.58	1.69	6.8	0.76
Monthly Benchmark	-3.75	3.55	-0.05	-7.5	-6.67	6.95	-3.53	-4.09	-1.82	-2.53	-10.13	2.56	3.69	0.59	-5.31	0.7	5.41	0.66
Market Value ($M)	22,541	23,479	23,375	22,148	20,494	21,593	21,128	20,430	19,664	19,416	29,844	30,275	31,039	31,256	29,826	30,331	32,229	32,475

International Equity Pool - Morgan Stanley Capital Intl. (EAFE)

April 2002

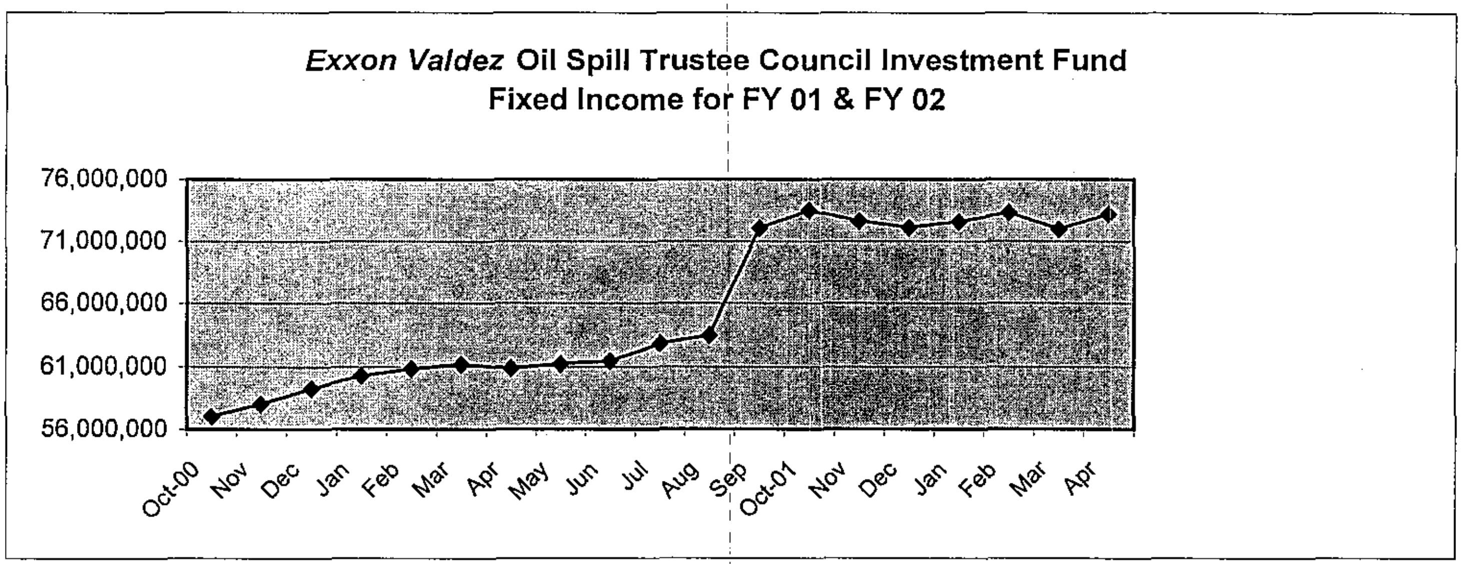


Domestic Equities Pool - Russell 3000 Index																		
NOTE: The increase in assets from August 2001 to September 2001 is due to Exxon's last payment and not earnings.																		
	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02
Monthly Return	-9.20	1.72	3.34	-9.14	-6.49	8.03	0.80	-1.86	-1.63	-5.9	-6.72	2.31	7.69	1.39	-1.25	-2.04	4.37	-5.25
Monthly Benchmark	-9.22	1.68	3.42	-9.14	-6.52	8.02	0.80	-1.84	-1.65	-5.89	-8.82	2.33	5.42	1.41	-1.25	-2.05	4.39	-5.25
Market Value ($M)	51,649	52,537	54,290	49,329	46,126	49,828	50,228	49,294	48,492	45,636	72,291	73,960	79,649	80,756	79,743	78,116	81,530	77,248



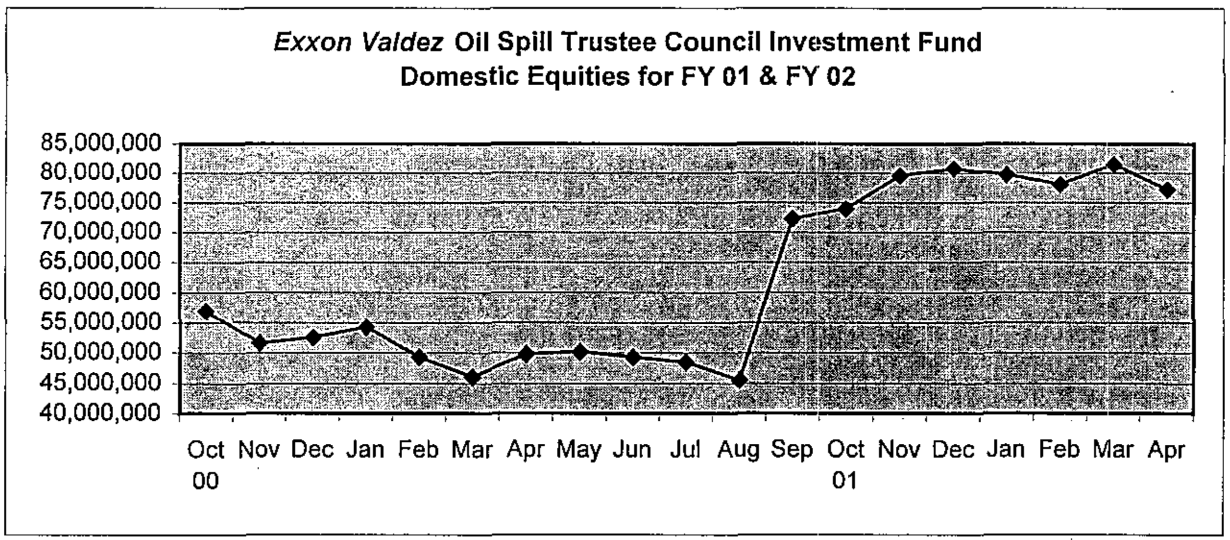
Domestic Equities Pool - Russell 3000 Index
April 2002
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
Nov-00
Dec-00
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Jan-02
Feb-02
Mar-02
Apr-02
Monthly Return
Monthly Benchmark

Oct-00	57,075,942
Nov	58,072,794
Dec	59,288,677
Jan	60,291,225
Feb	60,852,550
Mar	61,209,483
Apr	60,905,590
May	61,238,245
Jun	61,457,699
Jul	62,822,366
Aug	63,483,499
Sep	72,062,627
Oct-01	73,460,139
Nov	72,621,000
Dec	72,108,186
Jan	72,587,000
Feb	73,275,581
Mar	71,971,774
Apr	73,194,533



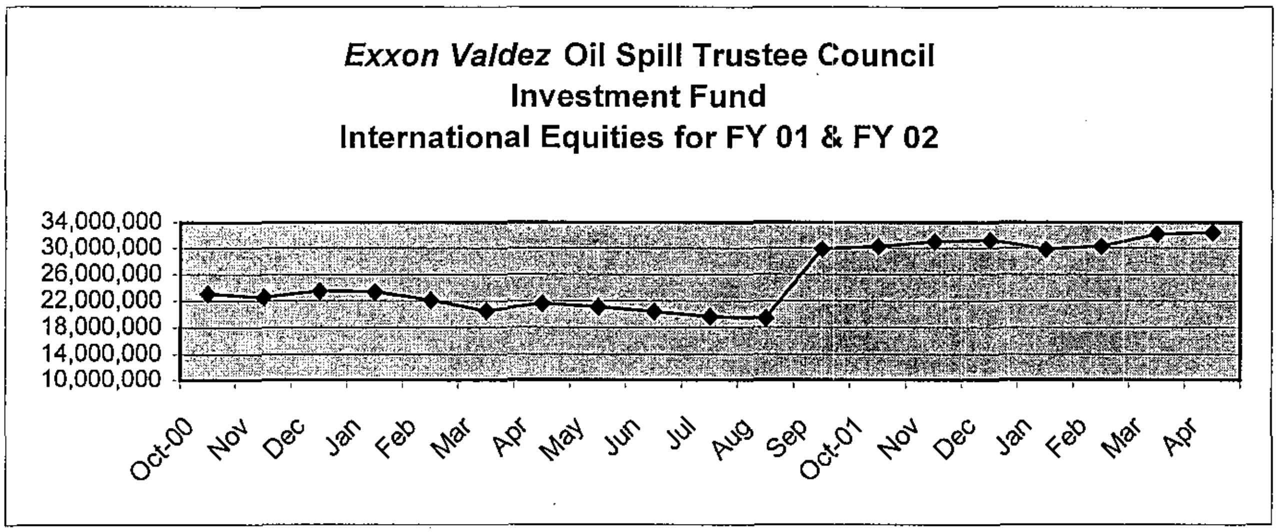
Note: September's increased amount is due to contributions from Exxon's last payment.

Oct 00	56,879,447
Nov	51,648,963
Dec	52,536,681
Jan	54,289,747
Feb	49,329,178
Mar	46,126,312
Apr	49,828,183
May	50,227,785
Jun	49,293,870
Jul	48,492,162
Aug	45,636,080
Sep	72,290,582
Oct 01	73,960,245
Nov	79,649,000
Dec	80,755,640
Jan	79,743,000
Feb	78,115,740
Mar	81,529,790
Apr	77,248,523



Note: September's increased amount is due to contributions from Exxon's last payment.

Oct-00	23,102,643
Nov	22,540,761
Dec	23,478,963
Jan	23,374,808
Feb	22,147,519
Mar	20,493,757
Apr	21,593,395
May	21,128,062
Jun	20,429,757
Jul	19,663,491
Aug	19,415,611
Sep	29,844,062
Oct-01	30,275,491
Nov	31,039,000
Dec	31,256,254
Jan	29,826,000
Feb	30,330,853
Mar	32,229,591
Apr	32,474,957



Note: September's increased amount is due to contributions from Exxon's last payment.

QUARTERLY PROJECT REPORT

Exxon Valdez Oil Spill Trustee Council

441 W. 5th Ave., Suite 500 • Anchorage, Alaska 99501-2340 • 907/278-8012 • fax 907/276-7178

MEMORANDUM

TO: Trustee Council

FROM: Sandra Schubert
Program Coordinator

THROUGH: Molly McCammon
Executive Director

DATE: May 29, 2002

RE: Quarterly Project Status Summary -- January 1 - March 31, 2002

This memorandum summarizes the status of reports for the quarter ending March 31, 2002, for all restoration projects funded by the Trustee Council for FY 92-01. The memorandum also includes progress updates for FY 02 projects and the status of the 22 NRDA reports that were not final at the time the settlement agreement was reached.

> **Attachment A** summarizes the status of project reports (including NRDA reports) by agency.
> **Attachment B** lists the reports that are significantly behind schedule. Reports are on this list if (1) their due dates have passed and they have not yet been submitted to the Chief Scientist, (2) they were reviewed by the Chief Scientist, returned to the PI for revision longer ago than six months, and have not been revised and resubmitted to the Chief Scientist, or (3) they were submitted to the Chief Scientist for peer review more than six months ago and have not yet been peer reviewed.
> **Attachment C** summarizes activities conducted during the January-March quarter for all projects underway in FY 02.

As of March 31, 2002, a total of 395 restoration project reports had been peer reviewed and accepted by the Chief Scientist (this is up from 381 reports accepted as of December 31, 2001). Once accepted by the Chief Scientist, reports are submitted to the Alaska Resources Library and Information Services (ARLIS). As of March 31, 364 reports were available to the public through ARLIS and other libraries around the state (this is up from 355 reports available as of December 31, 2001). Please contact the Trustee Council Office or ARLIS if you would like a list of the reports that are currently available to the public.

My biggest concern continues to be the large number of late reports (see Att. B). A few of these reports date back several years. I would appreciate any help you can provide in seeing that PIs in your agency submit the required project reports.

Status of FY 92 Project Reports as of March 31, 2002
A total of 75 reports are being produced on projects funded in the 1992 Work Plan. These reports are considered "final" reports and are subject to peer review and approval by the Chief Scientist. (NOTE: Reports "in progress" are in peer review, are under revision by the PI in response to peer reviewer comments, or have been revised and are undergoing a second review by the Chief Scientist.)

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
74	75	1	0

Status of FY 93 Project Reports as of March 31, 2002
A total of 28 final reports are being produced on projects funded in the 1993 Work Plan.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
25	1	1	1

Status of FY 94 Project Reports as of March 31, 2002
A total of 37 final reports are being produced on projects funded in the FY 94 Work Plan.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
37	0	0	0

Status of FY 95 Project Reports as of March 31, 2002
A total of 53 reports are being produced on projects funded in the FY 95 Work Plan. Beginning with the FY 95 project year, "annual" reports on continuing projects are peer reviewed, but are not required to be rewritten in response to peer review comments. Rather, the peer review comments are to be used to guide future work on the project.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
53	2	0	0

Status of FY 96 Projects as of March 31, 2002
A total of 50 reports are being produced on projects funded in the FY 96 Work Plan.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
47	1	1	1

Status of FY 97 Projects as of March 31, 2002
A total of 53 reports are being produced on projects funded in the FY 97 Work Plan.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
53	0	0	0

Status of FY 98 Projects as of March 31, 2002
A total of 47 reports are being produced on projects funded in the FY 98 Work Plan.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
38	4	5	0

Status of FY 99 Projects as of March 31, 2002
A total of 55 reports are being produced on projects funded in the FY 99 Work Plan.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist	Reports in Progress	No Report Yet Submitted

	but Not Yet Available to Public		
29	11	9	6

Status of FY 00 Projects as of March 31, 2002
A total of 43 reports are being produced on projects funded in the FY 00 Work Plan.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
7	15	12	8

Status of FY 01 Projects as of March 31, 2002
A total of 29eports are being produced on projects funded in the FY 01 Work Plan.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
1	0	18	10

Status of FY 02 Projects as of March 31, 2002
A project-by-project summary of activities conducted during the October-December quarter is presented in **Attachment C.**

Status of NRDA Reports as of March 31, 2002
A total of 22 NRDA reports that were not final at the time the settlement agreement was reached are in the process of being finalized.

Reports Available to Public at ARLIS	Reports Accepted by Chief Scientist but Not Yet Available to Public	Reports in Progress	No Report Yet Submitted
21	0	1	0

ATTACHMENT A

Summary of Project Report Status as of March 31, 2002

1992 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	2	0	0	2	2
ADFG	26	0	0	26	25
ADNR	1	0	0	1	1
DOI	33	0	0	33	33
NOAA	11	0	0	11	11
USFS	2	0	0	2	2
TOTAL	**75**	**0**	**0**	**75**	**74**

1993 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	2	0	0	2	2
ADFG	12	1	1	10	10
ADNR	0	0	0	0	0
DOI	9	0	0	9	9
NOAA	3	0	0	3	3
USFS	2	0	0	2	1
TOTAL	**28**	**1**	**1**	**26**	**25**

1994 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	1	0	0	1	1
ADFG	19	0	0	19	19
ADNR	2	0	0	2	2
DOI	6	0	0	6	6
NOAA	5	0	0	5	5
USFS	4	0	0	4	4
TOTAL	**37**	**0**	**0**	**37**	**37**

ATTACHMENT A

Summary of Project Report Status as of March 31, 2002

1995 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	4	0	0	3	4
ADFG	27	0	0	26	27
ADNR	1	0	0	1	1
DOI	7	0	0	7	7
NOAA	8	0	0	8	8
USFS	6	0	0	6	6
TOTAL	**53**	**0**	**0**	**51**	**53**

1996 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	1	0	0	1	0
ADFG	27	1	1	25	25
ADNR	3	0	0	3	3
DOI	3	0	0	3	3
NOAA	9	0	0	9	9
USFS	7	0	0	7	7
TOTAL	**50**	**1**	**1**	**48**	**47**

1997 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	2	0	0	2	2
ADFG	28	0	0	28	28
ADNR	4	0	0	4	4
DOI	6	0	0	6	6
NOAA	7	0	0	7	7
USFS	6	0	0	6	6
TOTAL	**53**	**0**	**0**	**53**	**53**

ATTACHMENT A

Summary of Project Report Status as of March 31, 2002

1998 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	1	0	1	0	0
ADFG	21	0	2	19	17
ADNR	2	0	0	2	2
DOI	7	0	0	7	7
NOAA	12	0	0	12	10
USFS	4	0	2	2	2
TOTAL	**47**	**0**	**5**	**42**	**38**

1999 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	1	0	0	1	0
ADFG	24	2	5	18	14
ADNR	4	0	1	3	3
DOI	10	0	2	8	4
NOAA	11	3	0	7	6
USFS	5	1	1	3	2
TOTAL	**55**	**6**	**9**	**40**	**29**

2000 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	2	0	1	1	0
ADFG	18	2	7	9	3
ADNR	0	0	0	0	0
DOI	9	4	0	5	2
NOAA	12	2	4	6	0
USFS	2	0	0	1	2
TOTAL	**43**	**8**	**12**	**22**	**7**

ATTACHMENT A

Summary of Project Report Status as of March 31, 2002

2001 WORK PLAN

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	0	0	0	0	0
ADFG	9	3	6	0	0
ADNR	1	0	0	1	1
DOI	7	2	5	0	0
NOAA	11	5	6	0	0
USFS	1	0	1	0	0
TOTAL	**29**	**10**	**18**	**1**	**1**

NRDA REPORT COMPLETION

AGENCY	NUMBER OF REPORTS	Not Yet Submitted to Chief Sci.	In Progress	Peer Rev'd/ Accepted by Chief Scientist	Available to Public at ARLIS
ADEC	1	0	0	1	1
ADFG	17	0	1	16	16
DOI	2	0	0	2	2
NOAA	2	0	0	2	2
TOTAL	**22**	**0**	**1**	**21**	**21**

ATTACHMENT B
Overdue Reports (as of 5/30/02)

Agency	Project Number	PI	Final or Annual	Project Title	Status of Report
ADEC	98291	See	Final	Chenega shoreline oiling	Peer reviewed; returned to PI for revision 2/18/00.
ADFG	93033-1	Rothe	Final	Harlequin duck - Afognak habitat assessment/PWS production	Peer reviewed; returned to PI for revision 11/14/95; most recent due date was 7/1/98; then expected 5/31/00; now expected 6/1/02.
ADFG	93033-2	Rothe	Final	Harlequin restoration	Never submitted; most recent due date was 7/1/98; then expected 5/31/00; now expected 7/1/02.
ADFG	96258A-1	Edmundson	Final	Sockeye: Kenai	Never submitted; was due 1/1/98 (with manuscript). PI retired 6/1/00; Edmundson has been assigned as new PI and will complete report as part of his PhD directed study--was to be submitted January 2002.
ADFG	98191A	Willette	Final	Oil-related embryo mortality	Peer reviewed; returned to PI for revision 4/20/00. Was expected 5/1/02.
ADFG	99139A2	Dickson	Final	Port Dick restoration	Peer reviewed; returned to PI for revision 12/15/00.
ADFG	99162B	Kennedy	Ms.	Herring disease	4 manuscripts were due 9/30/00; 3 not submitted.
ADFG	99252-1	L. Seeb	Final	Genetics project: pollock component	Never submitted; was due 9/30/99; then expected 4/30/00; then expected 3/02.
ADFG	99252-2	L. Seeb	Final	Genetics project: black rockfish component	Never submitted; was due 1/31/00; then expected 6/30/00; then expected 4/02.
ADFG	00273	Rosenberg	Annual	Surf scoters	Never submitted; was due 9/30/01.
ADFG	00371	Schell	Final	Harbor seal isotopes	Never submitted; was due 11/15/01 (extended from 9/30/01).
ADFG	00509	Small, Frost	Final	Harbor seal long-term monitoring	Peer reviewed; returned to PI for revision 6/18/01.
ADFG	01064	Frost	Ms.	Harbor seals	7 ms. due in March, June, Sept., and Dec. 2001 & March 2002 are overdue
ADFG	01163	E. Brown	Ms.	APEX synthesis ms. (A/T)	Never submitted; was due 9/30/01. Now expect 6/30/02.
ADFG	01481	Simeone	Video	Subsistence - intertidal	Never submitted; was due 12/15/01.
ADNR	99007A	Bittner	N'book	Archaeology	Restoration Notebook Series was due 4/15/00; never submitted. Bittner has taken over for Reger, who retired.

ATTACHMENT B

Overdue Reports (as of 5/30/02)

ADNR	99180	Weiner	Final	Kenai River Restoration	Peer reviewed; returned to PI for revision 10/11/01.
DOI	99163	Piatt	Final	APEX-Subproject M	Never submitted; was due 9/30/00.
DOI	99459	Irvine	Final	GOA residual oil	Peer reviewed; returned to PI for revision 3/27/01.
DOI	00169	Friesen	Final	Seabird genetics	Never submitted; was due 3/31/02; then expected 5/31/02; now expected 7/31/02.
DOI	00327-2	Divoky	Final	Pigeon guillemots	Never submitted; was due 9/30/01.
DOI	00501	Piatt	Final	Seabird monitoring protocols	Never submitted; was due 9/30/00; due date extended to 10/31/00; then expected 3/31/02.
DOI	01163	Piatt	ms.	APEX synthesis ms. (M/E/I/)	Never submitted; was due 9/30/01.
DOI	01338	Piatt	Final	Murre/kittiwake survival	Never submitted; was due 9/15/01; now expect 9/15/02.
DOI	01404	Nielsen	Annual	Archive tags	Never submitted; was due 4/15/02; then expected 5/15/02.
DOI	01555	Lanctot	Final	Stress hormones	Peer reviewed; returned to PI for revision 11/19/01. Now expected 10/1/02 as additional sample collection and lab work is need to respond to peer review.
NOAA	99090	Carls	Final	Mussel bed monitoring	Never submitted due to loss of 2 ABL personnel; was due 4/15/00; due date was extended to 8/25/00; then expected 1/1/01; then expected 2/02; then expected 5/02. (ms. also not submitted)
NOAA	99163	Duffy, et al	Final	APEX	Never submitted; was due 9/30/00 (all done except Piatt's subproject M).
NOAA	99347	Heintz	Final	Fatty acids & lipids RE diet composition	Never submitted; was due 9/30/00; then expected 10/30/01.
NOAA	00048	Ruggerone	Ms.	Sockeye salmon	2 manuscripts were due 12/99; then expected 11/15/00 and 3/01.
NOAA	00195	Short	Annual	Pristane	Never submitted; was due 4/15/01; then expected 7/1/01.
NOAA	00330	Pauly & Okey	Ms.	Mass-balance model	4 manuscripts were due 9/30/00; 1 not submitted.
NOAA	00454	Rice	Final	Salmon natal habitats	Never submitted; was due 9/30/01.
NOAA	00493	Anderson	Final	Trawl survey	Peer reviewed; returned to PI for revision 7/12/01.

ATTACHMENT B

Overdue Reports (as of 5/30/02)

NOAA	00510	McDonald	Ms.	Intertidal monitoring recommendations	Two manuscripts were due 4/15/00; one never submitted.
NOAA	00516	Day	Final	Murrelet habitat use	Peer reviewed; returned to PI for revision 10/11/01 (PI awaiting review from *Ecology* before revising).
NOAA	00598	Short	Ms.	EVO vs. regional background hydrocarbons	Never submitted; was due 8/00; was expected 7/1/01; then 5/02; now 8/02.
NOAA	01163	Duffy, et al	14 ms.	APEX synthesis ms.	Never submitted; were due 9/30/01.
NOAA	01195	Short	Annual	Pristane	Never submitted; was due 4/15/02; now expected 6/02.
NOAA	01401	O'Clair	Final	Spot shrimp	Never submitted; was due 4/15/02.
NOAA	01476	Heintz	Annual	Oiled incubation	Never submitted; was due 4/15/02.
NOAA	01492	Thedinga	Final	Bias in pink salmon embryo studies	Never submitted; was due 4/15/02.
NOAA	01551	Hansen	Final	Algal checklist	Never submitted; was due 10/1/01.
NOAA	01599	Short	Final	Yakataga oil seeps	Never submitted; was due 4/15/02.
USFS	98145	Reeves	Final	Cutts & dollys: anadromous forms	Peer reviewed; returned to PI for revision 12/15/00; was expected 1/02; then expected 4/02.
USFS	99339-2	Suring	Final	Human use model & recommendations	Never submitted; was due 12/31/99, then expected 4/1/02. PI transferred out of state and is completing on own time.

The following reports were submitted to the Chief Scientist for peer review more than 6 months ago:

			Date submitted:
01610	Annual	Kodiak Youth Area Watch	7/3/01
00245	Annual	Harbor seal biosampling	9/18/01

ATTACHMENT **DRAFT**

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02012-BAA	Photographic and Acoustic Monitoring of Killer Whales in Prince William Sound and Kenai Fjords	C. Matkin/North Gulf Oceanic Society	NOAA

Project Tasks to be Completed this Quarter

Oct-Dec
DONE-Analyze photos from 2001 fieldwork
DONE-Input data into GIS system

Jan - March
DONE-Summarize monitoring field work for 2001
DONE-Analyze killer whale calls from 2001
UNDERWAY; WILL INCLUDE IN FINAL REPORT DUE 4/15/03Analyze and interpret GIS data for Kenai Fjords region
DONE-Attend Annual Workshop (1/22-25)

April-June
DONE-Analyze remote hydrophone data collected through 2001
DUE DATE EXTENDED TO 4/15/03 (THE NOAA CONTRACT ON THIS PROJECT RUNS MARCH-FEB. EACH YEAR, RATHER THAN ON THE FISCAL YEAR); ANNUAL REPORT SUBMITTED 4/02-Final report due 4/30/02

July-Sept

Conferences
DONE; PRESENTED PAPER ON KILLER WHALE POPULATION DYNAMICS-November 2001: Biennial Conference on Biology of Marine Mammals, Vancouver, BC (funded in FY 01)

Publications
UNDERWAY-Matkin, et al. Populations of killer whales in PWS 11 years after EVOS; submit to Marine Mammal Science (carried over from FY 01)

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02052	**Natural Resource Management and Stewardship Capacity Building**	**P. Brown- Schwalenberg/CRRC**	**ADFG**

Project Tasks to be Completed this Quarter

NOTE: PROJECT DEFERRED IN AUGUST (EXCEPT FOR SMALL AMOUNT OF INTERIM FUNDS THAT HAVE BEEN AUTHORIZED TO PAY TRAVEL EXPENSES FOR COMMUNITY FACILITATORS TO ATTEND ANNUAL RESTORATION WORKSHOP). TC APPROVED BALANCE OF FUNDS 4/18/02, BUT AS OF 5/30/02 FUNDING WAS STILL UNDER REVIEW BY DOJ AND HAD NOT BEEN SUBMITTED TO COURT.

Jan-March
DONE-Community facilitators attend Annual Restoration Workshop (1/22-25)
?-Natural Resource Specialists attend Region X EPA Environmental Conference and Alaska Forum on the Environment Conference
?-Natural Resource Specialists attend BIA Integrated Resource Management Program Development Conference

April-June
DONE (MIMI HOGAN)-Hire Tribal Natural Resource Program Planner
Renew subcontracts with tribes for Natural Resource Specialists
Renew contract with TEK Specialist
Contract with a Science Advisor
Natural Resource Specialists attend Native American Fish & Wildlife Society Conference

July-Sept
Complete Tribal Natural Resource Management Plans for Eyak, Port Graham, Nanwalek, and Ouzinkie
Complete Inter-Tribal Integrated Natural Resource Management Plan
Complete Tatitlek Tribal Action Plans for specific marine species

Ongoing
Participate in GEM planning meetings and workshops
Participate in capacity building and training activities as the opportunities arise

FY 00 tasks not completed during FY 00:
-Identify species on which to develop monitoring programs at local level
-Pilot communities talk to adjacent landholders regarding stewardship & mgt.
-Develop draft GEM Community Integration Plan
-Work with non-pilot communities to develop tribal natural resource mgt. programs

02100	**Public Information, Science Management, and Administration**	**All Trustee Council Agencies**	**ALL**

Project Tasks to be Completed this Quarter

N/A

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02126	**Habitat Protection and Acquisition Support**	**ADNR, DOI/USFWS, U**	**ADNR USFS DOI**

Project Tasks to be Completed this Quarter

In FY 02, work is expected on the following parcels:

Small parcels:
Kodiak Tax & Larsen Bay Shareholder parcels: KAP 1098, 2000, 2019, 2042, 2069, and 6 not yet identified
USFS & UNIVERSITY CONTINUE NEGOTIATIONS OVER SUBSURFACE-Valdez Duck Flats: PWS 05
REQUEST FOR LEGISLATIVE AUTHORITY SUBMITTED IN GOVERNOR'S BUDGETValdez Duck Flats: PWS 06
USFS & UNIVERSITY CONTINUE NEGOTIATIONS OVER PURCHASE AGREEMENT-Jack Bay: PWS 1010
REQUEST FOR LEGISLATIVE AUTHORITY SUBMITTED IN GOVERNOR'S BUDGET-Kenai parcels: KEN 294 Anchor River, KEN 309 Ninilchik River, and Duck Flats
Alaska Peninsula parcels: KAP 281 3 Saints Bay, KAP 283 Chiniak Bay, KAP 285 Hook Bay

Large parcels:
EXTENSION-Koniag Phase II with exchange
English Bay Phase II
AKI Phase IV, exclusion V
Old Harbor excahnge
DONE-AJV final closing (part 2)
ONGOING-AJV subsurface
NEGOTIATIONS ONGOING-Karluk
Eyak final closing (Power Creek)
DONE-Tatitlek exchange

Proj.No.	Project Title	Proposer	Lead Agency
02144	**Common Murre Population Monitoring**	**D. Roseneau/USFWS**	**DOI**

Project Tasks to be Completed this Quarter

Oct-Dec

Jan-Mar
DONE-Attend Annual Workshop (1/22-25)
DONE-Submit draft final report for in-house review

April-June
DONE-Submit final report to Chief Scientist (4/15/02)

July-Sept

Proj.No.	Project Title	Proposer	Lead Agency
02154	**Support Costs: Archaeological Repository/Display Facilities/Exhibits**	**J. Bittner/ADNR**	**ADNR**

Project Tasks to be Completed this Quarter

N/A

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
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Proj.No.	Project Title	Proposer	Lead Agency
02159	Surveys to Monitor Marine Bird Abundance in Prince William Sound	D. Irons/USFWS	DOI

Project Tasks to be Completed this Quarter

NOTE: THIS PROJECT WAS APPROVED 12/11/01 CONTINGENT ON A REVISED DPD THAT REDUCES SCOPE TO FINAL REPORT PREPARATION ONLY; AS OF 5/30/02 REVISED DPD NOT YET RECEIVED.

Oct-Dec

Jan-Mar

April-June

July-Sept

Proj.No.	Project Title	Proposer	Lead Agency
02163M	APEX: Numerical and Functional Response of Seabirds to Fluctuations in Forage Fish Density	J. Piatt/USGS	DOI

Project Tasks to be Completed this Quarter

June 30

Complete 8 final synthesis manuscripts:
-Role of food supply & environmental variability in regulation of seabird population; Ecological Monographs
-Feeding ecology of common murres & black-legged kittiwakes in relation to food availability; MEPS
-Chick feeding rates, foraging time budgets, & nest site attendance of common murres & black-legged kittiwakes at 3 colonies with differing food regimes; Behavioral Ecology
-Breeding biology of common murres & black legged kittiwakes in relation to food availability; Ecology
-Spatial associations of seabirds and their prey; MEPS
-Foraging ecology of seabirds in lower Cook Inlet; Speckman PhD dissertation
-Cost of egg production in common murres; Oecologia
-Breeding biology and feeding ecology of horned puffins at Chisik Island; Condor

Sept 30

Submit manuscripts for journal publication

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
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Proj.No.	Project Title	Proposer	Lead Agency
02190	Construction of a Linkage Map for the Pink Salmon Genome	F. Allendorf/Univ. Montana	ADFG

Project Tasks to be Completed this Quarter

Conferences
National meeting ($900)

Manuscripts (from FY 01)
Lindner, et al. To be submitted to Genetics. Linkage map for pink salmon based on gynogenetic haploids & half-tetrads

by Dec 2001
GENOTYPED ALL 262 EXPERIMENTAL PINK SALMON COLLECTED IN AUG. & SEPT. 2001 AT 3 MICROSATELLITE LOCI (SSA408, 0MY301, 0TS1). Complete genetic analyses of fry from 1999 cohort samples at time of release from ASLC
Perform morphological analysis of returning adults from 1999 cohort

by Mar 2002
GENOTYPING COMPLETED AT 9 LOCI AND A GROWTH HORMONE LOCUS. THIS ALLOWED ALL THE FISH TO BE PLACED INTO THEIR FAMILY OF ORIGIN EXCEPT FOR 3 FISH THAT DO NOT BELONG TO THE 1999 COHORT. MAP COMPLETED; 103 OF 123 LOCI HAVE BEEN ADDED TO 33 LINKAGE GROUPS-Add markers to the even-year linkage map

April 15, 2002
Submit annual report

by July 2002
CALCULATED HERITABILITIES OF BODY LENGTH AT SEXUAL MATURITY AS WELL AS THOSE OF SEVERAL COMPONENTS OF FEMALE REPRODUCTIVE SUCCESS: MEAN EGG SIZE, TOTAL EGG NUMBER, TOTAL EGG WEIGHT-Perform genetic analyses of adults from 1999 cohort that return to ASLC

by Sept 2002
Perfrom data analysis to test for correlations between markers from the linkage map and traits associated with marine survival and fitness in the returns of the 1999 cohort
Submit ms. describing results of marine survival and fitness experiment
Submit ms. comparing odd- and even-year linkage maps

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
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Proj.No.	Project Title	Proposer	Lead Agency
02195	Pristane Monitoring in Mussels	J. Short, P. Harris/NOAA	NOAA

Project Tasks to be Completed this Quarter

NOTE: March 21, 2002 Executive Director approved additional year of sample collection in FY 02, rather than the closeout described in the DPD.

Oct-Dec
DONE-Submit sample collection and pristane concentration data to pristane database
DONE-Compile pink salmon survival data from PWSAC and ADF&G

Jan-March
DONE-Attend Annual Workshop (Jan 22-25)

April-June
DELAYED-Submit annual report (4/15)

July-Sept

Conferences
2 unidentified scientific meetings ($2,600)

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02210	Prince William Sound/Lower Cook Inlet Youth Area Watch	R. DeLorenzo/Chugach School District	ADFG

Project Tasks to be Completed this Quarter

Sept
? - JASON training (all YAW site coordinators and 5 additional teachers)
DONE-Site teacher orientation
DONE-School site orientation
DONE-Select students for participation

Oct-Dec
DONE-Student orientation & training
DONE-Complete protocol training for teachers
DONE-Prepare weather station at each site

Jan-March
CANCELED; NONE OF THE PROJECT'S STUDENTS WERE SELECTED TO PARTICIPATE IN THE BROADCAST-JASON live broadcast (1 coordinator, 2 students)
DONE-Coordinator sends data to PIs 3/1/02

April-June
DONE-Site teacher follow-up training
Coordinator sends data to PIs 6/1/02
Students complete project reports 6/1/02

July-Sept
-

Ongoing Student Activities:
-Maintain web site
-Bi-monthly mussel collection
-Daily weather station monitoring
-Collect harbor seal samples with local hunters
-Conduct local projects
-Assist in documenting local TEK
-Interact and exchange information with PIs

DRAFT

Exxon Valdez Oil Spill Project Status Summary
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Proj.No.	Project Title	Proposer	Lead Agency
02245	Community-Based Harbor Seal Management and Biological Sampling	V. Vanek/ADFG, M. Riedel/Alaska Native Harbor Seal Commission	ADFG

Project Tasks to be Completed this Quarter

Ongoing
Collect biological samples
Process samples

Oct-Dec
DELAYED; TRAINING FOR PERRYVILLE AREA NOW PLANNED FOR APRIL-Hold training sessions for new community technicians and students
ALSO: PARTICIPATE IN JASON PROJECT

Jan-Mar
UNABLE TO ATTEND DUE TO PARTICIPATION IN JASON PROJECT-Attend Annual Workshop (Jan 22-25)
CANCELED-Produce & distribute newsletter (ANHSC)

April-June
ANHSC meeting

July-Sept
Final report due 9/30/02

DRAFT

Exxon Valdez Oil Spill Project Status Summary
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Proj.No.	Project Title	Proposer	Lead Agency
02247	Kametolook River Coho Salmon Subsistence Project	J. McCullough, L. Scarbrough/ADFG	ADFG

Project Tasks to be Completed this Quarter

Oct-Dec -- ALL TASKS DONE
Local assistants conduct stream surveys for coho & report findings to ADFG
ADFG personnel travel to Perryville to capture adult coho & place in holding pens
Stream surveys & genetic /pathological work in local area river system for FTP requirement to transport coho eggs and/or juvenile fish to Kametolook R. and egg boxes
Set up school aquarium
Obtain FTP for school aquarium
Perform maintenance of instream incubation system
Conduct escapement surveys
Perform coho salmon egg take, fertilize eggs, place in incubation boxes (Kametook and a nearby river if FTP allows)
Sample salmon for genetic & pathology tests
Meet with students & community to discuss project
Meet with Chignik RPT/CRAA & Perryville Subsistence Work Group to discuss project

Dec-March
DONE-Local assistants make monthly trips to incubation boxes to inspect condition of boxes & eggs
UNDERWAY-ADFG analyze subsistence data
DONE-ADFG analyze commercial harvest data
DID NOT ATTEND-Attend Annual Workshop (Jan. 22-25)
DONE-Attend Chignik Subsistence Work Group meeting (Anchorage)
DONE-Attend Board of Fisheries meeting to discuss Kametolook project (Anchorage or Kodiak)

April-June
Meet with assessment team to evaluate project
-Local assistants monitor boxes for fry release
-Sanitize boxes after fry leaves
DONE MID-APRIL-Students release aquarium fry into Kametolook River

July-Sept
-RPT meet in Chignik Bay to review project status & look for other funding sources
Final report due 9/30/02

02250	Project Management	All Trustee Council Agencies	ALL

Project Tasks to be Completed this Quarter

N/A

DRAFT

Exxon Valdez Oil Spill Project Status Summary
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Proj.No.	Project Title	Proposer	Lead Agency
02256B-CLO	Sockeye Salmon Stocking at Solf Lake	D. Gillikin/USFS	USFS

Project Tasks to be Completed this Quarter

Jan
Attend Annual Workshop (Jan 22-25)

Jan-April
Prepare for field season; hire crew

April-July
-Evaluate fishway & monitor returning adult salmon

Sept
Final report due 9/30/02

02290	Hydrocarbon Database and Interpretation Service	J. Short, B. Nelson/NOAA	NOAA

Project Tasks to be Completed this Quarter

Jan
DONE-Attend Annual Workshop (Jan 22-25)

April 15
DONE-Submit annual report in form of updated release of hydrocarbon data software

Conferences
-Quality Assurance Control/NIST ($1,400)

02320	Sound Ecosystem Assessment (SEA): Printing the Final Report	W. Hauser/ADFG	ADFG

Project Tasks to be Completed this Quarter

Jan-Mar
DELAYED-Print and distribute final report.
DELAYED-Post final report on web.

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02340	**Toward Long-Term Oceanographic Monitoring of the Gulf of Alaska Ecosystem**	**T. Weingartner/ UAF**	**ADFG**

Project Tasks to be Completed this Quarter

Monthly
CTD surveys
Update homepage as data are processed & entered
Prepare windfields and acquire meteorological fieldds

Nov-Dec
DONE IN MARCH-Deploy mooring

Jan-Mar
DONE-Attend Annual Workshop (Jan 22-25)
ALSO PRESENTED SOME PROJECT RESULTS TO A NORTH POLE HIGH SCHOOL SCIENCE CLASS

April
DONE-Submit annual report 4/15
ALSO PRESENTED SOME PROJECT RESULTS TO GLOBEC NATIONAL SCIENCE STEERING COMMITTEE

Sept
Recover mooring, send instruments for post-calibration, begin data processing

Publications
Budget includes $1,000 in page charges for 1 ms.

02360-BAA	The *Exxon Valdez* Oil Spill: Guidance for Future Research Activities	**C. Elfring/Polar Research Board, NRC**	**NOAA**

Project Tasks to be Completed this Quarter

Oct-Dec
DONE-5th meeting (report-writing workshop, finalize conclusions & recommendations)

Jan-Mar
DONE-6th meeting (editorial subgroup work on final report)
DONE-Report prepared for NAS outside review process (Jan)
DONE-Outside review occurs (Jan)
DONE-Response to review (Feb)
DONE-Final revisions; NAS approval process (Mar)

April-June
DONE-Deliver prepublication copies of report (April)
-Published volume available (June 30)

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02395	**Workshop on Nearshore/Intertidal Monitoring**	**T. Dean/Coastal Resources Associates, C. Schoch/Kachemak Bay NERR**	**ADFG**

Project Tasks to be Completed this Quarter

Nov
DONE-Convene expert panel

Jan
DONE-Present draft plan at workshop (citizen review)

March 31
DRAFT FINAL REPORT SUBMITTED TO CHIEF SCIENTIST 4/4/02; UNDER PEER REVIEW-Complete plan and present to TC

Proj.No.	Project Title	Proposer	Lead Agency
02396	**Alaska Salmon Shark Assessment**	**J. Rice, L. Hulbert/NOAA**	**NOAA**

Project Tasks to be Completed this Quarter

Oct-Dec
DONE-Organize & analyze stomach data
DONE-Analyze SPOT2 satellite tag data (position only tags)

Dec-July
DONE-Attend Annual Workshop (Jan 22-25)
UNDERWAY; LAST TAG WILL POP UP IN JULY-Retrieve, analyze, and synthesize satellite tag data
UNDERWAY-Analyze salmon shark stomach contents from contributions to the project from other sources

Sept 30
Final report due

Proj.No.	Project Title	Proposer	Lead Agency
02401	**Assessment of Spot Shrimp Abundance in Prince William Sound**	**C. Hughey/ Valdez Native Tribe, C. O'Clair/ NOAA**	**NOAA**

Project Tasks to be Completed this Quarter

Oct-Dec
UNDERWAY-Complete comparison of spot shrimp abundance, sex and size composition, fecundity & proportion of ovigerous females between sites and years

Jan-March
?-Attend Annual Workshop (Jan 22-25)
DONE-Complete comparison of the abundance data and the date on population structure obtained under the project with historical data collected by ADF&G

April 15
DELAYED-Submit final report & recommendations to ADF&G for PWS shrimp management plan

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02404	Testing Archival Tag Technology in Coho Salmon	J. Nielsen/USGS-BRD	DOI

Project Tasks to be Completed this Quarter

Delayed from FY 01:
DONE-Deploy light sensor tag array on stationary buoy in PWS . Were recovered May 2002.

Dec-Jan
UNDERWAY FOR 487 COHO-Initiate accelerated growth protocols for 300 coho at Fort Richardson Hatchery.
UNDERWAY-Implement population monitoring for growth and survival in coho salmon.
DONE-Attend Annual Workshop (Jan 22-25)

March
DONE-Purchase additional archive tags (2nd generation) for coho study.
DONE, BUT USED PIT TAGS (NOT VI) BECAUSE THE PIT TAGS ARE MORE RELIABLE (VI TAGS WERE NOT ATTACHING WELL)-Initiate VI tagging in fish at critical size.

