11.6.3

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

MEMORANDUM

To: Trustee Council Members

From: Molly McCammon Eric Myers for
Executive Director

Date: March 24, 1995

Re: Briefing Materials for March 31, 1995 Meeting

In preparation for the March 31 teleconferenced meeting, I have enclosed the agenda, briefing materials, and several other informational items. This memo and the enclosures constitute your briefing packet for the March 31 meeting. Those materials not yet finalized will be sent to you for insertion in this packet. If you have any questions on these items, please don't hesitate to contact me.

1. Meeting Notes. The draft meeting notes for the February 13, February 17, February 22, February 28, and March 1 meetings are enclosed.

2. Financial Report. Enclosed are the financial statements as of February 28, 1995.

3. FY96 Invitation and Draft Long-Range Restoration Program. Enclosed as a separate document is the *Invitation to Submit Restoration Projects for Federal Fiscal 1996 and Draft Restoration Program: FY96 and Beyond*. This document is now out for public review through May 1. Project proposals are also due May 1. We are scheduling a series of public meetings throughout the spill area regarding the Invitation/Long-Range Restoration Program and welcome your participation if your schedule permits.

4. Alaska SeaLife Center. Included for your information is a status report from Project Coordinator Kim Sundberg.

5. Nearshore Vertebrate Predator Package. Enclosed is a copy of the Detailed Project Description and budget for this ecosystem project proposed by the National Biological Service. This proposal has been extensively reviewed by the Chief Scientist, the core reviewers and others, and received outstanding reviews. I am recommending that this project go forward as proposed, with

only minor changes as recommended by the Chief Scientist. The budget for this project is still under review, and a final recommendation will be submitted to you as soon as possible.

6. APEX/Forage fish Package. Enclosed is a copy of the Detailed Project Description and budget for this ecosystem project proposed by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. This proposal has been extensively reviewed by the Chief Scientist, the core reviewers, and others. In addition, the hydroacoustics portion of this project is the subject of an intensive review session in Cordova from March 28-30, along with the hydroacoustic portion of the SEA program. A final recommendation on this proposal is still being formulated, and will be sent to you as soon as possible prior to the March 31 meeting.

7. Technical amendments to AKI and Old Harbor resolutions. Language has been negotiated between the Alaska Department of Law and the U.S. Department of Justice regarding the so called "reverter" clause. This language has necessitated the Council to consider technical amendments to the AKI and Old Harbor resolutions. These amendments are being prepared by Department of Justice legal counsel Berry Roth, and will be circulated prior to the meeting. As a further note regarding these two actions, both offers have been approved overwhelmingly by their corporation shareholders, and final purchase agreements are expected to be signed in April.

8. Technical budget amendments. Minor budget modifications are proposed. A memo regarding these modifications will be provided under separate cover.

mm/raw

March 31, 1995

RESOLUTION OF THE
***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**

Whereas, the *Exxon Valdez* Oil Spill Trustee Council ("Trustee Council"), approved by Resolutions dated November 2, 1994, the use of the joint Federal and State of Alaska settlement funds for the acquisition of lands and interests in lands owned by Akhiok-Kaguyak, Inc. ("AKI") and Old Harbor Native Corporation ("OHNC") within the boundaries of the Kodiak National Wildlife Refuge;

Whereas, on March 15, 1995, the shareholders of AKI approved the sale and donation of lands and interests in such lands to the United States;

Whereas, on March 22, 1995, the shareholders of OHNC approved the sale and donation of lands and interests in such lands to the United States;

Whereas, all parties involved desire to complete the initial closings for these acquisitions at the earliest possible date in order to protect this key ecosystem and promote the restoration of the natural resources and related services injured as a result of the *Exxon Valdez* Oil Spill;

Whereas, the United States and the State of Alaska have continued to discuss and refine the most feasible means for accomplishing their mutual responsibility for restoration of the injured ecosystem;

Therefore, by unanimous consent, we the undersigned, duly authorized members of the Trustee Council, do hereby supplement and amend our November 2, 1994, Resolutions with respect to AKI and OHNC as follows:

1. The State of Alaska Department of Law and the Assistant Attorney General of the Environment and Natural Resources Division of the United States Department of Justice are hereby requested to petition, at the earliest possible date, the United States District Court for the District of Alaska for the disbursement and distribution to the United States of the initial installments of the joint settlement funds in the amounts set forth in those Resolutions.

2. The provisions of these Resolutions prohibiting the subsequent conveyance by the United States of the properties so acquired are hereby eliminated and in lieu thereof, the following shall apply:

> Title to the lands conveyed to the United States shall be subject to a right to be held by the State of Alaska to enforce the restoration and conservation purposes for which such acquisition is made. Conveyance instruments to establish such rights shall be subject to review and approval as to form and substance by the U.S. Department of Justice and the State of Alaska Department of Law.

3. Closing of these acquisitions shall not occur prior to the execution of implementing Purchase Agreements by the United States and approval by the Trustee Council Executive Director of the conveyance instruments to be used for compliance with the requirements of the respective November 2, 1994 Resolution, as supplemented and amended herein.

PHIL JANIK
Regional Forester
USDA Forest Service

Date:

BRUCE M. BOTELHO
Attorney General
State of Alaska

Date:

GEORGE T. FRAMPTON, JR.
Assistant Secretary for Fish
and Wildlife and Parks
U.S. Department of the Interior

Date:

STEVEN PENNOYER
Director, Alaska Region
National Marine Fisheries Service
U.S. Department of Commerce

Date:

FRANK RUE
Commissioner
Alaska Department of Fish and
Game

Date:

GENE BURDEN
Commissioner
Alaska Department of Environmental
Conservation

Date:

Project Leader: David C. Duffy
Alaska Natural Heritage Program
University of Alaska Anchorage
707 A Street
Anchorage AK 99501

APEX: Apex predator ecosystem experiment in Prince William Sound and the Gulf of Alaska

Ms. McCammon has indicated that a project on seabirds and their relation with forage species with a budget of 1.0 to 1.2 million dollars could be considered for funding during this fiscal year by the Exxon Valdez Oil Spill Trustee Council. We have therefore reduced our budget from $1,586,700 to $1,167,900, a reduction of over 25%. This reduction has been at the cost of delaying one project (proximate analysis of forage fish) and reducing the scope of the rest. The reduction depends on having access to existing Council-funded equipment as detailed in the budget notes, and on cost-sharing for acoustic and field work with an Mineral Management Service project in the Barren Islands area.

We have redefined our first-year objectives to focus on an intra-annual comparison between two colonies with very different forage food environments. We see this as a pilot project to test our principal organizing hypothesis: that the injured seabird species of Prince William Sound have failed to recover because of shifts in the trophic environment that they depend on.

We will combine our efforts to examine nestling-seabird diet, growth, body condition and survival between colonies with capelin, a nutritionally high-quality forage species, in the Barrens Islands and colonies in the Naked Island area in Prince William Sound (where capelin have been scarce or absent in diets and where populations of several seabirds have failed to recover following the oil spill).

If our initial efforts indicate that seabirds in the Sound are doing less well than those in the Barrens, we hope to expand the project to compare a series of colonies with different food environments over several years to examine the degree of inter-annual variation between and within colonies.

We will also conduct pilot projects to explore: 1) the degree of spatial variability of the food environment in Prince William Sound and its effect on reproductive success of kittiwakes and pigeon guillemots; 2) the degree of temporal variability in local fish abundance during summer; 3) the importance of local food concentrations for seabird foraging; and, 4) the feasibility of using fish energetic-condition as an index of population trends, 5) the foraging range of kittiwakes in PWS; and 6) we will conclude analysis of existing diet samples.

Our expected products after the first year are strong preliminary single-year tests of the hypotheses that:

Barrens/PWS
1. PWS seabird species (kittiwake, tufted puffin, pigeon guillemot) have a nutritionally poorer diet than do species in the Barrens (kittiwake, tufted puffin, common murre), and
2. nesting success and nestling condition in PWS are poorer, and
3. direct measurement through acoustic sampling and trawls will show nutritionally favorable forage species are more abundant in the Barrens, and/or
4. foraging studies show all or just nutritionally superior forage species are more accessible in the Barrens, and

Within PWS
5. acoustic sampling and foraging studies show spatial variability in prey abundance and availability, and
6. the distribution and abundance of forage species is temporally stable within our sampling period, and
7. this variability is reflected in differences in nesting productivity of a) kittiwakes during extensive (2 visit) surveys of up to 26 colonies across the Sound, b) kittiwakes studied intensively thoughout the breeding season at Shoup Bay, Eleanor Island, South Eaglek Bay and Naked Island, c) guillemots at Naked and Jackpot Islands, and d) puffins at Naked Island and Porpoise Rocks, and

General
8. historical data will prove to be available and useful for testing of hypotheses concerning forage fish population/ecosystem changes in the northern Gulf of Alaska and Prince William complex, and
8. pilot data will show sharp disparities in energetic condition

between prey species, suggesting strong, testable hypotheses for future work, and

9. completion of initial diet analysis will similarly suggest that competition for food, cannibalism, or predation are important factors in determining the composition of the forage community, generating strong, testable hypotheses for future work.

This first year will provide sufficient information to decide which projects can generate useful information to 1) further test the general hypothesis between sites and between years, and 2) to develop working hypotheses that can form the basis for long-term monitoring.

Exxon Valdez Oil Spill Trustee Council

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MEMORANDUM

To: Trustee Council Members

From: Molly McCammon
Executive Director

Date: March 30, 1995

Subj: Technical budget amendments

As reflected in the attached memo from Director of Administration Traci Cramer, the Council needs to take action on three technical budget items. These are not requests for additional funds. In two cases, they reflect the transfer of previously authorized funds between Trustee agencies. In the third case, the transfer is between two sub-projects within an already authorized project.

I recommend the Council approve a motion to adopt the technical budget amendments as described in the memo from Ms. Cramer.

mm/raw

Exxon Valdez Oil Spill Trustee Council
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MEMORANDUM

TO: Molly McCammon

FROM: Traci Cramer
Traci Cramer
Administrative Officer

DATE: March 29, 1995

RE: FFY 1995 Budget Amendments

Based on communication from the Trustee Agencies, the following amendments to the Federal Fiscal Year 1995 budget require consideration by the Trustee Council.

Transfers Between Trustee Agencies

No.	Title	Amount	From	To
95126	Habitat Protection Acquisition & Support	$80,000	USFS	ADNR

Comments - The funding associated with the acquisition of small parcels was appropriated to the USFS. After further review, it has been determined that the sponsoring agency will expedite the appraisal and acquisition process. It is requested that funding be transferred to the ADNR which is the land manager for the State of Alaska. After action by the Trustee Council, the FFY 1995 Revised Authorization will be:

USFS	$337.4	ADNR	$358.0

No.	Title	Amount	From	To
95163I	Forage Fish: Program Management and Integration	$130,600	NOAA	DOI

Comments - At the time that approval was provided for the project, the assignment of cooperating agencies was unknown. In mid-December it was determined that both NOAA and the DOI-FWS would be participating on the project. Since the agencies have been operating in this manner, it is requested that the transfer be retroactive back to inception of the project. After action by the Trustee Council, the FFY 1995 Revised Authorization will be:

NOAA	$19.4	DOI-FWS	$130.6

Transfers Between Trustee Projects

No.	Title	Amount
95139A1	Salmon Instream Habitat and Stock Restoration - Little Waterfall Creek	$25,000

Comments - The original scope of the project was to provide access to under utilized habitat with a capacity for 24,000 spawners. This included the modification of the lower 60 foot section of the fish pass and the modification of the upper 20 foot section. However, in the preparation of the bid it has become obvious that the available funding is insufficient to complete the fish pass work. It is requested that additional funding be provided to carry out the original intent of the project. After Trustee Council action, the FFY 1995 Revised Authorization will be $115.0.

No.	Title	Amount
95139C2	Salmon Instream Habitat and Stock Restoration - Lowe River	($25,000)

Comments - The Draft Environmental Assessment has been produced and comments in response revealed that some original planning assumptions may be flawed. Additional field data collection will be required in FFY 1995 before this project or a similar project in the Lowe River drainage can proceed. Since construction of the spawning channel cannot proceed as originally intended, funding is available for transfer to Little Waterfall Creek. After Trustee Council action, the FFY 1995 Revised Authorization will be $145.1.

cc: Eric Myers
Dave Gibbons, USFS
Carol Fries, ADNR
Byron Morris, NOAA
Catherine Berg, DOI
Bob Baldauf, DOI
Joe Sullivan, ADF&G

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MEMORANDUM

TO: Trustee Council

FROM: Molly McCammon, Executive Director

DATE: March 29, 1995

SUBJ: Recommendation — Project 95025/Nearshore Vertebrate Predator Project

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The purpose of this memorandum is to provide you with my recommendation concerning the proposed Project 95025/Nearshore Vertebrate Predator Project, a five year ecosystem investigation of resources injured in the nearshore environment.

The Chief Scientist has prepared a review memo dated March 22, 1995 (attached). The peer reviewers were unanimous in their praise of the project. Dr. Spies noted that the project leader, Dr. Leslie Holland Bartels/NBS, and the PIs have done an excellent job of reshaping the proposal into a cohesive package during the planning process. Dr. Spies has asked that a response be provided to the comments and recommendations of the peer reviewers, but also has indicated his strong support for the project.

I recommend that Project 95025 be authorized at a funding level of $606,100 for the remainder of FFY 95, with the project to proceed consistent with the provisions identified in the Chief Scientist's review memo and the conditions identified below.

<u>FFY 95 Budget</u>

The budget for FFY 95 is $606,100 for the remaining six months of FFY 1995. The most recent version of the budget (dated March 14, 1995) has been reviewed by Traci Cramer/Director of Administration.[1] A copy of the budget

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1 The most recent Project 95025/Nearshore Vertebrate Predator budget dated 3/14/95 is slightly higher ($606.1 vs. $596.2) than the version in the Trustee Council packet. The difference is attributable to certain proposed program management expenditures.

review memo is attached. The budget review identified a number of minor issues that should be resolved, but do not warrant a delay in proceeding with the project at this time. This further review will include examination of the Trustee Council equipment list to verify that requested equipment is not otherwise available from the existing inventory.

Traci Cramer will work with the Dr. Holland-Bartels to obtain further information regarding these budget matters in order to identify possible savings with budget revisions to be made accordingly.

FFY 96 and Beyond

The Trustee Council should be aware that initiation of this project at this time reflects a significant long-term commitment. Project 95025 proposes a budget of approximately $1.64 million each year during FY 96-FY 98, with a final FY 99 budget of $450,000. The appropriate level of funding for FFY 96 and beyond will be determined annually through the peer review/adaptive management process in light of project findings and developments. It is expected that a FFY 96 and beyond budget will be submitted by May 1, 1995 as part of the FFY 96 project review process.

Proposed Collections

It should also be noted that the study design for Project 95025 includes the proposed collection of certain seaducks. In FFY 95 (fall of 1995), the project proposes to collect 25 harlequin ducks to establish a condition index. Later in the project, 50 White winged scoters and 50 Barrows goldeneyes would be taken in each of two years (winter 96-97 and winter 97-98). A federal collection permit application has been submitted.

This element of the project requires further review prior to approval. It is recognized that any scientific project that proposes a collection of birds or mammals should be allowed to proceed only if there are substantial benefits to the restoration mission. Prior to any final approval regarding these elements of the project the Chief Scientist will review the proposed collections and consult with peer reviewers and others with appropriate expertise. The Chief Scientist's review will address issues concerning possible impacts to the species collected (i.e., number of birds to be collected, total population, health of the population, alternative data collection options including non-lethal taking methods, etc.), as well as the need and merit of a proposed collection as it relates to restoration goals (i.e., information that would be lost if there was no take and what would realistically be accomplished as a result of the collection).

The Chief Scientist will then make a recommendation to the Executive Director. The Executive Director will in turn inform the PAG and the Trustee Council of this recommendation in writing prior to final approval. All federal or State permits will be required prior to implementation of a project.

In conclusion, based on the strength of the peer review recommendation and after consideration of long-term restoration efforts and commitments, I believe that initiation of this project at this time is appropriate.

attachments:

— Chief Scientist review memo (March 22, 1995)
— Director of Administration budget review memo (March 28, 1995)

APPLIED marine SCIENCES

March 22, 1995

Molly McCammon
Executive Director
Exxon Valdez Oil Spill Trustee Council
645 G Street Ste.402
Anchorage, AK 99501

Re: Recommendation on **Nearshore Vertebrate Predator Project (95025)**

Dear Molly,

We received the detailed project description for the "Nearshore Vertebrate Predator Project" in our office on February 21, 1995. It was sent to several reviewers and they have provided written comments on the project description. The proposal was also the subject of a conference call on March 20, 1995 with the core reviewers, myself, Andy Gunther and you.

The project will focus on the recovery of a suite of important predators that were injured by the spill in the nearshore part of the Prince William Sound ecosystem: (1) two invertebrate consumers: sea otters and harlequin ducks, and (2) two fish eaters: river otters and Pigeon Guillemots. The study asks three basic questions: (1) Is the recovery of these species being constrained by intrinsic demographic factors? (e.g., intrinsic rate of population increase?) (2) Is the recovery of these species being constrained by food?, and (3) Is the recovery of these species being constrained by continuing oil exposure? There are separate approaches to answering each of these general questions. For the demographic factors, studies of the population sizes and growth rates of these predators will be carried out. For assessing the possible role of continuing oil toxicity, assessments of individual health of organisms will be carried out using a biochemical indicator of oil exposure and immune system indicators. For the food availability questions, the abundance of major prey items will be assessed in oiled and unoiled areas. The project is proposed to start in 1995 with an expenditure of $596K and to expand to $1.64M in FY1996 and FY1997.

The reviewers were unanimous in their praise of this project. Dr. Holland-Bartels, with the help of the Principal Investigators, has done an excellent job in molding the original proposed work into a cohesive package. It is obvious that the funds that were provided by the Trustee Council in November 1994 for further planning were a sound investment. This is a logically organized and defensible project, there are a series of well articulated hypotheses and alternative hypotheses. It is well focused on EVOS restoration goals. The reviewers also consider the four species chosen to represent important vertebrate species injured by the spill and to have been studied sufficiently in past studies so that we have a reasonable chance to determine what may be limiting their populations, and, therefore, their recovery.

The reviewers have some specific recommendations for improving certain aspects of the proposed studies that should be implemented. These suggested changes are not serious enough that I am requiring a revision or further consideration of the study plan before formulating a recommendation to you for funding. I do request that Dr. Holland-Bartels respond to the written comments and suggestions of the reviewers before the project goes into the field so that the reviewers can be satisfied that the field work is being properly conducted. The reviewer comments are appended to this letter.

Based on my evaluation of the project, the written reviews, and discussions with the reviewers I am recommending that this project be funded as an important ecosystem approach to understanding recovery of the nearshore portion of the marine ecosystem that was hard hit by the oil spill.

Sincerely yours,

Robert B. Spies
Chief Scientist

CC: L. Holland-Bartels

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MEMORANDUM

TO: Molly McCammon

FROM: Traci Cramer

Traci

DATE: March 28, 1995

RE: Nearshore/APEX Review

The following comments are provided for the Nearshore and the APEX projects.

Nearshore -

Federal Fiscal Year 1995

As proposed, the budget requests $606.1 for the remainder of FFY 1995 or six months. At a minimum, I feel that the budget could be reduced by at least $40.0. Areas that I would highlight as soft include the following:

1. It appears that the role of ADF&G is to pass a contract to the University of Alaska. In doing so, the department is has included $6.0 for program management costs and has assessed the appropriate indirect rate at a cost of $10.2. If this assumption is correct, is it necessary for ADF&G to include program management costs or can the budget be reduced $6.0?

2. While unclear, a question exists as to the level of travel required during 1995. In addition, it does not appear as if the agencies are utilizing savings from purchasing tickets in advance. While I recognize that a risk exists, they should be able to plan some of the activities in advance and take advantage of substantial savings. As an example the budget assumes 18 round trips between Anchorage and Cordova at $250 (full-fare) a trip or $4,500. When advance purchase would be $70 a trip and run $1,260. In all fairness, it must be pointed out the bulk of the travel is occurring in 1996.

3. The commodities line includes $9.0 for surgical supplies in 1995 and $9.0 in 1996. No justification is provided for the surgical supplies, so it is unclear what is being purchased.

4. The commodities line includes $3.0 for training in 1995 and $2.0 in 1996. While not to minimize the need for training, if the staffing information is correct, approximately $1.0 is being used to

train the individuals employed on this project, but the budget does not indicate what type of training is being provided.

5. The budget includes $1.5 for program management supplies which should be covered with general administration.

6. When you combine equipment being purchased for the contractors and that documented in the budget a total of $52.3 is budgeted for 1995. Included in that figure is $8.0 for miscellaneous equipment. I must caution, until we develop a method to track and share Trustee Council equipment, the ability to reduce equipment purchases without jeopardizing the projects is limited.

Federal Fiscal Year 1996
As proposed, the budget requests $1,680.5 for FFY 1996. At a minimum, I feel that the budget could be reduced by at least $150.0. Areas that I would highlight as soft include the following:

1. If ADF&G is simply a pass-through the $7.0 budgeted for program management could be deleted.

2. The budget for National Biological Service includes $88.7 for program management costs (before general administration). Is it necessary to carry this level of program management?

3. The budget includes $269.3 for chartering both vessels and air transportation and $22.2 to purchase fuel. It is unclear the level of coordination between the various components of the projects and why fuel must be purchased on top of the charters.

4. Again the budget did not assume the use of advance purchases on travel. See item #2 in the 1995 discussion.

5. The budget includes $2.2 for program management supplies which should be covered with general administration.

6. When you combine equipment being purchased for the contractors and that documented in the budget a total of $54.0 is budgeted for 1996. Included in that figure is $8.0 for miscellaneous equipment. I must caution, until we develop a method to track and share Trustee Council equipment, the ability to reduce equipment purchases without jeopardizing the projects is limited.

APEX -

Federal Fiscal Year 1995
The budget has been reduced from $1,586.8 to $1,167.9. This has been done by reducing program management costs, consolidating activities, and reducing the scope of various components. I feel that the agencies did a good job a reducing the costs and should be commended.

Federal Fiscal Year 1996
The budget requests $1,898.7 for FFY 1996. The agencies did not review the FFY 1996 budget at the same time that reduction where made to the FFY 1995 budget. However, it would be reasonable that approximately $500.0 could be saved. That would bring the request to roughly $1,398.7.

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MEMORANDUM

TO: Trustee Council

FROM: Molly McCammon, Executive Director

DATE: March 29, 1995

SUBJ: Recommendation — Project 95163/APEX - Forage Fish Project

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The purpose of this memorandum is to provide you with my recommendation concerning Project 95163/Apex Predator Ecosystem Experiment (APEX), the so-called "forage fish" project. As proposed, this is a multi-year investigation of the importance of forage fish resources to the recovery of injured seabirds.

The Chief Scientist has prepared a review memo dated March 28, 1995 (attached). This review notes that the project has undergone a significant evolution from its initial form and received substantial praise from the peer reviewers. The Project Leader, Dr. David Duffy, and the respective investigators deserve recognition for their effort to prepare this proposal.

I recommend that Project 95163 be authorized at a funding level of $1,167,900 for the remainder of FFY 95, with the project to proceed consistent with the provisions identified in the Chief Scientist's review memo and the other conditions identified below.

Importance of Project Review After First Field Season

As stated in the Chief Scientist review memo: "... a formal scientific review in the late fall of 1995 will be *essential* to make an assessment regarding the ability of the project to achieve its more challenging objectives" (italics in original). Certain methods and techniques proposed for use in the project are new and innovative and carry more risk than established techniques (especially some of the hydroacoustics work) and for this reason necessitate a more cautious approach to a long-term funding commitment. While envisioned as a multi-year effort, it is important to emphasize that initiation of the project in FFY 95 is conditioned upon a first year review in the late fall of 1995. This review will provide the basis for determining whether to proceed with the project and, if so, at what level of funding.

FFY 95 Budget

The proposed project budget is $1,167,900 for the remainder of FFY 95. This budget figure is substantially lower than the prior budget of $1,586,800 reflected in the materials enclosed in the Trustee Council packet. The revised budget is a result of examination and discussion among the Chief Scientist, NOAA staff, and the Project Leader. The budget reductions are summarized in a table and notes appended to this memo. The current budget has also been reviewed by Traci Cramer/Director of Administration. This review found that the agencies had done a good job of reducing program management costs, consolidating activities, and reducing the scope of certain activities. Traci Cramer will work with Bruce Wright/NOAA to finalize the detailed budget documentation within the $1,167,900 authorization.

FFY 96 and Beyond

The Trustee Council should be aware that if a favorable review in the fall of 1995 supports continuation, a significant long-term commitment to the project would be required to obtain meaningful results. At a minimum, it will be necessary to support the project effort through the first quarter of FFY 96 (i.e., through the late fall 1995 review). Following the fall review, the Trustee Council will be in a position to determine whether to proceed with a full-scale effort.

The FFY 96 budget is estimated at $1,898,700 and approximately $2 million per year has been projected for the period FFY 97-FFY 99. In the budget review prepared by the Director of Administration, it was noted that the effort to identify reductions for the FFY 95 budget has not yet been undertaken in the same manner for the FFY 96 budget. Substantial reductions to the FFY 96 figure could be expected upon closer examination.

The appropriate level of funding for FFY 96 and beyond will be determined annually through the peer review/adaptive management process in light of project findings and developments. It is expected that a refined FFY 96 and beyond budget will be submitted by May 1, 1995 as part of the FFY 96 project proposal review process.

The Director of Administration will work with the Project Leader to ensure that the FFY 96 budget documentation appropriately distinguishes first quarter activities.

In conclusion, based on the strength of the peer review recommendation and after consideration of long-term restoration efforts and commitments, I believe that initiation of this project at this time is appropriate.

attachments:

- — Chief Scientist review memo (March 28, 1995)
- — summary of Project 95163 budget revisions
- — Director of Administration budget review memo (March 28, 1995)

March 28, 1995

TO: Molly McCammon
Executive Director

FROM: Robert Spies, Chief Scientist
Andy Gunther, Asst. Chief Scientist

CC: Stan Senner

RE: Recommendation for APEX project

On March 1, 1995, a revised proposal for the "Seabird Forage Fish Interaction" project (95163) was received in our office. This project has undergone a significant evolution from its initial form, which we reviewed in a memo to Jim Ayers on September 2, 1994. Based upon the response of the principal investigators to that memo, the Trustee Council provided interim funding for further development of a project plan. This project is now entitled the "Apex Predator Ecosystem Experiment" (APEX), and includes an overview document and twelve appendices that describe each project component.

We have each examined the document, and we have obtained reviews from four other scientists. We have also had several discussions with the Project Leader (Dr. David Duffy)indicating some of our concerns, and he has responded with revisions to the proposal. Based upon the reviews of the proposal and the responses of the Project Leader, we now recommend this project for funding as described below.

Recommendation

The Trustee Council Work Plan for 1995 should include studies of forage fish because their composition, abundance, and distribution may be controlling the recovery of injured species. Restoration of injured species may not be possible if the factors controlling recovery remain unknown. The APEX proposal is a promising plan for addressing the question of whether forage fish availability is limiting the recovery of resources injured by the *Exxon Valdez* oil spill. The application of some of the methods are new and innovative (particularly the hydroacoustic technologies and their applications), and therefore carry more risk than established and routine oceanographic and biological techniques. On the other hand, the findings from a successful study will contribute greatly to understanding the ecosystem of the oil spill area. A formal scientific review in the late fall of 1995 will be *essential* to make an assessment regarding the ability of the project to achieve its more challenging objectives (see 5. below).

We recommend that the project be approved to begin work in FY95, provided that:

1. The primary objective for the first year of the project should be a comparison of the productivity of two bird colonies likely to have very different forage fish resources. This will provide a pilot phase of the project to test its basic organizing hypothesis, and provide a clear milestone by which to assess performance in the late fall of 1995.

2. The portions of the project addressing factors controlling forage fish resources should be scaled back significantly. We should first document a relationship between the productivity of injured birds and forage fish abundance and distribution prior to investing resources toward understanding the environmental factors that influence the distribution and abundance of the forage species. Given the cost of obtaining samples for these studies, we do recommend that a formal process of sample collection and archiving be conducted this year for future processing, as these samples can be efficiently obtained this year for very little additional cost.

3. Careful attention must be paid to hydroacoustic sampling and analysis methods to ensure that this project generates data that are comparable to those generated by several other studies examining fish distributions within the spill area. These studies include a seabird / forage fish project being funded the Minerals Management Service (lower Cook Inlet/Barren Islands), a sea lion foraging project being funded jointed by the National Marine Fisheries Service and ADF&G (Barren Islands), and the SEA program (Prince William Sound). All evidence so far suggests that the principal investigators of these studies are cooperating closely regarding hydroacoustic research. Similarly, seabird observations should be coordinated between the MMS project and APEX.

4. The hydroacoustic sampling program in APEX must be designed to detect temporal fluctuations in forage fish resources that could influence the productivity measures being conducted at the bird colonies. Repeated sampling of certain transects on a weekly basis, for example, is essential to determine the scales of temporal variation in forage fish abundance and distribution.

5. A detailed review of the results of the first year's work should be conducted in the late fall of 1995 as part of the Council's adaptive management process. At this time it will be *essential* to make an assessment regarding the ability of the project to achieve its more challenging objectives. These include: (1) using hydroacoustic technologies to differentiate forage fish species, (2) determining the abundance and distribution of forage fish species in the upper one meter of the water column, (3) integrating observations on foraging range and behavior of seabirds with estimates of abundance and distribution of prey species to make effective deductions regarding prey availability to seabirds, (4) determining the relative importance of demersal and pelagic prey to pigeon guillemots at Naked Island, and the abundance and distribution of important demersal species at this site, and (5) adequately identifying and surveying the foraging areas of kittiwakes, which can be very large.

Funding for FY96, which will be approved in August of 1995, should be contingent upon a satisfactory assessment of the performance of the project during the late fall review. If the project is not successful in achieving any of its more challenging objectives, serious consideration must be given to the prudence of conducting another season of field work until the problems are rectified.

6. The project should produce an integrated final report that includes a synthesized analysis of the data generated by each project component. If the project goes forward into future years, then interim reports will be prepared each year. The interim reports should also include a synthesis of key findings from each project component.

7. Many minor comments have been provided on each specific project component by the peer reviewers, and these have been delivered to Project Leader. These comments should be addressed in writing by the principal investigators prior to commencing work.

General Comments

In support of this recommendation we provide the following comments.

1. The Project Leader and the principal investigators are to be congratulated for the progress they have made in developing an integrated research proposal. They have been quite responsive to concerns expressed by the Chief Scientist and peer reviewers, and have in general done an excellent job in tackling a complex and challenging subject. In particular, they have made major strides regarding the management and integration of the project.

2. The proposal currently has two major objectives. First, the studies are designed to examine the impact of forage fish abundance and distribution on injured bird species. In addition, there are two projects (Appendices 2 and 4) that propose to examine the impact of oceanographic conditions and diet on the forage fishes themselves. While this is an important issue if we are to understand the causes of variations in forage fish populations, at this time it seems prudent to first investigate whether there is a demonstrable link between the productivity of injured species and the availability of forage fishes (e.g., "Is it food"?). Once this hypothesis is tested, we can consider examining the processes controlling forage fish abundance and distribution.

Consequently, we do not recommend going forward at this time with the projects described in Appendices 2 and 4. However, given the fact that forage fishes will be captured as part of the net collections associated with validating the hydroacoustic measurements, it seems reasonable to archive these samples for future energetic and diet analyses. The relative cost of archiving this samples is minor compared to the cost of capturing the fishes. The Project Leader has also suggested that limited analyses of these samples be conducted to provide information for planning of future sampling, and this also seems reasonable, assuming the cost of these analyses does not interfere with altering the study as described in the recommendation above and does not expand the budget beyond that deemed reasonable by the Executive Director.

3. As currently envisioned, the proposal calls for both intra-annual comparisons (between colonies in a given year) and inter-annual comparisons (time series analyses at a single colony). We concur with the recommendations of several reviewers that the project should focus upon intra-annual comparisons among colonies. Intra-annual comparisons, which will be testing spatial and within season heterogeneity in forage resources, will be more likely to result in detectable differences than interannual comparisons. The Project Leader and principal investigators will need to present a revised study plan that identifies which colonies will be studied in 1995, and document a data collection effort that will be adequate to characterize the key parameters at that colony. Clearly, an effort should be made to identify locations (such as the Barren Islands or Naked Island) where several species may be studied.

Structuring the project around interannual comparisons among colonies also has two other important benefits. First, the results of intra-annual comparisons are available after the end of the first field season. This generates a clear milestone for consideration as part of the Trustee Council's adaptive management process (see below). In addition, there is another research project beginning this year to examine the relationship between available forage resources and bird productivity in lower Cook Inlet (and hopefully the Barren Islands). This project is going to be conducted by the National Biological Survey with funding from the Minerals Management Service ($316,000 for FY95-96). By having two projects conducting intra-annual comparisons at different bird colonies, we will develop over the next few years a powerful dataset to address the question of the role of forage resources in controlling the productivity of injured bird species.

4. Critical to obtaining this dataset is the development of an independent measure of prey availability to the colonies under study by using hydroacoustic techniques to study the abundance and distribution of forage fish. Having this independent measure will allow us complete the line of reasoning: productivity is low because of dietary deficiencies that are correlated with certain patterns of prey resources. The validity of our interpretations will depend upon a determination that the proposed combination of hydroacoustic techniques and foraging observations provide a satisfactory measurement of prey availability. Hydroacoustic techniques are a proven method of estimating relative abundance and distribution of schooling fishes, and with concurrent net collections can be used to estimate species composition. However, estimates of abundance and distribution will have to be interpreted using information about foraging ranges and behavior to make statements about prey availability for injured species.

We cannot at this time predict how effectively these interpretations will be able to be made, and consider the assessment of the results from the 1994 pilot study (Project 94163) to be essential in this regard (the draft report from this study will be available in April, and findings will discussed at the workshop in Cordova the end of March). Hydroacoustic techniques will not provide us with absolute estimates of biomass; we will not be able to state with certainty that forage fish stocks are up are down from year to year. Instead, we will obtain information about the relative abundance of fish based upon the frequency of encounters along specific transects. For the broad scale transects, especially in conjunction with data from other hydroacoustic programs, we will be able to develop an understanding of the relative richness of different areas over time with regards to forage fish assemblages. In the finer scale work (more frequent transects in foraging areas), we will have information about the presence or absence of forage fishes to relate to predator productivity and health. These measurements will certainly be useful in making more informed judgments about food limitation of injured resources, but the strength of our interpretations will depend upon factors such as (1) our ability to correctly identify foraging habitat, (2) developing confident understanding of predator-prey relationships (i.e., in relation to guillemots as discussed above), (3) relating distribution of schooling fish at depth to foraging of kittiwakes at the surface, or (4) providing confident statements regarding the species composition of forage fish assemblages. Assessing the ability of the project to address these factors will be a key objective of the adaptive management review session. If the validity of our interpretations remains weak because of the inherent uncertainties in the methods being used, the program should not continue until these problems can be rectified.

5. Essential to prey availability measurements will also be a hydroacoustic sampling scheme that is designed to detected short-term fluctuations in forage fish abundance and distribution that may be important to the productivity of bird colonies. Miscellaneous observations by different scientists suggest that birds sometimes concentrate their foraging efforts at places where bathymetric or tidal influences concentrate prey. It is essential that we be able to determine if high-density forage patches are making significant contributions to the energy budgets of the bird colonies, and we therefore recommend an intensive systematic survey around colonies in the first year. The use of low-altitude aircraft surveys to locate persistent of quasi-permanent seabird foraging sites should be considered by the principal investigators. If the sampling scheme does not provide adequate spatial and temporal coverage to detect the impact of shorter term phenomena, the power of our interpretations of results will be significantly reduced.

We suggest that the Project Leader and principal investigators consider applying the resources saved from Appendices 2 and 4 toward more intensive sampling of forage fish abundance and distribution. The results of project 94163 should be considered in making this assessment. After one year of intensive sampling, the required intensity of sampling for adequately characterizing forage fish resources should be more apparent, and cruise schedules and budgets could be adjusted accordingly for 1996.

In addition, there is concern that the hydroacoustic equipment that is proposed for use is still in the final stages of testing and development. Our expert reviewer cautioned that the Project Leader should carefully match the capabilities of the hydroacoustic technology, and the hydroacoustic sampling plan, with the expectations of the APEX biologists for data.

6. It is essential that the data produced by the APEX project and the MMS project are comparable, as this will provide a much more powerful test of the central APEX hypothesis over the next two or three field seasons. Comparability will be achieved by utilizing similar techniques for (1) measurement of bird productivity and foraging, (2) calibrating and deploying hydroacoustic sampling equipment, and (3) data reduction and analysis techniques for acoustic signals. To achieve this end, we

have invited the principal investigator of the MMS project (Dr. John Piatt) to the hydroacoustic workshop in Cordova (to be held March 28-30, 1995). Dr. Piatt is also a collaborator on the APEX project (Appendix 1: Historic Review of Ecosystem Structure in the Prince William Sound / Gulf of Alaska Complex), and so coordination of his work with APEX has already begun.

7. There was strong support among the reviewers for the work proposed at the Barren Islands for several reasons. First, recent data suggest that the abundance of capelin around the Barren Islands has been increasing, providing the opportunity to study an area with an abundance of a forage species of known importance to seabirds. Second, there is evidence of very well-planned cooperation between the Barren Island project and several other studies (MMS seabird work, NMFS / ADF&G sea lion foraging study, and the murre satellite telemetry study [95021]). It is clear this coordination will result in efficient use of shared platforms and appropriate sharing of data. The data collected at the Barrens will also provide valuable information regarding the recovery of the murre colonies there. Due to the relative isolation of the Barrens, however, intensive hydroacoustic sampling in this region will be challenging. It will be essential to coordinate hydroacoustic sampling carefully with the MMS seabird project and NMFS / ADF&G sea lion project.

The proposal to study forage fish populations using the stomach contents of large predatory sport fish was also supported. Although there was some skepticism on the part of the reviewers that the demersal species discussed (cod and halibut) would prove adequate samplers of the pelagic environment, it is clear from limited sampling last year that halibut were consuming capelin. We recommend the proposal go forward in a pilot form in 1995, and then be evaluated prior to its continuation in the future.

8. The revised study plan should be subject to another review to avoid duplication of effort through coordination between study components and with other projects. For example, all the reviewers questioned the need to have three different laboratories (Appendices 4, 5, and 12) performing energetic analyses of forage fishes. The Project Leader now indicates that these analyses will be conducted by only one laboratory. The Project Leaders has also indicated that other apparent duplications will be eliminated. For example, why should the Tufted Puffin Foraging and Reproductive Success project (Appendix 11) be funded to visit W. Amatuli Island when the Barren Island Seabird Studies group (Appendix 10) will already be on E. Amatuli Island? (It is clear the two groups will be well coordinated, but wouldn't it be more efficient for one group be responsible for all work at the Barrens?) How does the work to be conducted under Appendix 11 relate to the work to be conducted by MMS?

9. With regards to focusing upon pigeon guillemots, data from project 94173 and other observations will need to verify that the guillemots under study in Appendix 8 are preying upon small schooling fish. The principal investigators indicate that guillemots at Naked Island are known to feed on demersal fish, and the abundance and distribution of these species will not be documented by hydroacoustic methods. If guillemots are preying upon demersal species, then there will be no measure of prey availability for pigeon guillemots developed in the APEX project.

Nearshore demersal fishes will be surveyed in the Nearshore Vertebrate Predator (NVP) project, and the Project Leader has indicated that close collaboration between NVP and APEX will occur in this regard.

10. We recommend that this project be reviewed as part of the Trustee Council's adaptive management process. During the fall of 1995, preliminary results of the project and implications for FY96 should be considered in a workshop setting similar to the review held in October, 1994, for project 94320. Funding in 1996 should be conditional upon the results of this review.

Original and Revised 95163 Budget

PROJECT COMPONENT	TITLE	ORIGINAL REQUEST	REVISED BUDGET
95163 A	Fish Survey & Biology	660.2	482.3
95163 B	Bird/Fish Interactions	112.4	86.6
95163 C	Fish Diet Overlap	90.0	60.0
95163 D	Puffins as Samplers	51.7	41.7
95163 E	Black-legged Kittiwakes	152.2	108.7
95163 F	Pigeon Guillemots	172.1	134.5
95163 G	Energetics	223.8	148.4
95163 H	Proximate Composition	38.6	0.0
95163 I	Project Leader	0.0	0.0
95163 J	Barren I. Murres & BLKs	36.1	36.1
95163 K	Fish as Samplers	15.1	15.1
95163 L	Barrens & Historical	34.5	54.5
TOTAL		$ 1,586.7	$ 1,167.9

(A) Reduce indirect cost from 42.2% to 25% of base and eliminate program manager costs. Combine July and August cruise to a 4-5 week cruise (save $50.0K). Eliminate the spring 1996 cruise from this budget request (save $50.0K).

(B) Make reductions described in 3/7/95 memo.

Expediter	10.0
Project Manager	11.0
emergency travel	0.6
travel to scientific meetings	2.0
film processing	0.2
publication page charges	0.5
safety training (from 2.5 to 1.0)	1.5

(C) Eliminate 9 man months of fish stomach analysis.

(D) Reduce budget to level submitted 10/95, plus a more complete survey of PWS. Reduce effort to only PWS. Amount for this survey is an estimate.

(E) Make reductions described in 3/7/95 memo.

Expediter	10.0
Project Manager	11.0
emergency travel	1.0
travel to scientific meetings	2.0
publication page charges	0.5
safety training (from 2.5 to 1.0)	1.5
misc. commodities & equip. (was 7.8)	4.0
boat fuel (from 13.5 to 7.0)	6.5
truck rental (from 4.0 to 2.0)	2.0
maintenance/cleaning/repair (was 11.6)	5.0

(F) Make reductions described in 3/7/95 memo.

Expediter	10.0
Project Manager	11.0
emergency travel	0.6
travel to scientific meetings	1.0
safety training (from 2.5 to 1.0)	1.5
boat fuel (from 13.5 to 7.0)	6.5
truck rental (from 5.0 to 3.0)	2.0
maintenance/cleaning/repair (was 11.6)	5.0

(G) Make reductions described in 3/7/95 memo (attached). Reduce indirect cost from 42.2% to 25% of base of $118.7K.

Boston Whaler (from TC?)	15.0
outboard motors (from TC?)	4.5
mustang suits (from TC?)	9.0
weatherport x 2 (from TC?)	2.8
field radios (reduce from 6.0 to 3.0)	3.0

(H) Eliminate this component from APEX project.
(I) Zero funding requested. Funding already approved in 95163I.
(J & K) No reductions
(L) Increase by $20.0K to increase forage fish survey of Barrens.

Exxon Valdez Oil Spill Trustee Council
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MEMORANDUM

TO: Molly McCammon

Traci

FROM: Traci Cramer

DATE: March 28, 1995

RE: Nearshore/APEX Review

The following comments are provided for the Nearshore and the APEX projects.

Nearshore -

Federal Fiscal Year 1995
As proposed, the budget requests $606.1 for the remainder of FFY 1995 or six months. At a minimum, I feel that the budget could be reduced by at least $40.0. Areas that I would highlight as soft include the following:

1. It appears that the role of ADF&G is to pass a contract to the University of Alaska. In doing so, the department is has included $6.0 for program management costs and has assessed the appropriate indirect rate at a cost of $10.2. If this assumption is correct, is it necessary for ADF&G to include program management costs or can the budget be reduced $6.0?

2. While unclear, a question exists as to the level of travel required during 1995. In addition, it does not appear as if the agencies are utilizing savings from purchasing tickets in advance. While I recognize that a risk exists, they should be able to plan some of the activities in advance and take advantage of substantial savings. As an example the budget assumes 18 round trips between Anchorage and Cordova at $250 (full-fare) a trip or $4,500. When advance purchase would be $70 a trip and run $1,260. In all fairness, it must be pointed out the bulk of the travel is occurring in 1996.

3. The commodities line includes $9.0 for surgical supplies in 1995 and $9.0 in 1996. No justification is provided for the surgical supplies, so it is unclear what is being purchased.

4. The commodities line includes $3.0 for training in 1995 and $2.0 in 1996. While not to minimize the need for training, if the staffing information is correct, approximately $1.0 is being used to

train the individuals employed on this project, but the budget does not indicate what type of training is being provided.

5. The budget includes $1.5 for program management supplies which should be covered with general administration.

6. When you combine equipment being purchased for the contractors and that documented in the budget a total of $52.3 is budgeted for 1995. Included in that figure is $8.0 for miscellaneous equipment. I must caution, until we develop a method to track and share Trustee Council equipment, the ability to reduce equipment purchases without jeopardizing the projects is limited.

Federal Fiscal Year 1996
As proposed, the budget requests $1,680.5 for FFY 1996. At a minimum, I feel that the budget could be reduced by at least $150.0. Areas that I would highlight as soft include the following:

1. If ADF&G is simply a pass-through the $7.0 budgeted for program management could be deleted.

2. The budget for National Biological Service includes $88.7 for program management costs (before general administration). Is it necessary to carry this level of program management?

3. The budget includes $269.3 for chartering both vessels and air transportation and $22.2 to purchase fuel. It is unclear the level of coordination between the various components of the projects and why fuel must be purchased on top of the charters.

4. Again the budget did not assume the use of advance purchases on travel. See item #2 in the 1995 discussion.

5. The budget includes $2.2 for program management supplies which should be covered with general administration.

6. When you combine equipment being purchased for the contractors and that documented in the budget a total of $54.0 is budgeted for 1996. Included in that figure is $8.0 for miscellaneous equipment. I must caution, until we develop a method to track and share Trustee Council equipment, the ability to reduce equipment purchases without jeopardizing the projects is limited.

APEX -

Federal Fiscal Year 1995
The budget has been reduced from $1,586.8 to $1,167.9. This has been done by reducing program management costs, consolidating activities, and reducing the scope of various components. I feel that the agencies did a good job a reducing the costs and should be commended.

Federal Fiscal Year 1996
The budget requests $1,898.7 for FFY 1996. The agencies did not review the FFY 1996 budget at the same time that reduction where made to the FFY 1995 budget. However, it would be reasonable that approximately $500.0 could be saved. That would bring the request to roughly $1,398.7.

Exxon Valdez Oil Spill Trustee Council
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MEMORANDUM

TO: Trustee Council

FROM: Molly McCammon, Executive Director

DATE: March 30, 1995

SUBJ: FY 95 Restoration Research Projects Involving Collections

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In FY 95, there are two projects that propose the collection of birds as part of the experimental research design (Project 95320Q/Avian Predation on Herring Spawn and Project 95025/Nearshore Vertebrate Predators). These elements of the respective projects have *not* been approved at this time and will be subject to further review by the Chief Scientist. This review will address both the possible impacts to the species collected (number of birds collected, population health, alternative methods) as well as the merit of a proposed collection project as it relates to restoration goals (what would be lost if there was no take and what can be accomplished with the collection).

After consulting with the Restoration Work Force, as well as federal and state agencies with permitting responsibilities regarding collections, a review process concerning any proposed collection of birds or mammals has been developed (attached). As indicated, the Chief Scientist will undertake a review and provide a recommendation to the Executive Director. The Executive Director will inform the PAG and the Trustee Council of this recommendation in writing prior to final approval of a collection. All federal and State permits will be required prior to implementation of a collection.

If you have questions concerning this process, please let me know.

attachment

DRAFT

REVIEW PROCESS FOR RESTORATION RESEARCH PROJECTS THAT INVOLVE COLLECTIONS

The Trustee Council is appropriately sensitive to the collection of birds or mammals as part of any restoration research project, for the Council's ultimate aim is to restore the health of the injured ecosystem. At the same time, it is recognized that in order for certain restoration research projects to achieve their objectives, certain collections may be required to gather information that could not otherwise be obtained. As stated in the *Restoration Plan*, "... possible negative effects on resources and services must be assessed in considering restoration projects." (Policy #7)

Any scientific project that proposes a take of birds or mammals should be allowed to proceed only if the advantages of doing so outweigh the disadvantages. The general health of the population being sampled needs to be assessed and a finding made that proposed collection(s) would not result in further injury to the health of the population being investigated.

In order for the Chief Scientist to recommend whether a proposed collection is necessary and appropriate to further restoration objectives, investigators should address each of the questions listed below. This information should be provided as part of a Detailed Project Description.

1. How many individuals are proposed to be collected and the approximate times and locations? How do these numbers compare with the total population in the general collecting area?

2. How is the general health of the population? Is the population increasing, decreasing or holding steady in the proposed sampling area? Is reproduction and young survival normal?

3. Is the proposed take likely to affect any population trends?

4. Is the proposed method of take humane? Are there any effective, alternative means to obtain the data?

5. What will be lost if there is no take allowed?

6. What can we realistically hope to learn that will justify this collection?

7. Have federal and/or state permits been secured? If not, why not?

The Chief Scientist will review proposed collection and consult with peer reviewers and others with appropriate expertise. If appropriate, the Chief Scientist could conduct this review concurrent with a federal and/or State permit review. The Chief Scientist will then make a recommendation to the Executive Director. The Executive Director will inform the PAG and the Trustee Council of this recommendation in writing prior to final approval of a Detailed Project Description. All federal or State permits will be required prior to implementation of a project.

Exxon Valdez Oil Spill Trustee Council

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MEMORANDUM

TO: Molly McCammon

FROM: Eric F. Myers

DATE: 3/27/95

SUBJ: Restoration Research Projects Involving Collections

This memo identifies FY 95 restoration research projects that propose collection of birds or mammals as part of the study design and recommends a process for addressing these proposed collections in FY 95 and the future.

BACKGROUND

Comments were obtained from the Restoration Work Force (RWF) on the draft collections review process prepared by the Chief Scientist. Major issues identified were:

1) the relationship of the Chief Scientist review to existing federal and state permit processes; and

2) the Chief Scientist review process structure.

Federal and State Collection Permits

Both the federal and State government require scientific collection permits.

Federal Permit: A scientific collection permit is required for migratory birds under 50 CFR 21, administered by the USDOI/Migratory Birds Management Division.[1] An application must be submitted that includes the species, number of birds, location and a "... statement of the purpose and justification for granting such a permit, including an outline of any research project

1 The federal Office of Migratory Bird Management is currently in the process of a nationwide review of the federal permitting policies regarding the collection of migratory birds. Draft dated February 1995.

involved." (50 CFR 21.23(b)) A "scientific review committee" that includes two representatives from the USFWS Migratory Birds Management Division, a representative of the NBS, and an ad hoc representative of the Alaska Department of Fish and Game, reviews the permit.

State Permit: A State permit for the collection of birds is also required (AS 16.05.930, 5 AAC 92.033). The State requires that the federal collection permit be issued first. Information required as part of the State permit application includes: numbers (by species and life stage) of birds to be collected; times and locations of collections; and a Study Plan (a written operational plan that identifies "... the purpose and need for the desired collections ... in addition to purpose and need, the application... should specify research objectives and procedures"). Permit are reviewed, issued or rejected by the ADFG Division of Wildlife Conservation.

Collections Proposed in the FY 95 Work Plan

Two FY 95 Work Plan projects propose taking of birds as part of the research design; no FY 95 projects propose the collection of mammals.[2]

95320Q/Avian Predation on Herring Spawn proposes collections involving five bird species to assess the impact of predation on herring spawn (forty individuals each of Glaucous-winged gull, Mew gull, Surfbird, Black Turnstone and Surf scoters). Permit applications are pending with both the USDOI and ADFG.

Project 95025/Nearshore Vertebrate Predators proposes collection of certain seaducks. In FY 95 (fall of 1995), the project proposes to collect 25 harlequin ducks to establish a condition index. Later in the project, 50 White winged scoters and 50 Barrows goldeneyes would be taken in each of two years (winter 96-97 and winter 97-98). A federal permit application has been submitted.[3]

Chief Scientist Review Process

The Chief Scientist drafted a collection policy that:

— identified specific questions that would address *impacts to the species* collected (i.e., number of birds to be collected, total population, health of the population, alternative data collection options including non-lethal taking methods, etc.);

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2 This does not include Project 95041/Introduced Predator Removal. With regard to Project 95163/Apex Predators-Forage Fish, although there was some consideration of lethal takings as part of the study design early on, the most current version of the project does not include takings.

3 Pers. comm., Dan Essler (786-3485).

— identified specific questions that would address the *need and merit of a proposed collection project as it relates to restoration goals* (i.e., what would be lost if there was no take, what can be accomplished as a result of the collection); and

— outlined a possible *process and structure for review of proposed collections* (i.e., a Collection Committee comprised of the Chief Scientist together with a representative of Audubon Society, the PAG, ADFG and USFWS).

It should be noted that while both the federal and State permit process include general requirements regarding the purpose and justification for a proposed collection, the questions enumerated in the Chief Scientist's draft identified specific issues in a manner more precisely articulated than in either the federal or State permit requirements.

DISCUSSION

1. **Relationship of Chief Scientist Review to Federal/State Permit Process:** One issue concerns whether the proposed Chief Scientist review process would be duplicative of federal and State collection permit processes.

   Discussion: The Chief Scientist review and the federal/State permit process serve related, complementary purposes. The federal/State permit process is fundamentally designed to address concerns about possible impacts to the species to be collected. Information requested by the Chief Scientist concerning impacts to species/populations will be needed for those permit applications and therefore does not present a significant additional burden to investigators. More importantly, the federal and State permit process does *not* address issues pertaining to the merit of a collection as it relates to the goals and objectives of the Trustee Council's restoration effort. The Chief Scientist review is appropriate to ensure that proposed collections serve the restoration mission and that any injury to individuals within an population or species are outweighed by the benefits.

2. **Structure of Chief Scientist Review:** A second issue concerned the structure of the Chief Scientist's review process with particular regard to the possible creation of a Collection Committee.

   Discussion: Given the extremely limited number of projects proposing collections, creation of a standing committee would not appear warranted. Review of a proposed collection can be addressed in the same manner as the existing project peer review (i.e., the Chief Scientist consults as needed with individuals with expertise). As appropriate, this consultation could include representatives of non-governmental organizations.

3. **Local Information and Outreach:** An additional issue identified concerned communication at the local level regarding actual collection activities.

   Discussion: In the case where collections proceed, it has been suggested that a special effort be made to inform local area residents (including local law enforcement agents) regarding the collection, the timing and its purpose, in order to reduce the potential for misunderstanding or adverse reaction.

RECOMMENDATION

A revised draft of the proposed collection review process is attached.

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attachments

— revised draft Collection Review Process (3/24/95)

DRAFT

REVIEW PROCESS FOR RESTORATION RESEARCH PROJECTS THAT INVOLVE COLLECTIONS

The Trustee Council is appropriately sensitive to the collection of birds or mammals as part of any restoration research project, for the Council's ultimate aim is to restore the health of the injured ecosystem. At the same time, it is recognized that in order for certain restoration research projects to achieve their objectives, certain collections may be required to gather information that could not otherwise be obtained. As stated in the *Restoration Plan*, "... possible negative effects on resources and services must be assessed in considering restoration projects." (Policy #7)

Any scientific project that proposes a take of birds or mammals should be allowed to proceed only if the advantages of doing so outweigh the disadvantages. The general health of the population being sampled needs to be assessed and a finding made that proposed collection(s) would not result in further injury to the health of the population being investigated.

In order for the Chief Scientist to recommend whether a proposed collection is necessary and appropriate to further restoration objectives, investigators should address each of the questions listed below. This information should be provided as part of a Detailed Project Description.

1. How many individuals are proposed to be collected and the approximate times and locations? How do these numbers compare with the total population in the general collecting area?
2. How is the general health of the population? Is the population increasing, decreasing or holding steady in the proposed sampling area? Is reproduction and young survival normal?
3. Is the proposed take likely to affect any population trends?
4. Is the proposed method of take humane? Are there any effective, alternative means to obtain the data?
5. What will be lost if there is no take allowed?
6. What can we realistically hope to learn that will justify this collection?
7. Have federal and/or state permits been secured? If not, why not?

The Chief Scientist will review proposed collection and consult with peer reviewers and others with appropriate expertise. If appropriate, the Chief Scientist could conduct this review concurrent with a federal and/or State permit review. The Chief Scientist will then make a recommendation to the Executive Director. The Executive Director will inform the PAG and the Trustee Council of this recommendation in writing prior to final approval of a Detailed Project Description. All federal or State permits will be required prior to implementation of a project.

Exxon Valdez Oil Spill Trustee Council

Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

AGENDA
EXXON VALDEZ OIL SPILL SETTLEMENT
TRUSTEE COUNCIL
MARCH 31, 1995 @ 2:00 P.M. -- TELECONFERENCE
Forest Service Conference Room 541A
Restoration Office--Anchorage

3/24/95
2:22 pm
DRAFT

1. Call to Order 2:00 p.m.
   - Approval of Agenda
   - Approval of February 13, 1995, February 22, February 24, February 28, and March 1, 1995 meeting notes.

2. Executive Director's Report - Molly McCammon
   - Financial Report
   - FY96 Invitation and Long Range Plan Status
   - Habitat Protection Status Report
   - Alaska Sealife Center Status Report

Action Items:

3. Nearshore Vertebrate Predator Package (NVP)

4. Apex Predator Package (Forage Fish/Seabird Interaction)

5. Technical Amendments to AKI and Old Harbor Resolutions

6. Technical Amendments to FY95 Budgets

Adjourn

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

TRUSTEE COUNCIL MEETING ACTIONS

February 13, 1995 @ 10:00 a.m.

By Molly McCammon
Executive Director

DRAFT

Trustee Council Members Present:

Dave Gibbons,●● USFS
Deborah Williams,●* USDOI
Steve Pennoyer, NMFS
Frank Rue,● ADF&G
Michelle Brown,● ADEC
Craig Tillery,●● ADOL

* Chair
● Alternates:
Deborah Williams served as an alternate for George T. Frampton, Jr. for the entire meeting.
Craig Tillery served as an alternate for Bruce Botelho for the entire meeting. Alex Swiderski served as Tillery's alternate from 3:50 p.m. on.
Frank Rue represented the Alaska Department of Fish and Game.
Dave Gibbons served as an alternate for Phil Janik for the entire meeting. Jim Wolfe represented USFS from 3:50 p.m. on.
Michelle Brown served as an alternate for Gene Burden for the entire meeting.

1. Approval of the Agenda

APPROVED MOTION: Approved the Agenda. (Attachment A)

APPROVED MOTION: Approved with minor changes, the December 2, 1994 and January 5, 1995 Trustee Council meeting notes. (Attachment B)

2. Executive Director's Report

APPROVED MOTION: Adjourn into Executive Session for the purpose of discussions on habitat protection negotiation strategies, Public Advisory Group nominations, large parcel negotiation status, and the small parcel protection process. Motion by Tillery, second by Pennoyer.

Off Record at 12:36 p.m.
Executive Session from 1:00 p.m. to 3:50 p.m.
On Record at 3:50 p.m.

DRAFT

3. Public Advisory Group Nominations

APPROVED MOTION: Public Advisory Group recommended nominations were made alphabetically as follows:
Aquaculture - Karl Becker, motion by Pennoyer, second by Rue.
Commercial Fishing - Thea Thomas, motion by Brown, second by Pennoyer.
Commercial Tourism - Nancy Lethcoe, motion by Brown, second by Pennoyer.
Conservation - Chip Dennerlein, motion by Rue, second by Brown.
Environmental - Pamela Brodie, motion by Pennoyer, second by Rue.
Forest Products - Kim Benton, motion by Pennoyer, second by Rue.
Local Government - Dave Cobb, motion by Pennoyer, second by Gibbons.
Native Landowner - Charles Totemoff, motion by Wolfe, second by Brown.
Recreation Users - Jim Diehl, motion by Wolfe, second by Brown.
Science/Academic - John French, motion by Pennoyer, second by Rue.
Sport Hunting and Fishing - Rupert Andrews, motion by Brown, second by Pennoyer.
Subsistence - Brenda Schwantes, motion by Brown, second by Pennoyer.
Public-at-Large - Chris Beck, motion by Rue, second by Brown. Martha Vlasoff, motion by Swiderski, second by Pennoyer. Jim King, motion by Pennoyer, second by Rue. Vern McCorkle, motion by Wolfe, second by Pennoyer. Gordon Zerbetz, motion by Rue, second by Brown.

4. Small Parcel Protection Process

APPROVED MOTION: Adopted the Small Parcel Protection Process resolution. (Attachment C) Motion by Rue, second by Pennoyer.

APPROVED MOTION: Move five low ranked parcels into the further consideration category described in the Small Parcel resolution (see above). The parcels include: Parcel Kenai 12, Parcel Kenai 29, Parcel Kodiak 22, Parcel KAP 220, and Parcel KAP 105 and 142. Motion by Pennoyer, second by Brown.

5. Project 95191-A

APPROVED MOTION: Approved an additional $210,100 for Project 95191-A, Egg and Alevin Mortality, to cover a budget oversight. Motion by Rue, second by Brown.

Meeting recessed.

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

TRUSTEE COUNCIL MEETING ACTIONS

February 17, 1995 @ 9:00 a.m.

By Molly McCammon
Executive Director

DRAFT

Trustee Council Members Present:

Phil Janik, USFS
•Deborah Williams, USDOI
Steve Pennoyer, NMFS
Frank Rue, ADF&G
•Michelle Brown, ADEC
•Craig Tillery, ADOL

* Chair
• Alternates:
Michelle Brown served as an alternate for Gene Burden for the entire meeting.
Craig Tillery served as an alternate for Bruce Botelho for the entire meeting.
Deborah Williams served as an alternate for George T. Frampton, Jr. for the entire meeting.

1. Executive Session

This entire meeting was in Executive Session for the purpose of discussing Eyak land acquisition negotiations.

Executive Session from 9:00 a.m. to 10:54 a.m.

Meeting recessed.

raw

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

TRUSTEE COUNCIL MEETING ACTIONS

February 22, 1995 @ 11:30 a.m.
Reconvened from February 13, 1995 Meeting

By Molly McCammon
Executive Director

DRAFT

Trustee Council Members Present:

Phil Janik, USFS
*●Deborah Williams, USDOI
Steve Pennoyer, NMFS
Frank Rue, ADF&G
●Michelle Brown, ADEC
●Craig Tillery,● ADOL

* Chair
● Alternates:
Michelle Brown served as an alternate for Gene Burden for the entire meeting.
Craig Tillery served as an alternate for Bruce Botelho for the entire meeting.
Deborah Williams served as an alternate for George T. Frampton, Jr. for the entire meeting.

1. Executive Session

APPROVED MOTION: Adjourn into Executive Session for the purpose of discussion on the Eyak land acquisition negotiations. Motion by Janik, second by Pennoyer.

Off record at 11:40 a.m.
Executive Session 11:40 a.m. to 2:08 p.m.
On record at 2:08 p.m.

2. Eyak Resolution

APPROVED MOTION: Authorized $4,130,000 for an offer to purchase a limited conservation easement in the form of a seven year moratorium on commercial timber located on a portion of the Orca Revised lands. This agreement is not intended to adversely impact Eyak's access and control of access to the land or their subsistence rights. Motion by Pennoyer, second by Rue.

Meeting adjourned.

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

TRUSTEE COUNCIL MEETING ACTIONS

February 24, 1995 @ 11:30 a.m.

By Molly McCammon
Executive Director

DRAFT

Trustee Council Members Present:

Phil Janik, USFS
*•Deborah Williams, USDOI
Steve Pennoyer, NMFS
Frank Rue, ADF&G
• Michelle Brown, ADEC
• Craig Tillery, ADOL

* Chair
• Alternates:
Michelle Brown served as an alternate for Gene Burden for the entire meeting.
Craig Tillery served as an alternate for Bruce Botelho for the entire meeting.
Deborah Williams served as an alternate for George T. Frampton, Jr. for the entire meeting.

1. Executive Session

Meeting began in Executive Session for the purpose of discussing Eyak land acquisition negotiations.

Off Record at 11:30 a.m.
Executive session 11:30 a.m. to 1:22 p.m.
On Record at 1:23 p.m.

2. Eyak

APPROVED MOTION: The Council rejects Eyak's counteroffer for $15 million, for the limited moratorium, and reaffirms their December 2, 1994 resolution. The Council offers to enter into mediation at the earliest available opportunity, mindful of Eyak's March 2, 1995 deadline. Mediation to commence with a mutually agreed upon mediator, date and time. Motion by Janik, second by Rue.

Meeting adjourned.

raw

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

TRUSTEE COUNCIL MEETING ACTIONS

February 28, 1995 @ 1:30 p.m.

By Molly McCammon
Executive Director

DRAFT

Trustee Council Members Present:

Phil Janik, USFS
●Deborah Williams, USDOI
Steve Pennoyer, NMFS
Frank Rue, ADF&G
●Ernie Piper, ADEC
●Craig Tillery, ADOL

* Chair
● Alternates:
Craig Tillery served as an alternate for Bruce Botelho for the entire meeting.
Ernie Piper served as an alternate for Gene Burden for the entire meeting.
Deborah Williams served as an alternate for George T. Frampton, Jr. for the entire meeting.

1. Executive Session

APPROVED MOTION: Adjourned into Executive Session for the purpose of discussing Eyak land acquisition negotiations.

Off Record at 1:30 p.m.
Executive Session from 1:30 p.m. to 3:00 p.m.
On Record at 3:00 p.m.

2. Eyak

Announcement: The Trustee Council will meet again tomorrow to continue their negotiations with Eyak to try to reach a mutually acceptable agreement between Eyak Corporation and the Trustee Council.

Meeting adjourned.

Exxon Valdez Oil Spill Trustee Council
Restoration Office
645 G Street, Suite 401, Anchorage, Alaska 99501-3451
Phone: (907) 278-8012 Fax: (907) 276-7178

TRUSTEE COUNCIL MEETING ACTIONS

March 1, 1995 @ 3:00 p.m.

By Molly McCammon
Executive Director

DRAFT

Trustee Council Members Present:

Phil Janik, USFS	*Frank Rue, ADF&G
•Deborah Williams, USDOI	Michelle Brown, ADEC
•Bill Hines, NMFS	•Craig Tillery, ADOL

* Chair
• Alternates:
Michelle Brown served as an alternate for Gene Burden for the entire meeting.
Deborah Williams served as an alternate for George T. Frampton, Jr. for the entire meeting.
Craig Tillery served as an alternate for Bruce Botelho for the entire meeting.
Bill Hines served as an alternate for Steve Pennoyer for the entire meeting.

1. Executive Session

Meeting began in Executive Session for the purpose of discussing the Eyak land acquisition negotiations.

Off Record at 3:00 p.m.
Executive Session from 3:00 p.m. to 4:25 p.m.
On Record at 4:25 p.m.

2. Eyak

APPROVED MOTION: The Trustee Council and Eyak agreed in a Statement of Intent to the following:
1) Redirect timber harvest to reduce impacts to Orca Narrows/Nelson Bay.
2) Immediately determine the value of timbered lands on the South side of Simpson Bay, within the Orca Sub-parcel, for the purpose of making an equal value (timber-rights for timber-rights) exchange with Eyak and Sherstone.

STATEMENT OF INTENT
between the
EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
and
EYAK CORPORATION
and SHERSTONE, INC.

The Trustee Council, the Eyak Corporation, and Sherstone, Inc. have worked cooperatively to identify means by which the restoration purposes of the Trustee Council can be furthered through the acquisition of properties, or interests in properties, owned by Eyak and Sherstone, Inc. while also recognizing the intent of Eyak and Sherstone, Inc. to pursue resource development on certain portions of the Orca Revised lands.

In order to protect habitat values important to restoration, while recognizing Eyak's and Sherstone's right and intent to harvest timber, the Trustee Council, Eyak Corporation and Sherstone, Inc. jointly recognize the following:

1. **Redirection of Timber Harvest to Reduce Impacts to Orca Narrows/Nelson Bay.** Sherstone proposes to redirect timber harvest plans, scheduled to start March 2, 1995, from highly visible areas along Orca Narrows/Nelson Bay to areas within the vicinity of Simpson Bay in consideration of the actions of the Trustee Council and the United States Forest Service (USFS) contemplated by this Statement of Intent.