April-June
96 OF 200 ARE DONE-Second year surgical implants of tags in captivity for estimates of survival, stress, swimming ability and delayed mortality in tagged fish at Fort Richardson Hatchery
DONE-Submit annual report (4/15)
-Release tagged coho wITh general hatchery release into Ship Creek

July-Sept
-Monitor and evaluate tagged fish recovery, survival, behavior and tag retention from fish recovered in the Ship Creek sport fishering and weir and the Cook Inlet commercial fishery
-Present at AFS meeting (Baltimore, August, $800)

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02407	Harlequin Duck Population Dynamics	D. Rosenberg/ADFG	ADFG

Project Tasks to be Completed this Quarter

Conferences
-Harlequin Duck Working Group ($1,100; Nov. 2002 Vancouver, BC)

Oct-Dec
DONE-Coordinate and plan surveys
DONE-Prepare equipment
DONE-Contract for vessel support
DONE-Hire personnel

Jan-March
DONE-Conduct population surveys
DONE-Attend Annual Workshop (1/22-25)

April-June
-Data analysis and report preparation
-Maintain equipment

July-Sept
-Submit final report (9/30/02)

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02423	**Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators**	**J. Bodkin, D. Esler/USGS-BRD**	**DOI**

Project Tasks to be Completed this Quarter

Conferences
American Ornithologists Union (date & location TBD)-Esler, $1,000
DONE-Conference on Biology of Marine Mammals, Nov. 2001, Vancouver, BC-Bodkin, $1,000

Oct-Dec
DONE-Conduct studies of captive flock of harlequins at ASLC (with birds captured late FY 01)
DONE-Capture harlequins for field studies of survival and CYP1A induction

Jan-March
DONE-Obtain/update marine mammal permits
DONE-Biopsy livers of captive harlequins for EROD activity
CANCELED; BIRDS CONTRACTED A VIRUS AND WILL NOT BE RE-RELEASED TO THE WILD-Release birds at original capture site
DONE-Monitor radioed harlequins for survival study

April-June
Collect beach-cast carcasses of sea otters
Aerial surveys of sea otters
Submit annual report (4/15/02)

July-Sept

02423am	**Patterns and Processes of Population Change in Selected Nearshore Vertebrate Predators (amendment)**	**S. Atkinson/ASLC**	**ADFG**

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDS FOR THIS AMENDMENT 4/18/02.

April-Sept.
-Conduct refined reovirus study
-Conduct feeding trial (vitamin study)
-Conduct stress assessment study (endocrine study)

Feb. 2003
Submit final report, which will consist of 4 ms.:
1. Reovirus study. Hollmen, et al
2. Vitamin/coagulopathy study. Tuomi, et al
3. Endocrine study--circadian pattern of cortisol release. Atkinson & Nilsson
4. Endocrine study--ACTH. Atkinson & Nilsson

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02441	Harbor Seal Recovery: Effects of Diet on Lipid Metabolism and Health	R. Davis/Texas A&M	ADFG

Project Tasks to be Completed this Quarter

Oct-Dec
UNDERWAY-Analyze remaining blubber samples

Jan-Mar
DELAYED-Statistical analysis and integration of data, including health and body condition results from Castellini

April-June
Submit final report (due 6/30/02)

July-Sept
Submit 5 ms. (page charges $500):
1. Effects of diet on fatty acid signature in blubber of harbor seals
2. Effects of diet on aerobic capacity and lipid content of harbor seal muscle
3. Spatial distribution of aerobic enzymes for lipid metabolism in muscles of harbor seals
4. Skeletal muscles of harbor seals are composed of oxidative fibers: implications for lipid metabolism
5. Aerobic capacity and lipid droplet density in heart, liver, kidneys, and small intestine of harbor seals

Proj.No.	Project Title	Proposer	Lead Agency
02455	GEM Data System	Restoration Office	ALL

Project Tasks to be Completed this Quarter

DATA SYSTEM MANAGER HIRED MID-APRIL 2002. DRAFT DATA POLICY CIRCULATED TO GEM DATA COMMITTEE AND TRUSTEE AGENCIES FOR REVIEW MAY 20. DEVELOPMENT OF NEW PROJECT TRACKING DATABASE UNDERWAY.

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02462-CLO	Effects of Disease on Pacific Herring Population Recovery in Prince William Sound	G. Marty/Univ. of California, Davis	ADFG

Project Tasks to be Completed this Quarter

FY 01 Tasks Not Completed
DONE-Statistical analysis of spring 2001 samples (Marty)
DONE-Scale analysis of spring 2001 samples (Carpenter)
DONE-Virology and bacteriology of spring 2001 samples (Meyers)

Oct-Dec
DONE (100 FISH)-Collect fall samples (Marty)
DONE-Scale analysis fall samples-age (Moffitt)

Jan-Mar
DONE-Virology & bacteriology fall samples (Meyers)
DONE-Attend Annual Workshop, 1/22-25 (Marty)

April-June
Collect spring samples (Marty)

July-Sept
Statistical analysis fall samples (Marty)
Scale analysis spring samples-age (Moffitt)
Virology & bacteriology spring samples (Meyers)

Oct-April
Statistical analysis spring samples (Marty)
Submit final report 4/15/03 (Marty)

Proj.No.	Project Title	Proposer	Lead Agency
02476	Effects of Oiled Incubation Substrate on Pink Salmon Reproduction	R. Heintz/NOAA	NOAA

Project Tasks to be Completed this Quarter

Oct-Dec
WILL BE DONE OCT/DEC 2002-Evaluate F2 survival to eyeing

Jan-March
DONE-Begin analysis of results & development of life history model

April-June

Aug-Oct
Final report due (9/15/03)

Conferences
SETAC ($1,800)

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02479	**Effects of Food Stress on Survival and Reproductive Performance of Seabirds**	**J. Piatt/USGS-BRD, A. Kitaysky/Univ. of Washington**	**DOI**

Project Tasks to be Completed this Quarter

NOTE: THIS SCHEDULE SUPERSEDES THAT IN THE 02479 DPD (letter on file McCammon to Piatt, 3/6/02)

Final Report Project /479 Final Report Due 4/30/03

Ms. #1 Endocrine responses to varying foraging conditions: stress or anti-stress hormones? Wingfield & Kitaysky Due 8/30/02

Ms. #2 & 3 Relationships among corticosterone levels, reproduction, food abundance, and post-breeding survival. Kitaysky, Piatt, Wingfield Due 4/30/03

Ms. #4 & 5 Relationships among food provisioning, nutritional state and corticosterone secretion in juvenile seabirds. Kitaysky, Wingfield, Piatt Due 8/30/02

Ms. #6 Field endocrinology protocol for monitoring seabird populations Due 8/30/02

02492	**Were Pink Salmon Embryo Studies in Prince William Sound Biased?**	**J. Thedinga/NOAA**	**NOAA**

Project Tasks to be Completed this Quarter

Incomplete Tasks from FY 01:

Complete 2 ms.

(1) Detection of pink salmon eggs killed by hydraulic sampling

(2) Ability of observers to discriminate shock mortality in pink salmon eggs as a function of time after shock

Oct-Dec

Jan-Mar

DONE-Attend Annual Workshop 1/22-25 (Thedinga)

April-June

Submit final report (4/15/02)

02514	**Lower Cook Inlet Waste Management Plan Implementation Phase 1**	**T. Turner/ADEC**	**ADEC**

Project Tasks to be Completed this Quarter

NOTE: THIS PROJECT WAS APPROVED BY THE TC 12/11/01.

Jan-Mar

DELAYED TO MAY-Site visit to each community--Seldovia, Nanwalek, Port Graham (Jan. 2002)

DELAYED TO JUNE-Submit recommendations to Trustee Council that might be addressed in a Phase II (Feb. 28, 2002)

April-June

DELAYED TO MAY/JUNEComplete training and follow-up visits to each community--Seldovia, Nanwalek, Port Graham (Jan-June 2002)

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02535	EVOS Trustee Council Restoration Program Final Report	J. Hunt/EVOS Restoration Office	ALL

Project Tasks to be Completed this Quarter

Oct-Dec

PROVIDED DRAFT TEXT OF BOOK TO EDITOR; OTHER TASKS DELAYED. AS OF 3/31/02, EDITOR STILL HAS DRAFT OUT FOR EXTERNAL REVIEW.

-Gather photos, graphics, etc.

-Work with publisher on design & content

-Layout book using PageMaker

-Edit & rewrite as needed

-Provide finished inside pages of book to editor

Sept. 2002

-Book is published

Proj.No.	Project Title	Proposer	Lead Agency
02538	Evaluation of Two Methods to Discriminate Pacific Herring Stocks along the Northern Gulf of Alaska	T. Otis/ADFG, R. Heintz/NOAA	NOAA & ADFG

Project Tasks to be Completed this Quarter

Oct-Dec

DONE-Collect fall samples of PWS herring and store them for possible future analysis (analysis depends on results of analysis of 2001 spring samples)

DONE-Perform fatty acid analyses of soft tissues from 2001 spring samples

UNDERWAY-Perform elemental analyses of otholiths from 2001 spring samples

Jan-Mar

UNDERWAY-Analyze results from spring 2001 samples expected Feb. 2002; TC approved funds for analysis of fall 2001 samples contingent on preliminary results of this analysis

DONE-Attend EVOS Annual Workshop (1/22-25)

April-June

EXTENDED TO 9/30/02-Submit final report (4/15/02)

July-Sept

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02543	Evaluation of Oil Remaining in the Intertidal from the *Exxon Valdez* Oil Spill	J. Short/NOAA	NOAA

Project Tasks to be Completed this Quarter

Oct-Apr
DONE-Enter FY 01 data into database
DONE-Analyze FY 01 gravimetric & fingerprinting GS-MS samples
DONE-Attend Annual Workshop (1/22-25)
ALSO, 2 MS. DRAFTED AND 1 MS. IN PREPARATION

May-Sept
HAVE REPORTED RESULTS TO LOCAL COMMUNITIES-Produce map depicting sampled locations and present to locals in PWS
Submit final report (9/30/02)

Proj.No.	Project Title	Proposer	Lead Agency
02550	**Alaska Resources Library and Information Services (ARLIS)**	**All Trustee Council Agencies**	**ALL**

Project Tasks to be Completed this Quarter

During the quarter ending 3/31/02, ARLIS staff received 4,089 visitors and 1,241 incoming calls; issued 134 new library cards; responded to 4,013 requests for in-depth information, 301 of which were EVOS questions (routine requests for EVOS documents are handled by the Restoration Office); and processed 3,328 interlibrary loans, including 56 requests for EVOS materials. ARLIS staff reviewed, approved, and distributed 5 final reports and 3 annual reports; 381 reports, 2 map sets, 3 CD-ROM sets, and 2 videos are now available. ARLIS staff obtained 2 articles to update the Restoration Office GEM reference files, and provided 6 topic bibliographies and scanned 5 documents for the Trustee Council web site. A mechanism is now in place to track hits to the ARLIS web page; hits for this quarter totaled 52,146, (4,400 hits a week average); among the top 15 requested files was the "oil spill links" with 246 hits. The lease for ARLIS space was renewed through August 2005. Independent reviewers completed a management assessment and presented results at the 2/1/02 Founders Board meeting. On 3/7/02, representatives of the Institute for Museum and Library Services presented ARLIS staff with the 2001 National Award for Library Service at the 2002 Alaska Library Association Conference in Anchorage.

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02552-BAA	Exchange Between Prince William Sound and the Gulf of Alaska	S. Vaughan/PWSSC	NOAA

Project Tasks to be Completed this Quarter

Oct-Dec

Jan-Mar
DONE-Attend Annual Workshop (1/22-25)
DID NOT ATTEND-Attend AGU Ocean Sciences Meeting, Honolulu, 2/11-15 ($2,000)

April-June
Retrieve mooring (May)

July-Sept

FY 03
Submit final report (4/15/03)

02556	Mapping Marine Habitats: Kachemak Bay	C. Schoch/Kachemak Bay NERR	ADFG

Project Tasks to be Completed this Quarter

NOTE: THIS PROJECT WAS APPROVED BY TC 4/18/02.

May-Sept.
-Complete fieldwork (high resolution mapping)
-Complete data entry
-Complete draft GIS database
-Submit final report

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02558	**Harbor Seal Recovery: Application of New Technologies for Monitoring Health**	S. Atkinson/UAF	ADFG

Project Tasks to be Completed this Quarter

FY 01 Tasks Not Completed at End of FY 01
DONE-Analyze FY 01 endocrine samples
UNDERWAY-Analyze FY 01 immunology samples

Conferences
DONE-Biennial Conference of the Biology of Marine Mammals, Vancouver, Canada ($1,600)

Monthly
ON TRACK-Blood sampling

Oct-Dec
UNDERWAY-Send blood & blubber samples from captive seals for contaminant analysis
DONE-Collect blood samples to assess circadian pattern of T3, T4, & cortisol

Jan-Mar
DONE-Undertake endocrine assays with batches of samples to assist with quality control
DONE-Attend Annual Workshop, 1/22-25

April-June
Seals collected for rehabilitation arrive at ASLC
DONE-Perform circadian sampling
DONE-Submit annual report (4/15)

July-Sept
Analyze endocrine & immunology samples
Release rehabilitation seals

Proj.No.	Project Title	Proposer	Lead Agency
02561	**Evaluating the Feasibility of Developing a Community- Based Forage Fish Sampling Project for GEM**	D. Roseneau/USFWS	DOI

Project Tasks to be Completed this Quarter

Oct-Dec
DONE (POSTERS, POSTER HANDOUTS, FISH IDENTIFICATION SHEETS, RELEVANT APEX REPORTS)-Prepare meeting materials & agendas
DONE-Contact key individuals
DONE-Set up community meetings

Jan-Mar
UNDERWAY-Community visits
DONE-Attend Annual Workshop (1/22-25)

April-June
Community visits

July-Sept
Compile & organize information collected

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02574-BAA	**Assessment of Bivalve Recovery on Treated Mixed-Soft Beaches in Prince William Sound**	**D. Lees/Littoral Eco.& Environ. Services**	**NOAA**

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDING FOR THIS PROJECT 12/11/01.

Jan-Mar
DONE-Contract with subcontractors
DONE-Commence sampling site selection process
DONE-Attend Annual Workshop (1/22-25)

April-June
Finalize list of candidate sampling sites
RESCHEDULED TO JULY 20-28-Conduct reconnaissance survey to finalize selection of sampling sites (June 9-16)
RESCHEDULED TO AUGUSTField sampling (June 22-30)
Ship bivalve and sediments samples to lab for analysis

July-Sept
Analyze bivalve and sediment samples

Proj.No.	Project Title	Proposer	Lead Agency
02584	**Evaluation of Airborne Remote Sensing Tools for GEM Monitoring**	**E. Brown/UAF, J. Churnside/NOAA**	**ADFG**

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDING FOR THIS PROJECT 12/11/01.

Conferences
4/29/02 E-MAIL FROM PI THAT CONFERENCE FUNDS BEING TRANSFERRED TO FIELD TRAVEL-Attend GLOBEC/PICES (Brown, $1,200 -- POSSIBLY OCT 2002, WHICH IS ACTUALLY IN FY 03...)

Jan-Mar
DONE-Attend Annual Workshop (1/22-25)
?-Develop survey design and flight plan

Apr-June
DONE; INSTRUMENT PACKAGE IS MOUNTED ON THE AIRCRAFT AND HAS BEEN FLYING SURVEYS IN MARCH AND HAS OTHER SURVEYS SCHEDULED FOR MAY PRIOR TO THE EVOS WORK-Complete instrumentation preparation and calibration

July-Sept
FIELD SCHEDULE FOR JULY WORK COMPLETED; COOPERATION PLANNED WITH ASLC AND GLOBEC IN NORTHERN GOA & WEST OF PWS-Complete field data collection
Initiate validation data collation
Complete signal processing

April 15, 2003
Submit final report

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02585	**Lingering Oil: Bioavailability and Effects to Prey and Predators**	**J. Rice, J. Short/NOAA; J. Bodkin, B. Ballachey/USGS; D. Esler/Simon Fraser Univ.**	**NOAA & DOI**

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDING FOR THIS PROJECT 12/11/01.

Jan-Mar
DONE-Plan sea otter capture
UNDERWAY-Obtain/update marine mammal permits
DONE-Biopsy livers of captive harlequins at ASLC for histopathology
DONE-NOAA deployment (Feb.)
DONE-NOAA pick-up cruise (Mar.)
DONE-Attend Annual Workshop (1/22-25)

Apr-June
NOAA deployment (June)

July-Sept
NOAA pick-up cruise (July)
Capture sea otters in WPWS; sample blood & liver (July)

02593	**River Otters and Fishes in the Nearshore Environment: A Synthesis**	**S. Jewett/UAF, M. Ben-David/U.Wyo., G. Blundell/UAF**	**ADFG**

Project Tasks to be Completed this Quarter

Oct-Dec
UNDERWAY-Complete spatial analyses of spatial & temporal data of fishes & otters

Jan-Mar
DONE-Attend Annual Workshop (1/22-25)

Sept
Submit manuscript to Ecology: Blundell, Brown, Kern, Ben-David, & Jewett. Forage fishes & river otter sociality: variation in spatial & temporal distributions.

02600	**Synthesis of the Ecological Findings from the EVOS Damage Assessment and Restoration Programs, 1989-2001**	**R. Spies/EVOS Chief Scientist, et al**	**ADNR**

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDING FOR THIS PROJECT 12/11/01.

Mar-May
DONE-Synthesis team meets to identify approach

July-Sept
-Preliminary chapter outlines completed
-List of references assembled
-Book outline finalized

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02603	**Implementation of an Ocean Circulation Model: A Transition from SEA to GEM**	**J. Wang/UAF**	**ADFG**

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDING FOR THIS PROJECT 12/11/01.

Conferences
DONE-Ocean Science meeting, Hawaii Feb. 9-16 ($1,700)

Jan-Mar
DONE-Complete tide simulation & preparation of NCEP climatological forcing
DONE-Attend Annual Workshop (1/22-25)
DONE-Start to implement the forcing data to the 3D-GOA model

July-Sept
Complete modeling of the seasonal cycle
Post simulation on web (9/15/02)

Dec 15, 2002 -- Final report due

02608	**Permanent Archiving of Specimens Collected in Nearshore Habitats**	**N. Foster/UAF**	**ADFG**

Project Tasks to be Completed this Quarter

Oct-Dec
DONE-Assign accession numbers and create accession log

Jan-Mar
DONE-Attend Annual Workshop (1/22-25)
UNDERWAY-Prepare specimen labels

Apr-June
UNDERWAY-Unpack specimens and sort by taxon

July-Sept
Label specimens and incorporate into Museum shelving
Provide all species locality data to Arctic Observatory database
Submit ms. on distribution of marine mollusks and polychaetes
Submit final report

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02610	Kodiak Archipelago Youth Area Watch	T. Schneider/Kodiak Island Borough School District	ADFG

Project Tasks to be Completed this Quarter

Sept-Dec
DONE-Students selected
DONE EXCEPT FOR AHKIOK (WEATHER DELAYS)-Site teacher, tribal, and researcher orientation
DONE EXCEPT FOR AHKIOK (WEATHER DELAYS)-Student orientation and training
DONE-Projects submitted to regional science fair

Jan-March
DONE-Attend Annual Workshop (Schneider, 1/22-25)

April-June
Regional workshop
Summer plans for continued work by students submitted to PI
Annual report due (4/15)

July-Sept
Participate in Science Camp

Proj.No.	Project Title	Proposer	Lead Agency
02612	Detecting and Understanding Marine-Terrestrial Linkages in the Kenai River Watershed	W. Hauser/ADFG	ADFG

Project Tasks to be Completed this Quarter

Oct-Dec
DONE-Form agency & technical science teams
DONE-Initiate planning meetings

Jan-Mar ~~NO UPDATE PROVIDED~~
DONE-Workshop (1/25)
Distribute draft plan for public comment & review (Feb) -DELAYED TO JULY

Apr-June
Submit final plan (April) -DELAYED TO SEPT. 30

July-Sept
Investigate funding sources

DRAFT

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Proj.No.	Project Title	Proposer	Lead Agency
02613	Mapping Marine Habitats: Prince William Sound to McCarty Fjord	J. Harper/Coastal & Ocean Resources, Inc.	ADFG

Project Tasks to be Completed this Quarter

NOTE: PROJECT APPROVED BY TC 4/18/02.

April-Sept

Field survey (aerial video imagery) of approximately 2,100 km of coastline during one of the following low-tide windows: June 11-15, June 23-27, or July 9-15

Project deliverables:

-Storage of interpreted data in a GIS-compatible database that is available online through ArcIMS

-Registration of metadata through the Alaska State Geo-spatial Data Clearinghouse

-Website from which other researchers and TC can acquire the data (perhaps PI's FTP site)

-Video imagery, as data, provided to TC directly as a dataset

02614	Monitoring Program for Near-Surface Temperature, Salinity, and Fluorescence in the Northern Pacific Ocean	S. Okkonen/UAF	ADFG

Project Tasks to be Completed this Quarter

Oct-Dec

DONE (DELIVERY DATE 2/15/02)-Order instrumentation & ancillary hardware

DELAYED TO JUNE. 3/31/02 QTR. RPT. SAYS, "WE ARE EXCHANGING THE SEABIRD MODEL SBE21 THERMOSALINOGRAPH FOR MODEL SBE45 IN RESPONSE TO CONCERNS BY POLAR TANKERS ABOUT THE FLOW RATE AND SIZE OF THE SBE21. THE SBE45 IS SMALLER AND HAS A LOWER FLOW RATE"-Install TSG & fluorometer on tanker

Jan-Sept

DONE-Attend Annual Workshop (1/22-25)

Data acquisition

02619	Mapping Marine Habitats: Kodiak	R. Foy/UAF, J. Harper/Coastal & Ocean Resources, Inc.	ADFG

Project Tasks to be Completed this Quarter

NOTE: PROJECT APPROVED BY TC 4/18/02.

April-Sept

Field survey (aerial video imagery) of approximately 1,600 km of coastline during the June 11-15 low-tide window

Project deliverables:

-Storage of interpreted data in a GIS-compatible database that is available online through ArcIMS

-Registration of metadata through the Alaska State Geo-spatial Data Clearinghouse

-Website from which other researchers and TC can acquire the data (perhaps PI's FTP site)

-Video imagery, as data, provided to TC directly as a dataset

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02622	Digital Maps from Existing Seasonal Environmental Sensitive Area Maps: Cook Inlet/ Kenai Peninsula	J. Whitney/NOAA	NOAA

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDING FOR THIS PROJECT 12/11/01.

Jan-Mar

DONE-Review content of 1994 summary ESI maps of Cook Inlet/Kenai Peninsula and provide any new or updated data to NOAA
?-Finalize digital files of Cook Inlet/Kenai Peninsula summary ESI maps
DONE-Attend Annual Workshop (1/22-25)

Apr-June

UNDERWAY-Finalize updated digital files into the 4 standardized digital map products
UNDERWAY-Prepare and review CDs of the above

July-Sept

Distribute final CD (100 cc) of the updated digital data for the summary maps (7/31/02)
Post the maps on web

Proj.No.	Project Title	Proposer	Lead Agency
02624-BAA	A CPR-Based Plankton Survey Using Ships of Opportunity to Monitor the Gulf of Alaska	S. Batten/SAHFOS, D. Welch/DFOC	NOAA

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDING FOR THIS PROJECT 12/11/01.

Conferences

Attend PICES XI, China (Oct. 2002) ($3,200)

Jan-Mar

DONE (BATTEN)-Attend Annual Workshop (1/22-25)
DONE-Ship equipment to vessel in Long Beach
DONE-1st sampling from AK to CA (late March)

Apr-June

DELAYED TO MAY-2nd sampling from AK to CA (late April)
DONE-Ship equipment to vessel in Vancouver
3rd sampling from AK to CA (early June)
Sampling from Vancouver to Kamchatka

July-Sept

4th sampling from AK to CA (mid-July)
5th sampling from AK to CA (mid-Aug)
Integrate biological data with physical data acquired by Okkonen & Royer
Preliminary taxonomic processing complete

April 15, 2003

Submit final report

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02630	Planning for GEM	Restoration Office	ALL

Project Tasks to be Completed this Quarter

Oct-Dec
DONE-Participate in PICES MONITOR task team meeting
DONE-Attend NPMR presentations on project results
DONE-Meet with NRC to hear oral comments on draft GEM Program Document
DONE-Hold physical oceanographic modeling workshop
DONE-Participate in Watershed Workshop Planning Meeting
DONE-Participate in US GOOS Steering Committee meeting
DONE-Complete GEM brochure
DONE-Update web site

Jan-Mar
DONE-Annual Workshop (1/22-25)
DONE-Issue FY 03 Invitation, Phase I
DONE-Participate in AGU meeting session on cross-shelf transport

April-June
DONE-Receive comments from NRC on GEM Program Document (Apr)
DONE-STAC process in place
DONE-First STAC meeting (May)
Subcommittee process in place
Submit revised GEM Program Document for TC approval (June)
Oceans & Watersheds Symposium (6/18-19)

July-Sept

Proj.No.	Project Title	Proposer	Lead Agency
02630am	Planning for GEM: ADEC Surface Water Quality Monitoring Amendment	R. Klein/ADEC	ADEC

Project Tasks to be Completed this Quarter

NOTE: TC approved funding for this component of Project 02630 2/25/02.

September 30, 2002
UNDERWAY WITH OASIS ENVIRONMENTAL CONSULTANTS; PROJECT WILL BE COMPLETED 6/30/02-Receive from term contractor final report summarizing surface water quality monitoring strategies that other states have developed and the approaches they use to fund their surface water quality monitoring programs.

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02636-BAA	Management Applications: Commercial Fishing	K. Adams, R. Mullins/Cordova	NOAA

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDS FOR THIS PROJECT 12/11/01 CONTINGENT ON A REVISED DPD; REVISED DPD APPROVED 2/25/02.

March-April
HELD MEETINGS 3/8/02 & 4/2/02; IDENTIFICATION OF ISSUES AND NEEDS UNDERWAY-Conduct 2 meetings of FMA (Fisheries Management Application working group)

September
Conduct 1 meeting of FMA

Proj.No.	Project Title	Proposer	Lead Agency
02649	Reconstructing Sockeye Populations in the Gulf of Alaska over the Last Several Thousand Years	B. Finney/UAF, D. Mann	ADFG

Project Tasks to be Completed this Quarter

Conferences
DID NOT ATTEND DUE TO SCHEDULING CONFLICT; WILL ATTEND OTHER APPROPRIATE CONFERENCE AT LATER DATE-AGU, San Francisco ($1,400)

Oct-Dec
UNDERWAY-Complete del15N analyses on Eshamy Lake and Solf Lake (control) cores
UNDERWAY-Submit Eshamy and Solf samples for 14C and 210Pb dating

Jan-Mar NO UPDATE PROVIDED
DONE-Attend Annual Workshop (1/22-25)
DELAYED; 3/31/02 QTR. RPT. SAYS, "WE BROKE OUR CORER IN ESHAMY LAKE IN APRIL. HAVE TO REDESIGN AND REBUILD OUR DEEP-WATER CORER. THIS TAKES TIME DUE TO MACHINE SHOP DELAYS AND THE NEED TO TEST THE NEW DESIGN. WE ARE HEADING TO KARLUK AND RED LAKES IN LATE JULY WITH THE NEW CORER. IF IT WORKS, WE WILL CORE THE MCCARTY FJORD LAKES AND UPPER RUSSIAN IN EARLY AUGUST"-Core Upper Russian Lake

Apr-June ALL TASKS DELAYED TO AUGUST
Complete del15N analyses on cores from Upper Russian Lake
Submit Upper Russian Lake samples for 14C and 210Pb dating
Core Delight and Desire lakes

July-Sept
Complete literature reviews of proxy data describing climate/oceanographic changes in northern GOA over last several millennia
Develop hypotheses relating changes in salmon populations to climatic changes
Submit ms. concerning applications of retrospective records of sockeye populations in fisheries management

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02656	Retrospective Analysis of Nearshore Marine Communities Based on Analysis of Archaeological Material and Isotopes	G. Irvine/USGS, J. Schaaf/NPS	DOI

Project Tasks to be Completed this Quarter

Oct-Dec

Jan-Mar
UNDERWAY; IDENTIFICATION OF LOWER MIDDEN MATTERIAL HAS BEEN DELAYED SO SOME ACTIVITIES WILL SLIP INTO FY 03 (SOME FY 02 FUNDS WILL LAPSE AND A LIKE AMOUNT OF FUNDS HAS BEEN REQUESTED UNDER 03656)-Complete evaluation of climate record, midden materials for selection of target dates and shells for analysis
DONE-Attend Annual Workshop (1/22-25)

April-July
Complete evaluation of isotopic techniques, preliminary assessments of recent material
Test archaeological material

Aug-Sept
Complete isotopic analysis of recent (test) bivalves and archaeological midden shells
Radiocarbon (14c) analysis of selected clam shells
Complete ecological analysis of composition/size structure of selected midden species
Present results to Ecological Society of America, Tucson ($2,800)

02667	Effectiveness of Citizens' Environmental Monitoring Program	S. Mauger/Cook Inlet Keeper	ADEC

Project Tasks to be Completed this Quarter

Oct-Dec 2001
UNDERWAY-Begin analysis of CEMP data to determine effectiveness of protocols

Jan-Mar 2002
DONE-Attend EVOS Annual Restoration Workshop (Jan. 22-25)
UNDERWAY-Continue analysis of CEMP data

April-June 2002
-Continue analysis of CEMP data

July-Sept 2002
-Complete analysis of CEMP data (July 31)
-Produce & release final report, which will include recommendations for improvements to CEMP protocols (Sept. 30)

Oct-Dec 2002
-Convene meeting with current & potential monitoring partners & agencies to communicate findings from analysis

Jan-April 2003
-Incorporate suggestions into the CEMP Quality Assurance Project Plan
-Submit final report to EVOS (April 15)

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02668	**Developing an Interactive Water Quality and Habitat Database and Making it Accessible on the Web**	J. Cooper/Cook Inlet Keeper	ADEC

Project Tasks to be Completed this Quarter

NOTE: TC APPROVED FUNDING FOR THIS PROJECT 12/11/01.

Jan-Mar
UNDERWAY-Contract with database and web specialist
UNDERWAY-Determine best data system that allows for all parameters and methods and meets committee's database priorities
UNDERWAY-Identify and create GIS maps and graphs to link with database
UNDERWAY-Create interface between database, GIS and internet
DONE-Attend Annual Workshop (1/22-25)
UNDERWAY-Establish securities for database access on the web
UNDERWAY-Formalize Standard Operative Procedures for quality overisght of database use and data management

Apr-June
Uplink database on the web and conduct press and other outreach to announce its availability
Oversee use of the database by monitoring partner groups as a way to enter and manage their habitat and water quality data

July-Sept
Evaluate product
Update web page

April 15, 2003
Submit final report

DRAFT

Exxon Valdez Oil Spill Project Status Summary
FY 02 Work Plan
Quarter Ending March 31, 2002

Proj.No.	Project Title	Proposer	Lead Agency
02671	**Coordinating Volunteer Vessels of Opportunity to Collect Oceanographic Data in Kachemak Bay and Lower Cook Inlet**	D. Stram, C. Schoch/Kachemak Bay NERR	ADFG

Project Tasks to be Completed this Quarter

Oct-Dec
DONE-Order equipment for KBBR boat (thermo-salinograph)
DONE-Construct and deploy Fall drift cards (KBBR)
DONE-Develop outreach plan (CIK)
DONE-Set up database (CIK)

Jan-Mar
DONEAttend Annual Workshop (1/22-25)
UNDERWAY-Install thermosalinograph on KBRR vessel
DONE-Construct Spring drift cards (KBRR)
DONE-KBRR personnel participate in workshop on oceanographic monitoring

Apr-June
Preliminary spring transects completed (KBRR, CIK)
Summer data collection transects
Deploy Spring drift cards (KBRR, CIK)

July-Sept
Analyze collected transect data (KBRR)
Complete volunteer vessel database
Complete drift card study
Establish protocol for data collection and processing (KBRR, CIK)
Submit final report

INJURED RESOURCES
UPDATE

Exxon Valdez Oil Spill Restoration Plan

DRAFT Update on Injured Resources and Services
April 30, 2002

Exxon Valdez Oil Spill Trustee Council
441 West 5th Avenue, Suite 500, Anchorage, AK 99501-2340
907-278-8012 800-478-7745 (in Alaska) 800-283-7745 (outside Alaska)

RESOURCES AND SERVICES INJURED BY THE SPILL

RESOURCES IN BOLDFACE HAVE BEEN RECATEGORIZED ON THIS RECOVERY LINE DURING THE MOST RECENT UPDATE (APRIL 30, 2002)

NOT RECOVERING

Species are showing little or no clear improvement from oil spill injuries.

Common loon
Cormorants (3 spp.)
Harbor seal
Pigeon guillemot

RECOVERING

Substantive progress is being made toward recovery objective. The amount of progress and time needed to achieve recovery vary depending on the resource.

Clams
Designated Wilderness Areas
Harlequin duck
Intertidal communities
Marbled murrelets
Mussels
Pacific herring
Sea otter
Sediments

RECOVERED

Recovery objectives have been met

Archaeological resources
Bald eagle

Black oystercatcher
Common murres
Pink salmon
Killer whales (AB pod)
River otter
Subtidal communities
Sockeye salmon

RECOVERY UNKNOWN
Limited data on life history or extent of injury; current research inconclusive or not complete.

Cutthroat trout
Dolly Varden
Kittlitz's murrelet
Rockfish

HUMAN SERVICES
Human services that depend on natural resources were also injured by the oil spill. These services are each considered to be recovering until the resources on which they depend are fully recovered.

Recreation & tourism
Commercial fishing
Passive uses
Subsistence

UPDATE ON INJURED RESOURCES AND SERVICES

Introduction

History and Purposes of the List

In November 1994, the *Exxon Valdez* Oil Spill Trustee Council adopted an official list of resources and services injured by the spill as part of its *Restoration Plan*. This list has served three main purposes in the Restoration Program:

1. It has highlighted injuries caused by the oil spill and cleanup efforts and helped the Trustees and the public track the status of important fish, wildlife, and other resources and services. The fish and wildlife on this list are thought to have suffered population-level or sublethal injuries, but the list does not include every species or resource that suffered some

degree of injury. For example, carcasses of about 90 different species of oiled birds were recovered in 1989, but only 10 species of birds are on the list of injured species.

2. It has helped guide the *Restoration Plan*. This was especially important in 1994 when the plan was first adopted, but the list still serves to highlight resources that are in need of consideration.
3. Finally, taken as a whole, the list of injured resources has helped the Trustees and the public track recovery of the overall ecosystem and the functions and human services that it provides.

The *Restoration Plan* states that the Injured Resources and Services list will be reviewed periodically and updated to reflect results from scientific studies and other information. With each review, a resource's progress toward a recovery objective is evaluated. The recovery objectives have been set to be as concrete and measurable as possible. However, they may be changed to reflect new insights about the nature of the injury and the best ways to evaluate recovery status.

The Injured Resources and Services list was first updated in September 1996. At that time the bald eagle was upgraded from recovering to recovered. In March 1999, a major review of recovery objectives and status occurred and several more changes were made. River otters were then considered to be recovered, and five resources—black oystercatchers, clams, marbled murrelets, Pacific herring, and sea otters—were upgraded to recovering. One resource, the common loon, was moved from recovery unknown to not recovering. Five resources remained as recovery unknown. All four human services were classified as recovering.

In 2002, more than 13 years after the spill, recovery continues to progress and more changes have been made to the list. Seven more species or resources have been moved to the recovered category: archaeological resources, black oystercatchers, common murres, killer whales, subtidal communities, sockeye salmon and pink salmon. In addition, harlequin ducks have been moved from the not recovered to the recovering category, and designated wilderness areas have been moved from the recovery unknown to the recovering category.

The 1994 *Restoration Plan* provides that the Injured Resources and Services list can be updated any time new information becomes available. The next major evaluation of changes in recovery status for all injured resources and lost or reduced services likely will be in 2006, 15 years after the 1991 settlement between the governments and Exxon and initiation of the restoration program.

How to Interpret this List

The assignment of resources to various categories continues to be based on judgements made after weighing the available evidence, including:

- estimates of population sizes and trajectories in the spill area;
- comparisons of population estimates in oiled and unoiled areas of the northern Gulf of Alaska;

- whether there has been continued exposure to residual oil in the spill area; and
- whether sublethal or chronic injuries persist or show improvement.

Some of the factors involved in making judgments about recovery status include:

1. *Uncertainties in population estimates.* Because of the variability in animal distributions and the challenges of getting accurate counts, especially of highly mobile fish, birds and marine mammals, most estimates of population size have wide ranges. For example, ranges that are between 40% greater or smaller (or even more) than the true population size will result from many census techniques. This range can be narrowed, but costs escalate with the increasing effort to obtain greater accuracy.

2. *Lack of prespill data.* Many of the resources affected by the spill had limited or no recent data on their status in 1989. In addition, some of the available pertinent data was the result of limited sampling and had wide ranges in the population estimates. Having such patchy data on resources made it difficult to accurately assess initial injury. In turn, any uncertainties in injury inevitably lead to uncertainties in estimating recovery.

3. *Interaction of spill and natural factors.* It is increasingly difficult to separate what may be lingering effects of the spill from changes that are natural or caused by factors unrelated to the oil spill. In fact, what is often observed appears to be an interaction between oil effects and natural changes, such as the effects of the 1998 *El Niño* on common murres in the Barren Islands which were recovering from oil spill impacts. We now understand much more about long-term changes in climate in the northern Gulf of Alaska and how these changes affect marine species.

4. *Emergence of new effects.* Since the *Exxon Valdez* oil spill affected an area rich in wildlife and was so well studied, it would not be surprising that there are findings without precedent in the scientific literature on oil effects. One example of such an unprecedented effect is the sensitivity of Pacific herring and pink salmon to low concentrations of weathered oil (Carls et al., 1999; Rice et al., 2001). We cannot discount evidence for an injury just because it had never been encountered in the aftermath of other spills.

Ecosystem Perspective and Recovery

The List of Injured Resources consists mainly of single species and resources, but, as noted above, it provides a basis for evaluating the recovery of the overall ecosystem, its functions, and the services that it provides to people. In fact, through the *Restoration Plan*, the Trustee Council adopted an ecological approach to restoration, and the studies and projects the Trustee Council sponsors have been ecological in character.

Page 35 of the *Restoration Plan* defines ecosystem recovery as follows:

> *Full ecological recovery will have been achieved when the population of flora and fauna are again present at former or prespill abundances, healthy and productive, and there is a full complement of age classes at the level that would have been present had the spill not*

occurred. A recovered ecosystem provides the same functions and services as would have been provided had the spill not occurred.

Using this definition, the coastal and marine ecosystem in the oil spill region has not fully recovered at this time from the effects of the oil spill. For example, harlequin ducks and sea otters still show signs of oil exposure and may be negatively affected by such exposure. Although full ecological recovery has not been achieved, the spill area ecosystem is still largely intact and functioning and on its way to recovery 13 years after the *Exxon Valdez* oil spill.

It is desirable to have injured resources obtain a state that would have occurred in the absence of the spill. However, it also is important to understand that ecosystems are dynamic and would have changed even in the absence of the oil spill. Given our present ability to predict multi-year changes in marine ecosystems—which is extremely limited—it is very difficult to know how the ecosystem would have changed in the absence of the spill. For that reason, it is also sometimes necessary to consider other measures (return to prespill status or attaining equivalent status in oiled and unoiled areas) in order to have more concrete objectives. Also, as mentioned above, baseline data describing fish and wildlife populations, to say nothing of complex intertidal and subtidal communities, were generally poor in 1989. Therefore, in revising this list judgements have been made in the face of increasing knowledge—but also, great uncertainty—of how natural changes have occurred in the northern Gulf of Alaska.

RESOURCES

ARCHAEOLOGICAL RESOURCES

Injury

The oil spill area is believed to contain more than 3,000 sites of archaeological and historical significance. Twenty-four archaeological sites on public lands are known to have been adversely affected by cleanup activities or looting and vandalism linked to the oil spill. Additional sites on both public and private lands were probably injured, but damage assessment studies were limited to public land and not designed to identify all such sites.

Documented injuries included theft of surface artifacts, masking of subtle clues used to identify and classify sites, violation of ancient burial sites, and destruction of evidence in layered sediments. In addition, residual oil may have contaminated sites.

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered to have recovered when spill-related injury ends, looting and vandalism are at or below prespill levels, and the artifacts and scientific data remaining in vandalized sites are preserved (e.g., through excavation, site stabilization, or other forms of documentation).

Recovery Status

Assessments of 14 sites in 1993 suggested that most of the archaeological vandalism that can be linked to the spill occurred early in 1989, before adequate constraints were put into place over the activities of oil spill cleanup personnel. Most vandalism took the form of "prospecting" for high yield sites. Once these problems were recognized, protective measures were implemented and successfully limited additional injury. Although some cases of vandalism were documented in the 1990s, there appears to be no spill-related vandalism at the present time.

From 1994-1997, two sites in Prince William Sound were partly documented, excavated, and stabilized by professional archaeologists because they had been so badly damaged by oiling and erosion. The presence of oil in sediment samples taken from four sites in 1995 did not appear to have been the result of re-oiling by *Exxon Valdez* oil. Residual oil does not appear to be contaminating any known archaeological sites.

In 1993, the Trustee Council provided part of the construction costs for the Alutiiq Archaeological Repository in Kodiak. This facility now houses Kodiak area artifacts that were collected during spill response. In 1999, the Trustee Council approved funding for an archaeological repository and local display facilities for artifacts from Prince William Sound and lower Cook Inlet. These are currently in various stages of contruction.

Based on the apparent absence or extremely low rate of spill-related vandalism and the preservation of artifacts and scientific data on archaeological sites and artifacts, archaeological resources are considered to be recovered.

BALD EAGLES

Injury

The bald eagle is an abundant resident of marine and riverine shoreline throughout the oil spill area. Following the oil spill, a total of 151 eagle carcasses was recovered from the spill area. Prince William Sound provides year-round and seasonal habitat for about 6,000 bald eagles, and within the sound it is estimated that about 250 bald eagles died as a result of the spill. There were no estimates of mortality outside the sound, but there were deaths throughout the spill area. In addition to direct mortalities, productivity was reduced in oiled areas of Prince William Sound in 1989.

Recovery Objective

Bald eagles will have recovered when their population and productivity have returned to prespill levels.

Recovery Status

Productivity was back to normal in 1990 and 1991, and an aerial survey of adults in 1995 indicated that the population had returned to or exceeded its prespill level in the sound. **In September 1996, the Trustee Council classified the bald eagle as recovered from the effects of the oil spill.**

BLACK OYSTERCATCHERS

Injury

Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. It is estimated that 1,500-2,000 oystercatchers breed in south-central Alaska. Only nine carcasses of adult oystercatchers were recovered following the spill, but the actual number of mortalities may have been several times higher.

In addition to direct mortalities, breeding activities were disrupted by the oil and cleanup activities. When comparing 1989 with 1991, significantly fewer pairs occupied and maintained nests on oiled Green Island, while during the same two years the number of pairs and nests remained similar on unoiled Montague Island. Nest success on Green Island was significantly lower in 1989 than in 1991, but Green Island nest success in 1989 was not lower than on Montague Island. In 1989, chicks disappeared from nests at a significantly greater rate on Green Island than from nests on Montague Island. Disturbance associated with cleanup operations also reduced productivity on Green Island in 1990. In general, the overt effects of the spill and cleanup had dissipated by 1991, and in that year productivity on Green Island exceeded that on Montague Island.