2. **Timber Rights Exchange and/or Land Conveyances.** In order to avoid timber harvest in the highly visible areas along Orca Narrows/Nelson Bay:

    - The Trustee Council will support efforts by the USFS to immediately determine the value of timbered lands on the south side of Simpson Bay, within the Orca Sub-parcel, for the purpose of making an equal value (timber-rights for timber-rights) exchange with Eyak and Sherstone, for timber rights in the highly visible areas along Orca Narrows/Nelson Bay that would otherwise be harvested.

    - Eyak, with the active support of the Trustee Council, will seek expedited conveyance of lands within the Simpson Bay drainage, Sections 15-16 of T14S, R3W, in order to supplement the volume of timber available for harvest in the Simpson Bay area.

- Concurrent with efforts to expedite conveyances, the USFS will explore opportunities to exchange timber rights from Sections 15-16 of T14S, R3W with Eyak and Sherstone for timber rights along Orca Narrows/Nelson Bay. The Trustee Council, Eyak Corporation, and Sherstone, Inc. all regard this approach as the preferred way to supplement timber volume for Sherstone's harvest from Sections 15-16 (T14S, R3W) in the Simpson Bay area.

Timber rights that may be acquired from Eyak and Sherstone through such an exchange will be applied to those highly visible lands along Orca Narrows/Nelson Bay, starting at the eastern edge of the Orca Sub-parcel and then progressively further to the northeast toward the Rude River drainage. It is recognized that as a result of timber rights exchanges contemplated by this agreement and a redirection of timber harvest activities, Sherstone would experience an increase in road costs across those lands along Orca Narrows/Nelson Bay being protected that it would otherwise harvest. It is intended that these incremental costs be mutually identified, agreed upon and compensated.

For the purposes of the timber exchanges contemplated by this Statement of Intent, the valuation shall be completed on a basis that establishes a value as if the timber had been cut by Sherstone using existing and applicable log prices and expenses.

3. **Limited Conservation Easement for Orca Revised Parcel.** The Trustee Council will authorize funds for the USFS to acquire a limited conservation easement on the Orca Revised lands along Orca Narrows/Nelson Bay for $200,000 consisting of commercial timber harvest rights for a period of time from March 1, 1995 through and including May 15, 1995. If the timber exchange for the Orca Sub-parcel is completed on or before May 15, 1995, the term of the limited conservation easement shall be extended through July 15, 1995. The US Forest Service will work with Sherstone, Inc. to complete a purchase agreement by March 10, 1995.

   The sum of $200,000 shall be paid to Sherstone for the limited conservation easement. If: 1) by May 15, 1995, the timber rights on the northwest side of the Orca Sub-parcel have been exchanged with Eyak and Sherstone; and 2) by July 15, 1995, the timber rights for Sections 15-16 have been exchanged with Eyak and Sherstone, or Sections 15-16 have otherwise been conveyed to Eyak, then Sherstone will allow $200,000 to be offset against any amounts due Sherstone as a result of increased costs described in 2 above or as a credit against the acquisition of other timber rights. Permits are a key component and could encumber Sherstone's ability to operate if there are delays that could affect Sherstone's operations.

4. **Access for Logging in Simpson Bay.** The Trustee Council recognizes that in order to access planned cutting units in the vicinity of Simpson Bay, road access from the log transfer facility in Orca Narrows/Nelson Bay across a portion of the Orca Sub-parcel will be needed and was provided for in the purchase agreement for the Orca Sub-parcel.

5. **Road Access Along Orca Narrows/Nelson Bay to the Rude River Drainage.** The Trustee Council recognizes that Sherstone's timber harvest plans include the harvest of lands in the Rude River drainage and that this will require road access along Orca Narrows/Nelson Bay. Sherstone recognizes the need to develop such a road in a manner that reduces or minimizes negative impacts to restoration values, to the extent practicable.

6. **Downed Timber on the Orca Sub-parcel.** The Trustee Council and Sherstone recognize that, if they can reach a mutually agreed upon value for the presently downed timber on the Orca Sub-parcel (approximately 10 acres), the net value of that timber will be applied to offset any payment or other value due Sherstone as a result of implementation of the provisions described in this Statement of Intent.

7. **Further Negotiation Schedule.** The Trustee Council, Eyak and Sherstone agree to develop a schedule by April 1 for further negotiations which are intended to address habitat protection on Eyak's and Sherstone's interests in the Other Lands (west of Shepard Point), including Sheep Bay, Port Gravina, and Windy Bay and other areas that have high restoration values of particular interest to the Trustee Council. This will include authorization by Eyak and Sherstone for the Trustee Council (through the USFS) to complete the appraisal of the Other Lands.

   It is also intended that the Trustee Council, Eyak, and Sherstone will work to identify those remaining highly visible lands along Orca Narrows/Nelson Bay to the mouth of the Rude River that would not be protected from timber harvest as a result of the timber exchanges contemplated by this Statement of Intent and to negotiate cooperatively to reach an agreement for their protection. Additionally, it is intended that negotiations will proceed on acquisition of the Core Lands. Timber cruise and other similar factual data will be shared with Sherstone and Eyak.

8. **Use of Mediation As Appropriate.** The Trustee Council, Eyak and Sherstone agree that they will work cooperatively as described above and

will use mediation, to the extent deemed appropriate by both parties, as a means of furthering these negotiations.

No contractual obligation enforceable against any party is created by this Statement of Intent.

On behalf of the *Exxon Valdez* Oil Spill Trustee Council, the Eyak Corporation, and Sherstone, Inc. this Statement of Intent is recognized and accepted this 1st day of March 1995,

Phil Janik, Regional Forester
Alaska Region
USDA - Forest Service

for Bruce Botelho, Attorney General
State of Alaska

For George T. Frampton, Jr., Assistant Secretary
for Fish and Wildlife and Parks
U.S. Department of the Interior

for Gene Burden, Commissioner
Alaska Department of
Environmental Conservation

Steve Pennoyer, Director
Alaska Region
National Marine Fisheries Service

Frank Rue, Commissioner
Alaska Department of Fish & Game

Donna Platt, President
Eyak Corporation

Luke Borer, President
Sherstone, Inc.

RESOLUTION OF THE *EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL

We, the undersigned, duly authorized members of the *Exxon Valdez* Oil Spill Trustee Council, considering the views of the public and as a supplement to our December 2, 1994, and February 22, 1995 Resolutions regarding the Orca Revised, Other, and Core Lands interests owned by the Eyak and Sherstone Corporations (hereafter jointly referred to as "Eyak") find as follows:

1. On December 2, 1994, the Trustee Council unanimously resolved to authorize an offer to purchase from Eyak the Core Lands in fee simple and certain interests in the Orca Revised lands. The acceptance of this offer was subject, among other things, to the preparation of conservation easements that allow for development on the Orca Revised lands only to the extent compatible with the restoration of injured natural resources and services, which Eyak was to convey, in perpetuity, to the United States. Eyak subsequently responded to the offer in the form of a proposal called the "Eyak Concept Change," dated December 12, 1994, which the Trustee Council did not consider consistent with its restoration objectives as presented in the December 2 Resolution.

of the Orca Revised Lands is important to maintaining water quality and riparian habitats for anadromous fish and maintaining nesting and foraging opportunities for marbled murrelets and bald eagles. The Orca Revised Lands have a high value for recreation/tourism and are highly visible to the nearby community of Cordova.

4. There is widespread public support for the acquisition of interests in the Orca Revised, Other, and Core Lands.

5. The acquisition of the interests in the Core Lands, Other Lands and the Orca Revised lands is an appropriate means to restore a portion of the injured resources and the lost or reduced services in the oil spill area. Acquisition of interests in these lands is consistent with the Final Restoration Plan.

6. On March 1, 1995 the Trustee Council recognized and accepted the Statement of Intent in the form attached.

THEREFORE, the Trustee Council authorizes funds for the United States, acting through the Forest Service, to acquire a limited conservation easement on the Orca Revised lands along Orca Narrows/Nelson Bay for $200,000 consisting of commercial timber harvest rights for a period of time from March 1, 1995 through and including May 15, 1995 or as extended consistent with the Statement of Intent.

Dated this 3rd day of March, 1995, at Anchorage and Juneau, Alaska.

PHIL JANIK
Regional Forester
USDA Forest Service

Craig J. Tillery
for BRUCE M. BOTELHO
Attorney General
State of Alaska

for GEORGE T. FRAMPTON, JR.
Assistant Secretary for Fish
and Wildlife and Parks
U.S. Dept. of the Interior

STEVEN PENNOYER
Director, Alaska Region
National Marine Fisheries
Service

FRANK RUE
Commissioner
Alaska Department of
Fish and Game

for GENE BURDEN
Commissioner
Alaska Department of
Environmental Conservation

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Exxon Valdez Oil Spill Trustee Council

Restoration Office
645 "G" Street, Anchorage, AK 99501
Phone: (907) 278-8012 Fax: (907) 276-7178

MEMORANDUM

TO: Trustee Council

THROUGH: Molly McCammon
Executive Director

FROM: Traci Cramer
Administrative Officer

DATE: March 21, 1995

RE: Financial Report as of February 28, 1995

Attached is the Statement of Revenue, Disbursements and Fees, and accompanying notes for the *Exxon Valdez* Joint Trust Fund for the period ending February 28, 1995.

The following is a summary of the information incorporated in the notes and contained on the statement.

Joint Trust Fund Account Balance	$109,136,814	
Less: Commitments (Note 6)	$31,319,584	
Less: Restoration Reserve Balance	$24,000,000	
Plus: Adjustments (Note 8)	$2,962,310	
Uncommitted Fund Balance		$56,779,540
Plus: Future Exxon Payments (Note 1)	$490,000,000	
Less: Future Reimbursements (Note 3)	$26,300,000	
Total Estimated Funds Available		$520,479,540

If you have any questions regarding the information provided please give me a call at 586-7238.

attachments

cc: Restoration Work Force
Bob Baldauf

STATEMENT OF REVENUE, DISBURSEMENT, AND [illegible]S
EXXON VALDEZ OIL SPILL JOINT TRUST FUN[illegible]
As of February 28, 1995

DRAFT

	Federal Fiscal Years Ending September 30			To Date	Cumulative
	1992	1993	1994	1995	Total
REVENUE:					
Contributions: (Note 1)					
Contributions from Exxon Corporation	90,000,000	250,000,000	70,000,000		410,000,000
Less: Credit to Exxon Corporation for clean-up costs incurred		(39,913,688)			(39,913,688)
Total Contributions	90,000,000	210,086,312	70,000,000	0	370,086,312
Interest Income: (Note 2)					
Exxon Corporation escrow account	831,233				831,233
Joint Trust Fund Account	596,000	1,378,000	3,736,000	2,456,472	8,166,472
Total Interest	1,427,233	1,378,000	3,736,000	2,456,472	8,997,705
Total Revenue	91,427,233	211,464,312	73,736,000	2,456,472	379,084,017
DISBURSEMENTS:					
Reimbursement of Past Costs: (Note 3)					
State of Alaska	29,267,842	29,000,000	25,000,000		83,267,842
United States	24,726,280	36,117,165	6,271,600		67,115,045
Total Reimbursements	53,994,122	65,117,165	31,271,600	0	150,382,887
Disbursements from Joint Trust Account: (Note 4)					
State of Alaska	6,559,200	18,529,113	44,546,266	19,434,190	89,068,769
United States	6,320,500	9,105,881	6,008,387	8,252,361	29,687,129
Total Disbursements	12,879,700	27,634,994	50,554,653	27,686,551	118,755,898
FEES:					
U.S. Court Fees (Note 5)	23,000	154,000	364,000	267,418	808,418
Total Disbursements and Fees	66,896,822	92,906,159	82,190,253	27,953,969	269,947,203
Increase (decrease) in Joint Trust	24,530,411	118,558,153	(8,454,253)	(25,497,497)	109,136,814
Joint Trust Account Balance, beginning balance	0	24,530,411	143,088,564	134,634,311	
Joint Trust Account Balance, end of period	24,530,411	143,088,564	134,634,311	109,136,814	
Commitments: (Note 6)					(31,319,584)
Restoration Reserve: (Note 7)					24,000,000
Adjustments: (Note 8)					2,962,310
Uncommitted Fund Balance					56,779,540
Remaining Reimbursements: (Note 3)					(26,300,000)
Total Estimated Funds Available					520,479,540

NOTES TO THE STATEMENT OF REVENUE, DISBURSEMENTS AND FEES
FOR THE *EXXON VALDEZ* JOINT TRUST FUND
As of February 28, 1995

1. Contributions - Pursuant to the agreement Exxon is to pay a total of $900,000,000.

Received to Date	$410,000,000
Future Payments	$490,000,000

2. Interest Income - In accordance with the MOA, the funds are deposited in the United States District Court, Court Registry Investment System (CRIS). All deposits with CRIS are maintained in United States government treasury securities with maturities of 100 days or less. Total earned since the last report is $873,472.

3. Reimbursement of Past Costs - Under the terms of the agreement, the United States and the State are reimbursed for expenses associated with the spill.

Reimbursements to Date	$150,382,887
Remaining Reimbursements	
United States	$3,000,000
State of Alaska	$23,300,000

4. Disbursements from the Joint Trust Account - There are no pending court requests.

5. Fees - CRIS charges a fee of 10% for cash management services. Total paid since the last report is $87,417.

6. Commitments - Includes $24,956,000 for the Trustee Council's contribution toward the Alaska Sealife Center in Seward and $6,363,584 for the final two installments (plus interest) for the Seal Bay purchase. The contributions for the Alaska Sealife Center will be made in September 1995 and 1996, with the Seal Bay payments due in November 1995 and 1996.

7. Restoration Reserve - The required documentation for establishment of the reserve has not been filed.

8. Adjustments - Under terms of the Agreement, both interest earned on previous disbursements and prior years unobligated funding or lapse are deducted from future court requests. Since the last court request $324,686 in interest have been earned and $2,637,624 have been reported as unobligated for the 1992 and 1993 Federal Fiscal Years.

	Interest	Lapse
United States	$3,849	$240,859
State of Alaska	$320,837	$2,396,765

DRAFT

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MEMORANDUM

State of Alaska
DEPARTMENT OF FISH AND GAME

TO: Molly McCammon
Executive Director
EVOS Trustee Council
Restoration Office

DATE: March 24, 1995
FILE: S-4.2.8.13.9

PHONE: 267-2334
FAX: 349-1723
E-MAIL: 72350.1610@cis.com

FROM: Kimbal A. Sundberg
Habitat Biologist
Habitat and Restoration Division
Anchorage

SUBJECT: Alaska SeaLife Center
Status Report

The following is a summary of current issues on the Alaska SeaLife Center (ASC) project. Per your request, the first five headings in this status report track with the provisions of the November 2, 1994 Trustee Council Resolution:

1. Detailed Construction Budget and Operating Plan

- The mid-design development presentation by the project architects, Livingston Slone and Cambridge Seven Associates was reviewed by the Scientific Work Group (SWG), including the Chief Scientist, on March 2 in Anchorage. Follow-up meetings were held on March 3 with designers and SWG members to specifically address issues related to the life support system, research tank and pool areas, wet and dry labs, equipment, animal clinic/quarantine, food storage/preparation, and dive locker. A recent mid-design development construction estimate indicates that the research and rehabilitation component of the project is within the $37.5 million budget. The final submission of the design development and construction estimates is scheduled for the first week of May. This will be used to formulate the detailed construction budget and construction cash flow projection.

- Leif Selkregg and I are continuing to develop the operating plan for the ASC. In late February we met with directors and staff of the Hatfield Marine Science Center (HMSC) and the Oregon Coast Aquarium (OCA) in Newport Oregon to obtain more information on their operations including organization, animal care costs, job descriptions, salaries, hiring procedures, financing, maintenance, and research overhead rates. We are using this information to refine our staffing and operational cost assumptions which will be used to develop cash flow needs for ramp-up and initial operations. Additionally, I have been working with local seafood processors/distributors and food scientists at the Fishery Industrial Technology Center to develop an animal food cost projection for the facility. A draft of the operations plan will be available in May.

The HMSC and OCA provide good models for crafting the ASC operations plan because of similarities in the missions and operating structures. The HMSC and OCA directors suggested closely linking the life support, animal husbandry and chief scientist functions to ensure a workable solution for carrying out the joint research, rehabilitation, and public education missions of the facility. They recommended filling key staff positions one year before completion of construction (i.e., 1996-97). The SWG reviewed this organization concept at their March 2 meeting and additionally recommended that the ASC Executive Director should have a science background. The ASC Executive Director is scheduled to be hired in 1996.

2. <u>Alaska Department of Fish and Game - City of Seward Agreement</u>

- The Cooperative Agreement between ADF&G and the City of Seward governing the construction, operation, and maintenance of the research component of the ASC is currently before the Seward City Council for review and adoption. This Agreement provides that the City of Seward will own the facility and provide for the operation and maintenance for its practical life. Among other things, the five provisions of the Trustee Council's November 2, 1994 Resolution are included as conditions of release of funds to Seward. The final negotiations on the Agreement have involved Alex Swiderski and Steven Daugherty, Department of Law; Deborah Boyd, Earnie Greek and myself, ADF&G; Brad Thompson, Division of Risk Management; Tyler Jones and Tom Klinkner (attorney representing City of Seward); and Darryl Schaefermeyer. Willard Dunham, Leif Selkregg, and Suzanne Cherot and Kathryn Black (attorneys representing SAAMS).

- Both the ADF&G - Seward agreement and a corollary SAAMS - City of Seward Agreement were the subject of a five hour work session with the Seward City Council on March 20. A Public Hearing and request for adoption of the agreements by City Council Resolution is scheduled for March 28. City Council adoption of the agreements is a prerequisite for Seward to lease the land to SAAMS for construction. Once adopted by the City Council, the ADF&G - City of Seward Agreement would be signed by Tyler Jones, Frank Rue, Kevin Brooks, the Director of the ADF&G Habitat & Restoration Division, and yourself.

3. <u>Mitigation Measures</u>

- The City of Seward, through SAAMS, will prepare a list of all permits and mitigation measures that have been stipulated for the project and will provide a description of the extent to which these measures are being implemented. The list will be periodically updated during the construction phase of the project. Maureen Sims is under contract to SAAMS to serve as the permitting and compliance coordinator for the project.

4. Governing and Management Structure - UAF Role

- The first draft of a Memorandum of Understanding between SAAMS and the University of Alaska Fairbanks (UAF) governing research operations at the ASC was transmitted to John Keating, UAF Provost on March 8. The MOU contains provisions for the affiliation of the ASC with the UAF, School of Fisheries and Ocean Sciences (SFOS). Additionally, the UAF would fill the ASC Chief Scientist position. The role of ASC Chief Scientist is defined in the MOU. Once the University has reviewed and responded to the draft MOU, it is expected to go before the SFOS Advisory Committee and the Board of Regents. It is anticipated that the MOU can be completed in June.

- Two positions on the SAAMS Board of Directors have been filled by University of Alaska (UA) appointments. UA President Jerome Komisar has participated on the SAAMS Board since January. Recently, Joan Wadlow, UAF Chancellor, was named to fill the second university seat. Bob Spies was named to the SAAMS Board in February and has been actively participating in Board development and fund raising workshops and meetings. Drs. Spies and Komisar are also active on the ASC Executive Director hiring committee. Additionally, Tom Tougas, President of Kenai Fjords Tours, has recently accepted a seat on the SAAMS Board.

5. Reports and Monitoring

- The requirement for the City of Seward to submit annual financial and project status reports to the Trustee Council has been made a condition of the ADF&G - City of Seward Agreement. Additionally, the City will be submitting monthly progress and financial reports to ADF&G as a condition for payments and a final report will be prepared following completion of construction. ADF&G will regularly monitor the construction of the facility and will continue to provide progress updates to you and others.

6. Other

- Upcoming Events:

  March 28 - Seward City Council Public Hearing on ADF&G and SAAMS Agreements

  April 6 - Briefing of Congressional Delegation, Washington D.C.

  April 18 - SAAMS Board Meeting

April 27 - Scheduled Signing of SAAMS Agreement by City of Seward

May 20 - Scheduled Ground Breaking Ceremony

Exxon Valdez Oil Spill Trustee Council
FY 95 Detailed Project Description

1. **Project Title:** Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators

2. **Project Number:** 95025

3. **Lead Trustee Agency:** National Biological Service

4. **Cooperating Agencies:** ADFG, NOAA, USFWS

5. **Project Start-up/ Completion Dates:** July 1995 to October 1999

6. **Expected Project Duration:** 5 years

7. **Cost of Project:** FY95 $596,208; FY96 $1,644,595; FY97 $1,644,595; FY98 $1,644,595; FY99 $450,000

8. **Geographic Area:** Western Prince William Sound

9. **Cooperators:**
   Dr. Brenda Ballachey - National Biological Service, Alaska Science Center (ASC)
   Mr. Jim Bodkin - National Biological Service, ASC
   Dr. Terry Bowyer - University of AK Fairbanks (UAF)
   Dr. Tom Dean - Coastal Resources Associates, Inc.
   Dr. Larry Duffy - UAF
   Mr. Dan Esler - National Biological Service, ASC
   Mr. Stephen Jewett - UAF
   Ms. Karen Laing - U.S. Fish and Wildlife Service
   Dr. Lyman McDonald -Western Ecosystems Technology
   Dr. Chuck O'Clair - National Marine Fisheries Service
   Dr. Alan Rebar - Purdue University
   Dr. Dan Roby - National Biological Service/UAF
   Dr. Paul Snyder - Purdue University
   Dr. Glenn VanBlaricom - National Biological Service/University of Washington

10. **Chief Scientist:**
    ____
    Dr. Leslie E. Holland-Bartels
    National Biological Service, ASC

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1.0 Introduction

1.1 Overview

The nearshore marine ecosystem of Prince William Sound (PWS) plays a critical role in the commercial, subsistence, and recreation economy of southcentral Alaska. Because of shorelines and coastal physiography, the nearshore ecosystem served as a repository for much of the oil spilled by the T/V *Exxon Valdez* (EVOS). As a result, many of the injured resources under study by the *Exxon Valdez* Trustees Council are components of the nearshore system (Table 1). Thus, we propose the Nearshore Vertebrate Predator (NVP) study, which describes a research approach for assessing the biological and ecological significance of trophic issues and contaminants present in the environment. We focus on the status of system recovery and a suite of injured apex predators as indicators of environmental stress--the invertebrate feeding sea otter and harlequin duck, and fish feeding pigeon guillemot and river otter. NVP takes a multispecies, integrated approach to assess several potential key mechanisms constraining recovery of the nearshore system. For our test species, EVOSTC (1994a) suggested that three of the twelve mechanisms hypothesized (Appendix 6.1) to be impacting the nearshore system had high potential as factors constraining recovery:

1) *Recovery of nearshore resources injured by EVOS is limited by recruitment processes;*

2) *Initial and/or residual oil in benthic habitats and in or on benthic prey organisms has had a limiting effect on the recovery of benthic foraging predators; and*

3) *EVOS induced changes in populations of benthic prey species have influenced the recovery of benthic foraging predators.*

Based on that consensus, the NVP study will examine status of recovery of the 4 selected nearshore vertebrate predators. We will measure population density, as well as demographic factors (e.g., size and age distributions, birth rates, survival rates) at both oiled and unoiled sites to examine possible reasons for lack of recovery, and to assess progress toward recovery given demographic restraints. Simply stated, we will ask "are vertebrate populations recovering, and if so, are they recovering as quickly as possible given potential rates of population increase?".

In contrast with these "recovery monitoring" studies, we will address two working hypotheses with respect to possible constraints to the recovery process:

1) *Initial and/or residual oil in benthic habitats and in or on benthic prey organisms has had a limiting effect on recovery of benthic foraging predators; and*

2) *Prey availability and competition for prey is constraining recovery of sea otters, river otters, pigeon guillemots, and harlequin ducks.*

In simpler terms, "is it oil?", or "is it food?". These questions will be addressed through evaluation of demographic measures, health assessments, biomarkers of oil exposure, and availability of prey for the four nearshore vertebrate predators.

1.2 General State of Recovery

The EVOS caused immediate, acute impacts to the nearshore ecosystem. Oil moved over 1,100 km of coastline (Morris and Loughlin 1994), with over 20% of the PWS shoreline heavily oiled (ADEC 1992). Additional disturbances of the nearshore system occurred as heavily oiled beaches were washed (Morris and Loughlin 1994). Mortalities occurred across the suite of apex predators in the system (Table 2) and mussels, clams, and other benthic invertebrates were injured (Houghton et al. 1993a, Highsmith et al. 1993). Initial changes in composition and abundance of nearshore invertebrates and apex vertebrate predators resulting from these acute mortalities and habitat disturbances likely caused continued modifications in important structuring processes in the nearshore invertebrate populations (i.e., competition, predation, and recruitment), thus constraining recovery.

Effective implementation of the EVOS Trustees Council's policy (EVOSTC 1994b) that "Restoration should contribute to a healthy, productive and biologically diverse ecosystem...", is complicated by the diversity and trophic interdependence of the numerous injured resources within the nearshore system. Beyond these ecological constraints, we are practically constrained in judging restoration by a lack of accurate and precise pre-spill population demographic data for many injured resources upon which to judge the progress of restoration. However, sufficient evidence exists to suggest that a wide variety of nearshore vertebrate predators and crucial subtidal and intertidal invertebrate prey are not recovered (Table 2, EVOSTC 1994a,b).

1.3 Factors Constraining Recovery

1.3.1 Demography

The rate of recovery of nearshore vertebrate predators may be constrained by oil-related factors (continued toxicity of oil and food availability) as well as non-oil related processes. The latter include death and birth processes as affected by factors such as intrinsic reproductive capacity and mortality due to adverse weather conditions. It may be, for example, that death and birth rates do not differ among injured and non-injured subpopulations of nearshore vertebrate predators, but that the rate of population increase is too slow to have allowed for complete recovery of the injured nearshore vertebrate predator populations. In other words, the nearshore vertebrate predator populations may not be fully recovered, but may be recovering as quickly as possible under naturally-occurring conditions, in the absence of continued effects of oil.

1.3.2 Continued Hydrocarbon Exposure

Today, hydrocarbon impacts may still exist. Between 8-16% of the 10.8 million gallons of crude oil spilled by the *Exxon Valdez* remains buried in marine sediments (Wolfe et al.

1994). Such oil is not subject to degradation by marine organisms and remains in a form that is toxic to many vertebrates (Braddock et al. in press, Tumeo et al. 1994). Moreover, microbial analyses suggest that oil in sediments along oiled shorelines is still several orders of magnitude more common than in unoiled sites (Tumeo et al. 1994). Various bioindicator and health measures suggest that continued injury may be occurring (Table 2).

Studies initiated following EVOS suggest continued biochemical effects potentially related to oil toxicity. Specifically, hematology and serum chemistries performed on blood and serum from sea otters suggested that animals sampled in oiled regions had greater antigenic stimulation (more inflammatory and/or infectious conditions) than did animals from unoiled areas (Rebar et al. 1993; Ballachey, unpubl. data). Indication of an inflammatory response to oil was further supported by observations of elevated concentrations of haptoglobin and interleukin 6 (IL-6) in serum from river otters in oiled areas (Duffy et al. 1994b). Jewett et al. (1994) reported hemosiderosis in demersal fishes from oiled areas. These initial observations support the hypothesis that continued exposure to crude oil may be affecting animal health through chronic or recurrent infections resulting from diminished immune responses. The effects of hydrocarbons on the immune system have been well documented (reviewed in White et al. 1994; Ward et al. 1985).

1.3.3 Food Availability

Biological communities of the nearshore region are functionally distinct from those of pelagic and upland realms by spatial, energetic, and structural considerations. Here, energy is transported from primary producers to apex predators through the sessile, subtidal and intertidal macrofaunal portions of the food chain (e.g., some mollusks and polychaetes) or demersal fishes (e.g., sculpins) to apex demersal predators (e.g., sea ducks and birds, sea and river otters), while in the pelagic zone, energy is transported from phytoplankton to microzooplankton to apex planktivores (e.g., whales) and predators such as salmon (Figure 1a, Parsons 1986). Considerable overlap and potential competition for food exists among the apex predators of the nearshore system (Figure 1b).

There is strong evidence to suggest that population densities of many nearshore vertebrate predators are limited by food. For example, Garshelis (1983) found that after initial immigration of sea otters into eastern PWS in 1979, the population increased rapidly over the next several years. Concurrent with this increase in otters was a rapid decline in many preferred prey items, including Dungeness crabs. Following prey reduction, sea otter populations declined and became relatively stable. Similar patterns have been observed at Amchitka Island (Kenyon 1969) and the Commander Islands (Burdin in press). Kruuk et al. (1991) noted that populations of *Lutra* were limited by the abundance of marine fishes. Other suggestions of food limitation exist for sea ducks (Stott and Olsen 1973).

There is circumstantial evidence that pigeon guillemots nesting at Naked Island in central PWS are food-limited. Historically, Naked Island has been an important breeding area for pigeon guillemots, supporting about 20% of the sound-wide breeding population. Concurrent with a 50% decline in the numbers of breeding guillemots at Naked Island, there has been a decline in growth rates of nestlings (D.L. Hayes, unpubl. data). These declines have been associated with a major diet shift for adult guillemots feeding nestlings. Before the EVOS, over one third of the prey fed to guillemot nestlings was sand lance, and most of the remaining prey items were blennies and sculpins (Kuletz 1983). After the EVOS, nestling diets on Naked Island were dominated by juvenile gadid, a comparatively low-quality prey, and sand lance constituted less than 10% of the diet (D.L. Hayes, unpubl. data). The apparent decline in the availability of a high-quality prey type (sand lance), and its replacement in the diet by prey types with half the energy density (cod, pollock), suggest that pigeon guillemot productivity on Naked Island is constrained at least in part by food availability.

There is evidence that population densities of at least some important vertebrate prey species declined as a result of the EVOS. For example, mussels, which are an important component of the diets of sea otters and sea ducks (Calkins 1978, Estes et al. 1981, Koehl et al. 1982, Sanger and Jones 1982, Vermeer and Bourne 1982, Doroff and Bodkin 1994, Patten 1994) were less abundant at oiled sites relative to unoiled sites following the EVOS (Highsmith et al. 1995). Many of the prey species of the nearshore vertebrate predators, including crabs (Jewett et al. 1994) limpets, chitons, and mussels (Highsmith et al. 1993) have failed to recover fully in some habitats.

The possibility of food limitation of vertebrate predators, coupled with the evidence for injury from the EVOS to prey species, suggests that recovery of some vertebrate populations may be food limited.

1.4 NVP Approach

1.4.1 Species Selection

1.4.1.1 Selection Criteria

We have identified two principal trophic pathways from primary production to apex predators in the nearshore ecosystem. One pathway leads through fishes, the other through benthic invertebrates. We will integrate component studies of apex predators, co-predators (within the invertebrate pathway), and prey with measures of individual and population health and environmental contaminants. This will improve our ability to determine the status of populations relative to recovery, isolate processes constraining recovery, and identify potential activities to facilitate recovery of injured resources. Four vertebrate predator species were selected for study because there was evidence for possible injury from the EVOS and for lack of recovery (see section 1.2 and Tables 1 and 2), they are important members of the nearshore ecosystem in PWS and elsewhere in the spill affected area, they represent species with a varied prey base (Figure 2), and their trophic dependence on nearshore prey items can be effectively measured. These species are sea otter (*Enhydra lutris*) and harlequin duck (*Histrionicus histrionicus*), and fish feeding pigeon guillemot (*Cepphus columba*) and river otter (*Lutra canadensis*). A brief description of the natural history of each species, evidence for injury from the EVOS, their amenability to research and their major foods follows. Also, we provide a rationale for inclusion in the study of primary prey species and brief overviews of previous studies of these prey.

1.4.1.2 Sea Otter

Sea otters live 10-15 years, become reproductive at 2-5 years, and produce single pups about once per year during prime reproductive age (3-9 years). They rely on their pelage rather than fat to maintain body temperature (Costa and Kooyman 1982). This means of thermoregulation requires a high metabolic rate that depends on a high caloric intake (up to 25% of their body mass in prey consumed per day). Constrained by diving limitations to waters < 100 m in depth, sea otters in PWS and elsewhere in the Pacific are distributed along a narrow band of nearshore habitat extending offshore from the intertidal zone. In PWS, about 80% of the sea otters are observed in water depths < 40 m (Bodkin, unpubl. data), with most foraging activity occurring within this depth (Reidman and Estes 1990). Home ranges of sea otters generally include from a few to > 40 km of coastline (Lensink 1962, Kenyon 1969, Garshelis and Garshelis 1984, Reidman and Estes 1990), thereby integrating environmental effects and influencing benthic community structure over large areas. Two consequences of sea otter physiology and habitat requirements are a high susceptibility to contaminants, particularly external oiling (Costa and Kooyman 1982), and a large influence on prey populations. Preferred prey of sea otters include sea urchins, mussels, clams, snails and crabs.

By late 1991, results of three injury assessment studies suggested that effects from the spill were continuing (Ballachey et al. 1994): the age class distributions of sea otters dying were abnormal relative to pre-spill data (Monson and Ballachey 1994), post-weaning survival was low, and surveys revealed no increase in abundance in oiled areas. By late 1993, juvenile survival had increased and mortality patterns appeared to begin returning to normal. However, surveys of abundance failed to detect increases of sea otters. Analyses of data from a new aerial-survey methodology implemented in 1992 indicate that densities of sea otters are up to an order of magnitude lower in areas of PWS where oiling was most severe and persistent and where sea otter mortality was high, and suggest that recovery had not occurred by 1994.

Sea otters are a good choice for investigating processes constraining recovery of the nearshore ecosystem for several reasons: 1) they reside nearshore and their activities (including food habits) can be quantified from shore, 2) their predominant prey are sedentary bivalves whose abundance and size class distribution can be easily measured, 3) effects of the EVOS are well documented, including both immediate and chronic injuries, 4) baseline data on sea otter population demographics, physiological indices and their prey are available specifically for PWS, 5) tools are available for unbiased and precise estimates of sea otter density, and 6) the role of sea otters in structuring invertebrate prey is well understood and provides an opportunity for not only a separate means of evaluating the status of the population, but also identifying potential mechanisms constraining recovery.

Proposed sea otter studies will include assessments of abundance, reproduction, mortality, prey selection, bioindicators and individual health. Measures of population status will be integrated with the abundances and size class distributions of marine invertebrates that compose most of the diet of sea otters.

1.4.1.3 Harlequin Duck

Harlequin ducks, like other sea ducks, are long-lived with relatively low annual reproductive output (Goudie et al. 1994). Breeding philopatry of sea ducks is high (e.g., Savard and Eadie 1989). If wintering site fidelity also is high (Limpert 1980, Goudie, pers. comm.), winter survival would directly influence annual changes in specific wintering populations. Because harlequin ducks spend much of their annual cycle on wintering areas, assessments of limiting factors during that period are valuable for determining population health and sustainability.

Harlequin ducks suffered direct oiling mortality during the initial stages of the oil spill and were at high risk during the spill because of the high numbers occupying PWS during March (Agler et al. 1994). Continued oil effects might have affected harlequin duck recovery. Patten (1994) found hydrocarbon metabolites in harlequin ducks collected from the oiled area, and also suggested that reproductive effort and productivity of harlequin ducks were lower in oiled areas.

Harlequin ducks are inextricably linked to nearshore habitats. They are spatially limited by foraging depth and occurrence of prey. Harlequin ducks feed on a diverse array of nearshore benthic invertebrates (Dzinbal and Jarvis 1982, Goudie and Ankney 1986, Goudie and Ryan 1991, Patten 1994). In general, sea ducks may be sensitive to constraints on food quality and availability because of the severe weather encountered in northern wintering areas; this may be especially true for harlequin ducks due to their small body size (Goudie and Ankney 1986). Life-history traits of harlequin ducks, coupled with the concentration of oil-spill injury on nearshore habitats, suggest that these birds will be particularly sensitive indicators of system health.

Proposed studies focus on assessments of differences in harlequin duck population health between oiled and unoiled study sites. This will include measures of female overwinter survival, harlequin duck abundance relative to prey resources, body composition and bioindicators of molting harlequin ducks, and distribution and habitat associations of wintering harlequin ducks.

1.4.1.4 Pigeon Guillemot

Guillemots are the most neritic members of the marine bird family Alcidae, which includes murres, puffins, and auks. Guillemots first breed at 2 years of age and adults have high annual survivorship (85%, Asbirk 1979). Young guillemots normally return to the natal area to breed. Nest site fidelity of breeding pairs is high and even in instances when pairs relocate nests, the distances involved are usually small (< 30 m). Eggs are laid in a wide variety of natural crevices and holes, but most nest sites in the study area are located in cavities in rock masses (K. Kuletz and K. Oakley, pers. comm). Eggs are usually laid about 50 cm from the entrance of the nest crevice (Asbirk 1979), thus eggs, chicks, and attending adults are frequently accessible for data collection. Guillemots are unusual among alcids in that they normally lay two-egg clutches and raise two chicks per nesting attempt. Guillemots carry whole fish in their bills to the nest-site crevice to feed their young. Thus, individual prey items can be identified, weighed, measured, and, if necessary, collected for contaminant analyses.

As of 1994, results of damage assessment studies indicated that the pigeon guillemot population on Naked Island is continuing to decline. Naked Island is a major guillemot breeding colony site in PWS and has been the site of breeding biology studies since the late 1970s. The diet of guillemot nestlings on Naked Island has changed considerably from the pre-spill period, and growth rates of nestlings have declined (D.L. Hayes, pers. comm.). Nestling growth rates are currently lower than those on Jackpot Island, a colony in PWS that was not oiled.

Pigeon guillemots are a well-suited species for monitoring nearshore ecosystem health for several reasons: 1) they are a common and widespread seabird species breeding in coastal Alaska, and in PWS specifically (Sowls et al. 1978, Sanger and Cody 1993); 2) they forage within 5 km of the nest site in the subtidal and nearshore zones (Drent 1965, Kuletz 1983); 3) unlike most seabird species, they do not breed in large, dense colonies; 4) they raise their young almost entirely on fish, preying primarily on nearshore demersal fish (e.g., blennies, sculpins) and on nearshore schooling fish (e.g., sandlance; Drent 1965, Kuletz 1983); and 5) the one- or two-chick broods are fed in the nest until the young reach adult body size.

Research is currently underway by project investigators (Roby, Duffy, and Bowyer) to assess pigeon guillemots as an avian bioindicator for coastal ecosystems in Alaska. This research is being conducted in Kachemak Bay, Alaska, and will provide crucial baseline information for the proposed work in PWS.

Proposed pigeon guillemot studies will include assessments of numbers of breeding pairs, reproductive success, nestling growth rates, fledgling condition indices, blood biomarkers of contaminant exposure, and other indices of individual health. Indices of reproductive success will be integrated with nestling provisioning rates, taxonomic composition of the diet, and the abundances of these fish taxa in foraging areas near nesting aggregations. Prey taxa will be assessed for evidence of exposure to petroleum hydrocarbons, including cytochrome P450. In addition, we will estimate the abundance of prey within the foraging range.

1.4.1.5 River Otter

River otters inhabiting marine environments make extensive use of, and concentrate their activities in, intertidal and subtidal zones (Larsen 1984, Woolington 1984, Dubuc et al. 1990, Bowyer et al. 1994). These high trophic-level carnivores are long-lived ($\geq$ 12 years; Docktor et al. 1987), and occur at densities of 0.2-0.8 otters/km of shoreline throughout the Gulf of Alaska (Testa et al. 1994). River otters are extremely sensitive to aquatic pollutants, yet continued to reside within the area of oil-contaminated shorelines in PWS, Alaska following the spill (Testa et al. 1994). These characteristics make river otters an excellent model for assessing effects of marine pollution on mammals, and provide an overall index to the health of the nearshore ecosystem.

River otters living in marine environments consume a diet dominated by marine fishes, which they prey upon in intertidal and subtidal zones; they also consume a wide variety of marine invertebrates (Larsen 1984, Stenson et al. 1984, Bowyer et al. 1994). Such nearshore areas are the most often affected by pollution. For instance, the spill contaminated extensive areas of the intertidal and subtidal environments, which was reflected in a loss of dietary diversity for otters inhabiting oil-contaminated shorelines (Bowyer et al. 1994). Likewise, river otters living in oiled areas exhibited a significantly lower body mass (when controlled for sex and total body length) than did otters inhabiting unoiled areas (Duffy et al. 1993). Otters have extremely large home ranges (20-40 km of shoreline--Bowyer et al. 1995), and hence integrate effects of pollution over wide areas.

Population dynamics of European otters (*Lutra lutra*) in coastal areas have been linked to the abundance of marine fishes (Kruuk et al. 1991); this is also likely the case for river otters inhabiting PWS. Bowyer et al. (1994) previously demonstrated that diversity of otter diets declined significantly following the spill. Similarly, body mass of otters was significantly lower on oiled, compared with unoiled, areas of PWS (Duffy et al. 1993, 1994b).

Proposed river otter studies will include assessments of abundance, morphometrics, and bioindicators of individual health. Indices of population status will be integrated with the abundances of marine fishes that compose most of the diet of river otters.

1.4.1.6 Invertebrates - Clams

Clams are an abundant and diverse component of the benthic invertebrate fauna of PWS, and the predominant prey of sea otters in PWS (Calkins 1978, Estes et al. 1981, Doroff and Bodkin 1994). All major nearshore sediment types in PWS support significant densities of clams. Species most commonly recognized in the diets of nearshore vertebrate predators are in four families: Veneridae: *Saxidomus giganteus* and *Protothaca staminea*; Myidae: *Mya truncata* and *Mya arenaria*; Mactridae: *Tresus capax*, and Tellinidae: *Macoma* spp. Venerids, myids, and mactrids are filter feeders while tellinids are deposit feeders. All clams listed here have a planktonic larval phase, and thus are subject to significant interannual and spatial variation in recruitment intensity in response to changing oceanographic conditions.

Houghton et al. (1993b) noted that densities of the little neck clam, *Protothaca staminea*, were lower at oiled (their "oiled" sites included "oiled/washed" and "oiled/not washed") than at unoiled sites in PWS following the EVOS. Recovery status of PWS clam resources is listed as "unknown" (Table 1). Hydrocarbon content of subtidal clam tissues did not reflect spill effects two years after the EVOS, and the EVOS apparently did not affect the representation of clams in sea otter diets in 1991 (Doroff and Bodkin 1994).

We will compare abundance, size distribution, and recruitment characteristics of predominant subtidal and intertidal clam populations in areas where sea otters have failed to recover from the EVOS with areas where sea otters apparently were not affected by the EVOS. Based on available information regarding clam-sea otter interactions, we expect two general outcomes for the EVOS-affected area. If clam populations include high densities of large individuals (maximum shell lengths exceeding 5-7 cm), we will conclude that food is not limiting sea otter recovery in the area. If clam populations do not include numerous large individuals and densities are relatively low, then we will conclude that food supply may be limiting sea otter recovery. In the latter case, two causal mechanisms are possible, both of which will be evaluated by our studies. Chronic recruitment failure or foraging by invertebrate predators could limit clam population size. Alternatively, residual effects of the spill also may limit clam population size. In addition, effects of co-predators (sea ducks and sea stars) will be examined.

1.4.1.7 Invertebrates - Sea Urchins

Sea urchins are a favored food of sea otters. There is strong evidence that the increase in otter populations in Alaska in the 1970's, led to a general reduction in sea urchin abundance (Dayton 1975, Estes et al. 1978, 1989, Duggins 1980). There are no quantitative subtidal surveys of sea urchin densities in PWS prior to immigration of sea otters. However, surveys conducted prior to the EVOS in the mid 1970's (Rosenthal et al. 1977) as well as those conducted after the spill (Jewett et al. 1994) suggest that there were few urchins present within the areas examined in the Sound, and that the few urchins observed were small and lived in cryptic habitats (under cobbles and boulders).

There is some evidence that sea urchin populations may be increasing in parts of PWS that were heavily oiled and now have relatively few sea otters. Anecdotal observations suggest increases in some intertidal and shallow subtidal habitats within Bay of Isles in 1993. No such aggregations were noted in extensive subtidal surveys in PWS in 1989 through 1991, and there were no aggregations observed at any unoiled sites in 1993. We suspect that such increases may result from reduced predation by sea otters. If the pattern of increased urchin abundance in oiled areas is documented, this would provide evidence that recovery of sea otters is limited by factors other than food availability.

Proposed assessments of sea urchins will include collection of abundance, size distribution, growth rate, and recruitment data at unoiled sites with large numbers of sea otters, and at oiled sites with few sea otters.

1.4.1.8 Invertebrates - Crabs

Crabs can make up a significant portion of the diet of sea otters (Calkins 1978). Following the immigration of sea otters into Prince William sound in the early 1970's, Dungeness crab population densities within the Sound declined markedly, presumably as the result of sea otter predation (Garshelis 1983). These and other cancer crabs are now rarely seen within the Sound. The helmet crab, *Telmessus cheriagonus*, is now the most abundant crab in the nearshore zone within the Sound (Jewett et al. 1994) and can make up a sizable fraction of the sea otter's diet (Doroff and Bodkin 1994). Helmet crabs were less abundant at oiled than at unoiled sites within shallow subtidal habitats following the EVOS, and populations had not fully recovered by 1993 (Jewett et al. 1994).

We will assess the abundance of all crab species at oiled (low otter density) sites and unoiled sites within the Sound.

1.4.1.9 Invertebrates - Mussels

Mussels are commonly eaten by sea otters in PWS, and generally represent a much higher proportion of the diet of juvenile sea otters than adults (Johnson 1987; Doroff and Bodkin 1994). Because mussels occur in the intertidal zone and require little effort to capture, they can be obtained readily by sea otters (Estes et al. 1981; VanBlaricom 1988). However, their caloric content is relatively low and they are not considered to be as valuable as many other sea otter prey (Garshelis 1983). Mussels also are important prey for a number of sea duck species (Koehl et al. 1982, Sanger and Jones 1982, Vermeer and Bourne 1982, Patten 1994).

Mussels have been the subject of a number of studies in PWS. However, extensive surveys of mussel abundance have been conducted only after the EVOS. Two major studies conducted after the EVOS included an examination of mussel populations in PWS. Houghton et al. (1993b, 1993c, 1993d, and 1993e) estimated abundance of *Mytilus* along with other epifauna at 21 locations in western PWS in 1991-92. Houghton et al. (1993b, 1993d) found no overall difference in abundance of *Mytilus* at unoiled beaches compared to beaches that had been oiled during the EVOS or oiled and subsequently cleaned with a hot-water wash treatment, although mussels suffered high mortality at certain stations that received high-pressure hot-water-wash treatment. Houghton et al. (1993c) present size-frequency data for *Mytilus* at 10 locations in PWS in May, July, and September 1991. Length-weight analysis of these mussels indicated that those at oiled sites did not appear to spawn in 1991. Mussels at oiled sites which were subsequently cleaned may have delayed spawning and spawned fewer times than mussels at unoiled sites (Houghton et al., 1993b). Houghton et al. (1993b) found that mussel populations in PWS exhibited a large amount of variation in the rates of growth of individuals.

VanBlaricom (1987, 1988) also found significant variation in growth rates and size distributions between populations of mussels at three locations in PWS prior to the oil spill. However, differences in growth rates could not account for the differences in size distributions between mussel populations. VanBlaricom (1987, 1988) concluded that mussel size distributions at his study sites were affected by sea otter predation.

Highsmith et al. (1993) estimated abundance and biomass of *Mytilus* at nine sites in PWS in late summer/early fall 1989 and in spring/summer 1990 and 1991. They found that *Mytilus* abundance at control sites exceeded that at oiled sites depending on habitat and tidal height (Highsmith et al. 1995). The size-frequency distribution of mussels was studied after the spill at three pairs of sites in Herring Bay by Institute of Marine Science biologists, but analysis of the data from that study is not complete (S. M. Saupe, pers. comm.).

Other studies of *Mytilus* that have been conducted in PWS have measured concentrations of petroleum hydrocarbons in mussel tissues before and after the EVOS (Karinen et al. 1993, Babcock et al. 1994). Neither study examined mussel abundance or size frequency distributions. Babcock et al. (1994) identified ten oiled mussel beds within the geographical areas proposed for the present study. Shigenaka and Henry (1994) compared hydrocarbon uptake by mussels with that by a semipermeable membrane device at a heavily oiled and extensively treated site on Smith Island. They concluded that sheens that had leached from subsurface deposits of residual oil, and particulate matter to which hydrocarbons were adsorbed were apparently more important exposure pathways than hydrocarbons dissolved in water. Keiser (1978) studied reproductive phenology, settlement, and growth in *Mytilus* in Port Valdez. She found that growth was seasonal with the most growth beginning in May after spawning and during the period when gametogenesis had ceased.

This component of the study will compare abundance and size-distribution of mussels in oiled areas where sea otters have failed to recover after the EVOS (e.g. northern Knight Island) with those in unoiled areas where sea otters were not appreciably affected by the EVOS (e.g., northwest Montague Is.). Food availability may be limiting recovery of sea otters in western PWS if three conditions are observed: (1) large mussels are reduced in abundance; (2) size frequency distribution of mussels is similar to that observed at areas where sea otters have not suffered reductions in abundance; and (3) alternate prey are not available, especially to young sea otters and females with dependent pups. If food availability is not limiting recovery of sea otters in PWS then large mussels should be abundant in western PWS. Abundance and size distribution of mussels in Barrow's goldeneye (*Bucephala islandica*) and white-winged scoter (*Melanitta fusca*) diets will be determined to understand the role of predation by these sea ducks in structuring mussel populations, with implications for interpretation of above-mentioned relationships between sea otters and mussels.

1.4.1.10 Pigeon Guillemot and River Otter Prey - Fishes

Both river otters and pigeon guillemots feed primarily on small benthic fishes common in the intertidal and shallow subtidal regions. Thus, assessing abundance of these fishes is necessary for understanding the role of food limitation is constraining recovery of these predators.

River otters in coastal Alaska have a broad diet consisting of a number of marine fishes and invertebrates common in the intertidal and shallow subtidal regions. Studies of river otters in PWS after the EVOS indicate that nearly 150 prey taxa are present in otter diets, with demersal fishes dominating in importance (Bowyer et al. 1994). The most commonly taken fishes are of the orders Gadiformes (Pacific cod, *Gadus macrocephalus*; Pacific tomcod, *Microgadus proximus*; walleye pollock, *Theragra chalcogramma*), Perciformes (searcher, *Bathymaster signatus*; crescent gunnel, *Pholis laeta*; Pacific sand lance, *Ammodytes hexapterus*), and Scorpaeniformes (greenlings, Hexagrammidae; sculpins, Cottidae; and poachers, Agonidae). Other marine food groups of lesser importance include gastropods, bivalves, and crabs. Diets of river otters from oiled areas changed after the EVOS (Bowyer et al. 1994). Fewer species were present in the diets of otters in oiled areas after the spill. Prey taxa that showed significant declines in the diets of otters at oiled sites relative to unoiled sites after the spill included perciform fishes (searcher, crescent gunnel, and Pacific sand lance) and Archaeogastropoda (keyhole limpets and the snail *Margarites* spp.). Bowyer et al. (1994) hypothesized that the change in diet may have resulted in reduced body mass that was noted in otters from an oiled area relative to an unoiled site (Duffy et al. 1994b).

They also speculated that oil in food items may have been responsible for toxicological effects in otters, as manifested by increased haptoglobins noted in otters from oiled areas (Duffy et al. 1994b).

Numerous investigations have revealed that the fish brought to the nesting pigeon guillemots chicks by the adults are primarily intertidal and nearshore bottomfishes (e.g., gunnels, sculpins) and nearshore schooling fish (e.g., sand lance) (Thoresen 1958; Drent 1965; Kuletz 1983; Emms and Verbeek 1991). In 1979-81 chicks in Prince William Sound were mainly fed sand lance, gunnels, pricklebacks and cottids, although a variety of other fishes were also taken (Kuletz 1983). Further south, along coastal British Columbia, the majority of fishes delivered to the chicks in 1984 and 1985 were either blennies (gunnels) or sculpins; sand lance and other fishes were less common (Emms and Verbeek 1991). In winter, after the chicks fledge, a substantial portion of the pigeon guillemot population leaves PWS and disperses throughout coastal Gulf of Alaska (D. Roby, R. Day, Pers. Commun., 1995).

Pigeon guillemots feed in the nearshore zone and eat a variety of fishes. The most common prey items that were brought to guillemot nests on Naked Island in 1994 were predominantly juvenile gadids, followed by pricklebacks, gunnels, sculpins and sand lance (D.L. Hayes, unpubl. data). The diet composition of guillemot nestlings on Naked Island has not always been dominated by juvenile gadids. In the late 1970's and early 1980's, the dominant prey types were sand lance, blennies (including pricklebacks and gunnels), sculpins and herring/smelt (Kuletz 1983).

There have been no studies on the availability or condition of pigeon guillemot or river otter prey that would allow one to make direct links between the effects of oil on prey and subsequent impacts on the predators. However, there are some data from independent studies in PWS that suggest that the abundance of some prey items in the diets of pigeon guillemots and river otters were reduced by oiling. Jewett et al. (1994) noted that gunnels were generally less abundant at oiled sites in 1990 and 1991, but did not differ significantly among treatments (oiled vs. unoiled).

There is also some evidence to suggest that prey items, especially intertidal ones, may be contaminated with oil, and may serve as a pathway of contamination of river otters. Gunnels collected in the shallow subtidal from oiled sites in 1993 had evidence of hemosiderosis in their tissues, an indicator of exposure to oil (Jewett et al. 1994).

Proposed studies of fish prey will include estimates of abundance at oiled and unoiled sites, and levels of cytochrome P450 within selected prey species.

1.4.2 General Approach

Our overall intent in this proposed study is to examine the status of recovery of nearshore vertebrate predators. As discussed above (section 1.3) the three factors most likely to be limiting recovery are intrinsic demographic constraints, continued hydrocarbon exposure, and food limitation (Figure 3). Demography will be examined by comparing population densities and parameters affecting population growth rates between oiled and unoiled sites. The question of continued exposure to oil will be assessed by comparing indicators of exposure to oil and individual health between oiled and unoiled sites. Food limitation will be considered by examining population densities and size class structures of dominant prey species. Concurrently, these studies will provide information regarding the status of recovery.

1.4.2.1 Demography

Analysis of change in vertebrate populations can be approached from several perspectives (Caughley 1977), including estimates or indices of abundance. Population abundance data provide evidence of direction and rate of change in numbers of individuals, but offer little insight into underlying processes responsible for any observed change. Data on measures of fecundity, survival, or dispersal enhance the identification of processes significant to changes in abundance.

Abundance of nearshore vertebrate predators will be measured at oiled and unoiled sites to compare recovery between these areas. In addition, we will measure demographic parameters (e.g., growth, survival, reproduction) in selected species to assess population health and also to determine if recovery of injured resources is proceeding at a rate that would be expected in the absence of continued oil toxicity or food limitations related to the effects of oil.

To assess whether recovery is proceeding as quickly as possible, considering no oil related limits to population growth rates, we will measure demographic factors of vertebrate predators and determine whether population growth rates and demographic parameters are consistent with models predicting growth rates in the absence of oil or food limitation effects. Studies of demographic factors also may provide insight into mechanisms of constraints on recovery, and to possible linkages between a lack of recovery and impacts of oil toxicity or food limitation. As an example, poor survival of pigeon guillemot chicks at oiled sites, coupled with a lack of preferred food items being brought to the nest at these sites, and a limited supply of these food items in oiled foraging areas would lend strong support to the hypothesis that food is limiting to pigeon guillemot recovery.

Demographic parameters to be measured will differ among nearshore vertebrate predators due to logistic and ecological considerations. For example, reproductive success can be effectively assessed only for sea otters and pigeon guillemots. However, overwinter survivorship is an appropriate measure of population health for harlequin ducks, because survival is thought to have a greater influence on population growth than annual reproductive success (Goudie et al. 1994) and numbers of harlequin ducks increase substantially in PWS during winter.

1.4.2.2 Population Health

Health of predator populations and the related issue of continued oil exposure will be assessed using a variety of measurements. These will allow for an assessment of the status of recovery of injured populations that is independent of measures of recovery based on population abundance or demographic data. This independent assessment of recovery may also provide a view of potential for recovery and long term population health that can not be evaluated by abundance or demographic characteristics. Measurements to be collected include assays of immune function, conventional hematology, cytochrome P450 levels (an enzyme indicative of continuing exposure to aromatic hydrocarbons), hydrocarbons, body condition and morphometrics.

Focusing on biological responses overcomes many limitations that plague chemical analysis of the environment (Payne et al. 1987). Measurement of tissue hydrocarbon burdens has been an important aspect of previous oil spill studies on top predators. However, potential advantages of measuring biomarkers include: (1) they may provide evidence of exposure to compounds that do not bioaccumulate or are rapidly metabolized; (2) they integrate the toxicological interactions resulting from exposure to complex mixtures of contaminants; (3) they present a biologically relevant measure of the cumulative adverse effect; and (4) they measure early responses of organisms to toxicant exposure and serve as short-term predictors of long-term adverse effects.

Over the past decade, the immune system has been increasingly investigated as a target organ system for assaying toxic damage (Luster et al. 1988, 1992). The immune system is an active and complex process dependent on the interaction of a diverse group of cell types and soluble factors orchestrated into a functional response. These inherently active and complex processes make the immune system especially sensitive and susceptible to toxic damage. Toxicity may occur either as a direct effect on immune function or as an indirect effect through an aberrant or abnormal immune response in the form of a hypersensitivity or allergic reaction. In those instances in which the immune response is a direct target, the result is most often expressed as an increased susceptibility to infections. Additionally, the direct effect also may be expressed as an autoimmune disease or neoplasia.

General methods to evaluate the mammalian immune system have been established and are available for most species. Assays are typically divided into those that evaluate the overall function of the immune system and those that evaluate specific components of the immune system (Luster et al. 1988). To document an effect on the immune system, the initial focus is on tests to detect gross effects. Tests in this category include: (1) conventional hematology; (2) serum immunoglobulin quantitation; and (3) in vitro lymphocyte proliferation assays. Most immune abnormalities are characterized as a suppressed response, although in some instances a hyper-response may be noted. Based on the results obtained in screening tests for gross effects on the immune system, specific functional tests can be performed to determine the exact parameter (organ system, cell or soluble factor) that is responsible for the noted abnormal response. A number of these specific tests have been adapted to or are being validated for the species we propose to evaluate, and could be utilized if warranted based on initial results of overall immune function tests.

The cytochrome P450 assays directly address the question of continued exposure to oil. Cytochromes P450 are a group of enzymes that metabolize a wide variety of endogenous and xenobiotic compounds (Appendix 6.2). One subgroup of these enzymes, the P450-1A family, is specifically induced by planar aromatic or chlorinated hydrocarbons, and thus its presence serves as a bioindicator of hydrocarbon exposure. While we can assess the exposure of predators to oil directly by measuring hydrocarbon levels in prey, the use of biomarkers may provide a more sensitive indicator to exposure via oil-contaminated prey, as well as indicating exposure via other routes (e.g., ingestion from grooming oiled pelage). Hydrocarbon levels in prey species are highly variable in time and space, and estimation of hydrocarbon levels in a small sample of available prey may not reflect true levels of exposure. In addition, vertebrate predators quickly metabolize hydrocarbons so that it may not be practical to measure exposure by measuring hydrocarbons in the predators' tissues.

Tissue samples from harlequin ducks collected in oiled and unoiled areas of PWS in 1993 showed differences in levels of P450 induction (R. Spies, pers. comm.). We will apply P450-1A assays to tissue samples collected from the four predator species, and in selected fish species that are prey to both pigeon guillemots and river otters. An additional measure of oil contamination, through ELISA assay for external oil on pelage or plumage (J. Mazet, pers. comm.), will be evaluated.

Body composition provides another assessment of health, as poor body condition may result in depression of population growth rates through affects on survival or reproductive effort. Exposure to contaminants can result in poorer body condition (e.g., Peakall et al. 1980, Hohman et al. 1990) and, even if immediate effects are not lethal, cause a reduction in subsequent rates of survival and reproductive success. Thus, we will examine variation in body composition as measures of the health of harlequin duck and pigeon guillemot populations.

1.4.2.3 Evaluation of Food Availability

The hypothesis that food availability may be limiting recovery of nearshore vertebrate predators will be addressed primarily by examining abundance of major prey items in oiled and unoiled areas. As indicated previously, there is strong evidence to suggest that at least some prey species may be less abundant at oiled sites. These include mussels, limpets, and littorines (Houghton et al. 1993b,d, Highsmith et al. 1993) which are food for both sea otters and harlequin ducks (Calkins 1978, VanBlaricom 1987, 1988, Patten 1994). Two favored foods of sea otters are *Protothaca staminea* and *Saxidomus giganteus* (Calkins 1978, VanBlaricom 1987, 1988). Houghton et al. (1993b,d) found fewer *P. staminea* at oiled and high-pressure hot water washed sites than at control and oiled sites; Jewett et al. (1994) found fewer *S. giganteus* at oiled sites. Evidence for an adverse effect of oil on fish species is less compelling although possible reductions in gunnels, a prey of both river otters and pigeon guillemots, have occurred within some oiled habitats.

Evaluation of abundance and size distribution data for prey items also will be useful for providing additional indirect evidence for a lack of recovery of some predator species. For example, it is well documented that sea otters prefer sea urchins as prey and that in the presence of strong predation by sea otters, both the abundance and average size of sea urchins is reduced (Figure 4).

However, evidence of lack of recovery of predators based on differences in abundance and/or size of prey may be confounded by several factors. First, many of the prey species serve as food for more than one predator. For example, mussels are prey of sea otters as well as sea ducks and sea stars (*Pycnopodia helianthoides* and *Evasterias troschelii*), and mussel size class distributions overlap in all of their diets. Second, differences in abundance of prey among sites may be due to differences in either recruitment or growth of prey, as well as predation. To account for these factors, it will be important to assess the relative impact of various predators on prey items, and to assess both recruitment and growth of the prey at the oiled and unoiled sites.

While not the primary focus of our efforts here, information obtained in assessing food limitation of nearshore vertebrate predators also will shed light on the question of "what structures nearshore benthic invertebrate communities?". While competition for space, rather than for food, broadly limits sessile filter-feeding invertebrates (Branch 1984), evidence has accumulated suggesting that predation frequently surpasses competition in structuring marine intertidal and shallow subtidal invertebrate communities (O'Clair and Zimmerman 1987). For example, the invertebrate predatory sea star has been the focus of considerable study as a structuring agent (Menge 1982, Paine et al. 1985; see review in O'Clair and Zimmerman 1987). Similarly, the vertebrate sea otter is also well documented as a force in structuring the organization of the nearshore benthic community (see review in O'Clair and Zimmerman 1987). For example, Estes and Palmisano (1974) compared the nearshore communities between areas with and without sea otters and focused on the preferred prey of sea otters, the sea urchin (*Strongylocentrotus*). Sea urchins, themselves, can cause large-scale kelp bed destruction (VanBlaricom and Estes 1988). In the presence of sea otters, Estes and Palmisano (1974) and Palmisano and Estes (1977) found urchins (a preferred prey item) were reduced and smaller (Figure 4). This reduced urchin biomass was accompanied by extensive kelp beds; mussels, barnacles, limpets and other invertebrates were reduced and ichthyofauna increased in abundance. Alternatively, in the absence of sea otters, they found larger and more abundant sea urchin populations, reduced kelp beds and more abundant mussels.

Other predators, such as sea ducks, also may structure invertebrate populations, although there are fewer data addressing this than for sea otters. For example, Bourne (1984) estimated that a flock of 200 scoters could consume 5.3 to 15.9 tons of clams during winter, and Faldborg et al. (1994) suggested that sea ducks were responsible for a dramatic decline in intertidal mussel populations in Denmark. Given the high number of sea ducks in PWS (Agler et al. 1994) and their reliance on benthic invertebrate prey, it seems likely that they may be having important effects on prey community structure.

2.0 Project Descriptions

2.1 Objectives - General

General objectives of the study are stated as follows:

A. Determine status of recovery of injured populations of nearshore vertebrate predators.

A.a. Determine if there are differences in abundance or indices to abundance between oiled and unoiled areas.

A.b. Determine if there are differences between oiled and unoiled areas with respect to demographic characteristics of nearshore vertebrate predator populations.

A.c. Determine if there are differences between oiled and unoiled sites with respect to measures of health of nearshore vertebrate predator populations.

A.d. Determine if there are differences in abundance or size distribution of prey between oiled and unoiled sites.

B. Determine if recovery of nearshore vertebrate predators is constrained by demographic factors unrelated to oil toxicity or food supply.

C. Determine if recovery of nearshore vertebrate predators is constrained by continued oil toxicity.

C.a. Determine if there are differences between oiled and unoiled sites with respect to bioindicators of exposure to oil in nearshore vertebrate predators.

C.b. Determine if bioindicators of exposure to oil differ between prey collected from oil and unoiled sites.

C.c. Determine if hydrocarbon levels in prey species differ between oiled and unoiled sites.

D. Determine if recovery of nearshore vertebrate predators is constrained by food availability.

We will address all major objectives for each of the 4 predators selected for study. Methods are detailed in sections 2.3 to 2.8.

2.2 General Study Design, Methods and Study Areas

The generalized study design calls for comparing predator abundance, demographic measures, health, indicators of oil exposure, and prey abundance within a selected oiled area and a selected unoiled area (Table 3). We are constrained to using selected areas, rather than a random sample of all potential oiled and unoiled areas for several reasons. First, the mobility of nearshore vertebrate predators makes it difficult to clearly define subpopulations of these species within PWS. For example, sea otters can range up to 40 km, making it difficult to select clearly defined replicate "oiled" subpopulations. Second, habitats within PWS are extremely diverse, making it difficult to segregate effects of oiling from other environmental factors, especially in cases where habitats in oiled and unoiled areas are clearly different. For example, it would be difficult to examine the effects of availability of sea urchins on sea otter abundance by comparing sea urchin density in the oiled area around Knight Island with an unoiled area from the extreme western portion of PWS because of potentially significant differences in exposure, oceanography, and geomorphology. The extreme western portion is heavily influenced by glacial runoff, and the resulting low salinity in this region likely would preclude establishment of sea urchins even in the absence of otters. Third, the areas representing the total of all oiled and unoiled areas are extremely large, and it would be impossible to effectively sample from the entirety of these areas given reasonable monetary constraints.

In using selected sites, we are restricted to making statistical inferences to these sites only, and not to the oiled and unoiled areas as a whole. Extrapolation of results to the broader oiled and unoiled parts of the sound will therefore rely on "best professional judgement". However, given the alternative of what would assuredly be an unworkable experimental design, we feel this is the only reasonable approach.

Study sites will be within generalized "oiled" and "unoiled" areas. The oiled area is identified as the Naked Island-Northern Knight Island group (Figure 5). Oiling was heaviest here, and population levels of sea otters were much lower here than at unoiled sites in PWS (Table 4). Harlequin duck densities also appear to be lower in this area. The unoiled sites will be along the northwestern shore of Montague Island (for sea otters and harlequin ducks) and around Jackpot Island (for river otters and pigeon guillemots). The unoiled sites are on the periphery of oiled areas.

More specific study locations will be selected from within each generalized area. For sea otters and harlequin ducks, we will focus on an oiled area on Naked and Northern Knight Island (area N, Figure 5) and an unoiled area on Montague Island (area M, Figure 5). These represent areas where we have estimates of population density for both harlequin ducks and sea otters, and are areas representative of foraging grounds for oiled and unoiled subpopulations of sea otters and harlequin ducks within the Sound.

The selected oiled area for sea otter and harlequin duck studies is composed of two, non-contiguous sites: one in Herring Bay and the other in Bay of Isles. We have chosen these two sites, rather than one contiguous site on either the eastern or western sides of Knight Island for several reasons. First, studies of sea otter abundance suggest that most sea otters occur within these bays rather than on more exposed coasts outside of the bays. Second, by including both bays, we believe that the extent of different intertidal and subtidal habitats will be comparable among oiled and unoiled areas. Soft sediment habitats are extensive at the Montague site, but relatively rare in oiled areas. Areas outside of the bays on Knight Island are generally sharply sloping rock faces, habitats not well represented on Montague. By restricting sampling to one contiguous oiled site, we suspect that available habitat for sampling of some otter prey, especially soft-sediment dwelling clams, would be severely limited. Finally, inclusion of the Herring Bay and Bay of Isles sites will provide a strong historical data base on the populations of both predators and prey. These are among the most extensively studied oiled sites within PWS.

For pigeon guillemots, selected study locations include approximately 10 km of shoreline which are feeding grounds for the birds. These are within a 4 km radius of two known areas of nesting for pigeon guillemots: one is an oiled area on Naked Island, and the other is an unoiled site near Jackpot Island (Area J, Figure 5).

For river otters, the selected study locations include an approximately 25 km section of shoreline in Herring Bay (oiled) and a 25 km section of shoreline near Jackpot Bay (unoiled). These both represent reasonable river otter habitat areas with old growth forest to the water's edge. The Herring Bay site was selected because there are historical data here for otters (Bowyer et al. 1994, Testa et al. 1994).

We have selected sites to maximize sampling efficiency from a logistical perspective as much as possible. For example, sea otter and harlequin duck study sites overlap completely and oiled study sites for river otters overlap with a part of oiled study sites for sea otters and harlequin ducks. However, complete overlap was not possible because no one site had appropriate habitat for all predator species.

The following sections describe methods that are general to several of the sudy species (e.g. various health and oil exposure methods, and habitat characterizations) as well as species specific methodologies. Detailed standard operating procedures are on file and available upon request.

2.3 General Methods for Determining Health and Exposure to Oil

2.3.1 Rationale

As indicated in section 1.4.2.2, we will examine a common suite of biomarkers for each of the nearshore vertebrate predator species to determine the health and oil exposure of oiled and unoiled populations. Health will be evaluated through hematology and immune function assays as well as morphometrics (weights, lengths, etc.) and, for harlequin ducks and pigeon guillemots, body composition measurements. Oil exposure will be evaluated by measurements of cytochrome P450-1A's, enzymes that are specific indicators of exposure to aromatic hydrocarbons (Appendix 6.2). P450 assays will be done for the four predator species and on vertebrate prey (selected fish species). Additional tests of oil exposure will include ELISA assay of pelage or plumage swabs and, if warranted based on outcome of P450 assays, analysis of hydrocarbon levels in tissue samples. A list of the assays to be performed, laboratory or location of the work, and candidate species are given in Table 5.

General methods for assessing health and oil exposure are presented below. Methods specific to each species will be addressed in sections 2.5 to 2.8.

2.3.2 Methods

2.3.2.1 Collection of Blood Samples

Samples will be collected at capture from sea and river otters (30 ml) by standard jugular venipuncture techniques, and from pigeon guillemots (1 ml) and harlequin ducks (2 ml) by brachial or jugular venipuncture. Blood volumes collected on sea and river otters will be sufficient to conduct conventional hematology, immune function and cytochrome P450 assays. For harlequin ducks and pigeon guillemots, because blood volumes will be limiting, the primary focus will be on conventional hematology.

Because Barrow's goldeneyes and white-winged scoters will be collected, primarily for assessments of sea duck predation pressure on bivalves (section 2.5.2.8), we also will be able to compare of bioindicators of health and exposure across study sites for these species. Tissue samples and blood will be taken immediately upon collection.

2.3.2.2 Conventional Hematology

For the CBC's (complete blood cell counts), WBC's (white blood cell counts) and serum chemistries, one EDTA tube, one serum tube and two blood smears from each animal will be prepared in the field. The EDTA sample, a portion of the serum and one blood smear will be sent to Corning Clinical Laboratories for the sea and river otter samples, and to a laboratory specializing in avian hematology for the bird samples. The remaining blood smear is to be sent to Purdue University. The remaining serum will be divided into aliquots for UAF and Purdue and frozen.

At UAF, agarose gel electrophoresis of total serum proteins will be performed as described by the manufacturer using a high resolution electrophoresis kit (Helena Laboratories, Beaumont, Texas, USA). Electrophoresis will be used to resolve the protein pattern into multiple zones. Two microliters of serum will be applied to the agarose gel, which will be subjected to electrophoresis in a cooled chamber at 100 volts for 1 hr. The agarose gels will be stained with Coomassie blue and individual zones will be quantified using a Beckman Model R-112 densitometer (Beckman, Palo Alto, California, USA) (Jeppson et al. 1979; Tilley et al. 1989). Serum protein levels will be determined using the Bio-Rad protein assay with bovine serum albumin as a standard (Bradford 1976).

Haptoglobins in serum will also be measured at UAF. Haptoglobins (Hp) are alpha glycoproteins that stoichiometrically bind free hemoglobin (Hb) in a haptoglobin-hemoglobin complex (Gordan and Koj 1985). Excess hemoglobin will be added to the serum sample in a 1 part of a 10% hemoglobin suspension to 20 parts of undiluted serum, and allowed to mix for 5 min. Two microliters of the sample mixture are then electrophoresed on agarose gels at 100 volts for 1 hr. After fixing the protein complex with 7.5% trichloroacetic acid, gels will be stained for hemoglobin using o-dianisidine, as described by the manufacturer (Helena Laboratories Technical Bulletin Number 5445). The Hp-Hb complex, which migrates in a different region from hemoglobin, is quantified by densitometry and results are expressed as mg of hemoglobin binding capacity per 100 ml of serum as described by the manufacturer (Helena Laboratories Technical Bulletin Number 5445; Valeri et al. 1965).

Samples for IL-6 will be analyzed at UAF using an immunochemical assay (Quantakine ELISA). Samples will be run in duplicate on a microtiter plate coated with a monoclonal antibody for IL-6. After washing away any unbound protein, an enzyme-linked polyclonal antibody for IL-6 will be used to detect IL-6 levels.

At Purdue, the serum samples from sea and river otters will be batch tested for serum electrophoresis (SEP) and immunoglobulin quantitation using standard methodologies. Serum protein electrophoresis offers information on relative protein distribution and allows for the calculation of absolute values (Melvin 1987). Many disease states may alter the electrophoretic pattern (Turnwald 1989). Acute phase, complement, immunoglobulin and coagulation proteins can all be assayed using SEP.

2.3.2.3 Immune Function Assays

From sea and river otters, a total of 20 ml of blood collected with 40U of preservative-free heparin/ml as the anticoagulant will be used to isolate buffy coat leukocytes. Blood samples will be processed using a technique modified from Truax et. al. (1993) on cryopreservation of buffy coat cells. Briefly, the blood will be centrifuged (800 xg, 20 minutes) to separate the sample into plasma, buffy coat, and RBC layers. Two ml of plasma will be removed from each sample and placed into a sterile tube. The remaining plasma will be removed, alliquoted and frozen for additional analyses. The buffy coat layer will be removed and resuspended in 2 ml of autologous plasma. Dimethylsulfoxide (DMSO) will be added to the cell suspension to a final concentration of 10% (v/v). The cell suspension will be divided equally into two cryovials. The cell suspensions will be kept on ice for 1 hour then transferred to a freezer overnight, and stored in liquid nitrogen until needed.

Frozen cells for analysis will be thawed rapidly in a 37°C water bath and immediately placed on ice. The sample will then be transferred to a 15 ml centrifuge tube and diluted to 10 ml with Hank's balanced salt solution (HBSS) containing 40 U of heparin/ml. The sample will then be layered over 4 ml of a ficoll gradient and centrifuged at 1600 x g for 30 minutes. The cells at the interface will be collected and washed 3 times in HBSS. Following the final wash the cells will be resuspended in RPMI 1640 medium supplemented with 10% (v/v) fetal clone, 2 mM L-glutamine, 25 mM 2-mercaptoethanol and antibiotics. Enumeration and viability will be assessed using trypan blue dye-exclusion. Lymphocyte proliferation assays will be performed using the mitogens PHA, Con A and PWM in 5 day cultures. All assays will be done in triplicate. Proliferation will be assayed by adding tritiated thymidine to the cultures at 16 hours prior to harvesting. Results will be recorded as counts per minute (cpm). Control wells will contain medium only.

2.3.2.4 Cytochrome P450 Assays

Three approaches will be taken to evaluate cytochrome P450 levels:

1) Immunohistochemistry (J. Stegeman, Wood's Hole Oceanographic Institution):

The induction of cytochrome P4501A (CYP1A) in tissues of the predator species will be evaluated by immunohistochemistry. Candidate tissues to be used include skin punches from flipper of sea otters and from ear of river otters; liver from sea ducks (sample at collection of Barrow's goldeneyes and white-winged Scoters; biopsy at surgery from Harlequins); foot web biopsy from captured harlequin ducks and pigeon guillemots; and liver from demersal fishes (sample at collection). Tissue samples will be preserved in 10% neutral buffered formalin immediately after collection and will be shipped to Wood's Hole Oceanographic Institute for analysis. Background information on CYP1A as a marker of hydrocarbon exposure and detail on the immunohistochemistry methods are presented in Appendix 6.2.

2) Immunochemical using Western Blotting (L. Duffy, UAF):

Western blotting is the process of immobilizing proteins on a solid membrane support (following a gel electrophoresis separation stage) and analyzing them using immunodetection. The blotting procedure reproduces the relative spatial arrangement of the proteins in the initial electrophoretogram. The immunodetection technique offers specificity through the use of an antibody specific for the blotted proteins.

Following blotting the membrane is treated with a blocking reagent to prevent nonspecific binding of the immunodetection reagents to the blotting membrane. The immunodetection procedure for otters utilizes an anti-rat cytochrome P450 IA1 (primary) antibody raised in rabbit which binds specifically to the immobilized cytochrome P450 IA1 isoenzyme. This antibody is also expected to work for birds. Validation of this is currently underway. The membrane is then detected with an anti-rabbit Ig-biotinylated species-specific (secondary) antibody. This in turn is detected with a streptavidin-horseradish peroxidase (HRP) conjugate which binds to the biotinylated secondary antibody and the molecular weight protein markers. After each incubation stage, any unbound antibodies or striptavidin-HRP conjugate are removed by washing with Tris buffered saline-Tween™20 solution. Detection using ECL detection reagents utilizes the bound horseradish peroxidase to catalyze the oxidation of luminol, in the presence of hydrogen peroxide (H_2O_2) and an enhancer. Following oxidation, the luminol is in an excited state which decays to the ground state via a light emitting pathway. This method has been validated for mammal liver samples. Currently, skin and foot pad biopsy samples are being evaluated.

3) Quantitative RT-PCR to measure cytochrome P450 (P.W. Snyder, Purdue University):

The purpose of this study is to use an established method (quantitative polymerase chain reaction) to measure cytochrome P450 expression in peripheral blood lymphocytes. The expression of genes encoding xenobiotic enzymes have been used as endpoints for investigating potential biomarkers for compounds that are known to activate the enzymes in question. In reference to hydrocarbons, induction of the cytochrome P450 isoenzymes is known to occur and thus support the idea that these enzymes may be biological markers of exposure. The lymphocytes will be isolated from blood samples drawn from animals captured from oiled and non-oiled sites. The method to be used will be adapted from the published method (Vanden Heuvel et al. 1993). Advantages of this technique are: (1) the use of peripheral blood samples for analysis; (2) the small sample size required for detection and (3) increased sensitivity as compared to other methods. Total RNA will be extracted from isolated peripheral blood lymphocytes and a reverse transcriptase-polymerase chain reaction (RT-PCR) assay will be used to quantify cytochrome P450 levels.

2.3.2.5 Hydrocarbon Analyses

Due to negative results from past studies on hydrocarbon contamination of clams (Doroff and Bodkin 1994) and sea otter tissues (Ballachey and Mulcahy 1993), we do not plan to assay for hydrocarbon levels *unless* other indicators of oil contamination (P450 assays) demonstrate continued exposure to hydrocarbons. However, we will collect and archive tissue samples from sea ducks and prey species (both demersal fishes and invertebrate prey) in the event that later analyses are warranted.

2.3.2.6 Assays of External Oil

Personnel at the CA Dept. of Fish and Game have recently adapted an ELISA assay to detect oil contamination of pelage under field conditions (J. Mazet, CDF&G, pers. comm). Controlled tests of the procedure show sensitivities in the range of less than or equal to .7 parts per million. To sample the pelage (or plumage), a 4x4 guaze swab is saturated with isopropanol and applied to the fur for 15 seconds. These swabs can then be assayed immediately (ELISA field kit) or frozen for later analysis. We intend to sample pelage or plumage of all captured sea otters, river otters, harlequin ducks and adult pigeon guillemots; however, ELISA analyses will be limited to a subset of the collected samples. If initial ELISA results are positive for contamination, or if the P450 assays indicate continuing hydrocarbon contamination, the remaining samples can be tested to evaluate external contamination as a route of oil exposure.

2.3.2.7 Body Composition

Body composition of pigeon guillemot fledglings and molting harlequin ducks will be used to assess population health in oiled and unoiled sites in PWS. Body composition can be measured directly, by collection and proximate analysis of the carcasses (Esler and Grand 1994), or it can be predicted using models that serve to index condition, once those models have been created based on collected individuals. We will use a number of methods to assess body composition for this study. Specific details are outlined in sections 2.6 and 2.7.

Body composition of pigeon guillemots and harlequin ducks will be estimated using nondestructive condition indices that incorporate body mass, morphometrics, and measures of total body electrical conductivity (TOBEC; Walsberg 1988, Roby 1991). The TOBEC method relies on the major difference in conductivity between lipids and other body constituents to estimate total lean body mass (Pethig 1979; Van Loan and Mayclin 1987). The difference between total body mass, as determined by weighing, and lean body mass, estimated by TOBEC, provides an estimate of total body fat. A major advantage of the technique is that measurements can be obtained rapidly and repeatedly without harm to the subject. Also, validation studies to date indicate that the accuracy of the technique can be high ($r^2 = 0.996$) (Bracco et al. 1983, Walsberg 1988, Roby 1991) if subjects are positioned consistently within the measurement chamber and plumage is dry. The TOBEC analyzer (SA-3000 Small Animal Body Composition Analyzer, EM-SCAN Inc., Springfield, IL) can be used in the field and powered from a 12 volt battery, so the subjects can be analyzed and released within a matter of minutes.

Although the TOBEC technique is nondestructive, it must be calibrated by sacrificing a sample of subjects of each species for proximate analysis of body composition. Collections for calibrations for pigeon guillemot fledglings will be conducted in Kachemak Bay during 1995, as part of a separate study. A sample of 25 harlequin ducks will be collected as part of this study (see section 2.6.2.3). Calibration curves for each species will be produced by regressing TOBEC value against lean body mass for the sample of subjects, and 95% confidence intervals for estimates of total body fat from TOBEC alone will be determined by the inverse regression procedure.

2.4 General Methods for Habitat Evaluation

2.4.1 Rationale

As part of studies of food availability, it will be necessary to estimate habitat type distribution within study sites. Habitats will be described by levels of exposure (either exposed or sheltered) and substrate type (rocky, boulders/cobble, gravel/sand/mud). These designations will be used in two ways. First, they will be used to direct sampling programs of prey species that are stratified by habitat type. In some cases, we know that some prey species occur only in specific habitats. For example, clams occur only where there are fine sediments (gravel/sand/mud). As a result, we need to know the distribution of these habitats so that we can randomly select sampling sites from appropriate habitats for clams within each area. Second, we will use habitat distribution data to determine abundance of prey items within each study area. Most studies of prey abundance will employ a stratified random sampling design, with stratification by tidal height (for intertidal prey species) or depth (for subtidal prey) as well as habitat type. Mean densities within each habitat type will be multiplied by the areal extent of each habitat type in order to determine the abundance of prey within each habitat. Total abundance within each area will be obtained by summing abundances from all habitats.

2.4.2 Methods

Distribution of habitat types within intertidal regions will be determined using a pre-existing Environmental Sensitivity Index GIS (Geographic Information System) database that lists geomorphological habitat types for shorelines throughout PWS (Gundlach et al. 1983). Shoreline types in this database will be verified by a visual census of all shorelines within our study areas conducted from a small boat. Shoreline type verification will be carried out in conjunction with side-scan-sonar surveys of subtidal habitats, described below.

There are no existing data on subtidal habitats, and it is impossible to determine subtidal habitat type from shoreline habitat data. Therefore, we will census all subtidal habitats within our study areas using side-scan sonar to define substrate types. The EG&G Model 260-TH system consists of a graphic recorder, digital processor and the dual frequency (100 & 390 kHz) shipboard selectable Model 272-TD sonar fish.

The sonar fish has two sets of linearly focused transducer arrays - one array on each side of the towed fish. Circuitry inside the towed fish energizes the transducers, causing them to project high intensity, high frequency bursts of acoustic energy at 100 (or 390) kHz in fan-shaped beams, narrow in the horizontal plane and wide in the vertical plane. These acoustic beams (sonar signals) project along the sea bed on both sides of the moving vessel. Objects, topographic features, and substrate changes on the sea bed reflect the signal back to the towed fish where it is received by the transducers, amplified, and sent up the tow cable to the graphic recorder on the ship.

The EG&G Model 260-TH digital thermal recorder produces a continuous permanent graphic record of the sea floor (analogous to a photograph) by electronically processing and then printing the information (line by line) to produce the sonar image of the sea floor. Signal synchronization is achieved by the recorder generating a trigger pulse and sending it to the towed fish and then waiting for the reflected signals. This system has a third channel that displays the depth of the water column beneath the towed fish that is used to digitally correct the image.

The range of the side-scan-sonar system can be selected from 12.5 meters up to 700 meters on each side of the ship. A 100 meter range scale has been selected for the described mapping system, using 100 kHz transducers. This combination provides the best compromise between resolution and mapping efficiency. A typical recording, with descriptive titles, is shown in Figure 6.

Mapping precision depends on the accuracy of vessel positioning during a survey. Accurate positioning will be provided using a differential Global Positioning System (GPS) interfaced with a navigation computer. The navigation computer provides a permanent record of the ranges, line and shot number updating, real time, and other related features. Data are stored on the computer hard drive and printed on paper and downloaded on 3.5" disk for backup. The actual path of the boat, or "vessel track" is later post-plotted from the date stored on the floppy disk by using a 36" X-Y plotter.

A single boat track will be run along the shore, with the boat positioned along the 4-10 m depth contour. The depth range covered by the sonar record will depend in part on the slope on the seabed at each location. However, it is anticipated that coverage of the sea floor will generally extend from depths of 12 m to the intertidal zone (0 m).There are no existing data on subtidal habitats, and it is impossible to determine subtidal habitat type from shoreline habitat data. Therefore, we will census all subtidal habitats within our study areas using side-scan-sonar to define substrate types. The side scan sonar system consists of a graphic recorder, digital processor and towed sonar fish. The sonar fish has two sets of linearly focused transducers - one set on each side of the towed fish. Circuitry inside the towed fish energizes the transducers, causing them to project high intensity, high frequency bursts of acoustic energy at 100 kHz in fan-shaped beams, narrow in the horizontal plane and wide in the vertical plane. These sound beams (sonar signals) project along the sea bed on both sides of the moving vessel. Objects, topographic features, and substrate changes on the sea bed reflect the signal back to the towed fish where it is received by the transducers, amplified, and sent up the tow cable to the graphic recorder on the ship.

The digital graphic recorder produces a continuous permanent graphic record of the sea floor by electronically processing and then printing the information (line by line) to produce the sonar image, as well as data from the water column. Signal synchronization is achieved by the recorder generating a trigger pulse and sending it to the towed fish and then waiting for the reflected signals.

Printing is accomplished by a high speed thermal printer in which each individual dot is digitally interpreted in order to produce 16 distinct gray shades on 43.2 cm (17.0") wide graphic recorder paper.

A single boat track will be run along the shoreline, with the boat positioned along the 6 m depth contour. The depth range covered by the sonar record will depend in part on the slope of the seabed at each location. However, it is anticipated that coverage of the sea floor will generally extend from depths of 12 m to the intertidal zone (0 m).

2.5 Specific Methods for Sea Otters

2.5.1 Rationale

2.5.1.1 Demographic Measures

Abundance of sea otters in area N (Figure 5) was less than 50% of pre-spill estimates in 1994 (Table 4). An aerial survey methodology recently developed by the National Biological Service and the U.S. Fish and Wildlife Service provides unbiased estimates with improved precision. The 1994 survey estimated 9,092 (se=1,422) sea otters in all of PWS excluding Orca Inlet. However, the point estimate for area N, because sea otters are relatively rare, is based on a small sample size and lacks precision. We propose to conduct an aerial survey of western PWS in July 1995. Available data on sea otter abundance are restricted to summer months and seasonal estimates in distribution are necessary to confirm the observed pattern of limited recovery throughout the year. The purpose of these surveys is to provide data on the seasonal distribution of sea otters in area N (including surrounding areas) with the objective of describing future change.

Skiff surveys along shoreline transects will be conducted in order to estimate the proportion of independent to dependent sea otters in a population. Reproductive rates are key variables in defining the rate of change in large mammal populations. Previous studies were unable to detect differences in the ratios of independent to dependent sea otters between oiled and unoiled areas of PWS (Bodkin and Udevitz 1991). However, their treatment area included portions of the spill area where there is little evidence of lack of recovery (lightly oiled as well as heavily oiled areas). We propose to limit our treatment (oiled area) to area N, where surveys suggest recovery is not occurring.

2.5.1.2 Health Measures and P450 Induction

Specific concerns over the health of sea otters in oiled areas persist due to differences between oiled and unoiled areas in juvenile survival and blood parameters. Survival rates of juvenile sea otters in western PWS were significantly lower than in non-oiled areas in both 1990-91 and 1992-93 (Rotterman and Monnett 1991; NBS unpublished data); however, survival rates for both areas were improved in 1992-93 compared to 1990-91. Pup weights at capture tended to be lower in oiled areas. In 1992 (and in previous post-spill collections), levels of blood serum enzymes indicative of liver disorders (ALT, GGT), and white cell counts (basophils, eosinophils) were elevated in both adult and juvenile sea otters, suggesting chronic or recurrent infections perhaps related to continued oil exposure. The increased levels of serum enzymes are consistent with changes observed in oiled otters exhibiting kidney and liver pathologies at the rehabilitation centers. No further blood samples have been collected since 1992. Sea otter studies proposed in the NVP project will evaluate animal condition (weights, lengths) and health (blood and immune measures). The inclusion of the P450 assays in the NVP will allow us to directly address the question of continuing exposure to oil as a factor in differences observed between sea otters oiled and unoiled areas.

2.5.1.3 Prey Availability

As identified in the introduction (section 1.4.2.3), sea otters have a well documented structuring effect on many of the nearshore marine invertebrates on which they prey. It is under this premise that we have developed one of the three principal avenues for evaluating those processes that are constraining recovery of nearshore vertebrate predators, in this case the sea otter. Based on previous food habits data from PWS, clams, mussels, and crabs are predominate prey items, comprising up to about 95% of the sea otters diet (Estes et al. 1981, Garshelis 1983, Johnson 1987, Doroff and Bodkin 1994). Additionally, observations by marine ecologists (Jewett et al. 1994) studying effects of the spill have identified increasing numbers of green sea urchins in at least one portion of northern Knight Island. Sea urchins are a favored prey of sea otters elsewhere. For these reasons we have selected clams, mussels, crabs, and urchins as potential measures of the effects of reduced sea otter predation on their prey, and thereby an indirect measure of the status of the sea otter population. However, other prey can be important in the diets of sea otters in PWS. These include the Dungeness (*Cancer magister*) and helmet crab (*Telmessus cheiragonus*) which may comprise up to 20% of the sea otter's diet. In addition, a wide array of other invertebrates are utilized by sea otters and are potentially valuable components of their diet, as well as potential indicators of predation pressure. These include snails, limpets, octopus, and sea cucumbers. The purpose of the estimation of sea otter diets is to validate findings of the invertebrate studies and to provide estimates of the relative importance of other prey items, which also may be indicative of community level changes in the nearshore ecosystem. Large changes in species composition of sea otter prey, either over time or between areas, may suggest potential mechanisms constraining recovery, as well as provide indirect evidence of the status of recovery.

The availability of major prey items will be assessed by conducting stratified random sampling surveys of prey density within each area. In addition, diets of sea otters will be verified by foraging surveys that indicate the types and numbers of prey items taken within each study area. The availability of several prey items (clams, mussels, and sea urchins), also will be assessed by measuring the size distribution of prey in oiled and unoiled areas. It is well documented that sea otter predation often results in prey populations having fewer, smaller individuals (Figure 4). This pattern has been observed for a number of prey species in a number of different habitat types (VanBlaricom and Estes 1988).

Interpretation of prey abundance and size class distributions is generally described in Figure 7. In terms of abundance, fewer prey at oiled sites would suggest that the recovery of predators in oiled areas could be food limited. There are a number of possible outcomes with respect to the size distribution of prey items. However, there are only two that seem likely. The first is one in which only small individuals are represented in subpopulations at both oiled and unoiled areas, size distributions of otter prey being strongly skewed toward smaller size classes if larger prey are missing from unoiled areas, but not oiled areas. The second likely outcome is one in which only small individuals are present in unoiled areas, but both large and small individuals are present in oiled areas with few predators (Figure 7). This would suggest that food is not limiting recovery at the oiled site. This outcome would suggest that recovery may be limited by food, especially if the density of prey is lower at oiled sites.

The interpretation of the abundance and size distributions of prey items is potentially confounded by several factors including the growth rate of prey, the recruitment of prey, and predation by other organisms whose diets overlap those of sea otters (principally sea ducks and sea stars). This is illustrated in Figure 8. We envision the processes of recruitment and post-recruitment predation as filters which influence the supply of invertebrate prey populations to sea otters and sea ducks. By influencing both the number and size distribution of prey, the various filters influence significantly the supply of prey to top-level carnivores. Thus, an understanding of the characteristics of each filter will be necessary for understanding constraints on recovery of injured populations of sea otters, as well as sea ducks.

The first filter in our model represents the recruitment process. Recruitment in benthic invertebrate prey is known to be strikingly variable among years, among seasons within years, and among locations on a number of scales. Variation results from changes in reproductive success of invertebrates and from spatial and temporal differences in processes which affect the transport and survival of planktonic larvae. Thus, characteristics of the recruitment filter change over time and among locations. In some situations the filter will allow no juveniles to pass, effectively shutting off the supply of individuals that would ultimately serve the nutritional needs of predators. In other situations the filter will have a few "openings," allowing low rates of recruitment, and in still other cases the filter will be "wide open," allowing for major recruitment events and the appearance of a dominant cohort in the benthic population. An improved understanding of recruitment filter characteristics will allow determination of the extent to which recruitment processes influence food supply to sea otters and sea ducks, thus affecting their status with regard to recovery from EVOS injury.

The other three filters in the model represent predation by invertebrate predators, sea ducks, and sea otters, respectively. Although we have displayed these filters sequentially for purposes of illustration, we suggest that they operate with some overlap in both space and time. The invertebrate predator filter probably primarily affects individual prey at the low end of the size spectrum of prey useful to sea ducks and sea otters (e.g., Paul and Feder 1975) (see Figure 7). However, there likely will be some overlap in utilization among all predators, especially for mussels and urchins. In our view, the invertebrate predator filter is functionally similar to the recruitment filter, influencing the supply of prey to sea ducks and sea otters. Characteristics of the invertebrate predator filter will vary to some degree by season and location because of changes in metabolic needs of the predators, changes in prey availability as influenced by the recruitment filter and local differences in predator density.

Characteristics of the sea duck filter will vary by season and location. Populations of sea ducks are considerably higher during winter (Agler et al. 1994) and fidelity to wintering sites may exist (Limpert 1980). Variability in features of the sea otter filter should be less dramatic than for sea ducks, although the foraging patterns of sea otters clearly can change by season and year and among locations as a result of population growth, distributional shifts, reproductive status, and changes in the range of available prey.

Specific prey individuals pass through the recruitment filter only once in their lives. Thereafter, however, they may pass through predation filters repeatedly. Multiple exposures to particular filters can be envisioned as feedback loops in the filter diagram, leading a particular range of prey abundance and size to be continuously modified by the effects of various filters. We have not included feedback loops in the diagram to minimize clutter, but feedback and multiple filtration are important conceptual elements in our model.

Our studies will seek an understanding of the qualities and variability of each of the filters indicated in Figure 8. We will test hypotheses regarding filter behavior and measure the structure of prey populations in the field. At the same time we will integrate existing knowledge and hypotheses about the relationships of predation and prey population structure and dynamics, producing a range of expected prey population characteristics. Expected population patterns will reflect differing emphases on factors that could be constraining prey densities and size distributions. Comparison of field data with hypothetical population patterns will provide improved understanding of food-related factors that could constrain the recovery of sea otters and sea ducks.

2.5.2 Methods

2.5.2.1 Aerial Surveys of Sea Otter Abundance

The aerial sea otter survey methodology we will employ is fully described in appendix C. The survey design consists of two components: (1) strip transect counts and (2) intensive search units.

1) Strip Transect Counts

Sea otter habitat is sampled in two strata, high density and low density, distinguished by distance from shore and depth contour. Survey effort is allocated proportional to expected sea otter abundance by adjusting the systematic spacing of transects within each stratum.

Transects with a 400 meter strip width on one side of a fixed-wing aircraft are surveyed by a single observer. Transects are flown at an airspeed of 65 mph (29 m/sec) and an altitude of 300 feet (91 m). The observer searches forward as far as conditions allow and out 400 m, indicated by marks on the aircraft struts, and records otter group size and location on a transect map. A group is defined as one or more otters spaced less than three otter lengths apart. Observation conditions are noted for each transect and the pilot does not assist in sighting sea otters.

2) Intensive Search Units

Intensive search units (ISU's) are used to estimate the proportion of sea otters not detected on strip transect counts. For adequate statistical power in calculation of the correction factor, each observer needs to obtain a preset number of ISU's. To arrive at this goal in an unbiased manner, observers pace themselves so ISU's are evenly distributed throughout the survey area.

ISU's are flown at intervals dependant on sampling intensity, throughout the survey period. An ISU is initiated by the sighting of a group and is followed by five concentric circles flown within the 400 m strip perpendicular to the group which initiated the ISU. The pilot uses a stopwatch to time the minimum one minute spacing between consecutive ISU's and guide the circumference of each circle. ISU circle locations are drawn on the transect map and group size and behavior is recorded on a separate form for each ISU. Number observed on the strip count and number observed during the circle counts are recorded for each group.

2.5.2.2 Estimation of Annual Production of Sea Otters

Estimates of annual reproduction, as indicated by ratios of independent to dependent sea otters, and patterns of habitat use will be obtained from small boat surveys. Surveys will be conducted in July and August each year.

Sample units will correspond to coastline transects established by Irons et al. (1988) and will extend offshore out to the 100 m depth contour or 1/2 the distance to the opposing shoreline, whichever is less. A subset of sample units will be randomly selected to be surveyed in each of the study sites (M and N; Figure 5).

The survey vessel will maneuver about 200 to 300 m offshore, and out to the offshore boundary as necessary to observe and classify all otters within each selected sample unit. Boat speed will be maintained at less than 15 mph. Surveys will be conducted only when viewing conditions are considered good or better (calm to light winds, sea state less than Beaufort 2).

Surveys crews will consist of two observers, including the boat operator. Crews will use high resolution binoculars. Otters will be classified as either dependent or independent. Dependent otters will be defined as sea otters smaller than, and in close association with, an adult. This definition includes, but is not limited to, pups in close physical contact, nursing, receiving food from, swimming with or being groomed by an adult sea otter. Independents will be defined as all other sea otters. Crews will record the number of dependent and independent sea otters found in each sample unit.

Each sample unit will be classified by coastline physiography and bathymetry into one of six categories. Coastline physiography will be categorized as protected bay, open coast, or island. Bathymetry will be categorized as either shallow (less than 31 m deep for more than 50% of the sample unit's length, 200 to 300 m offshore) or deep (greater than 31 m deep for more than 50% of the sample unit length). Depth determinations will be based on navigational charts and fathometer readings taken during the survey.

Ratios of independent to dependent sea otters will be obtained for each stratum and for each habitat type by summing over all sample units within each stratum or habitat type. Proportions of dependent sea otters will be calculated for each transect. Kruskal-Wallis tests will be used to evaluate differences in proportions among areas.

2.5.2.3 Beach Surveys of Sea Otter Mortality

Patterns of sea otter mortality will be determined by estimating age class structure of sea otters dying in PWS. By searching beaches each spring, samples of sea otter skulls will be obtained. A premolar tooth will be extracted the age of the animal at death will be estimated. Data collected in western PWS in the 1970's described a small proportion of prime age (ages 2-9) sea otters dying each year. Following the EVOS, in years 1990 - 1992, the age structure of dying otters in western PWS consisted of more prime age otters than would normally be expected. This is one of the findings that suggested that injuries to sea otters resulted not only from immediate mortality, but resulted in longer term, chronic injuries to the population. Data from 1993 and 1994 suggest that mortality may be returning to pre-spill patterns in western PWS. The purpose of this component of the study is to continue collecting carcasses in western PWS on an annual basis as a measure of the status of sea otter populations relative to recovery.

Mortality patterns, based on age distributions of the dying portion of the population, will be evaluated through recovery of beach-cast sea otter carcasses in western PWS. Beaches in the Green Island area of western PWS, surveyed for carcasses in 1976-84 by Johnson (1987), and again in 1990-94 (Monson and Ballachey 1994), will be surveyed in 1996. In addition, a limited number of beaches on Knight, Naked, and Montague Islands will be surveyed in 1996. Beaches will be surveyed once during late April or early May after snow melt but prior to summer revegetation, which may hide carcasses washed high on the beach by winter storms.

Surveys will consist of crews of two people walking along selected beaches searching for carcasses between the water line and the storm tide line. At least one member of each crew will have experience in beach surveys from previous field seasons. Generally, the search effort will focus on the high tide line and the storm tide line where skeletal remains often are found, while the lower beach is scanned for fresh carcasses. Efforts will be made to check behind large beached logs and other objects which can easily trap carcasses as waves wash over them.

Data recorded for each carcass will include: (1) relative location of carcass on the beach, (2) relative condition and completeness of carcass, (3) position of remains relative to previous year's vegetation, (4) relative age (adult, subadult, pup), (5) sex, and (6) specimens collected (e.g., entire carcass, skull, baculum, none). Skulls (when present) will be taken from all carcasses and a tooth extracted for aging (Garshelis 1984). Any fresh carcasses collected will be necropsied as soon as possible and tissue samples collected for potential toxicology and histopathology studies.

Otters will be categorized in three age classes: 1) juvenile, ages 0 and 1, 2) prime, ages 2-8, and 3) older, ages 9 and above. The distribution of age classes of all recovered carcasses will be determined for each area (eastern PWS and western PWS), and compared with the distribution obtained in other post-spill collections (1990-92) and pre-spill collections (1976-84), using Fisher's Exact Test (2-tailed).

2.5.2.4 Indicators of Health and P450 Induction

Sea otters will be captured in the 1996 and 1997 summer field seasons, with 60 animals captured each year (30 each at Area N and Area M). Capture will be done with either tangle nets, hand-held dip nets or under-water diver-held traps, all methods which have been used routinely in previous capture efforts. Sea otters will be sedated with a combination of fentanyl and diazepam and will be reversed with naltrexone following collection of data and samples. Sea otters will be tagged with unique color/number coded polyethylene tags in their hind flippers, and a coded transponder chip will be implanted subcutaneously in the right groin area. Flipper tags are often lost, so the transponder chips provides a permanent identification in the event that the animal is recaptured or recovered. Both methods of tagging have been used routinely in previous studies of sea otters, without deleterious effects. Morphometric data collected will include age class, sex, length, weight, girth, canine width and baculum length (in males). Morphological characters will include head color and tooth wear. The mouth will be checked for oral lesions, and if observed they will be surgically biopsied and preserved in formalin. A premolar tooth will be removed for age estimation.

A blood sample of up to 30 cc will be collected by jugular venipuncture from each sea otter and processed as described in the general methods section; conventional hematology (2.3.2.2), immune function assays (2.3.2.3) and cytochrome P450 assays (2.3.2.4) will be done. A skin punch is removed from the webbing of the flipper when inserting the flipper tag; this punch will be preserved in formalin for P450 assays (section 2.3.2.4). While sedated, the pelage of the sea otter will be sampled for external oil contamination (section 2.3.2.6).

2.5.2.5 Sea Otter Foraging

Sea otter prey will be determined at both study sites. The primary method of data collection will be observational, following standard operating procedures (Appendix C). Observations will be made from shore with the aid of high resolution telescopes (Questar Corporation) and 10X binoculars. Data will be collected at both locations within a six week period during the months of June, July and August, beginning in 1996. Data recorded will include sex, age class of focal animal (adult or juvenile), number of prey and relative prey size (A: < 2 cm, B: ≥ 2 to < 4 cm, C: ≥ 4 cm to < 8 cm, D: ≥ 8 to < 12 cm, and E: ≥ 12 cm), dive time, surface time, success rate and prey item to lowest taxon. Prey size will be visually estimated based on a mean forepaw width in sea otters of 4.5cm. Repeated dives will be recorded for a focal animal until a maximum of 50 identifiable prey items are observed per individual or until the animal is lost or discontinues foraging. Focal animal selection, when more than one otter is feeding at an observation site, will be random. A minimum of 500 identifiable prey items will be recorded at each of the two selected geographic areas. An attempt will be made to distribute foraging observations from all vantage points within each study area. Compiled foraging data will be compared to the invertebrate data collected, particularly as it pertains to species composition and size class composition. Adult animals will be categorized as male, independent female or female with a pup. Juveniles will be identified as small dark-headed otters estimated to be less than 24 months of age. Dependent otters will be classified as such. Data will be collected only during daylight hours, during all tidal cycles. Tidal state will be recorded for all observation periods.

2.5.2.6 Availability of Subtidal Clams

We will determine abundance and size structure of existing subtidal clam populations in nearshore habitats of PWS. Taxa to be evaluated will include, but will not be limited to: *Saxidomus giganteus*, *Protothaca staminea*, *Tresus capax*, *Clinocardium* spp., *Mya* spp., *Macoma* spp., and *Serripes groenlandicus*.

Based on results of the sidescan sonar habitat survey, we will select the two most prominent unconsolidated substratum types as sample strata. Within each stratum in each study area (i.e., Montague Island and Knight Island; Figure 5) we will sample at two depths, 6 and 12 m, in five replicate sites chosen from within each of the defined strata. Site selection initially will be random, but arbitrary adjustments may be necessary to ensure that site environmental attributes (e.g., exposure, current velocity) are comparable among the two study areas. A complete sample set will consist of 2 study areas x 2 strata x 5 sites x 2 depths = 40 samples. We will collect complete sample sets during summer months of 1996 - 1998. During 1995 we will complete the sidescan sonar survey, identify the strata, and if possible gather preliminary samples. Preliminary sampling will be done to: (1) verify the effectiveness of sampling techniques, and (2) gather preliminary population data necessary for calculations of minimum acceptable sample sizes for studies of abundance and size distribution.

Individual samples will be gathered by scuba divers. A temporary 50 m transect line will be placed at a pre-determined sample site. Individual sample frames (0.25 m^2 surface area) will be placed at random locations along the line and at random distances (5 m maximum) from the line. Numbers of frames sampled will be determined on the basis of preliminary studies. For obvious clams within each frame, calibrated rods will be placed in siphon holes to determine depth of individual clams below the sediment surface. Each sample will include a small sediment core taken prior to suction for subsequent determination of grain size distribution and organic carbon content. Each frame will be cleared by suction to a depth of at least 50 cm. The depth will be adjusted as necessary, based on preliminary sampling and rod probing, to ensure collection of all large clams within the frame. Suction will be done with a venturi dredge, with output filtered through a bag with mesh of approximately 0.5 cm. Bags will be brought to the surface and live clams will be sorted by hand from debris. Clams will be sorted by species and measured (maximum shell length, to nearest mm) with machinist's Vernier calipers. Clam count and size data will be recorded on standardized pre-printed data sheets. Data will be archived according to the NVP data management plan.

Samples of sediment and tissues from the three most abundant clam species will be archived for possible future analyses for hydrocarbon residues (see also section 2.5.2.7). Two sediment samples of 50 g each will be collected near the first location for suction sampling for each site on each date of sampling. After appropriate measurements are recorded, two tissue samples of 50 g each will be taken, for each of the three most abundant clam species, from suction samples. all samples of sediment and clam tissue will be frozen in the field and transported to laboratory facilities of the National Biological Service, Anchorage, Alaska, for archiving. Should biochemical measures of health in sea otters indicate the presence of a source of hydrocarbon contamination, sediment and tissue samples will be sent for appropriate hydrocarbon analyses to the Auke Bay, Alaska, Laboratory of the National Marine Fisheries Service, national Oceanic and Atmospheric Administration.
Clam data will be analyzed by species to determine mean and variance of density and size per site. Based on results of tests for normal distribution, mean density and size will be compared among replicate sites within study areas, and between study areas, using an appropriate parametric or nonparametric analysis of variance. Clam size data also will be analyzed with an appropriate cohort analysis to determine interannual variation in recruitment intensity.

We will determine the rate and pattern of recruitment to natural substrata in study sites as indicated above. We will use small diver-deployed coring devices to sample for newly-settled clams. Cores will be approximately 0.01 - 0.02 m^2 in surface area, sampling to a depth of 10-20 cm. Exact protocols will not be established until completion and analyses of preliminary samples. Numbers of cores necessary to support statistically meaningful contrasts also will be calculated based on preliminary sampling. Preliminary samples will be collected in 1995. A. sample will consist of 2 study areas x 4 sites = 8 samples (see section 2.5.2.8).

Individual cores will be located in the same way as sampling frames for suction samples. Cores will be capped with fine mesh screening and inserted gently, by hand, to minimize loss of organisms due to surface disturbance. Once in place, cores will be contained and extracted, and carried to a surface vessel. Cored sediments will be gently washed through a screen (0.5 mm square mesh) with filtered seawater. Retained materials will be fixed, stained with Rose Bengal and preserved for laboratory sorting.

In the laboratory, stained samples will be sorted for juvenile clams and for empty shells of juvenile clams. Only empty shells that are clearly fresh and intact will be retained. Clams will be categorized to the lowest possible taxonomic level and counted. Counts will be the sum of live clams and intact empty shells (the latter divided by two to avoid double-counting of individual clams). Data will be recorded on standard data sheets and archived as indicated above. Density data by taxonomic category will be compared within and among study areas in a manner analogous to suction samples, described above. An appropriate time series technique will be employed to assess interannual differences in recruitment intensity.

We will examine correlations of recruitment intensity of clams with habitat and oceanographic variables assessed in other EVOS-related projects. Completion of this task will rely on cooperation of investigators working on oceanographic characteristics and planktonic ecology during the time period of our study. If, as we expect, our data suggest significant variations between year or between locations in recruitment intensity (as indexed by densities of newly-recruited clams as described above), we will search for covarying physical or biological water-column processes such as current pattern, density and temperature fields, or primary productivity that might explain observed variation. The emergence of significant covariation will suggest models for constraints on clam recruitment that may be linked to constraints on recovery of nearshore vertebrate predators.

2.5.2.7 Invertebrate Co-Predators

We will determine densities and diets of predatory invertebrates in nearshore habitats of PWS that may be important competitors of sea otters for food. Initial efforts will focus on sea stars (*Pycnopodia helianthoides* and *Evasterias troschelii*), crabs (*Telmessus cheiragonus* and *Cancer* spp.), and snails (*Nucella* spp.). Predatory species of interest may be added or deleted from the above list depending on the results of literature review and preliminary field work. Two study areas, Montague Island and Knight Island (Figure 5) will be utilized. Within each area this project will use the same study sites at the same depths as indicated for the subtidal clam assessments. Sampled transects will be placed in adjacent non-overlapping positions to ensure that sampling effort for one project will not be disruptive to the other. In addition, data will be gathered from intertidal soft-substratum sites in the vicinity of subtidal sites. To the maximum possible extent, intertidal sampling sites will be done in or near sites selected for the intertidal clam study. Thus a complete subtidal sample will consist of 2 study areas x 2 subtidal strata x 2 depths x 5 sites = 40 samples. A complete intertidal sample will consist of 2 study areas x 5 sites = 10 samples.

Subtidal invertebrate predator data will be collected during scuba dives. A temporary 50-m transect line will be placed on the bottom. The line will be divided into 10 m segments. Within each segment, a random point on the line will be chosen. A 10-m line will be extended perpendicularly from the random point in one of two randomly chosen directions. Invertebrate predator species within 1 m of either side of the 10-m line will be counted, measured, and examined for dietary information. Thus each 50-m transect will provide five separate random subsamples of 20 m^2 each. Sea stars and snails will be located by simple visual survey. Crab counting methods will be determined during preliminary field work. If visual survey is found to be ineffective, crabs will be flushed by dragging a rake with close-set tines through the sediment, then counted and collected (see below).

Sea star size will be indexed by measuring the distance from the center of the mouth to the tip of the longest ray. Crab size will be indexed by measuring the maximum carapace width.

Snail size will be indexed by measuring the maximum shell dimension. Data on transect counts, body size indices, and size of prey items (see below) will be recorded on standardized, pre-printed data sheets. All data for the entire study (all objectives) will be managed and archived according to NVP program protocols and procedures.

Diet will be determined by direct examination during dives for sea stars and snails. *Pycnopodia helianthoides* swallows prey whole, requiring manual probing of the stomach to extract and identify prey. *Evasterias troschelii* and snails process prey externally, thus prey items can be easily removed from the mouth area. Prey items will either be identified and measured (maximum shell dimension) during sampling dives, or returned to the surface for later examination. If preliminary work indicates insufficient diver bottom time to complete all sampling tasks, collected predators will be carried to the surface for processing, and later returned alive to the bottom. All crabs located in samples will be transported to the surface and later dissected to remove stomach contents. Because crabs typically crush hard-shelled prey during ingestion, laboratory examination of stomach contents will be necessary to identify and enumerate prey.

Intertidal density data will be gathered for sea stars and crabs by counting all predatory invertebrates within 1 m on either side of a 50-m line placed parallel to shore at the tidal datum. Counts will be recorded on preprinted data sheets in 1 x 10 m segments (n = 10 segments per transect). Snails will be counted by searching 0.25 m^2 frames placed along the 50-m line. The minimum number of frames necessary for an adequate sample will be determined after preliminary field work during 1995. Diets will be assessed using the same methods as for subtidal samples (see above).

Complete samples will be gathered in winter 1995-96 and summer 1996. Preliminary work will be done during summer 1995 and will include testing and refinement of sampling techniques and determination of minimum sample sizes as indicated above.

During sampling for density and diet all observed individual predators will be scored for activity, as follows:

Sea stars:	Scored active if moving, excavating or ingesting prey, or digesting prey extraorally. Otherwise scored inactive.
Snails:	Scored active if moving or attacking prey. Otherwise scored inactive.
Crabs:	Scored active if moving or feeding. Otherwise scored inactive.

During preliminary studies in summer 1995, we will compare proportions of predators active during day and night dives, and during day and night low tides. If preliminary data indicate significant day/night differences, additional activity surveys will be done at night. If night surveys are necessary, data collected will be limited to activity indices only for those predators with a significant day/night difference in activity. Some crab species are visually sensitive to approaching objects, and may flee during sampling. Location and activity will be scored from the point at which individual crabs are first seen, to minimize bias against inactive individuals.

2.5.2.8 Availability of Intertidal Clams

Spawning by hard-shelled clams like littleneck and butter clams takes place in PWS primarily during June (Feder et al. 1979, H.M. Feder pers. comm.) followed by a 3 week planktonic larval stage (Chew and Ma 1987) before settlement to the benthos. Maximum densities of littleneck clams in PWS tend to occur near the 0.0 m tidal height (mean lower low water) (Paul and Feder 1973, Paul et al. 1976, Houghton et al. 1993b). Poor survival during the first winter has been identified as a limiting factor for PWS littleneck clams (Paul and Feder 1973). We will examine populations of intertidal clams (primarily littleneck and butter clams, but also other common clams utilized by sea otters) at study sites M and N (Figure 5).

A reconnaissance survey will be conducted in the summer (presumably July or August) of 1995 along these coastlines to determine the extent of potential clam beaches (mixed sand/gravel). This survey will occur concurrent with the side scan sonar survey designed to distinguish subtidal habitats adjacent to shore. Additional shoreline information will be obtained from records compiled from the 1989 shoreline surveys. Four beaches will be randomly selected from each of the two treatment areas.

From 1996 - 1998, assessment of recruitment from the previous season's spawning, as well as size and age structure, will be conducted during June. Four 0.25 m^2 samples will be randomly collected from each beach along a 30 m transect at the 0.0 m tidal height. The 30 m transect will randomly be placed at the 0.0 m tidal height on the beach. The sediment in each sample will be removed to a depth of 30 cm and first hand-sorted to remove larger bivalves. This sediment depth is necessary to obtain the deep-dwelling butter clams. Sediment will be washed through a series of screens, the smallest of which is 1.5 x 1.5 mm mesh, to obtain smaller clams. Seawater used for the washing process will be furnished by a portable pump. The sediment retained by the finest screen will be returned to the laboratory and examined for small specimens under a 2x lens and measurements on small clams will be conducted at the Institute of marine Science, University of Alaska Fairbanks. All larger clams will be identified, counted and measured, in the field and returned to the area when they were sampled. All sampling will occur during the low tide series in June 1996. A total of 16-0.25 m^2 samples will be examined for intertidal clams in each treatment area in 1996. All clam identifications, counts, measurements and aging will be conducted at the Institute of Marine Science, University of Alaska Fairbanks.

Samples of sediment and littleneck and butter clams will be archived for possible hydrocarbon analysis. Two 50 g samples of sediment will be collected adjacent to the first two 0.25 m^2 quadrants on each beach. Therefore, a total of eight sediment samples will be collected from each of the two treatment areas. Two 50 g samples of littleneck clams and butter clams will be collected adjacent to the 0.25 m^2 quadrants on each beach. Therefore, a total of eight 50 g tissue samples of the two clam species will be collected from each of the two treatment areas. The total sediment and clam samples that will be archived for hydrocarbon analyses in 1996 are 16 and 32, respectively. All hydrocarbon samples will be frozen in the field and stored at the National Biological Service facility in Anchorage. If various measures of health (e.g., P450 assay) for sea otters or sea ducks indicate presence of oil then the clam and sediment samples will be sent to the NOAA/NMFS Auke Bay facility for hydrocarbon analyses. This information may identify a potential mechanism of primary oil transport to predators.

2.5.2.8 Predation on Bivalves by Sea Duck Competitors

Sea otter and sea duck diets overlap broadly, especially with respect to bivalves. To assess predation pressure of sea ducks on populations of selected bivalves (mussels and sub- and inter-tidal clams) and possible confounding effects on interpretation of sea otter effects (see section 2.5.1.3 and Figure 8), models including diet, duck numbers, and estimates of caloric needs will be derived to estimate numbers, biomass, and size classes of invertebrate prey. In concert with data documenting invertebrate prey abundance and size class and sea otter diets, we can determine the extent of structuring by sea duck predation and its potential confusion with sea otter structuring.

Diets of Barrow's goldeneyes and white-winged scoters will be determined by collecting birds on the invertebrate study sites. Collections will occur at three periods during winter (November, January, and March) beginning in 1996. Approximately 50 birds of each species will be taken. Birds will be shot from foraging flocks. Immediately after collection, the esophagus, proventriculus, and gizzard will be tied off separately, removed as a unit, and injected with alcohol to halt digestion. Samples will be removed from the digestive tract the same day and stored in alcohol. Diet analysis will consist of sorting and identifying samples and quantifying: length, width, and wet mass of each item and wet mass, volume, and dry mass of each taxa per sample.

We will conduct complete counts of sea ducks within the Knight and Montague Island study sites (Figure 5). Sea duck counts will occur in November, January, and March, and will be replicated within a week if weather allows. Two observers will conduct the counts in a skiff following standard boat survey methods for marine birds. Methods will be consistent with those used by Klosiewski and Laing (1994) and Agler et al. (1994). During counts observers will collect information on species, gender, habitat, and foraging activity of all ducks observed.

2.5.2.9 Availability of Sea Urchins and Crabs

Sea urchin and crab abundances will be estimated from the Montague and Knight Island study sites (Figure 5). We have little prior data describing habitat preferences of urchins, and crabs appear to be widely distributed among habitats (Jewett et al. 1994). As a result, it will be necessary to sample within all habitats (at least during our initial year of sampling).

Extent of each habitat will be determined and divided into 200 m segments. We will then randomly select 6 sampling sites from each habitat and area. Each site will have a minimum of 200 m of contiguous habitat. Sampling will be conducted at a minimum of 4 sites per habitat. More sites will be sampled if it is possible to do so within the allotted cruise time.

We will sample sea urchins and crabs within two depth strata, 0 to 3 m and 3 to 6 m. Previous surveys as well as anecdotal observations indicate that both sea urchins and *Telmessus* in PWS are found in relatively shallow water. Jewett et al. (1994) noted much higher densities of *Telmessus* in shallow (less than 11 m) stations than at deeper sites, and noted highest densities of sea urchins in very shallow water (less than 3 m). Evidence from Cook Inlet and Kodiak Island, Alaska suggests that green urchins are more abundant in shallow waters. In the absence of otters, urchins are generally found in higher densities at depths less than 6 m (Dames and Moore 1976, Zimmerman et al. 1979, Lees and Driskell 1981). Dayton (1975) noted higher densities of green sea urchins in somewhat deeper water (greater than 18 m) in Amchitka Alaska, where sea otters were abundant. He attributed the lack of urchins in shallow water to greater foraging efficiency of otters at the shallower depths. Thus, while occasionally found in deeper waters, shallow populations of sea urchins appear to be the most important for otters. The sampling depths at each site will be randomly selected from the 0 to 3 and 3 to 6 m strata.

At each depth, divers will count sea urchins and crabs within a 100 to 200 m long transect that is 1 m in width. Divers will turn algal blades and smaller cobbles to find cryptic sea urchins. In addition to counting sea urchins and crabs, divers will also note the predominant substrate type (mud, sand, gravel, cobble, boulder, reef), the dominant vegetation type (none, eelgrass, *Laminaria, Agarum*, etc.), and the density of dominant sea stars (*Pycnopodia helianthoides* and *Dermasterias imbricata*). The sea stars will be counted because these are potential competitors of sea otters for some food items, especially clams and sea urchins (Duggins 1981, 1983).

The length of the transect will be measured in one of two ways. First, if it proves feasible, the transect length will be measured using differential GPS. Divers will enter the water at a starting buoy and then proceed along a compass course for a specified period of time. The time will be that generally considered necessary to cover about 200 m. The positions of the start and end point of the dive will be noted using differential GPS and the length of the transect will be determined. Differential GPS correction transmitters are now operational in the Sound, allowing for about 10 m accuracy in positioning. However, if is not certain whether clear reception of this signal will be available in all parts of the Sound. In the event that we are unable to use differential GPS, divers will determine transect lengths by moving a 2 m long measuring stick along the transect.

The size and average density of urchins will be determined for any aggregations that are noted along the transect. An aggregation will be defined as any 1 m^2 area in which there are 5 or more urchins. When aggregations are encountered, we will determine the size of the aggregation by marking the boundaries of the aggregation along two axes, onshore-offshore, and longshore. The positions of these boundaries will be noted using GPS, or meter tapes. We will then count the number of urchins within 9, 0.25 m^2 quadrats that are uniformly spaced along the axes of the aggregation.

We will determine the size (test diameter) of the first 100 urchins observed at each site. In addition, we will tag a minimum of 200 urchins from each aggregation found. The urchins will be collected and measured, and all within a size range of 15 to 18 mm will be tagged by placing them into a solution of calcein dye overnight (see also section 2.5.2.10). This has proven to be an effective method of marking animals for latter retrieval and determination of growth rates (based on marks left by Calcein in their skeletal material; Dixon et al. 1992). The urchins will be released into the same area from which they were collected. In fall, 1995 we will conduct preliminary sampling to test survey methods including GPS locating systems. Initial full scale sampling will be conducted in 1996.

The sampling plan for 1996 may be modified (if necessary) based on preliminary 1995 reconnaissance results. For example, some habitats or depth strata may be eliminated if they prove unsuitable for urchins and crabs. Otherwise, it is anticipated that comparable methods as described for sampling in 1996 will be used in year 3 estimation of abundance. Size distributions will be determined as in year 2, and a total of 200 urchins will be collected form each aggregation from which animals were collected and tagged in the previous year. These animals will be returned to the laboratory where they will be measured and the presence of a tag determined by viewing under a florescent microscope.

If we note differences in density among oiled and unoiled areas in 1996, we also will measure recruitment of urchins in 1997 (see also section 2.5.2.9). This will be done using nylon bristle brushes as larval collectors (Ebert et al. 1994). Brushes will be placed at each of 5 sites per area. Eight replicate brushes per site will be put out in April and collected and replaced by new brushes at monthly intervals through August of that year. The brushes will be returned to the laboratory where they will be washed, and the number of small urchins per brush will be counted.

2.5.2.10 Availability of Mussels

Within the Montague and Knight Island study areas (Figure 5) mussel abundance will be estimated using stratified random sampling with proportional allocation. Each length of coast will be initially divided into five strata based on shoreline type as characterized by the EVOS Damage Assessment Geoprocessing Group: 1) exposed rocky, 2) sheltered rocky, 3) gravel, 4) sheltered tidal flats, and 5) mixed sand and gravel. Four shoreline segments will be sampled in each stratum. A 30 m transect will be laid parallel to shore at the median tidal level of mussel distribution at randomly selected mussel beds in each randomly selected segment. Mussel densities will be estimated using 500 cm^2 quadrats. The quadrats will be placed randomly along each transect. The number of transects and quadrats will depend on the distribution of the mussel beds and mussel density in each bed as determined during preliminary sampling. A preliminary estimate of total sample size is 2 study areas x 5 strata x 4 shoreline segments x 15 replicates = 600 samples. The contents of each quadrat will be collected and subsequently washed over a 0.5 mm sieve. Mussels retained by the sieves will be counted. Small mussels (size range, 0.5-5mm) will be separated from organic detritus and sediment with a combination of flotation and elutriation in a sodium polytungstate solution.

In a subset of ten quadrats from each randomly selected mussel bed mussels will be collected and the maximum shell length of each mussel will be measured to the nearest 0.1 mm with a digital caliper connected to a portable data recorder. Lengths of smaller mussels will be obtained with an image analysis system. Mussels will be dried at 60°C and weighed at 24 h intervals to the nearest 0.001 g on a precision balance. This procedure will continue until mussel weights have stabilized. Subsequently, mussel tissue will be digested in 10% potassium hydroxide and the remaining shell dried to a constant weight. Tissue dry weight will be obtained by subtracting shell dry weight from mussel dry weight.

If differences in the size-frequency distributions of mussels are observed between areas M and N then individual mussels from each stratum in each area will be tagged with calcein to measure growth. The calcein solution will be prepared as described in Houghton et al. (1993b). Mussels will be held in the calcein solution for 24 h. Mussels will be tagged and released at intervals of three months. Tagged individuals will be retrieved at the end of each three month period, the periostracum will be removed and the increment of shell laid down after the calcein band (observed under an ultraviolet light) was incorporated into the shell will be measured using an image analysis system.

Mussels will be collected for tissue hydrocarbon analysis immediately adjacent to a subset of the randomly placed quadrats used for density estimates. Three composite samples of mussels will be collected from oiled and unoiled mussel beds at each study site. Samples will be placed in coolers with ice immediately after collection and will be frozen within an hour. Appropriate blanks will be collected at each site.

Analysis of variance will be used to compare mussel abundances between study areas. A nonparametric anova will be substituted if the data do not meet the assumptions of the parametric anova and standard transformations do not normalize the data and stabilize variance. Size-frequency distributions will be compared using the chi-square statistic after decomposition of the distributions to be compared into subpopulational nodes. Growth curves of mussels will be compared using analysis of covariance following curvilinear regression.

2.6 Specific Methods for Harlequin Ducks

2.6.1 Rationale

2.6.1.1 Demographic Measures

Sound-wide abundance estimates for birds are generated periodically by boat-based surveys (Agler et al. 1994). We propose to use previously collected boat survey data combined with an existing shoreline-type data set to answer three more specific questions. First, which shoreline-types, if any, are selected by harlequin ducks? Second, are densities of harlequin ducks in the oiled zone lower than expected based on habitat availability in the oiled zone and patterns of selection of those habitats in the unoiled area of PWS? The third question focuses on the heavily oiled Area N, which was selected as a study site because sea otter and harlequin duck densities appear to be unusually low there; do shoreline types in Area N contain fewer harlequin ducks than expected based on patterns of habitat selection in the unoiled area? Evidence of avoidance of apparently suitable habitat in the oiled zone would indicate oil-related causes of lack of recovery.

Demographic data will be collected to assess harlequin duck population health between study sites, in the form of studies of overwinter female survival. For long-lived species with relatively low annual productivity, like harlequin ducks, female survival is a primary determinant of population trends (Goudie et al. 1994). Sex ratios of nearly all ducks are skewed towards males (Bellrose 1980), i.e., fecundity is not limited by numbers of available males. In this study, both adult and subadult females will be marked. Adult female survival is particularly influential on population growth rates, while subadults may be more susceptible to mortality factors and, thus, provide indications of limiting factors as well as perturbations to the system.

2.6.1.2 Health Measures and P450 Induction

Bioindicators of harlequin duck health will be compared between study sites, including blood and tissue analyses described in sections 1.4.2.2 and 2.3. Body condition of molting harlequin ducks also will be compared between sites. Body condition can have critical influences on survival and reproduction, and thus is a good indicator of overall population health. For example, the waterfowl literature documents instances in which survival of wintering ducks varied with condition (Conroy et al. 1989, Longcore et al. 1991, Bergan and Smith 1993). Harlequin ducks may be particularly sensitive to body condition effects because of severe weather encountered in northern wintering areas (Goudie and Ankney 1986). Body composition affects reproduction through initiation date and clutch size effects (Esler and Grand 1994) and may affect breeding propensity of harlequin ducks. Exposure to contaminants in winter can influence waterfowl body weights or composition (Hohman et al. 1990), subsequently affecting survival or reproduction. Barrow's goldeneyes and white-winged scoters collected for diet assessment (section 2.5.2.8) also will be available for analyses of tissue, blood, and body condition.

2.6.1.3 Trophic Interactions

Harlequin ducks feed primarily on lacunid snails, limpets, chitons, mussels, and littorine snails (Goudie et al. 1986, Patten 1994) that live in the lower intertidal and shallow subtidal zone; however, foraging ecology relative to available food resources has never been addressed. There is evidence that some harlequin duck foods (e.g., limpets, mussels and some littorines) were injured following the EVOS (Highsmith et al. 1993). There is also evidence that sea duck distribution and abundance, including that of harlequin ducks, may be affected by foraging opportunities (Stott and Olsen 1973, Goudie and Ankney 1986). In this study, we will assess whether food availability differs between oiled and unoiled areas, and if so, whether food may be limiting recovery of harlequin ducks in oiled areas. As discussed in introductory remarks (section 1.4.2.3), a lack of preferred food items at oiled sites indicates possible inhibition of recovery in oiled areas as a result of food limitation. As a corollary, abundant food in oiled areas may well provide additional evidence for a lack of recovery, and will suggest that factors other than food (e.g., continued toxicity of oil or demographic constraints) may be limiting recovery.

2.6.2 Methods

2.6.2.1 Analysis of Harlequin Duck Distribution and Habitat

We will examine habitat use relative to Sound-wide availability using an existing shoreline-type data set of PWS (Research Planning Institute 1983) which was transferred to a computer GIS format after the spill (GIS Technical Group 1991). During the Damage Assessment phase of the spill, this data set was overlaid (B. Boyle, pers. comm.) on transects from boat surveys conducted over the last 20 years (Klosiewski and Laing 1994), and the linear distance of each shoreline type in a given bird survey transect was compiled (B. Boyle, pers. comm.).

For this project, we will place each transect in PWS in a category based on its dominant shoreline-type. To answer the first question discussed in 2.6.1 above, densities of harlequin ducks in each transect randomly sampled in boat surveys will then be compared statistically among shoreline-types to model expected densities by habitat. We will address the second question by comparing, by shoreline-type, predicted harlequin duck densities to densities in the oiled area. We will answer the third question by making a similar comparison specific to Area N.

2.6.2.2 Harlequin Duck Survival

Harlequin ducks will be captured during late August and early September by driving molting flocks into traps. Molting flocks will be located from a support vessel cruising slowly along shorelines. When molting flocks are located, a crew will be sent ahead to set the trap wings and pot at an appropriate site. When the trap is set, kayakers will slowly herd the flock into the trap. These methods have been successfully applied in British Columbia (Goudie, pers. comm.).

One hundred females will be outfitted with radio-transmitters each year, beginning in 1995. Fifty birds each will be marked in oiled and unoiled study sites. Samples will be evenly allocated between adults and subadults. The focus will be on females because their survival largely dictates population dynamics (Goudie et al. 1994). Capturing and marking birds will be conducted cooperatively with Alaska Department of Fish and Game investigators monitoring harlequin duck populations (EVOS project 95427).

Transmitters will be equipped with mortality switches. Transmitter life will be at least 210 days. Transmitters will be implanted in the body cavity with an external antenna. Implanted transmitters have been successfully used in waterfowl studies (e.g., Olsen et al. 1992, Haramis et al. 1993) and are less disruptive than backpack transmitters (Pietz et al. 1993, Rotella et al. 1993), especially for diving ducks (Korshgen et al. 1984). Surgeries will be conducted by a certified veterinarian experienced in avian implant surgeries, following procedures outlined in Alaska Science Center, National Biological Survey standard protocol.

These procedures have been used successfully for radio implants in spectacled eiders and common murres (Mulcahy, pers. comm.).

Radio telemetry flights will be conducted weekly through winter. Flights will detect each marked individual and note status and general location. For birds indicated as dead, the carcass will be recovered by boat or float plane as soon as possible. Collected carcasses will be examined for causes of mortality.

Data will be analyzed using a Kaplan-Meier staggered entry design (Pollock et al. 1989). Effects of oiling history, age, and condition (as estimated by condition indices described in section 2.6.2.3 below) will be examined with log-rank tests.

2.6.2.3 Health Measures and P450 Induction

A condition index for molting harlequin ducks will be derived to allow an accurate and nonlethal assessment of body composition for captured harlequin ducks. Condition will be modeled with a combination of morphological measures and measurements of total body electrical conductivity (TOBEC), which provides an accurate indication of total lean and lipid mass (Roby 1991). In 1995, a sample of 25 molting harlequin ducks will be collected in eastern Prince William Sound, where harlequin duck populations were not believed to have been injured. Collected birds will be captured during molting drives, treated similarly to other captured birds (see below), and then collected by injection of euthanasia solution intravenously or in the trachea. Carcass analysis of collected birds will be conducted following standard methods (Esler and Grand 1994). Models will then be created, using morphology and TOBEC measures, to predict body composition. Condition indices will be extremely valuable for estimating condition of molting harlequin ducks for assessments of (1) effects of condition on survival of radio-marked females (see above), and (2) differences in body condition between study sites (see below).

Harlequin ducks captured during molting drives will have blood drawn from the jugular or brachial veins for blood assays (section 2.3). A 3 mm foot web biopsy will be used as a nondestructive tissue sample for P450 measures (section 2.3). Morphology of each bird will be measured including body weight, tarsus, culmen, and wing length from the wrist notch to the end of the longest primary. Each bird will be passed through the TOBEC analyzer a minimum of six times to insure an accurate reading. Birds will be restrained with a nylon stocking to insure a common position for all birds during TOBEC analysis.

Stage of molt will be indexed by primary length. Linear models describing body condition variation through molt will be derived; slopes and intercepts will be compared between oiled and unoiled sites for each age and sex cohort.

2.6.2.4 Harlequin Duck Prey Abundance

During the first year of our study (summer 1995), we will census subtidal habitat types within oiled and unoiled areas regions of the Sound, and produce habitat maps (section 2.4). The following winter (November 1995-March 1996), we will assess population densities of harlequin ducks in these same areas, and determine the location (within approximately 30 m) of each duck or flock of ducks (section 2.5.2.8) Habitat and harlequin duck distribution maps will be overlaid to define habitats and areas with high duck densities.

During the fall of the following year, we will assess abundance of the 5 primary prey items within 12 randomly selected sites within high harlequin duck use areas: 6 in the oiled area and 6 in the unoiled area. A second duck survey conducted during the winter of 1996/1997, will confirm continued use of selected habitat. A second invertebrate survey of the same sites sampled in fall 1996 will be sampled again in spring 1997, after overwintering ducks have left the PWS.