Recovery Objective

Black oystercatchers will have recovered when the population returns to prespill levels and reproduction is within normal bounds. An increasing population trend and comparable hatching success and growth rates of chicks in oiled and unoiled areas, after taking into account geographic differences, will indicate that recovery is underway.

Recovery Status

Boat-based surveys of marine birds in Prince William Sound indicate that there are increases in numbers of oystercatchers in both the oiled and unoiled areas through 2000 (Stephenson et al., 2001). Given the fact that only 9 carcasses of this species were recovered in 1989 after the spill, it is likely that the population of the sound is probably as large or larger than previous to the spill.

In 1998 the Trustee Council sponsored a study to reassess the status of this species in Prince William Sound. The data indicated that oystercatchers have fully reoccupied and are nesting at oiled sites in the sound. The breeding phenology of nesting birds was relatively synchronous in oiled and unoiled areas, and no oil-related differences in clutch size, egg volume, or chick growth rates were detected. A high rate of nest failures on Green Island probably can be attributed to predation, not lingering effects of oil. **Given general agreement between these results and those of the earlier work, which indicated that the effects of the spill on black oystercatchers had largely dissipated by 1991, black oystercatchers are considered to be recovered from the oil spill.**

CLAMS

Injury

The magnitude of immediate impacts on clam populations varied with the species of clam, degree of oiling, and location. Some littleneck clams and some butter clams were probably killed and may have suffered slower growth rates as a result of the oil spill and cleanup activities.

Recovery Objective

Clams will have recovered when populations and productivity have returned to levels that would have prevailed in the absence of the oil spill, based on comparisons of oiled and unoiled sites.

Recovery Status

Studies by the NOAA Hazardous Materials Division and others have been conducted on intertidal and subtidal communities in relation to oiling and shoreline treatments. In general, these studies indicated that intertidal fauna dwelling in soft sediments, including various clam species, had recovered to some extent within one to three years after 1989 on oiled-but-untreated shorelines. As of 1997, full recovery had not been achieved, especially on shorelines that were oiled and treated by hot-water washes. One study found that densities of littleneck and butter clams were depressed through 1997 on oiled, treated mixed-sedimentary shores where fine sediments had been washed downslope during pressured water treatments.

Comparing oiled study sites on Knight Island with unoiled sites on Montague Island, researchers in the Nearshore Vertebrate Predator Project found a full range of size classes of clams at the oiled sites, as well as more large clams. However, oiled sites also had fewer juvenile clams and lower numbers of several species. **Based on all of the evidence summarized above, clams are recovering, but are not yet fully recovered from the effects of the oil spill.** The Trustee Council is sponsoring a study of clam populations in FY02 to determine if the populations of clams on treated beaches have improved since 1997.

COMMON LOONS

Injury

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Current population sizes in the spill area are not known for any of these species. Common loons in the spill area may number only a few thousand, including only hundreds in Prince William Sound. Common loons injured by the spill probably included a mixture of wintering and migrating birds. The specific breeding areas used by the loons affected by the spill are not known.

Recovery Objective

Common loons will have recovered when their population returns to prespill levels in the oil spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway.

Recovery Status

Boat-based surveys of marine birds in Prince William Sound give at least some insight into the recovery status of the loons affected by the oil spill. Prespill counts of loons exist only for 1972-1973 and 1984-1985. After the spill, contrasts between oiled and unoiled areas of the sound indicate that loons as a group are generally doing better in unoiled areas than in oiled areas. Thus, the survey data suggest that the oil spill had a negative effect on numbers of loons (all species combined) in the oiled parts of the sound. It is not known what the populations of loons may have been had the spill not occurred.

Based on the surveys carried out through 2000, there are indications of recovery, but only in 2000. In 2000 the highest counts ever recorded for common loons occurred in March surveys of Prince William Sound; however, these counts likely included some early migrants as well as wintering birds. In addition, July counts in 2000 were the third highest of the 11 years since 1972 with data. These increases were limited to the unoiled portion of the sound. Since loons are a highly mobile species with widely variable population numbers and the prespill data were limited, one year of high counts in the unoiled areas is insufficient to indicate that recovery has started. **Thus the common loon is considered still not to have recovered from the effects of the spill.**

COMMON MURRES

Injury

About 30,000 carcasses of oiled birds were picked up in the first four months following the oil spill, and 74 percent of them were common and thick-billed murres (mostly common murres). Many more murres probably died than actually were recovered. Based on surveys of index breeding colonies at such locations as the Barren Islands, Chiswell Islands, Triplet Islands, Puale Bay, and Ugiaushak Island, the spill area population may have declined by about 40 percent following the spill. In addition to direct losses of murres, there is evidence that the timing of reproduction was disrupted and productivity reduced. Interpretation of the effects of the spill, however, is complicated by incomplete prespill data and by indications that populations at some colonies were in decline before the oil spill.

Recovery Objective

Common murres will have recovered when populations at index colonies have returned to prespill levels and when productivity is sustained within normal bounds. Increasing population trends at index colonies will be indication that recovery is underway.

Recovery Status

Postspill monitoring at the breeding colonies in the Barren Islands indicated that reproductive success was within normal bounds by 1993, and it has stayed within these bounds each breeding season since then. During the period 1993-1997, the murres nested progressively earlier by 2-5 days each year, suggesting that the age and experience of nesting birds were increasing, as might be expected after a mass mortality event. By 1997, numbers of murres at the Barren Islands had increased, probably because 3-and 4-year old nonbreeding subadult birds that were hatched there in 1993 and 1994 were returning to their natal nesting colony. **Although there were low counts in 1996, the counts in 1997 through 1999 at this index site bring the colony sizes to prespill levels. That, coupled with normal productivity, indicate that recovery has been achieved for common murres.**

CORMORANTS

Injury

Cormorants are large fish-eating birds that spend much of their time on the water or perched on rocks near the water. Three species typically are found within the oil spill area. Carcasses of 838 cormorants were recovered following the oil spill, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. Many more cormorants probably died as a result of the spill, but their carcasses were not found. No regional population estimates are available for any of the cormorant species found in the oil spill area. In 1996, the U.S. Fish and Wildlife Service Alaska Seabird Colony Catalog, however, listed counts of 7,161 pelagic cormorants, 8,967 red-faced cormorants, and 1,558 double-crested cormorants in the oil spill area. These are direct counts at colonies, not overall population estimates, but they suggest that population sizes are small. In this context, it appears that injury to all three cormorant species was significant.

Counts on the outer Kenai Peninsula coast suggested that the direct mortality of cormorants due to oil resulted in fewer birds in this area in 1989 compared to 1986. In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species combined) in the oiled portion of Prince William Sound based on pre- and postspill boat surveys in July 1984-85 compared to 1989-91. It is not known what the counts and trends of comorants would have been in the absence of the oil spill.

Recovery Objective

Pelagic, red-faced, and double-crested cormorants will have recovered when they show an increasing population trend in Prince William Sound.

Recovery Status

More recent surveys (through 2000) have not shown a significant increasing population trend since the oil spill, and for that reason **these species are considered to be not recovering.**

CUTTHROAT TROUT

Injury

Prince William Sound is at the northwestern limit of the range of cutthroat trout. Local cutthroat trout populations are believed to be small, and the fish have small home ranges and are geographically isolated. Cutthroat trout, therefore, are highly vulnerable to exploitation, habitat alteration, or pollution. Following the oil spill, cutthroat trout in a small number of oiled index streams in Prince William Sound grew more slowly than in unoiled streams.

Recovery Objective

Cutthroat trout will have recovered when growth rates within oiled areas are similar to those for unoiled areas, after taking into account geographic differences.

Recovery Status

The apparent difference in growth rates between trout in oiled versus unoiled streams persisted through 1991. It was hypothesized that the slower rate of growth in oiled streams was the result of reduced food supplies or exposure to oil, and there was concern that reduced growth rates would result in reduced survival. However, preliminary data from a Trustee Council sponsored study of resident and anadromous forms of cutthroat trout in Prince William Sound suggest that there is significant genetic variation among trout from different locations across the sound. These data are consistent with the idea that cutthroat populations are small and isolated and effects other than oil could be causing the differences seen in the growth rates. The report on this work has experienced significant delays, but is near completion. **Pending the completion and review of this additional work, the recovery status of the cutthroat trout remains unknown.**

DESIGNATED WILDERNESS AREAS

Injury

The oil spill delivered oil in varying quantities to the waters and tidelands adjoining eight areas designated as wilderness areas and wilderness study areas by Congress or the Alaska State Legislature. Oil also was deposited above the mean high-tide line at these locations. During the intense cleanup seasons of 1989 and 1990, thousands of workers and hundreds of pieces of equipment were at work in the spill zone. This activity was an unprecedented imposition of people, noise, and activity on the area's undeveloped and normally sparsely occupied landscape. Although activity levels on these wilderness shores have returned to normal, at some locations there is still residual oil.

Recovery Objective

Designated wilderness areas will have recovered when oil is no longer encountered in them and the public perceives them to be recovered from the spill.

Recovery Status

Among the affected areas were designated wilderness in the Katmai National Park, wilderness study areas in the Chugach National Forest and Kenai Fjords National Park, and Kachemak Bay Wilderness State Park. Six moderately to heavily oiled sites on the Kenai and Katmai coasts were last surveyed in 1994, at which time some oil mousse persisted in a remarkably unweathered state on boulder-armored beaches at five sites. These sites were visited again in 1999. The data from these sites indicate that there is still oil along park shorelines on the Katmai coast. Surveys carried out in 2001 to determine the surface and subsurface distribution of oil in Prince William Sound found significant quantities of oil on shorelines within designated wilderness study areas. The amount of oil in Prince William Sound has probably decreased since the early 1990s, and natural processes will lead to further reductions. **Therefore, designated wilderness is recovering but has not recovered from the oil spill.**

DOLLY VARDEN

Injury

Dolly Varden are widely distributed in the spill area. In spring, anadromous forms of Dolly Varden migrate to the sea from the lakes and rivers where they spend the winter. Summers are spent feeding in nearshore marine waters. Thus, some Dolly Varden in Prince William Sound and perhaps at other locations were exposed to *Exxon Valdez* oil in 1989 and possibly beyond. In fact, concentrations of hydrocarbons in the bile of Dolly Varden were some of the highest of any fish sampled in 1989. Like the cutthroat trout, there is evidence from

1989-90 that Dolly Varden in a small number of oiled index streams in Prince William Sound grew more slowly than in unoiled streams. It was hypothesized that the slower rate of growth in oiled streams was the result of reduced food supplies or exposure to oil, and there was concern that reduced growth rates would result in reduced survival.

Recovery Objective

Dolly Varden will have recovered when growth rates within oiled streams are comparable to those in unoiled streams, after taking into account geographic differences.

Recovery Status

The growth differences between Dolly Varden in oiled and unoiled streams did not persist into the 1990-91 winter. No growth data have been gathered since 1991. In addition, by 1990 the concentrations of hydrocarbons in bile had dropped substantially.

In a 1991 restoration study sponsored by the Trustee Council, some tagged Dolly Varden moved considerable distances among streams within Prince William Sound, suggesting that mixing of overwintering stocks takes place during the summer in saltwater. This hypothesis is supported by preliminary data from another Trustee Council sponsored study, which indicates that Dolly Varden from different locations across the sound are genetically similar. The final report on this genetics study has been delayed, but should be completed soon. If this preliminary conclusion is born out, it would suggest that the Dolly Varden population in the sound should have little difficulty in recovering from any initial growth-related effects. **Pending completion of the genetics work and absent additional growth data, however, it is prudent to continue classifying the Dolly Varden as recovery unknown.**

HARBOR SEALS

Injury

Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the oil spill. *Exxon Valdez* oil affected harbor seal habitats, including key haul-out areas and adjacent waters, in Prince William Sound and as far away as Tugidak Island, near Kodiak. Estimated mortality as a direct result of the oil spill was about 300 seals in oiled parts of Prince William Sound. Based on aerial surveys conducted at trend-count haulout sites in central Prince William Sound before (1988) and after (1989) the oil spill, seals in oiled areas declined by 43 percent, compared to 11 percent in unoiled areas.

Recovery Objective

Harbor seals will have recovered from the effects of the oil spill when their population is stable or increasing.

Recovery Status

In a declining population deaths exceed births, and harbor seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill. It is not known what harbor seal populations would have been had the spill not occurred. For the period 1989-1997, the average estimated annual rate of decline was about 4.6 percent. **The population showed some signs of stabilizing in the 1990s, but surveys in 2000 and 2001 indicate that the decline is continuing. Therefore, harbor seals continue to be considered not recovering from effects of the oil spill.**

Environmental changes in the late 1970s may have reduced the amount or quality of prey resources, including such forage fishes as Pacific herring and capelin, available to harbor seals in the northern Gulf of Alaska ecosystem. These changes may have been responsible for or contributed to the initial prespill harbor seal decline, and the ecosystem may now support fewer seals than it did prior to the late 1970s. Recent studies, however, indicate that the seals in the sound, especially pups and yearlings, are in very good condition and do not show evidence of nutritional stress. Ongoing sources of mortality include killer whale predation, possible shark predation, subsistence hunting, and commercial fishery interactions (e.g., drowning in nets).

Satellite tagging studies sponsored by the Trustee Council and genetic studies carried out by the National Marine Fisheries Service indicate that harbor seals in the sound are largely resident throughout the year and have limited movement and interbreeding with other subpopulations in the northern Gulf of Alaska. This suggests that recovery must come largely through recruitment and survival within resident populations.

HARLEQUIN DUCKS

Injury

Harlequin ducks feed in intertidal and shallow subtidal habitats where most of the spilled oil was initially stranded. More than 200 harlequin ducks were found dead in 1989, mostly in Prince William Sound. Many more than that number probably died in the sound and perhaps thousands throughout the spill area. Because the spill occurred in early spring before wintering harlequins migrated from the sound to inland breeding sites, the initial effects of the spill likely affected harlequin duck productivity beyond the immediate spill zone. The geographic extent and magnitude of these extended impacts are not known.

Prespill data on harlequin populations and reproductive success are limited and difficult to interpret, but after the spill there was concern about poor reproductive success in the western versus eastern parts of Prince William Sound. This concern was based on observations of 7-15 broods in the eastern sound and few-to-no reports of broods in the western sound when comparable numbers of streams were surveyed.

Recovery Objective

Harlequin ducks will have recovered when hydrocarbon exposure is similar between oiled and unoiled areas; when numbers are stable or increasing; and when demographic attributes are similar and densities return to prespill levels.

Recovery Status

The current overwintering population of harlequin ducks in Prince William Sound is on the order of 18,000 ducks, while the summer population is about half that number. Surveys designed specifically to count harlequin ducks have been carried out in the fall, winter and spring in various years since the spill. Fall boat surveys to monitor molting-wintering harlequin ducks indicate a significant declining trend in the oiled western sound from 1995-1997, but no trend in the unoiled eastern sound. The spring harlequin duck surveys have only two years of data (1999 and 2000)—too little on which to draw conclusions, but increases in all areas of the sound in 2000 are promising. Spring surveys were also conducted in 2001 and 2002, but the results are not yet published. Other boat surveys designed to monitor an entire suite of marine birds in the sound have shown mixed results: an increasing trend in March surveys in unoiled areas, no trend in oiled areas between 1997 and 2000, and an increasing trend in both oiled and unoiled areas in July of these same years.

Postspill research does not indicate any differences in the age- and sex-structure of harlequin populations in the eastern and western parts of the sound, but it is clear that the breeding habitat in the western sound is very limited compared to what is available in the eastern sound. Some harlequins remain in the sound to nest in the spring and summer, mostly on the eastern side, but it is now suspected that most harlequins of breeding age and condition probably leave the sound altogether to nest in inland drainages. Thus, conclusions of reproductive failure based on lack of broods in the oiled area do not now seem warranted.

Oil remained in the subsurface of the intertidal zone through 2001, including under some mussel beds where harlequin ducks could be feeding. Biopsies from harlequin and Barrow's goldeneye ducks continue to show differences in an enzyme indicative of exposure to hydrocarbons between birds from oiled versus unoiled parts of the sound. These differences are consistent with the possibility of continued exposure to spill-derived hydrocarbons in the western sound. The biological effect of this possible exposure has not been established, but three years of data (1995-98 winters) on overwintering survival of adult female harlequins indicate significantly lower survival rates in oiled versus unoiled parts of the sound. This trend may be continuing. Although this result cannot be attributed unequivocally to oil exposure, there is reason for concern about possible oil exposure and reduced survival for harlequin ducks in the western sound.

Taken together, the population census trends, survival measures and indicators of exposure, suggest that the harlequin duck is recovering but has not recovered from the effects of the oil spill. Trustee Council sponsored studies give insight into prospects for recovery of harlequin ducks. Although some harlequin ducks make major seasonal movements, they exhibit high site fidelity to summer breeding sites and to molting and wintering sites during non-breeding seasons. Strong site fidelity may limit population recovery by immigration, but a genetic analysis of harlequin ducks indicates that the spill area population is homogeneous (i.e., very similar throughout). Taken together, these data are consistent with a low rate of dispersal, perhaps at the subadult stage, or a rapid expansion of the population in recent geological time. To the extent that there is subadult dispersal from adjacent expanding populations, such dispersal would enhance recovery. It is likely, however, that recovery will largely depend on recruitment and survival from within injured populations. This recovery may be compromised if exposure to lingering hydrocarbons reduces fitness and survival of harlequin ducks.

INTERTIDAL COMMUNITIES

Injury

Portions of 1,400 miles of coastline were oiled by the spill in Prince William Sound, on the Kenai and Alaska peninsulas, and in the Kodiak Archipelago. Both the oil and intensive cleanup activities had significant impacts on the flora and fauna of the intertidal zone. Intertidal communities are intrinsically important and are resources for subsistence users, sea and river otters, and a variety of birds, including black oystercatchers, harlequin ducks, and pigeon guillemots.

Initial impacts to intertidal organisms occurred at all tidal levels and in all types of habitats throughout the oil spill area. Many species of algae and invertebrates were less abundant at oiled sites than at unoiled reference sites. Some, more opportunistic species, including a small species of barnacle, oligochaete worms, and filamentous brown algae, colonized shores affected by the oil spill and cleanup activities. The abundance and reproductive potential of the common seaweed, *Fucus gardneri* (known as rockweed or popweed), also was reduced following the spill.

Recovery Objective

Intertidal communities will have recovered when community composition on oiled shorelines is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the reestablishment of important species, such as *Fucus*, at sheltered rocky sites, the convergence in community composition and organism abundance on oiled and unoiled shorelines, and the provision of adequate, uncontaminated food supplies for top predators in intertidal and nearshore habitats.

Recovery Status

In the lower and middle intertidal zones on oiled rocky shores, algal coverage and invertebrate abundances had returned by 1991 to coverages and abundances similar to those observed in unoiled areas. However, large fluctuations in the algal coverage have taken place in the oiled areas since the spill. This pattern is consistent with continued instability due to the original spill impact and the subsequent cleanup. However, instability of *Fucus* populations during the last 12 years probably results from a combination of spill- and naturally-induced changes, with a greater influence of natural events in the later years.

On the sheltered, bedrock shores that are common in Prince William Sound, full recovery of *Fucus* is crucial for the recovery of intertidal communities at these sites, since many invertebrate organisms depend on the cover provided by this seaweed. As of 1997, *Fucus* had not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities had been substantial. In other habitat types, such as estuaries and cobble beaches, many species did not show signs of recovery when they were last surveyed in 1991. In studies of the effects of cleanup activities on beaches, invertebrate molluscs and annelid worms on oiled and washed beaches were still much less abundant than on comparable unoiled beaches through 1997.

More recent data should soon be available, including results of a study in the summer of 2002 to determine if intertidal clam populations on oiled shorelines are comparable to those on unoiled shorelines. **Based on substantial progress, but the lack of full recovery of some soft-sediment intertidal invertebrates, as well as the continued presence of residual oil and the role of oil in initiating *Fucus* population instability, the intertidal communites are considered to be recovering.**

KILLER WHALES

Injury

More than 115 killer whales in eight "resident" pods regularly use Prince William Sound/Kenai Fjords as part of their ranges. Other whales in "transient" groups are observed in the sound less frequently. There has been particular concern about the resident AB pod, which numbered 36 animals prior to the spill. Fourteen whales disappeared from this pod in 1989 and 1990, and no young were recruited into the population. The original link between the AB pod losses and the oil spill was largely circumstantial, although the pod was observed surfacing in an *Exxon Valdez* oil slick following the spill in 1989. The rate of disappearance and likely mortality of killer whales in this well-studied pod far exceeded rates observed for other pods in British Columbia and Puget Sound over the last 30 years, and in the northern Gulf of Alaska over the last 18 years. Another possible cause for the disappearance of the whales in the AB pod was the possible shooting of killer whales due to conflicts with long-line fisheries prior to the oil spill. No long-line fisheries were carried out between the last count of this pod in 1988 and the spill in the spring of 1989, after which there were numerous missing whales. However, it is possible that the effects from the conflicts in the 1980s may still be apparent.

Recovery Objective

Killer whales in the AB pod will have recovered when the number of individuals in the pod is stable or increasing.

Killer whale researchers were concerned in the 1990s that the losses of key individuals in the AB pod in 1989 and 1990 would eventually lead to disintegration of the social structure of the AB pod and thus jeopardize its long term viability. For that reason, a modest recovery objective of a stable or increasing number of whales in AB pod was adopted in 1999.

Recovery Status

By 1993 the AB pod had increased to 26 individuals as births outpaced deaths. In 1995 mortalities, including animals orphaned in 1989-90, reduced the pod to 22 whales. Since 1995 the pod again has increased steadily in size to 26 individuals in 2001. Thus, social disintegration has not happened and an apparently stable structure has been achieved. Overall numbers within the major resident killer whale pods in Prince William Sound are at or exceed prespill levels, even though the AB pod—one of eight—may or may not regain its former size. While AB pod has not regained its prespill size of 36 individuals, **there has been sufficiently steady growth in the pod over the past six years so that there is confidence that the restoration objective of increasing or stable size has been met. Therefore the killer whales are considered to have recovered from the oil spill.**

In addition to the AB pod, there is concern that a decline in resightings of individuals within the AT1 group of transient killer whales has accelerated following the oil spill. Although there is no evidence linking the oil spill to the AT1 group, this update also reports on its status. Recent genetic analyses show that resident and transient killer whales in Prince William Sound are genetically distinct. Since 1990 and 1991, 11 individuals have been missing from the AT1 group and are now almost certainly dead. During that same period there has been no recruitment of calves into this pod of transients. Transient killer whales largely prey on marine mammals, and there has been a 60 percent decline in the harbor seal population in the sound over the last two decades. Changes in the availability of such an important prey species could influence killer whale distribution and reproduction. Trustee Council sponsored research on contaminants in killer whales in Prince William Sound indicates that some transient whales, including the AT1 group, are carrying high concentrations of PCBs, DDT, and DDT metabolites in their blubber. The presence of such contaminants is not related to the oil spill. The high concentrations of contaminants found in the transient whales are comparable to those found to cause reproductive problems in other marine mammals.

KITTLITZ'S MURRELETS

Injury

The Kittlitz's murrelet is found only in Alaska and portions of the Russian Far East. A large fraction of the world population, which may number only a few tens of thousands, breeds in Prince William Sound. The Kenai Peninsula coast and Kachemak Bay are also important concentration areas for this species. Very little is known about Kittlitz's murrelets, but they are known to associate closely with tidewater glaciers and nest on scree slopes and similar sites on the ground.

Seventy-two Kittlitz's murrelets were positively identified among the bird carcasses recovered after the oil spill. Nearly 450 more *Brachyramphus* murrelets were not identified to the species level, and it is reasonable to assume that some of these were Kittlitz's. In addition, many more murrelets probably were killed by the oil than were actually recovered. It is likely that about 500 individuals died as an acute effect of the oil spill, which would represent a substantial fraction of the world population.

Recovery Objective

No recovery objective can be identified for Kittlitz's murrelet at this time.

Recovery Status

Because so little is known about this species, the Trustee Council funded an exploratory study on the ecology and distribution of the Kittlitiz's murrelet in Prince William Sound starting in 1996. This project found that this species has an affinity for tidewater glaciers in the northern and northwestern parts of the sound. It also appears that reproductive output in 1996 and 1997 was extremely low or absent, and some Kittlitz's murrelets were apparently paired with marbled murrelets. There appear to be about 1,200-1,400 Kittlitz's murrelets during summer in the four bays studied in northern and northwestern sound. Another, more extensive marine bird boat survey conducted in 2001 suggests a sound-wide summer population of about 2,500 murrelets. These estimates are consistent with what is believed to be a small Alaska and world population.

The population data, indications of low reproductive success, and affinity to tidewater glaciers (of which the lower elevation glaciers are receding rapidly) are reasons for concern about the long-term conservation of Kittlitz's murrelets. **Specifically, with reference to the effects of the oil spill, however, the original extent of the injury and its recovery status are still unknown and may never be resolved. Therefore, this species is in the recovery unknown category.**

MARBLED MURRELETS

Injury

The northern Gulf of Alaska, including Prince William Sound, is a key area of concentration in the distribution of marbled murrelets. The marbled murrelet is federally listed as a threatened species in Washington, Oregon, and California; it also is listed as threatened in British Columbia. The marbled murrelet population in Prince William Sound had declined before the oil spill. The causes of the prespill decline are not known for certain, but environmental changes in the late 1970s probably reduced the availability or quality of prey resources. There is, nonetheless, clear evidence that oil caused injury to marbled murrelets in the sound. Carcasses of nearly 1,100 *Brachyramphus* murrelets were found after the spill, and about 90 percent of the murrelets that could be identified to the species level were marbled murrelets. Many more murrelets probably were killed by the oil than were found, perhaps as much as 7 percent of the spill area population.

Recovery Objective

Marbled murrelets will have recovered when their populations are stable or increasing. Stable or increasing productivity will be an indication that recovery is underway.

Recovery Status

The recovery of the marbled murrelet population in Prince William Sound is assessed primarily through standard marine bird boat-based surveys. As a result of boat surveys carried out in July for seven years from 1989-2000, densities of marbled murrelets decreased in both the oiled and unoiled areas of Prince William Sound. However, for the March surveys carried out in most years between 1990 and 2000, there have been no significant trends in the population size, although the counts have increased in both oiled and unoiled areas. The reason for the summer time declines in both oiled and unoiled areas is probably due to some factor other than the oil spill. The Trustee Council's Alaska Predator Ecosystem Experiment (APEX) project has investigated the relationship between marbled murrelet declines and the availability and abundance of forage fish, such as Pacific herring, sand lance, and capelin. It appears that there is a direct correlation between the availability of forage fish and production of young murrelets, based on the presence of juvenile murrelets on the water in Prince William Sound.

The summer time marbled murrelet population is not stable nor increasing, but the March population is stable over time. Marbled murrelet productivity, as measured by surveys of adults and juveniles on the water in Prince William Sound, appears to be within normal bounds. **On these bases, it appears that the marbled murrelet is at least recovering from the effects of the oil spill, but clearly has not yet recovered.**

MUSSELS

Injury

Mussels are an important prey species in the nearshore ecosystem throughout the spill area and are locally important for subsistence. Beds of mussels provide physical stability and habitat for other organisms in the intertidal zone and were purposely left alone during *Exxon Valdez* cleanup operations. In 1991, high concentrations of relatively unweathered oil were found in the mussels and in underlying byssal mats and sediments in certain dense mussel beds. The biological significance of oiled mussel beds is not known precisely, but they are potential pathways of oil contamination for bird and mammal populations (e.g., harlequin ducks and sea otters) which include mussels and other prey in and around mussel beds in their diets.

Recovery Objective

Mussels will have recovered when concentrations of oil in the mussels reach background levels.

Recovery Status

The Trustee Council's Nearshore Vertebrate Predator project has found evidence of hydrocarbon exposure in sea otters, river otters, harlequin ducks, and Barrow's goldeneyes in oiled parts of Prince William Sound in 1996 and 1997. Again in 2000 both sea otters and harlequin ducks showed evidence of oil exposure, but the pathway of such exposure has not been established. Both of these species include mussels in their diets.

About 30 mussel beds in Prince William Sound still contained *Exxon Valdez* oil residue when last sampled in 1995. Twelve of these beds had been cleaned on an experimental basis in 1993 and 1994. In 1995, oil hydrocarbon concentrations in mussels at half the treated beds were lower than would have been expected if the beds had not been cleaned. In 1996, however, limited sampling indicated that several of the cleaned beds had been recontaminated from surrounding or underlying oil residue.

Mussel beds along the outer Kenai Peninsula coast, the Alaska Peninsula, and Kodiak Archipelago were surveyed for the presence of oil in 1992, 1993, and 1995. In 1995, hydrocarbon concentrations in mussels and sediments at these Gulf of Alaska sites were generally lower than for sites in Prince William Sound, but at some sites substantial concentrations persisted. While several sites in Prince William Sound still contained high concentrations of oil in 1995, over half the sites surveyed demonstrated significant natural declines that suggest background concentrations should be reached in the next few years. Oil contamination in mussels, however, will likely persist for many years at certain sites that are well protected from wave action or where oil penetrated deeply into underlying sediments.

The latest available data, taken in 1999, indicates that oil is still being accumulated in mussels, but more data will be available soon on samples taken in the summer of 2001. Since the latest available data indicates that oil remains in mussels, they are considered to be recovering from the oil spill, but not yet recovered.

PACIFIC HERRING

Injury

Pacific herring spawned in intertidal and subtidal habitats in Prince William Sound shortly after the oil spill. A significant portion of these spawning habitats, as well as herring staging areas in the sound, were contaminated by oil. Field studies conducted in 1989 and 1990 documented increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Subsequent laboratory studies confirm that these effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries at a population level is not known.

The 1988 prespill year-class of Pacific herring was very strong in Prince William Sound, and, as a result, the estimated peak biomass of spawning adults in 1992 was very high. Despite the large spawning biomass in 1992, the population exhibited a density-dependent reduction in size of individuals, and in 1993 there was an unprecedented crash of the adult herring population. A viral disease and fungus may have been the immediate agents of mortality or a consequence of other stresses, such as a reduced food supply and increased competition for food.

Recovery Objective

Pacific herring will have recovered when the next highly successful year class is recruited into the spawning population and when other indicators of population health are sustained within normal bounds in Prince William Sound.

Recovery Status

Laboratory investigations since the 1993 population crash have shown that exposure to very low concentrations of *Exxon Valdez* oil can compromise the immune systems of adult herring and lead to expression of the viral disease. The extent to which the exposure to oil contributed to the 1993 disease outbreak is uncertain. There is also evidence that plankton production in the 1990s was less than in the 1980s, and so food limitation at the time of a peaking population may have contributed to the 1993 population crash.

Numbers of spawning herring in Prince William Sound remained depressed through the 1995 season. In 1997 and 1998 the spawning biomass was about double that of 1994, the season following the crash, and there were limited commercial harvests for herring in the sound. The increased biomasses in 1997 and 1998 were signs that recovery had begun. Unfortunately, in the last several years the recovery has stalled and the population has yet to recruit a highly successful year-class, which is fundamental to recovery of this species. There is evidence from limited collections in the spring of 2002 that a large proportion of the Pacific herring population in Prince William Sound is now composed of young, 3-year old fish. If this preliminary trend holds up, it is possible that the next large year class has moved into the population signaling the continuation of recovery. **Based on this information, the Pacific herring can only be considered to be recovering.**

The Trustee Council's Sound Ecosystem Assessment has resulted in new understanding of the importance of body condition in determining overwintering survival of herring and in the influences of the Gulf of Alaska on herring productivity within Prince William Sound. Ongoing research on herring disease in relation to commercial fishing practices, such as the enclosed "pound" fisheries, have direct implications for management of the herring fishery.

PIGEON GUILLEMOTS

Injury

Although pigeon guillemots are widely distributed in the north Pacific region, they do not occur anywhere in large concentrations. Because guillemots feed in shallow, nearshore waters, guillemots and the fish and invertebrates on which they prey are vulnerable to oil pollution. Like the marbled murrelet, there is evidence that the pigeon guillemot population in Prince William Sound declined before the oil spill. The causes of the prespill decline are not known for certain, but environmental changes in the late 1970s probably reduced the availability or quality of prey resources. There is, nonetheless, clear evidence that oil caused injury to the guillemot population in the sound. An estimated 10-15 percent of the spill area population died immediately following the spill. Boat-based surveys of marine birds before (1984-85) and after the oil spill indicated that the guillemot population declined throughout the oiled portion of the sound. It is not known what pigeon guillemot populations would be had the oil spill not occurred.

Recovery Objective

Pigeon guillemots will have recovered when their population is stable or increasing. Sustained productivity within normal bounds will be an indication that recovery is underway.

Recovery Status

Boat surveys have indicated that numbers of guillemots in the summer time remained depressed along both oiled and unoiled shorelines in the Prince William Sound through 2000. March surveys reveal no significant trends in abundance although the data appear to suggest a decline at this time of year as well. **For these reasons the pigeon guillemot is still considered to be not recovering from the effects of the oil spill.**

The Trustee Council's Alaska Predator Ecosystem Experiment (APEX) has investigated the possible link between pigeon guillemot declines and the availability of high-quality forage fish, such as Pacific herring and sand lance. This work has revealed a strong connection between the availability of certain prey fishes, especially sand lance, and guillemot chick growth rates, fledging weights, and nesting population size. The APEX project and the Nearshore Vertebrate Predator (NVP) project, also sponsored by the Trustee Council, addressed the possibility that exposure to oil is limiting the guillemot's recovery. The biochemical data indicated that adult guillemots were experiencing greater hydrocarbon exposures in western Prince William Sound than in the eastern portion of the sound as recently as 1999. However, guillemot chicks, which are restricted to the nest and are fed only fish, are not being exposed to hydrocarbons.

PINK SALMON

Injury

Certain features of the life history of pink salmon made this species highly vulnerable to damage from the oil spill. As much as 75 percent of wild pink salmon in Prince William Sound spawn in the intertidal portions of streams, where embryos deposited in the gravel were chronically exposed to hydrocarbon contamination in the water column or leaching from oil deposits on adjacent beaches. When juvenile pink salmon migrate to saltwater, they spend several weeks foraging for food in nearshore habitats. Thus, juvenile salmon entering seawater from both wild and hatchery sources could have been exposed to oil as they swam through oiled waters and fed along oiled beaches. Trustee Council sponsored studies have documented two primary types of injury due to the exposure of these early life stages: 1) growth rates in both wild and hatchery-reared juvenile pink salmon from oiled parts of the sound were reduced; and 2) there was increased egg mortality in oiled versus unoiled streams.

Recovery Objective

The Trustee Council's recovery objective in 1999 required a sequence of two years each of odd- and even-year runs without differences in egg mortality. This data is no longer gathered by the Alaska Department of Fish and Game because the expense of replicating the entire study for another four years, without being able to account for other factors, did not make it worth continuing. Therefore, a more realistic recovery objective is used based on hydrocarbon exposure of embryos since this is the major pathway of pink salmon exposure. Pink salmon will have recovered when ongoing oil exposure is negligible.

Recovery Status

In the years preceding the spill, returns of wild pink salmon in Prince William Sound varied from a maximum of 23.5 million fish in 1984 to a minimum of 2.1 million in 1988. Since the spill, returns of wild pinks have varied from a high of about 12.7 million fish in 1990 to a low of about 1.9 million in 1992. In 2001 the return of wild stock fish was estimated to be 6.7 million fish. The decade preceding the oil spill was a time of very high productivity for pink salmon in the sound, and, given the tremendous natural variation in adult returns, it is impractical to measure directly the extent to which wild salmon returns since 1989 were influenced by the oil spill. Based on intensive studies and mathematical models carried out following the spill, wild adult pink salmon returns to the sound's Southwest District in 1991 and 1992 were most likely reduced by a total of 11 percent. However, such an approach is unlikely to produce reliable multi-generational injury estimates. In addition, an analysis of escapement data from 1968-2001 showed no apparent time trends in annual escapements in either the oiled or unoiled parts of the sound. Therefore, there appear to be no observable effect at the population level at this time.

Reduced juvenile growth rates in Prince William Sound occurred only in the 1989 season, but higher egg mortality persisted in oiled compared to unoiled streams through 1993. No statistically significant differences in egg mortalities in oiled and unoiled streams were detected in 1994 through 1996, but in 1997 there was again a difference. It is not clear whether the 1997 difference was due to the effects of lingering weathered oil, perhaps newly exposed by storm-related disturbance of adjacent beaches, or due to other natural factors such as differences in the physical environment. Patches of weathered oil still persist in or near intertidal spawning habitats in a few of the streams used by pink salmon in southwestern Prince William Sound. In 1999 dissolved oil measurements were made in six of the most affected streams in the oil spill area. Methods were used that were extremely sensitive. Only one of the six streams had clearly measurable concentrations of oil. The one measurable concentration was about a thousand times lower than the concentration established through Trustee Council sponsored studies to be toxic to developing pink salmon embryos. Therefore, the biological impact of exposure of pink salmon embryos to lingering oil is negligible and is therefore unlikely to limit pink salmon populations. Recent measurements of hydrocarbons in other intertidal areas located near known subsurface oil deposits showed much higher concentrations of oil in the water, but were not located near salmon streams. **It is highly unlikely that oil is now accumulating in pink salmon embryos and having any significant effects. Therefore, the pink salmon are considered recovered from the effects of the oil spill.**

Throughout Alaska there is increasing recognition of the importance of changes in marine ecosystems on the growth and survival of salmon. The Sound Ecosystem Assessment (SEA) project explored oceanographic and ecological factors that influence production of pink salmon and Pacific herring in Prince William Sound. These factors include such things as the timing of spring plankton blooms and changes in circulation patterns that link the sound to the Gulf of Alaska, and are likely to have the greatest influence on year-to-year returns in both wild and hatchery stocks of pink salmon.

RIVER OTTERS

Injury

River otters have a low population density in Prince William Sound. Twelve river otter carcasses were found following the spill, but the actual total mortality is not known. Studies conducted during 1989-91 identified several differences between river otters in oiled and unoiled areas in Prince William Sound, including biochemical alterations, reduced diversity in prey species, reduced body size (length-weight), and increased home-range size. Because there were few prespill data, it is not certain that these differences are the result of the oil spill.

Recovery Objective

The river otter will have recovered when biochemical indices of hydrocarbon exposure or other stresses and indices of habitat use are similar between oiled and unoiled areas of Prince William Sound, after taking into account any geographic differences.

Recovery Status

Although some of the differences (e.g., values of blood characteristics) between river otters in oiled and unoiled areas in Prince William Sound persisted through 1996, there were few differences documented in 1997 and 1998. **Thus, there are no indications of possible lingering injury from the oil spill, and the Trustee Council's recovery objective has been met. River otters are considered to be recovered.**

Rockfish

Injury

Very little is known about rockfish populations (of several species) in the northern Gulf of Alaska. A small number of dead adult rockfish was recovered following the oil spill, and autopsies of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure to hydrocarbons and probable sublethal effects. In addition, closures to salmon fisheries apparently had the effect of increasing fishing pressure on rockfish, which, in turn, may have adversely affected local rockfish populations.

Recovery Objective

No recovery objective can be identified.

Recovery Status

The original extent of injury and the current recovery status of this species are unknown. Because little is known about rockfish abundance and species composition in the spill area and because rockfish are harvested commercially, even basic information about these species could provide a basis for improved management or, at least, the identification of priorities for more targeted research. Accordingly, starting in FY 1998, the Trustee Council sponsored a multi-year study of genetic stock structure in black, dusky, and yelloweye rockfish throughout the spill area and the adjacent Gulf of Alaska. The Alaska Department of Fish and Game study was not completed by the principal investigator.

Sea Otters

Injury

By the late 1800s, sea otters had been eliminated from most of their historical range in Alaska due to excessive harvesting by Russian and American fur traders. Surveys of sea otters in the 1970s and 1980s, however, indicated a healthy and expanding population in most of Alaska, including Prince William Sound. Today the only harvests of sea otters are for subsistence purposes. About 1,000 sea otter carcasses were recovered following the spill, and additional animals probably died but were not recovered. In 1990 and 1991, higher-than-expected proportions of prime-age adult sea otters were found dead in western Prince William Sound, and there was evidence of higher mortality of recently weaned juveniles in oiled areas.

Recovery Objective

Sea otters will have recovered when the population in oiled areas returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway.

Recovery Status

By 1992-93, overwintering mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of the sound. Based on both aerial and boat surveys conducted in western Prince William Sound, there is statistically significant evidence of a population increase following the oil spill (1993-98). Observations by local residents bear out this general increase. However, within the most heavily oiled bays in the western sound, such as those on northern Knight Island, the aerial surveys indicate that recovery is not complete.

The Trustee Council's Nearshore Vertebrate Predator project addressed the lack of recovery in sea otters in these heavily oiled bays. The lack of recovery may reflect the extended time required for population growth for a long-lived mammal with a low reproductive rate, but it also could reflect the effects of continuing exposure to hydrocarbons, or a combination of both factors. Through 2000, researchers have continued to find biochemical evidence of oil exposure in sea otters around northern Knight Island. Biochemical samples from 2001 are now being analyzed. An additional hypothesis is that food supplies are limiting recovery, but the evidence does not fully support this idea.

It is clear that sea otter recovery is underway for much of the spill area, with the exception of populations at the most heavily oiled bays in western Prince William Sound. For this reason, sea otters continue to be in the recovering category.

SEDIMENTS

Injury

Exxon Valdez oil penetrated deeply into cobble and boulder beaches that are common on shorelines throughout the spill area, especially in sheltered habitats. Cleaning and natural degradation removed much of the oil from the intertidal zone, but visually identifiable surface and subsurface oil persists at many locations.

Recovery Objective

Sediments will have recovered when there are no longer residues of *Exxon Valdez* oil on shorelines (both intertidal and subtidal) in the oil spill area. Declining oil residues and diminishing toxicity are indications that recovery is underway.

Recovery Status

A comprehensive survey of shorelines in Prince William Sound was conducted in 1993, but that survey has been repeated in the summer of 2001 with revised methods for better quantifying the oil remaining in intertidal sediments. The 2001 surveys indicate that about 20 acres of continuously oiled intertidal habitat now persist in Prince William Sound. While it appears that natural weathering processes are gradually reducing the amount of remaining oil in sediments, the amount estimated in 2001 is about twice the amount estimated to be in the sediments in 1993 (using methods that were designed in 1989 more for cleanup decisions than for quantitative estimates of remaining oil). The shorelines of the outer Kenai and Alaska Peninsula coasts get more wave action than most shorelines within Prince William Sound. These Gulf of Alaska sites tended to be contaminated with oil in the form of mousse, a stable emulsion of oil in water, which can persist for long periods in a largely unweathered state. Five of six index beaches on the gulf coast have a heavy boulder "armor" and were last visited in 1993 and 1994. At that time, surface and subsurface oil mousse persisted in a remarkably unweathered state.

In 1995, a shoreline survey team visited 30 sites in the Kodiak Archipelago that had measurable or reported oiling in 1990 and 1991. The survey carried out in 1995 around Kodiak Island found no oil or only trace amounts, so oiling in the Kodiak area has not persisted as it has in the sound. Following the oil spill, chemical analyses of oil in subtidal sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in subtidal sediments was mostly confined to the uppermost 20 meters water depths (below mean low tide), although elevated levels of hydrocarbon-degrading bacteria (associated with elevated hydrocarbons) were detected at depths of 40 and 100 meters in 1990 in Prince William Sound. By 1993 however, there was little evidence of *Exxon Valdez* oil and related elevated microbial activity at most index sites in Prince William Sound, except at those associated with sheltered beaches that were heavily oiled in 1989. These index sites—at Herring, Northwest, and Sleepy bays—are among the few sites at which substantial subsurface oiling is still known to occur.