Invertebrates will be sampled at 6 randomly selected 1 m^2 quadrats within the intertidal and shallow subtidal zone (from +1 m to -2 m MLLW) at each of the 12 sites. All vegetation from each quadrat will be removed by divers using SCUBA and will be placed in a small mesh bag underwater. All remaining epifauna will then be scraped from rocks and sampled using an airlift. Samples will be sorted in the laboratory and the number, size classes, and biomass (dry weight) of each of the 5 major prey items will be determined.

We will compare the mean density and biomass at each of the two areas (oiled and unoiled) in both fall (before duck foraging) and spring (after foraging) surveys using a two-way ANOVA.

2.7 Specific Methods for Pigeon Guillemots

2.7.1 Rationale

Guillemots have served as subjects in previous studies to assess the effects of ingested crude oil on marine birds (Peakall et al. 1980). Nestling black guillemots (*Cepphus grylle*), a very closely-related species of the pigeon guillemot, were fed single doses of weathered South Louisiana crude oil (WSLC) and subsequently monitored in their natural nest site where they were cared for by their parents. These experiments demonstrated that single doses of as little as 0.1 ml WSLC resulted in declines in growth rates, increases in plasma sodium levels and increases in nasal and adrenal gland masses. The effects of the single dose were not transient, as nestlings that were dosed at roughly two weeks post-hatch were 20% lighter than controls at five weeks of age (just prior to fledging). Such persistent sublethal effects may have serious consequences for post-fledging survival. Peakall et al.'s (1980) study clearly demonstrates that guillemot nestlings living normally in their chosen habitat are tolerant of handling and disturbance associated with assessing pollutant toxicity.

We will monitor blood parameters in pigeon guillemots breeding at Naked Island (oiled area) and Jackpot Island (unoiled area), PWS. Data on population size, reproductive success, prey composition and provisioning rates of breeding guillemots will be collected at these same sites as part of an on-going research project conducted by the Fish and Wildlife Service and directed by Dr. David Irons. Collection of blood samples from nestling and adult guillemots will be coordinated closely with Dr. Irons' field crew. Naked Island supports the highest breeding densities of guillemots in PWS (Sanger and Cody 1993) and a breeding population that is adequate for the proposed research (Oakley 1981, Kuletz 1983). The following parameters will be measured at accessible guillemot nests, in coordination with Dr. Irons' studies, as indices of parent-offspring productivity: 1) chick feeding rates; 2) chick meal size; 3) taxonomic composition of chick diets; 4) biochemical composition of chick food items; 5) chick growth rates and body composition; 6) nestling survival; and 7) fledging age, body mass, and body composition. Productivity will be compared with blood parameters used to monitor contaminant exposure. Nondestructive indices to stress induced by petroleum hydrocarbon ingestion will be used, such as levels of selected plasma immunoglobulins, blood plasma proteins, cell counts, and interleukin levels in blood of adults and chicks, body mass and body composition of adults and chicks, chick growth rates, and fledgling mass. These data will then be used to evaluate the factors that limit guillemot productivity. The results of this research project will provide us with the background necessary to use guillemots as avian indicators of nearshore ecosystem health in PWS.

2.7.2 Methods

2.7.2.1 Indices of Abundance and Health

Field studies will be conducted during the 1996 and 1997 (with options for 1998) breeding seasons in PWS. Fifty active and accessible nests will be located and marked during early incubation at an oiled (Naked Island) and an unoiled (Jackpot Island/Icy Bay) study site in each of the three breeding seasons. Field work will be coordinated with on-going U.S. Fish and Wildlife Service studies of factors limiting recovery of pigeon guillemots in PWS (D. Lindsey Hayes, PI), as part of the Seabird/forage Fish Project (95163). Active and accessible nests will be closely-monitored until the young fledge or the nesting attempt fails.

An attempt will be made to locate, identify, and map all active guillemot nest sites on Jackpot Island and on the western and northern shores of Naked Island. Active nest sites will be identified during the chick-rearing periods (regardless of whether the nest site is inaccessible) because active nest sites can be readily identified by the presence of adults transporting fish in their bills. Trends in the numbers of active nest sites, as well as nest site and colony abandonment rated, will serve as indices to population trends at each study site. Differences in trends of numbers of breeding pigeon guillemots at unoiled (Jackpot Island) and oiled (Naked Island) sites will be used as a demographic indicator of potential effects of the spill. In addition, guillemot adults that are captured at active nests for blood sample collection will be banded with USFWS leg bands for future identification. Pigeon guillemots are highly philopatric and usually return to breed in the same nest crevice each year, or one in close proximity. Consequently, mark-recapture rates can be used to estimate adult survivorship at the two study sites.

Differences in reproductive success (number of fledglings produced per nesting attempt) at the unoiled and oiled sites will be measured as an indicator of effects of the spill on population productivity. Reproductive success in pigeon guillemots can be subdivided into several components: (1) the proportion of breeding age birds that produce a clutch, (2) size of clutches (one or two eggs), (3) the proportion of laid eggs that successfully hatch, (4) the proportion of chicks that successfully fledge, and (5) the proportion of fledged young that survive the post-fledging period. Variable (1) and (5) are extremely difficult to measure, although fledgling body fat reserves can be used as an index to post-fledgling survival. Variables (2), (3), and (4) can be estimated in an unbiased manner (by employing the Mayfield method), if active nests are checked regularly after they are found. Active and accessible guillemot nests will be checked every four days during incubation to determine status, every other day during the hatching period to determine hatching success, and every four days during the nestling period to determine nestling survival rated, and to weigh and measure chicks for monitoring growth and development. The following parameters will be measured at accessible nests as indices of parent-offspring condition; (1) growth rates of body mass, wing length, and primary feathers in nestlings, (2) accumulation of fat reserves in fledglings, (3) total mass (corrected for body size) and body composition of adults during the chick-brooding period, and (4) fledging age and body mass. Clutch size hatching success, fledging success, and overall reproductive success will be compared between the oiled and unoiled study sites. Recent work on pigeon guillemots nesting on Naked and Jackpot islands (D. L. Hayes, unpubl. data) ensures that an adequate sample size of guillemot nests will be found shortly after laying.

Data on age-specific body mass, wing length, and primary feather length of nestlings will be separated by year and study site, and fit to Gompertz sigmoidal growth models. Growth constants (K), inflection points (I), and asymptotes (A) of fitted curves will be statistically analyzed for significant differences among years and study sites. Total body fat of chicks at 20 and 30 days post-hatch will be estimated by noninvasive (nondestructive) measurement of total body electrical conductivity (Walsberg 1988, Roby 1991). The SA-3000 Small Animal Body Composition Analyzer (EM-SCAN, Inc., Springfield, IL) will be validated for measuring body fat in guillemot chicks using a sample of chicks collected in Kachemak Bay, Alaska. Body mass, wing length, length of primary feathers, and TOBEC measurements will be used to develop a condition index for each chick at 20 and 30 days post-hatch.

To more accurately assess the health of individuals and potential effects of oil exposure, we will collect blood from guillemots at the oiled and unoiled study sites. We will use blood sampled from nestlings and adults to determine levels of acute phase blood proteins, such as haptoglobin, albumin, and metalothionine, that are indicative of exposure and tissue damage. We also will measure cytokines such as IL-1 and IL-6 and liver enzymes such as AST. We will supplement our blood molecular work with cellular studies, such as red cell volume, hematocrits, and immune functions (Heinz bodies will be looked for in guillemot blood samples). Differences in biomarker levels of blood collected from oiled and unoiled sites will be used to evaluate the effects of the spill on contaminant levels in the food supply.

Blood samples (1 ml) from guillemot nestlings will be collected by brachial vein puncture at ages 20 and 30 days post-hatch (guillemot chicks normally fledge at 30-40 days post-hatch). Blood samples will be collected in heparinized tuberculin syringes, transferred to Eppendorf centrifuge tubes for transport to the base camp, and centrifuged to separate plasma and cells. Plasma and cells will be frozen separately in propane freezers at the base camps. Blood samples will be collected using SOPs developed by us during the *Exxon Valdez* spill studies to preclude sample contamination. In the lab, plasma and blood cell samples will be analyzed for molecular and cellular biomarkers (e.g., characteristic morphological lesions of red blood cells associated with hemolytic anemia caused by oil ingestion [Leighton 1985]). A panel of biomarkers, including leukocyte counts, macrophage function, electrophoretic measurements of serum immunoglobins, and ELISA assays of interleukins will provide data on the health status of individuals and permit comparison of study sites. At UAF, we will perform haptoglobin assays, IL-1 and IL-6 assays, and immunoglobin typing assays for the blood samples collected from guillemots. Cell counts will be performed by a NBS contracted lab and macrophage function assays will be developed. Results from biomarker studies will be used to test biostatistical models that predict population health.

The impact of potential contaminant exposure on breeding adults will be monitored using a combination of direct and indirect methods. Attentiveness of adults will be monitored during the incubation period. Frequency of chick meal delivery and meal size will be determined during the chick rearing period by a combination of monitoring adult nest visitation rates and periodic weighing of chicks. Individual variation in exposure of adults (and nestlings) to petroleum hydrocarbons will be monitored by periodically collecting food samples from adults as they return to the nest site to feed nestlings and by collecting prey samples at sea (section 2.7.2.2). In the lab, samples of nestling food will be analyzed to determine levels of aliphatic and aromatic hydrocarbon fractions using a Iatroscan MK-5 TLC/FID Analyzer System. During the chick-brooding period (0-7 days post hatch), adult guillemots will be captured in the nest crevice, banded for later identification, and blood samples (1 ml) collected from the brachial vein. Blood samples will be analyzed for molecular and cellular biomarkers of contaminant exposure using the same techniques applied to nestling blood samples. These measurements will allow us to monitor the impact of various levels of contaminant exposure on physiological condition of nestlings and foraging efficiency of adults.

2.7.2.2 Prey Abundance

Surveys to assess abundances of nearshore demersal fishes that comprise a major proportion of guillemot diets will be conducted at the oiled study site (area N, western Naked Island) and the unoiled study site (area J, Jackpot Bay; Fig. 5). The target fishes include a variety of blennies, sculpins, and sand lance, because guillemots feed their young a diverse array of fish prey (Kuletz 1983).

During 1985, results from side-scan sonar surveys (section 2.4) will be used to define subtidal habitats. Fish sampling will be conducted from 1996-1988 and will be stratified, probably within four subtidal habitats. Within each habitat, six sites will be randomly selected and sampling will occur on 1 X 50 m transects parallel to shore at the 0-3 m depth stratum. A total of 18 transects will be sampled in each treatment area. Fishes will be identified and counted by SCUBA divers as they swim along the transect within 3 m of the bottom. For schooling fishes like Pacific sand lance, we will employ a variety of netting techniques. Twenty fish of each dominant taxa will be collected (be spearing, netting, and/or seining) from each area (oiled and unoiled) and archived for potential hydrocarbon analyses.

Prey availability will also be assessed from data on the provisioning rates of nestlings by parents. Active nests will be observed from blinds in order to measure chick meal delivery rates, as well as to estimate the taxonomic composition and size class distribution of nestling diets. Differences in parental provisioning rates, taxonomic composition, and size class distribution of nearshore demersal fishes fed to nestlings at unoiled and oiled sites will be used as an index to potential effects of the spill on prey availability. On-site estimates of nearshore demersal fish abundance will be compared with the rate and composition of prey delivered to nestlings in order to evaluate prey preferences in relation to availability.

2.8 Specific Methods for River Otters

2.8.1 Rationale

We will evaluate changes in population trends of river otters by examining the frequency of latrine site abandonment on oiled and unoiled areas. Kruuk et al. (1989) demonstrated a strong positive relationship between number of resident females and number of active holts (latrine sites) for European otters living in a marine environment. Likewise, Testa et al. (1994) showed that number of active latrines varied with estimated population size for river otters in PWS; however, too few areas were sampled to establish a regression line between these variables. Nonetheless, it is likely that abandonment of latrines provides a useful index to otter abundance, and can be used to evaluate trends in otter populations. Indeed, Duffy et al. (1994b) documented that river otters throughout oiled areas of PWS abandoned latrine sites at a rate over three times greater than did otters inhabiting unoiled areas. We will not be sampling all of the same areas we previously examined because of integration with other studies of vertebrate predators in the nearshore environment. If differences in oiled and unoiled areas still exist, it would be possible in subsequent years to evaluate the same sites that we sampled in 1991 to compare current values against that benchmark.

We previously developed a nonlethal method for evaluating the effects of marine pollutants (in this instance, crude oil) on the blood-enzyme chemistry of river otters (Duffy et al. 1994b). We first noted that blood haptoglobins (an acute-phase protein) were elevated in otters inhabiting areas where crude oil was prevalent one year following the oil spill (Duffy et al. 1993). Even two years after the oil spill and a major effort to clean oil-contaminated shores, we were able to construct a biostatistical model, using logistic regression, in which we classified > 86% of river otters correctly as having been captured in oiled or unoiled zones. This highly sensitive model used only blood values for haptoglobin, interleukin 6 (a cytokine), and AST (a liver enzyme). Our approach has already been extended for evaluating other marine mammals (Zenteno-Savin et al. 1993), and may be applicable to other vertebrates, especially marine birds. The strength of this line of research is that we have already developed the expertise necessary to live-capture river otters, have base-line data from oiled and unoiled areas throughout PWS, and have a predictive model that assesses the effects of oil contamination on otters, thereby providing an index to environmental health. This will provide a sensitive tool for examining the health of nearshore ecosystems.

2.8.2 Methods

2.8.2.1 Latrine Site Characteristics and Density

We will conduct searches of shorelines using the methods described in detail by Bowyer et al. (1994, 1995) and Testa et al. (1994). In 1996 and 1997 latrine sites will be characterized with respect to their topography, terrestrial vegetation (old growth, new growth, rock-grass-moss, or brush alder), intertidal substrate (sand, gravel, small rocks, large rocks, or bedrock) and distance from freshwater. Vegetation and intertidal substrate will be assessed for a 10-m arc with its pivotal point at mean high tide and extending in the appropriate direction (shore or ocean). This point will be aligned with the most obvious entrance to the latrine site. Relative cover of vegetation will be estimated visually; any category that does not compose 25% of the supratidal portion of the 10-m arc will be scored as 0. More abundant vegetational types will be assigned a rank of 1 to 4 (1 = 25%, 2 = 50%, 3 = 75%, 4 = 100% cover). This method will also be used to categorize intertidal substrates. Vegetated slopes will be measured from a point at mean high tide to a point 10-m distant toward the latrine site with a hand-held compass (nearest 5°). The tidal slope will be measured similarly from mean high tide to a point extending 10 m into the intertidal zone. Tidal state (high, incoming, outgoing or low) will be noted so that measurements can be corrected if necessary. The aspect of the latrine site will be recorded in eight compass quadrants, and exposure to wave action ranked into three broad categories from protected to exposed.

2.8.2.2 Morphometrics

Otters will be captured in 1996 and 1997 using Hancock live traps (Melquist and Dronkert 1987) placed on trails at latrine sites and monitored by means of a trap transmitter (Telonics, Mesa, Arizona, USA) that signals when a trap was sprung. We have used this method successfully in the past (Duffy et al. 1993, in press). The otter initially will be immobilized in the trap with a hand injection of ketamine hydrochloride (11 mg/kg estimated body weight, Sigma, St. Louis, Missouri, USA) and placed in a drugging box (Melquist and Hornocker 1983). Weights and measurements (see Duffy et al. 1993) will be taken and the blood sample drawn from the jugular vein. Sexes will be distinguished by the relative position of urogenital openings and palpitation of the baculum (Larson 1984). Age determinations will be based on tooth wear and overall size of otters (Stephenson 1977).

2.8.2.3 Biomarkers of Health and Cytochrome p450 Induction

During the past 15 years, xenobiotics have been shown to alter immune function (Fowles et al. 1993). Environmental chemicals interact with various parts of this complex system resulting in either suppression or hypersensitivity of immune activity and surveillance. A panel of biomarkers, including leukocyte counts, macrophage function, electrophoretic measurements of serum immunoglobins, and ELISA assays of interleukins will provide data on the health status of organisms and permit comparison of species.

At UAF, we will perform haptoglobin assays, IL-1 and IL-6 assays, and immunoglobin typing assays for the blood samples collected during this project. Cell counts will be performed by NBS contracted lab and macrophage function assays will be developed.

The following biomarker analyses will be performed on the samples (Fossi and Leonzio 1993): blood plasma protein and liver enzymes, cell counts and Heinz bodies, and interleukin levels. Haptoglobins, IL-6, and several blood enzymes have been used successfully as biomarkers for river otters (Duffy et al. 1993, 1994a, 1994b). We will continue using this productive approach.

2.8.2.4 Prey Abundance

Surveys to examine abundance and health of river otter forage fishes will be conducted as described in section 2.7.2.2.

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4.0 Tables

Table 1. Restoration strategies from the *Draft Restoration Plan*.

Biological Resources	Primary Restoration Strategy
Recovering Resources	*Primary Restoration Strategy*
Bald Eagle	• Rely on natural recovery
Black Oystercatcher	• Monitor recovery
Killer whale	• Protect injured resources and their habitats
Sockeye salmon at Red Lake*	
Resources Not Recovering	*Primary Restoration Strategy*
Common murre	• Conduct research to find out why these resources are not recovering
Harbor seal	• Initiate, sustain, or accelerate recovery
Harlequin duck	• Monitor recovery
Intertidal organisms	• Protect injured resources and their habitats
Marbled murrelet	
Pacific herring*	
Pigeon guillemot	
Pink salmon*	
Sea otter	
Alaska salmon (Kenai & Akalura Systems)*	
Subtidal organisms	
Recovery Unknown	*Primary Restoration Strategy*
Clams*	• Rely on natural recovery
Cutthroat trout	• Monitor recovery
Dolly Varden trout	• Protect injured resources and their habitats
River otter	
Rockfish	

* These resources are also important for subsistence or commercial fishing. For these resources, waiting for natural recovery may significantly harm a community or industry, and the strategies for subsistence or commercial fishing also apply.

Table 2. Injury and evidence for lack of recovery from the *Exxon Valdez* Oil Spill, 1989, in four top-level nearshore vertebrate predators as evidenced through demographic, bioindicator, and trophic factors.

Injured Resource	Injury to Nearshore Ecosystem and Lack of Recovery as Evidenced in Four Key Species	Status/ Recovery Strategy
Sea otters	DEMOGRAPHIC • Up to 4,000 acute mortalities	• Stable, not recovered
	• Various surveys suggest abundance of sea otters has not recovered to pre-spill numbers (Table 4) • Significant differences in juvenile survival between oiled and unoiled areas in 90/91 and 92/93. • Proportions of prime aged animals among dead different from pre-spill levels through 1991; however, returned to normal thereafter (Ballachey et al. 1994).	• Conduct research to find out why not recovering; hypotheses include continued hydrocarbon ingestion; spill-caused changes in benthic prey.
	BIOINDICATOR • Hemotological and serum chemistries suggest otters in oiled areas had higher incidence of inflammatory and/or infectious conditions. TROPHIC • Primary foods include mussels, clams, and urchins, as well as other subtidal organisms. Sea otters feed in the lower intertidal and subtidal areas, areas that were especially contaminated by oil spilled from the *Exxon Valdez* (Wolfe et al. 1994) and may still be exposed to hydrocarbons through their feeding (EVOSTC 1994a). • In areas where recovery has not occurred, increases in sea urchin densities (a preferred prey) have been observed (Jewett pers. comm.).	• Recovery judged when population abundance and distribution are comparable to pre-spill, and when all ages appear healthy

Injured Resource	Injury to Nearshore Ecosystem and Lack of Recovery as Evidenced in Four Key Species	Status/ Recovery Strategy
Sea ducks	**DEMOGRAPHIC** • 1,000 acute mortalities in Harlequins • 875 acute mortalities in other species • Populations of goldeneyes have increased more slowly in oiled vs unoiled areas in 1993 and 1994 (Agler et al. 1994, Agler pers. comm.). • Summer populations of harlequin ducks, which may be year-round residents, were lower than expected in the oiled area of Prince William Sound between 1989 and 1991 (Klosiewski and Laing 1994). **BIOINDICATOR** • Patten (1994) found hydrocarbon metabolites in sea ducks collected in oiled areas and also suggested that reproductive effort and productivity of harlequin ducks were lower in oiled areas. **PREDATOR/PREY** • Sea ducks rely heavily on mussels, clams, gastropods, urchins, and other subtidal and intertidal organisms that may continue to transport hydrocarbons through their food chain. They may also compete with other top predators for these prey. However, no specific assessment evidence of the potential for trophic-related constraints to recovery exists.	• Unknown • Conduct research to find out why not recovering; hypothesis related to oil-contaminated prey • Recovery judged for harlequins when breeding and postbreeding season densities and production of young return to pre-spill levels, or when no difference between spill and non-spill areas.

Injured Resource	Injury to Nearshore Ecosystem and Lack of Recovery as Evidenced in Four Key Species	Status/ Recovery Strategy
Pigeon guillemots	**DEMOGRAPHIC** • 1,500-3,000 killed by EVOS in 1989	• Stable or continuing decline
	• Populations in PWS have declined from c.15,000 in the 1970s to c.3,000-5,000 in 1993 based on boat surveys. Declines have been greater in oiled vs unoiled areas of PWS (Klosiewski and Laing, unpubl. data; Sanger and Cody 1993). • Number of breeding pairs on Naked Island (largest guillemot breeding aggregation in PWS) have declined c.50% since the late 1970s and give no evidence of recovery (D.L. Hayes, USFWS, pers. comm.)	• Conduct research to find out why recovering; likely causes climatic /oceanographic, prey limitations and predation
	BIOINDICATOR • Average growth rates of chicks have declined since the spill (Oakley and Kuletz 1993) and remained lower at Naked Island (oiled) versus Jackpot Island (unoiled) during the 1994 breeding season (D.L. Hayes, USFWS, unpubl. data). • Fledging weights of guillemot chicks on Naked Island (oiled area) were lower than on Jackpot Island (unoiled area) in 1994 (D.L. Hayes, USFWS).	• Recovery judged by stable or increasing populations
	TROPHIC • No direct evidence collected. However, nearshore demersal fish, primary prey of this species, demonstrate a high incidence of hemosiderosis in oiled eelgrass beds of Herring Bay (Jewett et al. 1994). This suggests continued exposure to hydrocarbons. Nearshore demersal fish comprised ~half the diet of chicks on Naked Island. • Sandlance, a schooling fish that burrows in nearshore sandy sediments, formerly comprised c. a third of the diet of chicks on Naked Island. Since the spill, the proportion in the diet has declined.	

Injured Resource	Injury to Nearshore Ecosystem and Lack of Recovery as Evidenced in Four Key Species	Status/ Recovery Strategy
River otters	**DEMOGRAPHIC** •Although some were killed, there was no catastrophic mortality--river otters continued to live in areas that were heavily oiled through 1990 (Testa et al. 1994) •Initially modified their use of habitat by avoiding heavily oiled shorelines (Bowyer et al. 1995). Selected habitat differently on oiled verses unoiled areas by concentrating their activities on steeper tidal slopes and using areas with greater exposure to wave action (Bowyer et al. 1994), where oil was less likely to persist (Wolfe et al. 1994) •In 1990, home ranges in oiled areas were 2x those in unoiled areas, suggesting a loss of habitat on oiled sites (Bowyer et al. 1995) •Continued exposure has adverse health effects; lower body mass in oiled vs. unoiled areas (Duffy et al. 1993, 1994b). Lower body mass often related to lower reproductive output in large mammals (Docktor et al. 1987) •Throughout broad areas of PWS, latrine sites (an index of population density) were abandoned at a rate three times greater on oiled versus unoiled areas (Duffy et al. 1994a). BIOINDICATOR •Continued exposure has adverse health effects; higher haptoglobin (an acute-phase protein indicator of damage) levels than in otters from unoiled areas (Duffy et al. 1993). TROPHIC •Diets in oiled vs unoiled areas were similar through 1990, but differed markedly by summer 1991 (Bowyer et al. 1994). A number of taxa were absent from the diet in oiled areas. •Nearshore demersal fish, primary prey of this species, demonstrate a high incidence of hemosiderosis in oiled eelgrass beds of Herring Bay (Jewett et al. 1994). This suggests continued exposure to hydrocarbons.	•Unknown •Rely on natural recovery, indications of recovery are when habitat use, food habitats and physiological indices return to pre-spill conditions.

Table 3. Summary of methods for the NVP project, listed by species and approach.

APPROACH	SEA OTTERS	HARLEQUIN DUCKS	PIGEON GUILLEMOTS	RIVER OTTERS
DEMOGRAPHY	•AERIAL SURVEYS OF ABUNDANCE •SURVEYS OF ANNUAL REPRODUCTION RATES •CARCASS RECOVERY TO EVALUATE MORTALITY PATTERNS	•ASSESSMENT OF HABITAT USE AND ABUNDANCE IN OILED AND UNOILED AREAS •OVERWINTER SURVIVAL OF FEMALES	•CHICK GROWTH RATES •REPRODUCTIVE SUCCESS •ADULT ATTENTIVENESS TO CHICKS •MEAL DELIVERY RATES AND MEAL SIZE	•LATRINE SITE ABANDONMENT AS AN INDEX OF ABUNDANCE
HEALTH AND OIL EXPOSURE	•BLOOD AND IMMUNE FUNCTION ASSAYS •P450 ASSAYS •MORPHOMETRICS/CONDITION	•BLOOD ASSAYS •P450 ASSAYS •BODY COMPOSITION	•BLOOD ASSAYS •P450 ASSAYS •BODY COMPOSITION OF CHICKS	•BLOOD AND IMMUNE FUNCTION ASSAYS •P450 ASSAYS •MORPHOMETRICS
TROPHIC INTERACTIONS	•ABUNDANCE, DISTRIBUTION AND SIZE CLASS STRUCTURE OF CLAMS, MUSSELS, SEA URCHINS, CRABS •PREY SELECTION AND FORAGING SUCCESS •ASSESSMENT OF OTHER FACTORS AFFECTING PREY ABUNDANCE: VARIATION IN RECRUITMENT AND GROWTH OF INVERTEBRATE PREY; COMPETING PREDATORS	•ABUNDANCE AND SIZE CLASS DISTRIBUTION OF PRIMARY INVERTEBRATE PREY	•ABUNDANCE OF PREY (DEMERSAL FISHES)	•ABUNDANCE OF PREY (DEMERSAL FISHES)

Table 4. Abundance of sea otters in Area N, (north & east Knight, Disk, Eleanor, Naked and Smith Is., approx 400 km^2).

Pre/ Post Spill	Year	Survey Type	Population Estimate
Pre	1973	Helicopter survey	294 (minimum, not corrected)
	1984-1985	Boat survey	261 (minimum, corrected for visual bias, but coastal transects only)
Spill	1989	EVOS mortality	182 (carcasses and rehabs, not corrected)
Post	1992	Aerial Survey	132 (corrected for visual bias)
	1993	Aerial Survey	77 (corrected for visual bias)
	1994	Aerial Survey	108 (corrected for visual bias)

Table 5. List of assays and measurements for evaluation of health and oil exposure.

Assay or Biomarker	Laboratory or Location	Sea Otters	Harlequin Ducks[a]	Pigeon Guillemots	River Otters	Demersal Fishes
		n=60	n=100	n=75 nestlings n=25 adults	n=30	n=40
Blood - CBC, WBC	PML/ Purdue	X	X	X	X	
Serum Chemistry	PML	X	X	X	X	
Interleukin-6	UAF	X	X	X	X	
Haptoglobin	UAF	X	X	X	X	
Immunoglobulin Quantitations	Purdue	X	X			
Serum electrophoresis	Purdue/UAF	X	X		X	
Lymphocyte Transformation Assay	Purdue	X	X		X	
Cytochrome P450 Immunohistochemistry	Wood's Hole	X	X	X	X	X
Cytochrome P450 Western Blotting	UAF	X		X	X	
Cytochrome P450 Quantitative PCR	Purdue	X			X	
Hydrocarbons in tissues (GC-MS)	GERG	X Archive	X Archive	X Archive	X Archive	X Archive
External oil (ELIZA)	In field/ UAF/NBS	X	X	X (Adults only)	X	
Morphometrics (weights, lengths)	In field	X	X	X	X	
Body Composition	UAF/NBS		X		X	

[a]100 Harlequins for study of overwinter survival. Also taken will be 50 each of Barrow's Goldeneye and White Wing Scoters to be collected for analysis of food habits; tissue samples from these collections will be archived so that health and oil exposure assays could be performed later if warranted based on results from other species

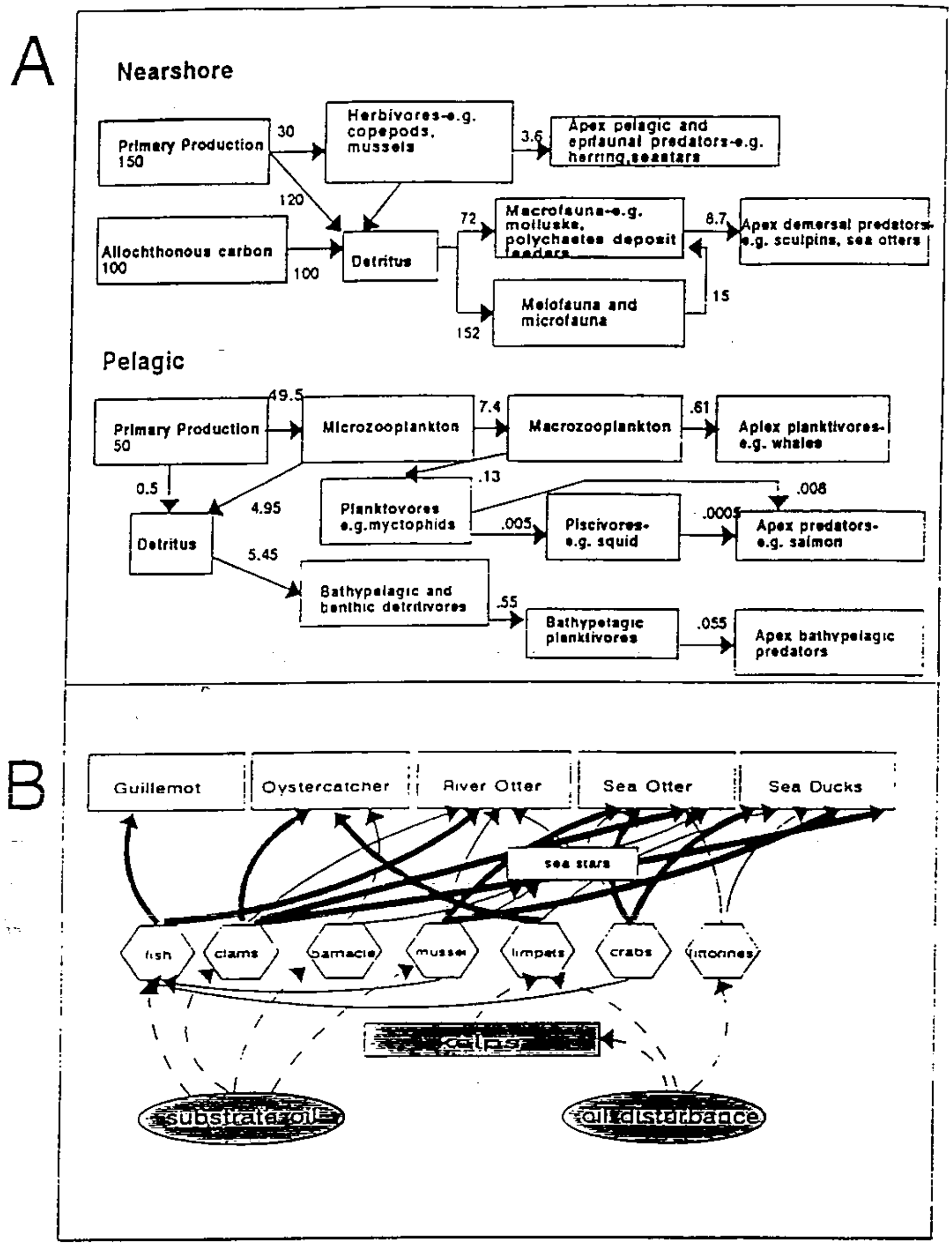


Figure 1. A). Generalized energy flow based on organic carbon transfers in the nearshore and pelagic ecosystem (modified from Parsons 1987. Figure 18-6). B). General trophic interrelations within the nearshore ecosystem (solid lines) and potential transfer or impacts from spilled oil (dashed lines).

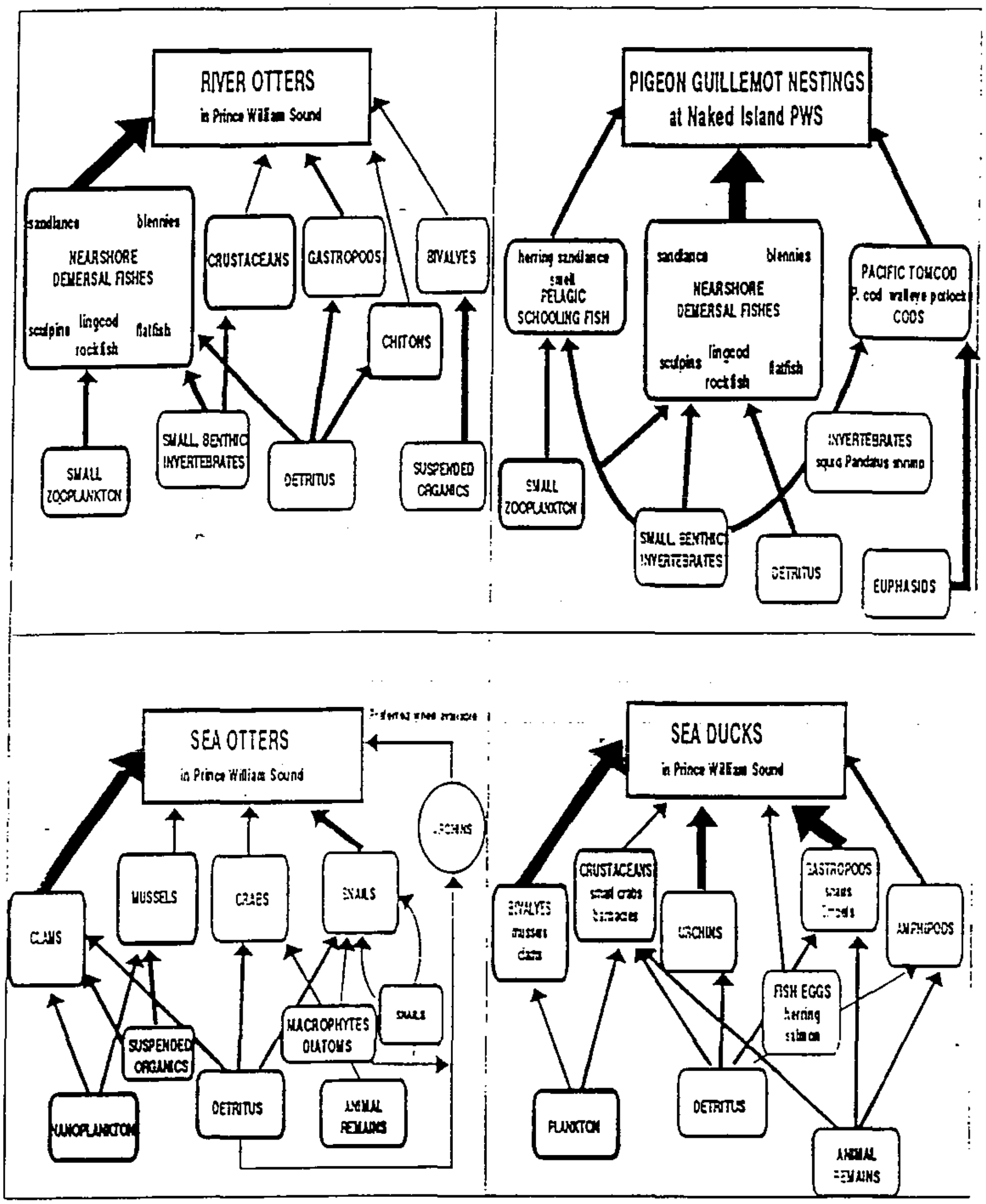


Figure 2. Food web of the four selected key species proposed for study under the Nearshore Vertebrate Predator 95025 package.

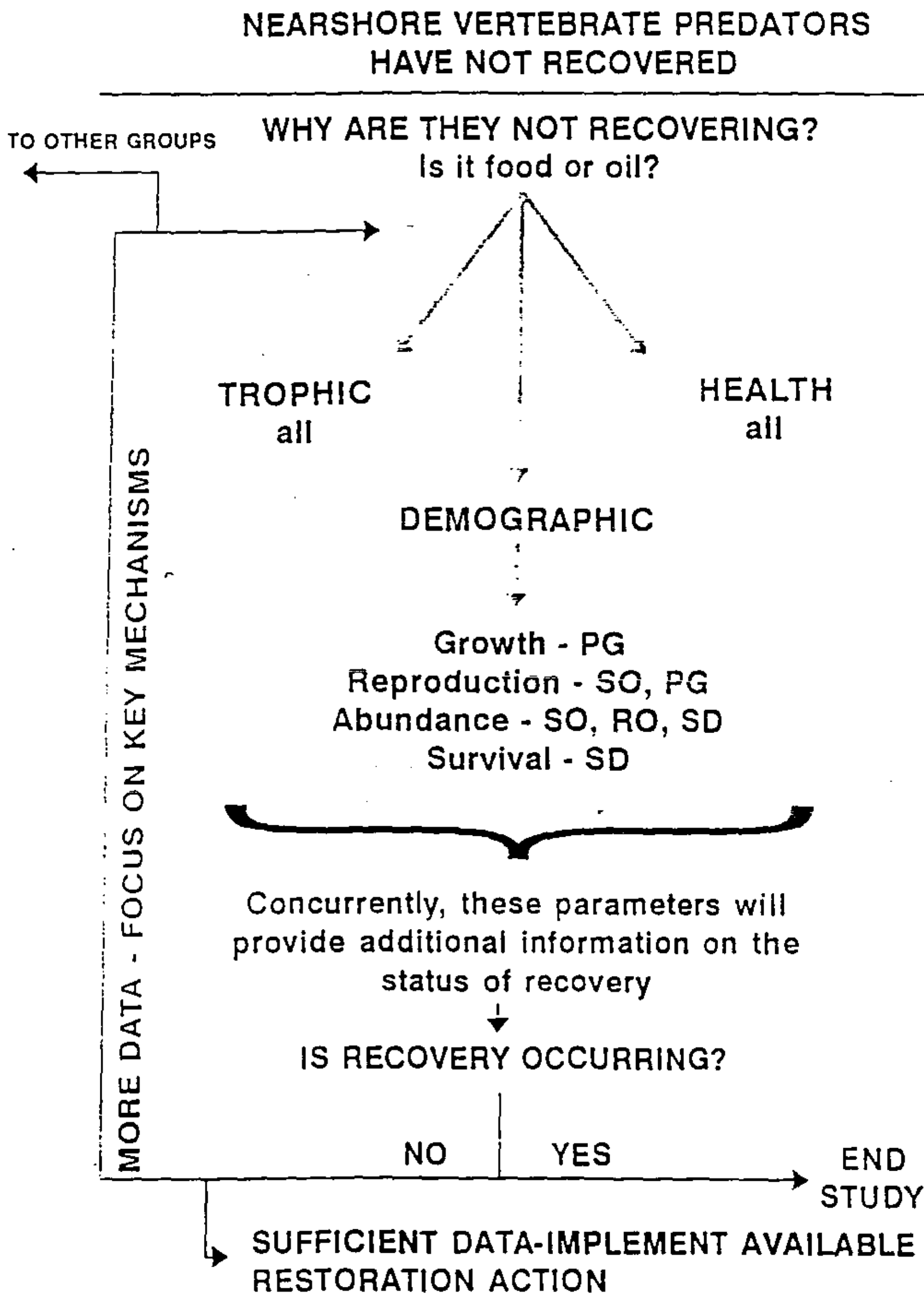


Figure 3. Approach to be taken in study.

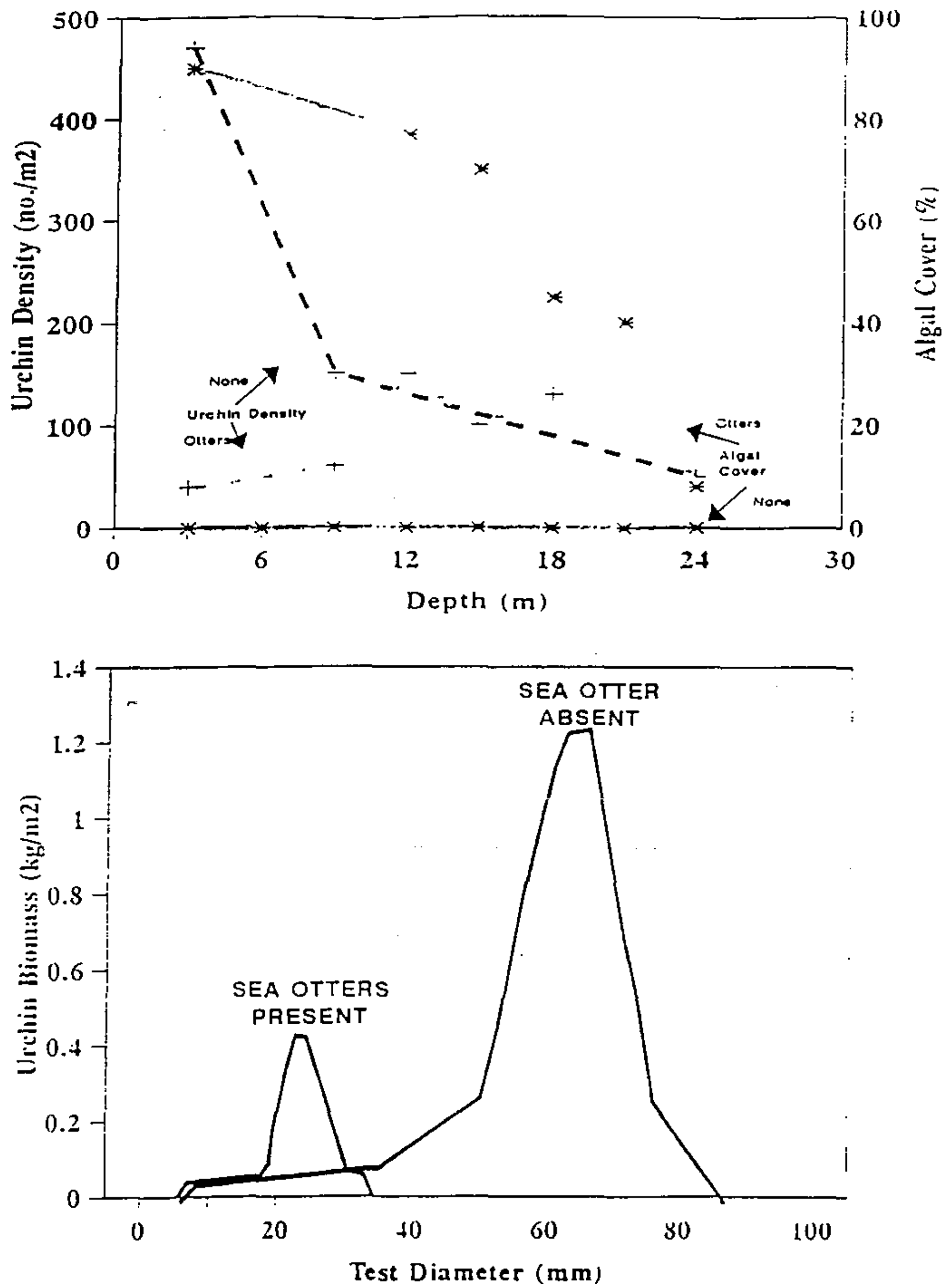


Figure 4. Comparative relationships of sea urchins population densities to algal cover and sizes of individual sea urchins to urchin biomass between Aleutian islands with sea otters (Amchitka) and without sea otters (Shemya). Modified from O'Clair and Zimmerman 1987, Figure 11-17, after Estes and Palmisano 1974.

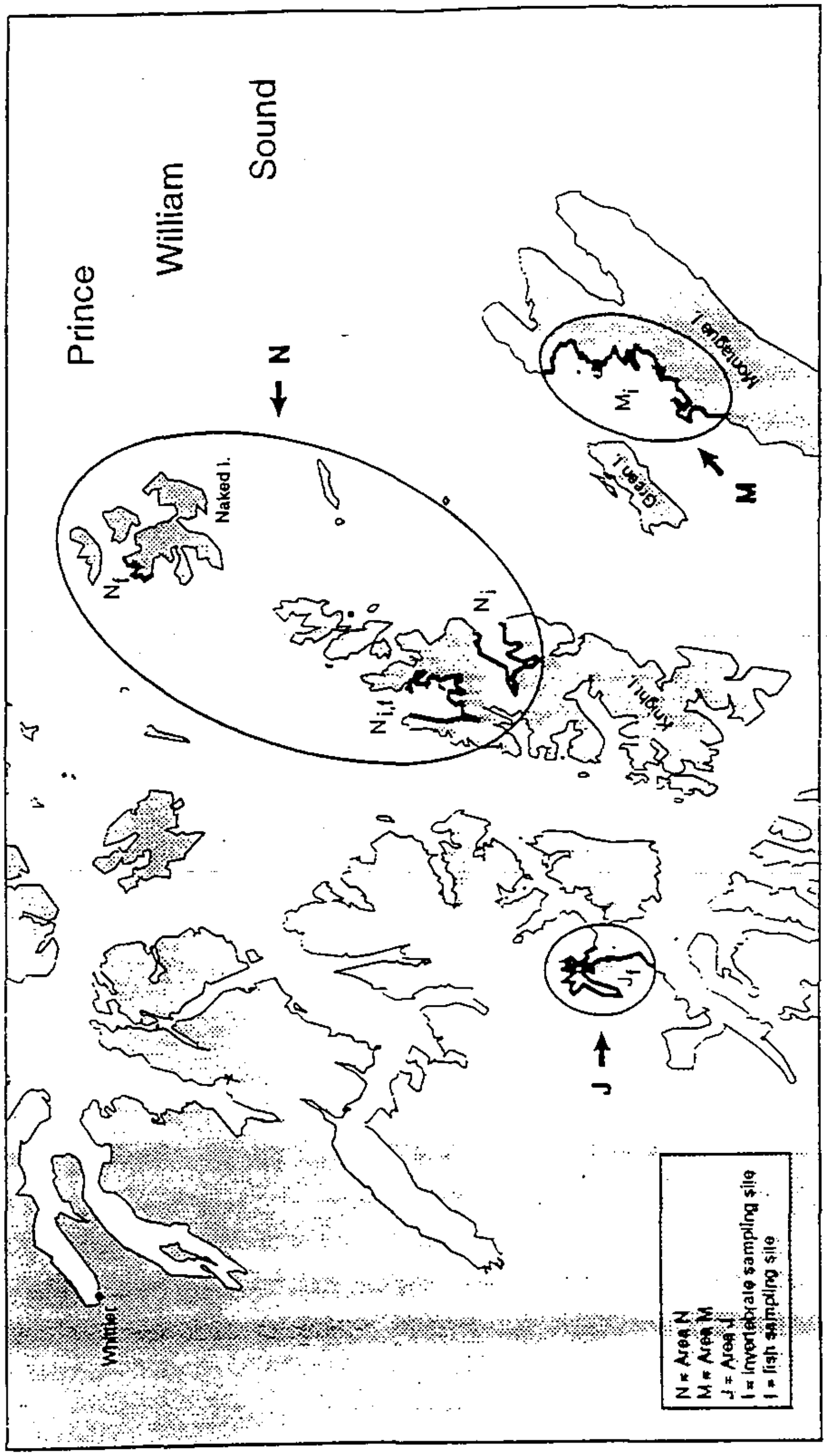


Figure 5. Study areas.

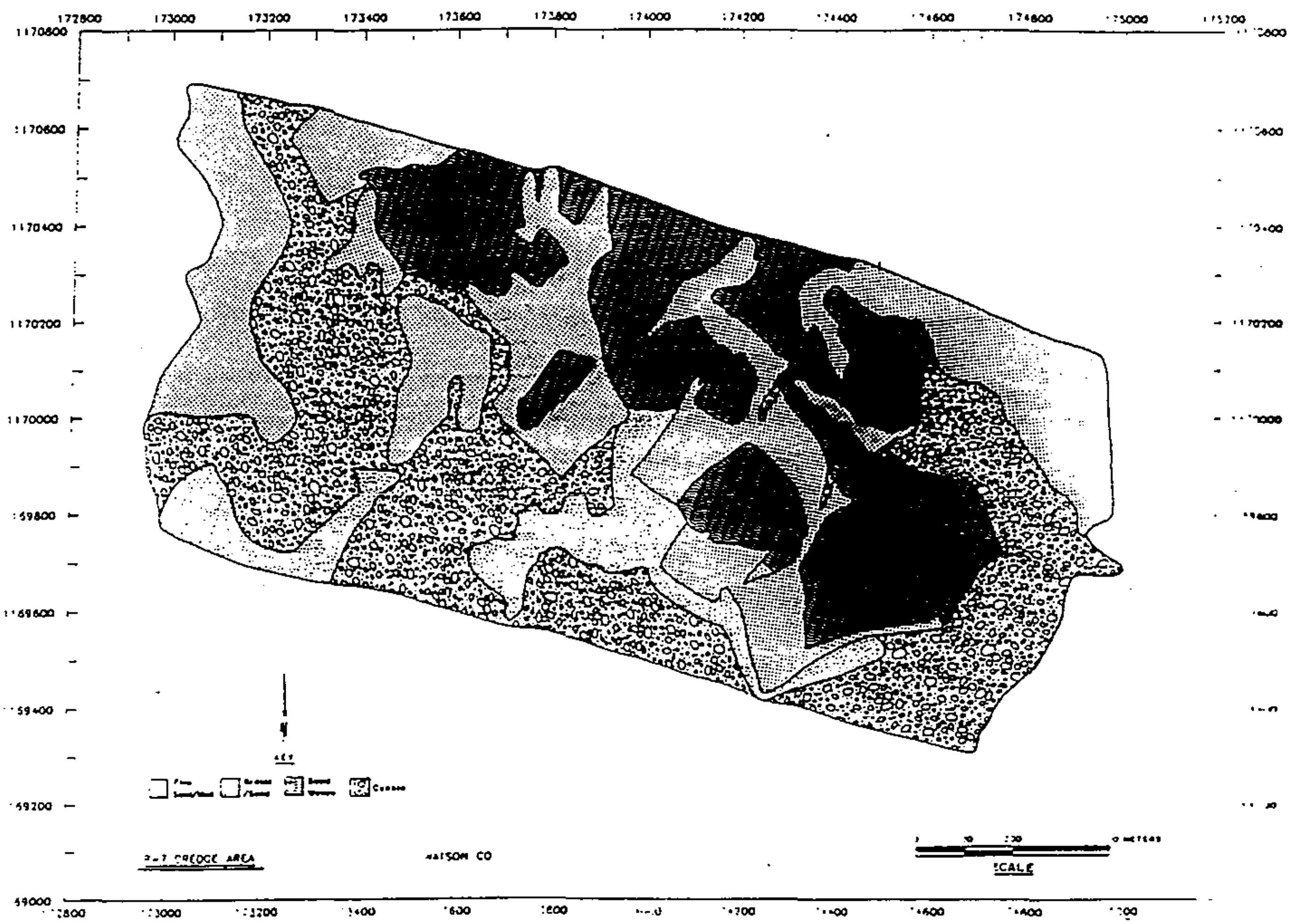
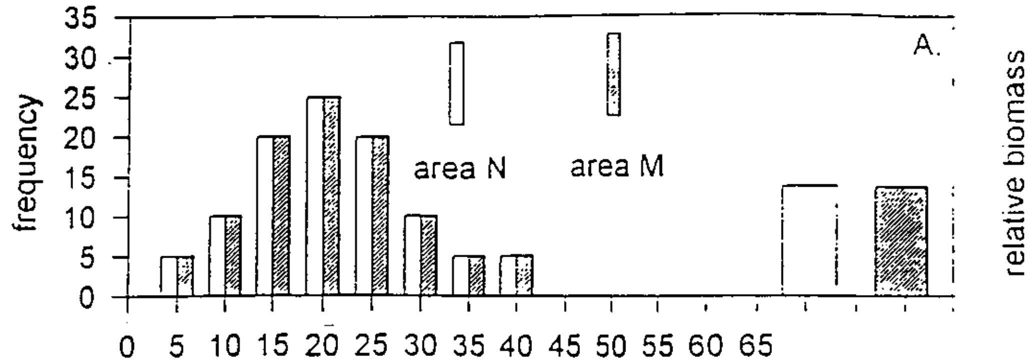


Figure 6. Example of a side-scan sonar record.

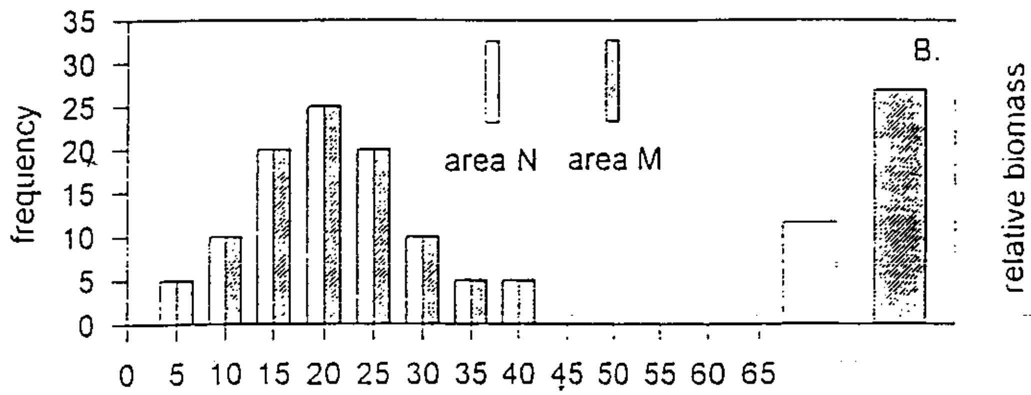
A. Size class structure of a "typical" invertebrate prey, in the presence of sea otters: assuming equal prey biomass among areas

Conclusion: predation pressures equivalent, recovery occurring



B. Size class structure of a " typical" invertebrate prey, in the presence of sea otters: assuming prey biomass is greater in area M

Conclusion: food is limiting, recovery uncertain



C. Size class structure of a "typical" invertebrate prey, in the presence (area M) and absence (area N) of sea otters: assuming prey biomass is greater in area N.

Conclusion: predation pressures not equivalent, recovery not occurring

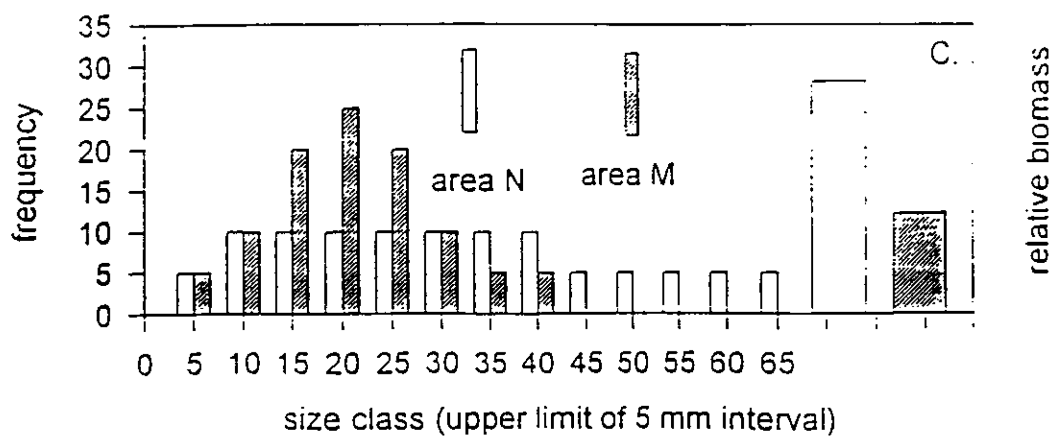


Figure 7. Three theoretical examples of how prey biomass and size class structure may be interpreted in relation to status of predator recovery and if food is at issue.

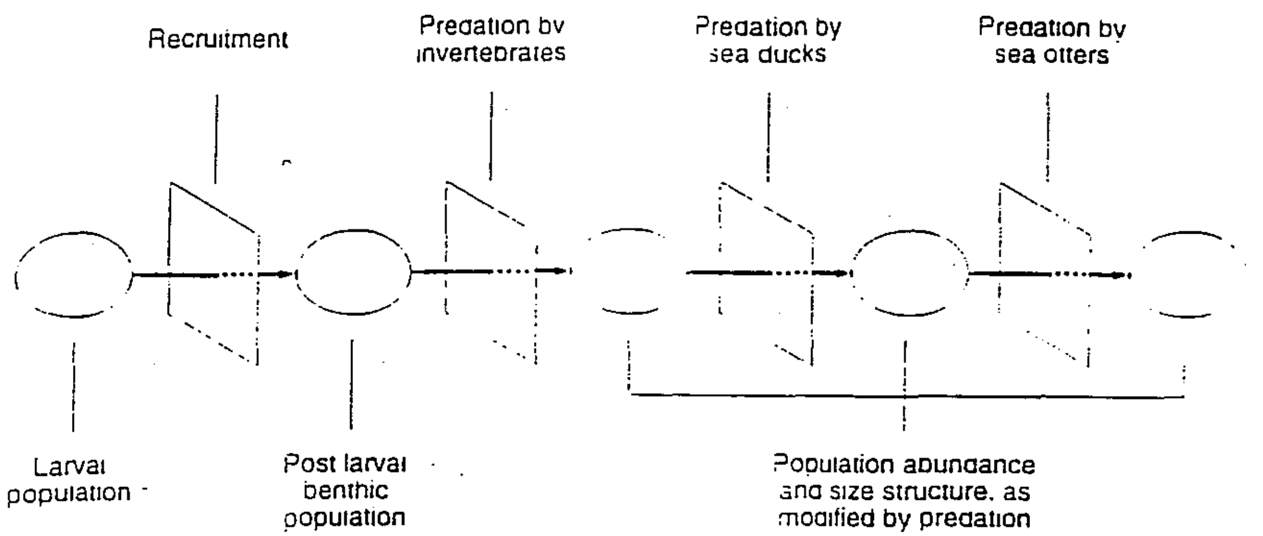


Figure 8. Theoretical "filters" that influence invertebrate prey size structure.

6.0 Appendices

6.1 General Hypotheses

Based on a wide variety of coordinated meetings including "Science for the Restoration Process" held April 13-15, 1994 (EVOSTC 1994b), a number of general hypotheses have been developed related to factors limiting recovery in the nearshore ecosystem:

1. *Involving Ecosystem Processes*

   1.a.Trophic Factors Hypotheses--
   1.a.i.The EVOS induced changes in populations of dominant competitors and resident predators in the nearshore region are limiting recovery of benthic communities;
   1.a.ii.EVOS induced changes in populations of benthic prey species have influenced the recovery of benthic foraging predators;
   1.a.iii.EVOS induced changes in top predators have influenced the recovery of EVOS injured benthic prey populations;

   1.b.Recruitment Hypothesis
   1.b.i.Recovery of nearshore resources injured by EVOS is limited by recruitment processes;

   1.c.Physical Limitations Hypothesis
   1.c.i.Physical processes limit the recovery of nearshore ecosystems.

2. *Involving Oiling From Initial or Continuing Exposure*
   2.a.Oil Toxicity/Contact Exposure Hypothesis
   2.a.i.Initial and/or residual oil in benthic habitats has a toxicological effect limiting the recovery of benthic communities ;
   2.a.ii.Initial and/or residual oil in benthic habitats and in or on benthic prey organisms has had a limiting effect on the recovery of benthic foraging predators;

6.2 Cytochrome P4501A Background and Methods

Provided by Dr. J. Stegeman, Woods Hole Oceanographic Institution

One of the most promising and revealing biomarkers of exposure to hydrocarbons is the induction of cytochrome P4501A. Numerous experimental studies confirm that in vertebrates selected HAH and PAH cause activation of genes classified in CYP gene family 1. These genes are further classified in gene subfamily 1A (hence, CYP1A) and subfamily 1B.

In terrestrial mammals there are at least two CYP1A genes, CYP1A1 and CYP1A2. The CYP1A1 is inducible in liver and extrahepatic organs. In birds there appear to be two CYP1A genes (Rifkind et al., 1994), not yet classified further. In fish there is clear evidence for induction of a P450 that may be orthologous to both the 1A1 and 1A2 forms (Stegeman, 1989; Morrison et al., 1995). In marine mammals there is at least one CYP1A, that is a CYP1A1-like protein (White al., 1994).

Studies with multiple species of fish, birds and mammals, from different parts of the world, have revealed close correlations between the levels of CYP1A and the levels of PCBs or PAH either in the organisms or in their immediate environment. Antibodies to the cytochrome P4501a from fish are now commonly used to demonstrate unambiguously that CYP1A forms are elevated in fish from contaminated regions. Studies in the flounder *Platichthys flesus* from Langsundsfjord, Norway (Stegeman et al., 1988), in starry flounder (*Platichthys stellatus*) from San Francisco Bay (Stegeman et al., unpublished), and in rattail (*Coryphaenoides armatus*) from the deep ocean (Stegeman et al., 1986) have all shown close correlation between the levels of induction of CYP1A in hepatic microsomes and the levels of total PCB residues. The content of CYP1A in the liver of birds correlates with the contamination by inducers (Rattner et al., 1993). In marine mammals there is close correlation between the amount of CYP1A in the liver and the content of toxic PCB residues on the blubber (White et al., 1994). The growing number of such studies provides a consistent picture, supporting use of the levels of a specific cytochrome P450 isozyme as a biomarker for levels of contaminants in the environment and/or in the organisms themselves. Thus, CYP1A induction can be a highly sensitive indicator or biomarker of the burden of toxic inducing compounds in vertebrate organisms, or their environment.

CYP1A Induction in Endothelial Cells

Most CYP1A induction studies have focused on the liver, a major site of metabolism of these compounds. However, extrahepatic organs are also prominent sites of CYP1A induction. We have used immunohistochemistry to detect induction in extrahepatic organs as a marker of exposure. A very significant site of induction established in general among the vertebrates is in the endothelial cells that line the blood vessel (Dees, Masters et al. 1982; Miller, Hinton et al. 1988; Stegeman, Miller et al. 1989; Smolowitz, Hahn et al. 1991). Endothelia form a barrier between blood and surrounding tissues in all organs. This gives it a potential role analogous to that of the skin or the intestinal epithelium, as a site at which xenobiotics can be intercepted before entering other functional cells of an organ. Xenobiotic metabolism in endothelial layers could influence strongly the identity and amounts of a compound distributed throughout the organism. As such, the endothelium could play an important role in pharmacokinetics. Processes determining the nature of the dose reaching target cells in other organs could also be a determining factor in, for example, toxic effects in the gonads, the brain and other key organs involved in reproduction. We also have examined the induction of CYP1A in mammalian endothelial cells in culture, establishing EC50 for induction by TCDD, 3,3',4,4'-tetrachlorobiphenyl and by benzo(a)pyrene (Stegeman et al. 1995).

The in vitro and in vivo studies suggest that the endothelium may be an ideal site for analysis of CYP1A induction. Examination of endothelium by immunohistochemistry or other techniques could make it possible to use small biopsy samples for analysis, avoiding destructive sampling of internal organs. The levels of CYP1A in endothelia could give an estimate of current and recent exposure not only of the organ in which the endothelium is examined, but of the organism in general. Thus, endothelial CYP1A expression in dermal endothelial cells present in the biopsy samples to be examined in this study should be predictive of exposure and induction in the endothelium in other organs, and possibly of other cell types where effects may be exerted. We are applying this approach to marine mammals (cetaceans).

Detection of Induction

Induction of CYP1A can be detected in several ways: 1) by catalytic (enzyme) assay, 2) by immunoassay, using antibodies to the CYP1A protein, or 3) by assay of the amount of the messenger RNA (mRNA) that codes for the protein. Catalytic assay, immunoassay and measurement of mRNA provide complimentary information, that can greatly amplify interpretations made in studies of CYP1A gene regulation (see for example, Kloepper-Sams and Stegeman, 1992). Specificity in detection is important.

> (1) Few enzyme activities are known to be catalyzed only or primarily by CYP1A forms are known; the O-deethylation of ethoxyresorufin (EROD) appears to be such an activity. Analysis requires properly frozen or fresh material.
>
> (2) Some of antibodies have been shown to cross-react widely with CYP1A proteins in species other than those from which the immunogen was purified. Monoclonal antibody 1-12-3 that we developed against a fish CYP1A1 (Kloepper-Sams et al., 1987) cross-reacts with CYP1A1 in every vertebrate species we have tested, more than 200 fish, birds, reptiles and mammals (Stegeman and Hahn, 1994). Species previously examined with this antibody include Harlequin ducks and pinnipeds (unpublished).
>
> (3) Several groups have developed cDNA probes or specific oligonucleotide sequences, for use in hybridization procedures to detect CYP1A mRNA. The primers that we have designed for cloning and sequencing of CYP1A from fish (Morrison et al, 1995) appear to be universally applicable to vertebrate CYP1A genes. These may be tested for applicability in a quantitative reverse-transcriptase -PCR approach to measure the amount of CYP1A MRNA in the species of concern.

Proposed Analyses

We propose to analyze the expression of CYP1A in tissues of the sea otters, river otters, harlequin ducks and pigeon guillemots or other vertebrate species, using whatever approach appears to be most suitable for the type of tissue and the method of preservation. At minimum we propose to use immunohistochemistry on skin biopsies as well as any other tissues that may be obtained. Samples will be preserved in 10 volumes of 10% buffered formalin. If possible, we would propose to corroborate the IHC results with immunoblot analysis. We will use the MAb 1-12-3 described above.

We also would propose to collaborate with investigators who propose to use quantitative RT-PCR, for example on blood samples (Lorr et al., 1992), if the biopsy samples do not provide suitable results by immunoassay.

Immunohistochemistry

Prior to immunochemical staining, standard 5 μm sections are deparaffinated and hydrated in 1% bovine serum albumin/ phosphate buffered saline (BSA/PBS). During the hydration process, sections are incubated in 0.5% H_2O_2 in methanol for 45 minutes to block endogenous peroxidase (Polak and Van Noorden 1983). Hydrated sections are immunochemically stained using an indirect peroxidase stain (Universal Immunoperoxidase Staining Kit (Murine), Signet Laboratories, Inc., Dedham, MA) with MAb 1-12-3 to scup CYP1A as the primary antibody, as described below. Previous immunofluorescent studies have demonstrated the specificity of Mab 1-12-3 for CYP1A in tissue sections by immunoadsorption.

After hydration in 1% BSA/PBS, sections are incubated in normal goat serum (NGS) for 20 minutes to block any possible nonspecific attachment of the secondary antibody (goat antimouse IgG)(Polak and Van Noorden 1983). Sections are washed once for 5 minutes and then incubated in 1/24,000 dilution (1.7 5g protein/ml) of Mab 1-12-3 in 1% BSA/PBS for 18 hours (overnight). Incubation in primary antibody is followed by washing with 1% BSA/ PBS. This wash procedure follows all antibody incubations. Next, sections are incubated in a 1/200 dilution of goat-antimouse IgG for 20 minutes, washed and then incubated in a 1/600 dilution of peroxidase labeled nonspecific mouse IgG for 20 minutes. After another wash, sections are incubated for 30 minutes in 3-amino-9-ethylcarbazole (AEC) in acetate buffer to develop color. Sections are rinsed and then counterstained with Mayers hematoxylin, and mounted in glycerol (Smolowitz, Hahn et al. 1991). Two types of controls are used: (1)

Sections of liver from a fish (scup; *Stenotomus chrysops*) with high and one with low content of CYP1A (as determined by EROD activity and immunoblotting) are included in every stained group as controls for the staining method. (2) Matching serial sections of all tissues are stained using a nonspecific IgG (Purified mouse myeloma protein, UPC-10, IgG2A, Organon Teknika, West Chester, PA) at 1.5 5g protein/ml of 1% BSA/PBS (Polak and Van Noorden 1983).