Based on the information above, sediments are considered to be recovering. However, the presence of surface and subsurface oil continues to compromise wilderness and recreational values, expose and potentially harm living organisms, and offend visitors and residents, especially those who engage in subsistence activities along still-oiled shorelines.

SOCKEYE SALMON

Injury

Commercial salmon fishing was closed in Prince William Sound and in portions of Cook Inlet and near Kodiak in 1989 to avoid any possibility of contaminated salmon being sent to market. As a result, there were higher-than-desirable numbers (i.e., "overescapement") of spawning sockeye salmon entering the Kenai River and also Red and Akalura lakes on Kodiak Island. Research carried out following the spill demonstrated that initially these high escapements produced an overabundance of juvenile sockeye that then overgrazed the zooplankton, thus altering planktonic food webs in the nursery lakes. The result was lost sockeye production as shown by reduced growth rates during the freshwater part of the sockeye life history and declines in the returns of adults per spawning sockeye.

Recovery Objective

Sockeye salmon in the Kenai River system and Red and Akalura lakes will have recovered when adult returns per spawner are within normal bounds.

Recovery Status

Although sockeye freshwater growth tended to return to normal within two or three years following the overescapement, there are indications that these systems are less stable for several years after an initial overescapement event. The negative effects of the 1989 overescapement on sockeye productivity, as measured by return per spawner, in the Kenai River watershed were readily apparent for returns from the brood years 1989-92. Production of zooplankton in both Red and Akalura lakes on Kodiak Island has rebounded from the effects of the overescapement at the time of the oil spill. By 1997, Red Lake had responded favorably in terms of smolt and adult production and was at or near prespill production of adult sockeye. At Akalura Lake there were low juvenile growth rates in freshwater during the period 1989-92, and these years of low growth correspond to low adult escapements during the period 1994-97. Starting in 1993, however, the production of smolts per adult increased sharply and the smolt sizes and age composition suggested that rearing conditions have improved. There also was concern about overescapement effects in lakes on Afognak Island and on the Alaska Peninsula. However, analysis of sockeye freshwater growth rates of juveniles from Chignik Lake on the Alaska Peninsula did not identify any impacts associated with a 1989 overescapement event. On the basis of catch data through 2001 and in view of recent analyses of return per spawner estimates presented to the Alaska Board of Fisheries in 2001, the return per spawner in the Kenai River system is within historical bounds. **Therefore, it is highly unlikely that the effects that reverberated from the overescapements in 1989 continue to affect sockeye salmon (e.g., cause abnormal returns per spawner) and this species is considered to be recovered from the effects of the oil spill.**

SUBTIDAL COMMUNITIES

Injury

Shallow subtidal habitats of Prince William Sound, from the lower intertidal zone to depths of about 20 meters, typically have dense stands of kelp or eelgrass and contain numerous polychaete worms, snails, clams, sea urchins, and other invertebrate life. These subtidal communities provide shelter and food for an array of nearshore fishes, birds, and marine mammals. Oil that was transported down to subtidal habitats, as well as subsequent cleanup activities involving extensive vessel traffic, apparently caused changes in the abundance and species composition of plant and animal populations below lower tides.

Biologically, negative effects of the oil were most evident for oil-sensitive species of amphipods, which were consistently less abundant at oiled than at unoiled sites. Reduced numbers of eelgrass shoots and flowers may have been due to increased turbidity associated with cleanup activities (e.g., boat traffic). Two species of sea stars and helmet crabs also were less abundant at oiled sites. Some invertebrates living in the sediment, including species in eight families of polychaete worms, two families of snails, and one family of mussels, were greater in numbers at oiled sites. These species are more tolerant of oil exposure and may have also responded to the organic enrichment associated with oil. Some of the species that showed increased numbers also may have benefited from reduced competition or predation due to the effects of the spill. It is also is to be expected that when comparing any two sets of bays that measuring a large number of species will turn up differences just on the basis of chance.

Recovery Objective

Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that in unoiled areas or consistent with natural differences between sites such as proportions of mud and sand.

Recovery Status

Different habitats, emphasizing eelgrass beds and adjacent areas of soft sediment, were compared at oiled and unoiled sites from 1990-1995. It is difficult to draw firm conclusions from this study, because it is hard to distinguish between natural site differences (e.g., percent sand and mud) and those differences actually resulting from the oil spill or cleanup. Concentrations of hydrocarbons in subtidal sediments were significantly higher at oiled sites than at unoiled reference sites but never very high by comparison with concentrations known to cause community responses in the scientific literature. These oil concentrations dropped sharply by 1991, but evidence of oil contamination due to *Exxon Valdez* oil persisted at some locations through 1995 at very low concentrations. **By 1995, based on postspill comparisons of oiled and unoiled sites, there was recovery of most constituents of the eelgrass community.** In 1999 an article had been published in the peer reviewed literature that acknowledged the role that natural factors may be playing in the remaining differences in subtidal communities between oiled and unoiled bays. **Given that the remaining faunal**

differences could likely be due to the influence of natural factors and given that seven more years of additional natural recovery have occurred since the last study of subtidal fauna, the subtidal communities are judged to be recovered from the effects of the oil spill.

HUMAN SERVICES

COMMERCIAL FISHING

Injury

Commercial fishing is a service that was reduced through injury to commercial fish species (see individual resource accounts) and also through fishing closures. In 1989, closures affected fisheries in Prince William Sound, Cook Inlet, the outer Kenai coast, Kodiak, and Chignik. These closures harmed the livelihoods of persons who fish for a living. The period before the oil spill was a time of relative prosperity for many commercial fishermen. The years 1987-88 saw some of the highest ever per pound prices for salmon and increased capitalization of the fishery. Thus, fishermen's expectations for income in 1989 were very high, making the fishery closures and other spill effects even more disruptive.

Recovery Objective

Commercial fishing will have recovered when the commercially important fish species have recovered and opportunities to catch these species are not lost or reduced because of the effects of the oil spill.

Recovery Status

Although pink salmon and sockeye salmon are considered to be recovered from the oil spill, recovery is still not complete for Pacific herring (see individual resource accounts), one of the injured resources that is commercially fished. The recovery status of rockfish is still unknown and will likely never be known. No spill-related district-wide fishery closures related to oil contamination have been in effect since 1989. However, the Prince William Sound herring fishery was closed from 1993-96 due to a disease outbreak that may be related to the oil spill, was open to limited commercial harvest in 1997 and 1998, and has remained closed since then. **For these reasons, commercial fishing, as a lost or reduced service, is in the process of recovering from the effects of the oil spill, but full recovery has not been achieved.**

For a variety of reasons, as discussed below, disruptions to income from commercial fishing continue today, as evidenced by changes in average earnings, ex-vessel prices, and limited entry permit values. For example, for the period 1981-2000, fishermen's average earnings in the Prince William Sound salmon seine fishery peaked in 1987 ($176,500), dropped in 1989 by more than half, rebounded in 1990, hit a new low in 1992-93 (runs in 1992-93 were the lowest in 15 years), then hovered somewhat below the 1989 level until 1999-2000, when average earnings climbed to the $130,000 level. Average per-fisher harvests have varied widely during this period, with the three highest years being 1996, 1999, and 2000. Ex-vessel prices were highest in the period 1987-90, and have been below prices of the early 1980s ever since. Limited entry permit prices in this fishery reached a peak in 1989-91, nearly double the price in any earlier year in this period, and have declined since to currently ten percent of their peak price (from $236,000 in 1989 to $22,000 in 2000). The number of permits fished, roughly 250 each year 1981-91, had declined to 130 in 2000.

Natural variability in fish returns and a number of economic changes in the commercial fishing industry since 1989 probably mean that many of these changes in income are not directly attributable to the spill. However, these factors also make discerning spill-related impacts difficult. Economic changes confronting the industry include the increased world supply of salmon (due primarily to farmed salmonids) and corresponding reduced prices, entry restrictions in certain fisheries (such as Individual Fishing Quotas, IFQs, for halibut and sablefish), allocation changes (e.g., a reduction in the allocation of Cook Inlet sockeye salmon to commercial fishermen), changes in processing capacity (closure of major processors in Cordova and Kenai, and a recently announced closure in Larsen Bay on Kodiak Island), and new measures imposed by the North Pacific Fishery Management Council on offshore groundfish fishing to protect the declining number of Steller sea lions.

Although a number of studies aimed at allocating financial impacts to the oil spill versus other factors have been carried out, the federal jury's compensatory award (as opposed to the $5 billion in punitive damages) in the private lawsuit against Exxon is the current legal determination of the liability and damages regarding commercial fishermen (including permit holders, fishing crew, spotter pilots, and vessel owners). The jury award was less than the damage claimed by commercial fishermen and more than that acknowledged by Exxon. In brief, the jury determined that any financial effects on fishermen after 1989, with the exception of the salmon seine fishery in Prince William Sound in 1992-93 and the herring fishery in Prince William Sound in 1993, are not attributable to the spill. The jury considered damage claims for the period 1989-95, including claims related to size of harvest, fish prices, limited entry permit values, and vessel values.

PASSIVE USE

Injury

Passive use encompasses nonuse values, such as the appreciation of the aesthetic and intrinsic values of undisturbed areas and the value derived from simply knowing that a resource exists. Injuries to passive use are tied to public perceptions of injured resources. Immediately following the oil spill, the State of Alaska, using a contingent valuation approach, measured substantial losses of passive use values resulting from the spill. This approach involved surveying a sample of U.S. households to elicit how much people would be willing to pay in additional taxes to fund a program designed to prevent future spills.

Prior to answering the survey questions, respondents were provided information about the spill's impact, including the number of miles of shoreline oiled, an estimate of the number of birds, sea otters, and harbor seals killed, and the conclusion that few fish were harmed, as well as projections of when recovery would occur (typically three to five years).

Recovery Objective

Passive uses will have recovered when people perceive that aesthetic and intrinsic values associated with the spill area are no longer diminished by the oil spill.

Recovery Status

Because recovery of a number of injured resources is incomplete and in some cases has not begun, the Trustee Council considers passive use, as a lost or reduced service, to be recovering from the spill but not yet recovered. In updating the status of passive uses, the Trustee Council has chosen not to repeat the contingent valuation study, which was very expensive and time consuming. However, the key to recovery of passive use is knowing that restoration of injured resources has occurred. Toward this end, in the years since the settlement between Exxon Corporation and the state and federal governments, the Council has undertaken a comprehensive program to restore injured resources and has made a deliberate and consistent effort to inform the public about the status of restoration.

The two key components of the Trustee Council's restoration effort are the research, monitoring, and general restoration program and the habitat protection and acquisition program. The research, monitoring, and general restoration program, which is funded each year through the annual work plan, focuses mostly on knowledge and stewardship as the best tools for long-term health of the marine ecosystem. It also includes development of tools to benefit fisheries management and some direct enhancement activities, such as improving access to spawning habitat. Projects to monitor the status of injured resources, including resources such as killer whales for which no active restoration may be possible, have also been funded through the annual work plan. The habitat protection program preserves habitat important to injured resources through the acquisition of land or interests in land. As of March 2002, the Council has protected more than 643,600 acres of habitat, including more than 1,400 miles of coastline and over 300 streams valuable for salmon spawning and rearing. A summary of the Council's public information efforts follows.

Each year the Trustee Council prepares a number of documents for distribution to the public including; annual work plans, which describe the work underway to restore the injured resources and services; the *Annual Status Report*, which reports to the public on the progress of restoration; and updates to the Restoration Plan (1996, 1999). The Council's annual restoration workshop, which is open to the public, provides another venue for reporting on the progress of restoration. The Council has also published its Restoration Notebook series, which tells the story of injury and recovery from the spill of select injured species.

In addition, from 1996 through early 1999 the Council aired a weekly radio series, "Alaska Coastal Currents", throughout the state. Since 1997, the Trustee Council has had a web site (www.oilspill.state.ak.us) that offers detailed information about restoration efforts.

Project final reports, are also available to the public through the Alaska Resource Library and Information Services (ARLIS) in Anchorage as well as at several other libraries in the state, at the Library of Congress, and through NTIS (National Technical Information Service). In addition, the Council supports researchers in publishing their project results in the peer-reviewed scientific literature, which expands their audience well beyond Alaska. Nearly 500 such papers have been published as of April 2002.

The 17-member Public Advisory Group (PAG), is an important means of keeping stakeholders and others informed of the progress of restoration. In addition to holding quarterly meetings with the Trustee Council staff, in many years the PAG has held an open house in one or more communities in the spill area. Additional public meetings have been held throughout the spill area. All meetings of the Council are widely advertised and opportunity for public comment, is always provided.

RECREATION AND TOURISM

Injury

The oil spill disrupted use of the spill area for recreation and tourism. In addition, resources important to recreation were injured and beaches used for recreational activities were oiled. Recreation was also affected by changes in human use in response to the spill. For example, displacement of use from oiled areas to unoiled areas, particularly in the years immediately following the spill, increased management problems and facility use in unoiled areas.

Recovery Objective

Recreation and tourism will have recovered, in large part, when the fish and wildlife resources on which they depend have recovered and recreation use of oiled beaches is no longer impaired.

Recovery Status

In the years since the spill, there has been a marked increase in the number of visitors to Alaska. Preliminary data for the summer of 2001 indicate over 1.2 million visitors, compared to approximately 600,000 visitors in the summer of 1989. Visitation to the spill area has experienced a similar increase. For example, since 1993 the annual number of visitors to the Kenai Fjords National Park Visitor Center has been nearly double what it was in 1988. In 2000, the number of visitors to the USFS Crooked Creek Visitor Information Center in Valdez was nearly 70 percent greater than in 1989. From 1989 to 1997, the number of sportfishers increased by 65% in Prince William Sound, by 25% in the Kodiak Region, and by 15% in the Kenai Peninsula region. In 2000, the numbers were up slightly for

Prince William Sound and Kodiak, and had decreased slightly for the Kenai Peninsula region.

Even though visitation has increased since the oil spill, however, the Trustee Council's recovery objective requires that the injured resources important to recreation be recovered and recreational use of oiled beaches not be impaired, and this objective has not been met. **Therefore, the Council finds recreation to be recovering from the effects of the spill, but not yet recovered.**

Several resources important for wildlife viewing still are not recovering from the spill or their recovery is unknown, including harbor seal, common loon, cormorant (three species), Kittlitz's murrelet, and pigeon guillemot. Other resources, including sea otter and marbled murrelet, are recovering. The bald eagle, another resource important for wildlife viewing, has recovered from the effects of the spill. (See individual resource accounts for more information on recovery status.)

Telephone interviews were conducted in early 1999 with key informants who recreated extensively in the oil spill area before the spill and currently. Contacted again in 2002, nearly all of the informants commented on increased visitation to the area since the spill. Informants with experience in Prince William Sound continued to report diminished wildlife sightings in the sound, particularly in heavily oiled areas such as around Knight Island. They reported seeing fewer seabirds, killer whales, sea lions, seals, and sea otters than were generally sighted before the spill, but also reported observing increases in the number of seabirds over the last several years. Key informants with experience along the outer Kenai coast reported diminished sightings of seabirds, seals, and sea lions. Changes in the amount of wildlife observed could be due to the oil spill or to other factors

Sportfishing resources for which the recovery status is unknown are cutthroat trout, Dolly Varden, and rockfish. In 1992-93, in response to evidence of injury to cutthroat trout, emergency closures were put in place in some locations in Prince William Sound. In addition, bag limits have been reduced since 1991 and a closure during the April 15-June 15 spawning season has been in effect since 1994. These measures reflect the management goals for a potentially vulnerable species at the edge of its range. The salmon species that were injured (pink and sockeye salmon) are recovered from the effects of the spill.

Harlequin ducks, which are hunted in the spill area, are still not recovered. The Alaska Board of Game restricted sport harvest of harlequin ducks in western Prince William Sound and Kenai Fjords in 1991. Those restrictions were removed in the 1999-2000 hunting season when sea duck limits were changed statewide to have different limits for resident and non-resident hunters. There are currently no special restrictions for harlequins in Prince William Sound or Kenai Fjords.

Trustee Council sponsored surveys of oiled shorelines indicate that residual oil is still present on some beaches. The results of the most recent survey in Prince William Sound (2001) indicate approximately 20 acres of shoreline are still contaminated with oil. Oil was found at 58 percent of the 91 sites assessed and is estimated to have the linear equivalent of 5.8

kilometers of contaminated shoreline. The most recent survey of the Kenai outer coast and the coast of Katmai National Park (1999) found oil mousse persisting in a remarkably unweathered state on five moderately-to-heavily-oiled boulder-armored beaches (the oil is chemically similar to 11-day old *Exxon Valdez* oil). A survey of 30 oiled sites in the Kodiak Archipelago in 1995 found no oil or only trace amounts.

Key informants telephoned in early 1999 indicated that some beaches in Prince William Sound, particularly in the western portion of the sound, continue to be avoided by some recreational users, particularly kayakers and campers, because of the presence of residual oil. Contacted again in early 2002, informants commented that visitors to the sound routinely inquire about the existence of oil on beaches, either in planning visits or while on tours. They also commented that experienced users of the sound can readily find oil on certain beaches and continue to avoid those areas. Since 1999, informants have indicated that the possible presence of residual oil has no effect on recreational activities along the outer Kenai coast, the Kodiak Archipelago, and the Lake Clark and Katmai national park coastlines.

In 1997, the Trustee Council provided funding for the residents of Chenega Bay, working with the Department of Environmental Conservation, to use PES-51, a citrus-based chemical agent, to clean some of the most heavily-oiled sites near their village. One year later, a statistical analysis showed that the cleanup method reduced the amount of oil remaining on these beaches by a factor of three compared with reductions observed on untreated beaches. However, considerable subsurface oil remains that was inaccessible at the time of treatment, but was uncovered during storms the following winter. NOAA's Auke Bay Lab found no biological injury due to the cleanup.

The State of Alaska dedicated over $10 million of its criminal settlement with Exxon to restoring recreational facilities and use in state parks in the spill area. Improvements include trails, cabins, boat launches, interpretive displays, and campsites. In addition, the Trustee Council funded U.S. Forest Service development of a human use model for western Prince William Sound, which is intended to aid planning for and mitigation of human uses so that injured species continue to be protected. The model may also assist in planning for future recreation needs in the sound.

SUBSISTENCE

Injury

Fifteen predominantly Alaskan Native communities (with a total population of about 2,200 people) in the oil spill area rely heavily on harvests of subsistence resources, such as fish, shellfish, seals, deer, and waterfowl. Many families in other communities also rely on the subsistence resources of the spill area.

Household interviews conducted with subsistence users in communities throughout the spill area in 1989 indicated that subsistence harvests of fish and wildlife in most of the communities declined substantially following the spill. Key factors in the reduced harvests included reduced availability of fish and wildlife, concern about possible health effects of eating oiled fish and wildlife, and disruption of the traditional lifestyle due to cleanup and related activities.

Recovery Objective

Subsistence will have recovered when injured resources used for subsistence are healthy and productive and exist at prespill levels. In addition, there is recognition that people must be confident that the resources are safe to eat and that the cultural values provided by gathering, preparing, and sharing food need to be reintegrated into community life.

Recovery Status

Household interviews were repeated each year 1990-93 and again in 1998. By 1993, the estimated size of the subsistence harvest and participation in subsistence activities appeared to have returned to prespill levels in some communities, with the harvest rebounding first in the communities of the Alaska Peninsula, Kodiak Island, and the lower Kenai Peninsula and lagging behind a year or more in the Prince William Sound communities.

In 1998, which is the most recent year in which household interviews were conducted, the interviews indicated that subsistence continues to recover from the effects of the oil spill, but has not yet recovered. The percentage of those interviewed who reported that subsistence uses are lower than before the spill has declined. Concerns about food safety and effects on the traditional lifestyle have lessened. Concerns about resource availability and greater harvest effort remain, but harvest levels in all communities interviewed are at or approaching prespill levels. Subsistence harvests in 1998 varied among communities from 250-500 pounds per person usable weight, indicating continued strong dependence on subsistence resources.

Regarding resource availability, subsistence users continued to report scarcity of a number of important subsistence resources, including harbor seals, herring, clams, and crab. These observations are generally consistent with scientific studies funded by the Trustee Council that continue to find that some subsistence species (e.g., harbor seals, Pacific herring, clams) are not recovered from the effects of the spill (see individual resource accounts).

According to those interviewed, the 1998 increase in pounds harvested at a time of continued reduced resource availability reflects greater harvest effort (traveling farther, spending more time and money) than would have been required before the spill to achieve a similar harvest. It also reflects increased reliance on fish in the subsistence diet. Increased fish harvests and decreased marine mammal and shellfish harvests occurred in most communities where interviews were conducted. The cultural and nutritional importance of each resource varies, and these changes in diet composition remain a serious concern to subsistence users.

The decline in shellfish consumption reflects food safety concerns as well as reduced availability of shellfish. From 1989-94, subsistence foods were tested for evidence of hydrocarbon contamination, with no or very low concentrations of petroleum hydrocarbons found in most subsistence foods. However, because some shellfish can readily accumulate hydrocarbons, subsistence users have been advised not to eat shellfish from beaches where oil can be seen or smelled on the surface or subsurface. By 1998, a large majority of those interviewed expressed confidence about most foods except certain shellfish, such as clams, and concerns about the presence of PSP (paralytic shellfish poisoning) in clams outweighed concerns about lingering hydrocarbon contamination from the oil spill.

Subsistence users continue to emphasize that the value of subsistence cannot be measured in pounds alone. Harvest levels do not encompass the cultural value of traditional and customary use of natural resources. Following the oil spill, there was concern that the spill disrupted opportunities for young people to learn cultural subsistence practices and techniques, and that this knowledge may be lost to them in the future. In 1998, the number of subsistence users reporting a decline in the influence of elders in teaching subsistence skills and values had decreased and the number reporting that young adults are learning enough subsistence skills had increased. Also, the number reporting less sharing of subsistence resources, another integral aspect of subsistence culture, had decreased. However, many of those interviewed continue to express concern about these elements of the traditional lifestyle, with more than 50 percent responding that the traditional way of life has not recovered since the spill.

In the 1998 household interviews, a number of subsistence users commented that some of the current influences on subsistence may not be attributable to the oil spill. Factors such as demographic changes in village populations, ecosystem-wide changes such as ocean warming, increased competition for subsistence resources by other people (e.g., sport fishing charters) and predators (e.g., sea otters), and increased awareness of PSP and other contaminants may play a role in resource availability, food safety, and participation in traditional practices. The Trustee Council will likely repeat the household interviews with subsistence users in communities through the spill area in 2004 or 2005.

Exxon Valdez Oil Spill Trustee Council

441 W. 5th Ave., Suite 500 • Anchorage, Alaska 99501-2340 • 907/278-8012 • fax 907/276-7178

MEMORANDUM

TO: Trustee Council Members

FROM: Molly McCammon
Executive Director

DATE: June 6, 2002

RE: GEM Revisions/NRC review

As you know, the pre-publication version of the National Research Council's review of the Trustee Council's GEM has been released. There are a few errors and typos that will be corrected before the final report is printed. I have also asked for consideration of some more substantial changes to the chapter on Community Involvement. Those are under consideration by the NRC now.

I have now carefully read through this report a number of times. It will be a useful guide as the GEM program develops in the next few years. However, its greatest use may be 5-7 years from now when the Trustee Council has the first external review of GEM.

As I mentioned earlier, the report is a mix of praise for the Trustee Council's GEM program and constructive criticism. Those sections of the document that resulted in misinterpretation or confusion on the part of the NRC clearly need to be rewritten. And in response to NRC suggestions, the entire document would benefit from some reorganization and streamlining that are currently underway.

The NRC supported

- the GEM vision of a long-term program (although they still cautioned that the goals were probably too broad, and the program would need focus provided in other ways);
- the GEM conceptual foundation (perhaps with some editorial work);
- the creation of a scientific advisory committee;
- the organization by habitat (with a caution of the need to address cross-habitat linkages);
- the modeling and data management chapters; and
- the scientific background chapter as an excellent synthesis of our knowledge of the GOA.

The NRC suggested that, as the program develops,

- we look for ways to help focus the program;
- we continue to involve the public and communities in planning and implementation; and
- we work further on the guiding hypotheses and questions.

We agree with all of these and will address them as the program develops further.

Three apparent criticisms that need clarification were:

- The TC appears to have turned its back on community involvement and merely views communities as a labor pool. These criticisms were a total surprise. We were aware that the August 2001 GEM Program Document did not clearly articulate how communities would be involved. In fact, we freely admitted that providing for meaningful community involvement in a program such as GEM is a challenge. However, I believe the Trustee Council has devoted greater proportions of its funds and efforts towards promoting meaningful community involvement than any other environmental research and monitoring program or organization, among the many that we studied in writing the GEM Program Document. We still don't have all the answers or the perfect solution, but I don't believe it was fair or accurate to question the Trustee Council's commitment. Without changing the final conclusion or recommendation, I have asked the NRC to consider some changes to the text of the chapter that would make it more accurate.
- The comments imply that the TC is not presently committed to data management, although on the other hand they say the data chapter of the GEM Program Document is well done. Because of the NRC's praise for the data management chapter, I believe these comments were intended more in reference to past data management issues. These were mostly created by the confidential nature of potentially litigation-sensitive materials under NRDA and the uncertain life expectancy of the Restoration Program. I have asked for clarification that the concern is related to the past and current oil spill program, not the future GEM Program.
- The role of the conceptual foundation in shaping GEM has been largely replaced by studies designed to meet short-term needs. We are reorganizing the GEM document to make it very clear that GEM continues to be a long term program with the focus on long term monitoring.

The NRC also strongly urged the Trustee Council to ensure that the GEM program was largely driven by "the science", as opposed to resource management needs or politics. On the other hand, the NRC strongly urged the Trustee Council to ensure that community input and knowledge had an equal place at the table with the scientists in developing and implementing the program. I have always viewed "politics" as another term for "people" or "the public." The challenge will always be to ensure the program is scientifically based and scientifically credible, yet responsive to the interests and concerns of resource managers, communities and the public.

One other set of recommendations by the NRC concerns GEM's role in Gulf of Alaska research. The committee recommended that GEM not be the central coordinating body for all marine research in the Gulf of Alaska; that GEM not be distracted by the idea of assuming leadership of Gulf of Alaska marine research; that GEM not fill the gaps in other programs; and that GEM not provide day-to-day support of resource management. The GEM Program is not intended to be the "leader" of GOA research. However, there may be products or services that GEM could provide (such as sponsoring State of the Gulf workshops or maintaining a database of ongoing research in the GOA) that may be useful to others. GEM is also not intended to "fill in the agencies' gaps". However, once research questions and monitoring variables and locations are determined, it only makes sense to put our funds where they are most needed, and to avoid duplication. And as mentioned earlier, the program needs to be responsive to resource management issues, if not totally "driven" by them.

The committee's chair, Mike Roman, will be available on teleconference to answer any questions you might have regarding the report. Otherwise, our plan is to do the following:

1. Reorganize the document and streamline the various sections.
2. Rewrite sections to clarify meaning and intent in response to specific comments and recommendations. Correct any inaccuracies and ambiguities in the text.
3. Further develop the concepts of community involvement and traditional knowledge.

Prepublication Copy

A Century of Ecosystem Science: Planning Long-Term Research in the Gulf of Alaska

MAY 8, 2002

Committee to Review the Gulf of Alaska Ecosystem Monitoring Program
Polar Research Board
Board on Environmental Studies and Toxicology
Division on Earth and Life Studies
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C.

This prepublication version of *A Century of Ecosystem Science: Planning Long-Term Research in the Gulf of Alaska* has been provided to the public to facilitate timely access to the committee's findings. Although the substance of the report is final, editorial changes may be made throughout the text and citations will be checked prior to publication. The final report will be available through the National Academy Press in June 2002.

A Century of Ecosystem Science: Planning Long-Term Research in the Gulf of Alaska

PREPUBLICATION COPY

Committee to Review the Gulf of Alaska Ecosystem Monitoring Program
Polar Research Board
Board on Environmental Studies and Toxicology
Division on Earth and Life Studies
National Research Council

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This study was supported by Contract/Grant No. CMRC/WASC/NOAA 50ABNF-0-00013 (BAA00360) between the National Academy of Sciences and Exxon Valdez Oil Spill Trustee Council. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

Copies of this report are available from:
Polar Research Board, HA454
2001 Wisconsin Avenue, NW
Washington, DC 20007
202-334-3479

or

National Academy Press
2101 Constitution Avenue, NW
Lockbox 285
Washington, DC 20055
800-624-6242
202-334-3313 (in the Washington metropolitan area)
http://www.nap.edu

Printed in the United States of America

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* Until November 2001.

Board on Environmental Studies and Toxicology

Preface

This report is in response to a request from the *Exxon Valdez* Oil Spill Trustee Council to review the Gulf of Alaska Ecosystem Monitoring and Research Program (GEM). To ensure that the GEM program is based on a science plan that is robust, far-reaching and scientifically sound, the Trustee Council asked the National Academies to serve as an independent advisor. The Academies appointed a special committee and charged it to review the scope and content of the program as it evolves. To meet this charge our committee reviewed Trustee Council planning documents and met with their representatives and with individuals representing various communities and user groups of the Gulf of Alaska region.

Trustee Council funds for long-term research in the Gulf of Alaska provide a rare opportunity for citizens, resource managers, and scientists to understand an ecosystem and obtain data essential to its long-term management. Virtually all ecosystems on Earth are influenced by natural changes and human activities. Sustained observations are necessary to separate the influences of these factors and to document natural fluctuations of ecosystem processes. We face this challenge in managing the living resources of all ecosystems. Thus the financial commitment to GEM, if coupled with careful planning and sound science, can serve as a model for ecosystem science and management. This is an exciting prospect.

This report is not an endorsement of a specific science plan for the long-term study of the Gulf of Alaska. While planning is well underway, the details of such a plan will arise after careful analysis, synthesis, and scientific deliberation. We focus this review on the planning process and scientific infrastructure necessary for a successful long-term environmental research program in the Gulf. We make recommendations on how the GEM planning process can be improved, based on the experience of the committee and lessons learned from other environmental research programs. Our report is divided into sections relating to planning long-term ecosystem science; the importance of a conceptual foundation; determining scope and geographic focus; organization structure; community involvement and traditional knowledge; data management; and synthesis, modeling, and evaluation. We recommend a course of action that has proven successful in planning and implementing other large interdisciplinary science programs.

Many people provided information to this committee as we prepared our report. In particular we would like to thank Molly McCammon, Phil Mundy, and Robert Spies of the Trustee Council; Gary Kompkoff from the Village of Tatilek; and Patty Brown-Schwalenberg of the Chugach Regional Resources Commission. On behalf of the entire committee I want to thank Chris Elfring of the Polar Research Board and David

Policansky of the Board on Environmental Studies and Toxicology. Their sage council, broad experience with the NRC process, diligence, and professionalism greatly contributed to this report. We thank Ann Carlisle of the Polar Research Board for her excellent logistic and administrative support. Finally, I especially want to thank my fellow committee members. They worked hard, gave unselfishly of their time, and patiently learned the language and biases of different scientific disciplines while they worked to meet our charge.

Michael Roman, *Chair*
Committee to Review the Gulf of
Alaska Ecosystem Monitoring
Program

Acknowledgments

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Kenneth H. Brink, Woods Hole Oceanographic Institution, Massachusetts
Ingrid C. Burke, College of Natural Resources, Fort Collins, Colorado
Robert B. Gramling, University of Southwestern Louisiana, Lafayette
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Sharon L. Smith, Rosenstiel School of Marine and Atmospheric Sciences, Miami, Florida
Judith Vergun, Oregon State University, Corvallis

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by Garry Brewer, Yale University. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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Executive Summary

"It is a piece of ancient Greek wisdom that counting and measuring things is a much surer path to knowledge and understanding than any other." (McCready, 2001)

In March 1989 the tanker *Exxon Valdez* ran aground on Bligh Reef in Prince William Sound, Alaska, and spilled about 11 million gallons of oil. One element of various legal proceedings occurring as a result of the spill was a civil settlement that required Exxon Corporation to pay $900 million over 10 years to restore resources injured by the spill and compensate for reduced or lost services the resources provide. The *Exxon Valdez* Oil Spill Trustee Council composed of three federal and three state members was established to administer the funds. As part of its mission, the Trustee Council has disbursed substantial funding for research, first for damage assessment activities and later for monitoring and research. Significantly, the Trustees also set aside some of the funds to create a permanent trust intended to support continued, long-term research and monitoring in the region after the settlement period had ended.

Planning for this new activity, called the Gulf Ecosystem Monitoring (GEM) program, is now well underway. To help ensure that the GEM program is based on a science plan that is robust, far-reaching, and scientifically sound, the Trustee Council asked the National Academies to serve as an independent advisor. In June 2000 the National Academies appointed a special committee and charged it to review the scope and content of the program as it evolved. During the committee's two-year tenure it met multiple times with Trustee Council staff and with scientists and community members to learn about the program's intended goals and structure. To date, the committee has provided two written reports: a short letter report (November 2000) that comments on the program planning schedule and a more detailed interim report (February 2001) that critiques an early draft of the GEM program science plan (EVOSTC, 2001).

The Trustee Council is to be commended for its foresight in setting aside money over the years to create the trust fund that will provide long-term support to the GEM program. As envisioned, that program will offer an unparalleled opportunity to increase understanding of how large marine ecosystems in general, and Prince William Sound and the Gulf of Alaska in particular, function and change over time. The committee believes that this program has the potential to make substantial contributions of importance to Alaska, the nation, and environmental science.

According to an early Trustee Council document, Restoration Update Winter 2000 (EVOSTC, 2000b), GEM was conceived to have three main components: long-term ecosystem monitoring (decades in duration); short-term focused research (one to several years in length); and ongoing community involvement, including use of traditional knowledge and local stewardship. The committee views this early simple vision of the program as a sound foundation upon which to build. In a later document (EVOSTC, 2000a) the purpose of the GEM program is further delineated to contain five program goals: detect, understand, predict, inform, and solve. The committee understands the general intent of these goals and the necessity of making the program responsive to both the needs of science and the needs of various agencies and the public. Nevertheless, as the committee discussed in its interim report, it remains concerned that these five goals are extremely diverse and far-reaching. While the GEM mission is a good general statement of intent, the committee remains concerned that such broad ambition exposes the program to the risk that it will be spread too thin to be effective.

This report reviews the planning document entitled "Gulf of Alaska Ecosystem and Monitoring Program" (NRC Draft), Volumes I and II, provided in September 2001 (EVOSTC, 2001). During the course of this study, the committee saw progress in a number of areas. For example, the committee believes that the GEM planners made a significant effort to include the interests of diverse stakeholders (the Trustee Council, scientists, various advisory groups) in the science plan. We are pleased to see that the planning process has caused an evolution in the draft and the thinking behind it. We commend GEM planners for not taking the easy route of simply picking stations and starting data collection, and for taking the time to think about the conceptual foundation and develop the hypotheses that are necessary to define data needs. Finally, we find that the conceptual foundation is much improved from earlier drafts and discussions; however, placing the conceptual foundation deep within Volume II is not appropriate because this late placement implies that it is an afterthought and not the foundation upon which the program is built. We conclude that GEM planners have made progress on the development of research hypotheses, although there is still room for more work in this area.

GEM staff has made good efforts to involve the science community in its planning activities. Through these contacts they have made a solid start on plans to use modeling effectively and in developing a data management strategy. The committee found that the science review section is very useful. Although it may seem obvious, many of these positive strides have occurred because the Trustee Council and GEM staff have set up a planning process and are allowing adequate time for input, discussion, and revision. This process will make for a significantly better program over the long term.

The committee has struggled, however, with its basic charge—to review the GEM program—because the science plan was literally evolving as we worked and we often were aiming at a moving target. We also struggled because, as scientists, we are more accustomed to dealing with research programs either instigated directly by scientists, such as the Global Ecosystem Dynamics program, or by agencies with clear mandates, such as Minerals Management Service's Environmental Studies program. Instead, GEM is a research program directed by a Trustee Council made up of six agency representatives, each carrying responsibilities for mission-oriented state and federal agencies. The Trustee Council's role is made especially difficult because of the legal requirement that all its decisions be unanimous. GEM is supported by a staff that includes both scientists and non-scientists who have the unenviable job of balancing not only the expectations of the science community (the norm when developing a new science program) but also the expectations of various other Alaskan stakeholders and the inevitable political forces present in the Trustee Council itself.

While this committee whole-heartedly endorses the idea of a long-term ecological research program in the Gulf of Alaska and commends the Trustee Council and other public decisionmakers for having the foresight to create such a program, we want to be clear that this report is not an endorsement of implementation of the GEM program as currently designed.

ELEMENTS OF A SOUND LONG-TERM SCIENCE PLAN

The GEM program offers an unparalleled opportunity to increase our understanding of the functioning of large marine ecosystems in general and the northern Gulf of Alaska and its adjacent waters in particular. Few other research programs have a century-long time horizon. Thus, along with the opportunity afforded by GEM comes an obligation to craft a research plan that can endure over time. This plan requires a core set of measurements that can be taken consistently and indefinitely, as well as some flexibility to adjust to changes in conceptual understanding and research interests.

Recent research evaluating coastal monitoring studies has identified seven themes necessary in all successful programs (Weisberg et al., 2000):

1. Clearly define program goals and anticipated management products.
2. Recognize the differences between physical and biological monitoring.
3. Accommodate differences in space-time scales among ecosystems as they affect sampling design.
4. Develop an effective archival and data dissemination strategy.
5. Develop data products that will be useful to decision makers.
6. Provide for periodic program review and flexibility in program design.
7. Establish a stable funding base and management infrastructure.

The committee concurs that these broad steps are central to all good research programs. In addition, the committee has identified a number of specific elements it deems essential for a successful long-term science program of the magnitude of GEM. These include development of a clear, strong conceptual foundation for the program, early definition of a geographic scope and focus for study, an organizational structure led by a qualified chief scientist, involvement of stakeholders in the planning process and research, substantial attention to data management to ensure safekeeping and accessibility, and periodic assessment of progress through synthesis and evaluation. The committee's report is structured into sections addressing these key elements.

CONCEPTUAL FOUNDATION

The GEM program is conceived as a long-term monitoring program, because long time series are essential to detecting ecosystem change. However, it is absolutely vital to recognize that long-term monitoring per se will not necessarily lead to a better scientific understanding of the ecosystem. The value and utility of monitoring depends critically on the variables measured, the spatial and temporal extent and intensity of sampling, and the methods employed. Without clear vision of the desired goals at the outset it is very difficult to establish monitoring programs that will provide data that will actually be useful over time. This is why the monitoring program must have a strong conceptual foundation and be driven by broad, "big-picture" hypotheses.

For GEM the conceptual foundation needs to be broad, precisely because of the long time scale of the program. No one can know which theories, taxa, or processes will emerge as critical to the public or managers, or relevant to ecosystem functioning in future decades. Conceptual foundations that rest on a few indicator species, highly specific hypotheses (e.g., Pacific Decadal Oscillation), or current human impacts (e.g., fishing) are likely to be too narrow and inflexible to support the GEM mission. Instead, GEM must incorporate the sense that marine ecosystems change in response to physical and biological changes and human impacts, as is clearly expressed in the GEM mission statement. GEM planners are aware of the difficulty of pursuing long-term monitoring in the face of short-term interests: The GEM program has provisions for multi-decade measurements and for shorter research programs targeting specific issues or hypotheses, so that GEM can respond to current concerns without sacrificing the gathering of long-term data sets that will prove increasingly useful as they accumulate.

Given its importance as a foundation and guiding force, the GEM conceptual foundation should not be hidden in volume II of the draft science plan (EVOSTC, 2001); it should be located early in the articulation of the GEM science plan.

SCOPE AND GEOGRAPHIC FOCUS

Three important, interrelated elements must be addressed when defining the scope of a science plan, as a way of focusing attention on a practical subset of the many possible research questions. The first two elements, geographic focus and research approach, serve to set bounds on "where" the plan is applied. The geographic focus delimits the spatial extent of the plan. Research approach is the decision about how to divide research efforts in the geographic area (e.g., habitat types, species, flows of energy or materials, or the consequences of specific perturbations). The third component of scope, determining generally "what" will be measured, follows once the first two elements are agreed on and involves the selection of long-term variables to measure.

When resources are finite, there are inevitable tradeoffs between the intensity and geographic scope of research. Given finite funds, multiple variables can be monitored in a small area or fewer variables can be measured in a larger area. The choice of geographic scale for a long-term science plan is based on considerations such as scientific criteria, the existing knowledge base, management needs, accessibility, and cost.

The GEM plan has taken the entire Gulf of Alaska as its geographic scope. In its interim report the committee recommended that GEM first focus long-term research in Prince William Sound, and then extend geographic coverage over time. The rationale underlying this recommendation was the difficulty of designing a useful research plan for such a broad area given limited funds, coupled with the utility of extending existing time series at the core of the area affected by the spill in 1989. Nevertheless, the Trustee Council is well within its prerogative to select any geographic scope, but if the program is to be successful, the scope should be justified on science and management grounds and must be appropriate to the funding level. Covering a large geographic scope in the absence of a scientific rationale (a unifying hypothesis) risks expending resources in a piecemeal fashion that will make synthesis and interpretation difficult.

Because of the tradeoff between geographic scope and intensity of research effort, science plans covering large areas must include methods for stratifying observations and allocating funds. This focus can be provided in a number of ways, including an emphasis on habitats (as selected by GEM planners) or via other organizing concepts such as species, hypotheses, time, or flows of energy. In the GEM planning document (EVOSTC, 2001), the decision to organize by habitat is acceptable, but there are several problems that should be addressed. In the draft plan, hypotheses are presented as repetitive questions in each habitat type, and they will need considerable refinement before they can guide research. Most importantly, the habitat divisions may create a barrier to understanding links and transfers among habitats. The committee cautions against the development of habitat-based subcommittees in the organizational structure, as there is substantial risk of neglecting linkages among habitats.

Different strategies will be required for the three types of research included in the GEM plan—measuring variables long-term, carrying out shorter-term studies of processes, and synthesizing and analyzing collected data sets. It is appropriate to devote considerable time and effort to making effective choices of what, where, and when to measure. The committee finds little indication that hypothesis-testing will play a role in designing long-term research. Without clear hypotheses, there is little guidance on how these variables will be chosen, although the process appears to include some modeling, gap analysis, and workshops.

ORGANIZATIONAL STRUCTURE

A credible scientific program must assure that the science base is sound and that program planning, implementation, community involvement, coordination, proposal solicitation, peer review, funding, interactions among investigators, data management, program oversight and review, and public outreach are efficient. Most interdisciplinary marine ecosystem programs have a scientific steering committee (the equivalent of the Scientific and Technical Committee proposed by GEM planners [shown in Figure 4-1]) and a chief scientist or scientific director that together develop and implement the science plan and provide program oversight. The chief scientist works closely with the steering committee, but is ultimately responsible for developing and implementing the program science plan, and has authority regarding all scientific decisions after consultation with the principle investigators and steering committee. The GEM plan does not include detail on organizational structure, but a flowchart provided by staff (Figure 4-1) contains the necessary elements, although how these elements are implemented and given authority for real action is, of course, key.

Science planning must continue during the life of the GEM program to assure program success. The core variables to be measured must be carefully selected and should not be modified without careful consideration during the life of GEM. This strategy will assure that consistent long-term data are obtained with the principal objective of distinguishing between human induced and natural changes in the Gulf of Alaska ecosystem. The Scientific and Technical Advisory Committee may be of value in both developing monitoring protocols and requests for proposals, but such a committee should not be the sole mechanism by which the variables to be measured are selected. Other input might be sought through targeted workshops designed to synthesize existing knowledge and determine the location and frequency of measurements of key biological, chemical, and physical variables.