Specific staining by MAb 1-12-3 will be evaluated by light microscopic examination of the stained sections. Cell types that stain and their associated occurrence and staining intensity will be recorded for each tissue section examined. At least two immunochemically stained sections will be examined from each sample. Comparative staining results for each sample will be described in relationship to whales from all samples, and reported as negative, mild, mild/moderate, moderate, strong or very strong. Quantitative comparisons will be made using the product of scaled values for intensity and occurrence.

Quantitative PCR and RT-PCR

RNA Isolation: We will initially apply quantitative RT-PCR methods to the analysis of pilot whale liver mRNA. We also will use samples of either scup or toadfish RNA as a procedural control, given that we have primers previously demonstrated to be effective with these species. Total RNA will be prepared as described above.

Amplification and Detection: Procedures will be those of (Gilliland et al. 1990) as modified by others (Vanden Heuvel et al. 1993). Eight or more equal aliquots of total RNA from a liver or skin sample, initially 0.1 5g RNA per aliquot, will be prepared and a dilution series of an internal standard will be added to the aliquots. A standard for the competitive PCR will be created by PCR reactions using CYP1A-gene specific primers. Conditions may vary but for example will be: 94 C for 1 min, 37 C for 1 min and 72 C for 90 seconds, 30 cycles. A PCR product of suitable size, e.g., about 170 bp, will be isolated and subcloned into a plasmid. Both the DNA plasmid construct and the cRNA transcript from the plasmid will be tested for utility as the internal standard for the competitive PCR. The amplified target sequence and internal standard will be resolved on 3% agarose gel, and visualized with ethidium bromide. Alternately, the bands will be detected by hybridization to a labelled cDNA probe.

The procedures for amplification will consider the sources of error as discussed by others (Foley, Leonard et al. 1993). The use of an internal control to minimize tube to tube variability is recommended, and has been used by (Vanden Heuvel, et al. 1993) who applied quantitative PCR to measure CYP1A1 in lymphocytes of humans (Vanden Heuvel, et al. 1993). However, in practice, Jefcoate et al have found that the internal control is not always necessary (Jefcoate, personal communication).

Immunoblot

Western blot analyses will be performed with microsomes prepared as previously described (Stegeman, Teng et al. 1990). 10-60 ug of microsomal protein will be run on SDS-PAGE gels and transferred overnight to 0.22 um nitrocellulose sheets (Scheicher and Schuell) at 4°C (BioRad transblot). Incubations of nitrocellulose will be carried out in the presence of 5% (w/v) dry milk in Tris-buffered saline (TBS) to block nonspecific reaction. Antibodies will be diluted in TBS/milk to 100 ug/ml and incubated with the nitrocellulose for appropriate times, 2 hours with MAb 1-12-3. The secondary antibody, alkaline-phosphatase conjugated goat anti-mouse IgG (BioRad) will be incubated with the sheets for 1 hour. Color will be developed by incubating the blots with 0.1 M $NaHCO_3$, 1mM $MgCl_2$ (pH 9.8) buffer containing 0.33 mg/ml nitroblue tetrazolium (BioRad) and 0.165 mg/ml 5-bromo-4-chloro-3-indoyl phosphate (BioRad), added in dimethylformamide as per the BioRad protocol for use with alkaline phosphatase. Alternately, we will use enhanced chemiluminescence. Antibody staining will be quantified densitometrically. Induced and uninduced scup liver microsomes will be used as controls.

Data will be analyzed using Abacus Concepts Statview®. Comparisons of means for CYP1A content or activity were made between groups from the various sites. A one way ANOVA using Fisher's protected least significant difference (PLSD) was used to establish significant differences between sites ($p < 0.05$).

Costs:

Costs for the proposed work are $140 per sample for analysis of CYP1A by immunohistochemistry, with a minimum of 100 samples. A sample is defined as one block of paraffin-embedded tissue. Cost will include preparation, processing, analysis and data reduction, and report writing, and will include technician and principal investigator time.

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7.0 Schedule

7.1 Proposed General Schedule

The NVP Project will begin in mid-summer 1995 with a program of primarily pilot efforts. These efforts will be used to establish final sample size and experimental design requirements for invertebrate sampling, validate a number of techniques and establish up-to-date sea otter population data prior to full study implementation in the spring of 1996. The investigators feel that these preliminary efforts will result in the most cost effective implementation of the full study design. In addition to these preliminary efforts, the sea duck component of the study will be initiated in full because of its fall/winter data collection needs. There will be full field seasons in 1996 and 1997. In December 1997, a full review of the first two years will be conducted to assess the status of species recovery and to allow for adaptive management options. Should all test species suggest recovery, the project would be recommended to move into final data analysis and report mode. It is most likely, however, that a full 1998 field season will be warranted or a modification to close out assessments that would focus on select components of the project with full analysis and project completion by October 1999. Because of this, only the FY 95-97 proposed schedules are provided below.

7.2 FY 1995 Draft Schedule

July
1. River otter/Pigeon Guillemot: Collection of tissue samples in Kachemak Bay (separate funding) to validate biomarker assays to be employed in 1996 and 1997.
2. Mussel/clam/urchin/fish and invertebrate predators: Side scan sonar to classify habitat types in Areas M, N, and J.
3. Mussel/clam/urchin/fish and invertebrate predators: Subtidal and intertidal reconnaissance survey of Areas M, N, and J to establish and test sampling methods and conduct test sampling required for conducting power analyses. Study site selection.
4. Sea otter: Aerial survey of western Prince William Sound.

August
1. Sea otter: Boat based surveys of sea otter reproduction.
2. Harlequin: Vessel charter for harlequin duck capture and collection.

September
1. Harlequin: Complete capture and collection, begin survival monitoring.

7.3 FY 1996 and 1997 Draft Field and Reporting Schedule

October
1. Harlequin: Continue survival monitoring.
2. Sea otter: Aerial survey of western Prince William Sound.

November
1. Harlequin: Continue survival monitoring and other sea duck skiff surveys.

December
1. Harlequin: Continue survival monitoring.
2. *All project components: Submission of brief field season summary reports.*
3. *Overall 95025 status report to EVOS Chief Scientist.*
4. *Project meeting to discuss field season outcomes and develop/revise proposed approach.*

January
1. Harlequin: Continue survival monitoring and other sea duck skiff surveys.
2. Invert. predator: Complete sampling of all study sites
3. *Reporting of project findings at Restoration Workshop*

Febuary
1. Harlequin: Continue survival monitoring.

March
1. Harlequin: Continue survival monitoring and other sea duck skiff surveys.

April
1. River otter: Live trapping for morphometrics and tissue sampling.
2. Sea otter: Beach-cast carcass survey.
3. *All project components (1996): Submission of 1995 Progress Reports.*
4. *All project components (1997): Submission of 1996 Progress Reports*

May
1. River otter: Live trapping for morpometrics and tissue sampling.
2. Pigeon Guillemot: Active nest surveys.

June
1. Pigeon Guillemot: Active nest surveys, blood sampling, prey sampling, and nest monitoring.
2. Sea Otter: Prey selection and foraging success.

July
1. Pigeon Guillemot: Active nest surveys, blood sampling, prey sampling, and nest monitoring.
2. Sea otter: Aerial survey of Prince William Sound, capture for morphometrics and tissue collection. Prey selection and foraging success.
3. Mussel/clam/urchin/fish and invertebrate predators: Vessel charter to sample Areas M, N, & J.

August
1. River otter: Latrine sites located, sampled, and monitored.
2. Pigeon Guillemot: Active nest surveys, blood sampling, prey sampling, and nest monitoring.
3. Sea otter: Boat based surveys of sea otter reproduction.
4. Harlequin: Vessel charter for harlequin duck capture.

September
1. Harlequin: Complete capture and collection, begin survival monitoring-96.

NOTE: Field sampling in 1997 will follow the 1996 schedule except for the addition of two winter mussel field sampling trips.

NOTE: All projects currently proposed are scheduled for comprehensive review at the end of FY 1997. It is possible that the results from fieldwork completed in 1995, 1996, and 1997 will indicate the need for modified, and/or additional fieldwork.

8.0 Existing Agency Program

The cooperating agencies under the Nearshore Vertebrate Predator Project 95025 have a variety of existing research programs related to the selected vertebrate predators and invertebrate prey under study. The Alaska Science Center has an extensive sea otter, sea bird, and coastal invertebrate program that has been involved in oil-spill related activities since 1989 as well as many complimentary research projects throughout coastal Alaska. The Center infrastructure is available to provide equipment, budget, and technical support to this effort. The University of Washington program personnel are active in the study of sea otters and invertebrates with a significant research history in Prince William Sound and the extensive University of Alaska coastal research program will serve to compliment the proposed research. Finally, the National Marine Fisheries Service actively participates in a number of oil-spill related studies and has extensive invertebrate expertise and equipment that will facilitate this effort.

9.0 Environmental Compliance

Study plans for this project are subject to approval by the Animal Care and Use Committee (ACUC) of the various cooperating agencies--the Alaska Science Center-National Biological Service (ASC-NBS), University of Washington (Washington Cooperative Fish and Wildlife Research Unit), University of Alaska-Fairbanks (Alaska Cooperative Fish and Wildlife Research Unit), National Marine Fisheries Service, and Alaska Department of Fish and Game, which are responsible for ensuring compliance with the provisions of the Animal Welfare Act. Documentation and currency of those reviews and approvals with be maintained the Program Chief Scientist, Dr. Leslie Holland-Bartels, ASC-NBS.

Many of the field work components of the study for vertebrates rely on observations and are non-intrusive. However, any capture activity is conducted under review of the above ACUC committees with final review of the Program Chief Scientist. Surgical implantation of transmitters will follow a standard protocol approved by the ACUC of the Alaska Science Center and will be conducted by or under the supervision of the ASC-NBS Research Veterinarian, Dr. Dan Mulcahy, PhD., DMV. The proposed Harlequin duck take will be reviewed and permitted under the following process: An application for the proposed collection will be submitted to the Division of Law Enforcement (LE), U. S. Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADFG). The USFWS will convene a panel of scientists to examine the application and research proposal for scientific merit and potential impact to populations and other research. A copy of the application is forwarded to the waterfowl coordinator, ADFG, who will provide an evaluation to LE. When the federal permit is issued it is submitted to ADFG, which initiates further review by headquarters staff before a state permit is issued. Federal and State permits must be in the possession of the permittee prior to any collection. Federal marine mammal permit for sea otter activities and general State collection permits are in possession or will be in place prior to initiation of any field work. The Program Chief Scientist will review permits for currency and keep documentation on file at ASC-NBS.

10.0 Performance Monitoring

This program is submitted by the Lead Agency Alaska Science Center, National Biological Service, located in Anchorage Alaska. Dr. Leslie Holland-Bartels, as Program Chief Scientist, NBS liaison to the Trustees, and Branch Chief for Marine Research for ASC-NBS will have both research and contractual oversight responsibilities for the program. Project personnel are either employees of the ASC-NBS or will function under contractual obligation to ASC-NBS through the Research Work Order Process (e.g. University of Washington and University of Alaska-Fairbanks) or are employees of other Trustee Agencies (e.g. USFWS, NMFS, ADFG).

Scientific and technical aspects of this study will be subject to internal review within the ASC-NBS, as the Program Manager. Cooperating agencies will provide regular internal review of their programs to the ASC in line with their established review processes. Work plans, study design, and final reports will be subject to the technical review of the Program

Statistician Dr. Lyman MacDonald and Program Chief Scientist Dr. Leslie Holland-Bartels, as well as the established internal review process of the ASC and the peer review process established by the Trustees Council and the EVOS Chief Scientist. Project dates/deadlines for products will be monitored by Leslie Holland-Bartels. Monthly teleconferences and semiannual project reviews will be held to ensure work is progressing on all components in a timely manner, and to identify and respond to specific issues or concerns. Significant findings presented in final reports will be submitted for publication in peer-reviewed scientific journals and presented at scientific meetings as they become available.

11.0 Coordination of Integrated Research Effort

This project was developed and submitted in cooperation among the National Biological Service, National Oceanic and Atmospheric Administration, U. S. Fish and Wildlife Service, Alaska Department of Fish and Game, University of Washington, and the University of Alaska-Fairbanks. Work conducted on the integrated Nearshore Vertebrate Predator Project will be coordinated among these agencies. Cooperation outside of the specified project participants includes coordination of field work and sharing of data with the monitoring efforts for pigeon guillemots under the Seabird/Forage Fish Interactions Project (Project 95163) to facilitate field operations and collection of common data. Many elements of the river otter and pigeon guillemot research is a parallel effort ongoing in Kachemak Bay (funded through the UAF Coastal Marine Institute) and will result in a broader examination of many of the bioindicator hypotheses forwarded in Project 95025. Harlequin duck molting drives are being coordinated with Dan Rosenberg of the Alaska Department of Fish and Game. Data from duck surveys and regarding duck condition and diets for populations at North Montague Island will be shared with Mary Anne Bishop of the Copper River Delta Institute. Oceanographic and existing invertebrate data specific to species under study for Project 95025 will be obtained through Project 95320, Prince William Sound System Investigation. Continuing information will be exchanged between this project and previous and ongoing nearshore efforts. Coordination through subject-specific workshops (e.g.Intertidal workshop planned for March 1995) and the annual EVOS Restoration Workshop will facilitate regular exchange of information and identification of further opportunities for economies through project collaborations.

12.0 Public Process

The project concept was developed as a result of the April 1994 "Science for the Restoration Process" workshop, a public forum. Continued discussion of the project occurred through the 1995 Work Plan and the initial project underwent public review through the Trustees Council process. Planning funds were approved by the Trustees in November 1994 at public meeting. Subsequently, a working meeting was held in November to discuss the framework for the project, also an open meeting. The Nearshore Vertebrate Predator Project was presented at January 1995 Trustees sponsored Restoration Workshop in Anchorage. Further opportunities for public input will be available at one March workshop and the Trustees meeting when the project proposal is presented.

13.0 Personnel Qualifications

Dr. Brenda Ballachey, Physiologist at the Alaska Science Center, NBS has been project manager and senior scientist for the damage assessment and restoration work on sea otters since 1990. She has over 15 peer reviewed scientific publications and was responsible for or author on 19 NRDA reports recently completed on sea otter issues.

Mr. Jim Bodkin, Research Wildlife Biologist, is the Project Leader for sea otter population research for the Alaska Science Center of NBS. He has over 18 peer-reviewed scientific publications and is involved in an active sea otter research program. He has actively studied and published on sea otter foraging ecology and community structuring since 1988 and has been principal investigator for sea otter survey methods development.

Dr. R. Terry Bowyer, Professor of Wildlife Ecology, University of Alaska Fairbanks. Dr. Bowyer has an extensive publication record (46). He has conducted extensive research on river otters and impacts of EVOS on this species.

Dr. Thomas A. Dean, is President of the ecological consulting firm Coastal Resources Associates, Inc, (CRA) in Vista, CA. He has over 20 years of experience in the study of nearshore ecosystems, and has authored over 20 publications, including several papers dealing with sea urchin and kelp interactions. He has extensive experience in long-term monitoring studies with marine plants and invertebrates. He has had a major role in both the shallow subtidal and intertidal EVOS investigations since 1989.

Dr. Lawrence Duffy, Professor of Chemistry and Biochemistry at the University of Alaska Fairbanks has been working in the area of toxicology for 15 years and is a member of the International Society of Toxicology. He has studied various bacterial and mammalian toxins. Since the *Exxon Valdez* oil spill, he has published four papers related to developing biomonitors. He is currently funded for two major environmental studies in Alaska. At the University, he teaches "Environmental Biochemistry and Biotechnology" and is a member of the Environmental Chemistry Program and Mammal Group.

Mr. Daniel Esler is a Wildlife Research Biologist for the Alaska Science Center, National Biological Service with a Master of Science in Wildlife Ecology, Department of Wildlife and Fisheries Sciences, Texas A&M University (Avian associations with hydrilla). He has worked primarily with aquatic birds, including extensive experience in Alaska. He has nine publications in national peer reviewed journals such as Wildlife Management, Wilson Bulletin, Journal of Field Ornithology, Condor and others.

Dr. Leslie Holland-Bartels, BS University of Massachusetts, MS Louisiana State University, Ph.D. Purdue University is the head of the Marine and Freshwater Ecology Research Program for the Alaska Science Center, NBS and directs research of 17 senior scientists in the areas of seabirds, marine mammals, anadromous fisheries, and associate habitat and population issues. She has 20 years experience in aquatic ecology and over 30 publications in national scientific journals on subjects ranging from contaminants, ecology of invertebrates, fisheries, water quality and aquatic ecology.

Mr. Stephen C. Jewett has been a Research Associate at the School of Fisheries and Ocean Science, University of Alaska Fairbanks, since 1975. During this time he has been involved in numerous benthic and intertidal investigations throughout Alaska that emphasize assessment and/or monitoring. He has authored more than 30 publications in scientific journals and books. He has been the coordinator of the federal/state EVOS shallow subtidal investigations in Prince William Sound (1989-1994).

Ms. Karen Laing, B.A. Stanford University, M.S. University of California, Davis, is a Wildlife Biologist for Migratory Bird Management, U.S. Fish and Wildlife Service, Anchorage, Alaska. Her research experience has focused on foraging ecology and population dynamics of waterfowl. Since 1991 she has designed, conducted and analyzed population surveys of waterfowl throughout the state. Earlier she was the Principal Investigator for Exxon Valdez Oil Spill Damage Assessment Bird Study No. 2, for which she conducted boat surveys of marine bird and mammal populations in Prince William Sound, Alaska. Her publications include Oil Spill Natural Resources Damage Assessment Bird Study No. 2. and publications in Condor, Applied Animal Behavioral Science, and Raptor Research.

Dr. Lyman MacDonald, B.S., M.S. Oklahoma State University, PhD. Colorado State University, is a biometrician with 25 years of comprehensive experience in the application of statistical methods to design, conduct, and analyze environmental and laboratory studies. He has designed and managed both large and small environmental impact assessment and monitoring programs.

Dr. Charles E. **O'Clair**, B.S. Zoology, 1963 University of Massachusetts, Ph.D. Fisheries, 1977, University of Washington. 1977-present: Fishery Biologist (Research), National Marine Fisheries Service, Auke Bay Laboratory, Juneau, Alaska. Research experience includes seven years of field and laboratory work on the effects of oil pollution and, later, the effects of logging on benthic invertebrates, eleven years of research on the ecology and behavior of Dungeness, king and Tanner crabs in relation to the management of these species, four years of research on the impact of the *Exxon Valdez* Oil Spill on subtidal sediments in Prince William Sound and the Gulf of Alaska and one year on the recovery of subtidal sediments in Prince William Sound.

Dr. Alan **Rebar** is Professor of Veterinary Clinical Pathology and Associate Dean for Research of the Department of Veterinary Pathobiology, Purdue University. He has been involved in EVOS clinical pathology studies of sea and river otters since 1991.

Dr. Dan Roby has conducted research on the physiological ecology and reproductive energetics of high latitude seabirds for the last 15 years. His field research on alcid reproductive biology has been in Alaska, Newfoundland, and Greenland, and he is currently conducting research on pigeon guillemots as bioindicators of nearshore ecosystem health in Kachemak Bay, Alaska. Dr. Roby's research on seabird reproductive energetics in the Arctic and Antarctic has been supported by the National Science Foundation. Roby is currently Assistant Unit Leader- Wildlife, Alaska cooperative Fish and Wildlife Research Unit, and is an Assistant Professor of Wildlife Ecology, Institute of Arctic Biology, University of Alaska Fairbanks. he has over 25 peer-reviewed scientific publication, 17 of them on topics in seabird ecology.

Dr. Paul W. Snyder is an Assistant Professor of Pathology and Immunotoxicology and Director of the Clinical Immunology laboratory of the Department of Veterinary Pathobiology, Purdue University. He is also a Diplomate of the American College of Veterinary Pathologists. his research interests are in the area of mechanism based studies on the pathology and immunology of xenobiotics on biological systems. He has an NIH-funded project related to the immunobiology of environmental contaminants.

Dr. Glenn R. VanBlaricom has conducted research on coastal ecosystems since 1970, and has been involved in research on sea otters and their ecosystems for 17 years. Dr. VanBlaricom studied relationships of sea otters and intertidal mussels in Prince William Sound from 1978 through 1986 and published papers on population size structure and individual growth rate of mussels, and effects of foraging by sea otters. Dr. VanBlaricom worked on sea otter rescue and rehabilitation in the immediate aftermath of EVOS, primarily in the Kenai region, and has published one paper on rehabilitation strategies. Currently Dr. VanBlaricom is Assistant Unit Leader (Wildlife), Washington Cooperative Fish and Wildlife Research Unit, and is Associate Professor of Fisheries in the School of Fisheries, University of Washington. He has 24 peer-reviewed scientific publications.

14.0 Budget

14.1 FY 1995 and FY 1996 Totals by Project

	FY95	FY96
River Otter/Pigeon Guillemot	51,595	173,528
Sea Otter	66,920	206,540
Harlequin Duck	175,120	336,930
Mussels	84,315	152,981
Subtidal Clams	38,810	69,796
Invertebrate Predators	35,077	98,511
Intertidal Clams	12,786	88,018
Urchins	33,841	183,074
Fishes	22,010	156,332
Harlequin Duck Prey	5,014	25,193
Side Scan Sonar	59,172	41,662
Project Management	11,550*	112,030
Project Totals	596,208	1,644,595

* $130K additional planning funds provided earlier

The NVP Project FY 95 budget figures do not include approximately $30K in commodities and equipment that may be needed for project completion. These include computers and field supplies that may be in the EVOS equipment list. We will supply a list of needed items to the EVOS office.

14.2 Detailed Budgets for FY 1995

Salaries/Travel/Contractual/Commodities/Equipment/Administration

Salaries

<u>River Otter/Pigeon Guillemot</u>		
Scientist 1 mo.		5,974
Grad student Ph.D. (12 mo.)		12,500
Grad student M.S. (12 mo.)		0
Lab Tech. 150 hrs. @ 12.00/hr		3,020
Account. Tech. 40 hr @ 13.92/hr		1,114
Benefits (leave: staff acct: Lab Tech		4,426
student tuition		4,608
	Subtotal	31,642
<u>Sea Otter</u>		
Superv. WB GS-12 (.5 mo.)		2,400
Research WB GS-11 (3 mo.)		12,700
Bio. Technician GS-7 (3 mo.)		8,500
	Subtotal	23,600
<u>Harlequin Duck</u>		
Veterinarian (1 mo.)		6,000
Research WB (4 mo.)		19,300
Wildlife Biologist (2 mo.)		9,600
Training		3,000
Bio. Technician (3 mo.)		7,200
	Subtotal	45,100

Mussels		
Fishery Biologist (3 mo.)		20,040
Fishery Biologist (1 mo.)		4,108
Fishery Biologist (3 mo.)		13,854
Lab Technician (3 mo.)		10,681
Project Manager (1 mo.)		5,000
	Subtotal	53,683
Subtidal Clams		
Graduate student		6,858
Tuition		1,399
Benefits		549
Hourly diving assistants		2,400
Benefits		240
	Subtotal	11,446
Invertebrate Predators		
Graduate student		6,396
Tuition		1,399
Benefits		512
Hourly diving assistants		2,400
Benefits		240
	Subtotal	10,947
Intertidal Clams		
Scientist 1 mo.		4,745
Benefits		2,687
	Subtotal	7,432

Urchins/Crabs		
Scientist		2,373
Divers		3,508
Benefits Scientist		1,344
Benefits staff		1,844
	Subtotal	9,069
Fishes		
Scientist		2,373
Scientist		2,373
Benefits, scientists		2,688
	Subtotal	7,434
Harlequin Duck Prey		
Scientist		1,500
Benefits		673
	Subtotal	2,173
Side Scan Sonar		
Scientist		1,500
Benefits		899
	Subtotal	2,399

Project Management		
Chief Scientist		3,400
Program Asst.		2,900
Secretarial		2,700
	Subtotal	9,000

Travel

River Otter/Pigeon Guillemot		
FAI/ANC/FAI (9 trips @ $200		1,800
Per diem in Anc. 9 days @ $138		1,242
	Subtotal	3,042
Sea Otter		
ANC/Cordova/Anch (2 @ $250)		500
Per diem Cordova 20 days @ $141		2,820
ARR to Whittier 1 25' boat r/t		1,500
	Subtotal	4,820
Harlequin Duck		
ANC/BC/ANC		1,500
ANC/CDV/ANC 12 @ $250		3,000
Per diem		3,000
	Subtotal	7,500
Mussels		
JNU/ANC/JNU 4 @ $600		2,400
JNU/SEW/JNU 4 @ $720		2,880

	Subtotal	5,280

Sub-Tidal Clams

Field Work SEA/ANC/SEA 5 @ $360		1,800
ANC/Whittier/ANC 5 @ $100		500
Meeting SEA/ANC/SEA 2 @ $360		720
ANC/Whittier/ANC 2 @ $100		200
Per diem 20 days @ $211		4,431
	Subtotal	7,651

Invertebrate Predators

Field SEA/ANC/SEA 4@ $360		1,440
ANC/Whittier/ANC 4 @ $100		400
Meeting SEA/ANC/SEA 1 @ $360		360
ANC/Whittie/ANC 1 @ $100		100
Per Diem 14ays @ $211/day		2,954
	Subtotal	5,254

Intertidal Clams

Field FAI/CDV/FAI 1 trip		500
Per diem 3 d at 141/d		423
	Subtotal	923

Urchins/Crabs

FAI/CDV/FAI 1 trip		500
Per diem 3 d at 141/d		423
	Subtotal	923

Fishes

Santa Barbra/CDV/Santa Barbra		800
Per diem 3 d at 141/d		423
	Subtotal	1,223

<u>Harlequin Duck Prey</u>	Subtotal	0

<u>Side Scan Sonar</u>		
Fai/Anc/Fai I at 200		200
Per diem 3 d at 211/d		633
	Subtotal	833

<u>Project Management</u>	Subtotal	0

Contractual

<u>River Otter/Pigeon Guillemot</u>		
Duplication computer fees		200
ELISA analysis (oil on pelage)		1,500
IG analysis		1,000
HP analysis		500
Telephone		500
	Subtotal	3,700

<u>Sea Otter</u>		
80 hrs. Scout aircraft @ $200/hour		16,000
Warehouse space at Cordova w/ USFS		2,000
Preliminary blood analysis (Snyder)		7,000
	Subtotal	25,000

Harlequin Duck		
Vessel charter 30 days @ $1500/day		45,000
Blood assays (CBC, WBC, serum)		2,500
Aircraft 24 hours @ $275/hour		6,600
Radio telemetry		700
	Subtotal	54,800
Mussels	Subtotal	0
Subtidal Clams		
Shipping		400
Copying/postage		300
Telephone		400
	Subtotal	1,100
Invertebrate Predators		
Photocopying/postage		300
Telephone		200
Shipping		400
	Subtotal	900
Intertidal Clams		
Freight		300
Telephone/FAX		200
	Subtotal	500

Urchins		
Coastal Resources Associates		4,409
Telephone/FAX		200
Vessel Charter		12,500
	Subtotal	17,209
Fishes		
Coastal Resources Associates		4,985
Telephone/FAX		200
	Subtotal	5,185
Harlequin Duck Prey		
Coastal Resources Associates		2,005
	Subtotal	2,005
Side Scan Sonar		
Coastal Resources Associates		15,778
Side Scan Sonar contract		30,000
	Subtotal	45,778
Project Management	Subtotal	0

Commodities

River Otter/Pigeon Guillemot		
Interlukin assay kits 2 @ $550		1,100
P450 array kits 2 @ $260		520
Blood panel arrays 30 @ $33.33		1,000
Blood storage & sampling supplies		900
	Subtotal	3,520
Sea Otter		
Fuel 500 gal. @ $3/gal.		1,500
Food 25 days @ $20/day		500
Office/field supplies, misc.		500
	Subtotal	2,500
Harlequin Duck		
Fuel 166 gal. @ $3/gal.		500
Surgical supplies		9,000
	Subtotal	9,500
Mussels		
Hydrocarbon chemistry supplies		500
Field & lab chemicals		2,300
Field & lab supplies		4,200
Elec. calipers & digital recorders		5,600
Weight/measure supplies		1,200
Publication/presentation costs		500
Shipping, containers, equip.maint.		3,000
	Subtotal	17,300

Subtidal Clams		
SCUBA equipment		8,500
Sampling equipment		1,650
Protective clothing		500
Safety/first aid		500
Skiff fuel		150
Photographic film		200
Spare parts, outboards		300
Glassware and chemicals		800
Shipping supplies		250
Office supplies		200
	Subtotal	13,550
Invertebrate Predators		
SCUBA equipment		9,000
Sampling equipment		1,500
Protective clothing		500
Safety/first aid		500
Skiff fuel		150
Photographic film		200
Spare parts, outboards		300
Glassware and chemicals		800
Shipping supplies		250
Office supplies		200
	Subtotal	13,400
Intertidal Clams		
Field supplies		800
Portable pump and hoses		1,000
	Subtotal	1,800

Urchins		
Diving supplies		1,000
	Subtotal	1,000
Fish		
Fish nets/spears and sampling equipment		4,500
	Subtotal	4,500
Harlequin Duck Prey	Subtotal	0
Side Scan Sonar		300
	Subtotal	300
Project Management		1,500
	Subtotal	1,500

Equipment

River Otter/Pigeon Guillemot		
Clinical centrifuge		5,000
	Subtotal	5,000
Sea Otter		
70 HP OB - OMC		4,000
Hand held VHF radios 2 ea		1,000

Subtotal 5,000

Harlequin Duck	
Radio transmitter 100 @ $200 ea	20,000
Radio receivers 2 @ $2,400	4,800
TOBEC	9,500
Miscellaneous	8,000
Subtotal	42,300
Mussel Subtotal	0
Subtidal clams Subtotal	0
Invertebrate Predators Subtotal	0
Intertidal Clams Subtotal	0
Urchins Subtotal	0
Fishes Subtotal	0
Harlequin Duck Prey Subtotal	0
Side Scan Sonar Subtotal	0

Project Management Subtotal 0

Note: 95 Field equipment needed through available EVOSTC equipment consists of

1. 2 Mark II (14-15') inflatable boats

2. 2 25 HP Outboard motors

3. 2 hand-held marine radios

Administration (OH)

River Otter/Pigeon Guillemot (10% of total direct)	4,690
Sea Otter (10% of total)	6,000
Harlequin Duck (10% of total)	15,920
Mussels (15% of salaries)	8,052
Subtidal clams	5,064
Invertebrate predators	4,576
Intertidal clams (20% TDC)	2,131
Urchins (20% TDC)	5,640
Fishes (20% TDC)	3,668
Harlequin Duck Prey (20% TDC)	836
Side Scan Sonar (20% of TDC)	9,862
Project Management	1,050

Totals by budget category

Salaries	213,923
Travel	37,449
Contractual	156,177
Commodities	68,870

Equipment	52,300
Administration	67,489
	596,208

Data Management Plan

Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators

1.0 Introduction

The proposed study of injury to, and recovery of, nearshore vertebrate predators (NVPs) following the *Exxon Valdez* oil spill (EVOS) is a multidisciplinary project, involving scientists with varied areas of expertise representing several organizations. The success of the project (hereafter termed NVP) depends in large part on the exchange of information among scientists within the program, and between the NVP project and other projects sponsored by the *Exxon Valdez* Oil Spill Trustee Council. Effective communication of information can only be achieved through the use of a data management plan that provides a common language for the data gathered and a common means of information transfer.

The following provides an outline of the data management plan to be used by the NVP project and gives steps for implementation of the plan. The specific goals of the plan are to:

1. Ensure accuracy and maintain integrity of the data as gathered by each investigator.
2. Provide for an efficient exchange of information among investigators and between the NVP and other projects.
3. Provide a mechanism by which data and reports can be archived.
4. Provide a framework by which analyses presented in reports can be traced to the underlying data obtained during the initial data collection.

There are several keys to the successful implementation of such a plan. First, the plan must follow a written document. Second, there must be a management framework that clearly defines responsibilities for the plan's implementation. Third, all Principal Investigators and their staffs must be trained to ensure that all data are obtained and transferred as specified by the plan.

It should be stressed that the following is an outline for such a plan. This document will provide a framework by which a more complete plan can be produced and implemented. The complete plan will include Standard Operating Procedures, Field Data Sheets, Data Standards

Documents, and Data Dictionaries for each of the individual projects. Here we will give only examples of these products.

2.0 Project Management and Information Flow

The project organization is outlined in Table 1. Dr. Leslie Holland-Bartles will act as Chief Scientist for the NVP project. Her responsibilities with respect to data management, will include selecting a Data Manager and ensuring that all Principal Investigators adhere to the data management plan. All data collected by individual Principal Investigators will remain their intellectual property. However, it is also understood that all data will be accessible to each of the Principal Investigators and the Chief Scientist. After collection and timely review, all data files will be submitted by the Principal Investigators to a central data clearinghouse maintained by the NVP Data Manager.

It will be the responsibility of the Data Manager to maintain the central database, and to provide an updated index of the database to Principal Investigators and the Chief Scientist upon request. The Data Manager will also be responsible for dissemination of information in the database to the Chief Scientist or to other Principal Investigators upon request. Any use of the data from other Principal Investigators, either in presentations, reports, or publications will require the permission of the Principal Investigator who gathered the data. All such requests and subsequent approvals or denials for use will be routed through the Data Manager and reviewed by the Chief Scientist.

It will be the responsibility of each Principal Investigator to ensure that the data presented to the Data Manager is in an appropriate, pre-determined format, and is an accurate representation of the data as collected. The Principal Investigators will designate specific persons on her/his staff who have authority to submit data or request data from the Data Manager.

3.0 Written Documentation

Written documentation will primarily be provided in the form of Standard Operating Procedures (SOPs). An example of an SOP is given in Appendix A. All procedures, including field operations, laboratory analyses, data management, data distribution, report production, and the archiving of files will be provided. In many cases, SOPs will be project specific and will be provided by individual Principal Investigators. Other SOPs (eg. procedures for transfer of data files) will be generic to all projects and will be produced by the Data Manager.

All Standard Operating Procedures will contain the author's name, the draft number, the effective date of the SOP, a brief statement of its purpose, and the specific training required to use the SOP.

4.0 Training

Before an SOP can be used, all of those persons who will utilize the procedure must be trained. The level of training will be dependent on the procedure and will be at the discretion of the Principal Investigator. At a minimum, all users will be required to have read the SOP, and to have demonstrated their understanding of it. More elaborate training procedures involving hands on training and proficiency testing may be required in some instances.

5.0 Structure of the Data

5.1 Introduction

In order to maintain a common database and to ensure efficient dissemination of data, a common format of the data will be required of all individual projects. The following provides guidelines on the structure of files and their format.

5.2 Types of Files

There will be six types of files maintained (Table 2). These include:

5. Field or laboratory data files - Data as initially recorded on field sheets, lab notebooks, etc.

6. Raw data files - Computer file with the edited data from field or laboratory data sheets.

7. History files - Computer text files associated with each raw file that contains of history or when data were entered and/or edited, and a description of edits.

8. Analysis files - Computer files that are used to manipulate or provide summaries of statistical analyses of the raw data.

9. Ouput files - Computer output provided by analysis.

10. Report file - Computer word processing, spreadsheet, or image files that make up a particular report.

A brief description of these files and specifications for associated file names and file types are given in Table 3.

All files will be maintained by Principal Investigators. A copy of the raw data files and associated history files will also be placed in a common database maintained by the Data Manager.

5.3 Analysis Flow Charts

Any presentation of data in a report will be accompanied by an appendix containing a flow diagram that describes the steps taken in producing the table or figure (Table 4). This flow chart will allow one to trace the summary presentation back to field or laboratory data sheets. The diagram will indicate all the names of any intermediate databases used in the production of the final table or figure, as well as the names of all analysis files.

5.4 File Structure

An example of each file type represented in the flow diagram described above (Table 4) is given in tables 5 through 9. Accompanying each raw data file will be a data dictionary that gives the format, acceptable range, and a brief description of each variable in the file (Tables 10 and 11). The variables used in raw data files can be unique to a given project or can be more generic. In cases where the same variable is to be used by several projects, this variable will be described and its format defined in a data dictionary common to all projects (Tables 12 and 13). This is to ensure that all projects are consistent in their naming of variables, so that data can be easily shared among projects. Separate data dictionaries will be provided for all variables that are unique to a given raw data file.

In addition, there will be a single database that describes the location of all sampling sites, and an associated data dictionary (Tables 14 and 15). This "site location" database will list all sites sampled by each of the projects, and will describe the location of the sampling sites based on a coordinate system that is the same for all projects. This database is critical to future linking of information from separate projects. For example, it may allow for the efficient determination of prey abundance within a certain region for which we also have estimates of river otter abundance. In addition, this database will allow us to easily place all sampling sites on a common map.

6.0 A Time Line for Data Management Procedures

The following is a time line for critical events in the data management process.

- Chief Scientist selects Data Manager
- PIs select individual data managers for their project

- PIs and Data Manager write SOPs, including field/laboratory data sheets, raw data file structure, and associated data dictionaries
- Data Manager reviews and approves SOPs
- Field data collected
- Data from field sheets are entered into a raw data file
- The raw file is checked and edited if necessary
- A history file is produced
- The raw file and associated history file are submitted to the Data Manager
- At monthly intervals, the PIs submit newly created or edited raw files and history files to the Data Manager. If no new or edited files are available, the PI will supply the Data Manager with a short written statement to that effect.
- At monthly intervals, the Data Manager provides an index of all available raw data files to the PIs.
- PIs or their designees conduct analyses and prepare flow charts for same
- PIs write reports and submit to the Chief Scientist along with flow diagrams
- PIs archive field data, raw data files, history files, analysis files, and reports
- Data Manager archives raw data files, history files, analyses flow diagrams, and overall project report

Table 1. Flow chart for data management of the Nearshore Vertebrate Predator Project.

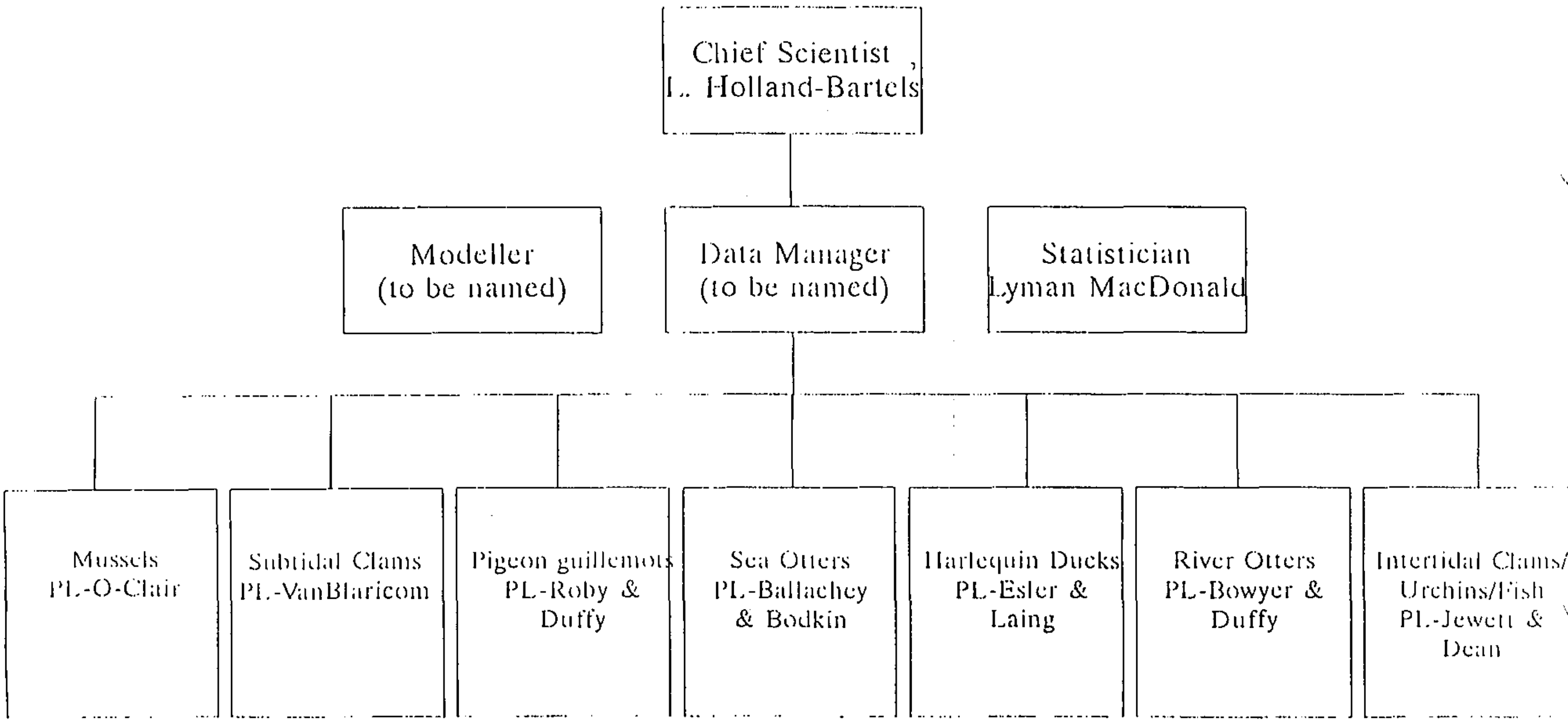

Table 2. Flow diagram showing the file types and the flow of data.

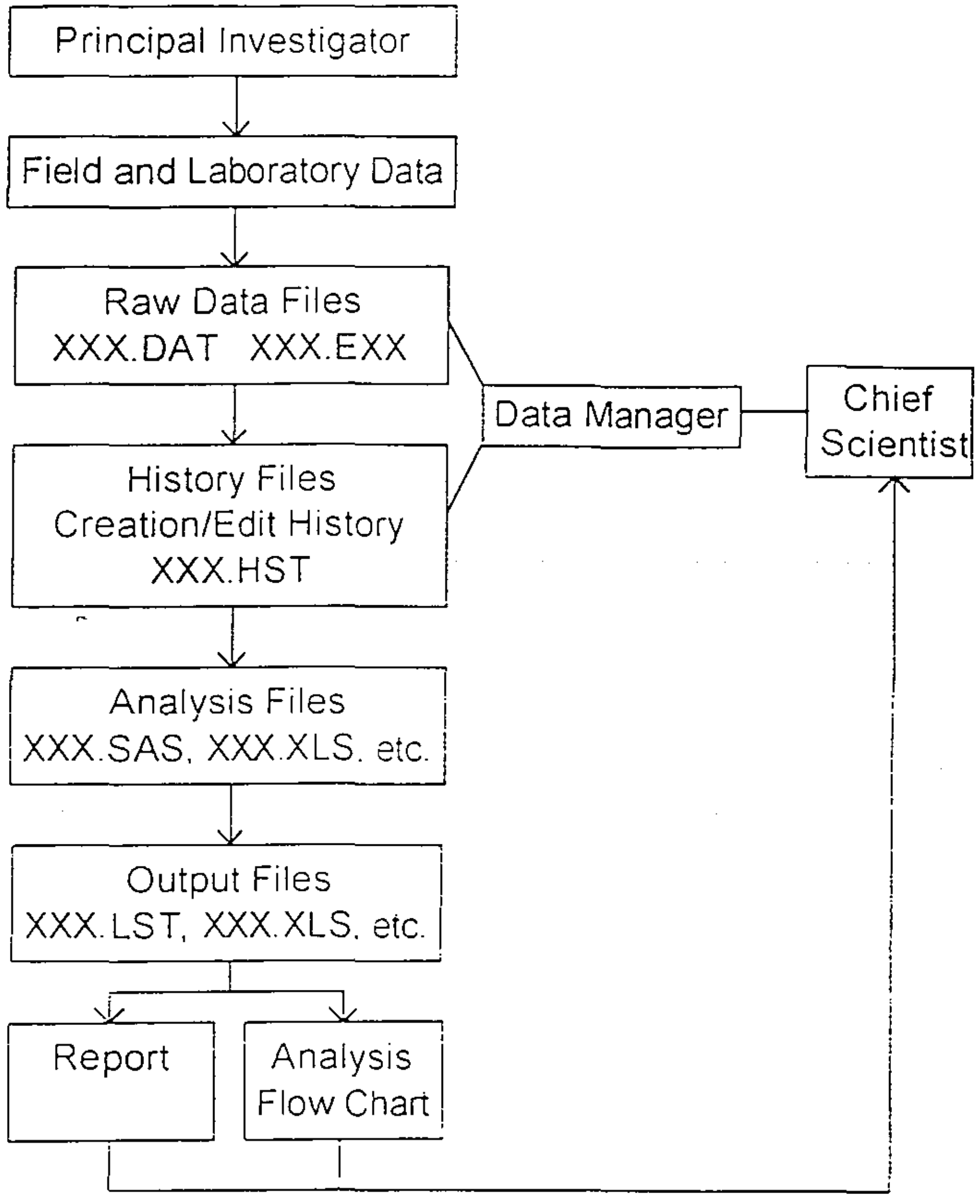

Table 3. Description of file types used in the Nearshore Vertebrate Predator project.

Category	File Name	File Type	Description
Field/Lab Data	None specified	None specified	Field data sheets, notebooks, data tapes, sonar records, etc.
Raw Data	Project code as first 2 digits	.dat (for ASCII) or .exx (for ArcInfo)	Computer file with data from field that has been entered, checked, and edited [1]
History	Same as corresponding Raw file	.hst	A text file (ASCII) containing date raw file was created, name of person who created file, date edits were made, who entered data, and a short description of edits
Analysis	None specified	determined by software (e.g. .sas, .xls, .wk1)	Any file which produces analyses, tables, charts, graphs, etc. For example, a SAS or EXCEL file that computes mean abundance from raw data
Output File	None specified	none specified	Output from analysis program (In some cases, output may be imbedded in analysis file)
Report File	AAANNNNA[2]	WP	First 2 letters are the project code. 3rd letter is the code for type of report (M = monthly, Q = quarterly, A = annual, F=final). Numbers are the month and year of the initial draft of the report. Last letter indicates draft number (a = 1, b = 2, etc.).

[1] Note: All raw files should be "sparsed". That is, all zero values should be included. For example, if no harlequin ducks were observed on a particular bird transect, then a "0" value (not a blank or missing value) should be entered. A " • " should appear in raw files for data that are truly missing.

[2] Format conventions: A = Alpha code, N = Numeric code

Table 4. Example of an analysis flow chart

Report: SUQ0995A.WP
Author: Dean et al.
Date: 15Sep95
Output: Table 4.2

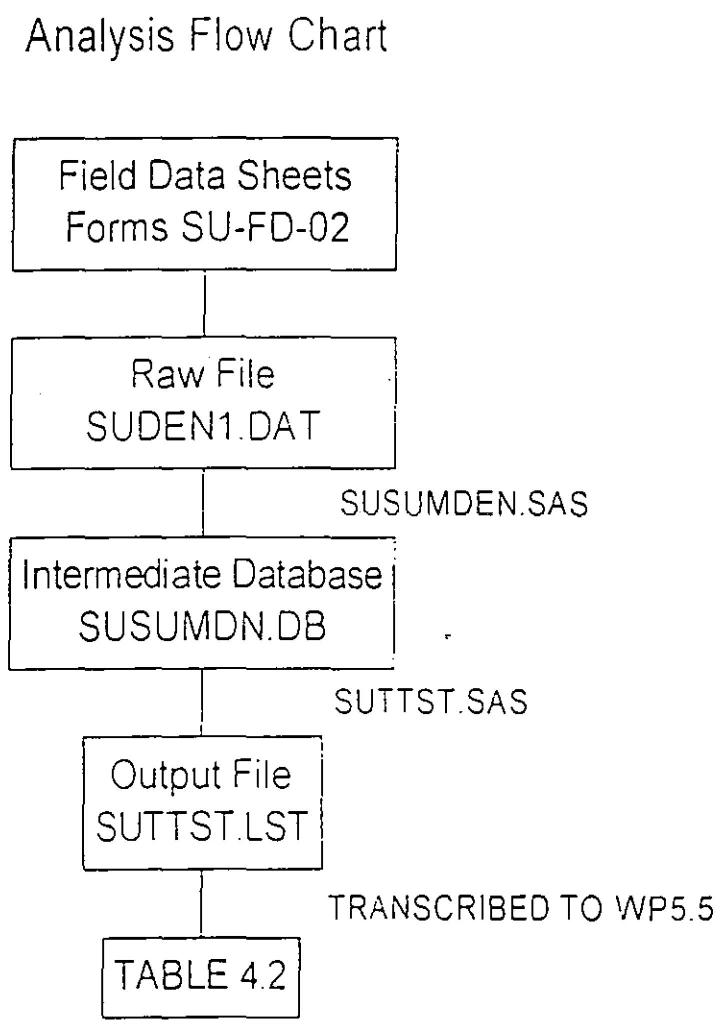

Table 5. Example of a field data sheet

Sea Urchin and Sea Otter Densities on Transects
Form SU-FD-01

Name:______________________________ Date:____________________

Site:________________________________ Depth Stratum:___________

Depth (ft) Actual:____________________ Depth (ft) Adjusted to MLLW:__________

Time In:_____________________________ Time Out:________________

Transect Coordinates (WGS 84)

LAT	1 _______ (start)	2 _______	3 _______	4 _______	5 _______ (end)
LONG	1 _______	2 _______	3 _______	4 _______	5 _______

Transect width (m)______

Segment =	Taxa	Size Class	?	Vegetation Type	Substrate Type	Notes

Table 6. Example of a raw data file.

Sea Urchin and Sea Star Densities
Form SU-RD-01
File Name - SUDEN1.DAT

Site	Date	Depth Stratum	Habitat Type	Depth (m-MLLW)	Transect Segment #	Transect width (m)	Coordinates Begin LAT	Coordinates Begin LONG	Coordinates End LAT	Coordinates End LONG	Taxa	Size Class	#	Vegetation Type	Substrate Type
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Sd	J	3	Ac	R
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Sd	HG	0	.	.
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Sd	HG	0		
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Ph	J	8	Ac	R
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Ph	J	4	Zm	S
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Ph	J	0		
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Di	J	2	Ac	R
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Di	J	1	Ac	C
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Di	HG	0		
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.625	147 40.021	60 23.701	147 40.099	Di	J	0		
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Sd	J	3	Ac	R
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Sd	HG	0	.	.
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Sd	HG	0	.	
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Ph	J	8	Ac	R
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Ph	J	4	Zm	S
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Ph	J	0	.	.
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Di	J	2	Ac	R
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Di	J	1	Ac	C
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Di	HG	0	.	
BI001	6-Jul-95	S	SR	2.8	1	1.0	60 23.701	147 40.099	60 23.902	147 40.108	Di	J	0		

Table 7. Example of a history file.

File Name - SUDEN HST

Date	Name	Action	Description
04JAN96	T. Dean	entered data	none
05JAN96	T. Dean	checked data	no errors found
08JAN96	T. Dean	edited data	changed zero to missing value for sea urchin density, J #3
23MAY97	T. Dean	edited data	changed depth from -2.8 to -2.5 for data of 06JUL95. Tide corrections were applied incorrectly.

Table 8. Example of an intermediate database

Mean Sea Urchin Densities
File name - SUSUMDN.DB

Site	Date	Depth	Depth	Habitat	Transect	#			# on			
		(m-MLLW)	Stratum	Type	Area (m2)	J	HG	A	Rock	Cobble	Gravel	Sand
BI-1	6-Jul-95	2.8	S	SR	192.6	8	1	2	1	10	0	0
BI-2	7-Jul-95	2.1	S	SR	185.6	0	1	0	1	0	0	0
BI-3	7-Jul-95	3.0	S	SR	208.8	0	0	0	0	0	0	0
KI-1	8-Jul-95	1.0	S	SR	219.3	0	6	2	1	7	0	0

Table 9. Example of table output.

Sea Urchin and Sea Star Densities

Table 4.2 Mean densities (no. m^{-2}) of sea urchins at shallow oiled (without sea otters) and nonoiled reference (with sea otters) sites in Prince William Sound in 1995.

	number m^{-2}			
Habitat	Oiled	Reference	n	P
Sheltered rocky	0.01	0.02	4	0.99
Sheltered cobble/gravel	0.05	0.01	4	0.92
Sheltered mud/sand	0.81	0.04	4	0.02
Exposed rocky	0.05	0.00	4	0.99
Exposed cobble/gravel	0.00	0.00	4	----

Table 10. Data dictionary for raw data files specific to sea urchin and fish studies.

DATA DICTIONARY FOR
RAW DATA FILES
(Sea urchin, Fish)

Variable	Variable Code	Format	Example	Range	Notes	
Depth Stratum	STRATUM	A	S	S or D	S = shallow(0-3m), MLLW D = deep(3-6m), MLLW	
Transect width (m)	TWIDTH	X.X	1.0	0.0-2.0	Adjusted to nearest tenth	
Transect segment	TSEG	X	1	1-9	Designates transects broken into several segments	
Size class	SIZE	AA	J	J, HG, A	Juvenile - <5cm Half grown - 5-10cm Adult- >10cm	(diameter for stars)
					Juvenile - <2cm Half grown - 2-5cm Adult- >5cm	(diameter for sea urchins)
Vegetation type	VEGTYPE	AA	AC	see list attached	Dominant vegetation type	
Substrate type	SUBTYPE	AA	R	see list attached	Dominant substrate type	

Table 11. Data dictionary for specific variable ranges specific to sea urchin and fish raw data files.

DATA DICTIONARY FOR
SPECIFIC VARIABLE RANGES
(Sea urchin and fish raw data files)

Invertebrate Taxa

Code	Species
Cx	Cancer crabs (Cancridae)
Di	Dermasterias imbricata
Et	Evasterias troschelli
Mx	Spider crabs (Majidae)
Os	Other sea stars
Ph	Pycnopodia helianthoides
Sd	Strongylocentrotus droebachiensis
Sf	Strongylocentrotus franciscanus
Tc	Telmessus cheiragonus

Vegetation Type

Code	Species
Ac	Agarum cribosum
Ct	Cymathere triplicata
Lg	Laminaria groenlandica
Lp	Laminaria praelonga
Ls	Laminaria saccharina
NA	None
Nl	Nereocystis luetkeana
Ob	Other brown algae
Ra	Red Algae
Zm	Zostera marina

Substrate Type

Code	Description
M	Mud/Silt (<0.0125mm)
S	Sand (≥0.0125mm, <1mm)
G	Gravel (≥1mm, <50mm)
C	Cobble (≥50mm, <300mm)
B	Boulder (≥300mm , <1m)
R	Rock (≥1m diameter or reef)

Table 12 Data dictionary for raw data files specific to all projects

DATA DICTIONARY FOR
RAW DATA FILES
(All Projects)

Variable	Variable Code	Format	Example	Range	Notes
Date	DATE	DDMMMYY	01JAN95	NA	
Time	TIME	HHMM	1235	0000 - 2400	Pacific Standard or Daylight Time Military Format
Water Depth	DEPTH	XX X	12 2	0 - 99 9	Record in m, adjusted to MLLW
GPS Coordinates	GPSCOORD	LAT - XX XX XXX LONG - XX XX XXX	60 23 625 147 40 099	degrees minutes 0 to 90 0 to 60 0 to 180 0 to 60	reference to WGS 84 datum, list as degrees-space-minutes and thousandths of minutes
Map Coordinates	MAPCOORD	LAT - XX XX XXX LONG - XX XX XXX	60 23 625 147 40 099	0 to 90 0 to 60 0 to 180 0 to 60	Albers projection
Project	PROJCODE	AA	SU	see attached list	
Site Name	SITE	AAXXX	BI001	NA	First two digits indicate site name (a Bay, Island, Passage), numbers following are sequential at the site
Taxa	TAXA	AA	Sd	see attached list	Code indicating taxa, usually initials of genus and species
Sex	SEX	A	M	M = male, F= female, U - unknown	

Table 13. Data dictionary for project codes

DATA DICTIONARY FOR PROJECT CODES
(All projects)

Code	Project	Principal Investigator
FS	Fish	Jewett, Dean
IC	Intertidal Clam	Jewett
MY	Mussel	O'Clair
PG	Pigeon Guellemot	Roby, Duffy
RO	River Otter	Bowyer, Duffy
SC	Subtidal Clam	VanBlaricom
SD	Sea Duck	Esler, Laing
SO	Sea Otter	Botkin, Ballachey
SS	Side Scan Sonar	Dean, Jewett
SU	Sea Urchin	Dean, Jewett

Table 14. Example of a site location database.

File name - SITELOC.DAT

Project	Site Name	Area	Tidal Zone	Habitat Type	Oil Category	Type	Buffer (m)	Coordinates A LAT	A LONG	B LAT	B LONG	C LAT	C LONG	D LAT	D LONG	Position Method
SU	BI001	KNT	S	SR	O	SHS		60 23.625	147 40.099	60 23.854	147 40.108					GPS
SU	BI002	KNT	S	SR	O	SHS		60 23.625	147 40.099	60 23.854	147 40.108					GPS
SU	SH001	MON	S	SS	R	SHS		60 23.625	147 40 099	60 23.854	147 40.108					GPS
SO	BISHARM	KNT	S		O	SHA	50	60 23 625	147 52 101	60 23.815	147 51 902					GPS
RO	JPB WS	JPB	T	OG	R	PT		60 20 025	148 10 020							MAP
SD	MIT001	MON	S		R	STA	60	60 23 625	147 52 101	60 20 025	147 52 102	60 20 025	147 53 102	60 21 086	147 53 102	GPS

Table 15 Data dictionary for site location raw data files specific to all projects.

DATA DICTIONARY FOR SITE LOCATION RAW DATA FILES
(All Projects)

Variable	Variable Code	Format	Example	Range	Notes
Project	PROJCODE	AA	SU	see list attached	
Site Name	SITE	AAAAXXXX	B1001	to be determined	
Area	AREA	AAA	NAK	see list of codes	
Tidal Zone	TIDEZONE	A	S	S, I, or T	S = subtidal (on/in water below MLLW), I = intertidal (on/in water between MLLW and HHW), T = terrestrial (above HHW)
Oil Category	OILCAT	A	O	O or R	O = oil, R = reference
Segment Type	SEGTYPE	AAA	SHS	see list of codes	
Buffer	BUFFER	XXX	20	1-999m	A distance from a shoreline segment that defines a polygon extending a given distance offshore from point A to point B
GPS Coordinates	GPSCOORD	LAT - XX XX XXX LONG - XX XX XXX	60 23 625 147 40 099	degrees minutes 0 to 90 0 to 60 0 to 180 0 to 60	reference to WGS 84 datum, list as degrees-space-minutes and thousandths of minutes
Map Coordinates	MAPCOORD	LAT - XX XX XXX LONG - XX XX XXX	60 23 625 147 40 099	0 to 90 0 to 60 0 to 180 0 to 60	Albers projection

Table 15 continued

Code	Area Name
MON	Montague Island
JPB	Jack Pot Bay
NAK	Naked Island - Knight Island

Code	Habitat Type
T	Terrestrial (above HHW)
SR	Sheltered rocky
SC	Sheltered cobble/gravel
SM	Sheltered mud/sand
ER	Exposed rocky
OG	Old growth spruce forest (?)
others to be added	

Sampling Area

Code	Type	Description
SHS	Shoreline segment	a continuous stretch of shoreline from point A to point B on the shore
STS	Straightline segment	a straight line from point A to point B
PT	Point	
SHA	Shoreline area	a complex polygon extending from point A to point B on the shore, and extending a specific distance from the shore (distance is defined as the buffer)
STA	Straightline area	a rectangular polygon defined by four pairs of coordinates

Appendix A.

SAMPLING PROTOCOL FOR SEA OTTER AERIAL SURVEYS

Overview of survey design

The survey design consists of 2 components: (1) strip transect counts and (2) intensive search units.

1) Strip Transect Counts

Sea otter habitat is sampled in two strata, high density and low density, distinguished by distance from shore and depth contour. The high density stratum extends from shore to 400 m seaward or to the 40 m depth contour, whichever is greater. The low density stratum extends from the high density line to a line 2 km offshore or to the 100 m depth contour, whichever is greater. Bays and inlets less than 6 km wide are sampled entirely, regardless of depth. Transects are spaced systematically within each stratum. Survey effort is allocated proportional to expected otter abundance in the respective strata.

Transects with a 400 meter strip width on one side of a fixed-wing aircraft are surveyed by a single observer. Transects are flown at an airspeed of 65 mph (29 m/s) and an altitude of 300 feet (91 m). The observer searches forward as far as conditions allow and out 400 m, indicated by marks on the aircraft struts, and records otter group size and location on a transect map. A group is defined as 1 or more otters spaced less than 3 otter lengths apart. Any group greater than 20 otters is circled until a complete count is made. A camera should be used to photograph any groups too large and concentrated to count accurately. The number of pups in a group is noted behind a slash (eg. 6/4 = 6 adults and 4 pups). Observation conditions are noted for each transect and the pilot does not assist in sighting sea otters.

Each strip or block of water to be sampled will have two possible flight paths, an A side and a B side (Fig. 1). The observer chooses a side from which to survey depending on direction of glare so the same block of water will be sampled. Because this method involves choosing one of 2 sets of waypoints per block (a start and end coordinate for the A side or a start and end coordinate for the B side), the observer will select either an A card or a B card for each region to load into the GPS.

2) Intensive Search Units

Intensive search units (ISU's) are flown at intervals dependant on sampling intensity*, throughout the survey period. An ISU is initiated by the sighting of a group and is followed by 5 concentric circles flown within the 400 m strip perpendicular to the group which initiated the ISU. The pilot uses a stopwatch to time the minimum 1 minute spacing between consecutive ISU's and guide the circumference of each circle. With a circle circumference of 1,256 m and an airspeed of 65 mph (29 m/s), it takes 43 seconds to complete a circle (eg. 11 seconds/quarter turn). With 5 circles, each ISU takes about 3.6 minutes to complete. ISU circle locations are drawn on the transect map and group size and behavior is recorded on a separate form for each ISU. For each group, record number observed on the strip count and number observed during the circle counts. Otters that swim into an ISU post factum are not included and groups greater than 20 otters cannot initiate an ISU.

Behavior is defined as "whatever the otter was doing before the plane got there" and recorded for each group as either diving (d) or nondiving (n). Diving otters include any individuals that swim below the surface and out of view, whether traveling or foraging. If any individual(s) in a group are diving, the whole group is classified as diving. Nondiving otters are animals seen resting, interacting, swimming (but not diving), or hauled-out on land or ice.

* The targeted number of ISU's per hour should be adjusted according to sea otter density. For example, say we have an area that is estimated to take 25 hours to survey and the goal is to have each observer fly 40 "usable" ISU's; an ISU must have more than one group to be considered usable. Because previous data show that only 40 to 55% of the ISU's end up being usable, surveyors should average at least 4 ISU's per hour. Considering the fact that, one does not always get 4 opportunities per hour - especially at lower sea otter densities, this actually means taking something like the first 6 opportunities per hour. However, two circumstances may justify deviation from the 6 ISU's per hour plan:

1) If the survey is not progressing rapidly enough because flying ISU's is too time intensive, *reduce* the minimum number of ISU's per hour slightly

2) If a running tally begins to show that, on average, less than 4 ISU's per hour are being flown, *increase* the targeted minimum number of ISU's per hour accordingly.

The bottom line is this: each observer needs to obtain a preset number of ISU's for adequate statistical power in calculation of the correction factor. To arrive at this goal in an unbiased manner, observers must pace themselves so ISU's are evenly distributed throughout the survey area.

Preflight

Survey equipment:
- stopwatches (2)
- 4 X 12 binoculars (low power, wide angle)
- clipboards (2)
- transect maps
- transect data forms
- ISU data forms
- list of transects waypoints
- Global Positioning System (GPS)

Appendix A.

memory cards with waypoints
35 mm camera with wide angle lens
high-speed film

Airplane windows must be cleaned each day prior to surveying.

Global Positioning System (GPS) coordinates used to locate transect starting and end points. must be entered as waypoints by hand or downloaded from an external source via a memory card.

Electrical tape markings on wing struts indicate the viewing angle and 400 m strip width when the aircraft wings are <u>level</u> at 300 feet (91.5 m) and the inside boundary is in-line with the outside edge of the airplane floats.

The following information is recorded at the top of each transect data form:

Date - Recorded in the DDMMMYY format.
Observer - First initial and up to 7 letters of last name.
Start time - Military format.
Aircraft - Should always be a tandem seater fixed wing which can safely survey at 65-70 mph.
Pilot - First initial and up to 7 letters of last name.
Area - General area being surveyed.

Observation conditions
Factors affecting observation conditions include wind velocity, seas, swell, cloud cover, glare, and precipitation. Wind strong enough to form whitecaps creates unacceptable observation conditions. Occasionally, when there is a short fetch, the water may be calm, but the wind is too strong to allow the pilot to fly concentric circles. Swell is only a problem when it is coupled with choppy seas. Cloud cover is desirable because it inhibits extreme sun-glade. Glare is a problem that can usually be moderated by observing from the side of the aircraft opposite the sun. Precipitation is usually not a problem unless it is extremely heavy.

Chop (C) and glare (G) are probably the most common and important factors effecting observation conditions. Chop is defined as any deviation from flat calm water up to whitecaps. Glare is defined as any amount of reflected light which may interfere with sightability. After each transect is surveyed, presence is noted as C, G, or C/G and modified by a quartile (eg. if 25% of the transect had chop and 100% had glare, observation conditions would be recorded as 1C/4G). Nothing is recorded in the conditions category if seas are flat calm and with no glare.

Observer fatigue
To ensure survey integrity, landing the plane and taking a break after every 1 to 2 hours of

survey time is essential for both observer and pilot. Survey quality will be compromised unless both are given a chance to exercise their legs, eat, go to the bathroom, and give their eyes a break so they can remain alert.

Vessel activity
Areas with fishing or recreational vessel activity should still be surveyed.

Unique habitat features
Local knowledge of unique habitat features may warrant modification of survey protocol:

1. **Extensive shoaling or shallow water (ie. mudflats)** may present the opportunity for extremely high sea otter densities with groups much too large to count with the same precision attainable in other survey areas. Photograph only otters within the strip or conduct complete counts, typically made in groups of five or ten otters at a time. Remember, groups >20 cannot initiate an ISU.

   Example: Orca Inlet, PWS. Bring a camera, a good lens, and plenty of film. Timing is important when surveying Orca Inlet; the survey period should center around a positive high tide - plan on a morning high tide due to the high probability of afternoon winds and heavy glare. Survey the entire area from Hawkin's cutoff to Nelson Bay on the same high tide because sea otter distribution can shift dramatically with tidal ebb and flow in this region.

2. **Cliffs** - How transects near cliffs are flown depends on the pilot's capabilities and prevailing weather conditions. For transects which intersect with cliff areas, including tidewater glaciers, discuss the following options with the pilot prior to surveying.

   In some circumstances, simply increasing airspeed for turning power near cliffs may be acceptable. However, in steep/cliff-walled narrow passages and inlets, it may be deemed too dangerous to fly perpendicular to the shoreline. In this case, as with large groups of sea otters, obtain complete counts of the area when possible.

   In larger steep-walled bays, where it is too difficult or costly to obtain a complete count, first survey the entire bay shoreline 400 m out. Then survey the offshore transect sections, using the 400 m shoreline strip just surveyed as an approach. Because this is a survey design modification, these data will be analyzed separately.

   Example: Herring Bay, PWS. Several cliff areas border this area.
   Example: Barry Glacier, PWS. Winds coming off this and other tidewater glaciers may create a downdraft across the face. The pilot should be aware of such unsafe flying conditions and abort a transect if necessary.

3. **Seabird colonies** - Transects which intersect with seabird colonies should be shortened

accordingly. These areas can be buffered for a certain distance in ARC dependant on factors such as colony size, species composition, and breeding status.

Example: Kodiak Island. Colonies located within 500m of a transect AND Black-legged Kittiwakes > 100 OR total murres > 100 OR total birds > 1,000 were selected from the seabird colony catalog as being important to avoid.

5. **Drifters** - During calm seas, for whatever reason - possibly a combination of ocean current patterns and geography - large numbers of sea otters can be found resting relatively far offshore, over extremely deep water, miles (up to 4 miles is not uncommon) from the nearest possible foraging area.