COMMUNITY INVOLVEMENT

Community involvement and the incorporation of traditional knowledge is critical to the GEM program's long-term success. Early GEM-related documents indicated a clear desire to incorporate community involvement and traditional knowledge, however this emphasis has receded in successive documents. The committee urges the Trustee Council to reconsider this change in emphasis.

Why is incorporation of community involvement and traditional knowledge important? First, community involvement and traditional knowledge can contribute to the overall focus on ecosystem monitoring. Local residents possess valuable ecological knowledge that can be directly incorporated into established scientific models. Local residents can be a source of important research questions and can help assure that research is relevant to both ecological and community needs. In addition, local residents offer potential efficiencies in data collection efforts.

A second rationale relates to equity issues. The GEM program, like the Trustee Council itself, is the result of settlement funds dedicated to restoration of an ecosystem damaged by a human technological disaster (Erikson, 1994). This damaged ecosystem includes resource-dependent human communities (Picou and Gill, 1996), and these stakeholders have a justifiable interest in the outcome of the resulting activities.

Public review does not equal public involvement, although it should be part of an overall commitment to public involvement. Meaningful community participation must consist of more than providing employment to local residents (to work on projects conceived and run by others). Treating local residents only as a potential labor pool ignores the critical factor of *who* asks the research questions. This does not mean that employing local residents is trivial or wrong but rather that the continued identification of involvement exclusively with employment is unnecessarily narrow.

The committee believes that community involvement should be designed to promote meaningful participation and provide for flexibility as the GEM program evolves. In many respects the program will be breaking new ground in terms of integrating community involvement into a long-term science plan. The committee is under no illusion that successful incorporation of community involvement and traditional knowledge in the program will be easy, but we conclude that it is necessary.

DATA AND INFORMATION MANAGEMENT

The legacy of the GEM program will be the data it collects. Given the objective of establishing a long-term measurement program in the Gulf of Alaska and its importance to both regional and national interests, GEM must make a strong commitment to data and information management. The goals must be to facilitate data exchange among GEM scientific investigators, make data available to the public and others outside the scientific community, and archive GEM data products.

GEM will need to make a major commitment to fund data management activities, probably through a Data Management Office composed of a data manager, assistants, and the necessary infrastructure to organize, disseminate, and archive data. That office would develop data policies; implement a data management system; ensure preservation of data with relevant documentation and metadata; review data management efforts; enforce data policies; and facilitate exchange of data with related oceanographic programs. GEM needs to be committed to the timely submission and sharing of all data collected by its researchers.

Data management must have sufficient resources to accomplish its mission. Successful coastal monitoring efforts allocate as much as 20 percent of their total budget to data management (Sustainable Biosphere Initiative, 1996; Weisberg et al., 2000).

The general description of the data management architecture in the draft GEM science plan is very good. The basic functions of data receipt, quality control, storage and maintenance, archiving, and retrieval are adequately addressed. The report recognizes that different types of data products will be needed for basic research and analysis, modeling, resource management applications, and public outreach. Access to the data archives and software display will be an important component of public outreach. There will be multiple levels of complexity to data access, ranging from users with limited experience to use by the investigators who gathered the data.

SYNTHESIS, MODELING, AND EVALUATION

The committee understands the difficulty of writing a science plan to guide the GEM program for the next 100 years. It is simply not possible to know everything that should be addressed. Thus, the plan will need to be flexible. It must include procedures requiring synthesis of knowledge at specific points in time and opportunities to evaluate past efforts and make adjustments in direction.

An initial synthesis needs to include several components. The first step for the GEM program to be successful, a much needed literature review, has been completed in the "Scientific Background" section in Volume II, Part 3 of the GEM plan. The second step, compilation, assessment, and analysis of data, has not been done. This step is critical to the third step, which is a synthesis of *Exxon Valdez* oil spill research from 1989 to the present. Although a few Trustee Council-supported programs have completed synthetic views of their results (e.g., *Fisheries Oceanography*, Vol. 10, Suppl. 1, "A Sound Ecosystem Assessment Synthesis"), many have not.

The knowledge gained and publicized about Prince William Sound is extensive because of Trustee Council funding. Retrospective analyses have led to new hypotheses and ideas in many instances; there is, however, much more to be gained from the past studies that should be used to direct the future of GEM. The synthesis of data and assessment of what has been learned in the recent studies will provide a baseline from which to develop hypotheses to guide GEM research. Annual reports are not peer-reviewed publications and do not qualify as syntheses.

Synthesis and modeling are interconnected. For example, initially one could create a conceptual model to identify quantities that need to be measured, collect data, synthesize data, and then create a more refined quantitative model. Alternatively, one could collect and synthesize data, and then generate a statistical model that could be used to collect more data to verify the model. Regardless of the order of these steps and the sophistication of the techniques, the components of synthesis and modeling are both critical. The combination of synthesis and modeling provides tools for evaluation of past work, testing the appropriateness and accuracy of hypotheses, and generation of new hypotheses.

The elements of a successful modeling component are outlined in the GEM plan. The GEM program should work toward more realistic and accurate numerical models for the prediction of ecological processes. The unparalleled opportunity of a long-term observation program in the Gulf of Alaska, coupled with a concerted effort in modeling, will produce exciting new tools for the management of the Gulf of Alaska's ecological resources.

CONCLUSIONS AND RECOMMENDATIONS

Opportunity for Sustained Study

Conclusion: GEM is an important opportunity to do truly long-term research in a marine ecosystem, and this long-term approach is essential to distinguish natural variability from human impacts. The long-term nature of the program, intended to cover a period of many decades, is the flagship contribution of the plan. Long-term research (i.e., monitoring) by definition must include sustained, consistent observations over a long period and thus requires a long-term commitment from the highest levels of decisionmakers. This commitment will require a substantial financial investment. Short- and medium-term research is an appropriate way to address current questions and management needs, but the fundamental importance of the long-term program should not be lost.

Recommendation: The majority of GEM funds should be spent on long-term research, that is, sustained observations of ecosystem components and ecological processes over decades. The committee concludes that the GEM program should emphasize long-term research and data management because this is its special contribution to scientific understanding in Alaska's marine environment; most other research programs are short-term. These long-term measurements will be necessary to differentiate the effects of natural variation from human-induced changes on the Gulf of Alaska ecosystem. The coastal Long-Term Ecological Research sites funded by the National Science Foundation provide good models of such long-term research.

Elements of a Sound Long-Term Research Plan

Conclusion: A sound, long-term research plan must clearly define its conceptual foundation, scope, organizational structure, data management methods, and methods for periodic synthesis and review. The conceptual foundation presented in the draft science plan is adequate and with modest restatement as a hypothesis could be a useful focus for research. The science plan and research objectives need to be directly linked to this conceptual foundation.

Recommendation: The current draft science plan (EVOSTC, 2001) needs to be shortened considerably by removing tangential materials so that it is a clear guide for the future. The conceptual foundation needs to be discussed early in the GEM planning document because that placement captures its importance as the fundamental building block on which the rest of the program depends. The science plan should include a broad conceptual foundation that is ecosystem-based. It should seek to understand natural and human-induced changes and it should be flexible to accommodate changing needs without compromising core long-term measurements. These hypotheses will provide a bridge between the conceptual foundation and the eventual implementation of the science program. Because the conceptual foundation states that the ecosystem is affected by both natural variability and human-induced change, as the plan is implemented both of these drivers should be addressed in studies.

Implementation of the GEM Program

Conclusion: The planning process for GEM has been difficult and costly, but the investment in planning is critical for success. Long-term measurements cannot begin until after the appropriate variables have been identified, and these must be based on the conceptual foundation and hypotheses. The planning and design of sampling will continue to take considerable time and effort in the early years of the program. It is more important to identify the right variables than to rush to collect data.

Recommendation: The GEM plan and planning process needs to provide careful consideration of what to measure, how often, and where, based on input from a broad cross-section of the scientific community, local communities, and managers. These decisions on hypotheses and attendant measurements should be made by the chief scientist working with the Scientific and Technical Advisory Committee and other independent scientists and stakeholders over the course of several years as program implementation gets underway.

GEM's Role in Gulf of Alaska Research

Conclusion: GEM's primary goal should be to develop a comprehensive and eventually predictive understanding of the Gulf of Alaska ecosystem. The long-term nature of GEM will enable it to serve as a framework for marine research in the Gulf of Alaska. Other programs will come and go on shorter time frames and should be encouraged to coordinate with GEM, but GEM does not have the resources to be the central coordinating body for all such efforts.

Recommendation: The focus of GEM should be its long-term program, and GEM decisionmakers should not try to do too much or this will dilute GEM's limited resources and impact. Because of the long time frame of GEM, it can provide a building block for partnering with other programs that will come and go, but it should not be distracted by the idea of assuming leadership of Gulf of Alaska marine research.

Recommendation: GEM should not see its role as filling the gaps in other programs, because adding these kinds of activities will inevitably erode funding for the GEM core measurements. This does not preclude GEM from involvement in other programs in which the research is addressing issues or collecting data that has been identified as necessary for addressing the central hypotheses of GEM.

Recommendation: It simply is not possible for GEM, given its resources, to play a leadership role in both scientific research and day-to-day support of resource management. GEM should not be involved in the types of monitoring that are typically the responsibilities of agencies. GEM should not subsume routine surveys, stock assessments, and data collection that have been the normal province of resource management agencies. Of course, a large monitoring program like GEM will supply much information that is useful to resource management agencies as a result of its own activities.

Community Involvement

Conclusion: The GEM plan does not currently describe effective and meaningful ways to involve local communities. This involvement should occur at all stages, from planning (e.g., selecting the questions to be addressed and variables to be monitored) to oversight and review. Local knowledge and traditional ecological knowledge can be used to generate ecologically sound and socially relevant research ideas. Science and community partnerships can lead to achievements that neither could attain independently. Specifically, such collaborations provide scientific knowledge as well as community education and local support of science. These outcomes are important especially because of the long-term nature of GEM; such involvement might be less critical in shorter programs, but the century-scale requires the establishment of long-term bonds.

Recommendation: The Trustee Council and GEM program staff must continue to seek ways to build meaningful community involvement at all stages of planning and implementation, from selecting the questions to be addressed and identifying the variables to be monitored to providing program oversight. It was outside the scope of this committee to advise specifically on what programs or methods to use; neither are we as experienced as GEM staff in dealing with Alaska's diverse communities of interest. Nonetheless, we are certain that the community involvement debate will continue until better resolution of this issue is found.

Geographic Scope

Conclusion: No program can be expected to meet the needs of all potential data users, and tradeoffs are inevitable between the intensity and spatial range of sampling. That is, if the scope of GEM is physically large, then its long-term research component will be able to collect less information at any one site (because there is a finite amount of information that can be collected with finite financial resources). If the scope of GEM is physically smaller, there can be more monitoring sites or more types of information collected. Research projects and sampling will need to be selected very carefully to avoid diluting activities so that their usefulness is limited. GEM planners can choose to obtain more limited information from a large area or more in-depth information from a smaller area.

Recommendation: GEM planners must make an explicit choice on how to focus the program's research. There are many options for carrying out coordinated research that avoids piecemeal projects. One option is to concentrate on a particular geographic area, as the committee recommended in its interim report. Another possibility is to target a few variables across a broad geographic range, such as measuring physical oceanographic variables over long time periods (temperature, salinity, currents). It is possible to concentrate attention on particular habitats in a large geographic range. These choices must be guided by the conceptual foundation and the hypotheses selected for investigation.

Using Habitat as an Organizing Concept

Conclusion: GEM or any large research program can organize its effort and funds in many ways and still be successful. The habitat approach described in the GEM science plan is one way of dividing attention and funds, and it has the advantage of being understandable to many of the program's key stakeholders. GEM planners need to be aware of its one critical disadvantage: a habitat approach can fail to address key linkages, flows, and processes between habitats, which is where many of the most interesting lessons of the long-term GEM program might be seen.

Recommendation: Given the habitat approach selected GEM planners must make a concerted effort to ensure that the program has clear, concrete mechanisms to address cross-habitat links. This does not necessarily mean creating a linkage subcommittee but rather building into each habitat study the opportunity to make measurements of flows among habitats and highlight other interactions. Across-habitat connections must be addressed during synthesis and modeling. These efforts are essential to creating a truly integrated program, where the whole is greater than the sum of the parts.

Organizational Structure

Conclusion: The GEM research plan is being developed to carry out long-term research, short-term research, and synthesis and modeling of data sets. Soliciting proposals, evaluating proposals, and the time frame for the research effort and its funding will differ for these scientific activities. The current science plan does not distinguish among these activities in terms of the procedures necessary to manage them and achieve useful results, or even that the goals of these three approaches differ. Strong scientific guidance is required through all the activities of GEM.

Recommendation: GEM planners, with input from the science community, should identify how these three kinds of scientific endeavors will be incorporated and managed within the science plan. For instance, long-term research projects (i.e., monitoring), short-term research projects, and synthesis efforts will require different mechanisms for proposal solicitation and evaluation and different time frames for funding.

Recommendation: The scientific leadership of the GEM program should be in the hands of a chief scientist advised by a Scientific and Technical Advisory Committee. The chief scientist should have adequate assistance to execute the program.

Conclusion: The organizational structure supporting GEM should be set up to ensure ongoing, independent scientific oversight and review. It should be easy for new researchers and local community members to be involved in planning and carrying out the research projects. If the Scientific and Technical Advisory Committee is to function effectively and play a leadership role in developing and directing the GEM scientific and technical program, its membership must be selected carefully.

Recommendation: The Scientific and Technical Advisory Committee will play a key role in leading the GEM program and ensuring program credibility. Committee members should be chosen based on their scientific expertise and their ability to link across the marine habitats and disciplines. To obtain the best program oversight over time there should be regular rotation of the members of all advisory groups, such as the Scientific and Technical Advisory Committee. Advisory Committee members should be and should be perceived to be neutral parties who are focused on the long-term success of the program. Members may need to be compensated for their service; they should have term limits of three to five years with no direct GEM research funding during their period of service.

Recommendation: The design of proposal solicitations and final recommendations for Trustee Council funding should be major functions of the Scientific and Technical Advisory Committee and chief scientist. In designing proposal solicitations, the Advisory Committee should be responsible for developing the scientific and technical subjects required to address GEM goals. Community workshops hosted by the Scientific and Technical Advisory Committee would be one method to help articulate community-generated research needs and could be a way to increase the participation of local communities that use Gulf of Alaska resources. The Scientific and Technical Advisory Committee and chief scientist should be responsible for organizing workshops designed to provide input on core variables to be measured over time. Final decisions on variable selection can be based on hypotheses proposing how each variable provides insight into human and climate-based changes in the ecosystem.

Recommendation: There should be an open process for nominating individuals to serve on the Scientific and Technical Advisory Committee, both during its initial formation and as the GEM program continues. Various independent scientific groups can assist in the initial formation to help broaden the selection process and find candidates with suitable experience in the initiation and implementation of large-scale, long-term ecological research. The chief scientist should review the nominations and recommend selections, with appropriate documentation, to the Trustees, who are responsible for the appointments.

Data and Information Management

Conclusion: There will be significant costs associated with data and sample processing and with data archiving. It is a common mistake to underestimate the cost of data and information management. To extract the full scientific value of any research program data and information must be made available to the scientific community, resource managers, policy makers, and the public on a timely basis. Each of these audiences will require information in a different format. The committee commends the initial development of data management procedures; careful implementation of these procedures is key.

Recommendation: GEM should create a comprehensive Data Management Office (not just an archive but a group of people who address these issues). Other large science programs spend as much as 20 percent of funds on data management. The multi-decadal scale of GEM will require a similar commitment.

1

Planning Long-Term Ecosystem Science

In 1989 the T/V *Exxon Valdez* spilled about 11 million gallons of crude oil into Prince William Sound in Alaska, setting off a cascade of effects that still have repercussions more than a decade later (Figure 1-1). One result was that in 1991 the U.S. District Court approved a civil settlement that required Exxon Corporation to pay the United States and the State of Alaska $900 million over 10 years to restore the resources injured by the spill and to compensate for the reduced or lost services (human uses) the resources provided. Under the court-approved terms of the settlement the *Exxon Valdez* Oil Spill Trustee Council made up of three federal and three state members was formed to administer these funds. The mission of the Trustee Council has been to return the environment to a "healthy, productive, world-renowned ecosystem" by restoring, replacing, enhancing, or acquiring the equivalent of natural resources injured by the spill and the services provided by those resources. It also set aside some of the funds to create a permanent trust to support continued, long-term research and monitoring in the region. At this point the Trustee Council is developing a plan to guide this new research program, to be known as the Gulf Ecosystem Monitoring (GEM) program.

As part of its mission the Trustee Council has disbursed research funds for almost 10 years, at first for damage assessment activities and then for monitoring and research to better understand the ecosystem and to understand impacts of the oil spill on important "resource clusters," or communities/resources (e.g., salmon, herring, marine mammals, subsistence resources). Extensive research has been conducted over the decade, making this the most studied cold water marine oil spill in history. In keeping with its mandate and after extensive public input the Trustee Council decided to use the trust fund to support continued research and monitoring in the region into the future. The GEM program has a unique opportunity to obtain the long time series of data necessary to support research on the effects of decadal-scale change on the structure, function, and ability of a marine ecosystem to provide goods and services to people. This research program will provide the depth and continuity of data collection necessary for both practical management lessons and deeper understanding of the causes and effects of ecosystem change.

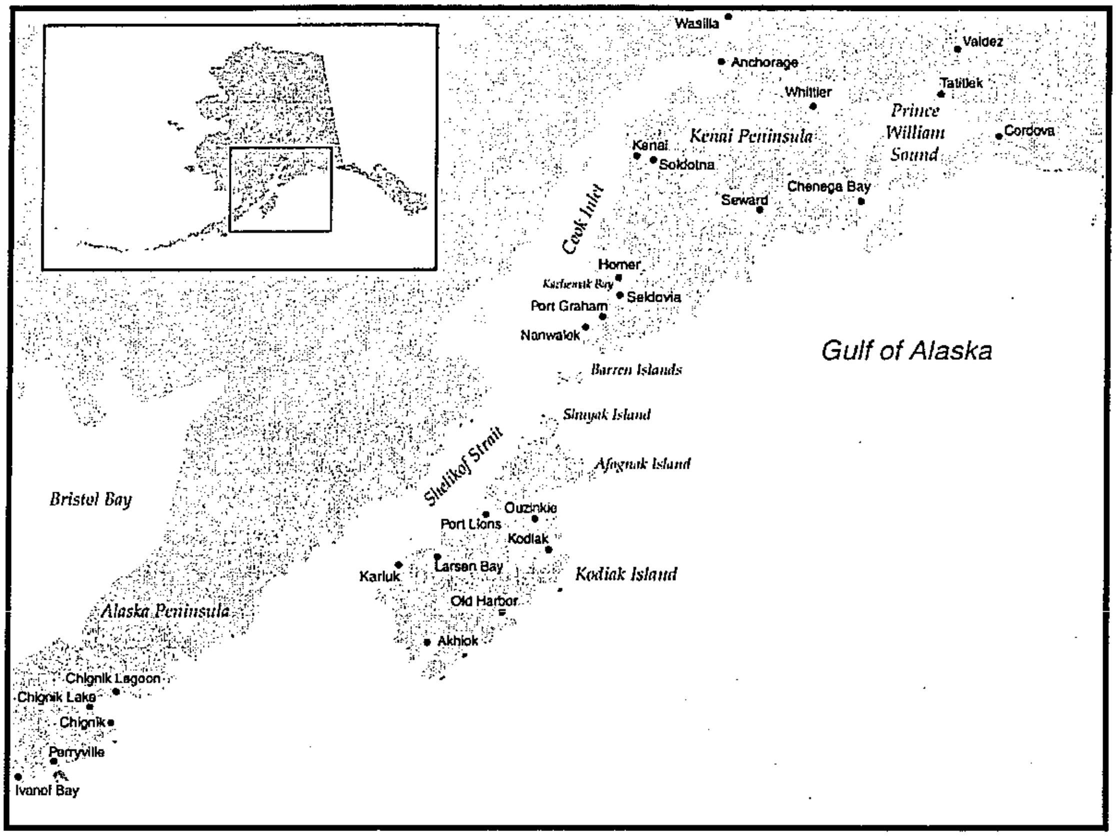

FIGURE 1-1 Region encompassed by GEM.

The Trustee Council showed great foresight in setting aside funds over the years to create the trust fund that will now provide long-term funding to the GEM program. As envisioned, the program will offer an unparalleled opportunity to increase understanding of how large marine ecosystems in general, and Prince William Sound and the Gulf of Alaska in particular, function and change over time. The committee believes that it stands to be a significant program of importance to Alaska, the nation, and the scientific community.

THE COMMITTEE'S CHARGE

To ensure that its plan for long-term research and monitoring in the Gulf of Alaska ecosystem is the best possible, the Trustee Council asked the National Academies for assistance, and a specially appointed committee was formed to review the scope, content, and structure of the draft science program and draft research and monitoring plan. The Committee to Review the Gulf of Alaska Ecosystem Monitoring Program was asked to provide independent scientific guidance to the Trustee Council, research community, and public as the Trustee Council develops a comprehensive plan for a long-term, interdisciplinary research and monitoring program in the northern Gulf of Alaska. Specifically, the committee was charged to

- gain, through briefings and literature review, familiarity with the relevant body of scientific knowledge, including but not limited to that developed by the research and monitoring activities sponsored by the Trustee Council in the past.
- convene one or more information-gathering meetings in Alaska, where researchers, the public, and other interested people can convey their perspectives on what the research and monitoring plan should accomplish.
- review the general strategy proposed in the draft science program (which includes information on the social and political context, mission, approach, and scientific background) and make suggestions for improvement.
- review the draft research and monitoring plan, including the scope, structure, and quality of the approach proposed for a long-term research and monitoring program in the northern Gulf of Alaska. This includes whether the conceptual foundation provides an adequate basis for long-term research and monitoring, and whether the research and monitoring plan adequately addresses gaps in the knowledge base and existing uncertainties.

Since this committee was formed in June 2000 we met five times to discuss the GEM program and consider the strengths and weaknesses of the program's planning documents. We have conveyed our comments and recommendations in a letter report (November 2000) with advice on program timing and in a more detailed interim report (February 2001) that critiqued an early draft of the program's science plan. These reports focused on the early planning for GEM, were specific to the draft planning documents, and were primarily directed to program staff. In this final report we provide broader comments and a document that has more general and longer-lasting lessons about which elements are essential to the success of a long-term research and environmental monitoring program such as GEM.

ELEMENTS OF A SOUND LONG-TERM SCIENCE PLAN

The world's oceans have long been viewed as producing an inexhaustible supply of protein and other goods and services for human use. But evidence of the adverse effects of human activities on marine ecosystems is increasing and reminding us that the ocean's resources are not inexhaustible (NRC, 1999a). It is increasingly clear that the structure and functioning of marine ecosystems is profoundly linked to variability and changes in ocean climate and that those changes can occur rapidly. One of the greatest challenges facing society, and particularly managers of marine living resources in the Gulf of Alaska and elsewhere, is to understand the relative effects of human activities and natural changes in ocean climate on the goods and services supplied by marine ecosystems (NRC, 1996).

Why is this so difficult? One reason is that marine ecosystems are large, complex interactive systems in which organisms, habitats, and external influences act together to regulate both the abundance and distribution of species (NRC, 1999a). Species interactions and the effects of variability in ocean climate on those interactions occur at spatial scales ranging from centimeters to hundreds of kilometers and on temporal scales ranging from minutes to decades. Human activities also act at various scales and may act selectively on certain components of an ecosystem (e.g., higher trophic levels), although such activities can have cascading effects throughout marine ecosystems (Carpenter et al., 1985; NRC, 1996). These disparate spatial and temporal scales make it difficult to measure the processes affecting marine ecosystems and to monitor ecosystem structure and functioning (Weisberg et al., 2000). The diversity of temporal scales at which important processes affect marine ecosystems makes it difficult to measure many of these processes over short periods of time. Finally, perturbations to marine ecosystems often appear to act in subtle, nonlinear ways making it difficult to understand the consequences on ecosystem components that may be of particular interest to society, such as birds, mammals, and fishes. Given these challenges, we commend the Trustee Council for having the vision to develop a long-term ecological monitoring program that stands to have great enduring value to the stakeholders of this vast and diverse marine ecosystem.

Good management requires good information and the knowledge of how to use this information to predict the outcome of management decisions. Thus, a prerequisite of good management is good science. As the committee noted in its interim report, given the complexity of marine ecosystems and the failure of single-species management to produce sustainable fisheries in many parts of the world (NRC, 1999a), it is not surprising that both scientists and managers have increasingly promoted the concepts of multi-species or ecosystem-based management. However, it is clear that not enough is known about most large marine ecosystems, including the Gulf of Alaska, to implement a useful whole-system approach to management.

It is reasonable to ask what an ecosystem-based approach to management could provide in the medium term that a single-species approach cannot. The National Research Council's Committee on Ecosystem Management for Sustainable Marine Fisheries considered two benefits (NRC, 1999a). One benefit is that it broadens the policy framework to include a wide range of ecosystem goods and services and it acknowledges the critical role of ecosystem processing in providing those goods and services. Another benefit is that there is an explicit recognition that segments of society may have different goals and values with respect to marine ecosystems and that those goals and values may conflict. The committee believes that the promise of an ecosystem-based approach to resource management, which recognizes the changing nature of both the physical environment and species interactions and the fact that many of these changes occur at time scales greater than several years, provides a forceful scientific rationale or conceptual foundation for the GEM program. The other benefit is an explicit recognition that segments of society may have different goals and values concerning marine ecosystems and that those goals and values may conflict. To meet its goals effectively the GEM program must take a longer (interdecadal) view at appropriate spatial scales.

GEM can respond to current concerns without sacrificing long-term data sets that will prove increasingly useful as they accumulate. A well-designed and broad-based program will provide the best possible scientific basis for dealing with short-term ecological issues of public concern. Indeed, a strongly designed program will provide a sound basis for additional attention to be paid to matters of urgency or immediate public concern, even if they are not central to the program itself. However, GEM will have to be carefully constructed to avoid being excessively distracted by real or perceived ecological crises. It will, therefore, be important to define clearly not only the program goals in terms of scientific questions but also the products of the program that are expected to be of value to managers (Weisberg et al., 2000). As stated by Weisberg et al., "The most successful programs have been those with clearly defined users for the data they produce, which requires early interaction between scientists responsible for designing the program and targeted data users." The GEM program should not be used to substitute for routine monitoring and stock assessment activities that have customarily been the province of state and federal agencies. Such a use of GEM funding would constitute a tragic waste of an extraordinary opportunity.

As conceived, GEM is meant to be a long-term monitoring activity, and long time series are essential to detecting change on intermediate and long time scales. It is vital to recognize that long-term monitoring per se will not necessarily lead to a better scientific understanding of the ecosystem. The value and utility of monitoring critically depends on the variables measured, the spatial and temporal extent, and intensity of sampling. Without clear vision at the outset it is difficult to establish monitoring programs that will provide useful data for sound resource management. This is why the monitoring program must have a strong conceptual foundation and be hypothesis-driven (Box 1-1).

BOX 1-1

Providing Focus By Selecting Key Research Questions

GEM is a unique opportunity to establish a realistic long-term monitoring program. Thus one logical approach would be to focus the program around long-term monitoring as the core activity, with smaller elements added to meet other goals, and base the science plan around this two-prong structure. To make success more likely program planners would need to select a few key questions to guide the work, and these questions in turn should be based on some clear conceptual model (e.g., NRC 1995, 2000). One way to begin is to ask what parameters are most able to provide insight into the desired questions if there is a long time series of data available. Another approach is to identify the questions for their own sake and let them suggest the parameters to be monitored.

The questions listed in Appendix C 2 of EVOSTC (2000a) are a good start. The quality and relevance of the questions suggested by members of various communities that made presentations in Anchorage on October 6, 2000, were excellent. For example, the question about the degree to which ocean conditions (productivity) affect the growth and survival of juvenile salmon and hence the degree to which science can help predict the probable percentage of returns from hatchery releases is very relevant. To answer this question requires information on physical, chemical, and biological features of the ocean, including information about salmon. Long time series of information on such factors would not only help answer the specific question but would be of great use for understanding related questions, such as insights into fluctuations in the populations of other important ecosystem components, including marine mammals, crabs, marine birds, and herring.

Several approaches could provide greater focus on GEM during implementation, even given its broad mission and goals. The committee is not recommending these as the "right" tasks, but as illustrations of the range of thinking that is necessary.

- Develop a whole-ecosystem fishery model as a guide to think about what needs to be monitored. Such a model would use current and historical data to relate yields to climate data and contaminant levels and might stress biological and physical endpoints (zooplankton and phytoplankton blooms, macrofauna populations) and climate and physical oceanography endpoints, in conjunction with modeling.

- Identify indicator taxa for monitoring. Species should be selected based on the ability of monitoring information to provide information on ecosystem functioning, not solely to reflect economic value or political importance. This takes smart choices so the indicator species reflect a wide set of variables for measurement and serve as sentinels to provide clear and early warning of change.

- Conduct or take advantage of large-scale adaptive management studies that others implement. The Trustee Council does not have the authority to impose management changes, but it could, for example, follow population trajectories in areas with and without fishery closures or record biogeochemical variables in bays before and after aquaculture operations are instituted.

The unique aspect of GEM is the guarantee of funding over a long time frame and the possibility of consistent, long-term measurement of species and processes in the Gulf of Alaska and Prince William Sound. Although it will require sustained commitment, long-term monitoring is an essential underpinning of the major goals of the GEM program, which stands to have great value as a model for how to monitor and understand other complex marine ecosystems. After all, the management issues facing users of Prince William Sound and the Gulf of Alaska are much the same as those found elsewhere in Alaska's marine waters and around the globe. Making long-term research the focus of GEM will create greater benefits to both basic understanding of the gulf ecosystem and its long-term management than would an abundance of short-term projects, many of which could be funded in other ways.

Monitoring over extremely long time periods, such as envisioned in GEM, cannot be differentiated from research; research designed to evaluate the ecological impact of climate change is of longer duration that the familiar three- to five-year process studies (Box 1-2). The development of long time series measurement is a crucial research tool for understanding ecosystem function. Along with the opportunity afforded by GEM comes an obligation to craft a research plan that can withstand the test of time. This requires a core set of measurements that can be taken consistently and indefinitely, as well as flexibility to alter both conceptual understanding and research interests. Long-term programs should be modified only when a compelling case is made that change will improve the program (Weisberg et al., 2000).

The committee identified a number of elements deemed essential for a successful long-term science program of the magnitude necessary to fulfill the mission statement and goals articulated for the GEM program by the Trustee Council (EVOSTC, 2000a). These elements are similar to those in a recent synthesis of lessons learned in a number of large-scale coastal monitoring efforts (Box 1-3; Weisberg et al., 2000). In addition, the committee examined a number of existing science plans for lessons to help guide GEM planning (Box 1-4); although great variety was found in these plans, they generally confirm the importance of the elements determined by this committee as important.

BOX 1-2

Monitoring versus Research

In oceanography today repeated measurements made for long periods of time are termed monitoring. Repeated measurements are made over shorter periods of time are termed scientific research. The only difference between the two is the duration of the sampling. Since the purpose of the long- and short-term measurements is the same, that is, observing the oceans, both should be considered as aspects of scientific research. Therefore, monitoring and research are indistinguishable from one another except in duration of the observations.

It is expected that some measurements will be made over the entire duration of GEM, whereas others will be of briefer duration—years, months, days, or hours. The short-term measurements will allow the study of short-term processes, but their contributions to scientific research are not necessarily greater or lesser than the sustained observations. Therefore, the GEM research program should consist of ocean observations of various durations with short-term sampling embedded within the sustained observations.

Elements seen as essential to the GEM program include:

1. *A conceptual foundation.* A conceptual foundation expresses the main focus of a plan and provides a general picture of how parts of the ecosystem function and interact. A broad conceptual foundation with a sound scientific basis provides a strong scientific justification for a program and helps to defend it from criticism and political pressures over time. It provides an intellectual structure that can guide modification of the program if that becomes necessary.

2. *A scope and geographic focus for study.* In any ecosystem study, a trade-off exists between the extent of the region to be studied and the quality, density, and frequency of measurements (Weisberg et al., 2000). It is necessary to identify that portion of an ecosystem that can be monitored with sufficient intensity to provide the density of measurements needed to identify change at the desired level of scientific confidence. The *Exxon* Valdez Oil Spill affected Prince William Sound, the northern and western Gulf of Alaska, and lower Cook Inlet. Selecting an appropriate subset of the northern Gulf and its adjacent waters that can be studied over the long term as a connected whole will challenge the GEM program.

3. *Scientific leadership.* GEM must have strong scientific leadership. A Scientific and Technical Advisory Committee should provide scientific oversight and

ensure the scientific integrity and quality of the GEM program. An appointed chief scientist or science director should have responsibility for leading and implementing the GEM science program.

The selection of particular projects and observations is achieved through a program's organizational structure, influences who is involved in honing the conceptual foundation into testable hypotheses and research questions, and how open the program is to new personnel and ideas. A vibrant and innovative program must encourage new people to become involved over time, yet long-term plans inevitably reward people with previous experience.

Periodic external review of the science program can ensure that the chief scientist and the Scientific and Technical Advisory Committee have the vision and discipline necessary to run a successful program.

4. *Involvement of stakeholders in the planning process.* Large scientific programs designed to understand ecosystems used by a variety of different communities require the support of those communities if the programs are to be of maximum utility. Communities affected by such studies include not just program managers and the scientists involved in conducting research, but also those who live adjacent to the ecosystem, those who harvest resources (whether for subsistence or commercial use) in the ecosystem, and those who use the ecosystem for recreation. When those diverse communities can be brought together to plan the studies, rather than just being asked to approve or comment on what others have planned, there is a greater chance of a more holistic view of the goods and services of concern to society and thus the opportunity to design a more satisfactory science program that will enjoy long-term community support.

5. *Management of data to ensure safekeeping and accessibility.* Data management is crucial to a monitoring program because of the need for storing and retrieving large amounts of data (Weisberg et al., 2000). Large long-term scientific studies generate enormous amounts of data, data that must be useful far into the future. One fundamental aspect of data management is that it be designed specifically to support the central purpose of a long-term science program, that is, the comparison of measurements over long periods of time. First it is essential that there be a mechanism for archiving data that will be durable and that permits data transfer from one storage medium to another as technological innovations appear. A second challenge is to support real-time sharing of data within the program, which is essential for collaboration and integration between disciplines and geographic subdivisions of the study. Third, there needs to be public access to data and data products so that the broader community can assess the progress of "their" ecosystem study. Delivery of timely and appropriate data products will be essential if decision makers are to benefit from the program (Weisberg et al., 2000). The successful accomplishment of these three elements makes the data management program the heart of a large long-term scientific program.

6. *Assessment of progress via synthesis and evaluation.* Synthesis and evaluation are essential scientific activities. They provide information on whether a program is making progress toward testing hypotheses and in achieving an understanding of ecosystem function. Syntheses will require a variety of modeling efforts (conceptual, statistical, and numerical), and one should be aware that both the modeling of results and

the acquisition of data will vary considerably between physical and biological aspects of the research program (Weisberg et al., 2000). Although generating syntheses of long-term data from these different disciplines is likely to be a challenge, doing so will be important to the long-term success of the GEM program.

This report is divided into sections that address the above elements and includes insights drawn from other long-term science plans regarding issues such as governance structures and data management. Finally, the committee summarizes its conclusions about planning the GEM program and provides recommendations to help guide its continued development.

BOX 1-3

Themes Needed in All Coastal Monitoring Programs

1. Clearly define program goals and anticipated management products.
2. Recognize the differences between physical and biological monitoring.
3. Differences in space-time scales among ecosystems affect sampling design.
4. Develop an effective data dissemination strategy.
5. Develop data products that will be useful to decision makers.
6. Provide for periodic program review and flexibility in program design.
7. Establish a stable funding base and management infrastructure.

BOX 1-4

Common Elements of Other Science Plans

The term "science plan" has an elusive definition, encompassing documents as disparate as specific research proposed for the upcoming field season (e.g., Palmer Station Long-term Ecological Research) and new visions of multi-disciplinary research to inspire funding (e.g., RIDGE 2000). We examined a number of science plans in an effort to define our expectations of the GEM program plan. These plans are described briefly here.

1. The Long-term Ecological Research (LTER) funded by the National Science Foundation (NSF) is perhaps the premier long-term scientific monitoring program in the United States. The coastal LTERs (e.g., Everglades, Georgia, Santa Barbara) are of particular relevance to the GEM program because they—like GEM—consider the connection between marine and terrestrial ecosystems. In addition to perhaps providing some ideas to follow as models for GEM, there are opportunities for scientific exchange between scientists working on those LTERs and GEM scientists, and perhaps even the possibility of joint activities, especially where large-scale processes are involved. Many of the Long-term Ecological Research (LTER) sites include science plans or proposals outlining the goals of on-going research and organizational structure of personnel involved in projects and administration. <http://lternet.edu>.

2. SOLAS (Surface Ocean Lower Atmosphere Study) seeks "to achieve quantitative understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and the atmosphere, and how this coupled system affects and is affected by climate and environmental change." SOLAS has three foci: biogeochemical interactions and feedbacks between ocean and atmosphere; exchange processes at the air-sea interface and the role of transport and transformation in the atmospheric and oceanic boundary layers; air-sea flux of CO^2

and other long-lived radiatively active gases. The science plan addresses the importance of modeling and long time series. <http://www.ifm.uni-kiel.de/ch/solas/plan-index.html>.

3. The science plan for EOS (Earth Observing System) justifies measurements being taken using a variety of remote-sensing techniques. Among science plans it is unusual in being exceptionally long (the summary alone is 64 pages) and incorporating mostly background rather than unanswered questions. No organizational structure is outlined, presumably because this fits within NASA structures. "The Earth Observing System (EOS) Science Plan is the product of leading scientists around the world who are participating in NASA's ESE/EOS program. The purpose of the Plan is to state the concerns and problems facing Earth Science today, and to indicate contributions that will be made toward providing solutions to those problems, primarily through the use of satellite-based observations that will be obtained with EOS satellites and instruments." Seven focal areas are: atmospheric circulation, ocean, atmospheric chemistry, hydrology, cryosphere, stratosphere, and volcanoes. <http://eospso.gsfc.nasa.gov/sci_plan/chapters.html>.

4. The SALSA (Semi-Arid Land Surface Atmosphere program) science plan was prepared by the U.S. Department of Agriculture's Agricultural Research Service to inspire and encourage collaboration. Much like the GEM program, "the Semi-Arid Land-Surface-Atmosphere Program is a multi-agency, multi-national global-change research effort that seeks to evaluate the consequences of natural and human-induced environmental change in semi-arid regions. The ultimate goal of SALSA is to advance scientific understanding of the semi-arid portion of the hydrosphere-biosphere interface in order to provide reliable information for environmental decision-making. SALSA will accomplish this through a long-term, integrated program of observation, process research, modeling, assessment, and information management, using both existing and innovative technologies, and sustained by cooperation among scientists and information users." Unlike the GEM program, SALSA has no money of its own; government agencies intend to provide data management capacity and to encourage and enhance scientific collaboration. <www.tucson.ars.ag.gov/salsa/archive/documents/plans/salsascienceplan.PDF>.

5. PSAMP (Puget Sound Ambient Monitoring program) documents are not billed as a science plan, but they demonstrate how one group has justified the use of indicators in a marine system. "Monitoring and research are vital to understanding the status of Puget Sound's health. The Puget Sound Ambient Monitoring Program (PSAMP) brings together local, state, and federal agencies—coordinated by the Action Team—to assess trends in environmental quality in the Sound. Information from the program is used to evaluate the effectiveness of the management plan and set priorities for the work plan. Through PSAMP studies, data on marine and fresh waters, fish, sediments and shellfish in Puget Sound have been collected since 1989; surveys of nearshore habitat have been conducted since 1991; marine bird populations have been surveyed since 1992; and marine bird contamination has been studied since 1995." <http://www.wa.gov/puget_sound/Programs/PSAMP.htm>.

6. RIDGE (Ridge Inter-Disciplinary Global Experiments) 2000: "This plan is the product of three highly interdisciplinary planning meetings attended by more than two hundred scientists. Attendees strongly endorsed the creation of a RIDGE 2000 program that will work towards a comprehensive, integrated understanding of the relationships among the geological and geophysical processes of planetary renewal at mid-ocean ridges and the seafloor and subseafloor ecosystems that they support. Studies under this new program will be defined by an integrated, whole-system approach encompassing a wide range of disciplines, and a progressive focus within scientifically defined, limited geographic areas." The science plan distinguishes integrated (multiple disciplines focused on one place), exploratory (discovery of new places), and time-critical studies (responding to tectonic events). Each category is addressed in terms of overarching goal (conceptual foundation), questions and hypotheses, and the scope or approach

for answering the questions. Technology (measurement devices) and infrastructure (data management) are addressed at the end of the plan. Because the plan was written to motivate federal funding of portions of the plan, there is no explicit description of organizational structure. <http://ridge.oce.orst.edu/R2K/R2Ksciplan/>.

7. "The IPRC (International Pacific Research Center) Science Plan defines the Center's overall structure. It states the IPRC mission, presents four scientific themes and goals, describes specific objectives, and outlines strategies for attaining them." Three of the themes are geographic, focused on Pacific and Indian ocean climate variation, effects of western Pacific Ocean flows on climate, and the Asia-Australian monsoon system. The fourth theme addresses global change as it affects Asia-Pacific climate. The plan includes personnel and infrastructure requirements, and mechanisms for internal management and external guidance. <http://iprc.soest.hawaii.edu/iprc_science/>.

These brief descriptions should make it clear that almost all have at their core a working understanding of the structure and function of a complex environmental system. Surprisingly, many of the plans incorporate long-term change or natural versus anthropogenic change in this conceptual foundation. The following elements are common to many of the plans we examined:

1. The conceptual model and hypotheses to be tested are defined early in the plan.
2. The scope of the plan is defined in terms of place (PSAMP), linkages and flows (SOLAS), or habitat (SALSA, RIDGE).
3. Products relevant to management or plans for outreach are described.
4. Data management strategies are provided.
5. The goals of most programs are expected to be achieved through a combination of long-term research, short-term research, and modeling and synthesis.

These common elements map fairly well onto the elements the committee evaluated for GEM: conceptual foundation, scope, community involvement, data management, and synthesis and review. We note the lack in most plans of explicit descriptions of organizational structure. This lack probably occurs because the organizational structures are already in place (for instance, in NASA) or because they will never be in place (for many of the science plans that describe loose collaborations). GEM, however, requires an organizational structure to be defined that will disburse funds and involve communities effectively. One other major difference is the size of the plans: Most science plans (with the exception of EOS) tend to be 10-30 pages long. Such conciseness is intentional so that the purpose, scope, and methods can be synthesized down to a clear foundation, and knowing that the scientists involved will work out as the program evolves.

The committee also notes that no plans are designed to involve local communities or traditional ecological knowledge in the formation of research questions and activities. Rather, these plans portray community involvement only through outreach. GEM is in the challenging but exciting position to craft a science plan that bridges science and society in ground-breaking fashion.