Example: Port Wells, PWS. Hundreds of sea otters were found scattered throughout this area with flat calm seas on 2 consecutive survey years. As a result, Port Wells was reclassified and as high density stratum.

4. **Glacial moraine** - Similar to the drifter situation, sea otters may be found over deep water on either side of this glacial feature.

Example: Unakwik, PWS. Like Port Wells, Upper Unakwik was reclassified as high density stratum.

Planning an aerial survey
Several key points should be considered when planning an aerial survey:

1) Unless current sea otter distribution is already well known, it is well worth the effort to do some reconnaissance. This will help define the survey area and determine the number of observers needed, spacing of ISU's, etc.

2) Plan on using 1 observer per 5,000 otters.

3) Having an experienced technical pilot is extremely important. Low level flying is, by nature, a hazardous proposition with little room for error; many biologists are killed this way. While safety is the foremost consideration, a pilot must also be skilled at highly technical flying. Survey methodology not only involves low-level flying, but also requires intimate familiarity with a GPS and the ability to fly in a straight line at a fixed heading with a fixed altitude, fixed speed, level wings, from and to fixed points in the sky. Consider the added challenge of flying concentric 400 meter circles, spotting other air traffic, managing fuel, dealing with wind and glare, traveling around fog banks, listening to radio traffic, looking at a survey map, and other distractions as well. Choose the best pilot available.

Appendix A.

DATA DICTIONARY FOR RAW DATA FILES
(Sea Otter Abundance)

Variable	Variable Code	Format	Example	Range	Description
Date	DATE	DDMMMYY	01JUL95	NA	
Observer	OBSRVR	AAAAAAAA	JBodkin	NA	First initial and up to 7 letters of last name
Start Time	STIME	HHMM	1430	0000 - 2400	Military format
Aircraft	AIRCRFT	AAAAA	Scout	NA	Aircraft model
Pilot	PILOT	AAAAAAAA	Pkearney	NA	First initial and up to 7 letters of last name
Area	AREA	AAA	NAK	see list attached	Area being surveyed in Prince William Sound
Transect Number	TNUM	XXXX	44	1 - 9999	Unique transect number
Strip Count	SCOUNT	XXXX	12	0 - 9999	Number of independent/dependent sea otters in each group
Adults	ADULT	XXXX	4	0 - 9999	Number of independent sea otters
Pups	PUP	XXXX	2	0 - 9999	Number of dependent sea otters
Chop	CHOP	X	2	0 - 4	Quartile of transect with chop
Glare	GLARE	X	1	0 - 4	Quartile of transect with glare
ISU Number	ISUNUM	XXXX	22	1 - 9999	Intensive Search Unit number

95035

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NEARSHORE VERTEBRATE PREDATOR PROJECT
DETAILED BUDGET FFY 1996

SALARIES

River Otters/Pigeon Guillemots (Roby, Bowyer, Duffy)			
Scientist 1 mo.	5,014		
Grad student Ph.D. (12 mo.)	12,500		
Grad student M.S. (12 mo.)	11,440		
Lab Tech.	6,282		
Field Tehnician	12,064		
Account. Tech. 40 hr @ 13.92/hr	1,114		
Benefits (staff leave)	7,896		
Student tuition	9,648		
		Subtotal	65,958
Sea Otters (Ballachey, Bodkin)			
Superv. WB GS-12 (3 mo.)	15,000		
Research WB GS-11 (6 mo.)	24,000		
Biotechnician GS-7 (6 mo.)	18,000		
		Subtotal	57,000
Harlequin Ducks (Esler, Laing)			
Veterinarian (1 mo.)	6,000		
Research WB (12 mo.)	58,000		
Wildlife Biologist (4 mo.)	17,400		
Bio. Technician (12 mo.)	28,800		
Training	2,000		
		Subtotal	112,200
Mussels (O'Clair)			
Fishery Biologist (3 mo.)	20,040		
Fishery Biologist (1 mo.)	4,108		
Fishery Biologist (3 mo.)	13,854		
Lab Technician (12 mo.)	32,864		
Chemist GS-11	14,916		
Project Manager (1 mo.)	5,000		
		Subtotal	90,782

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Subtidal Clams (VanBlaricom)		
Graduate student	17,145	
Tuition	6,156	
Benefits	1,372	
Hourly diving assistants	3,200	
Benefits	320	
Hourly Lab asst.	2,600	
Benefits	240	
	Subtotal	31,033
Invertebrate Predators (VanBlaricom)		
Graduate student	16,990	
Tuition	6,156	
Benefits	1,280	
Hourly diving assistants	6,400	
Benefits	640	
	Subtotal	31,466
Intertidal Clams (Jewett & Dean)		
Scientist (10 mo.)	40,837	
Benefits	21,744	
	Subtotal	62,581
Urchins/Crabs (Jewett & Dean)		
Scientist	14,948	
Divers	7,225	
Technician	3,005	
Benefits Scientist	8,461	
Benefits staff	5,828	
	Subtotal	39,467
Fishes		
Scientist (5 mo.)	23,948	
Technician/Divers	6,613	
Benefits	17,529	
	Subtotal	48,095

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Harlequin Duck Prey			
Scientist		4,982	
Technician		3,005	
Benefits		4,949	
	Subtotal		12,936
Side Scan Sonar			
Scientist		2,373	
Benefits		1,344	
	Subtotal		3.717
Project Management			
Chief Scientist		17,500	
Program Asst.		14,000	
Secretarial		2,800	
Data Manager		27,500	
Modeller		4,846	
	Subtotal		66,646
TRAVEL			
River Otters/Pigeon Guillemots			
FAI/VDZ/FAI (8 trips @ $380)		3,040	
SITKA/VDZ/SITKA		460	
FAI/ANC/FAI (12 trips @ $200)		2,400	
Per diem in Anchorage		2,100	
	Subtotal		8,000
Sea Otters			
ANC/Cordova/ANC (16 trips @ $250)		4,000	
Per diem Cordova (60 days @ $141)		8,460	
Rail to Whittier, 25' boat - 2 RT		3,000	
	Subtotal		15,460

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Harlequin Ducks		
Meetings/Workshops	2,500	
ANC/CDV/ANC (20 trips @ $250)	5,000	
Per diem	4,000	
Subtotal		11,500
Mussels		
JNU/ANC/JNU (8 trips @ $600)	4,800	
JNU/SEW/JNU (8 @ trips @ $720)	5,760	
Subtotal		10,560
Subtidal Clams		
Field Work SEA/ANC/SEA (4 trips @ $360)	1,440	
ANC/Whittier/ANC (4 trips @ $150)	600	
Meetings SEA/ANC/SEA (4 trips @ $360)	1,440	
ANC/Whittier/ANC 2 @ $100	200	
Per diem 28 days @ $225	6,300	
Conferences	2,000	
Subtotal		11,980
Invertebrate Predators		
Field work SEA/ANC/SEA (8 trips @ $382)	3,056	
ANC/Whittier/ANC (8 trips @ $110)	880	
Meetings SEA/ANC/SEA (2 trips @ $382)	764	
Per diem 30 days @ $225	6750	
Conferences	1,600	
Subtotal		13,050
Intertidal Clams		
Field FAI/CDV/FAI (2 trips @ $500)	1,000	
Per diem (9 days @ $141)	1,269	
FAI/ANC/FAI (1 trip @ $200)	200	
Subtotal		2,469

Urchins/Crabs			
FAI/CDV/FAI (3 trips @ $500)		1,500	
FAI/SD/FAI (1 trip @ $800)		800	
Per diem (14 days at $141)		1,974	
	Subtotal		4,274
Fishes			
Santa Barbara/CDV/Santa Barbara (2 trips @ $800)		1,600	
FAI/CDV/FAI (1 trip @ $600)		600	
Per diem (6 days @ $141)		846	
	Subtotal		3,046
Harlequin Duck Prey			
FAI/ANC/FAI (1 trip @ $200)		200	
Per diem (2 days @ $211)		422	
	Subtotal		622
Side Scan Sonar			
FAI/ANC/FAI (1 trip @ $200)		200	
Per diem (3 days @ $211)		633	
	Subtotal		833
Project Management			
ANC/FAI/ANC (2@200)		400	
ANC/Cordova/ANC (2@250)		500	
Per diem (14@141)		2,052	
	Subtotal		2,952

CONTRACTUAL

River Otters/Pigeon Guillemots	
Vehicles (lease, FAI/VDZ/FAI)	2,250
Equipment maintenance	1,850
ADF&G - Contract (project assistance)	10,000
Project support services	5,000
Freight	3,000
Publication costs	1,000
Vessel charter (25 days @ $400)	10,000

Duplication/computer fees	600	
ELISA analysis (oil on pelage)	1,600	
IG analysis	2,000	
HP analysis	1,000	
Telephone	400	
Subtotal		38,700

Sea Otters		
Veterinarian (7 days @ $300)	2,100	
Shipping	3,000	
160 hrs. Scout aircraft @ $200/hour	32,000	
Warehouse space at Cordova w/ USFS	2,000	
Blood, immune function and oil exposure assays (costs for all four NVP species)	60,000	
Air taxi (24 hrs. @ $250)	6,000	
Subtotal		105,100

Harlequin Ducks		
Vessel charter (50 days @ $1500)	75,000	
Aircraft (192 hrs. @ $275)	52,800	
Body composition analyses	5,000	
Statistical consulting	2,000	
Radio telemetry	5,800	
Subtotal		140,600

Mussels		
Vessel charter (14 days @ $1600)	22,400	
Subtotal		22,400

Subtidal Clams		
Shipping	900	
Copying/postage	400	
Computer consultant	2,500	
Graphics/Publication costs	500	
Telephone	500	
Subtotal		4,800

Invertebrate Predators			
Shipping		800	
Copying/postage		500	
Telephone		500	
Vessel charter (21 days @ $1600)		33,600	
Computer consultant		2,500	
Graphics/Publication costs		500	
	Subtotal		38,400
Intertidal Clams			
Freight		500	
Telephone/FAX		300	
Sediment analysis		6,000	
Reporting		500	
	Subtotal		7,300
Urchins/Crabs			
Freight		200	
Coastal Resources Associates		51,022	
Telephone/FAX		300	
Vessel Charter (21 days at $2500)		52,500	
	Subtotal		104,022
Fishes			
Coastal Resources Associates		40,136	
Telephone/FAX		300	
Vessel charter (15 days at $2500)		37,500	
Freight		200	
	Subtotal		78,136
Harlequin Duck Prey			
Coastal Resources Associates		7,036	
Telephone/FAX		200	
	Subtotal		7,236

Side Scan Sonar			
Coastal Resources Associates		15,085	
Side Scan Sonar contract		15,000	
	Subtotal		30,085
Project Management			
Statistical Consultation		15,000	
	Subtotal		15.000

COMMODITIES

River Otters/Pigeon Guillemots			
Lab supplies/assay kits			
2 Interleukin kits		1,100	
2 P450 kits		520	
68 blood panel assays		2,380	
Food (14 weeks @ $600)		8,000	
Camp gear (sleeping bags, pads, chairs, cots)		1881	
Camp/sample prep. fold-out table (3 @ $92)		276	
Pesola scales (8 @ $50)		400	
Whirl-pacs		200	
Miscellaneous boat safety supplies		350	
MSR Waterworks filtration system (2 each + replace)		355	
First aid kit (2 @ $132)		264	
Miscellaneous field camp supplies		1000	
Climbing gear		1450	
Day packs (3 @ $50)		150	
Rite-in-rain notebooks, data sheets		325	
Rain gear		1000	
Waders/hip boots (4 @ $119)		476	
Boat fuel (65 gal/day @ $2/gal, 90 days)		11,700	
Propane tank, 100 lbs (4 @ $120)		480	
Propane regulator, lines		250	
Coleman propane stove, 2 burner (2 @ $68)		136	
Camp cooking supplies		300	
Hancock live traps (34 @ $245.25)		8,339	
Bait for live traps		500	
Blood sampling/storage supplies		3,500	
	Subtotal		45,332

Sea Otters		
Fuel (2500 gal @ $3/gal)	7,500	
Food (60 days @ $20/day)	1,200	
Office/field supplies, miscellaneous	1,500	
Subtotal		10,200
Harlequin Ducks		
Fuel (1000 gal @ $3/gal)	3,000	
Surgical supplies	9,000	
Equipment maintenance	2,000	
Subtotal		14,000
Mussels		
Hydrocarbon chemistry supplies	2,500	
Field & lab chemicals	2,300	
Field & lab supplies (pumps, sieves, jars)	1,200	
Weight/measure supplies	600	
Publication/presentation costs	500	
Shipping, freight, containers, equip. maintenance	2,000	
Image analysis	5,000	
Subtotal		14,100
Subtidal Clams		
SCUBA gear	1,500	
Sampling supplies	2,800	
Skiff fuel	160	
Photographic film	225	
Spare parts, outboards	500	
Shipping supplies	200	
Subtotal		5,385

Invertebrate Predators			
SCUBA gear		1,500	
Sampling supplies		3,000	
Skiff fuel		320	
Photographic film		225	
Spare parts, outboards		300	
Shipping supplies		200	
	Subtotal		5,545
Intertidal Clams			
Field supplies		500	
Computer software		500	
	Subtotal		1,000
Urchins/Crabs			
Diving supplies		2,500	
	Subtotal		2,500
Fishes			
Sampling equipment		1,000	
	Subtotal		1,000
Harlequin Duck Prey			
Lab supplies		200	
	Subtotal		200
Side Scan Sonar		50	
	Subtotal		50
Project Management		2,248	
	Subtotal		2,248

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EQUIPMENT

River Otters/Pigeon Guillemots		
Centrifuge, field, DC powered	1,341	
Propane freezers (2 @ $1450)	2,900	
Top-loading balance, battery powered (2 @ $500)	1,000	
Subtotal		5,241
Sea Otters		
70 HP Outboard engine, OMC	4,000	
Capture gear and supplies	5,000	
Hand held VHF radios (2 @ $500)	1,000	
Subtotal		10,000
Harlequin Ducks		
Radio transmitters (100 @ $200 ea)	20,000	
Miscellaneous	8,000	
Subtotal		28,000
Mussel		0
Subtidal Clams		
Dissecting microscope	7,500	
Subtotal		7,500
Invertebrate Predators		0
Intertidal Clams		0
Urchins/Crabs		0
Fishes		0
Harlequin Duck Prey		0
Side Scan Sonar		0

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Project Management 0

Note: FFY 96 field equipment needed through available EVOSTC equipment consists of

1. 2 Mark II (14-15') inflatable boats
2. 2 25 HP Outboard motors
3. 2 hand-held marine radios
4. Heater, propane
6. Binoculars, low-light- 3 ea
7. Mustang suits
8. Survival suits
9. Laptop computer-486 minimum
10. Desktop computer-486 minimum, printer

ADMINISTRATION (Overhead)

River Otters/Pigeon Guillemots (10% of total direct)	16,323
Sea Otters (10% of total)	19,776
Harlequin Ducks (10% of total)	30,630
Mussels (15% of salaries)	13,617
Subtidal clams	9,078
Invertebrate predators	12,850
Intertidal clams (20% of total direct)	14,670
Urchins/Crabs (20% of total direct)	30,053
Fishes (20% of total direct)	26,055

Harlequin Duck Prey (20% of total direct)	4,199
Side Scan Sonar (20% of total direct)	6,937
Project Management (10% of total)	8,700
Subtotal	193,843

TOTALS by Budget Category

Salaries	640,626
Travel	81,794
Contractual	576,779
Commodities	100,812
Equipment	50,741
Administration	193,843

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TOTALS by Project Component

River Otters/Pigeon Guillemots	179,554	
Sea Otters	217,536	
Harlequin Ducks	336,930	
Mussels	151,459	
Subtidal Clams	69,776	
Invertebrate Predators	101,311	
Intertidal Clams	88,020	
Urchins/Crabs	180,316	
Fishes	156,332	
Harlequin Duck Prey	25,193	
Side Scan Sonar	41,622	
Project Management	95,546	
NVP PROJECT TOTAL, FFY 1996		**1,644,595**

APPLIED
marine
SCIENCES

March 22, 1995

Molly McCammon
Executive Director
Exxon Valdez Oil Spill Trustee Council
645 G Street Ste.402
Anchorage, AK 99501

Re: Recommendation on Nearshore Vertebrate Predator Project (95025)

Dear Molly,

We received the detailed project description for the "Nearshore Vertebrate Predator Project" in our office on February 21, 1995. It was sent to several reviewers and they have provided written comments on the project description. The proposal was also the subject of a conference call on March 20, 1995 with the core reviewers, myself, Andy Gunther and you.

The project will focus on the recovery of a suite of important predators that were injured by the spill in the nearshore part of the Prince William Sound ecosystem: (1) two invertebrate consumers: sea otters and harlequin ducks, and (2) two fish eaters: river otters and Pigeon Guillemots. The study asks three basic questions: (1) Is the recovery of these species being constrained by intrinsic demographic factors? (e.g., intrinsic rate of population increase?) (2) Is the recovery of these species being constrained by food?, and (3) Is the recovery of these species being constrained by continuing oil exposure? There are separate approaches to answering each of these general questions. For the demographic factors, studies of the population sizes and growth rates of these predators will be carried out. For assessing the possible role of continuing oil toxicity, assessments of individual health of organisms will be carried out using a biochemical indicator of oil exposure and immune system indicators. For the food availability questions, the abundance of major prey items will be assessed in oiled and unoiled areas. The project is proposed to start in 1995 with an expenditure of $596K and to expand to $1.64M in FY1996 and FY1997.

The reviewers were unanimous in their praise of this project. Dr. Holland-Bartels, with the help of the Principal Investigators, has done an excellent job in molding the original proposed work into a cohesive package. It is obvious that the funds that were provided by the Trustee Council in November 1994 for further planning were a sound investment. This is a logically organized and defensible project, there are a series of well articulated hypotheses and alternative hypotheses. It is well focused on EVOS restoration goals. The reviewers also consider the four species chosen to represent important vertebrate species injured by the spill and to have been studied sufficiently in past studies so that we have a reasonable chance to determine what may be limiting their populations, and, therefore, their recovery.

The reviewers have some specific recommendations for improving certain aspects of the proposed studies that should be implemented. These suggested changes are not serious enough that I am requiring a revision or further consideration of the study plan before formulating a recommendation to you for funding. I do request that Dr. Holland-Bartels respond to the written comments and suggestions of the reviewers before the project goes into the field so that the reviewers can be satisfied that the field work is being properly conducted. The reviewer comments are appended to this letter.

Based on my evaluation of the project, the written reviews, and discussions with the reviewers I am recommending that this project be funded as an important ecosystem approach to understanding recovery of the nearshore portion of the marine ecosystem that was hard hit by the oil spill.

Sincerely yours,

Robert B. Spies
Chief Scientist

CC: L. Holland-Bartels

APEX:

APEX PREDATOR ECOSYSTEM EXPERIMENT IN PRINCE WILLIAM SOUND AND THE GULF OF ALASKA

A PROPOSAL TO THE EXXON VALDEZ OIL SPILL TRUSTEES

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APEX 5

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INTRODUCTION

The spill from the oil tanker Exxon Valdez resulted in significant mortality of several seabirds and in acute massive damage to Prince William Sound (PWS) and the Gulf of Alaska (GOA) (Piatt et al. 1990). Five years following the spill, several species have not recovered (Agler et al. 1994a,b; Klosiewski and Laing 1994). This may be the result of lingering effects of the oil spill (toxicity of prey, sublethal effects of oil exposure to organisms, or enduring changes to ecosystem structure). On the other hand, other non-oil factors may be involved, such as predation, climate-driven ecosystem changes, or even 'random' perturbations (cf. Piatt and Anderson 1995).

Both to aid in the recovery of injured resources and to safeguard the long-term health of Prince William Sound, we need to understand the ecological processes that control the ecosystem. This project focuses on the trophic interactions of seabirds and the forage species they feed on. We chose food as the focus because: 1) much of seabird population theory (Ashmole 1963) and several empirical field tests (e.g. Furness and Birkhead 1984; Birt et al. 1987) have identified food as an important limiting factor; 2) seabird/fish researchers in the PWS/GOA complex have concluded that major changes in food have occurred during the period (e.g. Hatch et al. 1993; Springer 1993); 3) other factors such as oil toxicity and climate change might express themselves through the food supply (e.g. Duffy 1993); and 4) a knowledge of the forage food base is critical for other apex predators, such as marine mammals and predatory fish, as well as for any larger effort to manage Prince William Sound's marine resources in a sustainable manner.

In addition, testing the importance of abiotic factors such as El Niño/Southern Oscillation (Duffy 1993) or 18.6 year nodal tides (Royer 1993) requires data sets at least as long as the expected frequencies. In testing biotic factors first, we also acquire time-series that can be used for subsequent tests of abiotic factors.

We propose to study the distribution and abundance of prey species through acoustic sampling in relation to food, environmental conditions and possible competitors, then to examine the physical, behavioral and competitive limits to access to these forage species for seabirds. We will examine the reproductive consequences of such limitations for pigeon guillemots *Cepphus columba* and black-legged kittiwakes *Rissa tridactyla*, with pilot components to determine if we can extend the examination to tufted puffins *Lunda cirrhata* , common murres *Uria aalge* and predatory fish. By examining the diet and reproductive consequences for a surface-feeder (kittiwake), a benthic diver (pigeon guillemot), two pelagic divers (puffin and murre), and large fish, we should be able to build up a picture of the forage base for the entire seabird community, setting the stage for a long-term, low-cost monitoring program.

Seabird Species

Prince William Sound has large populations of seabirds, although these are not as numerous or diverse as populations elsewhere in the Gulf of Alaska region (Sowls et al. 1978; DeGange and Sanger 1987).

The main breeding species within the Sound are marbled murrelets *Brachyramphus marmoratum* , black-legged kittiwakes , glaucous-winged gulls *Larus glaucescens*, and pigeon guillemots, with smaller numbers of double-crested cormorants *Phalacrocorax auritus*, mew gulls *Larus canus*, Arctic terns *Sterna paradisaea*, and horned *Lunda corniculata* and tufted puffins (Isleib and Kessel 1973; Sowls et al. 1987). Kittlitz's murrelets *Brachyramphus brevirostre* are also frequent in the Sound, presumably breeding (Isleib and Kessel 1973; Klosiewski and Laing 1994).

In contrast, northern fulmars *Fulmarus glacialis,* and Leach's storm-petrels *O. leucorhoa* are absent from the Sound. Fork-tailed storm-petrels *Oceanodroma furcata* are known from only a single colony (Isleib and Kessel 1973). Absence of appropriate cliff-nesting habitat in much of the Sound may restrict breeding by common murres (D. Roseneau, pers. observ.) and, to a lesser extent, by kittiwakes. The same may be true for pelagic *Phalacrocorax pelagicus* and red-faced cormorants *P. urile* which use cliff ledges (Sowls et al. 1978).

Population Trends: Numerous species have declined between surveys in the 1970's and the 1990's in Prince William Sound: cormorant spp., kittiwake, glaucous-winged gull, Arctic tern, Kittlitz's and marbled murrelets, tufted and horned puffin, and pigeon guillemot (Klosiewski and Laing 1994; D. Irons, pers. comm.). Colony trends for kittiwakes have been inconsistent with changes in total numbers, although kittiwake productivity has dropped between 1984 - 1989 and 1990 - 1993 (D. Irons, pers. comm.). The population of pigeon guillemots *(Cepphus columba)* in PWS has decreased from about 15,000 in the 1970's (Isleib and Kessel 1973) to about 3,000 in 1993 (Sanger and Cody 1993). Based on censuses taken around the Naked Island complex (Naked, Peak, Storey, Smith, and Little Smith Islands), pre-spill counts (ca. 2,000 guillemots) were roughly twice as high as post-spill counts (ca. 1,000 guillemots; Oakley and Kuletz 1993). Pigeon guillemots are listed as "Not recovering" in the 1994 Exxon Valdez Oil Spill Restoration Plan.

Common murres were among the species most damaged by the oil spill, but most of the oiled birds nested outside PWS (Piatt et al. 1990). Murres are also listed as "Not recovering" in the 1994 Exxon Valdez Oil Spill Restoration Plan.

Seabird diets: The best evidence for a shift in trophic resources for seabirds within Prince William Sound comes from pigeon guillemots. No long-term data sets exist for other species (Springer 1993) or, like black-legged kittiwakes, they exhibit great year to year variability (D. Irons, unpubl. data).

In 1994, sand lance accounted for only about 1% of prey items fed to guillemot chicks at Jackpot Island and about 8% at Naked Island (Oakley and Kuletz 1993); in contrast, in 1979 the sand lance component at Naked Island was about 55% (Kuletz 1983). Gadids were much more prevalent in the diet of guillemot chicks on Naked Island in 1994 (ca. 30%) than they were in 1979-1981 (< 7%; Kuletz 1983).

Pre-spill studies of pigeon guillemots breeding at Naked Island suggest that sand lance are a preferred prey during chick-rearing (Kuletz 1983). Breeding pairs that specialized on sand lance tended to initiate nesting attempts earlier and produce chicks that grew faster and fledged at higher weights than did breeding pairs that preyed mostly upon blennies and sculpins, at least in years when sand lance were readily available. Consequently, the overall productivity of the guillemot population was higher when sand lance were available.

The decline in the prevalence of sand lance in the diet of guillemots breeding at Naked Island might be a key element in the failure of this species to recover from the oil spill. The schooling behavior of sand lance, coupled with their high lipid content relative to that of gadids and nearshore bottom fish, might make this species a particularly high-quality forage resource for PWS pigeon guillemots. This is consistent with the observation that other seabird species (e.g., puffins, murres, kittiwakes) experience enhanced reproductive success when sand lance are available (Pearson 1968; Harris and Hislop 1978; Hunt et al. 1980; Vermeer 1979, 1980).

Outside the Sound, there is evidence of a shift in forage species and in seabird diets and populations in the North Pacific and Bering Sea (Springer 1993), but the significance of this to conditions in PWS remains unknown. Hatch (FIGURE 1; unpubl. data) showed a great increase in pollock in 1994 compared to 1978 and 1990 in diets of tufted puffins and a corresponding decrease in sand lance in diets of both tufted puffin and rhinoceros auklet *Cerorhinca monocerata* at Middleton Island. Summarizing data from five species in the Gulf of Alaska, Piatt and Anderson (1995) documented a dramatic shift from capelin to other species, primarily sand lance (FIGURE 2).

Forage Species

Forage species include planktivorous fishes and invertebrates. Planktivorous fish species that occur in PWS and are known or likely prey of apex predators include Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), walleye pollock (*Theragra chalcogramma*), capelin (*Mallotus villosus*) and eulachon (*Thaleichthys pacificus*). Among these, Pacific herring are commercially valuable in PWS and have been studied extensively by Alaska Department of Fish and Game (ADF&G) to facilitate management. Data available for Pacific herring include population size, year-class abundance, and growth. Walleye pollock are commercially valuable in the western GOA and the Bering Sea; consequently there are considerable data describing populations and biology in those area, but relatively little information exists on pollock in PWS. The other fish species are not commercially important in Alaska and have received little study (Adkinson 1993), although some scattered information allows a preliminary assessment of their life-history features, distributions and food habits.

Pacific herring populations in PWS are monitored through egg surveys, with subsamples aged to estimate year-class abundances. Through the 1980's herring abundances were relatively high in PWS, with cyclical strong year classes. In 1993 and 1994 herring populations declined sharply. Adults had relatively high incidences of lesions caused by viral hemorrhagic septicemia (VHS), and the mean size at age was abnormally low. Apparently herring populations in PWS have been seriously stressed in recent years. Although linkage to EVOS has not been clearly demonstrated, problems with herring may stem from post-EVOS changes in the pelagic production system of PWS. In that case, other forage species may have been similarly affected. Herring are prey for many apex predators, including seabirds and marine mammals.

In the western GOA and Bering Sea juvenile walleye pollock are planktivorous, and are preyed upon by apex predators. In Shelikof Strait in April, walleye pollock comprised about 99% of midwater planktivores (Brodeur and Merati 1993). In PWS walleye pollock are probably an important forage species. In a bottom trawl survey of PWS, walleye pollock were the most abundant species (Parks and Zenger 1979), and walleye pollock were the most abundant larval fishes found in ichthyoplankton samples collected in 1989 after the EVOS (B. Norcross, pers. comm.). Juvenile walleye pollock are very important constituents of the diets of piscivorous seabirds (Springer and Byrd 1989; Divoky 1981) and marine mammals (Lowry et al. 1989; Pitcher 1980, 1981).

Pacific sand lance occur throughout the GOA and are important forage species wherever they occur. They are planktivorous, feeding on euphausiids and copepods, with euphausiids more important in winter months (Craig 1987a). Throughout their range, calanoid copepods have generally been reported as their principal prey (Simenstad et al. 1979; Rogers et al. 1979; Cross et al. 1978; Craig 1987). Pacific sand lance have been reported as prey for a variety of marine seabirds (Sealy 1975; Vermeer 1979; Drury et al. 1981; Springer et al. 1984; Wilson and Manuwal 1986). They are also eaten by many marine mammals including harbor seals (Pitcher 1980) and Steller's sea lions (Pitcher 1981). There is little information on the abundance and distribution of sand lance in the PWS area, but they are probably an important intermediate link in the food webs that support apex predators.

Two smelt species, capelin and eulachon, are probably important forage species in PWS. In a bottom trawl survey conducted in April, eulachon was the fifth most abundant species collected overall, but it was the dominant species at depths over 200 fm. (Parks and Zenger 1979). These fish were ready to spawn and apparently were intercepted while migrating to their spawning grounds in rivers. Eulachon are important forage species throughout Alaska, and may be the most important forage fish in the southern Bering Sea (Warner and Shafford 1981).

Capelin spawn on nearshore sandy substrates. In the northern Gulf of Alaska (Kodiak) they spawn in May and June (Warner and Shafford 1978; Pahlke 1985). They are prey of many piscivorous seabirds (Baird and Gould 1985) and marine mammals (Fiscus et al. 1964).

A striking feature of the forage fishes, and one that has important implications for this project, is the difference among the species in spawning times and locations. Spawning aggregations, migrations to spawning grounds, and post-spawning dispersion patterns must result in temporal and geographic variation in availability of forage fishes. The structure of reproduction among the potentially important forage fishes is:

SPECIES	SPAWN TIME	LOCATION
Pacific sand lance	December-February	Probably shallow nearshore

Pacific herring	March-April	Intertidal, shallow subtidal hard substrates, macrophytes
Walleye pollock	April-May	Pelagic, deep
Eulachon	April-May	Streams, near tide-water
Capelin	May-June	Intertidal, shallow subtidal depositional beaches

Initial analysis of diets (Sturdevant 1995: FIGURE 3) demonstrated considerable overlap in diet between pollock and sand lance, pink salmon fry and sand lance, and between herring and capelin, suggesting the potential for competitive interactions between guilds of forage fish species. However, these analyes were based on limited samples and size classes, so the situation is likely to be more complex (Sturdevant 1995).

Macrozooplankton: Euphausiids, shrimp, mysids, and amphipods are a central component in the diets of sand lance, capelin and pollock, as well as of young salmon (Clausen 1983; Coyle and Paul 1992; Livingston et al. 1986; Straty 1972). When aggregated in sufficient densities, macrozooplankton are fed on directly by marine birds (Coyle et al. 1992; Hunt et al. 1981; Oji 1980). Swarming behavior by breeding euphausiids (Paul et al. 1990b) and physical factors (Coyle et al. 1992; Coyle and Cooney 1993) may concentrate macrozooplankton and micronekton into aggregations of density suitable for efficient foraging by predators. Unfortunately, there is little information on the abundance, distribution and fluctuations of these key invertebrate taxa in the EVOS impact region. In the GOA, zooplankton abundance has varied on a decadal time scale (Brodeur and Ware 1992); and, superimposed on longer cycles, are interannual fluctuations as high as 300% (Frost 1983; Coyle et al. 1990; Coyle and Paul 1990, 1992; Paul et al. 1990a, 1990b, 1991; Paul and Coyle 1993). Such variability in abundance may directly or indirectly affect populations of apex predators in PWS.

Constraints on Research

Historical data are scarce and often poorly documented, especially for forage fish that are not commercially important (Adkinson et al. 1993). However imperfect, such time series provide the only way directly to test hypotheses at the decadal scale. Interannual and intra-annual comparisons of ecosystems with differing abundances of forage fish allow initial tests of these same hypotheses at the scale of one to three years, the proposed duration of this project. We assume that the factors that determined relative abundance of forage fish historically continue to operate contemporaneously. Finally, geographic comparisons within the same time periods provide an additional test of the effects of different ecosystem conditions and of different relative forage species abundances.

Measuring prey availability is not an easy task. While indirect indices, such as changes in fisheries landings, can approximate prey available to seabirds, the most effective measurements are direct, such as acoustic counts of fish, using surface ships and transect sampling. This requires careful calibration of the acoustic devices and an ability to identify the different fish species. Identification of fish is typically done with nets or trawls on the acoustic targets, but improved hydroacoustic technology can allow identification based on school shape and characteristics or even based on individual fish. Another approach to measuring forage fish presence and abundance is to study the diets of predatory fish (Ashmole and Ashmole 1967).

While the fish-sampling methodology is available, it is not always clear at what scale nesting seabirds are exploiting their environments, yet such information is vital if indices of abundance are to be linked to events at a seabird colony. Correlations of seabird and food abundance appear to increase with scale (Heinemann et al. 1989; Erikstad et al.1990).

It is possible to measure distribution of seabirds foraging away from nesting colonies directly at sea (Eulerian sampling: e.g. Wilson et al 1988) or indirectly through use of radio or satellite-tracking of individual birds (LaGrangian sampling: e.g. Irons 1992), or by time elapsed during foraging trips (Cairns et al. 1987; Wanless and Harris 1992).

Even if forage fish and foraging birds can be measured at an appropriate scale, such measurements do not necessarily represent food available to foraging birds. Food availability may be locally enhanced by local oceanographic features (Coyle et al. 1992). Seabird species may differ in their choice of fish schools based on fish density (Piatt 1990), depth (Burger and Simpson 1986), or preferred foraging area (Irons 1992). Seabird species may arrive or depart from interspecific foraging aggregations at different times in their development: a species may be able to forage at a fish school only before other species arrive to displace it (Hoffman et al. 1981). Intense interspecific interactions between Pacific alcids occur underwater (Duffy et al. 1987) so mechanisms for competitive exclusion exist.

Although food availability can be assessed, measuring its relation to reproductive success is complicated. There must also be enough variability in diet between years to detect such relations. This does not appear to be a problem in the Gulf of Alaska area (e.g. Baird 1990; Irons 1992; Oakley and Kuletz 1993; S. Hatch, pers. comm).

While seabirds have some capacity to buffer their chick-rearing and foraging against variations in food supply (Cairns et al. 1987; Burger and Piatt 1990; Irons 1992), there is abundant evidence of differential reproductive response to changes in prey availability (e.g. Braun and Hunt 1983; Ricklefs et al. 1984; Springer et al. 1986; Irons 1992). Over time, there must generally be enough food to support a breeding population at a particular seabird site, but within and between years, there may be food shortages with effects ranging from reduction in growth of young to total colony failure (e.g. Murphy et al. 1991; Harris and Wanless 1990). Food may fall short both in amount and in quality (cf. Vader et al. 1990).

Even if mortality does not occur, these shortfalls may be reflected in differences in body growth-rate and composition of nestling seabirds or in the masses at which they leave the nest. The latter has been reported to predict survival of the young once they fledge (Perrins et al. 1973).

Research Approach

All these are formidable problems, but we believe they can be successfully tackled by framing a series of hypotheses that serve to organize our research and by collaborative research across disciplines.

Our research will look at the effect of different forage food availability measured acoustically on reproductive parameters of kittiwakes and pigeon guillemots between years and within years at two (guillemot) and 26 sites (kittiwake) sites in PWS . A pilot project will attempt the same measurements for tufted puffins within GOA. We will also compare the effect of a capelin-rich forage environment outside PWS with the post-EVOS forage environment within the Sound for kittiwakes and puffins. The energetic and nutritional bases for these effects will also be explored. We will also explore the availability of forage species in terms of their own behavior and in terms of the behavior and interactions of their predators.

While we test the effects of possible food limitations on the recovery of Prince William Sound seabirds, we also need to understand the ecosystem mechanisms that might be causing such limitations. We suggest that studies of mechanisms of change should focus on productivity measures of forage species. This is because changes in forage productivity would likely influence the general levels of abundance as well as availability of forage species as food for seabirds.

Finally, the sum of all these efforts should allow us sufficient understanding to identify simple, inexpensive parameters that can be measured to monitor the state of overall forage species/seabird interactions within the PWS ecosystem.

General hypothesis:

A shift in the Prince William Sound marine trophic structure has prevented recovery of injured resources.

Working Hypotheses

1. The trophic structure of PWS has changed at the decadal scale

testable assumption: Intra-annual variability in diet and other trend data are less than at the annual or decadal level;

a. prediction: Historical data on bird and predatory fish diets, net samples, fisheries landings, and other available data will show shifts in trophic structure at the decadal scale.

b. prediction: Changes will be linked to shifts in environmental conditions

test: Analysis of available data will show shifts at the decadal level. Such shifts will be coherently expressed across different data sets. Historically, forage species that eat each other or have high diet overlaps will show inverse population trends.

task: Piatt (Appendix 1).

2. Planktivory is the factor determining abundance of the

preferred forage species of seabirds

testable assumptions: we can measure fish diet and we can measure some relative index of forage fish abundance, population trends should be visible within the three-year sample period of this study.

a. prediction: Diets will differ between forage species.

b. prediction: Forage species differ in their daily energy budgets and in the food rations that satisfy such demands

test: Species with favorable energy balances will be more common and have positive population trends. Species with high diet overlaps or a trophic relationship will show inverse trends over the three years of the study.

tasks: Sturdevant (Appendix 2)
Coyle and Thorne (Appendix 3)
Haldorson and Paul (Appendix 4)

3. Forage species differ in their spatial responses to oceanographic processes

testable assumption: we can identify and sample forage fish species acoustically and/or with nets and make simultaneous environmental measurements.

a. prediction: The occurrence of each forage species is associated with a predictable suite of environmental conditions, such as date, depth, or water temperature.

b. prediction: The condition-indices and growth rates of forage species will differ in relation to a predictable suite of environmental conditions.

test: Measure the distribution, abundance, and condition of forage species with simultaneous collection of environmental data; cross correlate or use multivariate statistics to identify relevant parameters that separate species.

task: Coyle and Thorne (Appendix 3)
Haldorson and Paul (Appendix 4)

4. Productivity and size of forage species change the energy potentially available for seabirds

testable assumptions: forage fish differ measurably in body condition and size between species, between seasons, and between years; we can detect trends in forage species over three years or hindcast trends based on historical data (e.g. seabird diets and herring landings)

a. prediction: spawning species will be richer energetic prey than are non-spawners (cf. Montevecchi and Piatt 1984)

b. prediction: spawning aggregations are larger than non-spawning aggregations

c. prediction: measures of fish productivity reflect direction and changes in fish stocks

test: Compare size and proximate analyses of forage species with multi-year population indices to identify body-condition parameters that can be used to monitor fish populations.

tasks: Coyle and Thome (Appendix 3)
Worthy (Appendix 5)

5. Forage fish characteristics and interactions among seabirds limit availability of seabird prey

testable assumptions: prey differ in depth, school size, fish size, distance offshore; seabirds differ in foraging characteristics.

a. prediction: Inter- and intra-specific interactions of seabirds determine access to prey at patches

b. prediction: Differences in seabird morphology and foraging characteristics determine access to prey

test: During transects, record group size, group density, depth/duration of dive, frequency of foraging methods, distance foraged from colony, and competitive interactions for each seabird species.

test: Compare seabird species assemblages at food patches of different sizes and species.

tasks: Ostrand (Appendix 6)

6. Seabird foraging group size and species composition reflect prey patch size

testable assumption: school size for schooling species remains constant within but differs between species (Radovich 1979) or it varies within species in response to food levels (Duffy and Wissel 1988)

a. prediction: Inshore foragers will have smaller flock sizes than do off-shore foragers

b. prediction: Foraging flock group size will decline over the breeding season as birds shift from spawning herring to other prey with smaller school-patch sizes.

c. prediction: Foraging-flock composition will change with school size.

d. prediction: Inshore patches are smaller than offshore patches within and between prey species.

e. prediction: Patch (school) size is constant within species.

test: Regress mean seabird foraging group size on transects with mean patch size for each month and subregion of transects.

test: Determine characteristic patch size for forage species by month and distance/depth offshore.

tasks: Ostrand (Appendix 6)
Coyle and Thorne (Appendix 3)

7. Seabird diet composition and amount reflects changes in the relative abundance and distribution of forage fish at relevant scales around colonies

testable assumptions: Seabird foraging decreases with distance from colony so an effective foraging zone can be determined; acoustic sampling can determine relative abundance indices for each colony's foraging zone (relative biomass, number of schools, number of accessible schools, or, in the worst case, simply presence/absence of prey).

a. prediction: The greater the overlap in foraging zones between colonies, the less the difference in diet

b. prediction: Seabird diet composition directly reflects relative forage species abundance-indices in surrounding waters, as measured by acoustic surveys and by analysis of predatory-fish stomachs.

c. prediction: Seabird diet composition reflects forage fish acoustic abundance determinations, once these are corrected for relative availability, based on seabird species-specific foraging constraints.

test: Determine effective foraging ranges based on Eulerian (at-sea transects) and LaGrangian (radiotracking of kittiwakes, murres and puffins; direct observation of guillemots).

test: Determine overlap in foraging zones between colonies (cf. Furness and Birkhead 1984; Cairns 1989).

test: Compare black-legged kittiwake, pigeon guillemot, and tufted puffin diet data in Prince William Sound with acoustically-derived forage fish abundance-indices at appropriate scale, determined above.

test: Compare relative forage species proportions in seabird (tufted puffin, pigeon guillemot, black-legged kittiwake, common murre) diets in several study areas (PWS, Barrens) with acoustic indices and predatory fish stomachs, both within and between years.

tasks: Coyle and Thorne (Appendix 3)
Ostrand (Appendix 6)

Irons (Appendix 7)
Hayes (Appendix 8)
Roseneau (Appendix 9)
Roseneau (Appendix 10)
Hatch (Appendix 11)

8. Changes in seabird reproductive productivity reflect differences in forage fish abundance as measured in adult seabird foraging trips, chick-meal size and chick-provisioning rates

testable assumption: A linear relation exists between parameters (Occam's Razor). Some initial work (Irons 1992) indicates the presence of response thresholds and nonlinear responses but this needs to be confirmed. We assume that meal mass and provisioning rate vary; however, these may exhibit an asymptotic maximum.

a. prediction: Chick provisioning rates are linearly related to amount of food and to growth and survival of nestling black-legged kittiwakes, puffins, murres, and pigeon guillemots.

b. prediction: Meal mass per chick provisioning is linearly related to amount of growth and survival of nestling black-legged kittiwakes, tufted puffins, common murres, and pigeon guillemots.

c. prediction: adults will respond initially to changes in food availability with changes in foraging effort (duration or length of trip), providing a buffer in predictions a and b.

test: measure length of foraging trips, frequency of trips, meal size, growth and survival of young kittiwakes and guillemots, with additional data from pilot studies of tufted puffins and common murres.

tasks: Irons (Appendix 7)
Hayes (Appendix 8)
Roseneau (Appendix 10)
Hatch (Appendix 11)

9. Seabird reproductive productivity is determined by differences in forage fish nutritional quality

testable assumption: Differences in nutritional quality will be greater than any buffering in determining growth rate; substantial differences in forage prey species and seabird diet exist between sites.

a. prediction: Meal energy and nutritional content are linearly related to both short-term and fledging growth and body state parameters (cf.

Montevecchi and Piatt 1984).

test: Measure food, energy/nutritional intake, and resulting growth and body parameters in kittiwakes (2 sites), pigeon guillemots (2 sites: one benthic prey, one pelagic prey), and puffins (one site) in Prince William Sound where herring and sand lance have apparently been declining and of kittiwakes (one site), murres (one site) and puffins (one site) at the Barren Islands where capelin, a high-nutrient food, has recently been abundant.

tasks: Roby (Appendix 12)
Worthy (Appendix 5)
with: Hatch (Appendix 11)
Hayes (Appendix 8)
Irons (Appendix 7)
Roseneau (Appendix 10)

10. Seabird species within a community react predictably to different prey bases

testable prediction: A synthesis of results from the present and existing research will provide a coherent picture of seabird/forage species interactions and their effects that is consistent with differences in species.

prediction: One or more parameters will be an effective alias for forage/seabird community interactions.

test: Develop a unified model that can predict future responses of seabird communities to changes in the forage base and to environmental change. We can then identify a few simple parameters that can be used to monitor the seabird community on a continuing basis.

task: While initial modelling will begin with the first results, a formal effort will not begin until after the second field season and will be included in the third-year budget.

Collaboration

Collaboration within APEX

To be effective, this study requires tight cooperation between its various components. Many of the hypotheses involve integration of data from one component to another (FIGURE 4). For example, acoustic surveys and trawls will give us an index of forage species abundance (Coyle and Thorne) but not necessarily of availability to seabirds, which requires data on foraging capabilities of different species (Ostrand) and their foraging ranges (Irons, Hatch, Ostrand). By combining data sets, we can compare availability with diet and reproductive data for individual seabird species (Hatch, Hays, Iron, Roseneau). These in turn can only be evaluated in light of the nutritional quality of their food. This requires proximate analysis of diet items (Worthy) and an energy/nutrient budget (Roby). Similarly, to understand the interactions between forage species that may account for their shifts in abundance, we need measures of their present abundance (Coyle and Thorne), their diets (Sturdevant) and their energetic requirements (Haldorson and Paul). These in turn require some index of stability of the ecosystem and past evidence of shifts in its stability (Piatt). Taken altogether, we should be able to construct simple 'rules' about how the ecosystem works, that can be tested through monitoring (Duffy and all P.I.'s).

Logistically, the components are also tightly linked (see appendices). The pigeon guillemot component will provide much of the logistic support for the puffin component and the seabird energetics study in PWS. The murre/kittiwake study on the Barren Islands will similarly support the puffin component.

The energetics component will share measurements of nestling parameters made by the guillemot, kittiwake, puffin and murre components. The seabird-foraging component will use the acoustic/trawl survey component, as well as survey work by the SEA project, as platforms for its data collection. Proximate, diet and energetic analyses of fish will depend on fish collected by the trawl surveys, the sampling of predatory fish from charter-boat captains, and on the reproductive studies of kittiwakes, puffins, murres and guillemots.

Collaboration with EVOS Projects

While our initial emphasis is on a tight collaborative structure within the APEX study, we will share fish samples with the Sea Program and will make acoustic data available to both SEA and the marine mammal projects. The proximate analysis data will similarly be used by the marine mammal research projects. In turn, we will be using SEA survey vessels and acoustic data for the seabird foraging component. We will also use SEA data on zooplankton abundance to compare with the condition of forage fish (Appendix 4).

SEA is using Biosonics acoustic gear. We are also using this gear and Dr. Thorne of Biosonics is one of our P.I.'s. Similarly, Dr. Paul is a P.I. in both programs. These two positions should help to ensure ongoing coordination.

Although our research questions and survey designs differ, we share hardware with the SEA acoustic project that allows interchange of data. Similarly, our physical measurements (e.g. CTD's) can be imported into the SEA data structure. We have not asked for funds to support such integration, as it does not serve to test our present hypotheses, but we would be happy to move forward with such an effort, if it were to be supported by the Trustee Council.

We have begun discussions with SEA on modelling efforts for PWS. Obviously these will depend on multi-year data sets that capture some of the variability of the system. SEA is essentially a bottom-up trophic approach while APEX is top down. This suggests that future modelling would be complementary.

Coordination with outside projects

In relations with projects outside the study, we are relying on a U. S. Fish and Wildlife study of kittiwake productivity ($89 K/year) to examine the relation between fish abundance and kittiwake productivity (D. Irons). Similarly, matching funds from the National Biological Service ($15 K: J. Piatt) and 'in-kind' services from the U.S. Fish and Wildlife Service will allow us to obtain useful information from the Barren Islands area where the seabird community apparently has a strong forage base, in contrast to apparent conditions in PWS. Piatt's NBS study, focusing primarily on Kachemak Bay and using generally similar techniques and research approaches, will provide comparative data on an additional seabird ecosystem and will allow a collaborative approach to looking at seabird/forage species interactions at larger scales. We will be able also to draw on his initial findings on bird activvity at foraging'hot spots' while designing our work in year two.

Diet analyses for fish will be supported through salaries by NOAA. Similarly, our tufted puffin study will be supported by $30 K in NBS funds and will be complemented by an $118 K NBS study examining puffin productivity at 11 sites in an arc from southeast Alaska through the Aleutians to eastern Russia. (S. Hatch).

In addition, we hope to collaborate with the Ocean Carrying Capacity Study of the Auke Bay Laboratory of NMFS which will be looking at large-scale distribution of forage fish in the Gulf of Alaska. Potentially, we can jointly address the issue of whether PWS forage-species relative abundance reflects or is independent of abundance of the same species in the Gulf.

Appendix 1

J. Piatt

95163L

Historic review of ecosystem structure in the Prince William Sound/Gulf of Alaska complex

Introduction

It appears that marine fish communities have changed markedly in the Gulf of Alaska during the past 20 years. Coincident with cyclical fluctuations in sea-water temperatures, the abundance of small forage species (e.g., shrimp, capelin) declined precipitously in the late 1970's while populations of large predatory fish (e.g., pollock, cod, and flatfish) increased dramatically (Anderson et al. 1994). Seabird diets shifted from mostly capelin in the 1970's, to mostly sand lance and juvenile pollock in the late 1980's (Piatt and Anderson 1995). A variety of seabirds and marine mammals both inside and outside of the oil spill zone exhibited signs of food stress (population declines, reduced productivity, die-offs) throughout the 1980's and early 1990's.

This project will compile and analyze available unpublished and published data to i) examine historical trends in the species composition and abundance of forage fish communities in the Gulf of Alaska during the past 40 years, and, ii) based on the results and conclusions of this analysis, identify possible research projects to test hypotheses about ongoing and future changes in forage fish communities.

Need for the project

Assessing the effects upon, and recovery of, species injured in the Exxon Valdez oil spill depends on our understanding of natural changes in the Gulf of Alaska marine ecosystem. At present, compelling data from a 21-year time series of scientific trawl catches at one site (Pavlov Bay) in the western Gulf of Alaska (Anderson et al. 1994; Piatt and Anderson 1995) provides the basis for conclusions about long-term changes in forage fish communities. This change in community composition was accompanied by about a 50% decrease in overall fish biomass, and has profound implications for interpreting changes in population biology of dependent predators.

The Pavlov Bay study is the longest continuous survey conducted at a single site in the Gulf of Alaska by the National Marine Fisheries Service (NMFS). But how applicable are these observations to other areas of the Gulf of Alaska-- in particular, the area affected by the Exxon Valdez oil spill? Preliminary analysis of some data suggest that these trends occurred throughout the northwestern Gulf of Alaska, but a large volume of trawl data from this region has never been analyzed.

In addition to Pavlov Bay, NMFS conducted trawls using the same gear in numerous bays, offshore gullys, and island passes from Unimak Pass to Castle Cape; beginning as early as 1957. Using trawl nets with the same design, the Alaska Department of Fish and Game (ADF&G) and NMFS also sampled areas from Castle Cape to Cape Douglas (Cook Inlet), and 4,666 trawls were conducted in the bays and gullys around Kodiak and Afognak islands since 1971. In total, some 9000 individual tows have been conducted in the region, of which about 70% were conducted in the spill area (including Afognak, Shelikof Strait, Alaska Peninsula, and Kodiak Island). Species composition and wet weight biomass were recorded on all these surveys.

Similarly, ADF&G has conducted shrimp trawl surveys in lower Cook Inlet since about 1977. In total, about 1200 individual tows were conducted over this time period, mostly in the area from Kachemak Bay to the Barren Islands. For the years 1977 to 1988, the catch biomass was quantified, but fish species composition may have only been recorded qualitatively. Beginning in 1989, trawl catches were subsampled for species biomass composition. Shellfish/groundfish surveys with a larger-mesh trawl net have been conducted in lower Cook Inlet since 1989.

As part of ongoing research on pollock in the Gulf of Alaska, NMFS has conducted numerous trawls and hydroacoustic surveys in the region since about 1984. Information of forage fish may be more limited from these surveys, however, as they used primarily large mesh bottom trawls for groundfish and fine-mesh mid-water trawls for larval pollock. Nonetheless, these data may be useful in assessing trends in some forage species (K. Bailey, pers. comm.).

In addition to these continuous sampling programs, a variety of studies have been conducted on forage fish species in the Gulf of Alaska during the past 30 years (e.g. Frost and McCrone 1979; Blackburn 1978; Dick and Warner 1982; Dames and Moore 1983; Rogers et al. 1983). Various studies on predator diets in the Gulf of Alaska provide additional historical information on forage fish abundance and distribution (e.g., Sanger 1986; Hatch and Sanger 1992; Merrick and Calkins 1984; Piatt and Anderson 1995; Livingston 1993).

It is desirable to analyze and synthesize these data on forage fish species for several reasons: i) for interpretation of long-term trends in populations and trophic relations of higher vertebrate species, ii) to verify and supplement the site-specific data available on trends in forage fish from Pavlov Bay, iii) to provide a historical basis for predicting future trends in forage fish populations, and, iv) to suggest what kinds of research should be conducted in the future to test hypotheses about forage fish populations.

Objectives

1. Compile existing data from NMFS and ADF&G trawls in the Gulf of Alaska into usable computer databases.
2. Identify forage species of interest from historical data on diets of higher predators in the Gulf of Alaska.
3. Analyze forage fish databases with respect to forage species consumed historically by higher predators. Focus on temporal and geographic variation in forage fish communities.
4. Synthesize all available data on forage species and trophic relationships of predators.
5. Identify potentially useful future research to test hypotheses about changes in forage fish communities in the Gulf of

Alaska.

Methods

Raw data on forage fish catches in trawl nets are in various states of accessibility. The first step is to inventory available data and determine which datasets are useful, and what work is required to get them on line for analysis. Many data have been entered on computer already, but these need to be checked for errors (e.g., find missing data, correct geo-positional data, validate catch weights, etc.) and corrected. Several older historical data, particularly from lower Cook Inlet, need to be compiled and entered into the computer for the first time. More recent data (e.g., 1985 onwards) from all sources are largely available for analysis at the present time.

Following a review of available information (published and unpublished) on the historical diets of seabirds and marine mammals in the Gulf of Alaska, the forage fish data will be analyzed to examine temporal and geographic patterns of variability in key forage fish species. Finally, the data on forage fish and trophic relationships of predators will be synthesized to examine how, and possibly why, trophic relationships have changed over time in the Gulf of Alaska.

The project is anticipated to take 1.5 years for completion. Inventory and compilation of data will take place during the remainder of FY95, and data analysis and reporting will take place in FY96.

Schedule

April-September 1995	Inventory trawl databases, begin data compilation and correction, compile literature on predator diets.
October 1995-March 1996	Analyze forage fish databases, prepare summary reports.
April-September 1996	Synthesize data and prepare draft final report.
December 1996	Final report.

Technical Support

No technical support is required for this project. All technical support is available in-house to the primary investigators.

Location

Data will be analyzed at research instituions in Kodiak (Alaska Fisheries Science Center, NMFS), Homer (Commercial Fisheries Management and Development, ADF&G) and Anchorage (Alaska Science Center, NBS).

Coordination of Integrated Research Effort

APEX 23

This project is a collaborative effort between NBS (John Piatt, Anchorage), NMFS (Paul Anderson, Kodiak; Richard Merrick, Seattle) and ADF&G (William Bechtol, Homer; Jim Blackburn, Kodiak). The study will be coordinated with researchers involved in EVOS forage fish studies in Prince William Sound.

Appendix 2

Sturdevant 95163C

Fish Stomach Contents Analysis

The carrying capacity of PWS for forage fish is a function of primary and secondary productivity and the degree of prey resource partitioning (Cooney 1993). Lack of knowledge about prey resource partitioning among forage fish limits efforts to estimate the carrying capacity of PWS. Prey resource partitioning among forage fish species is a function of the degree of habitat and diet overlap among species. Diets of many of the forage fish species have not been completely described, particularly for juvenile stages. This information is needed to characterize the species' trophic niches, which must be determined before niche overlap can be assessed and the potential for resource competition between species can be inferred.

Trophic relationships must be examined seasonally over as many stages of the life history as possible. A species' preferred foraging habitat may change with hydrographic conditions and reflect foraging behaviors that also change during life history stages. Species caught in the same area may nevertheless have foraged in different levels of the water column, and therefore exhibit low dietary overlap. Niche overlap between age-1 herring and capelin, for example, was highest in the spring when both species foraged in the water column; after the water column stratified, herring switched to a surface-foraging mode in response to a newly available prey assemblage (Coyle and Paul 1992). Niche overlap between the two species then decreased as capelin continued to feed in the water column. Such trophic shifts suggest that species which are not competitors during one season or life history stage may compete at another time.

Trophic web information from the diet study will be used to help establish the basic structure of future ecosystem models of PWS. These models will incorporate data on changing oceanographic regimes, primary and secondary productivity, diet overlap and prey selection, and fish distribution. They are necessary for understanding recovery of predatory species and are useful in guiding recovery activities.

Project Design

The 1995 sampling program will be a continuation of the 1994 pilot project (Project 94163) to determine diet overlap and prey selection among forage fish species. In 1994, samples of 12 species of forage fish were collected. Diet overlap is best determined by analyzing stomach contents of species collected in the same area at the same time. Sympatric species were therefore assigned high priority for stomach processing. Work on the spring and late summer priority collections is nearly completed. However, some species are poorly represented. Important forage fish species such as sand lance and capelin were caught relatively infrequently and rarely co-occurred with others. Samples of allopatric species were initially assigned non-priority processing status. However, because of their importance in seabird diets (eg. Irons 1992; Hatch et al. 1993) coupled with the lack of information about their trophic niches, it is important that these species be examined. Completion of priority sample processing provides an opportunity to analyze the non-priority samples, including July and November collections and species collected allopatrically throughout the 1994 season, before July 1, 1995, when additional samples are collected. This work will also provide important information on how food habits vary when potential competitors are absent versus when the species occur sympatrically and information on seasonal changes in forage fish diets.

Objective

Determine forage fish prey using stomach contents analysis for fish collected from nearshore and offshore sites, and estimate degree of diet overlap among species.

Results

Results of stomach analyses on forage fish collected in the spring and late summer of 1994 will be summarized in the annual report due March 31, 1995. Because results are not complete, the 1995 sampling program will continue to focus on basic diet and prey selection information. The 1994 data are being used to determine what species collections are lacking (see above), refine sample size estimates, evaluate several analytical techniques for describing diet overlap and prey electivity, and determine if prey categories can be pooled in future years.

Three examples from the 1994 stomach analysis illustrate both what we have learned and areas where information is lacking. First, preliminary results suggest that diets of herring and pollock overlap extensively in spring (FIGURE 3). Principal prey biomass was composed of large and small calanoids and larvaceans. However, only 11% of the 27 sets with either of these fish species contained both species. The potential species interactions suggested by the data pooled in FIGURE 3 must be examined with respect to spatial and temporal factors as well as specific prey taxa. We cannot infer competition between herring and pollock until we examine which copepods are consumed when and where.

Second, we note tantalizing results for pink salmon fry and sand lance (mean lengths 65 mm and 135 mm, respectively) collected sympatrically from a single haul in the spring. Principal diet components, small copepods, were similar to observations from studies in other areas (eg. Sturdevant et al. 1995; Craig 1987). However, sand lance stomachs contained approximately four times the biomass of small copepods and 10 times the biomass of the pteropod, *Limacina*, as did pink salmon. Sand lance and juvenile pink salmon interactions must be closely examined to determine if competition with high densities of fry in Prince William Sound affects populations of sand lance available to foraging marine birds. Third, 1994 results are being used to assess the need for finer resolution in data on prey selection and the diel feeding patterns of forage fish species.

Preliminary data show that herring and other forage species consume large, surface-dwelling and deep-water copepods. *Epilabidocera longipedata*, a surface-swarming species (B. Wing, pers. comm., Auke Bay Laboratory) and the diel vertical migrators, *Metridia ohkotensis* and *M. pacifica* (Hattori 1989) were both prey items; at times, they were consumed by the same individual and at other times they occurred separately in fish from different hauls.

To test hypotheses about prey availability, prey selection, and diet overlap among forage fish species, future sampling may require that we determine the depth distribution and vertical migration of their prey, and the time and depth of fish feeding in the water column. The diet overlap project is expected to require at least one additional year of sample collections (1996) in order to examine species which were under-represented in 1994 collections and to collect better information on the distribution, abundance and availability of prey species which are only now being identified.

Methods

Forage fish will be sampled in nearshore and offshore areas, using nets. Each species will be identified and length and weight measured for a minimum of 150 individuals randomly selected from each sample. Fifteen fish from each species/size class will be preserved from each sample. The abdomens of fish larger than 100 mm will be slit before specimens are fixed in 10% formaldehyde solution. The stomach contents of 10 randomly selected individuals in good condition from each net-set will be analyzed.

Sample Collection

Fish stomach samples and zooplankton/epibenthic invertebrate samples will be collected in 1995 in Prince William Sound by members of both the SEA and APEX projects. This cooperative effort will extend the sampling season and collection area, thus providing a more complete representation of available forage fish species and their diets. While the SEA Project (Salmon Growth and Predation) sampling efforts will not necessarily focus in areas where seabirds are concentrated, and, although net sampling gear will be different, samples collected by SEA in 1994 have complemented the APEX study design in several ways: they provide diet data for the early life history stages of forage fish species, data on larger fish during an earlier season in the year than the FY94 Forage Fish project has collected, and data on species which were not collected later in the year with the trawl gear operated by the FY 94 Forage Fish Project (eg., sand lance). SEA also collected plankton data for fish prey selection, which was not collected by the FY94 Forage Fish project.

Forage Fish

Spring forage fish samples will be collected from April-June, 1995, by the Salmon Growth and Predation component of SEA under the direction of Mark Willette, ADFG. In the 1995 study design, SEA will again sample nearshore and offshore sites, but will emphasize a diel sampling pattern. Samples will be collected with the same purse seines, beach seines, tow nets and mid-water trawls used in 1994. In the nearshore area, samples will be collected at 4-hour intervals along four transects each having four stations, for a total of 16 nearshore stations. A single offshore station will be sampled at the end of each nearshore transect. An average of 3 species is expected to be collected in each haul. For each species collected, the stomachs of 10 individuals will be analyzed, although 15 will be preserved to allow for damaged specimens. The maximum potential number of stomach samples which could be analyzed from samples collected by SEA in spring, 1995, is estimated as follows: 4 transects x (4 + 1) stations x 3 species x 10 specimens x 20 days x 6 times per day = 72,000 stomach samples (Tables 1 and 2). Priority for processing stomach samples will be assigned when the actual number collected is known.

Summer and fall forage fish samples will also be collected for the diet study and other analyses during June, July and October, 1995, by members of the APEX project. As in 1994, a mid-water trawl, Methot trawl and an NIO net having three different mesh sizes will be fished. Fish sampling efforts will target schools detected by hydroacoustic assessments in areas where foraging marine birds are concentrated. The focus on seabirds requires a flexible sampling design, although hydroacoustic transects will be established *a priori*.

Fish samples will not be collected randomly, but an attempt will be made to classify the collection sites according to the strata used in the 1994 SEA sampling design (offshore, moderate slope passage, steep slope passage, bay). Some sites may replicate the SEA sites in western PWS. In addition, the 1995 sampling techniques will be modified and additional gear will be operated in 1995 to attempt to collect the underrepresented species. The maximum projected number of stomach samples to be processed from summer, 1995, samples is estimated as follows: 3 hauls per day x 20 days x 3 species or life history stages per haul x 10 specimens each = 1,800 stomach samples per cruise, for a total of 5,400 samples during the 3-cruise season. Specimens will be required for several joint APEX project components. If hauls do not contain enough specimens of some species, sample sharing may extend the biological data that can be collected from these fish, provided that technicians representing the various projects are present. Instead of immediately fixing specimens in 10% formaldehyde solution for later stomach analysis, some stomach samples could be removed and/or analyzed on board the vessel. Doing this would allow the carcass and possibly the contents to be frozen for other project analyses, including fatty acid and stable isotope analyses (which require fresh frozen specimens).

Prey Resources

Prey resource samples will be collected from April-June, 1995, by the Salmon Growth and Predation component of SEA and in June, July and October 1995 by the APEX Project, in conjunction with fish sampling (Tables 3 and 4). SEA samples will be collected at 20 sites each having 4 nearshore and 4 offshore stations; 8 sites will be sampled in northwest PWS in May and in June, and 4 sites will be sampled in southwest PWS in June, for a total of 160 zooplankton and epibenthic samples. Epibenthic prey will be sampled with a pump near net-set stations. A diver-operated plexiglass frame (0.6 m x 0.6 m x 1 m) will be placed over the substrate at each sample site, and epibenthic animals removed with the pump. Each sample will be sieved through 100 micron mesh to retain potential prey animals. Replicate epibenthic samples will be combined in a single sample bottle (n = 160). Zooplankton samples (n = 160) will be collected with a ring-net (0.5 m diameter, 100 micron mesh) towed vertically from 25 m depth to the surface; replicate samples will be combined in a single sample bottle. All samples will be preserved in 10% buffered formaldehyde solution.

Summer and fall prey resource samples will also be collected on APEX cruises. A 1-m NIO net with 250 micron mesh cod end and flow meter will be operated at each forage fish sampling station. A single double-oblique tow will be made from the lower depth of the targeted fish school to the surface (Table 4). If samples are desired for other APEX Projects analyses, a second double-oblique tow can be made or the sample from the single tow can be split on board the vessel and preserved or frozen as needs dictate. Prey resource samples to be used for the diet study will be preserved in 10% buffered formaldehyde solution. Epibenthic samples will not be collected.

Laboratory Methods

As in 1994, forage fish stomach samples and prey samples (zooplankton/epibenthic invertebrates) collected in 1995 by personnel from ADF&G, NMFS, and UAF will be jointly analyzed at the NMFS Auke Bay Laboratory under the direction of Molly Sturdevant and at the University of Alaska Fairbanks, Institute of Marine Science, under the direction of Stephen Jewett. The following methodology details the laboratory protocol.

Fish Samples: Samples will be shipped in monthly batches to each laboratory as soon after collection as possible. Each laboratory will receive one half of the samples collected each month. Samples fixed in 10% buffered formaldehyde solution will be received in 250 or 500 ml wide-mouth polyethylene bottles labelled by set number, date, time, latitude, longitude, geartype, species. An inventory and data summary detailing relevant sample collection information will be included with the samples. Fish stomach samples will be transferred to 50% isopropanol for preservation after fixation in formaldehyde solution for a minimum of 20 days to allow shrinkage to stabilize. Of the 5-10 specimens per species received from each haul, each lab will process only 5 fish in good condition.

Stomach contents will be examined after fish samples have been in 50% isopropanol for a minimum of 10 days. At each laboratory, five fish will be selected for stomach contents analysis from each sample bottle using a random numbers table. The remainder of the fish in the sample bottle will be saved in 50% isopropanol in the original sample bottle. Each laboratory will use its preferred data forms to record sample measurements. Consistency in recording data variables will be assured through the measurement criteria (Tables 5-7) and species code list established in 1994. Whole fish will be blotted dry, weighed to the nearest 0.01 g and measured (standard fork length) to the nearest 0.5 mm. Fish showing evidence of regurgitation (gaping mouths and/or prey regurgitated into the fixative solution) will not be analyzed.

Fish stomachs, including the region from the pharynx immediately behind the gills to the pylorus, will be excised from the body cavity. The foregut will be blotted dry and weighed full to an accuracy of 1.0 mg, the contents will be removed, and the empty stomach blotted and weighed again. Total stomach contents wet weight will be estimated by subtraction. Stomach fullness and prey digestion will be visually assessed and semiquantitative index values recorded. Relative fullness will be coded as: 1=empty, 2= trace, 3=25%, 4=50%, 5=75%, 6=100% full, and 7=distended. The fullness code provides an index of the amount of food consumed relative to the fish's stomach size. The state of digestion will be coded as: 0=fresh, 1=partially digested, 2=mostly digested, 3=stomach empty. These codes provide indications of how recently the fish ate as well as general prey condition, which reflects the level of identification possible.

Prey items in the gut will be completely teased apart and identified to the lowest possible taxonomic level and enumerated. Prey identification efforts will be concentrated on identifying copepods to examine prey selection by species, sex and life history stage and within large and small copepod size groups. Where possible, partially digested large copepods which cannot be completely identified will be distinguished as pristane-manufacturing species (*Neocalanus* spp., *Calanus* spp.) or non-pristane-manufacturing species (eg., *Metridia* spp., *Epilabidocera longipedata*). After samples have been processed, gut contents will be placed in a labelled vial in 50% isopropanol.

Standard subsampling techniques will be employed when stomachs are so large and/or full that counting every prey item is not practical. The protocol for subsampling stomach contents was developed during 1994 sample processing and is patterned after general methods (Kask and Sibert 1976). We have compared total prey counts of important prey taxa to abundance estimates from various stomach subsampling methods and have developed a decision-making process. Stomach contents are initially scanned to determine the predominant prey categories present, the state of digestion of contents, and a rough estimate of total prey consumed. Consideration of stomach content qualities such as oiliness and 'mushiness' then allows a consistent choice of the most reliable and accurate method of subsampling for a given sample's condition. The protocol for selecting the appropriate subsampling method is currently detailed in a draft techniques manuscript.

Each laboratory will build a voucher collection (preserved in 50% isopropanol) composed of specimens (n=40) from each important taxonomic group. These will be used for reference and training purposes and possibly to obtain weights of prey categories for which literature values are unavailable or inappropriate. Individual prey codes and the number counted or estimated by subsampling will be recorded for each fish specimen. After the first batch of samples has been completed, each laboratory will ship a subsample (n=20) from its voucher collection to the alternate laboratory. Each laboratory will inspect the reference collection from the alternate laboratory. If the laboratories do not agree regarding the identification of an organism, appropriate taxonomists will be contacted to resolve the issue.

Prey Resources: The composition of available prey resources will be estimated from laboratory analyses of ring net, NIO net and epibenthic pump samples. Replicates from each type of sample (zooplankton and epibenthic invertebrates) will be combined and preserved in 10% buffered formaldehyde solution. A subset of samples representing sites where forage fish are collected will be analyzed in detail by ABL and IMS to determine prey availability and prey selection (Tables 3 and 4). Auke Bay Laboratory and the Institute of Marine Science will each analyze in detail half of the 180 zooplankton samples collected on FY94 Forage Fish cruises. Samples will be received in 250 or 500 ml wide-mouth polyethylene bottles labelled by set number, date, time, latitude, longitude, and sampling method. Samples will be shipped to each laboratory as soon as possible after collection. An inventory and data summary detailing relevant sample collection information will be included with the samples.

A Hansen-Stempel pipette will be used to collect at least two random subsamples (1, 5, or 10 ml capacity) from each sample bottle after appropriate dilution. Samples will be diluted to achieve a minimum total count of 500 animals. Zooplankton and epibenthic invertebrates will be identified to the lowest practical taxon and enumerated in each subsample. Total biomass in each taxonomic group will be estimated by the product of average body blotted-dry weight and abundance. Literature values for average blotted-dry wet weight of each species or developmental stage will be used when available. A data summary of average blotted-dry wet weights for each taxonomic group will be provided to each laboratory. When literature values are not available, mean blotted-dry wet weight will be determined by weighing a sample (n=50) of intact specimens. The composition of available prey will be described by pooling the data from epibenthic and zooplankton samples standardized to a one m^2 surface area.

Each laboratory will randomly select 5% of the stomach, zooplankton, and epibenthic invertebrate samples from each batch for a quality assurance/quality control (QAQC) test. The QAQC test set and any associated voucher specimens from each batch will be shipped to the alternate laboratory as soon as possible. Prey items in the vials containing stomach samples will be processed by the alternate laboratory using the same methods applied to all other samples. Results from QAQC tests will be mailed to the project leader as soon as possible after completion of each test. If results from the two laboratories are significantly different, a teleconference will be conducted to determine the cause of the difference. If procedures at a specific laboratory are found to be in error, the remaining fish or plankton in the original sample bottle will be re-analyzed. If after two QAQC tests, results from the two laboratories are not substantially different, the QAQC procedure will be discontinued. An annual workshop/training session will be held at one of the laboratories to review prey identification, determine which taxa need finer-resolution identification, and to evaluate any problem areas.

Products

Raw Data: All data submissions from the laboratories processing samples will be made no later than January 30, 1996. Data submissions will be provided to NMFS by each laboratory after each batch of samples is completed. Each laboratory will be responsible for data entry and error checking. All electronic data will be checked against laboratory forms after entry. The raw data will consist of fish measurements and prey counts for each taxon/life history stage identified per fish or prey resource sample. Fish stomach contents and prey resource data will be reported in three data files. Data files from the two labs will be merged into a single RBASE file to be incorporated into the database managed by the EVOS Trustee Council (95089) and the SEA project (95320J).

Data Analysis and Reporting

The products from the UAF and NMFS laboratory components will be used in several statistical/quantitative methods of assessing fish diets and prey resources. The annual report summarizing results from analyses of samples collected in the past year will be prepared January-March and due in April, 1996.

Diet composition, diet overlap and prey selection will be described when data from the two labs are merged. The possibility of a laboratory effect on prey abundance and composition will be tested by comparing results from subsamples analyzed by each lab. A paired-t statistic will be used to test for differences between labs in the measurement of absolute and relative abundance and biomass of each prey item and in the measurement of stomach fullness. A Multivariate Analysis of Variance (MANOVA) statistic will be used initially to test for no overall laboratory effect on diet composition of each forage fish species. Tests will be conducted at the $P = 0.05$ significance level.

A multi-factorial sampling design will be employed to estimate diet composition, diet overlap and prey selection among forage fish species. Spatial and temporal factors will be included in design strata. Strata will be based on date and transect/station (SEA) or area/station (APEX). For SEA data analysis, strata will consist of four transects with five stations each. For APEX data analysis, strata will consist of geographic area and stations. Station will be used as the sample unit in the analyses. Analysis will also incorporate forage fish species and size class. Size related shifts in diet have been noted in several fish species, including Pacific cod (Livingston 1989), walleye pollock (Dwyer et al. 1987) and juvenile salmonids (Landingham and Mothershead 1988).

Forage fish diets will first be described using three measures of prey composition. Diet composition will be expressed as proportion of total abundance, total prey biomass (wet weight) and frequency of occurrence of individual and pooled taxa. Prey resource composition will be expressed as a proportion of total abundance and total biomass. Prey biomass in each taxonomic group will be estimated as the product of prey abundance and average prey wet weight (blotted dry) obtained from the literature or direct measurements. Stomach fullness will be expressed as a proportion of fish body weight. These diet composition measures will be the attributes used in further statistical analyses.

Diel changes in diet composition of the forage fish species will be tested using data collected during six time-periods per day at SEA transect stations (see above). MANOVA will be used to examine diel changes in prey biomass and a discrete data analysis will be used to examine diel changes in prey abundance. Data may require transformation for ANOVA procedures (Willette 1995). Diet overlap indices will be used to evaluate diel patterns of diet similarity between pairs of forage fish. If significant diel changes in diet overlap are detected, time of day will be incorporated into the sampling design in future years.

Seasonal and spatial changes in diets will be related to prey availability and prey selection will be described. Seasonal and interannual changes in food habits and in the amount of diet overlap will be determined by comparing results from spring, summer and fall sample collections over a minimum of three years. Diets of fish collected in different habitats will be compared to assess spatial variability in the amount of overlap. Spatial and temporal changes in prey resource composition and abundance will be similarly assessed. Differences in the degree of diet overlap between pairs of forage fish species and within species among strata will be tested using measures of niche overlap (see Krebs 1989). The Morisita-Horn index will be used with abundance data and the Horn index will be used with biomass data. Other indices, such as the Percent Similarity Index, will also be investigated as analytical tools.

Multivariate methods will be used to evaluate diet similarity patterns and prey resource composition, and to compare diet and prey composition by time and location. (see Ludwig and Reynolds 1988; Digby and Kempton 1987). Possible tools include cluster analysis, principle component analysis and correspondence analysis.

Prey selection will also be examined using food habits and prey resource data (see Krebs 1989). Ivlev's (1961) electivity index, and Manly's alpha (Manly et al. 1972) will be used to measure prey preferences of each forage fish species. Preference for each available prey taxon will be compared among forage fish species and habitat types. MANOVA methods will be used statistically to assess prey and diet composition and dietary preference (e.g. Manly 1986; Johnson and Wichern 1988). Data will be transformed when necessary to meet the assumption of residual normality.

Existing Agency Program

The major activities for this project include use of NOAA biological lab space and microscopes for sample analysis and storage, and computers for database management and statistical analysis. These activities will be integrated and supported by the normal operations of the Salmon Program at ABL. NOAA will contribute 3 months of salary for the Principal Investigator, beyond the 3 months funded by this study, for coordinating and managing the project. NOAA will also contribute one month of the Project Manager's and Program Manager's time.

Coordination of Integrated Research Effort

This project will be highly integrated with several components of the APEX project, several components of the SEA project, and marine mammal projects. The Salmon Growth and Predation components of SEA and the APEX Forage Fish Sampling Component (Appendix 3) will collect forage fish samples for later stomach contents analysis in nearshore and offshore habitats using mid-water trawls and beach and purse seines. Age-weight-length data will be collected from the forage fish to accompany hydroacoustic data.

Appendix 3

Coyle and Thorne 95163A

Determination of the distribution and abundance of forage species

Objectives

Sub Task 1.
1. Provide an estimate of the distribution and abundance of forage species relative to areas of known concentration of marine seabirds and mammals.
2. Describe the species composition of the forage base and size distributions of the most abundant forage species.

Sub Task 2.
1. Coordinate forage fish surveys with personnel from the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to insure that data are taken in known foraging areas of marine birds and mammals.
2. Provide comfortable facilities and food on the field cruises for 1 - 2 agency biologists.

SubTask 3.
Determine size composition of important forage species in the study area.

SubTask 4.
Provide samples of forage fishes to NMFS for food-habit analyses and additional material for stable-isotope and related analyses.

SubTask 5.
Gather basic oceanographic data describing conditions in the study area, and salinity, temperature, and sigma-t profiles of the water column and water depth at all data collection sites.

ACOUSTIC COMPONENT, CTD AND DATA INTEGRATION (COYLE AND THORNE)

Introduction
A major goal of the forage fish project is the evaluation of the distribution and abundance of forage fish relative to bird distribution and physical features affecting fish distribution. These fishes are sand lance, capelin, juvenile walleye pollock, and herring. The main tool for measuring the distribution and abundance of forage fishes is hydroacoustics. High resolution CTD transects will be used to evaluate the vertical and horizontal physical structure of the water column. Bird data will be collected by observers from another component (Appendix 6), concurrently with acoustic data to

determine the relationship between bird distribution and diet and acoustically measured fish densities. The bird and acoustic data acquisition programs will both be interfaced to GPS navigation systems to insure that both data sets can be properly integrated. Software for bird collection has been written to automatically record GPS data with bird observations in real time. Net samples will be used to identify targets detected by the acoustic system. The following is a detailed presentation of the hydroacoustic sampling plan for 1995, with background statements and explanations of the techniques and equipment to be used. Additional information is provided on CTD sampling and data integration.

Background

An understanding of the relationship between forage fish species and seabird distribution requires data collection at a variety of spatial and temporal scales. Hydroacoustics can measure horizontal and vertical abundance and biomass at scales not possible by traditional net sampling techniques. Acoustics has been used to map fish (Thorne and Blackburn 1984; Thorne et al. 1977; Thorne 1977; Thorne et al., 1982; Mathisen et al. 1978) and plankton using a variety of deployment techniques (Green et al. 1988; Green and Wiebe 1988; Green et al. 1989; Green et al. 1991). Acoustics have been used to examine fine-scale biological patchiness (Nero et al. 1990), aggregated migration pathways of Atlantic cod (Rose 1993), forage fish distributional characteristics in Chesapeake Bay (Brandt et al. 1992) and the spatial patterns of a variety of aquatic populations (Gerlotto 1993; Baussant et al. 1993; Simard et al. 1993). Biosonics equipment has also been deployed to measure acoustic biomass relative to tidally-generated frontal features (Coyle and Cooney 1993) and the relationship between murre foraging, tidal currents and water masses in the southeast Bering Sea (Coyle et al. 1992).

The experience and knowledge gained during these investigations, combined with recent advances in acoustic technology, provide the background and experience required for effective application of hydroacoustic techniques to document distribution, abundance, and availability of forage fishes to foraging birds in Prince William Sound. Hydroacoustics will permit the sampling density required to assess the highly aggregated forage fish schools distributed over mesoscale dimensions and to document individual interactions between avian predators and prey at very small scales. The broad size range of individual targets from zooplankton to apex predators requires multifrequency sampling and an extremely high dynamic range.

Milestones

1995

1. Conduct acoustic surveys in July, August, and October.
2. Determine depth distribution of major forage species.
3. Estimate population size and age distributions for major forage species.

1996

1. Conduct acoustic surveys and collect biological specimens in May, July, August, and October.

1997

1. Conduct acoustic surveys and collect biological specimens in May, July, August, and October.

METHODS

Acoustic sampling and relation to abundance and availability

Acoustic surveys will be used to measure the abundance and distributional characteristics of forage fish relative to bird feeding activity. An important objective is to evaluate the abundance and availability of forage fish in relation to the locations of "successful" and "unsuccessful" kittiwake and pigeon guillemot colonies in PWS, with an additional pilot project assessing the same relationship for puffins.

The surveys will consist of line transects through Prince William Sound to provide a general map of fish distribution and abundance in relation to kittiwake colonies (Appendix 7; FIGURE 5). Abundance and activity of seabirds will be documented concurrently with acoustic observations along each transect (Appendix 6).

Acoustic surveys will be run using a BioSonics DT4000 digital transducer system. One hundred twenty and 420 kHz down-looking transducers will measure the vertical distribution of zooplankton and fish along the ship's track and a side-looking 420 kHz transducer will measure abundance of near-surface targets. Dr. Thorne has developed techniques to minimize surface reverberation and developed relationships between effective range and sea state. Side-looking deployment will be especially important for the study of fish distribution and abundance relative to foraging of surface-feeding seabirds.

Specifications of the DT4000 include high dynamic range, low noise, GPS input, school classification software, TS measurement, high resolution chirp transmission and complete raw data storage. The system includes visual editing software for efficient data analysis. All three transducers will be single-beam for reasons outlined below.

Calibration

Accurate calibration is critical for both relative and absolute measures of fish abundance. The systems used in this study will be calibrated with U.S. Naval standard hydrophones prior to and after field use. In addition, the calibration parameters will be routinely checked during cruises with standard target spheres developed at the Marine Laboratory, Aberdeen, Scotland, and optimized for each frequency. The calm conditions in Prince William Sound and diagnostic programs developed for the new generation of digital transducers will facilitate field calibration. The diagnostic programs evaluate the echoes from standard targets and compare them with the expected returns based on hydrophone calibrations stored in the digital transducer memory.

Target strength measurements

Target strength measurements are required to compute absolute abundance and estimate the size of the acoustic targets. However, absolute abundance is not as critical an objective as relative abundance with respect to seabird foraging and reproductive success. Real-time in situ target strength information is often not obtainable with schooling fishes because individual targets are difficult to resolve and measure. Nevertheless, we intend to make every effort to estimate absolute abundance as accurately as possible emphasizing accurate calibration since accurate calibration is critical to absolute population estimates. Biomass - target strength relationships for herring, pollock and other fish of interest have been developed during numerous surveys (Thorne 1977; Thorne et al. 1982; Thorne et al. 1983; Thorne 1983; Traynor, pers. comm. Northwest and Alaska Fisheries Center, NMFS) and use of these data supplemented with in situ data where possible should allow absolute abundance estimation with reasonable accuracy.

While target strength is critical for absolute biomass estimates, estimation of fish length from target strength data is of limited value for the following reasons: 1) Accurate in situ target strength measurements of schooled fishes is not usually possible, and 2) the inherent variability in target strength - fish length measurements is so great that the results are of limited value even when such measurements are possible. The small variation in the size of forage fish is swamped by the high variability in the target strength estimate.

Three types of acoustic systems have been used for target strength measurements: split beam, dual beam and single beam. Several comparisons between split-beam and dual-beam capabilities have demonstrated that mean target strength estimates by the two systems are similar but split beam yields the highest precision. However, split beam is limited to lower frequencies and has inherently lower single target resolution, which can seriously bias the results (Barange and Soule 1994). Split-beam would therefore be least suitable for the forage fish study.

While dual-beam would provide a viable alternative for the forage fish objectives, Hedgepeth (1994) has shown that single-beam systems provide very similar measurement capabilities with less complexity. Because in situ measurement of fish size provides only a minimal contribution to the objectives of this study, we propose to use single-beam acoustic systems rather than the more complex dual-beam system.

Species Identification

Inherent in the APEX program objectives is the need to separate abundance estimates into species categories. Net sampling in conjunction with acoustic surveys will be the primary method for species identifications. However, the high cost and selectivity of net sampling must necessarily limit its application in the field. Therefore, acoustic school classification techniques will be applied to minimize the number of net samples required. Many investigators have had success with species identification based on school classification. The DT4000, with total raw data storage, opens new opportunities for success with these techniques and we intend to utilize them fully. We believe that school classification techniques will eventually be every bit as effective as direct capture. We will work closely with the SEA project, since they have similar acoustic equipment and species identification objectives.

CTD measurements and data management

Water mass properties will be evaluated by running fine-scale CTD transects across regions of interest using a Seabird model 19 CTD. Data will be converted to ASCII and computer generated contour plots of temperature, salinity and density will be produced on ship board. Acoustic data will be converted to ASCII and contours of acoustically determined biomass will also be generated. Concurrently collected bird data will be sorted and plotted for comparison of bird densities with acoustic biomass and water column structure. These on-board computer analyses should permit real-time analysis of results so that ship time can be more effectively targeted on regions of interest.

Programs will be written in Quick Basic for ship board use and a programmer will be on hand to modify programs as required. Acoustic data analysis will be done on UNIX work stations. This should provide the speed and data storage capability necessary for analysis of large data sets generated by the DT4000. However, a 1 G hard drive is requested to ensure sufficient space for any PC computations which may be necessary and a tape interface is needed to store and retrieve the data. Data management will be done on an INGRES data management system. Programs for data recovery and analysis on the UNIX system will be written in FORTRAN. The use of a work station should ensure easy comparison between SEA and APEX data bases.

BIOSONICS INC. SUBCONTRACT

We have chosen the Biosonics for the following reasons:

1. The equipment deployed will have the highest resolution of the available systems. All processing electronics are housed in the transducers, thus eliminating noise in the tow cable, a major limitation in the resolution of other systems.

2. All of the raw data will be stored digitally and can be recovered at any precision desired, without the use of analog taping equipment. This capability will be essential to our program of data subsampling in evaluating various survey designs for future work.

3. The low noise of the system should permit detection of individual zooplankton.

4. Visual editing software permits rapid and efficient data editing.

5. Biosonics has provided acoustic equipment for the SEA project. The application of Biosonics equipment for the forage fish project will insure easy comparison of data sets between the two projects.

NET SAMPLING COMPONENT FOR THE DISTRIBUTION AND ABUNDANCE WORK (HALDORSON AND PAUL)

Hydroacoustic sampling will be the primary method used to quantify the abundance of forage species in Prince William Sound. However, net sampling will be needed to identify the species comprising the hydroacoustic signals and to provide biological samples for life history, condition and energetics studies of forage species. In the 1994 November cruise we evaluated the effectiveness of two large mid-water nets for sampling forage fishes:

> Methot Net - a 5 m^2 fixed frame net with an Isaacs-Kidd depressor.
>
> Modified Canadian mid-water herring trawl - a research-scale (100 m^2 opening) version of a mid-water commercial trawl.

The mid-water herring trawl proved to be the most effective sampling gear for the forage species of interest and will be the primary sampling tool we will use in all cases except near-surface sampling and sampling in shallow water. For near-surface sampling we will use either the Methot Net rigged for surface sampling, or a small purse seine. For shallow-water sampling we will use a small purse seine or a beach seine.

Ship time

The project will use the ADF&G R/V MEDEIA and a similar chartered commercial vessel when the R/V MEDEIA is not available during the 1995 field season sampling. The MEDEIA was used for the 1994 November Forage Fish research cruise and proved to be exceptionally capable for the type of sampling we will employ in 1995. In this proposal we are requesting support for four research cruises:

July 1995 --20 days of ship time to conduct hydroacoustic and net sampling in Prince William Sound. The primary objective of this cruise will be to assess the distribution and abundance of forage species in the Sound in support of bird foraging studies. A secondary objective will be to collect biological samples for life history, condition, and energetics studies of forage species.

August 1995 --20 days of ship time with the same sampling procedures and objectives as the July cruise.

October 1995 -- 12 days of ship time to conduct limited hydroacoustic sampling, and extensive net sampling in PWS. The primary objective of this cruise will be to collect biological samples for life history, condition and energetics studies of forage species.

Spring 1996 -- 12 days of ship time, with the same sampling procedures and objectives as the October 1995 cruise.

SURVEY COORDINATION

Surveys will be planned cooperatively with biologists from USFWS, NMFS, and SEA project. At least two weeks prior to both survey cruises a meeting will be held in Juneau or Anchorage with representatives from those agencies, the project leader, and at least one of the principal investigators from the University. We assume that those agencies will provide any travel funds required by their participants. At that meeting, a survey design will be developed, and plans will be made to ensure that one or two biologists from the appropriate agencies are included in the cruise plan. Immediately after this meeting, we will prepare a cruise plan that will be circulated to all participants, including all University project participants, agency biologists from USFWS and NMFS, the SEA project, and the COTR.

In planning for the two cruises, we will include provisions to house and feed one or two agency biologists. We will also provide work space and oceanographic information to the agency biologists who participate in the cruises.

DECK SAMPLING

Samples collected will be sorted by species, and the lengths of individuals of important forage species will be measured.

Invertebrates: Macroinvertebrates will be preserved shortly after collection, and sorted by species later. The difficulties of identifying invertebrates to species will preclude working them up in the field. For example, there are likely to be at least four species of euphausiids in PWS. We will fix and preserve macrozooplankton samples from NIO nets and sort and measure them in the laboratory.

Fishes: Fish larger than about 50 mm will be identified in the field. We will sort samples to species, and measure all fish, unless net hauls contain large numbers of individuals of some species. In the case of large catches we will randomly subsample and measure 100 - 200 individuals of each species. Collections from the Methot net and mid-water trawl will be processed in this way.

We will preserve and furnish samples for food habits studies, and additional samples for other agencies for stable isotope and lipid analyses. Those agencies for whom we collect fish will provide:

a) written directions as to the number of each species they require, and directions for preserving them.
b) all preservatives and sample containers, including shipping containers.
c) freezers, if they request frozen samples.
d) arrangements for sample shipping, and payment of all shipping charges.

OCEANOGRAPHIC DATA

We will collect oceanographic data at all of our survey stations and sampling sites. At each transect and collection site we will use a Seabird SEACAT CTD to sample the water column from the surface to 200 m depth, or to within 5 m of the bottom at shallower stations. This instrument has an internal data logger, and will record conductivity, temperature and depth. From this data we will produce vertical profiles of salinity, temperature and sigma-T at all stations. The data will also be available as ASCII files for agency biologists and SEA researchers. We will compare our data to the more extensive data set compiled by SEA researchers to determine if the distributions of forage species we observe are related to oceanographic features such as frontal zones, convergences, pycnoclines or major currents.

SURVEY DESIGN

Our acoustic surveying has four main goals:

1. to provide an overview of forage prey distribution and relative abundance within the Sound. This will also identify 'hotspots', concentrations of forage prey and foraging seabirds, for future work.
2. to allow comparison of relative forage abundance with nesting parameters of seabirds.
3. to examine the effect of forage school size and other characteristics in relation to seabird foraging.
4. to collect fish and invertebrates for energetic and life history work.
5. in the future, to study use of hotspots by different species.

Design of the acoustic surveys will be based on analyses of the reconnaissance surveys conducted in Agust and November 1994. Survey features that will be determined include: 1) length of transects; 2) stratification; 3) systematic or random sampling design; 4) stratification allocation; and 5) number of transects per strata.

Hydroacoustic survey design

Our basic approach will be to randomly subsample the acoustic transect data collected in the hydroacoustic reconnaissance surveys. We will assess the variability associated with various alternative survey design features, including:

1. Length of transect (sample unit size): The length of individual transects will be the sample unit size. Very short transects will typically result in higher variability within a sampling stratum, compared to longer transects. We will determine the appropriate length of individual transects by randomly subsampling different length segments from the long transects that will make up the reconnaissance surveys. We will examine changes in the coefficient of variation (ratio of standard deviation to mean) as a function of transect length to determine the appropriate length of individual sample units.

2. Stratified or non-stratified survey: Stratification can markedly reduce the variance of survey estimates when between-strata variance exceeds within stratum variance (Cochran 1977, Leaman 1981). The method of Sukhatme and Sakhatme (1970) will be used to estimate the gain in precision due to stratification versus simple random sampling. In the case of trawl survey for Atlantic cod, stratification actually led to decreased precision (Gavaris and Smith 1987). We will examine several stratification criteria by drawing random subsamples from the 1994 data set to determine if a stratification scheme will improve precision of our estimates. Gavaris and Smith (1987) and Leaman (1981) present details of this process, and we will follow their procedures.

3. Stratification allocation: If stratification appears to be warranted, we will investigate two options for allocating stations (transects) to strata. In proportional allocation, the number of stations are assigned to strata in proportion to the area of each stratum. In optimal allocation, stations are assigned in proportion to the product of the area and the standard deviation of abundance estimates in each stratum. We will use the results of the 1994 survey to determine if optimal allocation decreases variances using the techniques outlined by Leaman (1981). A good example of this approach is presented in Gavaris and Smith (1987).

4. Systematic versus random assignment of stations: Sampling stations may be assigned by random selection or in a systematic design. Systematic designs have the advantage of uniform area coverage and reduce the probability of missing large concentrations of aggregated populations (Leaman 1981). However, systematic sampling results in reduced precision of estimates. Variances of the mean of systematic samples are provided by Cochran (1977), and a useful summary of the process for comparing systematic and random surveys is presented by Leaman (1981). We will follow the techniques outlined by Leaman (1981), using the 1994 survey results, to assess the increase of variance associated with a systematic sampling design.

5. Number of replicate samples: To assess the minimum number of replicate samples required per stratum we will randomly subsample a range of sample sizes from the appropriate sections of transect data collected in 1994. We will examine the standard error of the resulting mean estimates as a function of sample size (Mohn et al. 1987). The standard error should stabilize at some point, indicating the minimum number of replicates that should be taken in that stratum. For example, Mohn et al. (1987) found that between 20 and 40 replicate samples per stratum were required to stabilize the standard error of sea scallop density estimates (using trawl data).

6. Estimating biases in net samples: In association with acoustic transects, we will use net sampling to identify the species found at depths with high densities of acoustic targets. Following each acoustic transect where concentrations of forage fish are found, we will conduct short (10 - 20 minute) hauls of the mid-water herring trawl at the depths where acoustic targets were most concentrated.

Forage fish samples collected with the mid-water trawl will be sorted to species immediately after collection. All individuals will be measured to fork length, unless catches exceed 200 - 300 fish, in which case we will randomly subsample about 100 fish for measurement. All measured fish will be frozen for later laboratory analyses.

Net sampling in this project has the objective of describing the species composition and population size structures of component species of those forage species being assessed with hydroacousic techniques. Our objective in using a large range of gear sizes is to collect the entire spectrum of the forage community, and to assess avoidance and escapement associated with each gear type. Avoidance occurs when organisms actively move out of the net path, while escapement occurs when organisms pass through the meshes after entering the net. Avoidance is quantified by comparing the upper part of the size ranges between nets with progressively larger net openings, or by comparing size distributions in catches taken during the day and night (assuming that at night individuals do not see the net coming). Escapement is quantified by comparing the lower part of size ranges in sampling gear with progressively larger mesh size. The sampling systems we will employ cover a large range of mouth openings (1 - 50 m^2) and mesh sizes (1mm - > 1 cm). With the resultant correction factors, we will be able to provide accurate estimates of the species composition and size distributions of the forage community.

APEX 44

Appendix 4

Haldorson and Paul 95163A

Measures of Productivity of Forage Species

Introduction

Knowing that the forage species change in abundance from place to place within the Sound, and from year to year, will be helpful in understanding possible corresponding changes in success in seabird reproduction. However, by the end of this project, more knowledge about forage fishes should be available than simply observations of abundance change. Information about why the changes occurred will add credence to interpretations about the direction and magnitude of the changes. When independent measures of productivity change simultaneously and consistently with changes in abundance estimates, they support the original measurements.

We suggest that studies of mechanisms of change could focus on productivity measures of forage species. Such changes would likely influence the general levels of abundance as well as availability of forage species as food for seabirds. This information will help the project to evaluate the primary hypothesis that food is reponsible for variation in the reproductive rates of seabirds.

Background

The abundance of fishes utilized by piscivorous birds in Prince William Sound may be determined by a variety of interacting processes, including recruitment levels, predation, and availability of zooplankton prey. Production of herbivorous zooplankton may set an upper limit to the carrying capacity of PWS for forage fishes. For example, in major oceanic upwelling areas, such as those off South Africa, California and Peru, the production of planktivorous forage fishes appears to be limited by phytoplankton and zooplankton production (Shannon and Field 1985). When forage fishes are limited by trophic carrying capacity, the production and abundances of the component species will be affected by competitive interactions. In upwelling systems, the two major planktivorous forage fishes (anchovy and sardine) have repeatedly demonstrated reciprocal shifts in abundance that are indicative of competition for limited food resources (MacCall 1986; Shannon and Field 1985). Similarily, in Lake Michigan the forage fish community is structured by competitive interactions that result in dramatic changes in species composition (Stewart et al. 1981). If food competition is occurring among the forage species in Prince William Sound, the forage fish populations should exhibit reduced productivity that will be expressed in diagnostic changes in energy use and life history characteristics such as growth, fecundity and age at maturity.

Milestones

1995

1. Determine size and age of sexual maturity for males and females of major forage species.
2. Estimate seasonal growth increments for most abundant age classes of major forage fishes.
3. Develop preliminary growth models for major forage fishes.

1996

1. Compare seasonal growth increments of selected species in 1995 and 1996.
2. Compare seasonal gonad weights in 1995 and 1996.
3. Develop preliminary seasonal daily rations for target species, based on seasonal growth increments and estimates of gross production efficiency.

1997

1. Compare seasonal growth rates, size at age, and gonad weights among three years of data for selected forage species.
2. Complete seasonal energy budgets for target species, including comparisons of daily rations on a seasonal basis among three years of data.

Feeding habits and daily rations

Abundance fluctuations among forage fishes in Prince William Sound may be interrelated if they are competing for limiting prey resources. For example, increased abundances of herring and planktivorous juvenile salmon during the 1980's may have affected the production of other forage species such as sand lance and capelin. Other planktivorous fishes, such as juvenile walleye pollock, may be exceptionally abundant in some years and may affect the production of forage species through competition. To determine if the abundance and species composition of the forage fish assemblage are being affected by competition for prey we will pursue two research objectives.

1) Measure the relationship between abundances of planktivores in PWS and the condition of selected forage species. By comparing measures of condition and productivity of forage species with the overall abundance of planktivores we will determine if years with high levels of planktivory are marked by reductions in condition indices and production of the forage species. This study will require annual estimates of zooplankton abundance. Zooplankton studies in the SEA project should provide those data.

2) Development of a trophic model of energy flow through the pelagic community. A trophic model will provide a way to quantify changes in energy flow, and to predict the effects of changes in the composition of the forage fish assemblage. Such a trophic model will require quantified estimates of feeding by forage species, including prey use by season and life-stage; and annualized estimates of consumption, by species, within the Sound. Using this approach, Gilman (1994) determined that on Georges Bank up to 20% of annual zooplankton production may be consumed by northern sand lance. With such information, a trophic model

can identify those species that are likely to be affected by abundance changes in any other component of the forage fish group. In addition, by comparing total consumption requirements of planktivorous fishes to the availability of zooplankton, it may be determined whether prey abundance is limiting production and standing stocks of forage fishes.

An energy budget for a species of fish in a particular ecosystem is typically estimated by compiling budgets for those life stages with similar food habits, growth and reproduction. Then, based on population age/size structure, the individual energy budgets are expanded to give an overall annualized estimate of consumption by the species. The basis for virtually all such energy budget studies is the mass balance equation (Soofiani and Hawkins 1985)

$$G + R = C - M - E$$

Where G = somatic growth, R = reproductive output, C = energy consumed, M = metabolic energy use, and E = energy excreted. Many of the important parameters in the mass balance equation may be estimated from literature values; for example, assimilation efficiency (proportion of consumption not excreted) and energy going to metabolism at various temperatures are available for many species, and general models have been developed. However, to use the energy budget to estimate energy flow and prey use in a particular system, growth rates and energy to reproduction must be measured directly; then, seasonal and annual consumption of prey may be estimated using the mass balance energy budget.

Milestones

1995

1. Identify key fish and invertebrate forage species that support the epilagic food web.

1996-98

1. Measure seasonal and interannual somatic eneregy content of common forage species and provide samples of isotopic and C/N measurements to SEA investigators.
2. Begin energetic modeling of energy consumption for key forage species. Provide energetic models to stomach analysis component (Appendix 2) so that comparisons of prey selection and competition can be made for forage species vs. herring and juvenile salmon.

1999

1. Monitor and model the somatic energy content of forage species so that indirect measures such as condition factor, length-weight ratios, etc. can be used to estimate energy content.

METHODS

Methods for determination of growth rates and rations

Laboratory **Analyses**

All fish from field collections will be measured for fork length and standard length. Otoliths will be removed from a length-stratified subsample and stored in glycerine. The body cavity will be opened and the sex and reproductive condition will be assessed. For mature individuals, the gonads will be removed for separate weighing. The stomach will be opened and the contents removed and placed in 10% formalin. The fish (and gonads of mature individuals) will be weighed (wet weight) and then dried in a drying oven until dry weights have stabilized.

Forage fishes will be sampled seasonally to quantify prey use patterns, seasonal growth rates, energy to reproduction and changes in condition indices. Estimates of daily ration based on energy budget estimations will be tested for accuracy by conducting field-based direct estimates of daily ration for selected species and life stages.

Overall growth rates will be estimated for forage fish species by otolith aging of length-stratified subsamples. Length and weights of length-stratified subsamples will be measured to develop length-weight regressions and for the development of Fulton-type length-weight condition indices. Seasonal growth will be measured by mean length and weight at age for each study species at a minimum of three times during the year (Spring, Summer, Fall).

Daily rations of energy consumption will be estimated based on our field measures of age-specific seasonal growth rates and reproductive energy investment. The daily ration of various prey categories will be estimated, based on literature values for the energy content of planktonic prey. Daily ration estimates will be expanded to seasonal estimates, and then to annual estimates. Our ultimate goal is to produce daily, seasonal and annual prey consumption estimates for each important forage species.

Whole body energy of forage species

The methods applied to the whole body energy of forage species will be similar to those used by the investigator in previous bioenergetic studies (Harris et al. 1985; Paul and Fuji, 1989; Paul et al. 1993; Smith et al. 1988; Smith et al. 1990). All the species of forage fish and macrozooplankton will be collected during the July, August, fall and spring sampling programs and frozen at sea.

Specimens will be taken during the cruises and returned to the lab where they will be divided into groups based on species sex, length, age, and condition factor [CF = g wet wt x 100/(cm fork length)^3]. There will be a minimum of 100 fish of each species in every sample. Wet weight will be measured to the nearest tenth of a gram. Small subsamples of adult fish ovary will be removed for energy measurement. Each fish will be individually tagged, and freeze dried. After freeze drying they will be placed in a convection oven at 60°C until they reach a constant weight. Individual wet and dry weight values will be used to calculate the moisture content.

Dried individuals will be ground in a mill and measurements of ash and caloric content made. The percentage of ash will be determined by weighing a subsample, placing it in a crucible with a loose fitting top, and heating gradually over 3 h to 600°C and maintaining that temperature for one h. The muffle furnace will be allowed to cool to room temperature before opening. Sample energy content will be determined by bomb calorimetry.

Energetic estimates of eggs not spawned will be obtained from the post spawning samples. Ovarian energy measures will be coordinated with fecundity estimates carried out by other investigators.

Appendix 5

Worthy 95163H

Proximate Analysis of Forage Fish

There is increasing interest in the use of energetic models to study interactions between seabirds or marine mammals and their prey. Often these models are based upon energy transfer between predator and prey. Although these models require information on the energy content or proximate composition of these species, few data are available (Kizevetter 1973; Stansby 1976; Perez 1994). Those data that have been published have limited application because of the inherent seasonal and annual variability in the value of the prey. The goal of this project is to assess on a seasonal and annual basis the value of the major prey species that would be of significance to Prince William Sound seabirds. These data will allow the development of models that predict the response of seabird species to changes in their forage prey base. The data will also be of use in studies of Killer Whales and Harbor Seals in the Sound.

Project Design

Objectives

This project will assess seasonal and annual changes in the proximate composition of the major fish species in PWS. Data on the composition and energetic values of prey for seabirds and marine mammals are very limited. Most data that are available are for commercial species consumed by humans. These data are further limited in their ecological application because they usually cover only the edible fillets that people consume. Another major limitiation in existing databases is the lack of information on seasonal variability. For example, herring can vary from 3% to 22% lipid on a seasonal basis. Incorporating such variability into models is essential to making them functionally realistic.

Methods

Species to be analyzed are listed in Table 1. This list may change as we increase our understanding of seabird diets. Samples will be collected from seabird and predatory fish diet sampling and from on-board and ad hoc sampling, as needed, attempting to obtain representative size classes consumed by predators. Samples will be frozen immediately and shipped to Texas A & M University. All the required expertise and equipment for analysis are available on-site at Texas A&M University--Galveston. This includes all the specialized equipment for composition and energetics analyses, as well as archival capabilities for samples and the computer-related software for full statistical analysis of the data.

All analytical techniques are described in detail by Worthy and Lavigne (1983) and Hislop et al. (1991). Analysis will be performed on freeze-dried, ground fish and will include determinations of water content, total lipid content, total protein content, ash content, and energy density. Initially, wet mass, sex, and length of each individual specimen will be recorded. Specimens will then be combined, ground, and homogenized prior to freeze-drying. Water content will be determined gravimetrically by lyophilization of ground, homogenized prey until constant mass has been obtained. This will be accomplished using a LabConco Lycophilizer over a period of 4-5 days. Once the samples are dried, they will be finely ground using a Spex 8000 Mixer/mill. This ground material will be used in all subsequent analyses and will also be stored and available for other investigators to use in future studies.

Lipid content will be measured gravimetrically by Soxhlet extraction using petroleum ether as the solvent. Protein content will be assessed using a modified Kjeldhal analysis. Ash content will be determined by ashing at 550ºC for 2 h in an ashing oven. Ground lyophilized samples will be analyzed for energy content by means of a Parr adiabatic bomb calorimeter.

Table 1.

Species to be sampled

Pacific Herring*	*Clupea harengus pallasi*
Rockfish*	*Sebastes* spp.
Cutthroat Trout	*Salmo clarkii*
Capelin*	*Mallotus villosus*
Rainbow Smelt	*Osmerus mordax*
Sand Lance*	*Ammodytes hexapterus*
Eulachon	*Thaleichthys pacificus*
Pacific Cod	*Gadus macrocephalus*
Walleye Pollock*	*Theragra chalcogramma*
Sablefish	*Anopoploma fimbria*
Pacific Sandfish	*Trichodon tricodon*
Pink Salmon	*Onchorhynchus gorbuscha*
Sockeye Salmon	*O. nerka*
King Salmon	*O. tshawytscha*
Silver Salmon	*O. kisutch*
Chum Salmon	*O. iceta*

* Priority species for analysis

Appendix 6

Ostrand 95163B

Foraging of seabirds

Seabird surveys will be conducted simultaneously with the hydroacoustic surveys described in Appendix 3 and on those conducted by the SEA project, employing techniques similar to those used to conduct population surveys in Prince William Sound (Decker and Irons 1990; Klosiewski and Laing 1994).

While conducting hydroacoustic transects, all birds observed within 100 meters of the survey vessel will be recorded. Bird behavior will be recorded categorically as: (a) in the air, (b) on floating object, (c) on water, (d) following boat, (e) active foraging, or (f) potential foraging. Active foraging (e) is defined as actual observation of foraging behavior such as diving for food or holding food in the bill. Behavior is categorized as (f) potential foraging when ≥ 2 grouped birds are observed on the water or circling overhead.

Foraging will be further typed as surface-seizing, dipping, surface-diving, plunge diving, etc.(Harper et al.1985) and duration of submergence will be recorded opportunistically to allow estimates of foraging depth (cf. Duffy 1983). Foraging situations will be categorized to type (e.g. fish school, marine mammal, offal, flotsam, or other). Behavioral interactions between foraging birds, such as food piracy and aggressive displacement, will also be recorded.

Data will be directly entered into a computer file via a voice-activated system. The data-entry system will be programmed to enter time and location of each observation continuously, to the nearest minute. Location will be recorded directly from the ship's geographical positioning system. Hydroacoustics data will be linked to the bird data by aligning common locations of each data file.

Foraging patches are defined as sites at which two or more birds are observed foraging. Hydroacoustic and trawl data will be used to determine species composition of foraging patches, depth, and size of patch. Conductivity, temperature and depth data, collected at selected locations along transects, will also be utilized to determine patch characteristics. Data on distance from shore and bathometric features will be obtained from geographic information system computer analysis. Tide tables will be used to determine if tide is flood, ebb, or slack and spring or neap, at the time of each recorded observation.

Analysis

Multivariate analysis of variance (Dillon and Goldstein 1984) will be used to determine which variables differ significantly among foraging patches and schools of forage fish not exploited by birds. Those differing variables will then be used to describe the characteristics of foraging patches for different prey and seabird species. The entire hydroacoustics data set, including both exploited and unexploited schools, with be queried to determine the number of schools that meet the characteristics of foraging patches, thereby creating a subset of potential foraging sites. A ratio of foraging patches to potential foraging sites will then be computed. The ratio will provide insight into how birds respond to changes in the availability of forage fish when computed over several years.

To compare the distribution of seabirds and forage fish within years and to examine change over the duration of the study, a quantification of distribution will be necessary. Various forms of spatial analysis (Ripley 1981) may be used, depending on initial examination of the data.

To obtain insight into patterns in seabird/forage fish interactions, analyzes will be conducted for several combinations of both bird and forage fish data. Iterations will be conducted for individual species and groupings of species such as picivorous birds with and without plankton feeders, surface foraging birds, diving birds, and size classes of forage fish.

We will also examine the frequency of different nesting species (especially tufted puffin and black-legged kittiwake) at different distances from nesting colonies. This will give us incidence functions that can be used to assess the scales at which forage acoustic abundance should be compared with reproductive parameters at colonies. These incidence functions can also be cross-checked with LaGrangian functions derived from measurements of radiotracked kittiwakes and puffins.

Appendix 7

Irons 95163E

Reproduction and foraging of Black-legged Kittiwakes

Objectives

Determine relative food availability to kittiwakes by the following:

a. Monitoring reproductive parameters such as egg laying date, clutch size, hatching success, brood size at hatching, growth rates, fledging success, brood size at fledging, adult attendance, and overall productivity.
b. Monitoring diets and foraging parameters such as foraging trip length, foraging trip distance, foraging areas, chick provisioning rates, and species and size of prey consumed.
c. Monitoring survival rates of adults.

Methods

Egg laying dates, clutch size, hatching success, fledging success and overall productivity data will be collected from the Shoup Bay and Eleanor Island colonies by setting up a series of representative plots throughout the colonies. Plots will be checked every three days throughout the nesting season. Clutch size will be recorded at 10 colonies in Prince William Sound (PWS) for which there are historical data. Hatching success and brood size at hatching will be recorded at four colonies in PWS: Shoup Bay, Eleanor Island, South Eaglek Bay and Naked Island. Overall productivity and brood size at fledging will be recorded for 26 colonies in PWS (FIGURE 5).

Hatching success is calculated as the number of eggs hatched divided by the number of eggs laid. Fledging success is calculated as the number of chicks fledged divided by the number of chicks hatched. Overall productivity is calculated as the number of chicks in nests just before fledging divided by the number of nests built.

To determine growth rates, chicks of birds without radios will be weighed to the nearest gram with 300 g and 500 g Pesola scales every three days from hatching to just before fledging. Chick growth rates of some radio-tagged birds will be recorded to determine if they are different from chick growth rates of birds without radios. Chicks will be selected from accessible nests in several areas at Shoup Bay and all accessible chicks will be weighed at Eleanor Island. All accessible chicks will also be weighed at the South Eaglek Bay colony and the Naked Island colony. Growth rates will be calculated for the near-linear portion of the growth curve (i.e., 60 - 300 g) by dividing the weight gain by the number of days. For kittiwakes, this method produces results that are virtually identical to Ricklefs' (1967) maximum instantaneous growth rates (Galbraith 1983).

We will collect diet samples from adults at Shoup Bay, Eleanor Island, South

Eaglek Bay and Naked Island colonies from May through August. Adults will be caught with a noose-pole or noose carpets. Ten samples a week will be collected at Shoup Bay, five samples a week will be collected from Eleanor Island and five to ten samples will be collected once a month at South Eaglek Bay and Naked Island colonies. Diet samples will be taken from chicks by collecting food they regurgitate after we approach or handle them. The same number of samples will be taken from chicks as adults.

We will take only one food sample from the chicks in a nest and we will sample each chick only once during the nesting season if possible. All samples will be preserved in 70% ethyl alcohol for later analysis. Otoliths will be used to determine fish species and lengths (Messieh 1975, Springer et al. 1986). Fish ages will be determined from their lengths (E. Biggs, pers. comm., Alaska Department of Fish and Game).

Data on foraging behavior and adult attendance will be obtained for radio-tagged birds. Birds will be radio-tagged by catching them at accessible nests with a noose-pole. Transmitters in 164-168 MHz range will be attached to 30 adult birds each at Shoup Bay and Eleanor Island. The radio packages weigh about 11 grams, which is about 2.5% of a kittiwake's body mass and will be attached under the base of the tail (Anderson and Ricklefs 1987; Irons 1992). To aid in visual observations of the birds, each bird will be banded with a unique combination of color bands and head, breast, and tail feathers will be dyed unique color combinations.

Data on the foraging trip length, trip distance and foraging area of radio-tagged birds will be collected by following individual birds with a boat throughout entire foraging trips. An eight-meter Boston Whaler will be used, which is large enough and fast enough (60 kph) to follow birds under most sea conditions in PWS. To select a bird to follow, we will wait near the colony until we detect a radio-tagged bird leaving the area; then we will follow it. We will follow only birds with chicks.

Following birds involves three people: a boat driver, an observer, and a recorder. We record the location and duration of flying, feeding, and resting behaviors for birds during entire foraging trips. Flying is recorded as either traveling or searching behavior; birds flying in one direction are considered traveling, and birds flying in circles or back and forth are considered searching. The number of feeding attempts is recorded for each bird; a feeding attempt is defined as a surface plunge or surface seize (Ashmole 1971). The number and locations of feeding sites are recorded using GPS. A bird is considered to be feeding in a different site if it moves more than one km between feeding attempts. Birds are considered resting when they are on the water and not feeding or when they are on land or flotsam. If we lose sight of a bird while following, it is recorded as lost.

Data on the foraging trip length and foraging areas of radio-tagged birds will also be collected by using remote receiving stations (RRSs). RRSs are composed of a 164 to 168 MHz Advanced Telemetry Systems receiver connected to an Advanced Telemetry Systems data-collection computer. The receiver and computer are powered by an 80 amp/hour lead-acid battery, which is charged by a three amp solar panel. The receiver and computer are housed in a waterproof, plastic "Pelican" case. The type of antenna that will be used depends on the range desired. For the RRS set up at colonies a two element "H" antenna will be used; for all other locations a more powerful five-element Yagi antenna will be used. Antennae at all sites except at the colonies will be attached to 10 meter extension poles; at the colony the RRS antenna will be mounted on a two meter pole. The RRSs monitor the frequency of each radio-tagged bird every 200 seconds. RRSs will placed at the Shoup Bay and Eleanor Island colonies and at potential foraging areas to record the presence of radio-tagged birds. The ranges of the RRSs will be tested using a boat equipped with four radio transmitters attached to a kite and elevated to 3, 15, and 30 meters above the water. The range boundaries of the RRSs will be approximate because of variation in the strength of the transmitters and the heights that birds fly.

We will identify the foraging ranges within which 60% and 95% of all activity occurs, to establish appropriate scales at which comparison with acoustic fish data can occur. For example, FIGURE 6 shows the 5 km range around each colony in PWS, while FIGURE 7 shows the 40 km range. The 5 km range shows almost no overlap in foraging areas between colonies, suggesting a great potential for differences in diet and in fish abundance between colonies, while the 40 km range shows great overlap, suggesting a reduced probability of encountering such differences.

Data on the location of feeding flocks and of feeding behavior of radio-tagged birds will be accumulated by following radio-tagged birds. A feeding flock will be defined as two or more surface-feeding birds feeding by surface plunging or surface seizing within 10 meters of each other (i.e., presumed to be feeding on the same school of fish) within a period of one minute.

Chick provisioning rates will be obtained from chicks at Shoup Bay and Eleanor Island colonies. Data will be collected by observing chicks at 20 nests for several hours and recording each time a chick is fed by an adult.

Adult survival rates will be determined from marked birds at Shoup Bay. Approximately 600 birds were individually colored banded in 1991. To determine survival rates, birds will be observed for a two to three week period in May until all birds have been sighted. These data will be compared to data collected in 1994 to determine how many birds did not return to the colony.

Analyses

One-way ANOVAs will be used to compare all behavioral data and growth rates of chicks from four colonies (SAS 1988). Tukey multiple-comparison tests will be used to determine significant differences between locations and years (SAS 1988). The chi-square 2x2 test for differences in probabilities (Zar 1984) will be used to compare clutch sizes, hatching success, fledging success, nest attendance, brood sizes, brood reduction and overall productivity. Student's t-test (Zar 1984) will be used to compare growth rates of chicks that are reared by radio-tagged birds and chicks that are reared by birds without radios and chick provisioning rates. Distances that birds fly, which will be recorded while following the birds, will be measured using Atlas GIS. The maximum distance that radio-tagged birds fly to feed is defined as the distance from the colony to the farthest feeding site. The total cumulative distance that radio-tagged birds fly on foraging trips is defined as the total length of its path during a trip. Pursuit and handling times will be combined with search time to analyze time budgets of radio-tagged birds because both are insignificant compared to time spent searching, and because pursuit and handling of prey happen so quickly that it is difficult to accurately record their durations (Irons 1992). Frequency of occurrence of prey in the diet samples will be used to determine the relative importance of each species. Means are reported ± one standard error. Results will be considered significantly different at $P=0.05$.

Schedule

April 1995 - May 1995	Prepare for field season
May - August 1995	Field work
August - November 1995	Contract for diet analysis
September - November 1995	Data analysis
December 1995 - January 1996	Report Writing
31 January 1996	Draft Report
31 March 1996	Final Report

Technical Support

This project will require technical support for analysis of diet samples and GIS mapping.

Appendix 8

Hayes 95163F

Reproduction of Pigeon Guillemots Populations in Prince William Sound in Relation to Food

Considerable baseline data on pigeon guillemot populations and their foraging and reproductive ecology in PWS have been collected both before and after the oil spill. Continuation of these efforts is essential for monitoring any trends in the PWS guillemot populations and for determining the factors limiting their recovery at the ecosystem level. Food supply, predation, or oil toxicity might limit reproductive success. This project, in conjunction with the Seabird Energetics component will help assess the relative importance of sand lance and other forage fish resources for successful reproduction in PWS guillemots.

It is important that this project go forward in 1995 to maintain the sample size of nests that was built up with considerable effort during the 1994 field season. Only 35 percent of the nests we monitored on Naked Island had been monitored in the past by Kuletz (1983) or by Oakley and Kuletz (1993). The rest were new, and many of these were found late in the season during the chick-rearing period, when guillemots were observed making food deliveries to chicks. It is essential to have known nest sites that can be checked from before egg laying through fledging to estimate breeding chronology and, more importantly, productivity of pigeon guillemots in PWS. This will also allow us to determine at which stage of the breeding cycle guillemots are most vulnerable.

If our return to Naked Island and Jackpot Island is postponed by one or more years, we will lose some of these active nest sites to attrition, and thus reduce our sample size. This is the problem we faced in 1994, when we resumed monitoring of colonies that had not been studied since 1990. Oakley and Kuletz (1993) had similar problems when starting their study. They found only 40 of 85 previously marked nests, and only eight of those were active.

Objectives

1. Determine if availability of food is limiting reproductive success of guillemots by collecting the following kinds of data:

   a. Measuring breeding parameters, including phenology, egg volume, chick growth rates, fledging weights, and reproductive success at colonies on Naked and Jackpot Islands.

   b. Measuring foraging parameters, including diet and provisioning rates of chicks, duration of foraging trips, and location of foraging areas.

c. Obtaining independent data from the Forage Fish Assessment component (Appendix 3: 95163A) on the abundance of various forage fishes within the foraging areas used by guillemots during the chick-rearing period.

Methods

Fifty-one guillemot nests on Naked Island and 37 guillemot nests on Jackpot Island were located during the 1994 field season. Although not all of these were accessible to field personnel, they were monitored in some manner (e.g., for productivity and chick growth rates when possible, or at least provisioning rates if nests were inaccessible). These same two study sites will be used during the 1995 field season. We expect to find a few more accessible nests at Jackpot Island and several more at Naked Island during the next field season.

Reproductive success will be monitored using standard field techniques involving periodic nest checks. A portable, infrared-sensitive video camera system, specifically designed for inspecting dark burrows and holes, will be used to monitor those nests that cannot be checked by conventional means.

All known nests will be checked from before egg laying through fledging to determine nesting chronolgy. Morphometric data for determining growth rates will be acquired at regular intervals during the chick-rearing period. Provisioning rates and diets of chicks will be determined whenever possible throughout this period by observing them from strategically located blinds or from boats anchored offshore. Some, if not all, of the feeding watches will cover the entire daylight period. In 1994, guillemots collectively delivered fish to their chicks during all daylight hours, but at any particular nest, there might be gaps of several hours in which no deliveries were made.

Estimates of adult survival will require the successful marking of birds (especially breeding adults, which are likely to return to the same nest each year) with unique color band combinations during the 1995 and future field seasons. In 1994, 80 birds were banded (19 adults and 61 chicks). Various methods of capturing adults (mist nets, noose mats, net traps at the nest entrance, and by hand at the nest) were tried in 1994. Although almost all of these methods are quite labor-intensive, certain methods are more effective at particular phases of the breeding season. Thus, we should be able to band more adults next year if we plan our capture efforts accordingly. Because of the high degree of nest-site fidelity in pigeon guillemots, known breeding birds not sighted the following season will be assumed to be dead. Marked birds are also useful in determining sex, activity budgets, and reproductive histories of individual birds.

Schedule

April 1995	Prepare for field work
May - August 1995	Field work/data collection
September - November 1995	Data analysis
December - January 1996	Report writing
31 January 1996	Draft report

Location
Most, if not all, of our work in 1995 will be concentrated on Naked and Jackpot islands. Naked Island is ideal for studying pigeon guillemots for the following reasons: 1) Naked and nearby islands (Peak, Storey, Smith, and Little Smith) support approximately one fourth of the guillemots in PWS; 2) there are many previously identified, accessible nest sites on the island; 3) there are excellent baseline data on the island's guillemot population that were obtained both before and after the oil spill, and finally; 4) Cabin Bay provides a suitable field camp site and an excellent anchorage for our boats. Jackpot Island was first used as a study site for pigeon guillemots in 1994. Its small size and numerous accessible nests make it an excellent study site. In 1994, considerable effort was made to find other guillemot study sites in PWS, but these two islands are the only ones that met our criteria: large numbers of guillemots and accessible nest sites.

Jackpot Island diets are primarily pelagic while Naked Island diets have been both benthic and pelagic. Naked Island is especially important as a study site because of its long history of guillemot research.

PROJECT IMPLEMENTATION

The U. S. Fish and Wildlife Service has the appropriate expertise to conduct the monitoring project outlined above. This agency employs several people with extensive experience in studying the breeding biology and feeding ecology of guillemots.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The Forage Fish Assessment component (Appendix 3: 95163A) will provide data on fish distribution, abundance, and species composition, while the Foraging Birds component (Appendix 6: 95163B) will provide pertinent data on the foraging behavior of guillemots in relation to the distribution and abundance of forage fish. At the guillemot study sites (Naked and Jackpot Islands), personnel from the pigeon guillemot component will work closely with those of the Seabird Energetics component (Appendix 12: 95163G). Because of the difficulty in finding accessible nests, it is imperative that the Seabird Energetics component have access to most of the pigeon guillemot nest sites that were located and used during the 1994 field season. In addition, the projects are coordinating their efforts so that the kinds of data and measurements needed by each component are collected only once, and in the same manner. This might involve a division of labor (and possibly nest sites, or even study sites) between the two components and subsequent sharing of the data, or perhaps having members from each field crew present during each nest check.

Appendix 9

Roseneau 95163K

Using predatory fish to sample forage fish

Methods

Data collection: This study will test the feasibility and effectiveness of obtaining low cost spatial and temporal information on forage fish in the northern Gulf of Alaska through cooperation with local charter-boat operators. Charter boats can collect stomachs from sport-caught halibut and cod (cod are not targeted by this fishery but they are often caught and kept for bait). Halibut and cod are opportunistic aggressive predators that operate at a variety of depths in the water column. Both species prey heavily on some of the same forage fishes that murres, kittiwakes, and other seabirds eat when these prey are abundant (e.g. capelin and sand lance). Conversely, when forage fish are scarce or absent, halibut and cod feed indiscriminately on a variety of other prey items that fish-eating seabirds may not be able to utilize (e.g. larger fishes and invertebrates).

The charter boat sport fishing fleet has grown dramatically in the northern Gulf of Alaska in recent years and many of these vessels regularly fish for halibut in lower Cook Inlet between Anchor Point and the shelf break, Kennedy Entrance between the Kenai Peninsula and the Barren Islands, the Barren Islands (as many as 20 boats have been seen in the West Amatuli/Ushagat/Nord Island area on peak days in 1993-1994 (Roseneau, pers. observ.), the Kodiak Archipelago, the entrance to Resurrection Bay and Blying Sound, and in some areas of Prince William Sound.

To test the sampling method, three or four Homer-based charter boat companies operating one to six vessels each and a similar number of Seward-based operators will be asked to voluntarily bring in stomachs from halibut and cod caught near the Barren Islands and in Kennedy Entrance, lower Cook Inlet, and Blying Sound, on a weekly basis during 1 May - 1 September 1995. The Barren Island/Kennedy Entrance/lower Cook Inlet area was included because murres, kittiwakes, and puffins nesting in the Barren Islands feed in this area of extensive charter-boat activity.

Depending on how individual charter-boat skippers handle fish, stomachs will be removed and labeled at sea, stored in ice coolers, and brought back to Homer and Seward, or fish will be tagged with pertinent locality data and their stomachs will be removed during cleaning at the Homer and Seward docks. Following schedules provided by the charter boat operators, vessels will be met to pick up stomachs, verify catch locations, and to obtain other types of information. These will include sizes of fish yielding the stomachs, the depths at which they were caught, and visual sightings of schooling fish/seabird melees. After stomachs are picked up, they will be taken to a wet-lab facility for same-day processing.

At the lab, stomachs will be opened and checked for fish species in the size ranges that murres, kittiwakes and puffins typically eat (e.g. capelin, sand lance, herring, gadids, and flatfishes). Fishes will be identified with the aid of standard keys, high quality photographs, and voucher specimens. The P.I. is experienced with identification of all the species of interest and will teach volunteer assistants accurate means of identification.

Data on numbers and species of forage fish found in the stomachs, catch dates and locations, and notes on other stomach contents will be entered into a computer database. The database will be designed to allow information to be sorted rapidly into several distinct geographical areas (e.g. Barren Islands, eastern and western Kennedy Entrance, lower Cook Inlet, lower Kachemak Bay, eastern and western Blying Sound) in weekly and monthly increments of time.

Subsamples of forage fish recovered from halibut and cod stomachs will be labeled and preserved in 10% buffered formaldehyde, 75% ethanol-2% glycerin, or by freezing to allow future multiple uses, including analysis of stomach contents, aging via otoliths, and nutrient analysis.

Samples preserved in formaldehyde will be shipped to Molly Sturdevant at the NMFS Auke Bay laboratory on a monthly basis for analysis of stomach contents (Appendix 2). Specimens preserved in ethanol-glycerin or by freezing will be sent to other researchers (J. Piatt at NBS; R. Merrick, NMFS, F. Mueter, IMS).

Data Analysis: Data from the FY95 predatory fish sampling study will be used to assess the effectiveness of the method in obtaining broad-scale low-cost information on forage fish in the Gulf of Alaska. This information will also be used to evaluate the effectiveness of obtaining low-cost temporal, spatial, and relative abundance data on forage fish that can be integrated with seabird studies (e.g. general overall presence and absence, changes in relative abundance and species composition over time, particularly during pre-laying and chick-rearing periods).

Data analysis will be simple and straight forward. Numbers and species obtained from the halibut and cod stomachs will be organized by geographic area and time, quantified, and reduced to bar-charts showing weekly and monthly changes in species composition and relative abundance in the areas of interest. Information from Blying Sound will be sent to APEX investigators. Data from lower Cool Inlet, Kennedy Entrance, and the Barren Islands will be compared with a variety of data collected on murres, kittiwakes, and puffins nesting on the islands to determine if relationships can be detected between reproductive variables and the species composition/relative abundance time-series generated by the predatory-fish sampling program.

Products will include summaries of raw data, NOAA charts showing collection locations and times, and bar charts showing changes in relative abundance and species abundance over time in the areas of interest. When complete, results of the FY95 pilot project will be evaluated to see if a second year of research is warranted for FY96.

Existing Agency Program

This pilot project will make use of Alaska Maritime National Wildlife Refuge lab, storage, and office space in Homer, Alaska. The Refuge will also provide identification aids and computers for database managment and analysis. The National Park Service will supply lab, office and storage space for data entry at the Kenai Fjords National Park in Seward, Alaska.

Coordination and Integration of Research Effort

This pilot project will be integrated with several components of the Seabird/Forage Fish Project. Spatial and temporal information on species composition and relative abundance of forage fish in Blying Sound will be provided to fisheries and bird investigators, and specimens collected during the program will be used in studies of forage fish diets. The project will also be closely integrated with a Minerals Management Service-sponsored Seabird/Ecosystem Study in Kachemak Bay and lower Cook Inlet that will be conducted by J. Piatt (NBS, FY95-FY96).

Information generated on species composition and spatial/temporal distribution and abundance in lower Cook Inlet, Kennedy Entrance and the Barren Island waters will be shared with J. Piatt (NBS) for comparison with a trawl/acoustic survey that will use the same acoustic hardware as the APEX acoustic component. Joint analysis of data may be undertaken subsequently if warranted.

The data will also be shared with D. Roby (Appendix 12) for comparison with seabird dietary and growth information. Data will also be shared with a joint NMFS/ADFG sealion study that will be conducted in the Barren Islands in FY95. In return, NMFS will provide information from its late June-mid July trawl-acoustic surveys (R, Merrick). F. Mueter, Institute of Marine Sciences, will also provide data on foraging fish found in stomachs of predator fish obtained by long-lining in Barren Island waters.

Appendix 10

Roseneau 95163K

Barren Islands Seabird Studies

Introduction

This study component is a pilot project that is scheduled to be implemented in the Barren Is. in mid-June FY95. The pilot study is designed to collect data on common murres, black-legged kittiwakes, and tufted puffins that will be used in a multi-species analysis of seabird productivity and energetics. Products will include data on nesting chronology, productivity, feeding rates of chicks, time-budgets of adults, species of fish fed to chicks, and meal sizes of chicks (data types vary slightly between species—see below).

The Barren Is. seabird study component was developed and integrated into the seabird/forage fish project for two reasons. Massive schools of spawning capelin, an important forage fish species that has been scarce in the northern Gulf of Alaska since the late 1970's (see Piatt and Anderson 1995), were present in Barren Is. waters in FY94 (Roseneau et al. 1995). The presence of these large spawning concentrations suggests that a major food web shift may be occurring in the vicinity of these islands that will provide a prime opportunity for studying seabird - forage fish relationships that may help us understand why certain seabird species have not been recovering in the Prince William Sound area.

In addition, expenses and data can be shared with a Minerals Management Service - National Biological Service (MMS-NBS) seabird/ecosystem study and a National Marine Fisheries Service - Alaska Dept. of Fish and Game (NMFS-ADFG) sea lion project that will begin collecting information on seabirds, fisheries resources, and oceanographic conditions in the Barren Islands in FY95 (see the section on coordination and integration of research efforts below). Initiating a pilot seabird study at the East Amatuli I. - Light Rock colony to take advantage of these complimentary programs will provide the seabird/forage fish project with a considerable amount of useful information from this area of interest at well below normal costs.

Data Collection

The study will be conducted only at the East Amatuli Island - Light Rock colony to conserve funds and maximize opportunities to collect high-quality data (study plots at this colony sample a much wider range of nesting habitats and can be visited more frequently, compared to Nord Island study plots where work was done in FY93-FY94.). Data will be collected by an experienced team of three observers stationed at the Amatuli Cove camp from June 15 to September 7 (two team members have a combined total of 10 field seasons experience working at East Amatuli Island). The observers will commute to and from study sites via small boats or by hiking.

Nesting chronology and productivity data on murres and kittiwakes will be collected from the same 10 study plots used to obtain this information during FY93-

FY94 restoration studies (Projects 93049 and 94039; see Roseneau et al. 1995a,b). The plots, first established in FY93 by the same people assigned to collect data in FY95, sample a wide range of nesting habitats and contain a total of about 300 murre and 200 kittiwake nest sites. The same standardized methods used to collect these data in FY93-FY94 will be employed in FY95. Study plots will be visited every two to three days, weather permitting, and nest sites will be observed from two previously established viewing posts for the presence or absence of eggs and chicks (in the case of murres, observations of incubating and brooding postures will also be used to help determine if pairs are attending eggs or chicks).

Observations will begin before eggs are laid and end after fledging peaks. Plots and nest sites will be located by using photo guides and plot maps, and data will be recorded on waterproof forms using standardized codes. Data collected during the study will be used to calculate several measurements of productivity (e.g., numbers of eggs laid and hatched and chicks fledged per plot, per pair, and per total number of adults). These data will also be used to determine timing of nesting events (e.g. first laying dates, and mean and median laying, hatching, and fledging dates).

Information on any factors or events that might adversely affect the reproductive success of murres and kittiwakes will also be collected (e.g. avian predation events, human disturbance events, adverse weather conditions). During any predation events or other episodes that may cause adults to flush from the nesting cliffs, special care will be taken to record all losses of eggs or chicks.

Data will also be collected on feeding rates of murre and kittiwake chicks and time-budgets of adults. This information will be obtained by monitoring about 20 pairs of murres and 20 pairs of kittiwakes with chicks on two special plots that will be established for these purposes (sample sizes were determined in consultation with D. Roby, UAF, and J. Piatt, NBS). Basic methods for collecting these data have been described by Burger and Piatt (1990). Initially, pairs with chicks will be observed for several days to determine the best times of day for making observations. After this information is obtained, a data collection schedule will be set up to include both maximum and minimum tide cycles (as recommended by J. Piatt, pers. comm.). Following this schedule, the murre and kittiwake pairs will be observed closely for four to six hours per day, four to six times during the chick rearing period (tidal cycles and the length of the chick-rearing periods dictate the number of times data will be collected on each species—murres will probably be checked four times and kittiwakes five to six times during breeding season). During these intensive nest site watches, all food deliveries to chicks and lengths of time adults spend away from nest sites will be noted. These data will be used to calculate weekly and seasonal chick feeding frequency and time-budget indices for both species .