2

The Importance of a Conceptual Foundation

The stated mission of the Gulf Ecosystem Monitoring (GEM) program is broad and ambitious: "to sustain a healthy and biologically diverse marine ecosystem in the northern Gulf of Alaska 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" (EVOSTC, 2000a). According to this mission, GEM has a dual purpose: to sustain a healthy ecosystem *and* to ensure sustainable human uses of the marine resources. The second part of the mission statement assumes that these objectives will be accomplished by understanding how both natural changes and human activities influence ecosystem productivity. Implicit in this rationale is that it is possible to separate the causes of natural changes from human-induced changes. It also assumes that a successful monitoring program has to take into account both climate change *and* changing patterns of human exploitation (e.g., fishing practices), which could call for attention to a very complex array of variables.

The GEM program is a long-term monitoring program, and long time series are essential to detecting ecosystem change on intermediate and long time scales. The first step in any research program, particularly one such as GEM, is development of a conceptual foundation, which must be broad, because of the program's long time scale. No one can know what theories, taxa, or processes will emerge as critical to the public or managers or relevant to ecosystem functioning in future decades. The choice of a conceptual foundation is critical, as this will drive the choice of species and parameters to monitor. Conceptual foundations that rest on a few indicator species, specific hypotheses about marine ecosystems (e.g., Pacific Decadal Oscillation), or current human impacts (e.g., fishing) are likely to be too narrow and inflexible to support the GEM mission. Instead, the GEM conceptual foundation needs to incorporate the sense that marine ecosystems (processes and taxa) change in response to physical and biological changes and human impacts, as is clearly expressed in the mission statement. Even if the same endpoints for monitoring could be reached by choosing variables to measure in the absence of a broad conceptual foundation (NRC, 1995), it would be difficult to justify them without a conceptual foundation that provides the broad context and helps illustrate relationships.

A solid conceptual foundation will buffer GEM against inevitable shifts in public concerns, such as current concerns with Steller sea lions. Indeed, GEM is aware of the difficulty of pursuing long-term monitoring in the face of short-term interests. There are provisions for multi-decade measurements and for shorter research programs targeting specific issues or hypotheses, so that GEM can respond to current concerns without sacrificing long-term data sets that will prove increasingly useful as they accumulate. A well-designed and broad-based program will provide the best scientific basis for understanding many ecological issues of public concern.

Rendering the conceptual foundation into specific research activities implies the generation of questions. These questions can come from members of the scientific community as well as members of the native communities, fishing communities, state and federal resource managers, and any other stakeholders. The benefits of meaningfully incorporating local communities are twofold: local knowledge and participation can enrich the scientific program and reciprocally provide a broader basis of support and understanding for the program mission. Indeed, while it is appropriate and probably necessary that a scientific conceptual foundation be developed primarily by scientists, the ability of local communities to inform and provide knowledge of the ecosystem must be emphasized.

Finally, the conceptual foundation must be compatible with the mission of GEM. This mission, as stated in the program, is broad and somewhat indefinite. Despite its breadth, the mission does focus some attention on the reciprocal interactions between humans and the marine environment, although the emphasis is heavily on natural variability, with less attention to measuring human-induced change. Humans derive goods, services, and pleasure from the ocean and consequently, marine systems are affected by these human activities. This occurs in a context of regional climatic and oceanic change, changes that will inevitably and unpredictably occur during the time scale of GEM.

Almost all resource management issues require society to determine the cause of observed system changes. Thus, the conceptual foundation provides a framework for thinking about the kinds of measurements and studies that will be needed if we hope to understand the influences of environmental variation and human activities on the delivery of goods and services from the marine ecosystems. To do this effectively the architects of the GEM program have appropriately taken the long-term view.

The GEM conceptual foundation in the second volume of the August 31, 2000 draft science plan is adequate; it is broad enough to serve over time, interdisciplinary, and encompasses ecosystem interconnections. It deals with both oceanic and terrestrial ecosystems and the ways in which climate and humans influence the production of energy and its flow through these interconnected systems. With a modest restatement, so it is phrased as an hypothesis, the conceptual foundation could provide a useful guide for research:

> *"The Gulf of Alaska, its surrounding watersheds, and human populations are an interconnected set of ecosystems that must be studied and monitored as an integrated whole. Within this interconnected set, at time-scales of years to decades, climate and human impacts are the two most important driving forces in determining the amount of primary production and its transfer to upper trophic-level organisms of concern to humans."*

Given its importance as guiding force, the GEM conceptual foundation needs to be up front in the GEM science plan instead of in Volume II, Chapter 4. The committee interprets the placement of the conceptual foundation at the end of Volume II as an indication that it is of lesser importance than other elements of the draft science plan. Without a clear and prominent conceptual foundation, it will be exceedingly difficult for the GEM program to remain on course over the coming years as various short-term needs will divert resources and hinder long-term achievements.

The committee is therefore concerned that in the draft science plan it appears that the role of the conceptual foundation in shaping the GEM has been largely replaced by studies designed to meet short-term needs. There seems to be a critical change in the thinking about the GEM program, from a long-term scientific program driven by a cascade of hypotheses that would determine what, where, and when measurements should be taken, to a program driven by the need to conduct studies in a range of habitats and locations of dubious scientific connection. If this change in emphasis is implemented, GEM is unlikely to fulfill its potential and make unique contributions to improving our understanding of the structure and functioning of a marine ecosystem. We are also concerned that the GEM document gives more emphasis to natural variability as compared to human-induced changes on the Gulf of Alaska ecosystem when both are key parts in the conceptual foundation.

THE SCIENCE PLAN AS A BRIDGE BETWEEN THE CONCEPTUAL FOUNDATION AND A WORKING SCIENCE PROGRAM

A science plan provides the broad outline for translating a conceptual foundation into a working science program by expanding the conceptual foundation into a series of testable hypotheses, questions, or objectives. In the case of the GEM, these hypotheses might concern how energy flows through the various parts of the Gulf of Alaska and Prince William Sound marine ecosystems, and how climate variability at annual to decadal scales might interact with human activities to shape the goods and services obtainable from these ecosystems. Thus, the science plan provides a guideline for the implementation of the GEM program and is the initial guide to scientists, managers, and other stakeholders as they refine the program. While one might not foresee changes in the conceptual foundation of the program, the science plan would be open to modification as new information is gained.

In developing the science plan it may be useful to contrast the ways that we might expect climate and human activities to influence these marine ecosystems. One might expect that climate, through its influences on physical processes as well as through the rates of biological processes through the effects of temperature, will have its primary effects through bottom-up processes that determine the timing, amount, and fate of primary production, including its transfer from one habitat to another. These bottom-up processes are expected to dominate basin and shelf processes, including those in the Alaska Coastal Current. In contrast, one might expect that human activities, through harvest of marine resources, including fish, shellfish, and marine mammals, and through the addition of hatchery-raised fishes, will have their primary effects through top-down processes. In the case of the removal of commercially harvested species, the result may be a redirection of energy flow from commercially valuable species (e.g., pollock) to less desired species (e.g., arrowtooth flounder). These impacts are likely to be strongest in inshore and shelf habitats, including Prince William Sound. The other major human impact on this system, pollution, is likely to have its effects restricted to the nearshore, intertidal, and watershed habitats and may exert both top-down and bottom-up impacts. Climate and humans can under some circumstances affect either bottom-up or top-down processes and climate and human impacts may vary in type between habitats. The role of bottom-up and top-down processes in regulating basin, shelf, and watershed ecosystems should be considered when building and implementing a sound GEM science plan.

Questions stemming from the above general hypotheses that might be useful for guiding the development of the core set of measurements could include, for example: How does high (i.e., interannual) and low frequency (i.e., decadal or longer) variation in climate affect the timing, duration, and amount of primary production? How does the timing or duration of primary production influence the fate of organisms dependent on it? What are the fluxes of nutrients and materials between the habitats of interest, and how do these fluxes affect the eventual fate of production in sustaining species of interest to humans? What are the ecosystem-wide effects of the removal or addition of large biomasses of predatory fishes by humans? How does the introduction of pollution affect the ecosystem and how important is the timing, duration, and magnitude of pollutant release? How do fluxes of freshwater, nutrients, and organisms between watersheds and ocean environments affect the dynamics of the ecosystems of the region?

Although there are a number of subsidiary hypotheses presented in Chapter 4 of the GEM document (EVOSTC, 2001), there is little effort to tie them into the program's conceptual foundation or to explore how they might provide the connections needed between the conceptual foundation and the development of the science program. Thus, the GEM team has not used the conceptual foundation to develop its research plan. The conceptual foundation provides a clear, concise framework of the functioning of the Gulf of Alaska and Prince William Sound marine ecosystems. If the GEM is to be coherent and successful over the long term, the conceptual framework must be at the center of the program, with all research and monitoring emerging from and addressing it.

The development of the science plan from the conceptual framework will benefit from a review of existing data. Such a review should take advantage of the many years of research funded by the *Exxon Valdez* Oil Spill Trustee Council, as well as the results of the many independently funded research activities that have occurred in the northern Gulf of Alaska and adjacent waters. These syntheses should include investigation of what has been learned about ecosystem function in the Bering Sea, other areas of the North Pacific and in the sub-Arctic seas of the North Atlantic Ocean and the Barents Sea. The hypotheses used to focus GEM's long term research will set the course of the program for many years to come. Deciding on the best approach is not something that should be done quickly or without benefit of other programs. A carefully crafted conceptual framework and attendant hypotheses will determine the success or failure of the program.

A broad conceptual foundation with a sound scientific basis provides a strong scientific justification for the program. It provides an intellectual structure that can guide modification of the program if that becomes necessary. One might ask if this approach is too academic for a program that includes applied management goals and whether it would preclude the study of issues identified by managers or the public. The opposite is true. If the GEM program has a broad scientific foundation, then short-term issues of public concern can be addressed as elements in this broad construct. Even more important, a sound scientific framework would make it much more likely that the GEM program will collect the most useful and important ecological information. However urgent an environmental issue might be, understanding and managing it almost always depends on scientific understanding. Thus, a soundly designed program based on a scientific conceptual foundation should not be seen as an alternative to local community and public concerns. Instead, it should be recognized as the only way to do that effectively over the long term. The committee offers the following recommendations to achieve this broad goal:

- The science plan should include a broad conceptual foundation that is ecosystem-based. It should seek to understand natural and human-induced changes and it should be flexible to accommodate changing needs without compromising core long-term measurements.
- The GEM science plan should articulate two or three fundamental hypotheses about the ecosystem that then should be used to guide the selection for monitoring of particular species and other physical, biological, and human aspects of the ecosystem.

3

Determining Scope and Geographic Focus

SCOPE

Three interrelated elements must be defined when setting the scope of a science plan in order to focus attention and resources on a practical subset of the vast array of possible research questions. The first two elements, geographic focus and research approach, serve to set bounds on "where" the plan is applied. The geographic focus delimits the spatial extent of the plan. The research approach is the decision about how to divide research efforts in the geographic area. For instance, based on the program's main goals planners might elect to give disproportionate attention to particular habitat types, species, flows of energy or materials, or the consequences of specific perturbations. The third component of scope is determining generally "what" will be measured, which follows once the first two elements are agreed on and involves the selection of core long-term variables to measure.

GEOGRAPHIC FOCUS

When resources are finite, there are inevitable tradeoffs between the intensity and geographic focus of research. Multiple variables can be monitored in a small area, but only a few are feasible to monitor at multiple locations. The choice of geographic scale for a long-term science plan should include the following considerations:

Scientific criteria. Is the scale relevant to the hypotheses of interest? Specific questions about human-induced and other changes can be framed at a variety of scales. For example, at relatively small scales: How does the consumption of intertidal herbivores by humans affect algal production? At relatively large scales: Is offshore production, as indicated by chlorophyll, related to the nesting success of seabirds? According to its title, the GEM plan takes the Gulf of Alaska as its scope. However, the central hypothesis of the plan—that natural and anthropogenic factors interact to influence biological productivity – could be addressed at a variety of scales in the Gulf of Alaska.

Building on the knowledge base. As a new research program is developed it can build on past work in three ways: by continuing past work (extending the time frame), by collecting information on unstudied variables (extending the intensity), or by collecting information in unstudied locations (extending the spatial scale). The choice among these options requires that existing data be synthesized first. Many of the natural changes in the Gulf of Alaska are thought to cycle at intervals of several decades. Because little monitoring has been ongoing for such long periods, continuing past measurements may represent the most effective way of testing for variation at this temporal scale. Second, if two existing measurements show striking correlations, measuring new variables can be an effective way of testing the mechanisms of interaction among complex environmental factors. For instance, if ocean survival of salmon varies with phytoplankton production, then measuring forage fish abundance and demography could provide an intermediate food-web linkage. Finally, extending the spatial scale of measurements is important for determining the generality of hypotheses that have previously been tested only locally. This last choice in particular requires adequate synthesis of existing data; otherwise, it is impossible to ask whether existing patterns are general (because there are no existing patterns).

Management needs. Although GEM's mandate is not resource management, most large science programs are justified in part by the usefulness of products provided for decisionmakers (Weisberg et al. 2000). Most management issues are fundamentally local, because this is the scale of human impacts (barring atmospheric change); however, the precise locations where prior data would be useful can shift over time. For instance, baseline data in Prince William Sound would be useful if another oil spill occurred there, but it would not address eutrophication in Cook Inlet. A broad geographic scope can improve the chances that long-term measurements remain relevant as management issues change.

Accessibility and cost. Cost is the basic limitation setting the tradeoff between intensity and scale of monitoring. One drawback of a large geographic scope is that tremendous resources are required simply to travel to research sites. Travel costs may be reduced if monitoring is carried out in local communities and if automated data collection is used for basic measurements. Many hypotheses can be tested using a variety of methodologies, variables, or research sites. For instance, Pajak (2000) proposed 13 fundamental ways to measure ecosystem sustainability, incorporating ecological and social considerations, and provided six variables that would be suitable for each. It follows that cost could be used as a criterion for choosing among monitoring sites or variables with similar ecological importance.

The GEM plan has taken the entire Gulf of Alaska as its geographic scope. In its interim report the committee recommended that GEM initiate long-term research in Prince William Sound, then extend geographic coverage over time. The rationale underlying this recommendation was the difficulty of designing a useful research plan for a broader area given limited funds, coupled with the utility of extending time series at the core of the area affected by the spill in 1989. The Trustee Council is well within its prerogative to select any geographic scope, however, if the program is to be successful, the scope should be justified on science and management grounds and must be appropriate to the funding level.

Although it is possible to justify a focus on the entire Gulf of Alaska given the above criteria for selecting geographic scope, the committee is concerned that the geographic scope has been chosen primarily to be sure that all stakeholders get a "piece of the pie." Covering a large geographic scope in the absence of a scientific rationale (unifying framework) risks dividing resources in a piecemeal fashion that will make synthesis and interpretation difficult. Indeed, this problem is epitomized by the list of interim projects in GEM planning documents. There is a strong geographic focus on Kachemak Bay and Cook Inlet, for instance, which may reflect the distribution of humans along the coast rather than addressing core hypotheses. In addition, existing oceanographic measurements (GAK1 hydrographic station, ADCP current measurements at Hinchinbrook Entrance, thermosalinograph and fluorometer on a tanker, and thermosalinograph on a Kachemak Bay boat) are not obviously linked to the three projects on modeling ocean circulation.

A politically motivated scope is particularly detrimental to long-term monitoring if the projects focus intensely on particular areas for short periods of time. If GEM activities are directed by current management concerns, it is likely that the geographic focus will be buffeted, and the monitoring will fail to provide the long time series it is uniquely poised to generate. If the geographic scope remains as the entire Gulf of Alaska, it is imperative that the choice of variables to measure be made with extreme care.

The Gulf of Alaska is an area of about 1.2 million km^2 and the continental shelf in the Gulf of Alaska is 0.37 million km^2, about 10 percent of the entire U.S. continental shelf area (Hood, 1986). GEM is projected to provide about $6 million annually for research and staff to facilitate science and education (<www.oilspill.state.ak.us/future/future.htm>). Other large programs in marine science provide an instructive comparison (Table 3-1). The focus of each of these programs is much more targeted than is GEM, yet most have more money to spend on a per-area basis (Table 3-1). We suspect that it will be difficult for GEM to do more with less than in each of these programs:

HABITATS AS A DIVISIONAL UNIT

Because of the tradeoff between geographic scope and intensity of research effort, science plans covering large areas must include methods for stratifying observations and allocating funds for short-term process studies. This focus can be provided in a number of ways.

1. *Flows of energy, impact, or materials*. The plan could focus on one or a few important flows through the geographic area, for instance, across-shelf transport or movement of pollutants through food webs.
2. *Habitats or regions*. The plan could foster research in smaller areas that are believed to be representative of a broader region or habitat type.
3. *Species*. The plan could focus on one or a few species throughout the geographic area.
4. *Hypotheses*. The plan could target research toward a restricted hypothesis, for instance taking measurements that would support or disprove the Pacific Decadal Oscillation as a cyclic climatic shift.

5. *Time*. The plan could incorporate intentions to develop research projects in different areas over time. This strategy would approximate that of the U.S. Environmental Protection Agency's National Estuary Program (<www.epa.gov/nep>), which provides funds to develop management plans in one estuary after another. This strategy is generally inappropriate when the plan's mandate is to generate consistent long-term data sets.

TABLE 3-1 Comparison of Funding Levels for Large Marine Research Programs.

Program	Annual Funding ($)	Shoreline Length (km)*	Annual Funding ($ per km)	Area (km^2)	Annual Funding Per Area ($)
GEM[a]	6×10^6	1,500	4,000	1.2×10^6	5
PISCO[b]	5.75×10^6	2,000	2,875		
GLOBEC[c]	3×10^6	250	12,000	48,000	62
SEA[d]	3×10^6			38,000	80
Chesapeake Bay[e]	12×10^6	7,000	1,700	5,900	2,000

*NOTE: For these different programs, the method for determining shoreline length is inconsistent so these comparisons are approximate. GEM and GLOBEC are done similarly but the others might be determined using fractals that can make the length a less dependable number

[a] GEM Shoreline length measured on map; annual funding estimated.
[b] PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans) addresses benthic-pelagic coupling on rocky shores in California and Oregon. Shoreline length from <www.piscoweb.org>. Annual funding estimated.
[c] GLOBEC (Global Ocean Ecosystem Dynamics) focused on a small area of the Gulf of Alaska. Shoreline length measured on map; annual funding estimated.
[d] SEA (Sound Ecosystem Assessment) was a major portion of EVOSTC-funded research, developed in 1993 and running for seven years. Information from GEM program and <www.oilspill.ak.us/research/resrch.htm#SEA3>.
[e] Chesapeake Bay shoreline length from <222.gmu.edu/bios/bay/cbpo/into.htm>; funding level estimated by committee.

Of these options for stratifying observations, habitat is perhaps the most widely used approach. Division by habitat has one clear advantage for GEM implementation: it clarifies the amount of money being spent close to and far from shore. The GEM plan articulates a rationale for focusing on nearshore observations and studies; this area is relatively unstudied, and people living along the coast interact with it directly.

Division by habitat has several problems. In the GEM document, hypotheses are presented as repetitive questions listed for each habitat type, but they would need considerable refinement before they could be a useful guide for research. For example, the GEM document asks the same questions for continental shelf and nearshore areas, although these areas have different natural and anthropogenic forcing functions (see Table 3-2) Most importantly, the habitat divisions may set up a barrier to understanding links and transfers among habitats. The committee cautions against the development of habitat-based subcommittees in the organizational structure, as there is substantial risk of neglecting linkages among habitats in setting research goals.

Table 3-2 reproduces, in tabular form, the habitat-specific questions that form the core of the GEM plan (vol. 1, ch. 3). These questions actually begin to develop a set of hypotheses about how natural and anthropogenic factors influence ecosystem functioning, recognizing that different factors may be important in different habitats. As these hypotheses are refined by a scientific steering committee, they could help guide the selection of long-term observations and process-oriented research.

TABLE 3-2 Current Hypotheses about Natural and Anthropogenic Forcing Functions in Four Gulf of Alaska Habitats as Provided in Volume 1, Chapter 3 of the GEM Plan (EVOSTC, 2001).

Habitat Type	Natural Forcing Functions	Anthropogenic Forcing Functions	Habitat Variable of Interest
Watershed	Climate	Habitat degradation Fishing	Marine-related production (nutrients from salmon)
Intertidal/subtidal	Currents Predation	Development Urbanization	Community structure and dynamics
Alaska Coastal Current	Strength, structure, and dynamics of the Alaska Coastal Current	Fishing Pollution	Production of phytoplankton, zooplankton, birds, fish, mammals
Offshore	Alaskan Current/ Alaskan stream Mixed layer depth Wind stress Downwelling	Pollution	Carbon production and shoreward transport

The committee discussed these working hypotheses in some detail, and it offers a few observations about the current framework. These observations are not meant to be prescriptive; they simply point out areas that require additional consideration. Some of the forcing functions are not parallel. For instance, "climate" is hypothesized to affect watershed production, but more specifically "wind stress, mixed layer depth, and downwelling" are hypothesized to affect production offshore. Some of the habitat variables of interest, which should reflect ecosystem functioning, are too general or inclusive to measure. Specifically, "production of phytoplankton, zooplankton, birds, fish, and mammals" would require monitoring all taxa in the coastal region.

TABLE 3-3 Potential Habitat Divisions in the Gulf of Alaska and Hypotheses about Most Important Factors Influencing Biological Production.

Habitat Type	Natural Forcing Functions	Anthropogenic Forcing Functions	Strongest Across-Habitat Links	Habitat Variable of Interest
Watershed	Rainfall Offshore production	Habitat degradation Fishing	Salmon returns	Marine-related production within watersheds
Intertidal/subtidal	Predation	Shoreline development Pollution Direct exploitation	Larval and food delivery from continental shelf	Recruitment and species interaction strengths
Nearshore, including Alaska Coastal Current	Wind stress Freshwater	Fishing Pollution	Freshwater input	Biomass and production of phytoplankton, zooplankton, and forage fish
Continental shelf	Resupply of nutrients Currents Mixed layer depth	Anthropogenic climate change	Across-shelf flows	
Offshore	Mixed layer depth Wind stress	Anthropogenic climate change	Across-shelf flows	Phytoplankton production and shoreward transport

Similarly, "community structure and dynamics" in the intertidal/subtidal zone provides no indication of which taxonomic groups are expected to be most sensitive to change or most important to human communities. The metrics most sensitive to perturbations or stresses may not be abundance but the size or age structure of populations (Paine et al., 1996; Driskell et al., 2000; Monson et al., 2000).

The Alaska Coastal Current travels through a relatively narrow band (< 50 km) of the coastal region of the Gulf of Alaska, so it would be useful to use two different habitats instead: (1) the nearshore to 50 km, including bays, sounds, and the Alaska Coastal Current; and (2) the continental shelf that extends from the nearshore to the shelf break. Finally, it is possible to incorporate across-habitat linkages by developing hypotheses about how different habitats may be strongly coupled or the degree to which they behave independently.

Table 3-3 provides a refined set of hypotheses about how natural and anthropogenic forcing functions and across-habitat linkages may influence biological production. We emphasize again that this framework is not prescriptive but is provided to illustrate how study of linkages might be accomplished. These kinds of refinements should be made as the plan develops, using existing scientific data to justify choices of most important forcing functions. Both the forcing functions and "habitat" response need to be measured to test the underlying hypotheses.

CHOICE OF VARIABLES AND RESEARCH PROJECTS

The three types of research included in the GEM plan—measuring variables over the long-term, carrying out shorter-term studies of processes, and synthesizing and analyzing collected data sets—will require different strategies for implementation (from the call for proposals to the selection process to the evaluation phase). Recognizing that many large scientific programs focus on just one or two of these types of research, it is clear that GEM planners will face challenges giving appropriate weight to each type and designing implementation strategies for each. Important points for GEM planners to consider for each type include:

- Long-term research requires a large amount of up-front effort to choose variables. Determining who carries out long-term research is particularly difficult because it cannot (and should not) be assumed that the same research group will collect the information for the next 100 years. Data collection efforts should be evaluated on the order of every five years. Sampling protocols should be kept as constant as possible and if changes in technology occur, ample attention should be paid to inter-calibration of the time series.
- Short-term process studies will give the GEM program some of the flexibility it needs; typically, requests for proposals for this type of work occur every one to two years, so that the focus can be changed in accordance with steering committee and community interests.
- Synthesis should be an ongoing effort, some of which will involve modeling. Invitations for proposals should occur every two to four years, and a postdoctoral program might be an excellent way to have long-term data sets analyzed in novel ways (for instance, see the National Center for Ecological Analysis and Synthesis postdoc program at <http://www.nceas.ucsb.edu/frames.html>).

Balancing Long- and Short-Term Research

Long- and short-term studies differ in their focus and their funding requirements. A research plan that aims to fund both, as the GEM program does, must decide how to balance resource allocation to best meet its program goals. The present GEM draft plan does not address this critical issue. The term "monitoring" has always been in the title of the GEM plan, and the committee believes this focus on long-term research should remain central to the GEM program. Many of the biological and physical processes of interest to GEM operate at decadal or longer temporal scales, and require long-term measurement if patterns and variability are to be evaluated.

The ability of GEM to support long-term marine ecosystem studies is essentially unprecedented. No other current programs have this capability, nor are they likely to. In contrast, there are numerous funding sources for short-term research projects. The committee recognizes that short-term studies can be valuable for optimizing long-term study design. For example, they might be used to evaluate which of several techniques are most appropriate for remote sensing of nearshore measurements. The committee feels the GEM Program should start out by devoting the majority of its resources, perhaps even all of them, to setting up and maintaining the long-term research program, with few resources used initially for short-term research. (Resource allocation is discussed in more detail in Chapter 4.)

Strategies for Effective Choice of Long-Term Measurements

A well-crafted, long-term research plan addresses the program objectives as defined in a mission statement and a conceptual foundation. Although spatial and temporal scope (i.e., where to conduct measurements and for how long) may be settled in many ways, the core variables (what to measure and how often) usually flow from hypotheses and models. A comprehensive database of existing research results can aid in the development of these hypotheses. For effective management of coastal resources, monitoring programs must collect data at multiple scales, and most importantly, must link measurements between these scales, an often difficult process (Weisberg et al., 2000). Such linkages are necessary to provide managers with predictive models of the interrelated processes underlying ecosystem function to support wise decisions for managing resources.

Because of the long time frame of GEM, it is critical that the core variables for monitoring be chosen with great care . The GEM plan outlines a general strategy for identifying these variables and implementing the monitoring program (Figures 3-1 and 3-2). This strategy shows that GEM's mission and goals imply a broad conceptual foundation, from which will emerge hypotheses. Research to address these hypotheses will be carried out if similar work is not already being done. In short, hypotheses and questions get priority, and the plan recognizes the utility of asking whether existing data can address these questions before embarking on entirely new data collection. The committee agrees with this general strategy.

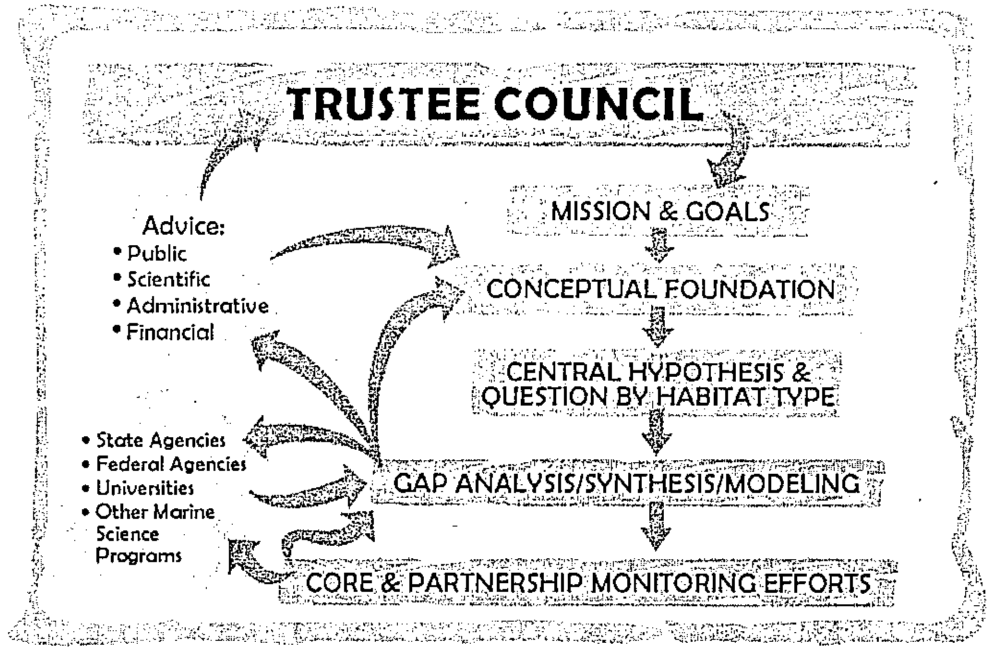

FIGURE 3-1 In the GEM plan selection of the variables to be measured starts with the mission and goals established by the Trustee Council, as expressed in the conceptual foundation, and is developed with input from numerous sources (EVOSTC, 2001, Vol. I, p. 38).

The role of synthesis. The GEM plan is inconsistent in exactly how synthesis fits into the choice of long-term variables. Selection of long-term measurements may include some modeling (EVOSTC, 2001, vol. I, p. 37 - "Initial synthesis activities, including modeling, would support identification and development of testable hypotheses."). Data synthesis is identified as preceding research in some parts of the text (EVOSTC, 2001, vol. I, p. 37 – "Synthesis—Research – Monitoring"), but is listed as concurrent with research in other sections (research and synthesis are identified as concurrent activities in 2003, the first year of plan implementation). What is an appropriate order?

1. Hypotheses can precede synthesis; indeed, they can help guide it.
2. Some variables for long-term measurements may need to be chosen before synthesis is complete, because synthesis should continue through the life of GEM.
3. Data synthesis must be included in an ongoing process throughout the life of the GEM program to optimize identification of additional variables for both short- and long-term projects.

For the GEM program enormous amounts of data already exist on the physical and biological features of the Gulf of Alaska, much of which has been generated by Trustee Council-supported research undertaken since the *Exxon Valdez* oil spill. At present these data have been gathered but have not been synthesized into a comprehensive, easily accessible database. Creation of such a database should begin immediately, with rapid updating of data in a readily usable form. (Approaches to data synthesis and model building are discussed in more detail in Chapter 7.)

The role of workshops. Identification of suitable variables for long-term research will in the end be carried out by the steering committee as it develops proposal solicitations and evaluation criteria. While these proposal invitations must be derived from GEM's conceptual foundation to maintain program focus, it is critical that community input be incorporated into the proposal solicitation at this early stage of the program. Two ways that substantive community input could be obtained would be through the Public Advisory Committee and by holding a series of workshops covering variables for long-term measurements. Workshops are not included in the plan but do appear to be funded this year (e.g., concerning herring, ocean circulation, and intertidal monitoring as described in EVOSTC [2001], vol. I, p. 56). It is unclear whether they will include community, manager, and researcher participation.

Valuable metrics of long-term change are those most sensitive to climate and/or anthropogenic trends or perturbations. In this regard GEM might also consider variables that serve as markers of ecosystem health. Such markers have been used in other long-term research programs (Box 3-1).

BOX 3-1

Markers of Ecosystem Health

Parameters or markers associated with ecosystem health have been used in numerous monitoring programs such as the Bermuda Atlantic Time Series (BATS), Hawaii Ocean Time Series (HOTS) and California Cooperative Fisheries Investigations (CALCOFI). GEM should look to these programs for guidance in choosing such markers, keeping in mind that some indicators may not be appropriate for the Gulf of Alaska ecosystem. For example, biodiversity has been used as an indicator of ecosystem health in many programs but may not be appropriate for high stress environments. In Alaska rapid colonizers may be wiped out catastrophically by winter storms, yet return the following year. Such natural patterns in community structure must be distinguished from anthropogenic effects for biodiversity to be a useful indicator of ecosystem health in the Gulf of Alaska.

Implementation of the Plan

Proposal solicitations based on the conceptual foundation and designed by an integrated group of scientists and community stakeholders will ensure that both quality science and issues of relevance to the community are incorporated into the plan. Selection of those proposals that best address the solicitation will ensure that the variables most sensitive to changes in the system, and most relevant to the program's goals, are chosen for long-term measurement. Data synthesis must be seen as an ongoing process and provisions made to ensure timely incorporation of new data into the database. A commitment to timely data synthesis will facilitate timely recognition of patterns and their normal range of variability. If long-term baseline data had been available for more species in the Gulf of Alaska at the time of the spill, managers would have been able to determine whether shifts in population densities were due to the spill and cleanup efforts or simply reflected population trends already in progress at the time of the accident.

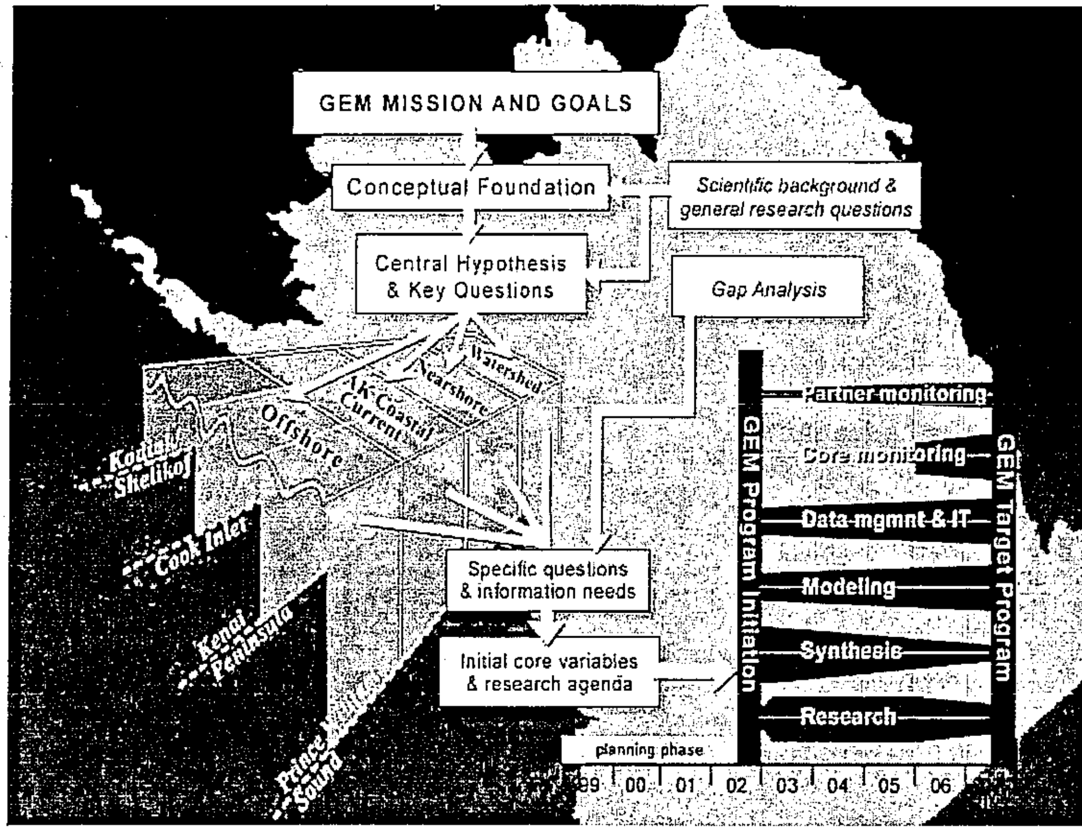

FIGURE 3-2 A schematic overview of the structure of the GEM program, from the GEM draft science plan, showing the relation of key concepts to the habitat and the schedule of implementation (EVOSTC, 2001, vol. I, p. iii).

Concerns About Choice of Variables

The choice of variables to monitor should not be done exclusively through gap analysis or by partnering with existing programs. Selection procedures need to address how often and where variables will be measured at the same time that particular variables are chosen. Effective implementation of the strategy for selecting variables, which we believe needs to address community interests, will be difficult. Elaboration of these concerns follows.

Partnering. The success of any long-term research program ultimately depends on an unwavering commitment to repeated measurement of a set of core variables that is not altered over the life of the program. While variables may be added, core variables must never be dropped or the usefulness of the long-term data set will be compromised. In this regard, GEM should not rely on partnering with other scientific programs for collection of any core variables. These programs will invariably be shorter-lived than GEM, and have different goals and foci.

Gap analysis. The GEM Draft Plan proposes the identification, and filling, of gaps in our knowledge base (gap analysis) as a critical step for identifying core variables (Figure 3-2). While the committee acknowledges the need for basing decisions on a comprehensive, scientific database of the Gulf of Alaska, filling gaps without hypothesizing how the resulting data specifically relate to the conceptual foundation runs the real risk of expending resources to generate data of little relevance to the program. There will always be information gaps, and as we learn more about the system, more gaps will be identified. Whether or not filling these gaps is necessary can only be determined using a hypothesis-based approach.

An example of what may happen using the gap analysis strategy as outlined in the GEM Draft Plan is that measurements of temperature and salinity might be identified as high priority. Regions within Prince William Sound such as College Fjord might be identified as locations where no such measurements have been done. Thus, lack of temperature and salinity data in this area would be identified as a knowledge gap and given high priority. If the location was populated with people and marine mammals, this area might become the highest priority for gap analysis. These measurements might be prioritized because they would be less expensive to collect relative to similar measurements taken in a remote region offshore on the continental shelf. However, such sampling within the fjord would not necessarily lead to a better general understanding of marine processes.

Community involvement. Communities can play a significant role in generating scientific ideas that are relevant to the goals of the GEM program. The culture and livelihood of local stakeholders often depends on the health of the ecosystem. Their intimate knowledge of the dynamics of the system, based on daily, and often generational, experience (e.g., changes in predator and/or prey abundance in response to climate change or to the introduction of hatchery-reared fish) can significantly broaden the range of research questions and approaches. Incorporation of meaningful community involvement in the *generation* of scientific questions for a research plan of GEM's scope and duration would significantly enhance both the quality of the science and its relevance to the community. Further, involved citizens whose efforts and contributions are meaningfully incorporated into the plan are more likely to provide strong support for the program for the future. Finally, the concerns of stakeholders often reflect the concerns of managers. While many of these concerns can best be addressed by the long-term research program, some may reflect specific issues or hypotheses that require more immediate answers. These could be addressed by incorporating short-term studies (3-5 years) into the monitoring program, thereby allowing GEM to respond to current concerns without sacrificing long-term data sets that will prove increasingly useful as they accumulate. A research plan that incorporates meaningful community involvement would serve as a model for other programs grappling with how to address the concerns of resource managers and local communities into their science plans. (The value of community involvement is further discussed in Chapter 5.)

Implementation. Finally, how the program will be implemented must be made clear. The roles and responsibilities of each participant and committee must be clearly defined, and the paths of information flow outlined, to demonstrate how the program will operate in practice. The design of long-term programs can take several years (Box 3-2), however, a carefully designed plan is well-worth such an investment. Collection of the wrong data, poor program management, or other flaws in the plan could seriously jeopardize GEM's credibility and erode long-term support for the program.

BOX 3-2

The Evolution Of Major Science Plans Takes Time

The creation of all long-term science plans takes time because the process of developing the plan is as important as the details included in the plan. For example, the U.S. portion of the Joint Global Ocean Flux Study (JGOFS) had its beginnings in 1984, with the international component starting about three years later (NRC, 1999b). The formation of this effort was not simple.

Initially, the U.S. Global Ocean Flux Study (GOFS) was an outgrowth of three separate science community projects that were active in the early 1980s: the National Academies' Ocean Studies Board was investigating the feasibility of a program that would conduct long-term studies of the biological and chemical dynamics of the ocean on basin-wide and global scales; the NSF Advisory Committee for the Ocean Science Program was developing a long-range plan, and a separate National Academies committee had identified initial priorities for the International Geosphere-Biosphere Programme. As the relationships among these activities became clear, and with support from NSF, NASA, ONR, and NOAA, a group of scientists met in 1984 at Woods Hole under the auspices of the National Academies. This generated the basic scientific underpinnings that defined the proposed mission for GOFS and led to the GOFS Scientific Steering Committee, which was formed in 1985. Then, after continued discussion and planning, in 1987 an overview document was published that more fully outlined the program. Between 1986 and 1990, the science community produced nine reports that summarized the recommendations of workshops designed to expand on the general plans, covering topics such as water column processes, benthic processes, continental margins, data management, and modeling. Finally, in 1990 the JGOFS Long Range Science Plan was published, based in part on the recommendations of the workshops. It was 1995 when JGOFS released an Implementation Plan, which gave the status of the JGOFS research and future directions.

One strength of a major research program is the ability to draw and direct a significant amount of talent and scientific interest toward a large and often high profile scientific challenge. But to realize that opportunity requires significant advance planning and coordination, and one key element is taking the time necessary to allow wide participation in the program's definition and evolution.

Source: NRC, 1999b.

4

Organizational Structure

Major marine ecosystem programs require a large commitment of human and fiscal resources, and the assurance of scientific credibility and coordination are essential. The effectiveness and character of marine ecosystem research and monitoring programs are greatly influenced by their organizational structure, because it is the structure that ensures that the goals of the science plan are translated into specific research activities. A credible scientific program must be structured so that program planning and review, implementation, community involvement, coordination, proposal solicitation, peer review and funding, interactions among investigators, data management, oversight, and public outreach all are facilitated efficiently.

Most interdisciplinary marine ecosystem programs have a scientific steering committee and a chief scientist (or scientific director) that together develop and implement the science plan and provide program oversight (Figure 4-1). In this science management structure, the chief scientist (who serves as an ex-officio member of the steering committee) works jointly with the steering committee and is empowered to develop and implement the program science plan. The chief scientist has authority regarding all scientific decisions after consultation with the program principle investigators and the steering committee. The chief scientist must concentrate on developing and implementing the program science and informing the interested communities of program results. To allow time for these scientific activities, the program's scientific administrative duties are usually delegated by the chief scientist. The chief scientist of interdisciplinary science programs similar to the Gulf Ecosystem Monitoring (GEM) program are normally scientifically well-rounded investigators who are respected nationally and internationally by their peers. The *Exxon Valdez* Oil Spill Trustee Council should seriously consider the adoption of a similar organizational scheme. The recruitment of suitable candidates might be made easier if there were a relationship of the individual with a university.

The GEM program implementation plan envisions that interactions between the Public Advisory Committee, Scientific and Technical Advisory Committee, and the general public, along with an external GEM program review every five to seven years, will provide the needed scientific oversight. The committee agrees that the chief scientist working with the Scientific and Technical Advisory Committee (which is, in essence, the "steering committee" referred to above) and the Public Advisory Committee should play a key role in program oversight. If GEM is to succeed, its oversight activities must address issues such as the preparation of science and program implementation plans, proposal solicitation and peer review, investigator information exchange, program data management and outreach to Alaska natives and other communities of interest. The Scientific and Technical Advisory Committee, working with the chief scientist, should play the dominant role in assuring GEM scientific program credibility and direction.

Science planning must continue during the life of the GEM program to assure program success. Initially the core variables to be monitored must be carefully selected and should not be modified without careful consideration during the life of GEM. This will assure that consistent long-term data are obtained with a principal objective of distinguishing between human-induced and natural changes in the Gulf of Alaska ecosystem. A monitoring subcommittee reporting to the Scientific and Technical Advisory Committee may be of value in both developing monitoring protocols and requests for proposals, but such a committee should not be the sole mechanism by which the variables to be monitored are selected. The GEM program as a whole should be involved with the selection of variables to be monitored. This might be achieved through a series of targeted workshops to assist the chief scientist and/or Scientific and Technical Advisory Committee in determining location and frequency of measurements needed to monitor key biological, chemical, and physical variables. The importance of the early synthesis to the long-term success of GEM cannot be overstated.

The GEM program must develop a clear implementation plan that includes some well-defined milestones and coordination among the agencies and programs conducting short- and long-term ecosystem research in the Gulf of Alaska. The plan should provide for an iterative assessment and evaluation of program objectives. Program reviews, both internal and external, should include:

1. evaluation of progress made toward the scientific objectives;
2. recommendations for any needed changes to scientific goals and the implementation plan;
3. identification of opportunities for greater involvement of scientific, native and local communities in planning and implementation of the GEM program; and
4. reporting of GEM results to relevant scientific and Gulf of Alaska communities and GEM sponsors.

The GEM organizational structure must include procedures for efficiently soliciting and evaluating of research proposals. Not only the scientific community but also other communities, such as Alaska natives and commercial fishers, need to be a part of the GEM management of proposal solicitations and funding approval. These communities require an effective way of submitting quality proposals addressing their needs. GEM should actively recruit participation of these communities to assure program openness and that its foundation is built on the broadest community base. Proposal reviews should have a peer review foundation. GEM staff and GEM-funded scientists may serve as proposal reviewers, but additional peer reviewers, not employed or funded by GEM, should evaluate each proposal. The GEM program will require solicitation of proposals to collect specific required core measurements along with those solicited to conduct innovative science. GEM must assure that the core measurements are collected efficiently and consistently on an ongoing basis. Sufficient resources should be available for sample processing (e.g., species identification and enumeration) in a reasonable period of time. The funding of the core measurements must receive the highest priority and may require the majority of GEM funds.

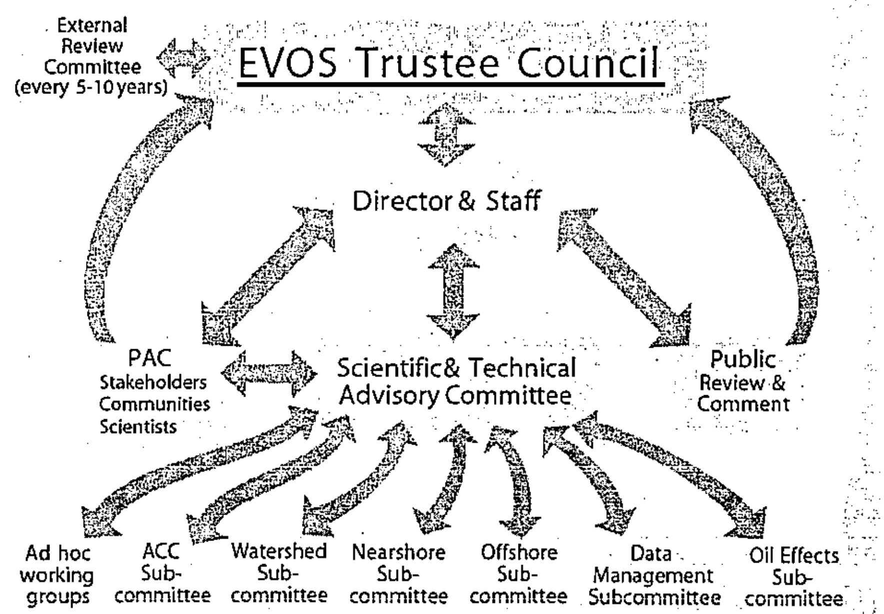

FIGURE 4-1 This figure describes the proposed decision-making and management structure for implementing the GEM program document and the GEM monitoring and research plan. Information and guidance flows between the Trustee Council and the Program Advisory Committee, the Scientific and Technical Advisory Committee, and the public at large, through the executive director and staff. The six-member Trustee Council makes all funding, programmatic, and policy decisions. All decisions must be unanimous. The Trustee Council relies on the executive director and staff to ensure that decisions are implemented and that the advice and review from the Program Advisory Committee, the Scientific and Technical Advisory Committee, and the public are organized and summarized to assist its decision-making. The Program Advisory Committee, which is required by the settlement to be established under the Federal Advisory Committee Act, consists of stakeholders, scientists, and community representatives who meet at least twice a year to provide advice and feedback to the Trustee Council on the overall direction of the program, including proposals to be funded. The Program Advisory Committee takes an active role in setting priorities and ensuring that the overall program is responsive to public interests and needs. The Program Advisory Committee is not intended to be the only conduit for public input. Additional public advice is sought on a regular and formal basis from the public at large, including public notice of all meetings, regular opportunities for public comment, and public hearings. The Scientific and Technical Advisory Committee provides key technical review and advice for the program, both from the "bottom up," using a group of subcommittees organized by habitat and other functions (e.g., data management), and from the "top down," by a core committee composed of subcommittee chairs and other distinguished scientists

and technical experts. The subcommittees help develop testable hypotheses, identify core variables and monitoring stations, and assist with peer review of proposals. The core committee ensures that the program is comprehensive across all habitats in working to answer the central questions and hypotheses. In addition, the Trustee Council is advised by an independent External Review Committee convened at the request of the Trustee Council and at least once every five years, to conduct a review of the GEM program.

The GEM organizational structure will need to direct over time the issue of the balance between long-term monitoring and process studies in the GEM program and the associated funds devoted to each of these activities, as the allocation of funds is not explicitly discussed in the GEM strategic plan. Given the funds that will be available over the first decade, it is unlikely that the long-term monitoring program could be achieved unless a major fraction of funds is committed to this activity. It is very likely that the desired monitoring program could require the entire budget, because monitoring costs include data collection, data processing, and electronic data storage, and maintenance. The costs of data processing, storage, and maintenance should not be underestimated or undervalued. The longer-term success of the program will depend heavily on the early and continued commitment to all components of monitoring.

This means that the decision to fund short-term process studies will need to consider the extent to which such studies may jeopardize long-term measurements. GEM managers should expect that establishing and implementing the long-term monitoring plan will dominate the early years of the GEM program and that process studies will play a larger role once the long-term measurements are in place. Over the longer term the balance between long-term monitoring and process studies should be guided by the GEM goals to detect and understand changes in marine ecosystem structure and functioning, as a basis to inform, solve, and predict the consequences of these changes. To be true to its mission and to achieve GEM goals, the monitoring component cannot be compromised and must be the GEM program centerpiece.

The GEM organizational structure must make certain that data management receives serious and consistent attention. The importance of data management and data archiving cannot be overemphasized given the long-term objectives of GEM (see Chapter 6). Program leadership must track data management progress effectively; and a comprehensive data management group is the best way to accomplish this. An effective data management subcommittee could play a key role in assuring that data management and archiving are effective and efficient. Proper data management will make data easily available for analysis, synthesis, and modeling exercises conducted throughout the life of the GEM program.

The GEM organizational structure must include mechanisms (such as the existing Public Advisory Committee) to inform the public of the status of scientific accomplishments and their usefulness in the management of Gulf of Alaska resources. As discussed in Chapter 5, additional ways are needed to increase collaboration between traditional ecological knowledge and modern science. Scientists have learned that traditional knowledge can be a useful source of ecosystem information, for example, the co-management of marine mammals, such as the bowhead whale, by an Alaskan native commission and federal and state agencies and the use of Little Diomede Island Inupiat seal-hunting knowledge to capture and track a ringed seal more than 400 miles through the frozen Chuckchi Sea. GEM should foster collaboration with the various Gulf of Alaska communities (see Chapter 5 for community involvement details). Collaboration will advance our understanding of the Gulf of Alaska ecosystem and benefit subsistence and other community resource users.

The GEM Scientific and Technical Advisory Committee, along with interactions with the chief scientist and Program Advisory Committee will need to play a key role in developing the Gulf of Alaska ecosystem monitoring and associated research science plan and in implementing the plan. The Scientific and Technical Advisory Committee in consultation with the chief scientist should provide creative leadership, including the evaluation of GEM's scientific direction; make appropriate scientific program changes when needed; and direct the activities needed to carry out the plan, including solicitation and selection of proposals that best address GEM's goals. Some additional subcommittees may need to be established, and interactions with these could assist the chief scientist and Scientific and Technical Advisory Committee in providing program leadership. Sub-committees should be established, however, only after identification of need. If such committees are arbitrarily established they can be divisive and a hindrance to successful advancement of the program goals.

Proposal solicitations and final recommendations for Trustee Council funding should be a major function of the chief scientist and Scientific and Technical Advisory Committee. The chief scientist and Scientific and Technical Advisory Committee should develop the scientific and technical subjects required to address GEM goals, as well as participate actively in the development of requests for proposals. Workshops hosted by the Scientific and Technical Advisory Committee to determine community-generated research needs may be an effective method for bringing the local communities resources into the proposal generation and solicitation process. The chief scientist and Scientific and Technical Advisory Committee should organize workshops related to choosing the variables to be monitored over time—keeping in mind that the final selection of variables should be based on hypotheses about how those variables would provide insight into relevant ecosystem processes—and workshops to facilitate the linkage of traditional ecological knowledge with modern science.

If the Scientific and Technical Advisory Committee is to function effectively and play a key role in advising the chief scientist and guiding the GEM scientific and technical program, its membership must be based on their scientific expertise and their ability to translate across the marine habitats and disciplines. Scientific and Technical Advisory Committee members must be perceived to be neutral, unbiased, and focused on the long-term success of the GEM program. The addition of some of its members to the Program Advisory Committee should assist with the integration of local community needs with the GEM scientific research planning process. Scientific and Technical Advisory Committee membership will require regular rotation to obtain the best oversight of GEM over time. Scientific and Technical Advisory Committee members could be compensated and they should have term limits of three to five years, with no direct GEM research or project funding during the period of service.

5

Community Involvement and Traditional Knowledge

Community involvement and the incorporation of traditional knowledge in the Gulf Ecosystem Monitoring (GEM) program is critical to the program's long-term success. Early *Exxon Valdez* Oil Spill Trustee Council documents indicated a clear desire to incorporate community involvement and traditional knowledge into the GEM program. This emphasis on community involvement and traditional knowledge has receded in successive documents reviewed by the committee. The committee's interim report addressed the importance of community involvement and use of traditional knowledge, but the current science plan appears to give these issues less, not more, attention. The committee, once again, urges the Trustee Council to review these issues in earnest. The role of communities is too important and the Trustees' intentions too ambiguous to delegate resolution of these issues to staff at this critical juncture in the initiation of the GEM program. Below we present questions that the Trustee Council must address as it considers the role of community involvement and traditional knowledge.

The commitment to and philosophy regarding community involvement and traditional knowledge needs much more clarification and explanation, whether in the GEM plan or in supplementary documents. As noted, the place of community involvement and traditional knowledge has been redefined over the course of the committee's review. Thus, the first question for the Trustee Council is whether it indeed believes that community involvement and traditional knowledge *should be* a part of the GEM program? The committee believes that community involvement and traditional knowledge should be explicitly incorporated in the GEM program. Such a partnership has proven successful in Nova Scotia with the formation of the Fisherman and Scientist Research Society (Box 5-1).

If community involvement and traditional knowledge are to be incorporated, the next question is *why* is incorporation of community involvement and traditional knowledge important? First, the committee believes that community involvement and traditional knowledge are important because as program components they can contribute to the focus on ecosystem monitoring. Local residents possess valuable ecological knowledge—information that can be directly incorporated into established scientific models. Local residents can be a source of important research questions and can help assure that research is relevant to both ecological and community needs. In addition, local participants offer potential efficiencies in data collection efforts. Local participants are likely to be critical to the success of any stewardship goals associated with the GEM program. Local participation can build constituent support for the GEM program, which is important for a program intended to operate for centuries.

BOX 5-1

**An Example of Community Involvement:
The Fisherman and Scientist Research Society**

Community involvement in scientific research aimed at gaining a better understanding of marine ecosystems can bring benefits. However, communities must have a role in helping to define what will be done and how it will be done. They must be actively involved in conducting the research, analyzing data, and disseminating the results to members of the community and other stakeholders.

One example of community involvement and how long it can take to develop is underway among coastal fishermen and fisheries biologists from the Canadian Department of Fisheries and Oceans in Nova Scotia. The Fisherman and Scientist Research Society was formed in the early 1990s to help develop a common understanding of the status of commercially harvested fishes and invertebrates on the continental shelf off Nova Scotia. Officers of the society are fishermen elected by the membership. The executive is advised by directors at large drawn from the membership and participating member scientists, a Communications Committee, and a Scientific Program Committee. More than 300 members from across the province meet annually to discuss the results of research undertaken in the previous year and to plan major new initiatives. The first several years represented a difficult and uncertain period for the society. It takes time, hard work, and a commitment to succeed to overcome existing biases and to build new relationships based on mutual respect.

Over the past eight years, however, the society has made tremendous strides. It has undertaken collaborative research on a range of topics, including inshore fish abundance surveys, fish tagging, studies on fish diets and physical condition, lobster recruitment, and coastal ocean temperature. The impetus behind most of these studies has come from questions posed by the membership with involvement at the community level. As the society matures the range and scope of the research continues to grow, providing fisheries scientists and oceanographers with an opportunity to address questions that would be difficult to address otherwise.

SOURCE: NRC, 2001.

The committee is not alone in recognizing the practical significance of traditional knowledge to contemporary sciences such as ecology, conservation, biology, pharmaceuticals, forestry, fish and wildlife sciences. The International Union for the Conservation of Nature (IUCN, 1986) lists the following arenas in which traditional knowledge can prove useful to science and environmental applications: new biological insights, resource management, conservation education, reserve design and management, development planning, environmental assessment, and commodity development. Traditional knowledge also has strong potential for informing the science of ecological restoration (Martinez, 1994; Kimmerer, 2000). Ford (2001) suggests that traditional knowledge plays a vital role in ecological monitoring and early warning signs of ecosystem change.

In sum, one answer to the "why" question is that it is in the best interests of the GEM program goals to incorporate community involvement and traditional knowledge. This is a profoundly utilitarian rationale—locals can help the program—but it is potentially a source of foundation for future problems. Such issues should be approached cautiously by the Trustee Council with careful attention given to the cultural and social significance of the participation of the residents of Prince William Sound in the GEM program. Indeed, it appears that the noticeable retreat of communities from GEM program planning activities arises from the perceptions that the relationship between science programs and communities has been relatively one-sided in the past, and that the GEM program will continue this relationship in the future.

The issue of the relationship between the traditional scientific community and the communities of the *Exxon Valdez* Oil Spill region presents a second broad rationale for incorporation of community involvement and traditional knowledge into the GEM program. The second rationale rests on an equity argument, which is distinct from the utilitarian rationale above. The GEM program, like the Trustee Council itself, is a result of settlement funds dedicated to restoration of an ecosystem damaged by a human technological disaster (Erikson, 1994). This ecosystem includes resource-dependent human communities (Picou and Gill, 1996), and these local communities have strong interest as stakeholders in the outcome of restoration activities (including long-term monitoring). The GEM program is a science program: It can be a science program without the involvement of local people, but it can be fashioned as a science program with effective local involvement with real gains to its relevance and no loss to its scientific credibility.

The equity argument in favor of community involvement compels consideration of some key definitional issues. What do the terms "community" and "involvement" mean? The committee suggests that "community" includes both the geographic communities of the GEM program region and more broadly the people who live and work in that region. Defining "involvement" is more complex and lies at the root of the issues concerning community involvement in the GEM program.

Throughout the committee's review the Trustee Council view of involvement appeared to be a blend of employment opportunities and peripheral advisory roles. The GEM program documents suggest a general level of Trustee Council comfort with continuation of this view. At the same time, the committee has received the clear sense that local communities are increasingly uncomfortable with this status quo approach to involvement. The situation resembles the proverbial "ships passing in the night" as GEM planners attempt to find more ways to build beach survey crews (staffed by local residents) into the GEM program and plan for more people on the Public Advisory Committee, while residents continue to press for more access to and participation in all phases of the program.

There is an abundant literature on traditional knowledge (e.g., Johannes, 1989; Baines and Williams, 1993; Rose, 1993) and on participatory research (e.g., Castellano, 1993; Chambers, 1997; Hall, 1981; Holland and Blackburn, 1998; Park 1993; Park and Williams, 1999). A pervasive theme throughout this literature is the relationship between local people and scientific research programs that is directly relevant to the community involvement/traditional knowledge issues confronting the GEM program. Consider, for example, the distinction between involvement in actual program planning and execution versus providing public advice on programs and projects presented *to* locals, rather than designed *by* locals:

> *[T]here is an inherent flaw in calling for more participatory forms of management when the specific goals are predetermined. Under such conditions local people's role in the management process necessarily remains prescribed and largely symbolic. It is the contention of the authors, that whereas there is a discourse of participatory marine management, the practice remains hierarchical and inclined toward use of the knowledge of those with the most formal education and the least experience... (Glaesel and Simonitsch, 2001).*

Public review does not equal public involvement; it is only part of an overall commitment to public involvement. Similarly, meaningful community participation must consist of more than providing employment to locals (to work on projects conceived and run by others). Treating local residents only as a potential labor pool ignores the critical factor of *who* asks the research questions. This does not mean that employing local residents is trivial or somehow wrong, but rather that the continued identification of involvement exclusively with employment is unnecessarily narrow and impedes an understanding of why the relationship between the Trustee Council and local residents is strained.

It might be instructive to consider a reversal of roles. What if the scientific community was treated as a labor pool for a long-term monitoring program administered and controlled by local communities? Even if the pay was good, can there be any doubt that the scientific community would demand a more substantive role in the program? We believe that either extreme (treating the local communities or the scientific community exclusively as a labor pool and source of secondary advice) is untenable.

If substantive community involvement is to be a feature of the GEM program, the next question is *how* can that involvement be fostered at this planning and initiation stage? Moving beyond mere expression of support for community involvement requires confronting issues of relationships:

> *[T]here remains the challenge of establishing effective relationships between the community and external institutions. The power relationships which prevail represent possibly the most critical factor (Castellano, 1993:152).*

As we noted in our interim report the entire GEM program needs a foundation that is simple, robust, and adaptable that permits local issues to be addressed in a meaningful way from the very beginning of the program. We noted that there are essentially three possible arrangements to consider in terms of providing a foundation for community involvement. First, every project could be required to feature community involvement. Second, the program could include a separate, distinct community GEM program that would operate with autonomy. Third, the GEM program could be structured to aim for a balanced distribution of power and opportunity between the scientific and local communities.

The first approach is severely flawed because it consists solely of a formulaic insistence on community involvement in every project that will do little more than encourage tokenism. The second approach has merit, but it introduces inevitable difficulties of allocating between communities (or between groups of communities) and would limit opportunities for genuinely mutual exchange between scientists and local residents. The second approach is largely embodied in a proposal put forward by the Chugach Regional Resources Council representing several Alaska native villages in the GEM region. Alaska native communities have no direct representation on the Trustee Council and this appears to be a source of tension distinct from more general questions of involvement. The Chugach Council representatives who met with the committee spoke of a desire to institute a community GEM program on a government-to-government basis in terms of their relationship to the Trustee Council. Over the course of the GEM program it appears that the Trustee Council will have to be sensitive to sovereignty issues regardless of whatever actions are taken in terms of incorporating Alaska native involvement in the GEM program.

The committee repeats its recommendation from our interim report: GEM should pursue an approach to community involvement based on shared power and shared opportunity between the scientific and local communities. The goal of shared power requires community representation at all organizational levels. For community-originated studies to be effective these structural provisions of power to communities must be accompanied by opportunities to receive funding. To ensure genuine incorporation of community interests and local knowledge and experience, the program should have some flexibility to fund proposals written outside the standard format and phrasing of the scientific establishment. There might also be a mechanism (e.g., periodic training sessions) to support communities wishing to submit proposals.

The institutional and communicative barriers confronting communities can be substantial. For example, Castellano (1993) states:

> *[C]ommunity groups typically encounter resistance in local and regional agencies to community-sponsored proposals to vary the application of inappropriate rules. ...*
>
> *A second issue is management of communications between communities and institutions when the actors operate from differing styles of communication. In general, the greater the distance between the cultural forms prevalent in the community and the cultural forms recognized or legitimated in the institutions, the more difficult it will be for both sides to recognize the commonalities that permit accommodation of community proposals by the institutions. If congruence between community proposals and institutional priorities is not easily identified, advocates within the institution will be subjected to personal risk in attempting to sell the ideas*

> *to their colleagues. The packaging of community proposals to emphasize points of congruence between new approaches and accepted practices, and the identification of persons or units in the institutions with a mandate to act in the field are strategic imperatives* (Castellano, 1993:153).

The kinds of barriers to effective community involvement highlighted in the literature are evident in the GEM planning process. For example, the committee was informed that one significant aspect of community involvement envisioned for the GEM program consisted of the subcommittees featured in the discussion of "guidance on GEM program development and implementation" in Section 6.3 of Volume I. The description of the subcommittees (p. 70) underscores some of the communicative and perceptual challenges confronting program planners and local communities.

> *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 be of interest in selecting members to promote collaboration and cooperation.*

The essence of the problem here is that the very language that is ostensibly intended to invite community participation is instead likely to be interpreted as repelling community participation.

In summary, the committee recommends that community involvement be designed throughout the GEM program in a manner that promotes meaningful involvement and provides for flexibility into the future as the GEM program evolves. Approaching community involvement in the fashion recommended by the committee should be regarded as a work in progress, because building the necessary relationships and developing a process that works will take time (Box 5-1). In many respects the GEM program will be breaking new ground in integrating community involvement into a long-term science plan. As one step in rethinking its commitment to community involvement, the Trustee Council should review community outreach programs designed by the Prince William Sound Regional Citizen's Advisory Council, which have been successfully used in communities and native villages affected by the *Exxon Valdez* oil spill (<www.pwsrcac.org>). This may provide direction for designing activities that promote substantive participation and involvement of local residents in all phases of the GEM program.

The committee is under no illusion that successful incorporation of community involvement and traditional knowledge in the GEM program will be easy. It will take more than just the inclusion of the words "community involvement" and "traditional knowledge" in program planning documents. It will require the engagement of planners, administrators, and researchers representing the scientific community with relevant experts and literature regarding participatory research and traditional knowledge, and most of all, with residents of local communities on shared terms. It will require the local communities to recognize that the GEM program will not address all their needs and aspirations. Nonetheless, the opportunity to develop community participation in the GEM science program will benefit all parties involved and should be seriously pursued by the Trustee Council.

6

Data and Information Management

Efficient archiving and dissemination of data is critical to any long-term research program. Careful, early attention to data management can ensure that the data collected are truly useful in capturing trends and illustrating changes in the system over time. The Long-Term Ecological Research sites supported by the National Science Foundation again provide models of how to organize and manage long-term ecological data sets. The GEM program must include a strong commitment to data and information management. To extract the full scientific value of GEM data and information must be made available to the scientific community, resource managers, policy makers and the public on a timely basis. Data management must be designed to facilitate data exchange among GEM scientific investigators, make data available to the public and outside scientific community, and archive the data products.

The success of GEM will be critically dependent on establishing some kind of Data Management Office, which would be staffed with a data manager and others as needed to organize, disseminate, and archive the data. The data manager would participate in the planning of the sampling program, organizing the data, assuring data quality, archiving the data and providing data to the principal investigator and public. There should be a Data Management Subcommittee to help provide periodic outside advice on data policies; the data management system; preservation of data with relevant documentation and metadata; advice on enforcement of data policies; and to facilitate exchange of data with related oceanographic programs. Both data managers and scientists should serve on the Data Management Subcommittee to facilitate the interaction of scientists with the data management staff so that data management policies and procedures are in tune with the scientific focus of GEM. These groups would develop a data policy that establishes the rules for submitting data and models; facilitates quality control of the data by the data management office; insures that the data are properly archived; ensures the rights of the scientific investigators; promotes the exchange of data between investigators; and ultimately, makes the data available to the general public and outside scientific community. These data management policies are followed by large scientific oceanographic programs such as the Joint Global Ocean Flux program (<www.usjgofs.whoi.edu>); Global Ecosystem Dynamics (<globec.oce.orst.edu/groups/nep>), and the Coastal Ocean Processes program (<www.skio.peachnet.edu/coop>).

GEM needs to be committed to the timely submission and sharing of all data collected by its researchers. In accepting support each principal investigator should be obligated to meet the requirements of the GEM data policy. These should include submitting collected data in the established format within set periods from collection. Investigators should be encouraged to exchange data and models with other GEM scientists to promote integration and synthesis.

Data management must have sufficient resources to accomplish its necessary functions in support of the GEM program. According to recent reviews, some of the most successful coastal monitoring efforts allocate as much as 20 percent of their total budget toward data management (Sustainable Biosphere Initiative, 1996; Weisberg et al, 2000). To be successful GEM will need to make a similar financial commitment to data management. A program such as GEM with a long commitment to observations of ecosystem processes will be viewed regionally, nationally, and internationally for leadership in data management.

A body of data exists for the Gulf of Alaska to which GEM investigators will need ready access. One of the first tasks of the Data Management Office should be to install this relevant data into the GEM database. Examples of pertinent ancillary data sets are NOAA's Tropical Atmosphere-Ocean El Niño Southern Oscillation data, Pacific Decadal Oscillation estimates, the Gulf of Alaska Global Ecosystem Dynamics program, and historical regional oceanographic and climate data. Another example is the North Pacific Marine Science Organization's Technical Committee on Data Exchange Website that contains links to long-term, interdisciplinary data sets for the North Pacific. These data archives will be essential to ecosystem modeling and synthesis in the GEM program. Also essential to the initial planning of the GEM program will be data collected in the past decade with *Exxon Valdez* Oil Spill funding. These data need to be synthesized to guide the selection of the sampling sites and measured parameters of the GEM coastal time-series observations. These data must also be made available to collaborating scientists, scientists outside the program, the public, and resource managers.

The policy of such federal agencies as the National Science Foundation, Office of Naval Research and the National Oceanographic and Atmospheric Administration is that two years after collection, data should be available to the general public and scientific community through the National Oceanographic Data Center (NODC). Data collected by the GEM program should be submitted to the NODC in addition to being made available to the public through the GEM web site or similar structures.

The general description of the data management architecture in the draft GEM science plan is very good. The data management functions of data receipt, quality control, storage and maintenance, archiving, and retrieval are recognized and adequately addressed. The report recognizes that different types of data products will be needed for basic research and analysis, modeling, resource management applications, and public outreach. Access to the data archives and software display will be an important public outreach component. There would be multiple levels of complexity to the data access ranging from users with limited backgrounds with these data to use by the investigators who gathered the data.

One of our chief concerns was the lack of recognition of the importance of an established data policy and a willingness to enforce it. One of the first tasks of the GEM Data Management Subcommittee should be to establish a data policy to which all investigators must adhere and to help GEM set up the structure of the Data Management Office. It was apparent in reviewing the *Exxon Valdez* Oil Spill Website that it was difficult or impossible to retrieve data collected from past research projects. This trend must change if the GEM program hopes to realize its potential for understanding the Gulf of Alaska ecosystem. Data collected should be easily retrieved by various user groups, as is the case for programs such as the Joint Global Ocean Flux Experiment (<www.usjgofs.whoi.edu>), Global Ocean Ecosystem Dynamics Experiment (<globec.whoi.edu and globec.oce.orst.edu>), or, more generally, the data available from the National Snow and Ice Data Center (<http://nsidc.org/index.html>). The Data Management Office must have sufficient staff and infrastructure support for receipt, quality control, archiving, and retrieval of data products required by its user groups.

7

Synthesis, Modeling, and Evaluation

Writing a science plan to guide the Gulf Ecosystem Monitoring (GEM) program for the next 100 years is no easy task. It is simply not possible to know everything that should be addressed. To be useful over the long-term, the plan will need to be flexible. The issues in 10 years, or 20, or 50 may be different from today's issues. Concerns about the ecosystem may change in the face of the possibility of increased tourism, terrestrial resource harvests (timber), hydroelectric development, and other changes in water usage and land use. Even so, we must qualify that we do not expect the GEM document to address each of these issues. This is where flexibility becomes important. The plan needs a system in place for synthesis of knowledge at specific points in time and evaluation of what has been learned and what needs to be done next to progress in understanding the ecosystem.

SYNTHESIS

An initial synthesis needs to include several components. The first step, a much-needed literature review, has been completed in the "Scientific Background" section in Volume II, Part 3, of the GEM plan (EVOSTC, 2001). Recent information from other geographic areas that contain relevant information can be incorporated when needed for specific topics. The second step, compilation, assessment and analyses of databases, has not been done. This step is critical to accommodate the imperative third step, which is a synthesis of *Exxon Valdez* Oil Spill research from 1989 to the present. Though a few programs have completed synthetic views of their results (e.g., *Fisheries Oceanography* vol. 10, [Suppl. 1] – "A Sound Ecosystem Assessment [SEA] Synthesis"), most have not. Many studies that have been funded over the past 13 years have yet to be published. Annual reports are not publications and certainly do not qualify as syntheses.

The knowledge gained about Prince William Sound is extensive because of *Exxon Valdez* Oil Spill funding. Retrospective analyses have led to new hypotheses and ideas in many instances, not the least of which is the concept of a "regime shift" (Francis and Hare, 1994; Hollowed and Wooster, 1995; Anderson and Piatt, 1999) and the Pacific Decadal Oscillation (Mantua and Hare, in press). However, there is much more to be gained from past studies that should be used to direct the future of GEM. The completion of the third step will lead to the fourth step: assessment of accomplishment of past goals. The synthesis of data and assessment of what has been learned in the recent studies will provide a starting place from which to hone hypotheses needed to direct GEM research.

The generation of new hypotheses will lead to proposals for new work, which in turn will lead to the need for additional synthesis. Synthesis is an iterative process and as such is both the first and last steps. For GEM to continue to be successful, periodic re-synthesis of new data will be needed. A synthesis will assure that there is not a long lag time in publication of results and access to data of other GEM researchers, such as currently experienced under *Exxon Valdez* Oil Spill. A periodic synthesis on the scale of five-year increments will promote comparisons between past and recent conditions. Additionally, scheduled syntheses will ensure evaluation of program direction.

> *"One presumption in a long-term program is that technology will change, providing opportunities for collecting new data types or collecting existing data more efficiently. Another presumption is that users will become more sophisticated, and their needs will change as they become accustomed to the data streams that are produced. Many successful programs incorporate periodic program review to assess how the program should change in response to these new collection opportunities and needs."* (Weisberg et al., 2000)

The synthesis will tell whether the science plan and the structure of the program is working.

As GEM is envisioned to be a 100-year plan, we suggest that a time line on a scale longer than five years be included in the GEM plan. We have emphasized that long-term research is the linchpin of this program, and the projected time line should reflect that effort. Within that time line periodic syntheses should figure prominently. Synthesis should be viewed as a key component of the plan and funding for synthesis should be incorporated. While periodic review is necessary, the long-term research should be modified only when a strong case can be made for improving the program (Weisberg, et al., 2000). The synthesis and review should involve a wide range of scientists and community members, as data users are critical to the review process (Weisberg, et al., 2000).

MODELING

Synthesis and modeling are interconnected. For example, one first could create a conceptual model that will tell which quantities need to be measured, collect data, synthesize data, and then create a more quantitative model. Alternatively, one could collect and synthesize data, and then create a statistical model that could be used to collect more data to verify the model. In a third approach, one could perform a synthesis on retrospective data and create a working model, also known as an hypothesis, which would be used to design data collections that are synthesized into more sophisticated models. Note that the models and syntheses may take many forms from conceptual to highly quantitative. Regardless of the order of these steps and the sophistication of the techniques, the components of synthesis and modeling are both critical. The combination of synthesis and modeling are tools for evaluation of past work: testing the appropriateness and accuracy of hypotheses and generation of new hypotheses. This approach will keep the GEM program moving forward by addressing issues that arise from the conceptual foundation and filling gaps identified during the evaluative process.

The elements of a successful modeling component are outlined in the GEM monitoring plan. It is worth emphasizing that modeling should be a component in all phases of GEM as a research, synthetic, and diagnostic tool. The strategic elements for a successful ocean-observing program are a combination of in situ observations, remote sensing, and modeling (Strategic Design Plan for the Coastal Component of the Global Ocean Observing System, 2000). All three elements complement each other to provide a more comprehensive view of the environment. Because of the different spatial and temporal scales of response and variability in the physical environment and living resources of the Gulf of Alaska, models will be needed to merge disparate and discontinuous measurements. A hierarchy of models (statistical, theoretical, empirical) should be employed in the GEM program. The skill of models should be routinely assessed. Some models will require some form of data assimilation using information collected during the monitoring program. The data are inserted into the model to insure that the model outcome more closely resembles the in situ observations. The GEM program should work toward more realistic and accurate numerical models for the prediction of ecological processes. The unparalleled opportunity of a long-term observation program in the Gulf of Alaska coupled with a concerted effort in modeling will produce exciting new tools for the management of the Gulf of Alaska's living resources.

REVIEW OF THE GEM SCIENCE BACKGROUND SECTION

GEM planners have already made a first synthesis by compiling information in the GEM planning document (EVOSTC, 2001). The current "Science Background" section is a good comprehensive review of relevant knowledge. The document establishes a common background that can be used as source material. This should stand as an indication of what is known at this time. This state of knowledge in this work plan does not need to be updated, as the updating will take place routinely through GEM synthesis efforts. This is an excellent background from which synthesis efforts can begin.

We applaud the GEM writing committee on the excellent scientific background that they created in Volume II, Part 3. This scientific background contains up-to-date knowledge and is well presented. In most cases there is a referenced, accepted scientific basis for the material presented. The use of figures to demonstrate concepts and points is well done. This document will be useful to inform the Trustees, scientific community, and the public. We recognize, however, that all interested parties will not read the entire document; we suggest that the "Executive Summary" highlights in non-technical language the main scientific points on which GEM is based.

Generally the physical oceanography is well presented in Volume II of the GEM document. The major deficiency is the lack of attention to processes that might take place on the mid-shelf. While the shelf is addressed in the document, when the choice of habitats is selected, the document turns rather quickly from the Alaska Coastal Current to the offshore areas of the shelf break, continental slope, and deep ocean basin. The mid-shelf region might be very important to the nutrient fluxes and primary production of the region, because relatively deep nutrients must get into the euphotic zone, and the pathway is unknown.

There are some smaller inaccuracies and over-simplifications in the physical oceanography section. For example, the definition of the shelf as being located at depths of less than or equal to 200 m is wrong, given that there are many locations deeper than that, including locations in Prince William Sound. There are also some problems with the discussion of circulation in Prince William Sound. Although this circulation is intimately connected with the circulation of the Gulf of Alaska, the plan emphasizes the circulation of the central Gulf of Alaska over the circulation over the adjacent shelf, and the thrust of this document pushes the studies into the deep Gulf of Alaska.

In the GEM plan the discussion of time and special scales is very brief. This topic might well be the weakest part of the GEM program. The processes that affect primary production are going to have space scales on the order of kilometers. Single monitoring stations will not be useful tools. Granted, Ocean Station P and GAK1 measurements have added to our understanding of the system, but these are really "first looks" similar to an initial Mars probe. From ongoing studies, mesoscale physical and biological processes on the shelf are appearing to be important in the Gulf of Alaska. A program to measure on these time and space scales over the entire shelf will be very, very expensive to maintain. In addition, it is important to make measurements in winter, as this might well be the most critical time for the marine populations. Or GEM could break the problem; for example, in meteorology the long period changes are climate-related problems whereas there are daily changes (weather) embedded in these long-term processes. There are similar time and space scales in oceanographic processes, and sampling must be designed to measurement all these scales. There is no distinction in the document with regard to the atmosphere. For example, GEM should develop studies to address the seasonal variability embedded in the long-term monitoring program. Three to five years of seasonal measurements will be required to determine the seasonal signal. After those studies scientists should be able to reduce the measurements into a monitoring mode, assuming that an increased understanding will allow more targeted sampling. Unfortunately, there is no example of a system in which this has been done.

There are some physical science statements with which we disagree or question. We question the source of the statement about long-term warming of the northeastern Pacific Ocean. This has not been substantiated with data to date. The longest air temperature time-series for the region (Sitka, Alaska) shows no increasing trend since 1828 (Royer, 1993). We question where the iron limitation hypothesis came from. The hypothesis that the primary productivity on the shelf of the northern Gulf of Alaska is not documented. It seems likely that there is enough iron from terrestrial sources to offset any depletion, however, these measurements have not been made.

The biological support for the science is good, and we commend the GEM team for this strong compilation of the current state of knowledge. Simultaneously, we would like the GEM plan to recognize the tentative nature of some of the most recent unpublished findings. Be aware that the conclusions may change when studies are completed and prior to publication. GEM should not be dependent on tentative findings.

A 100-year plan should be only a broad outline with details to be worked out in work plans. A broad-brush understanding of the area in question at this time in history is necessary for the start of a 100-year plan. It is inappropriate to include detailed research questions in the "Scientific Background" section, such as: " Do diurnal-period shelf waves along the Kodiak shelf influence biological production and the dispersal of planktonic organisms (EVOSTC, 2001, Vol. II, p. 64)?" We suggest that these questions be removed from the document. The objective of this section of the document is to set the stage for the scientific questions and hypotheses to be generated. We cannot fault the questions themselves, because they ask just about everything. They are at once extremely general and too detailed. Including this level of detailed questions in the background of this document leads us as reviewers to believe that all research will be restricted to addressing these specific questions. That would discourage original hypothesis generation and research in the proposal process.

In conclusion, we believe that the GEM plan we reviewed provides an excellent scientific background for the Gulf of Alaska region. We want to see a synthesis of data that have been collected under *Exxon Valdez* Oil Spill and we want to see periodic re-synthesis and evaluation. We suggest that various types of modeling will be useful tools to aid this synthetic process.

8

Conclusions and Recommendations

The *Exxon Valdez* Oil Spill Trustee Council is to be commended for its foresight in setting aside funds over the years to create the trust fund to provide long-term funding to the Gulf Ecosystem Monitoring (GEM) program. The GEM program will offer an unparalleled opportunity to increase understanding of how large marine ecosystems in general and Prince William Sound and the Gulf of Alaska in particular function and change over time. The committee believes this program has the potential to make substantial contributions of importance to Alaska, the nation, and environmental science.

Since this committee was formed in June 2000, it has met five times to learn about and discuss the GEM program. We have conveyed our comments and recommendations in a letter report (November 2000) with advice on program timing and a more detailed interim report (February 2001) that critiqued an early draft of the program science plan. These reports focused on the early planning, were specific to the draft planning documents, and were primarily directed to program staff. In this final report we provide broader comments and a document that has more general and longer-lasting lessons about which elements are essential to the success of a long-term research and environmental monitoring program such as GEM.

GEM's mission as stated in EVOSTC, 2000a, is ambitious: "to sustain a healthy and biologically diverse marine ecosystem in the northern Gulf of Alaska 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." The purpose of any mission statement is to serve as a general guiding principle and statement of underlying philosophy and approach, and this mission statement accomplishes this purpose. However, putting this statement into practice is likely to prove difficult.

According to an early EVOSTC document (EVOSTC, 2000b), GEM was conceived to have three main components:

1. long-term ecosystem monitoring (decades in duration);
2. short-term focused research (one to several years in length); and
3. ongoing community involvement, including use of traditional knowledge and local stewardship.

The committee still views this early vision of the program as a sound foundation on which to build. In a later document (EVOSTC, 2000a) the purpose of the GEM program is further delineated to contain five program goals: detect, understand, predict, inform, and solve. The committee understands the general intent of these goals and the necessity of making the program respond to both the needs of science and the needs of its political constituency. But as discussed in earlier reports, the committee remains concerned that these five goals are extremely diverse and far-reaching. While the GEM mission is a good general statement of intent, the committee's concern is that addressing all five goals will present the risk that the research and monitoring program will be spread too thin to be effective.

In its review of the evolving GEM long-term research program the committee noted some positive strides. We believe that the GEM planners tried to include the interests of diverse stakeholders (Trustee Council, scientists, various advisory groups). We are pleased to see that the planning process has caused an evolution in the draft and the thinking behind it. We commend GEM planners for not taking the easy route of simply picking stations and starting data collection, and that they took the time to think about the conceptual foundation and develop the hypotheses that are necessary to define data needs. We find the conceptual foundation is much improved; however, placing the conceptual foundation deep in Volume II of the plan is not appropriate. That late placement implies that it is an afterthought and not the foundation upon which the program is built. It is, however, a good point of departure for GEM, and we assume it will evolve as the program moves toward implementation. We believe that GEM planners have made progress on the development of hypotheses, although there is still room for more work in this area.

GEM staff members have made a good effort to reach out to the science community. They have a good start on their discussion of and approach for using modeling effectively; and they have made very good progress in setting up a strategy for data management. We found that the science review section is very useful. Although it may seem obvious, many of these positive strides have occurred because the Trustee Council and GEM staff have set up a planning process and are allowing time for the evolution of thinking.

The committee has struggled, however, with its basic charge (to review the GEM program) because the program was literally evolving as we worked and we often were dealing with a "moving target." We also struggled because, as scientists, we are more accustomed to dealing with research programs instigated and directed by scientists, such as the Global Ecosystem Dynamics program, or by agencies with clear mandates, such as Mineral Management Service's Environmental Studies program. Instead, GEM is a research program directed by a Trustee Council made up of six agency representatives, each carrying responsibilities for mission-oriented state and federal agencies. Their role is made especially difficult because of the legal requirement that all their decisions be unanimous. GEM is supported by a staff that includes both scientists and non-scientists who have the unenviable job of balancing not only the expectations of the science community (the norm when developing a new science program) but also the expectations of various other Alaskan stakeholders and the inevitable political forces of the Trustee Council itself.

While this committee whole-heartedly endorses the idea of a long-term ecological research program in the Gulf of Alaska and commends the Trustee Council and other decisionmakers for creating such a program, we must stress that this report is not an endorsement for implementation of the GEM program as currently designed. Our proposed changes are described in the following conclusions and recommendations.

CONCLUSIONS AND RECOMMENDATIONS

Opportunity for Sustained Study

Conclusion: GEM is an important opportunity to do truly long-term research in a marine ecosystem, and this long-term approach is essential to distinguish natural variability from human impacts. The long-term nature of the program, intended to cover a period of many decades, is the flagship contribution of the plan. Long-term research (i.e., monitoring) by definition must include sustained, consistent observations over a long period and thus requires a long-term commitment from the highest levels of decisionmakers. This commitment will require a substantial financial investment. Short- and medium-term research is an appropriate way to address current questions and management needs, but the fundamental importance of the long-term program should not be lost.

Recommendation: The majority of GEM funds should be spent on long-term research, that is, sustained observations of ecosystem components and ecological processes over decades. The committee concludes that the GEM program should emphasize long-term research and data management because this is its special contribution to scientific understanding in Alaska's marine environment; most other research programs are short-term. These long-term measurements will be necessary to differentiate the effects of natural variation from human-induced changes on the Gulf of Alaska ecosystem. The coastal Long-Term Ecological Research sites funded by the National Science Foundation provide good models of such long-term research.

Elements of a Sound Long-Term Research Plan

Conclusion: A sound, long-term research plan must clearly define its conceptual foundation, scope, organizational structure, data management methods, and methods for periodic synthesis and review. The conceptual foundation presented in the draft science plan is adequate and with modest restatement as a hypothesis could be a useful focus for research. The science plan and research objectives need to be directly linked to this conceptual foundation.

Recommendation: The current draft science plan (EVOSTC, 2001) needs to be shortened considerably by removing tangential materials so that it is a clear guide for the future. The conceptual foundation needs to be discussed early in the GEM planning document because that placement captures its importance as the fundamental building block on which the rest of the program depends. The science plan should include a broad conceptual foundation that is ecosystem-based. It should seek to understand natural and human-induced changes and it should be flexible to accommodate changing needs without compromising core long-term measurements. These hypotheses will provide a bridge between the conceptual foundation and the eventual implementation of the science program. Because the conceptual foundation states that the ecosystem is affected by both natural variability and human-induced change, as the plan is implemented both of these drivers should be addressed in studies.

Implementation of the GEM Program

Conclusion: The planning process for GEM has been difficult and costly, but the investment in planning is critical for success. Long-term measurements cannot begin until after the appropriate variables have been identified, and these must be based on the conceptual foundation and hypotheses. The planning and design of sampling will continue to take considerable time and effort in the early years of the program. It is more important to identify the right variables than to rush to collect data.

Recommendation: The GEM plan and planning process needs to provide careful consideration of what to measure, how often, and where, based on input from a broad cross-section of the scientific community, local communities, and managers. These decisions on hypotheses and attendant measurements should be made by the chief scientist working with the Scientific and Technical Advisory Committee and other independent scientists and stakeholders over the course of several years as program implementation gets underway.

GEM's Role in Gulf of Alaska Research

Conclusion: GEM's primary goal should be to develop a comprehensive and eventually predictive understanding of the Gulf of Alaska ecosystem. The long-term nature of GEM will enable it to serve as a framework for marine research in the Gulf of Alaska. Other programs will come and go on shorter time frames and should be encouraged to coordinate with GEM, but GEM does not have the resources to be the central coordinating body for all such efforts.

Recommendation: The focus of GEM should be its long-term program, and GEM decisionmakers should not try to do too much or this will dilute GEM's limited resources and impact. Because of the long time frame of GEM, it can provide a building block for partnering with other programs that will come and go, but it should not be distracted by the idea of assuming leadership of Gulf of Alaska marine research.

Recommendation: GEM should not see its role as filling the gaps in other programs, because adding these kinds of activities will inevitably erode funding for the GEM core measurements. This does not preclude GEM from involvement in other programs in which the research is addressing issues or collecting data that has been identified as necessary for addressing the central hypotheses of GEM.

Recommendation: It simply is not possible for GEM, given its resources, to play a leadership role in both scientific research and day-to-day support of resource management. GEM should not be involved in the types of monitoring that are typically the responsibilities of agencies. GEM should not subsume routine surveys, stock assessments, and data collection that have been the normal province of resource management agencies. Of course, a large monitoring program like GEM will supply much information that is useful to resource management agencies as a result of its own activities.

Community Involvement

Conclusion: The GEM plan does not currently describe effective and meaningful ways to involve local communities. This involvement should occur at all stages, from planning (e.g., selecting the questions to be addressed and variables to be monitored) to oversight and review. Local knowledge and traditional ecological knowledge can be used to generate ecologically sound and socially relevant research ideas. Science and community partnerships can lead to achievements that neither could attain independently. Specifically, such collaborations provide scientific knowledge as well as community education and local support of science. These outcomes are important especially because of the long-term nature of GEM; such involvement might be less critical in shorter programs, but the century-scale requires the establishment of long-term bonds.

Recommendation: The Trustee Council and GEM program staff must continue to seek ways to build meaningful community involvement at all stages of planning and implementation, from selecting the questions to be addressed and identifying the variables to be monitored to providing program oversight. It was outside the scope of this committee to advise specifically on what programs or methods to use; neither are we as experienced as GEM staff in dealing with Alaska's diverse communities of interest. Nonetheless, we are certain that the community involvement debate will continue until better resolution of this issue is found.

Geographic Scope

Conclusion: No program can be expected to meet the needs of all potential data users, and tradeoffs are inevitable between the intensity and spatial range of sampling. That is, if the scope of GEM is physically large, then its long-term research component will be able to collect less information at any one site (because there is a finite amount of information that can be collected with finite financial resources). If the scope of GEM is physically smaller, there can be more monitoring sites or more types of information collected. Research projects and sampling will need to be selected very carefully to avoid diluting activities so that their usefulness is limited. GEM planners can choose to obtain more limited information from a large area or more in-depth information from a smaller area.

Recommendation: GEM planners must make an explicit choice on how to focus the program's research. There are many options for carrying out coordinated research that avoids piecemeal projects. One option is to concentrate on a particular geographic area, as the committee recommended in its interim report. Another possibility is to target a few variables across a broad geographic range, such as measuring physical oceanographic variables over long time periods (temperature, salinity, currents). It is possible to concentrate attention on particular habitats in a large geographic range. These choices must be guided by the conceptual foundation and the hypotheses selected for investigation.

Using Habitat as an Organizing Concept

Conclusion: GEM or any large research program can organize its effort and funds in many ways and still be successful. The habitat approach described in the GEM science plan is one way of dividing attention and funds, and it has the advantage of being understandable to many of the program's key stakeholders. GEM planners need to be aware of its one critical disadvantage: a habitat approach can fail to address key linkages, flows, and processes between habitats, which is where many of the most interesting lessons of the long-term GEM program might be seen.

Recommendation: Given the habitat approach selected GEM planners must make a concerted effort to ensure that the program has clear, concrete mechanisms to address cross-habitat links. This does not necessarily mean creating a linkage subcommittee but rather building into each habitat study the opportunity to make measurements of flows among habitats and highlight other interactions. Across-habitat connections must be addressed during synthesis and modeling. These efforts are essential to creating a truly integrated program, where the whole is greater than the sum of the parts.

Organizational Structure

Conclusion: The GEM research plan is being developed to carry out long-term research, short-term research, and synthesis and modeling of data sets. Soliciting proposals, evaluating proposals, and the time frame for the research effort and its funding will differ for these scientific activities. The current science plan does not distinguish among these activities in terms of the procedures necessary to manage them and achieve useful results, or even that the goals of these three approaches differ. Strong scientific guidance is required through all the activities of GEM.

Recommendation: GEM planners, with input from the science community, should identify how these three kinds of scientific endeavors will be incorporated and managed within the science plan. For instance, long-term research projects (i.e., monitoring), short-term research projects, and synthesis efforts will require different mechanisms for proposal solicitation and evaluation and different time frames for funding.

Recommendation: The scientific leadership of the GEM program should be in the hands of a chief scientist advised by a Scientific and Technical Advisory Committee. The chief scientist should have adequate assistance to execute the program.

Conclusion: The organizational structure supporting GEM should be set up to ensure ongoing, independent scientific oversight and review. It should be easy for new researchers and local community members to be involved in planning and carrying out the research projects. If the Scientific and Technical Advisory Committee is to function effectively and play a leadership role in developing and directing the GEM scientific and technical program, its membership must be selected carefully.

Recommendation: The Scientific and Technical Advisory Committee will play a key role in leading the GEM program and ensuring program credibility. Scientific and Technical Advisory Committee members should be chosen based on their scientific expertise and their ability to link across the marine habitats and disciplines. To obtain the best program oversight over time there should be regular rotation of the members of all advisory groups, such as the Scientific and Technical Advisory Committee. Advisory Committee members should be and should be perceived to be neutral parties who are focused on the long-term success of the program. Members may need to be compensated for their service; they should have term limits of three to five years with no direct GEM research funding during their period of service.

Recommendation: The design of proposal solicitations and final recommendations for Trustee Council funding should be major functions of the Scientific and Technical Advisory Committee and chief scientist. In designing proposal solicitations, the Advisory Committee should be responsible for developing the scientific and technical subjects required to address GEM goals. Community workshops hosted by the Scientific and Technical Advisory Committee would be one method to help articulate community-generated research needs and could be a way to increase the participation of local communities that use Gulf of Alaska resources. The Scientific and Technical Advisory Committee and chief scientist should be responsible for organizing workshops designed to provide input on core variables to be measured over time. Final decisions on variable selection can be based on hypotheses proposing how each variable provides insight into human and climate-based changes in the ecosystem.

Recommendation: There should be an open process for nominating individuals to serve on the Scientific and Technical Advisory Committee, both during its initial formation and as the GEM program continues. Various independent scientific groups can assist in the initial formation to help broaden the selection process and find candidates with suitable experience in the initiation and implementation of large-scale, long-term ecological research. The chief scientist should review the nominations and recommend selections, with appropriate documentation, to the Trustees, who are responsible for the appointments.

Data and Information Management

Conclusion: There will be significant costs associated with data and sample processing and with data archiving. It is a common mistake to underestimate the cost of data and information management. To extract the full scientific value of any research program data and information must be made available to the scientific community, resource managers, policy makers, and the public on a timely basis. Each of these audiences will require information in a different format. The committee commends the initial development of data management procedures; careful implementation of these procedures is key.

Recommendation: GEM should create a comprehensive Data Management Office (not just an archive but a group of people who address these issues). Other large science programs spend as much as 20 percent of funds on data management. The multi-decadal scale of GEM will require a similar commitment.

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A

Biosketches of the Committee's Members

Michael Roman, *chair*, is a professor at Horn Point Environmental Laboratories at the University System of Maryland's Center for Environmental Sciences. His research interests are biological oceanography, zooplankton ecology, food-web dynamics, estuarine and coastal interaction, and the carbon cycle in the ocean. Dr. Roman was chair of the Coastal Ocean Processes Steering Committee for the National Science Foundation and has experience leading a multidisciplinary activity. He brings a broad ecological perspective to this setting.

Don Bowen is a research scientist at the Marine Fish Division of the Bedford Institute of Oceanography's Department of Fisheries and Oceans in Canada. His research has focused on the population dynamics, foraging ecology, and ecological energetics of pinnipeds. Objectives of these studies are twofold: to understand the diversity of pinniped life histories and to understand the nature of competitive interactions between seals and commercial fisheries. Since 1997 Dr. Bowen has also conducted ecological research on the northern right whale with the aim to foster the recovery of the species.

Adria A. Elskus is an assistant professor of environmental physiology at the T.H. Morgan School of Biological Sciences at the University of Kentucky. Her scientific background includes work in endocrinology, geochemistry, biochemistry, and physiology, and she has worked as a consultant in industry, as a toxicologist and chemist in government, and in academia. Her research interests include the fate and effects of contaminants, including petroleum, in aquatic ecosystems, particularly effects on reproduction; adaptation to environmental contaminants; organic pollutant metabolism and the interplay of hormones and pollutants; and the biochemical mechanisms of pollutant effects. She also has specific experience in the analysis of samples collected from oil spill sites.

John J. Goering is a professor emeritus and former associate director of the Institute of Marine Science, University of Alaska, Fairbanks. He is well known as one of the first to make significant discoveries in the areas of the marine nitrogen cycle, the silicon cycle, and silicon and nitrogen assimilation by phytoplankton. He has served as vice-president and later president of the Pacific Section of the American Society of Limnology and Oceanography, as chair of the Oil Spill Recovery Institute Science Advisory Committee, and as a member of the North Slope Borough Science Advisory Committee and the Coastal Marine Institute Technical Advisory Committee.

George Hunt is a professor of ocean ecology at the University of California, Irvine. Dr. Hunt has published extensively on the foraging ecology of marine birds, mechanisms for trophic transfer to top predators in marine ecosystems and the impacts of oil spills on marine birds. He is currently investigating how climate variability can affect the control of energy flow in the Bering Sea. Dr. Hunt is a Fellow of the American Association for the Advancement of Science and the American Ornithologists Union, and has previously served on the NRC's Committee on Mono Basin, (1985-1987), the Ecology Subcommittee of the Committee to review Outer Continental Shelf Environmental Studies Program (19861992), and the Committee to review Alaskan Outer Continental Shelf Environmental Information (1991-1994).

Seth Macinko is a assistant professor at the Department of Marine Affairs, University of Rhode Island. Previously he was a social and economic policy analyst at the Alaska Department of Fish and Game. He also fished commercially off Alaska from 1979 to 1983. His research interests are broadly focused on the interconnections between natural resource management (especially marine resources), environmental history, and political ecology. He is particularly interested in the role of institutional arrangements and culture in resource management. Current projects are focused on distributional issues involving access to marine resources property rights in marine fisheries, the role of place and community in property right reformations, and linkages between marine resources and community development.

Donal T. Manahan is the Director of Marine Biology at the University of Southern California. He is an environmental physiologist active in many areas of science in the Antarctic, as well as in temperate regions and deep-sea hydrothermal vents. His research includes physiological ecology of early stages (larvae) of animal development, animal/chemical interactions in the ocean, and the genetic bases of physiological processes. In education he is currently the director of an international Ph.D.-level training course in Antarctica, "Integrative Biology and Adaptation of Antarctic Marine Organisms." Dr. Manahan was the chair of the Polar Research Board from 1999-2002 and serves as the board's liaison to this activity.

Brenda Norcross is a professor of fisheries oceanography in the School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks. Her research centers on fish and their habitats, including human-induced effects on the environment. She has studied flatfishes in Alaskan waters and has modeled nursery habitats. Dr. Norcross headed the herring component of the multi-investigator Sound Ecosystem Assessment project, which investigated the environment of Prince William Sound following the *Exxon Valdez* oil spill. That research resulted in a synthetic knowledge of the juvenile life stage of herring. She also has studied distribution of juvenile fishes and their availability to marine mammals, especially Steller sea lions.

J. Steven Picou is a professor of sociology and chair of the Department of Sociology and Anthropology, University of South Alabama. He is a leading authority on the social impacts of technological disasters and also has active research interests in clinical sociology and environmental sociology. From 1989 to 1992 he directed an interdisciplinary team of social scientists for assessing the community impacts of the *Exxon Valdez* oil spill. Dr. Picou also developed and implemented a clinical community intervention program in Cordova, Alaska, from 1994-1997 that was designed to reduce chronic, spill-related social and psychological impacts. At present, he is directing a long-term study of social consequences of the *Exxon Valdez* litigation and chronic ecological degradation in Prince William Sound, Alaska, and two projects on the health risks of consuming contaminated fish in the Mobile Bay Estuary in Alabama.

Tom Royer holds the Samuel and Fay Slover Distinguished Chair in Oceanography at Old Dominion University. Dr. Royer is a leading authority on the oceanography of the Gulf of Alaska. His research interests are in deep ocean and coastal hydrography and currents, long-time series measurements, and air-sea interactions. He was at the University of Alaska for several decades, where he was one of the cornerstones of their academic and research programs and where his discovery of a significant coastal current along the coast of Alaska, driven by freshwater discharge, allowed a reasonable prediction of the trajectory of the oil released during the 1989 *Exxon Valdez* oil spill. He represented the University of Alaska, Fairbanks in UNOLS for many years and led the UAF ship program. He has a very broad view of marine science, and he has seen extensive service on many panels, boards, and committees.

Jennifer Ruesink is an assistant professor of zoology at the University of Washington. Her areas of academic interest include community ecology, especially food-web interactions; species invasions; the conservation of biological diversity; and ecosystem functioning. She has studied the ecological impacts of the *Exxon Valdez* oil spill on the ecology of tidal communities in Prince William Sound, including work with National Academy of Science member Dr. Robert Paine.

Karl Turekian is a Silliman Professor of Geology and Geophysics at Yale University. He also is the director of the Institute of Biospheric Studies and the director of the Center for the Study of Global Change. His research areas include marine geochemistry, atmospheric geochemistry of cosmogenic, radon daughter and man-made radionuclides, surficial and groundwater geochemistry of radionuclides, planetary degassing, geochronology based on uranium decay chain and radiocarbon of the Pleistocene, osmium isotope geochemistry, meteorite origins in relation to planetary systems, oceanic upwelling, and climate change. Dr. Turekian is an NAS member and has served on several NRC Boards and Committees including the Ocean Studies Board and the Committee on Global Change Research.

B
Acronyms

ACC	Alaska Coastal Current
ADCP	acoustic Doppler current profiler
BATS	Bermuda Atlantic Time Series
CalCOFI	California Cooperative Fisheries Investigations
EOS	NASA's Earth Observing System
EVOS	*Exxon Valdez* oil spill
EVOSTC	*Exxon Valdez* Oil Spill Trustee Council
GAK1	Gulf of Alaska station 1 located at the mouth of Resurrection Bay (60 N, 149 W)
GEM	Gulf Ecosystem Monitoring
GLOBEC	Global Ecosystem Dynamics program
GOA	Gulf of Alaska
GOFS	U.S. Global Ocean Flux Study
HOTS	Hawaii Ocean Time Series
IPRC	International Pacific Research Center
JGOFS	Joint Global Ocean Flux Study
LTER	Long-term Ecological Research
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NSF	National Science Foundation
ONR	Office of Naval Research
PSAMP	Puget Sound Ambient Monitoring Program

PWS	Prince William Sound
RFP	Request for Proposals
RIDGE	Ridge Inter-Disciplinary Global Experiments
SALSA	Semi-arid Land Surface Atmosphere Program
SOLAS	Surface Ocean Lower Atmosphere Study

PAC CHARTER

Exxon Valdez Oil Spill Trustee Council

441 W. 5th Ave., Suite 500 • Anchorage, Alaska 99501-2340 • 907/278-8012 • fax 907/276-7178

MEMORANDUM

TO: EVOS Trustee Council

FROM: Molly McCammon
Executive Director

RE: PAC (Public Advisory Committee) Charter: Additional Revisions

DATE: June 4, 2002

Following the Trustee Council's approval April 19, 2002 of the revised PAC charter, it was submitted to the DOI solicitor's office for review. This was the next required step in the process of formal adoption of the charter by the Secretary of the Interior.

The solicitor directed us to make several changes in the charter, as follows. These changes are reflected in a newly revised draft, which is attached.

<u>#6 (pp. 2-4) Membership, Selection and Service:</u>

- Clarify that at least one member shall represent each of the 14 interests identified, and that no more than 3 members shall be appointed for any single interest.
- Provide a definition for each of the identified interests.
- Specify that the Secretary of the Interior, with consent of the Trustees, may remove PAC members (as opposed to Trustees removing PAC members directly), and delete the finite list of reasons for removal (was "...for reasons of malfeasance, incompetence, or failure to attend to membership responsibilities.")

<u>#7 (p. 4) Expenses:</u>

- Clarify that PAC members receive travel and per diem, but not compensation.

<u>#11 (pp. 5-6) Authority:</u>

- Correct the cite for the Federal Advisory Committee Act (FACA).

One additional change has been made at my direction. The references to "Program Advisory Committee" throughout the charter have been replaced with "Public Advisory Committee." The reality was that whenever we talked about the committee, we referred to it as the "public" advisory committee, as the use of the word "public" more accurately reflects the membership and purpose of the committee.

6/4/02 draft

CHARTER
EXXON VALDEZ OIL SPILL PUBLIC ADVISORY COMMITTEE

1. Official Designation: *Exxon Valdez* Oil Spill Public Advisory Committee.

2. Objectives and Scope: In accordance with and pursuant to Paragraph V.A.4 of the Memorandum of Agreement and Consent Decree entered into by the United States of America, through the Department of Justice, and the State of Alaska, through the Attorney General, on August 27, 1991 and approved by the United States District Court for the District of Alaska in settlement of United States of America v. State of Alaska, Civil Action No. A91-081 CV, hereinafter referred to as the MOA, the Public Advisory Committee shall advise the Trustees (State of Alaska Department of Law, State of Alaska Department of Fish and Game, State of Alaska Department of Environmental Conservation, U.S. Department of Agriculture, the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce, and the U.S. Department of the Interior) through the Trustee Council with respect to the following matters:

   All decisions relating to injury assessment, restoration activities, or other use of natural resource damage recoveries obtained by the Governments, including all decisions regarding:

   a. Planning, evaluation, and allocation of available funds;

   b. Planning, evaluation, and conduct of injury assessments and restoration activities;

   c. Planning, evaluation, and conduct of long-term monitoring and research activities;

   d. Coordination of a, b, and c.

3. Period of Time Necessary for the Committee Activities: By order of the District Court for the District of Alaska, the Public Advisory Committee is to advise the Trustees, appointed to administer the fund established in settlement of United States v. Exxon Corporation, Civil Action No. A91-082, and State of Alaska v. Exxon Corporation, Civil Action No. A91-083, both in the United States District Court for the District of Alaska, in all matters described in Paragraph V.A.1 of the MOA referenced above. Final payment into the fund was September 1, 2001. A four-year period allowing the opportunity for the Trustees to reopen the agreement to possibly receive additional compensation for injuries begins October 1, 2002, and ends September 30, 2006. It is expected that the need for the Public

Advisory Committee will continue until at least September 30, 2006. Extension of the Committee beyond such date is subject to the unanimous written consent of the designated trustees.

4. Official to Whom the Public Advisory Committee Reports: The Public Advisory Committee shall report to the *Exxon Valdez* Settlement Trustee Council through the Chair of the Public Advisory Committee at Trustee Council meetings. Other members of the Committee may report with the Chair, as appropriate. The Trustee Council's regular agenda shall include a period during which the Public Advisory Committee representative(s) may report on its activities, ask questions of the Trustee Council, and be available for questioning by the Trustee Council. The U.S. Department of the Interior is the designated Federal agency to which the Public Advisory Committee reports to ensure compliance with the Federal Advisory Committee Act, including the responsibility of ensuring the necessary support for the Public Advisory Committee. The Designated Federal Officer is the Alaska Office of Environmental Policy and Compliance's Regional Environmental Assistant, or his/her designee.

5. Administrative Support: Administrative support for the Public Advisory Committee shall be provided by the Trustee Council's Executive Director. The Executive Director shall prepare an annual budget for the Public Advisory Committee. The budget shall provide the Public Advisory Committee such funds as the Trustee Council deems appropriate for administrative support for the Public Advisory Committee, from the *Exxon Valdez* Oil Spill Investment Fund established as a result of the settlement of United States v. Exxon Corporation and State of Alaska v. Exxon Corporation. The estimated annual operating cost for the Public Advisory Committee is $55,000.00, including an estimated .5 staff years.

6. Public Advisory Committee Membership, Selection, and Service: The Public Advisory Committee shall consist of 20 members, including a Chair and Vice-Chair. At least one member will be appointed to represent one of each of the 14 interests identified below, but no more than three members shall be appointed for any given interest.

   a. Qualifications for Service - Representatives shall be chosen based on their demonstrated knowledge of the region, peoples, or principal economic and social activities of the area affected by the *Exxon Valdez* oil spill, roughly the northern Gulf of Alaska, or by demonstrated expertise in public lands and resource management or research as it relates to restoration, as applicable. Members shall be appointed to represent a balanced representation of the following interests/qualifications that are prevalent in the affected area:

   (1) aquaculture and mariculture: organizations and individuals involved in these industries, including fish

hatcheries and oyster/shellfish farming, etc.

(2) commercial fishing: organizations and individuals involved in commercially fishing for salmon, halibut, herring, shellfish and bottom fish; including boat captains and crews, cannery owners/operators, and fish buyers, etc.

(3) commercial tourism: organizations and individuals involved in promoting or providing commercial travel or recreational opportunities, including charter boating, guiding services, visitor associations, boat/kayak rental companies, etc.

(4) recreation users: organizations and individuals involved in the broad spectrum of recreation activities that occur within the area, including kayaking, power boating, sailing, sightseeing, etc.

(5) conservation and environmental: organizations and individuals interested in the wise use and protection of natural resources.

(6) local government: representatives of the incorporated cities and boroughs in the affected area.

(7) Native landowner: representatives of the regional or village corporations established by the Alaska Native Claims Settlement Act in the affected area.

(8) tribal government: representatives of federally-recognized tribes in the affected area.

(9) science/technical: organizations, institutions, and individuals involved in, or with expertise in, scientific and research aspects of the affected area/resources and/or the effects of the oil spill and/or the technical application of scientific information.

(10) sport hunting and fishing: organizations and individuals involved in hunting and/or fishing for pleasure.

(11) subsistence: individuals who customarily and traditionally use wild renewable resources for direct

personal or family consumption as food, shelter, fuel, clothing, tools or transportation; for the making and selling of handicraft articles; and for customary trade.

(12) marine transportation: organizations and individuals involved in transport of goods and services in marine waters, including piloting, tug operations, barge operations, oil tankers and pipelines, shipping companies, etc.

(13) regional monitoring programs: organizations and individuals involved in monitoring and reporting on environmental conditions in the affected area, including monitoring for pollution and the status of biological resources, etc.

(14) public-at-large: individuals who meet the general qualifications in paragraph 6.a, and may or may not meet additional interest qualifications.

b. Nomination and Selection - Nominations for membership may be submitted by any source. The Science and Technical Advisory Committee shall nominate at least one, but not more than three, members to represent science/technical interests. From these nominations the Trustee Council will recommend membership to the Trustees, and following selection by the Trustees, the Secretary of the Interior appoints those selected by the Trustees.

c. Minimum Term - Each member may serve two years from the date of appointment. Members are eligible for renomination and reappointment at the close of their terms. With consent of the Trustees, the Secretary of the Interior may remove a member or officer of the Public Advisory Committee.

d. Officers - The Public Advisory Committee shall have a Chair and a Vice-Chair elected by the membership.

7. Expenses: Travel, per diem, and administrative support shall be borne by the Trustee Council using funds from the *Exxon Valdez* Oil Spill Investment Fund established in settlement of United States v. Exxon Corporation and State of Alaska v. Exxon Corporation. While away from home or regular place of business in performance of business of the Public Advisory Committee, members shall receive travel expenses, including per diem in lieu of subsistence, at the applicable government rate. Members will not receive compensation for their time spent on Public Advisory Committee business.

8. Public Advisory Committee Meetings and Records: The Public Advisory Committee shall meet no less than two times per year.

   a. All Public Advisory Committee meetings will be open to the public. Any member of the public is permitted to file a written statement with the Public Advisory Committee and any member of the public may speak at a Public Advisory Committee meeting.

   b. Detailed minutes of all meetings, including the time, date and place of the meeting, names of the Public Advisory Committee members and other staff of the Trustee Council present, names of the public who presented oral or written statements, an estimate of the number of other public present, an accurate description of each matter discussed and each matter resolved, if any, by the Public Advisory Committee, shall be prepared and made available to the public through the Executive Director. The Chair shall certify to the accuracy of all minutes of the Public Advisory Committee.

   c. Meetings of the Public Advisory Committee shall be held at a reasonable time and in a place reasonably accessible to the public. Notice of meetings shall be published in accordance with AS 44.62.310(e), AS 44.62.175 and 41 CFR 102-3.150.

   d. All accounts and records of the activities and transactions of the Public Advisory Committee shall be kept and maintained by the Staff of the Executive Director and, subject to the provisions of 5 U.S.C. section 552, such accounts and records shall be available for public inspection at the offices of the Executive Director.

   e. All rules and procedures governing the proceedings of the Public Advisory Committee must be approved by the Trustee Council.

9. Administrative Authority: The Public Advisory Committee functions are advisory only, and its officers shall have no administrative authority by virtue of their membership. The Trustee Council, through the Executive Director, shall procure all needed space, supplies, equipment, and support for the Public Advisory Committee.

10. Termination Date: The Federal Advisory Committee Act, as amended (5 U.S.C. App. 2), requires that the Public Advisory Committee shall terminate two years from the date of filing of this Charter unless the Committee is renewed before that date in accordance with the requirements of that Act.

11. Authority: This Public Advisory Committee is established as mandated by Paragraph

V.A.4 of the MOA and shall be located in Alaska. Additional authority for its creation is found in the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. subsection 9601 et seq.; and the Federal Advisory Committee Act, as amended, 5 U.S.C. App. 2.

____
Secretary of the Interior
Date Signed: ____________________
Date Filed: _____________________

FY 03 DRAFT PHASE II
INVITATION

6/4/02 REVIEW DRAFT

FY 03 PHASE II INVITATION

NOTE TO READER:

Attached for your review is a draft of the FY 03 Phase II invitation. The invitation was developed in concept by the STAC (Science & Technical Advisory Committee) and is currently under review by the STAC. Copies have also been provided to Trustee agency project managers. The Trustee Council will be briefed on this draft on June 14, 2002. The invitation is scheduled to be issued on about July 15, 2002 with proposals due about September 4, 2002.

The cap set by the Trustee Council for the FY 03 work plan (Phases I and II) is $6 million. Under Phase I, 33 proposals requesting $4.3 million were received. The Executive Director's preliminary recommendation of which Phase I proposals to fund totals roughly $4 million, leaving roughly $2 million available for Phase II.

Phase II will consist of proposals to begin implementation of GEM as well as some additional GEM-related synthesis projects. Phase I consists of proposals to (a) continue FY 02 projects on lingering oil-related injury and conduct a few new projects on lingering oil effects and (b) continue FY 02 GEM transition projects and conduct a few new GEM-related synthesis projects. Phase I also includes the science and data management, public information, and administrative components of the Trustee Council's program.

memophii

INTRODUCTION

In 1989, the *T/V Exxon Valdez* spilled 11 million gallons of crude oil into Prince William Sound. In 1991, the U.S. District Court approved a civil settlement that required Exxon Corporation to pay the United States and the State of Alaska $900 million to restore the resources injured by the spill, and the reduced or lost services (human uses) the resources provide. Under the court-approved terms of the settlement, a Trustee Council of three federal and three state members administers the restoration fund to restore the resources and services injured by the spill.

Each year the Trustee Council invites individuals, private industry, government agencies, and other interested parties to submit proposals for projects to be included in the annual work plan. This year, the FY 03 invitation is being issued in two phases:

> <u>Phase I</u>, which was issued in February 2002, solicited proposals to (a) continue FY 02 projects on lingering oil-related injury and conduct new, innovative work on lingering oil effects and (b) continue FY 02 GEM transition projects and conduct new GEM-related synthesis projects. Phase I also contains funds for the science and data management, public information, and administrative components of the Trustee Council's program. The Council's Executive Director is recommending awards under Phase I of roughly $4.0 million (approximately $1.2 million related to lingering oil effects, $1.0 million related to GEM, and $1.8 million for science and data management, public information, and administration). The Trustee Council is scheduled to take action on this recommendation on August 6, 2002.
>
> <u>Phase II</u>, which is this invitation, solicits proposals to begin implementation of GEM. The total amount of awards under Phase II will be roughly $2.0 million.

This invitation has three parts:

- **Introduction.** This section describes the work plan process and funding caps. It also includes a notice for a Broad Agency Announcement (BAA) that is being issued concurrently with this invitation.
- **Invitation.** This section provides background on GEM, describes the status of GEM planning and implementation, identifies GEM transition projects recommended for funding through the FY 03: Phase I invitation, and invites proposals for FY 03: Phase II.
- **Instructions for Submitting a Proposal.** This section gives detailed instructions for preparing and submitting a proposal. It also describes how proposals will be evaluated.

Work Plan Process

Milestones in the development of the FY 03 work plan are described in Table 1.

Table 1. Milestones for FY 03 Work Plan

Feb. 15, 2002	*FY 03: Phase I Invitation* issued.
April 15, 2002	FY 03: Phase I proposals due.
June 15, 2002	Executive Director's recommendation on FY 03: Phase I projects out for public comment.
Aug. 6, 2002	Trustee Council scheduled to approve FY 03: Phase I projects.
July 15, 2002*	*FY 03: Phase II Invitation* issued.
Sept. 4, 2002*	FY 03: Phase II proposals due.
Oct. 28, 2002*	Executive Director's recommendation on FY 03: Phase II projects out for public comment.
Nov. 25, 2002	Trustee Council scheduled to approve FY 03: Phase II projects.

** tentative date*

Funding Caps

As part of its decision to establish GEM, the Trustee Council established an investment fund and adopted an investment strategy which provides for inflation-proofing the fund and includes annual funding caps for FY 03 and all future years. The caps include both the work plan (all GEM and lingering oil projects) and the science and data management/public information/administrative costs of the program.

As illustrated in Table 2, the cap for FY 03 has been set at $6 million. The public information/administrative component of the program is expected to cost roughly $1.1 million in FY 03, leaving roughly $4.9 million for the work plan. Of this amount, approximately $2.9 million is recommended for award under Phase I of the invitation, and approximately $2 million is expected to be awarded under Phase II.

The cap for FY 04 has also been set at $6.0 million. Beginning in FY 05, the cap will be determined by investment earnings. The Trustee Council's investment strategy provides for spending at a level not to exceed 4.5 percent of the average market value of the fund over the prior three to five years.

Table 2. Program Funding

FY 03 and Future Year Caps	
→ FY 03	$6.0 million
FY 04	$6.0 million
FY 05	$5.6 million (estimate)
FY 06 +	$5.7 million (estimate)

Attention Proposers Who Represent a Private Organization or Non-Profit Group: Submit Through the BAA

As part of this invitation, the National Oceanic and Atmospheric Administration (NOAA) is issuing a Broad Agency Announcement (BAA) on behalf of the Trustee Council, requesting proposals for any of the research or monitoring topics identified in this invitation. Proposers representing private organizations and non-profit groups, , please see page xx for information on submitting a proposal under the BAA.

Attention All Proposers: New Data Policy & Report Writing Procedures

For those of you who have participated in the Trustee Council's restoration program in the past, please note that the Council has adopted a new data policy and revised its project report requirements. See page XX for more discussion of these changes. The data policy and the report procedures are available for downloading from the Council's web site (www.oilspill.state.ak.us) or upon request from the Trustee Council Office.

INVITATION

This invitation solicits proposals to begin implementation of the Gulf of Alaska Monitoring and Research Program (GEM).

Background on GEM

GEM is a long-term effort to increase understanding of Gulf of Alaska ecosystems and to monitor natural and human-induced change in these systems. GEM's mission is to:

> *Sustain a healthy and biologically diverse marine ecosystem in the northern Gulf of Alaska 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 will be funded through a $120 million endowment established by the Trustee Council from the remaining *Exxon Valdez* oil spill settlement funds. The Council has endowed this program as a final legacy of its mission to restore the fish and wildlife resources injured by the spill. In making the decision to allocate these funds for a long-term program of monitoring and research, the Council explicitly recognized that complete recovery from the oil spill may not occur for decades and that full restoration of these resources will most likely be achieved through long-term observation and, as needed, restoration actions. The 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 Gulf of Alaska (GOA). This knowledge can only be provided through a long-term monitoring and research program that will span decades, if not centuries. 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

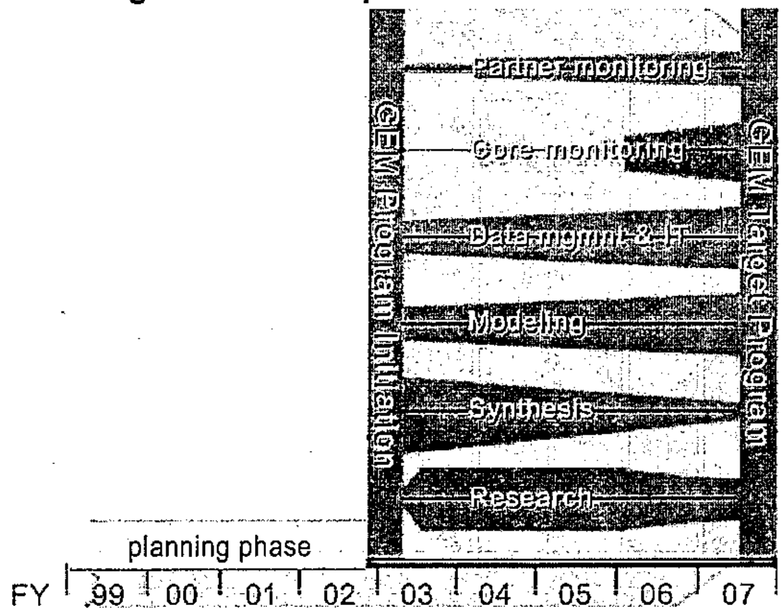
5. PREDICT: Develop the capacity to predict the status and trends of natural resources for use by resource managers and consumers.

Consistent with the Trustee Council's *Exxon Valdez* Oil Spill Restoration Plan (1994), GEM 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, the Kodiak Archipelago, and the Alaska Peninsula. Recognizing that the marine ecosystems affected by the spill do not have discrete boundaries, some monitoring and research activities may extend into adjacent areas of the northern GOA.

Four habitat types, representative of the GEM project area, are used to better organize the GEM program: watersheds, intertidal/subtidal, Alaska Coastal Current (ACC), and offshore (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. It is fully recognized that linkages, flows, and processes between the habitat types must be studied. The scientific strategy of GEM uses a central hypothesis and key questions developed from a conceptual foundation to establish the initial direction for the program in each of the four habitat types. From this starting point, GEM follows a path of synthesis, research, and monitoring to detect, understand and, eventually, predict changes in living marine-related resources in the GEM region.

Figure 1 shows the prioritization for implementing the GEM program through research, synthesis, modeling, data management and information technology, core monitoring, and partner monitoring over the next five years.

Figure 1: GEM Implementation Schedule



For additional information on GEM, please review the GEM Program Document, which is available on the Trustee Council's website (http://www.oilspill.state.ak.us/gem/) along with other GEM-related information.

Status of GEM

[NOTE: BY THE TIME THIS INVITATION IS ISSUED, GEM PROGRAM DOCUMENT SHOULD BE REVISED, APPROVED BY TC, AND ON TC'S WEB PAGE. LANGUAGE IN THIS SECTION WILL BE CHANGED ACCORDINGLY]. In August 2001, the GEM Program Document was submitted to the National Research Council (NRC) for review. The Trustee Council received comments from the NRC in May 2002 and is in the process of revising the document.

Also in May, the Scientific and Technical Advisory Committee (STAC) had its first meeting. The STAC is a standing committee that will play a key role in guiding the GEM program and ensuring it is implemented with a high degree of scientific integrity. The Council will be issuing a call for nominations for three subcommittees to support the STAC and program implementation: a lingering oil effects subcommittee, a GEM habitat subcommittee, and a data management subcommittee. The GEM habitat subcommittee may be further divided by habitat type (i.e., watershed, intertidal/subtidal, Alaska Coastal Current, and offshore). The subcommittees, which will be composed of scientists, resource managers, community members and other experts, will assist the

STAC in identifying priority areas for synthesis, research, and monitoring.

Once the STAC and subcommittees are in place, the GEM program will begin full implementation. Until then, funded activities will be limited to synthesis projects and initial research in the intertidal/subtidal areas. An informal subcommittee process is already underway on the intertidal/subtidal area. Three workshops have been held—in November 2001, and January and April 2002—resulting in a general consensus on some limited research to be done in this habitat area.

In February 2002, the Trustee Council issued Phase I of its FY 03 invitation which solicited proposals to (a) continue FY 02 projects on lingering oil-related injury and conduct new, innovative work on lingering oil effects and (b) continue FY 02 GEM transition projects and conduct new GEM-related synthesis projects. Sixteen GEM-related proposals were received and are currently under review. The Council is scheduled to approve Phase I projects in August 2002. This document is Phase II of the FY 03 invitation and solicits proposals to begin implementation of GEM.

Invitation Topic Areas

This invitation is organized by the following topic areas: cross-habitat linkage topics (which extend across GEM habitat types) and the intertidal/subtidal, watershed, Alaska Coastal Current (ACC), and offshore habitat areas.

CROSS-HABITAT LINKAGES

Cross-habitat linkages extend across GEM habitat types.

Synthesis

Synthesis projects build on and update the current understanding of the northern Gulf of Alaska. They bring together existing data from any number of disciplines, times, and regions to evaluate different aspects of GEM's central hypothesis and key questions, as well as related ideas. Within the GEM program, synthesis is defined as interdisciplinary and/or concerned with multiple habitat types.

Synthesis is used (1) to provide direction for developing hypotheses to be tested and, combined with research and monitoring, to update and refine the GEM conceptual foundation; (2) 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 (3) 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, it logically becomes a companion to research. In addition, synthesis will be conducted periodically throughout the GEM program.

Phase I Proposals Recommended for Funding

- Underway in FY 02 and recommended for continuation through the Phase I invitation: Project 02600 is synthesizing the results from 12 years of post-spill study in the Trustee Council's damage assessment and restoration programs.
- Recommended for funding through the Phase I invitation: Project 03625 will prepare a synthesis paper on the present structure of the pelagic ecosystem of Prince William Sound.

Phase II Invitation

- Proposals are invited to use data, literature and other information sources from the Gulf of Alaska and adjacent waters to develop hypotheses for focusing GEM's long-term research and monitoring programs.
- Proposals are invited to make important regional data sets or bodies of literature more readily accessible to researchers in the biological and physical sciences, to natural resource managers, to resource-dependent people such as subsistence and commercial fishers, or to educators in natural sciences.
- Proposals are invited to compile, assess and analyze biological and physical datasets from *Exxon Valdez* Oil Spill research from 1989 to the present

Modeling

Modeling projects make clear the relationships between the parts and processes of the ecosystem. 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. The purposes of modeling under GEM are to: (1) inform, communicate, and provide common problem definition; (2) identify core variables and relationships; (3) set priorities; (4) improve and develop experimental (monitoring) designs; and (5) improve decision-making and risk assessment.

Modeling, monitoring, and data management strategies must work in concert for each to be fully effective. 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 program can be made more effective. Modeling also helps interpret data for the use of synthesis and research activities.

Phase I Proposals Recommended for Funding

- Underway in FY 02: Project 02603 is expanding the ocean circulation model developed under SEA (Sound Ecosystem Assessment) to the Gulf of Alaska.

Phase II Invitation

- The Trustee Council is not soliciting for modeling proposals at this time, but will consider new innovative proposals in this area.

Community Involvement

Meaningful public and community participation is an essential part of the Trustee Council's process. This includes involvement of communities and stakeholders in monitoring, data analysis and issue prioritization and a commitment to communicate research results to the public through workshops, seminars, and the like.

Phase I Proposals Recommended for Funding

- Underway in FY 02 and recommended for continuation through the Phase I invitation: Project 02052 is developing local natural resource stewardship capacity in villages in the spill area; Projects 02210 and 02610 involve junior and senior high school students in marine research projects in the spill area; Project 02561 is exploring involving local residents in long-term forage fish monitoring studies; Project 02636 is working to build a bridge between the scientific and commercial fishing communities.
- Recommended for funding through the Phase I invitation: Project 03575 will design a community involvement and community-based monitoring component for GEM.

Phase II Invitation

- The Trustee Council is not soliciting for community involvement proposals at this time, pending the results of Project 03575, Designing a Community Involvement/Community-Based Monitoring Plan for GEM (see above).

HABITAT TOPICS

Habitat topics are topics that are defined within a GEM habitat type.

Watershed

Projects in the watershed habitat focus on long-term monitoring of marine-related productivity in watersheds to evaluate the effects of human activities and natural forces. The key question the GEM program seeks to answer with respect to watersheds 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?*

Phase I Proposals Recommended for Funding

- Underway in FY 02 and recommended for continuation through the Phase I invitation: Project 02649 is reconstructing changes in sockeye salmon abundance using the 15N record left by salmon carcasses in the sediments of spawning lakes.
- Will be completed in FY 02: Project 02612 is studying the role of marine-derived nutrients in the Kenai River ecosystem; Project 02668 is creating a database designed to improve management of citizen-collected water quality data.
- Recommended for funding through the Phase I invitation: Project 03596 will support continued operation of a water flow gauge used in water quality monitoring on the Ninilchik River.

Phase II Invitation

- The Trustee Council is not soliciting for watershed proposals at this time, but will consider new innovative proposals in this area. Synthesis proposals that cut across habitat types and may include watersheds are being solicited (see page XX).

Intertidal/subtidal

Projects in the intertidal/subtidal habitat area focus on identifying how human activities and natural events can change the community structure of the intertidal/subtidal (intertidal and subtidal) areas. The key question GEM seeks to answer with respect to intertidal/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 intertidal/subtidal habitats?*

Phase I Proposals Recommended for Funding

- Underway in FY 02 and recommended for continuation through the Phase I invitation: Project 02584 is exploring airborne remote sensing instrumentation as a monitoring tool for GEM; Project 02656 is investigating long-term patterns of productivity and species abundances in intertidal/subtidal communities via analysis of archaeological material and isotopes.
- Underway in FY 02: Projects 02613 and 02619 are conducting aerial video imaging of the coastline from Prince William Sound to McCarty Fjord and along the northern section of Kodiak and Afognak islands.