Fishes brought to murre and kittiwake chicks will be identified as often as possible during the study to obtain basic information on availability of prey. Most of this information will be obtained during regular plot and nest site watches (i.e., during times when chronology-productivity, feeding rate, and time-budget data are being collected). However, blocks of time averaging about 8-10 hours/week will be set aside to supplement these observations. Fishes brought to murre chicks will be observed with the aid of spotting scopes and binoculars and identified to species or basic category type (e.g., capelin, sand lance, herring, gadids, flatfishes, pricklebacks, other fishes, unidentified fishes). Observers assigned to the project have experience visually identifying these basic prey-types in murre bills. In the case of kittiwakes, which regurgitate food, a set of accessible nests will be watched and after feedings occur, chicks will be gently captured and "puked" to obtain samples of prey. About 10-15 samples will be collected every week during the chick-rearing period, which should be sufficient to obtain basic information on prey species brought to chicks and detect any dramatic seasonal changes in utilization of prey (this technique has been used successfully to identify abrupt periods of sand lance presence/absence at colonies in the Chukchi Sea; D.G. Roseneau, unpubl. data). Kittiwake chick regurgitation's will be weighed to provide information on meal sizes (both wet and dry weights may be used, depending on specific needs of other investigators—e.g., D. Roby: Appendix 12). [Note: Samples of fishes will be preserved in 5% buffered formaldehyde for 24 hours and then transferred to 50% isopropanol and returned to Homer for verification of in-field identifications (see Hatch and Sanger 1992).]

Several types of information will also be collected on tufted puffins, including nesting chronology, burrow densities and occupancy rates, numbers of occupied burrows producing chicks, chick-growth rates, and types of food brought to chicks. These data will be obtained from five previously established study plots on East Amatuli I. in August after chicks are about one week old (disturbing burrows earlier in the nesting season often results in abandonment).

Hatch dates will be initially estimated by observing percentages of adults returning to burrows with fish in their bills during 1000 - 1300 h (in previous years, chicks were about one week old on these plots when about 20% of the adults had bill-loads). To supplment this information, small samples of 5 - 10 burrows will be checked every week in other sections of the colony to see if eggs have hatched.

Burrow occupancy will be determined via a number of indicators (e.g., presence of guano, matted vegetation, evidence of fresh digging). Active burrows will be marked on three study plots with survey flags and 30 chicks will be carefully removed and weighed and measured every five to seven days until they reach fledging age (wing chord will be the primary measurement). An additional 20 chicks on two other plots will be weighed and measured just three times during the chick-rearing period to measure effects of disturbance at the more frequently visited plots.

Just before fledging begins, data on burrow densities, occupancy rates, and numbers and sizes of chicks will be collected from four 3-m wide transects containing 270 m^2 that have been monitored every year since 1986. Prey items brought to chicks will be obtained from about 100 active burrows about once each week during the chick-rearing period in other sections of the colony by temporarily blocking burrow entrances for three-hour periods with wire-mesh screens in other ~~w~~sections of the colony (adults often drop fish when burrow entrances are blocked; see Hatch and Sanger 1992). Specimens will be weighed and measured, and those that can be visually identified will be placed back into burrows. Specimens that cannot be easily identified will be preserved in 5% buffered formaldehyde for 24 hours and then transferred to 50% isopropanol for later identification in the lab (see Hatch and Sanger 1992).

Because water temperatures are an important factor influencing both seabirds and their prey (see Springer et al. 1984), water temperatures will be measured near the East Amatuli I. - Light Rock colony at regular intervals throughout the study. A data logger - probe unit will be set up at Light Rock to provide a daily record of sea surface temperatures (SST), and SST will also be measured with calibrated hand-held thermometers at several other locations around East Amatuli Island on a weekly basis during late June - early September.

Data Analysis

Data collected to measure murre and kittiwake chick-feeding rates and amounts of time spent away from nests, foraging for food, will be analyzed in a manner that will provide chick-feeding frequency and time-budget indices for murres and kittiwakes. In both cases, calculations will be made in weekly increments and for the entire chick-rearing period.

For feeding frequencies, the number of times chicks are fed will be divided by the number of hours of observation. Time budgets will also be calculated in a similar manner, as percentages. Data may be manipulated in slightly different ways to fit the needs of other investigators (Appendix 11, Appendix 12; J. Piatt).

Observations of fish fed to murre and kittiwake chicks will be reported as percentages of identified vs. unidentified categories (e.g. capelin, sand lance, herring, gadids, flatfishes, prickle-backs vs. unidentified fishes). These calculations will be made in weekly increments and for the entire chick-rearing periods.

Puffin chick growth-rates will be reported for wing-growth as centimeters/day and for body weight as grams/day. Actual hatch dates will not be known, because burrows will not be checked until chicks are about one week old (see above). Ages of chicks will be estimated by using the first wing measurement and a growth equation reported by Amaral (1976). The growth rate of each chick will be determined by linear regresssion of the wing measurements that are obtained when the chicks are 10-40 days old; growth is nearly linear during this period (A. B. Kettle and P. D. Boersma, unpubl. data). Other calculations, using measurements from chicks that are 5-30 days old, will be made for comparison with growth rate calculations from chicks that are 5 - 30 days old for comparison with growth rate calculations made by S. Hatch (Appendix 11).

Growth rate and other information on puffins obtained in FY95 (e.g. timing of nesting events, proportion of active vs. inactive burrows, number of chicks per occupied burrow) will be compared with data collected from the same plots during 1994 and for other years, as they become available (e.g. mid-1970's - early 1980's and 1990 - 1993; these data are currently being prepared for publication by A. B. Kettle and P. D. Boersma).

Standardized methods used during FY93-FY94 common murre restoration studies (Projects 93049 and 94039) will be employed to analyze FY95 murre and kittiwake productivity data. Nest sites with incomplete observatyion records will be eliminated from the database. The remaining data will then be analyzed to obtain chronology and productivity information, using plots as sample units (e.g. first-laying dates, mean and median laying, hatching and fledging dates; numbers of eggs laid and hatched; and chicks fledged per plot, per pair, and per total number of adults).

Median hatch date will be used as the primary measure of chronology. Laying and hatching dates will be calculated for each site as mid-points between pre- and post-event observations, and chick ages will be derived from hatch dates obtained during nesting chronology calculations (see above) and from direct observations of chicks. At murre sites where the range of possible laying dates is samaller than the range of possible hatching dates, hatching dates will be calculated by adding 32 days to laying dates (see Byrd 1986; Dragoo and Dragoo 1994). At kittiwake sites, hatching dates will be calculated by adding 27 days to laying dates (see Dragoo and Dragoo 1994). During the murre productivity analysis, chicks that are at least 15 days old before disappearing from nest sites will be counted as "fledged" unless specific data are available to indicate that they died of natural causes (see Hunt et al. 1981; Byrd 1986, 1989; Dragoo and Dragoo 1994). In the kittiwake analysis, chicks that are 33 days old before disappearing will be considered fledged (Dragoo and Dragoo 1994).

Because productivity is an important measurement for assessing the recovery status of common murres (see Proceedings of the Science fo the Restoration Process Workshop, April 13-15, 1994), the murre productivity data will be compared with information collected in previous postspill years (e.g. 1989-1994). ANOVA and Tukey HSD multiple comparison tests will be run to see if there are significant differences among years. Also, Kendall's Tau test will be used to check for trends.

Data on water temperatures will be summarized in tabular form. The information will be divided into seasonal blocks of time.

Existing Agency Program

The Alaska Maritime National Wildlife Refuge will furnish all office and warehouse space, computers, and radio communications systems needed for the project. In FY95, the refuge will also provide up to two months of the principal investigator's time at no additional cost. In addition, the refuge will furnish several items of field equipment for the study (e.g., back-up outboard motors, radios, tents, survival gear), and emergency medical consultation services for the field camp under its refuge-wide remote emergency medical services program contract.

Coordination of Integrated Research Effort

The Barren Island seabird study is fully coordinated and integrated with the APEX project (indeed, several aspects of the study design have been custom-tailored to meet various investigators' specific needs in consultation with them). Data on murre, kittiwake, and puffin productivity, feeding rates and meal sizes of chicks, and time-budgets of adults will be sent to D. Roby, University of Alaska-Fairbanks, for use in the energetics component of the project (Appendix 12). Roby will also receive information on species of forage fish fed to chicks and specimens of fish for nutrient analysis. Puffin data collected on the East Amatuli Island plots will also be shared with S. Hatch, National Biological Service (Appendix 11). Communications with Roby and Hatch will be maintained on a regular basis to ensure that their data needs are fully met).

The Barren Is. seabird project is also completely coordinated and integrated with the MMS-NBS Kachemak Bay - lower Cook Inlet seabird/ecosystem study that will be conducted by J. Piatt, National Biological Service, during FY95-FY96. Indeed, Piatt and D. Roseneau, the principal investigator of the Barren Islands project have agreed to work closely together and collaborate on data acquisition and analyses, because the studies will directly compliment one another. Because of Piatt's interest in obtaining data from the Barren Is. colonies, he has agreed to provide $15.0K to help fund the FY95 work. Piatt has also tentatively offered to contribute a similar dollar amount in FY96 (the level of this funding will depend on the amount he receives for a second year of study). In addition to his FY95 monetary contribution, Piatt will attempt to help defray logistical costs by coordinating his vessel schedule with the Barren Island project, and he will provide a variety of information to the Barren Island seabird study, including hydroacoustic and forage fish trawl survey results; oceanographic measurements; murre, kittiwake, and puffin stomach content analyses; stable isotope and nutrient analyses; and chronology-productivity results from other nearby Gulf of Alaska seabird colonies (e.g., Gull, Flat, Chisik, and Duck islands). In return, the Barren Island seabird project will supply Piatt with specific sets of murre, kittiwake, and puffin data, including information on nesting chronology, productivity, feeding rates of chicks, time-budgets of adults, and species of forage fish fed to chicks.

The joint National Marine Fisheries Service - Alaska Dept. of Fish and Game sea lion study being conducted in the Barren Islands during FY95 is also coordinated with the Barren Island seabird project. D. Merrick, NMFS, will be making hydroacoustic-trawl surveys within a 16 km radius of the Sugarloaf Island sea lion rookery in late June - mid-July. He has agreed to share the results of these surveys with the principal investigator of the seabird project. Also, during the late June - mid-July survey work, he will specifically check any areas around the Barren Islands that seabird project personnel may be able to identify as forage fish "hot spots" via observations of feeding birds and whales. Maps showing FY94 feeding concentrations of birds and whales are currently being prepared for Merrick to assist him in planning his FY95 Barren Islands surveys. [Note: Merrick and Piatt are also in the process of coordinating the hydroacoustic-trawl survey portions of their respective projects.]

The Barren Islands seabird project will also provide key logistical support to a Trustee Council-sponsored murre satellite telemetry study that will be initiated in the Barren Islands in FY95. S. Hatch, National Biological Service, plans to visit the islands in early July to capture several murres on East Amatuli Light Rock and implant transmitters in them. Barren Islands project personnel will help Hatch accomplish this difficult task by transporting his team to and from Light Rock and providing them with the technical expertise and assistance they will need to safely land on and climb Light Rock (personnel assigned to assist Hatch's team have five field season's experience landing on this rugged offshore islet). The Barren Islands seabird project will also provide vital field camp support for the murre satellite telemetry study (e.g., radio communications, sleeping and cooking facilities, work space for conducting transmitter implant work) and some support will also be provided for puffin work at West Amatuli Island. [Note: Hatch's original satellite telemetry study plan counted on receiving the above support. In the event the Barren Island seabird component is not funded in FY95, Hatch will need additional funds to work at this study location—i.e., he will need to supply his own boat, outboard motors, fuel, and much larger quantities of camping gear, and pay the logistical costs of transporting these items to East Amatuli Island]

We can also collect some information on tufted puffins that can be analyzed in the same collaborative way, without compromising other work or adding to the cost, because these data can be obtained during August on days when weather prevents boating to murre-kittiwake productivity plots (data on burrow density and occupancy, chick growth rates, and chick food samples are available from FY94 and these variables were also monitored for several years during the mid-1970's - early 1980's, and during 1990-1993).

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Appendix 11

Hatch 95163D

Tufted Puffin Foraging and Reproductive Success

Introduction

Tufted puffins are cost-effective samplers of forage fish, providing information on distribution, species composition, and relative abundances that can be difficult to obtain by other means (Hatch and Sanger 1992). During the chick-rearing period, tufted puffins are thought to feed on much the same prey as do black-legged kittiwakes where the two species occur together, but, unlike kittiwakes, they can dive to depths of at least 50-60m in pursuit of prey that remain below the surface, unavailable to kittiwakes. Puffins differ from pigeon guillemots in their much greater reliance on pelagic prey species such as sand lance, capelin, and juvenile pollock. Guillemots often prey heavily on nearshore demersal species such as sculpins, pricklebacks and blennies. This component of the APEX project will strengthen the overall study design by offering comparisons between surface-feeding kittiwakes and diving puffins, and between offshore feeding puffins and nearshore feeeding guillemots, through measurements of the same parameters for puffins as for the other species. The data will also be shared with the energetics component (Appendix 12). It will also allow regional comparisons with a larger survey of puffin diets by the National Biological Service and cooperators throughout the northern range of the puffin.

Study Sites and Methods

Proposed sites for data collection include two locations in Prince William Sound and one in the Barren Islands:

a. Naked Island area--Tufted puffins are not abundant breeders within the main part of Prince William Sound, but previous workers report several hundreds of puffins nesting on portions of Naked and Smith islands (Sowls et al. 1978). One or more colonies in this vicinity will be worked relatively intensively with the aim of compliing a complete data set (as described below) within this core study area of the APEX project. The prey base of puffins in this area is unknown but probably includes sand lance, pollock and possibly herring.

b. Porpoise Rocks--Located in Hinchinbrook Entrance to Prince William Sound, the Porpoise Rocks colony contains an estimated 2,000 breeding puffins (Sowls et al. 1978). The local prey base is unknown but it may differ substantially from that of the Naked Island area because of this colony's proximity to the Gulf of Alaska coastal current.

c. Barren Islands--Located at the center of an oceanographically complex and dynamic region at the mouth of Cook Inlet, the Barren Islands support some 200,000 breeding puffins (Sowls et al. 1978). West Amatuli (95,000 puffins), situated immediately adjacent to East Amatuli, is the island chosen for intensive work in 1995. Unlike Prince William Sound, general observations at the Barren Islands in the last two years suggest that capelin are abundant in the area and may be an important prey resource for puffins and other seabirds (Roseneau, pers. observ.). Puffin studies planned for this area are intended to complement the APEX and NBS work proposed for murres, puffins, and kittiwakes in the Barrens in 1995. Observations on puffin feeding and productivity will be augmented by a pilot study of foraging range and seasonal movements using satellite telemetry, a project independently funded by the National Biological Service for 1995.

The suite of parameters, or a subset thereof, to be measured in each of the study colonies includes nestling diet composition (numbers, frequency, age/size classes of prey taxa), food delivery rates, chick growth and condition, and breeding productivity. Diet samples will be fresh frozen for compositional analysis under the seabird energetics project (Appendix 12). Techniques specific to each of these parameters are as follows:

a. chick diets: Puffin diet samples are collected most efficiently by placing wire screens over the entrances to burrows (Hatch and Sanger 1992). Unable to enter, returning adults drop their food loads on or near the screens, which are removed when the sampled are retrieved after 1 - 3 h. Samples are washed, bagged, and preserved for later analysis in the laboratory. To maximize the quantity of food obtained, morning hours are usually most productive, because puffins generally make a food delivery soon after first daylight. Sampling will also be conducted at other times of day to check for possible diurnal variation in diet composition.

b. food delivery rates: These are calculated as the product of meal frequency and average meal size. The former will be estimated by conducting all-day watches on 5 - 10 active burrows simultaneously from a blind on four or more days during the chick-rearing period. The number of visits per burrow per hour by food-carrying adults will be quantified. Average meal size will be estimated by placing wire muzzles on a sample of chicks and retrieving the food loads left in the nest chamber by adults. This technique is more invasive and laborious than the screening method but more likely to permit collection of discrete and complete bill loads. The effects of chick age and seasonality in food delivery rates will be controlled for inter-year comparisons by conducting the food watches on approximately the same dates each year.

c. chick growth and condition: Two indices of chick development will be obtained at the more intensively studied colonies (Naked Island and West Amatuli). The first is a measure of mass change per unit time for a sample of variously aged chicks (n = 30) whose weights and wing measurments are measured on two occasions 5 - 10 days apart (cf. Ricklefs et al. 1984).

Sampled chicks will be between 5 - 30 days of age (estimated from wing lengths) when first and last measured. Over that interval, the growth rate is approximately linear and can be expressed simply as grams day^{-1}. The second index is the ratio of individual body mass to wing-length, which expresses the condition (fat stores) of a given chick relative to other chicks of the same age. This index is useful for inter-year and inter-colony comparisons when extended observations on chick development are impractical.

d. productivity: Puffin productivity (late-stage chicks per burrow) will be estimated by checking a minimum of 100 burrows in each colony, using a minature remote video camera with an infrared light source (e.g. the "Burrow Probe" system offered by Fuhrman Diversified, Inc.).

This system is strongly recommended because it 1) minimizes destruction of nest sites and loss of chick production that almost inevitably occurs when excavating burrows to record presence/absence of chicks (this is especially important in small, marginal colonies such as those in Prince william Sound), 2) increases the probability of attaining the desired sample sizes and eliminate bias due to inassessibility of some nest chambers (banks too steep, burrow too long, situated under boulders or tree roots), and 3) enables workers to increase their success rate in screening burrows for food samples by allowing them to work only with burrows that are known to contain chicks. This instrument will also be used to check burrows non-destructively earlier in the nesting cycle than late chick stage (early egg stage at Naked Island and Porpoise Rocks, late incubation or early chick stage at the Barren islands), providing more detailed information on the stages at which nesting failures occur.

Because emphasis will be given in 1995 to the puffin colonies offering the greatest overlap with other components of the APEX project, the data obtained from the Porpoise Rocks colony will be reduced to a single collection made over a 4 - 5 day period in August, overall productivity (chicks per burrow) based on a single observation ($n \geq 100$), and the chick condition index (weight-wing length ratio for n = 30 individuals).

Schedule

20 - 30 June	PI and project assistant conduct reconnaisance of potential study sites in Prince William Sound, select colonies in the Naked/Smith islands area, check burrows during egg stage with burrow probe video system.
15 - 20 July	PI, project assistant, and two volunteers set up camp in the Barren Islands. Volunteers remain for approximately six weeks of work on West Amatuli.
21 July - 30 August	Project assistant and one volunteer return to PWS for further data collection at Naked/Smith and Porpoise Rock colonies.

28 - 30 August PWS and Barren Island field personnel return to Anchorage.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The combination of guillemot and kittiwake projects in Prince William Sound will support this project logistically by transporting field crews and their gear from Whittier to Naked Island and from Naked Island to Porpoise Rocks by 25-foot Boston Whaler (two complete trips in June and July-August respectively).

The Barren Islands murre and kittiwake project (Appendix 10) will assist this project by loaning an inflatable boat and outboard motors or otherwise transporting field personnel intermittently between the proposed camp on East Amatuli and a spike camp for puffin work on West Amatuli. The murre/kittiwake project will furnish a VHF radio for communication between East and West Amatuli islands. Logistic costs (vessel and helicopter charters and other travel expenses) of the Barrens Island trip will be further shared with the NBS murre telemetry study (Project 95021) already funded for 1995.

Relative abundances of forage fish species in puffin diets will be compared with the results of hydroacoustic and net sampling operations in Prince William Sound, based on estimated foraging ranges and the results of satellite-tracking in the Barren Islands. Data on puffin nestling diets, food delivery, chick condition and productivity, as well as frozen food samples from Prince William Sound and the Barren Islands, will be furnished by this project for use in a multi-species analysis of energetics and seabird producivity (Appendix 12). This project will supply two portable propane freezers for this purpose.

Cost-sharing with NBS

Direct costs contributed by the National Biological Service toward this project in 1995 will total $30 K, including one month of PI salary ($6K), three months of project assistant salary ($10K), satellite telemetry pilot project ($10K), laboratory analysis of food samples ($2K) and miscellaneous equipment and supplies ($2K).

APEX 74

Appendix 12

Roby 95163G

Seabird Energetics

Reproductive success in seabirds is largely dependent on foraging constraints experienced by breeding adults. Previous studies on the reproductive energetics of seabirds have indicated that productivity is energy-limited, particularly during brood-rearing (Roby 1991a). Also, the young of most seabird species accumulate substantial fat stores prior to fledging, an energy reserve that is crucial for post-fledging survival (Perrins et al. 1973). Data on foraging habitats, prey availability, and diet composition are critical for understanding the effects of changes in the distribution and abundance of forage fish resources on the productivity and dynamics of seabird populations.

The composition of forage fish is particularly relevant to reproductive success because it is the primary determinant of the energy density of chick diets. Parent seabirds that transport chick meals in their stomachs (e.g., kittiwakes) or in a specialized pouch (e.g., auklets) normally transport meals that are close to the maximum load. Seabirds that transport chick meals as single prey items held in the bill (e.g., guillemots, murres, murrelets) experience additional constraints on meal size if optimal-sized prey are not readily available. Consequently, seabird parents that provision their young with fish high in lipids are able to support faster growing chicks that fledge earlier and with larger fat reserves. This is because the energy density of lipid is approximately twice that of protein and carbohydrate. Also, forage fish are generally very low in carbohydrates, and metabolism of protein as an energy source requires the energetically expensive process of excreting the resultant nitrogenous waste. While breeding adults can afford to consume prey that are low quality (i.e., low in lipid) but abundant, reproductive success is largely dependent on provisioning young with high quality (i.e., high in lipid) food items. If prey of adequate quality to support normal nestling growth and development are not available, nestlings either starve in the nest or prolong the nestling period and fledge with low fat reserves.

Forage fish vary considerably in lipid content, lipid:protein ratio, energy density, and nutritional quality. Much of the energy content of prey consumed by seabirds is in the form of neutral lipids, especially triglycerides and wax esters, and wax esters in particular are known to be difficult to digest (Nevenzel 1970; Lee et al. 1972; Benson et al. 1972, Sargent 1976; Clarke 1984, In press). In some seabird prey, such as lanternfishes (Myctophidae) and eulachon, lipids may constitute over 50% of dry mass (A. R. Place, unpubl. data; J. Piatt, unpubl. data; S. Payne, unpubl. data); while in other prey, such as juvenile walleye pollock and Pacific cod, lipids are frequently less than 5% of dry mass (J. Wejak, unpubl. data; J. Piatt, unpubl. data). This means that a given fresh mass of lanternfish or eulachon may have 3-4 times the energy content of the same mass of juvenile pollock or Pacific cod. Published values for lipid content (% dry mass) of other forage fish are generally intermediate between those of lanternfish and juvenile pollock: herring - 36.7%, sand lance - 24.4%, smelt (Osmeridae) - 15.8%, capelin - 15.3% (Montevecchi et al. 1984; Barrett et al. 1987; Massias and Becker 1990). These studies have shown that for a particular species of forage fish, lipid content can vary widely with season, sex, reproductive status, and age class. For example, sand lance can vary from 6.3% lipid (% dry mass; J. Piatt, unpubl. data) to 31.5% lipid (Hislop et al. 1991) and gravid female capelin have nearly twice the energy density of male capelin (Montevecchi and Piatt 1984). By increasing the proportion of high-lipid fish in chick diets, parents can increase the energy density of chick meals in order to compensate for the low frequency of chick feeding (Ricklefs 1984a; Ricklefs et al. 1985).

NEED FOR THE PROJECT

This study is relevant to the APEX Project and EVOS Restoration Work because it is designed to develop a better understanding of how shifts in the diet of seabirds breeding in PWS affect reproductive success. Unlike marine mammals, seabirds offer the possibility of directly measuring diet composition and feeding rates, and their relation to productivity. By monitoring the composition and provisioning rates of seabird nestling diets, prey preferences can be assessed. Measuring provisioning rates is crucial because even very poor quality prey may constitute an acceptable diet if it can be supplied at a high rate. Understanding the diet composition, foraging niche, and energetic constraints on seabirds breeding within the spill area will be crucial for designing management initiatives to enhance productivity in species that are failing to recover from EVOS. If forage fish that are high in lipids are an essential resource for successful reproduction, then efforts can be focused on assessing stocks of preferred forage fish and the factors that impinge on the availability of these resources within foraging range of breeding colonies in PWS. As long as the significance of diet composition is not understood, it will be difficult to interpret shifts in the utilization of forage fishes and develop a management plan for effective recovery of damaged species.

There is a definite need for information on the relationship between diet and reproductive success for pigeon guillemots, common murres, and marbled murrelets, all seabird species that are failing to recover from EVOS at an acceptable rate (1994 Exxon Valdez Oil Spill Restoration Plan). However, the latter two species pose serious problems for studies of diet composition in the spill area. For common murres it is difficult to collect quantitative data on diet composition, feeding rate, meal size, and chick growth rates without seriously impacting productivity because this species nests in dense colonies on narrow ledges where human activity can cause high losses of eggs and chicks. Murre chicks leave the nest site to go to sea at only c. 21 days post-hatch, when they are only 20% of adult mass. The murre colonies most damaged by the spill and slowest to recover are located in the Barren Islands, site of a pilot project to determine if energetics diet can be successfully collected (Appendix 10; Appendix 11).

Marbled murrelet nests are usually located high in mature conifers and are very difficult to locate. Most nest visits by parents provisioning young occur at night, so monitoring chick diets is highly problematic.

Guillemots are the most neritic members of the marine bird family Alcidae (i.e., murres, puffins, and auks), and like the other members of the family, capture prey during pursuit-dives. Pigeon guillemots are well-suited for monitoring forage fish availability for several reasons: (1) they are a common and widespread seabird species breeding in Prince William Sound (Sowls et al. 1978); (2) they primarily forage within 5 km of the nest site (Drent 1965); (3) unlike most seabird species, they do not breed in large, dense colonies; (4) they raise their young almost entirely on fish; (5) they prey on a wide variety of fishes, including schooling forage fish (e.g., sand lance, herring, smelt) and subtidal/nearshore demersal fish (blennies, sculpins; Drent 1965; Kuletz 1983); (6) the one- or two-chick broods are fed in the nest until the young reach adult body size. In addition, there is strong evidence that most guillemot pairs breeding at Naked Island within the spill area have specialized on schooling forage fish during the chick-rearing period, and that these pairs fail to raise young when forage fish are not available (Kuletz 1983). Guillemots carry whole fish in their bills to the nest-site crevice to feed their young. Thus individual prey items can be identified, weighed, measured, and collected for composition analyses.

Black-legged kittiwakes also breed abundantly in the spill area and rely largely on forage fish during reproduction. Unlike guillemots, kittiwakes are efficient fliers, forage at considerable distances from the nest, and capture prey at or near the surface. Although kittiwakes are highly colonial, cliff-nesting seabirds, they construct nests and can be readily studied at the breeding colony without causing substantial egg loss and chick mortality. Several breeding colonies of black-legged kittiwakes in PWS are easily accessible so that chicks can be weighed regularly without resorting to technical climbing (D. Irons, pers. comm.). Diets fed to kittiwake chicks in PWS consist primarily of schooling forage fish (i.e., sand lance, herring, juvenile walleye pollock), but when forage fish are scarce, euphausiids may be substituted. Like guillemots, kittiwakes can raise one- or two-chick broods, and chicks remain in the nest until nearly adult size. Together with pigeon guillemots, black-legged kittiwakes are excellent bioindicators of the distribution and abundance of preferred forage fish in PWS.

In addition to the two main species, the study will undertake pilot projects on puffins in PWS and the Barren Islands and on murres and kittiwakes in the Barren Islands (Appendices 11, 12).

The proposed research is the first focused study to investigate the effects of diet composition on reproductive energetics and productivity of piscivorous seabirds in PWS. The research will result in a fundamental advance in our understanding of the significance of prey composition for seabird reproduction, as well as for other seabirds and marine mammals that breed in PWS. The research will also provide new information relevant to several additional areas of study: (1) comparative biochemical composition and physiological condition of forage fishes, (2) factors such as age class, sex, size, and reproductive status as they influence the nutritional quality of forage fishes, (3) responses of breeding seabirds to shifts in prey availability, and (4) the energetic consequences of foraging on different prey with differing energy content. This research will be the first to (1) measure the nutritional quality of various forage fishes used by breeding seabirds in PWS, (2) use data on diet composition and provisioning rates to construct energetics models of chick growth and survival, and (3) monitor fat deposition rates of individual seabird chicks on differing dietary regimes by repeated, noninvasive analysis. In addition, the results will have broader implications for our understanding of dietary constraints on reproductive success in other piscivorous seabirds damaged by the spill, such as marbled murrelet and the cormorant species, and will enhance our understanding of the adaptive significance of prey preferences in these seabirds. These results are crucial for understanding the factors constraining recovery of marine birds and mammals damaged by the spill.

Objectives

The overall objective of the proposed research is to determine the energy content and nutritional value of various forage fishes used by seabirds breeding in PWS/GOA, and to relate differences in prey quality and availability to reproductive success and physiological condition of breeding adults. The proposed research will emphasize pigeon guillemots and black-legged kittiwakes for practical reasons, but prey composition and quality will be evaluated for common murres, marbled murrelets, and tufted puffins as data and samples permit. Specific objectives are enumerated below:

1. To determine the nutritional quality of various forage fish species consumed by seabirds in the EVOS area as a function of size, sex, age class, and reproductive status, including:
    a) lipid content
    b) water content
    c) ash-free lean dry matter (protein) content
    d) energy density (kJ/g fresh mass)
    e) lipid composition (triglyceride, wax ester, mono- and diglyceride, free fatty acid, phospholipid)

2. To determine dietary parameters of pigeon guillemot, common murre, tufted puffin, and black-legged kittiwake chicks in PWS, including:
    a) provisioning rate (meal size X delivery rate)
    b) taxonomic composition of the diet
    c) biochemical composition of the diet
    d) energy density of the diet

3. To determine the relationship between diet and the growth, development, and survival of seabird nestlings. Variables measured will include:
    a) growth rates of total body mass, lean body mass, and total body fat
    b) rates and patterns of flight feather development
    c) fledgling body mass and fat reserves

d) fledging age

4. To determine the contribution of specific forage fish resources to the overall productivity of seabird breeding pairs, including:
   a) body composition (physiological condition) of parents raising chicks
   b) gross foraging efficiency of parents
   c) conversion efficiency of food to biomass in chicks
   d) net production efficiency of the parent/offspring unit

B. Methods

The proposed research approach utilizes a combination of sample/data collection in the field (in conjunction with other APEX components in PWS) and laboratory analyses. Sample collection and field data collection will be conducted concurrently during the 1995-1998 breeding seasons at two guillemot and two kittiwake colonies in PWS. A minimum of 30 active and accessible nests of each species will be located and marked prior to hatching at each of the study colonies during the four breeding seasons. These nests will be closely-monitored until the young fledge or the nesting attempt fails.

Fresh samples of forage fishes used by guillemots will be collected for proximate analysis using three techniques: (1) temporarily placing "neckties" on guillemot chicks to prevent them from swallowing prey delivered by parents and retrieving samples from chicks, (2) temporarily placing obstructions in the entrance of guillemot nest crevices immediately after arrival of an adult with a chick meal and retrieving samples from adults, and (3) capturing adults carrying forage fish in noose traps as they approach the nest and retrieving samples from adults. Supplemental samples of guillemot forage fishes will be collected using minnow traps deployed in guillemot foraging areas and by netting specimens at low tide.

Kittiwakes transport chick meals in the stomach and esophagus, so chick diet samples will consist of semi-digested food. Kittiwake meal samples are normally collected when chicks regurgitate during routine weighing and measuring. Fresh specimens of forage fishes used by kittiwakes will be provided from at-sea trawls (Appendix 3).

Fresh fish samples and kittiwake regurgitations will be weighed (± 0.1 g) in the field and immediately frozen in small, propane-powered freezers that will be maintained at each of the four study sites. Samples will be shipped frozen to my laboratory at the University of Alaska Fairbanks, where they will be kept frozen until proximate analysis. In the lab, forage fish specimens will be reweighed (± 0.1 mg), identified to species, aged, sexed, measured, and reproductive status (gravid, recently spawned, nonreproductive) determined.

Kittiwake regurgitations will be sorted into prey classes to the extent feasible, but otherwise handled as with fresh prey samples. Forage fish specimens will be dried to constant mass in a convection oven at 60°C to determine water content. Lipid content of a subsample of dried forage fish will be determined by solvent extraction using a soxhlet apparatus (Soxtec HT-12) and hexane/IPA 7:2 (v:v) as the solvent system. Lean dry fish samples will then be ashed in a muffle furnace at 550°C in order to calculate ash-free lean dry mass by subtraction.

A subsample of dried forage fish samples will be combusted in a bomb calorimeter to determine energy density. Energy content of chick diets will be calculated from both the energy densities determined by bomb calorimetry and the composition (water, lipid, ash-free lean dry matter, and ash) of forage fish along with published energy equivalents of these fractions (Roby 1991).

The lipid composition of forage fish (percentage wax esters, triglycerides, mono- and diglycerides, free fatty acids, and phospholipids of total lipids) will be determined by extracting total lipids from a subsample of fresh-frozen forage fish using the Bligh and Dyer (1959) technique. Extracted lipids will then be separated into the various lipid classes and quantitated using TLC/FID analysis procedures on a Mark IV Iatroscan. This procedure will allow us to determine the percentage of total lipids in forage fish that are in the form of wax esters and other refractory (hard to digest) lipid classes (Roby et al. 1986). My laboratory is equipped with all the instrumentation required for proximate analysis of samples, including a Soxtec HT-12 soxhlet apparatus; an Iatroscan TLC/FID system; and a Parr automated adiabatic bomb calorimeter.

Chick provisioning rates for pigeon guillemots and black-legged kittiwakes in PWS will be determined by monitoring active nests to determine meal delivery rates throughout the 24 h period. Average meal size, taxonomic and biochemical composition of the diet, and average energy density of chick meals will be determined as part of analyses of diet samples collected from guillemot and kittiwake chicks.

Known-age chicks will be weighed and measured regularly to determine individual growth rates throughout the nestling period. Total body fat of chicks at 20 and 30 days post-hatch will be determined by noninvasive (nondestructive) measurement of total body electrical conductivity (Walsberg 1988, Roby 1991). Fat reserves of chicks will be measured in the field using total body electrical conductivity (TOBEC) fat analyzers (SA-3000 Small Animal Body Composition Analyzer from EM-SCAN, Inc., Springfield, IL) that I currently have in my lab.

The TOBEC method relies on the major difference in conductivity between lipids and other body constituents to estimate total lean body mass (Pethig 1979; Van Loan and Mayclin 1987). The difference between total body mass, as determined by weighing, and lean body mass, estimated by TOBEC, provides an estimate of total body fat. A major advantage of the technique is that measurements can be obtained rapidly and repeatedly without harm to the subject. Also, validation studies to date indicate that accuracy is high ($r^2 = .996$) (Bracco et al. 1983, Walsberg 1988, Roby 1991b). The SA-3000 TOBEC analyzer can be used in the field and powered from a 12 volt battery, so chicks can be measured for TOBEC and returned to their nest in a matter of minutes. Body mass, primary feather development, and total body fat measurements will be used to develop a condition index for each chick at 20 and 30 days post-hatch.

The effects of diet composition on the physiological condition of breeding adults will be monitored using a combination of direct and indirect methods. Attentiveness of adults will be monitored during the incubation period. Adults will be captured on the nest early in the chick-rearing period and body composition determined nondestructively by TOBEC analysis. Frequency of chick meal delivery and meal size will be determined during the chick-rearing period as part of diet composition studies.

Data on chick age-specific body mass, wing chord, and primary feather length will be separated by year and colony for each species, and fit to Gompertz sigmoidal growth models. Growth constants (K), inflection points (I), and asymptotes (A) of fitted curves will be statistically analyzed for significant differences among years and colonies. Fledgling fat reserves estimated from TOBEC analysis will be compared among colonies and years. Gross foraging efficiency of adults will be calculated from daily energy expenditure by the following equation:

$$([M \cdot F \cdot D] + DEE) / DEE = GFE,$$

where M is average chick meal mass in grams, F is average frequency of meal delivery in meals day^{-1} $parent^{-1}$, D is energy density of chick meals in kJ/gram, DEE is adult daily energy expenditure in kJ/day, and GFE is adult gross foraging efficiency in kJ consumed/kJ expended. Daily energy expenditures of pigeon guillemots, black-legged kittiwakes, and common murres have been measured previously using the doubly-labeled water technique and are available in the published literature (Birt-Friesen et al. 1990).

Net production efficiency of chicks as a function of age will be calculated by regressing the change in body mass over a 24 h period against the mass of food consumed during the period, as determined by periodic weighing. Comparison of food conversion efficiency of chicks will provide an estimate of the relative energetic efficiency of diets composed of various forage fishes. The net production efficiency of the parent/offspring unit will be calculated for each diet and each year for both species using the equation:

$$CFCE / ([DEE \cdot 2] + [M \cdot F \cdot D]) = TNPE,$$

where CFCE is chick food conversion efficiency in grams of body mass gained per gram food ingested, TNPE is the total net production efficiency of the parent/offspring unit in grams gained by chicks per kJ of energy expended by both parents, and other variables are as described above.

Schedule

Field work in Prince William Sound will be conducted during the 1995, 1996 1997, and 1998 breeding seasons. Data collection during four field seasons will be necessary in order to provide minimal information on interannual variation in diet composition and reproductive success.

Guillemots and kittiwakes normally lay eggs from late May to late June and raise their young during July and August. Field crews will be set up at each of the four colonies in mid-May. Active, accessible nests of the two study species will be located and marked during late May and June, prior to hatching. Marked nests will be checked daily during the hatching period (if possible) to determine hatching date, and, in the case of two-chick broods, chicks will be banded soon after hatching so that individual growth rates can be monitored throughout the nestling period. Samples of chick meals and measurements of chick feeding rates will be collected throughout the nestling period. Chicks will be monitored throughout the nestling period in order to determine growth rates, fledgling mass, fledging age, and survival until fledging.

Following the field season, chick meals will be analyzed in the lab in order to determine the taxonomic and biochemical composition of guillemot and kittiwake diets and their relationship to chick growth and survival. These analyses will be completed before the next field season in order to determine the results prior to collecting additional samples from the field. A draft annual report for this component will be prepared in February and a final report will be submitted in March for incorporation into a synthesis Annual Report for the APEX Project in June.

Following the analysis of samples collected during the 1998 field season, data collected during the four field seasons will be analyzed for relationships between diet composition and reproductive success by May 1999. The results of these analyses of diet composition and its relation to productivity and chick growth will be prepared in manuscript form and submitted by the end of FY 1999.

Technical Support

Laboratory analyses of the biochemical composition and energy content of forage fishes will be conducted in the laboratory of the PI. No analyses will be subcontracted to other laboratories. No new laboratory equipment will need to be purchased for the proposed research with funds provided by the grant. A laboratory technician will be hired to help the PI and graduate research assistant with processing chick meals and diet samples, and with performing of routine laboratory analyses.

Location

The proposed field work will be conducted in PWS during FY 1995, with pilot projects in adjacent parts of the oil spill area. PWS supports accessible breeding populations of guillemots, puffins, and kittiwakes that are more than adequate for the proposed research. Field work on guillemots will be conducted at breeding colonies on Naked Island and Jackpot Island. Naked Island is surrounded by a broad shallow shelf, whereas Jackpot Island is in deep water. Consequently, the foraging habitats available within foraging distance of the two colonies are markedly different.

Approximately 500 pigeon guillemots nest along the shores of Naked Island (Sanger and Cody 1993), as well as smaller numbers of marbled murrelets and tufted puffins. The Naked Island base camp would offer an ideal base for field studies on guillemots (D. Irons, pers. comm.), and Naked Island supports the highest breeding densities of guillemots in PWS (Sanger and Cody 1993). In addition, Naked Island has been the site of long term studies since the early 1980s by the U. S. Fish and Wildlife Service on factors affecting reproductive success of pigeon guillemots in PWS (Kuletz 1983). Jackpot Island supports about 50 breeding pairs of guillemots that are nesting at extremely high densities and in unusually accessible nests (G. Sanger, D. L. Hayes, pers. comm.). Additional guillemot nests will be located and monitored adjacent to Jackpot Island in Icy Bay. Both Naked Island and Jackpot Island were the site of intensive studies of guillemot nesting success during the 1994 field season and have been selected for continued studies (BPD 95163F) as part of the APEX Project (D. L. Hayes, pers. comm.).

Field work on kittiwakes in PWS will be conducted at two breeding colonies, one at Shoup Bay (off Valdez Arm) which supports approximately 400 breeding pairs of black-legged kittiwakes and another at Eleanor Island (adjacent to Naked Island) which supports about 550 breeding pairs. The Shoup Bay colony is the site of continuing long-term studies of kittiwake nesting ecology in PWS by the Fish and Wildlife Service and Eleanor Island has been selected as a site for intensive study for comparison (D. Irons, pers. comm.). Both colonies include large numbers of readily accessible nests.

Pilot projects collecting nesting and diet parameters for tufted puffins will be conducted in the Barren Island and in PWS (Appendix 11); similar data for common murres and kittiwakes will also be collected from the Barrens (Appendix 10)

The at-sea foraging distribution of pigeon guillemots near Naked Island and Jackpot Island has been the subject of previous study (Sanger and Cody 1993), as has the species composition of the diet (Kuletz 1983; D. L. Hayes, unpubl. data). Kittiwake foraging distribution and reproductive success has been monitored at the Shoup Bay colony for several years (D. Irons, pers. comm.). In addition, component 95163B (Appendix 6) will provide data on the distribution of foraging kittiwakes and guillemots in the vicinity of the four study colonies during the chick-rearing period. A field camp operated by the Fish and Wildlife Service is available for field workers on Naked Island and at Shoup Bay and is within walking distance or short boat ride of colonies where adequate numbers of accessible guillemot and kittiwake nests are available.

PROJECT IMPLEMENTATION

The proposed research will be implemented by the University of Alaska Fairbanks, closely coordinated with and in cooperation with U.S. Fish and Wildlife Service biologists with expertise on the proposed study species in the proposed study area. The PI (Daniel D. Roby) has extensive experience with studies of the reproductive energetics of high latitude seabirds and the relationship between diet composition and productivity. The PI currently has in his laboratory the analytical equipment necessary to accomplish the proposed laboratory analyses and is familiar with the relevant analytical procedures. To the PI's knowledge, the expertise and equipment necessary for the proposed research are not available within the federal and state agencies that comprise the Trustees Council. The PI will be assisted by a Graduate Research Assistant (Ph.D. candidate), field technicians, and undergraduate field assistants who will be carefully selected from the applicant pool as qualified to participate in the proposed research.

COORDINATION OF INTEGRATED RESEARCH EFFORT

The research described in this proposal is a component within the APEX Project (95163) and dove-tails nicely with new and continuing research to assess factors limiting recovery of seabird populations damaged by EVOS. It is also relevant to efforts toward developing seabird models as upper trophic level sentinels of changes in the availability of forage fishes, such as sand lance, juvenile pollock, herring, capelin, and smelt.

The proposed research approach utilizes prey composition, reproduction rates, and energetics models to help identify and quantify the present level of forage fish availability within the PWS ecosystem. This approach is necessary because evaluation of the stocks of various forage fishes is extremely complex due to temporal and spatial variability and unpredictability in the distribution of forage fishes in PWS.

Studies of foraging, reproduction, and population recovery following the EVOS are on-going for pigeon guillemots, common murres, and marbled murrelets. Black-legged kittiwakes are currently being used as indicators of ecosystem function and health within PWS, and tufted puffins as proposed as samplers of forage fishes in PWS. This proposal complements and enhances other proposed studies on pigeon guillemots, puffins, murres, and black-legged kittiwakes without duplication of effort. The PI on the present proposal has been and will continue to work closely with Dr. David Irons (PI on component 95163E: Appendix 7) and D. Lindsey Hayes (PI on component 95163F: Appendix 8) in developing protocols for collecting field data on kittiwakes and guillemots so as to minimize project cost and maximize data acquisition.

All these subprojects require information on chick feeding rates, chick meal size, and taxonomic composition of chick diets in order to meet their objectives. Collecting these data is extremely labor intensive and the cooperation of these three components in collecting these data will greatly enhance sample sizes. The three components also require data on chick growth rates (body mass and flight feather development), nestling survival, body composition and mass of fledglings, and fledging age. Again, cooperation and coordination between these three components will greatly enhance sample sizes and the power of statistical tests and inferences. The field crews for the three components will work together to ensure that data collection methods and procedures are consistent. In addition, components 95163E (Appendix 7) and 95163F (Appendix 8) will assist this component in its efforts to collect food items for analysis of biochemical composition of the diet and to collect data on the body composition of adults and chicks.

Additional cooperators include Dr. Scott Hatch (PI for component 95163D: Appendix 11). Dr. Hatch's component will collect forage fish and breeding parameters from breeding tufted puffins on Naked Island and nearby Smith and Little Smith islands in PWS and from West Amatuli in the Barren Islands. Considerable overlap between diets of tufted puffins, black-legged kittiwakes, and pigeon guillemots is expected, so forage fish samples collected as part of this component will be extremely useful for determining the biochemical composition and energy density of guillemot and kittiwake diets.

K. Kuletz (PI for Project 95031, "Reproductive Success as a Factor Affecting Recovery of Murrelets in PWS") will be working on Naked Island and may collect some data on diet composition of breeding marbled murrelets incidental to her studies. These data will be extremely useful for comparison with diet composition of guillemots and kittiwakes.

Component 95163H (Appendix 5) will assess the quality of various forage fishes that are major prey for marine birds and mammals. Dr. Worthy's study will use fish specimens collected during shipboard surveys throughout the year to provide background data for the entire APEX Project, including this component. Comparison between the proximate composition of forage fishes collected at sea and those fed to seabird nestlings will provide a valuable means of assessing the role of prey selection for enhancing the quality of seabird diets. Sample treatment and proximate analysis procedures will be consistent between the two components, so that the results are comparable. These two projects will be coordinated so as not to duplicate efforts to obtain data on the proximate composition of forage fishes used by guillemots and kittiwakes during the breeding season.

In order to understand dietary factors responsible for poor reproductive performance of seabirds in PWS, it is essential to conduct simultaneous shipboard work (hydroacoustic surveys in conjunction with net sampling) to assess the distribution, abundance, and species composition of forage fishes in seabird foraging areas. That research was funded by the Trustees Council (Project 94163) and the continuation of this project (Appendix 3) will be invaluable for interpretation of data on diets collected as part of the present proposal. In addition, the integrated studies that comprise the SEA Program (95320A-Y) will provide an important foundation for understanding ecosystem function in PWS as it relates to seabird/forage fish interactions.

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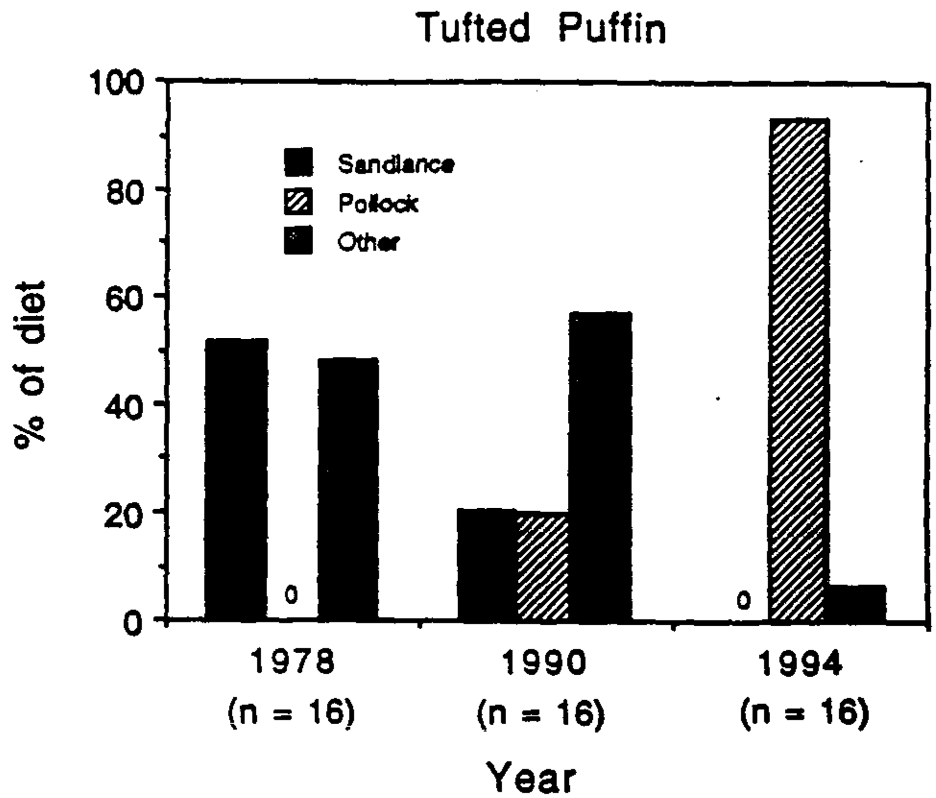
FIGURE 1.

Diets of tufted puffins and rhinoceros auklets at Middleton Island: 1978, 1990, and 1994 (S. Hatch, unpubl. data).

Trends in Puffin Nestling Diets - Middleton Island



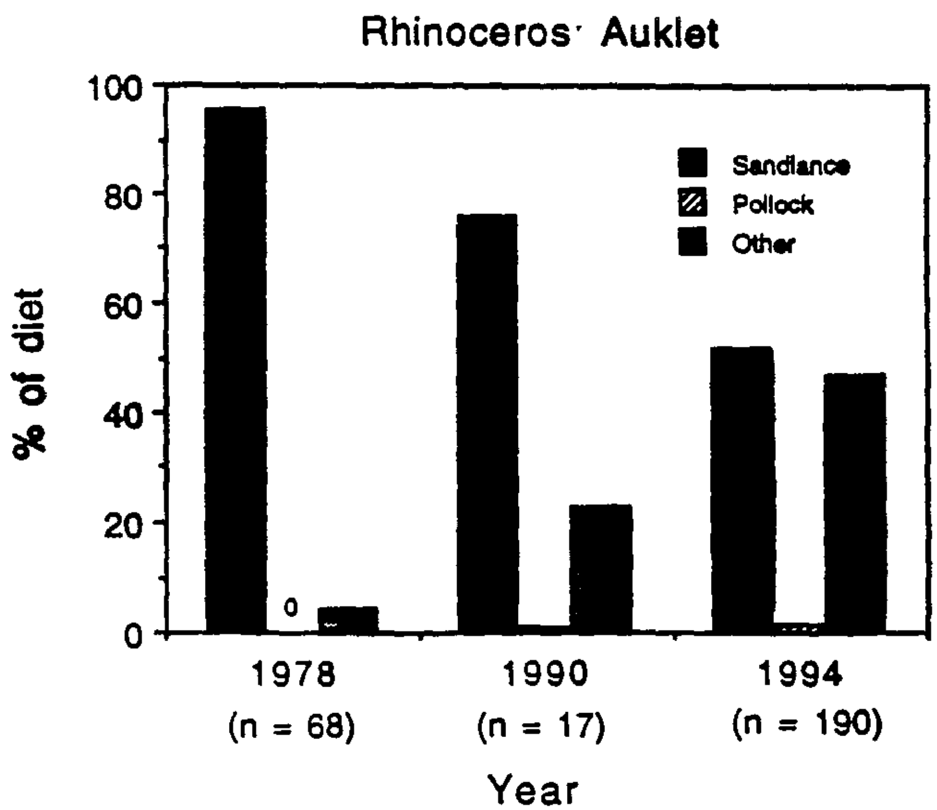


FIGURE 2.

Change in frequency of occurrence of prey species between 1975 - 1978 and 1988 - 1991 for five seabird species in the Gulf of Alaska (from Piatt and Anderson 1995)

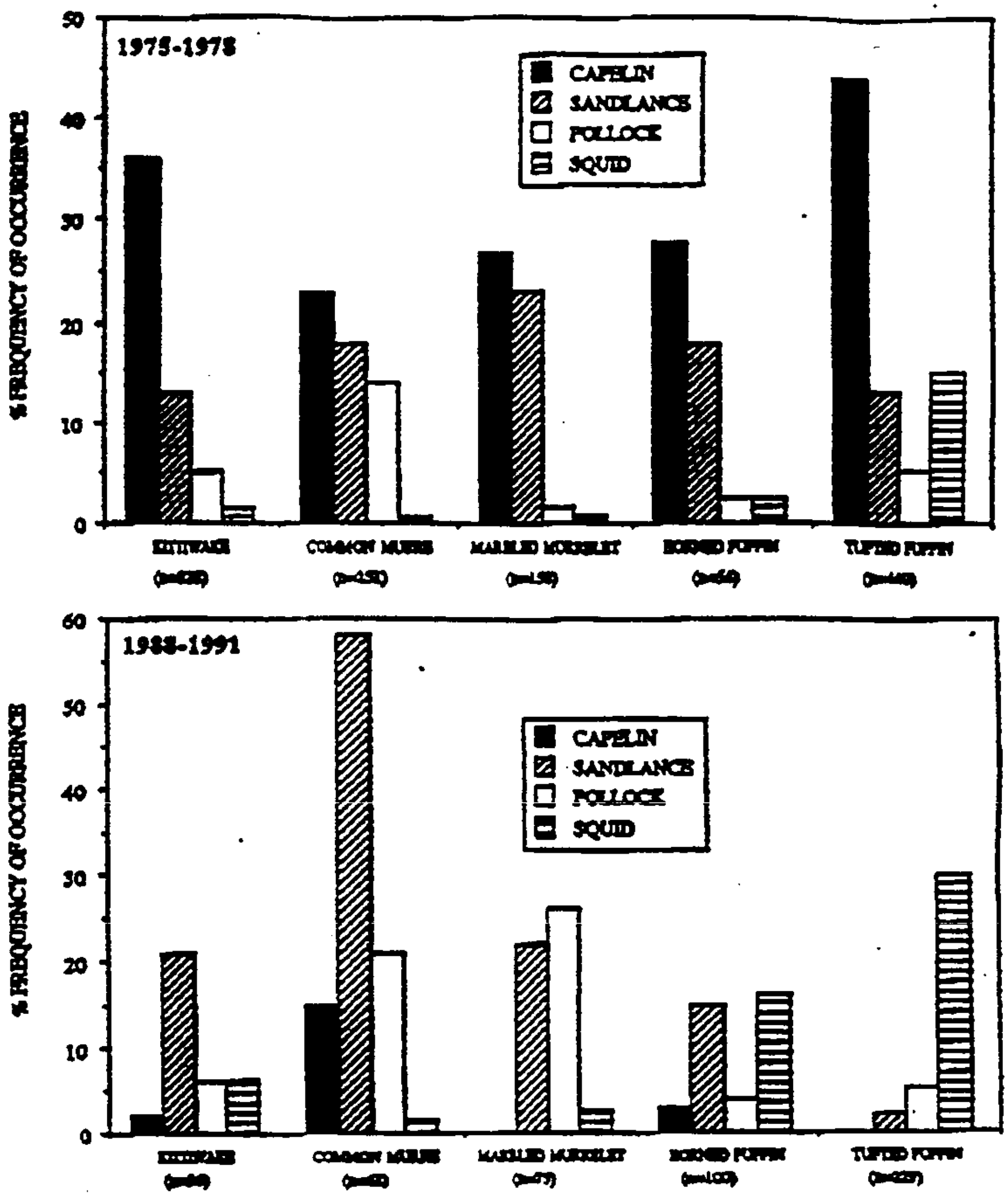

1975-1978
CAPELIN
SANDLANCE
POLLOCK
SQUID
% FREQUENCY OF OCCURRENCE
0
10
20
30
40
50
1988-1991
CAPELIN
SANDLANCE
POLLOCK
SQUID
% FREQUENCY OF OCCURRENCE
0
10
20
30
40
50
60

FIGURE 3.

Initial analysis of prey utilization by 11 forage fish species as a percentage of prey group wet-weight (Sturdevant 1995)

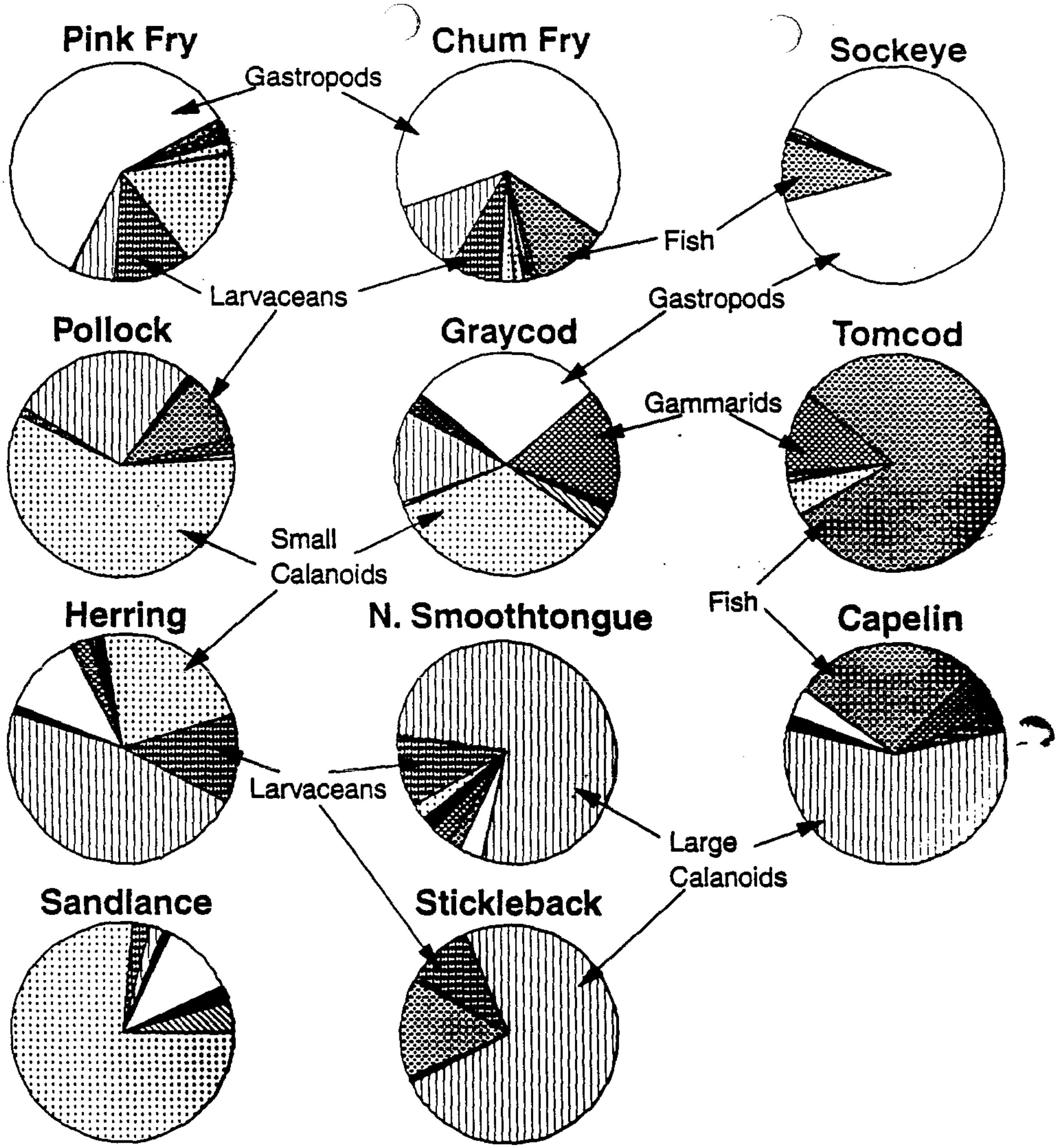
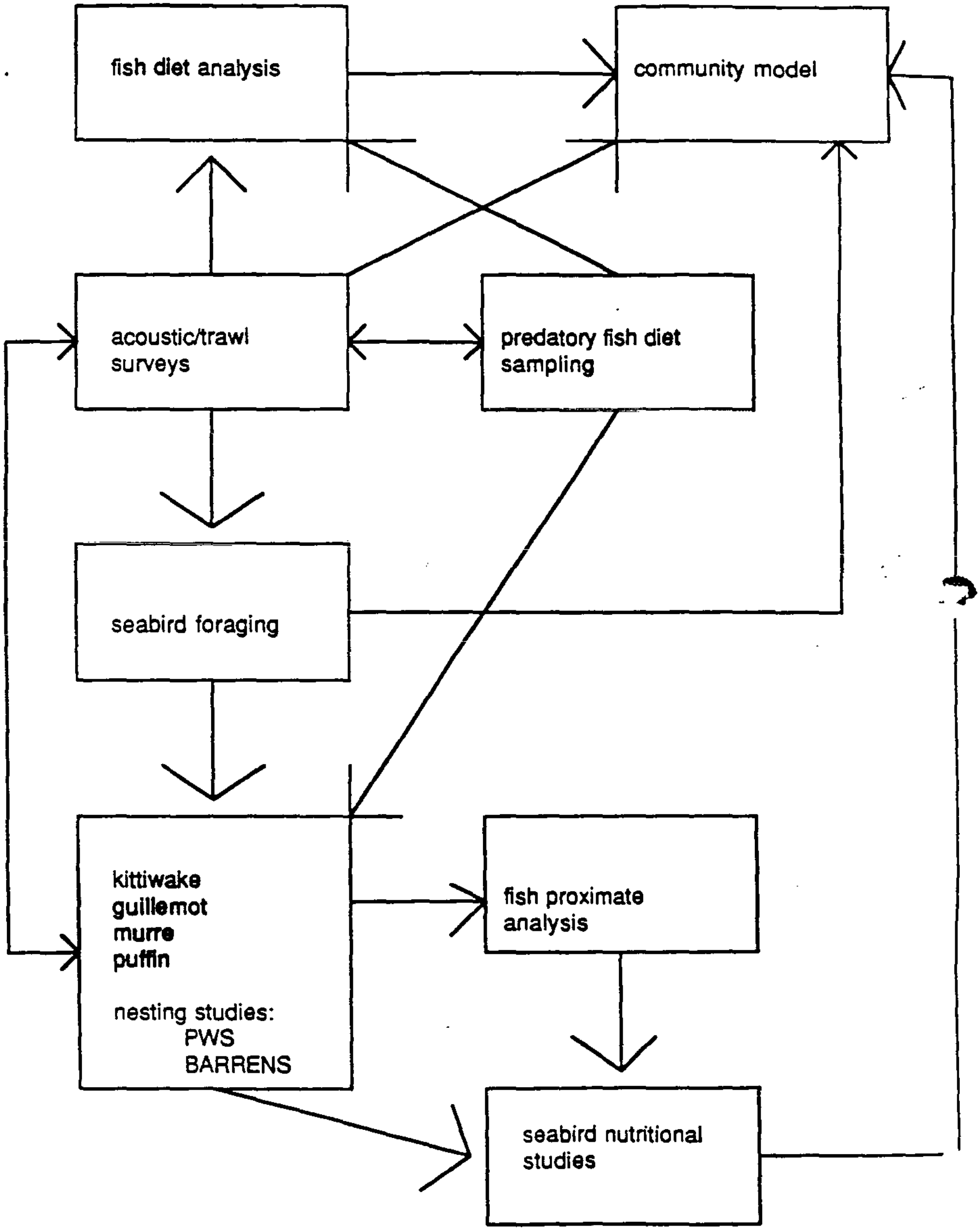


Figure 1. Prey utilization by 11 forage fish species as a percentage of prey group wet weight. Fish were collected from late April to mid-June, 1994. Minor prey not indicated included cladocerans, barnacle nauplii and cyprids, bivalve larvae, chaetognaths, cyphonautes larvae, euphausiids, harpacticoids, hyperiids, insects, invertebrate eggs, polychaetes and decapod zoeae.

FIGURE 4.

Data flow between projects in the APEX Program.

INFORMATION FLOW IN THE APEX PROJECT



APEX 107

FIGURE 5.

Black-legged kittiwake colonies in Prince William Sound

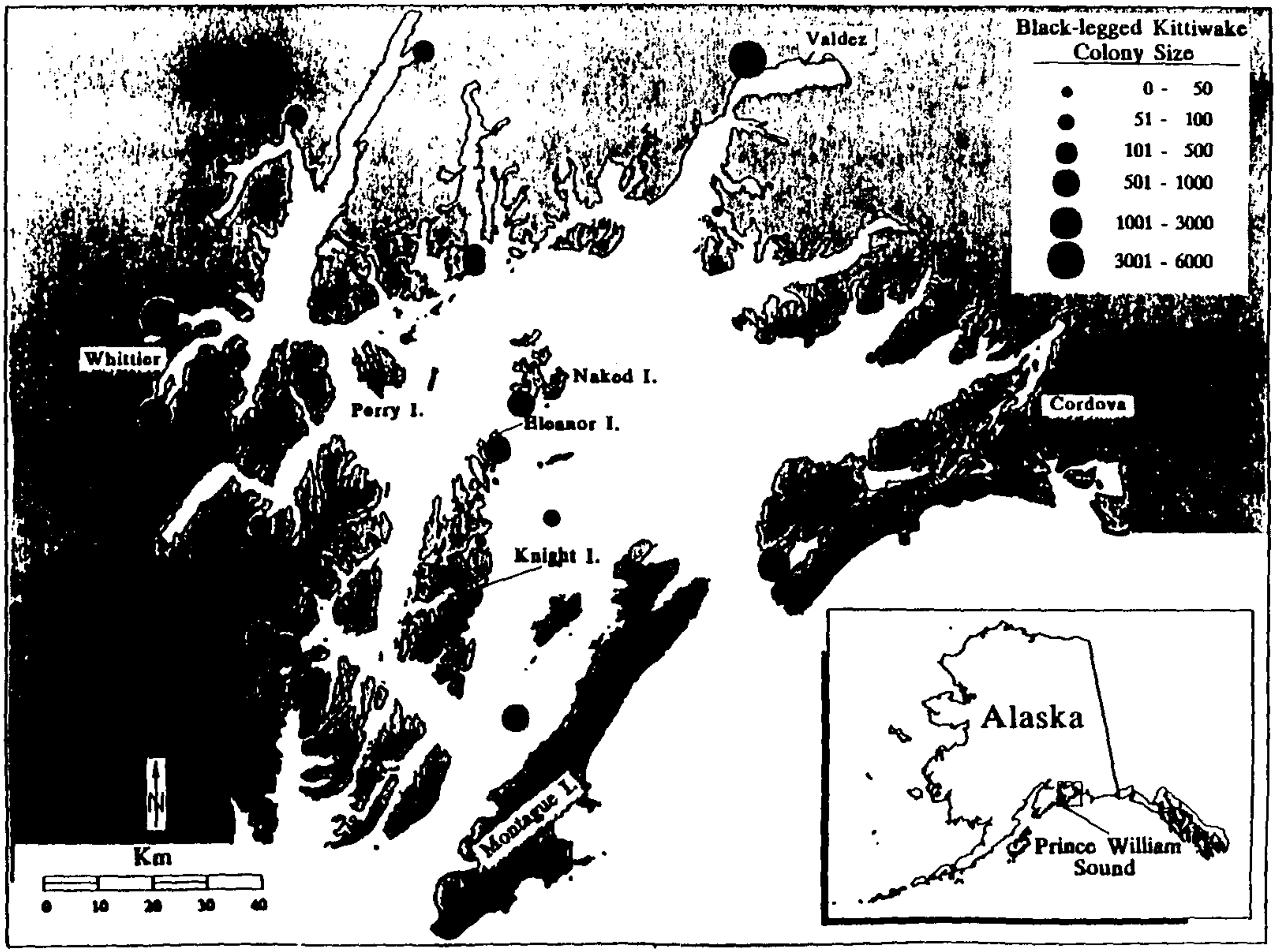

Black-legged Kittiwake
Colony Size
0 - 50
51 - 100
101 - 500
501 - 1000
1001 - 3000
3001 - 6000
Valdez
Whittier
Perry I.
Nakod I.
Eleanor I.
Knight I.
Cordova
Montague I.
N
Km
0 10 20 30 40
Alaska
Prince William
Sound

FIGURE 6.

Five-kilometer foraging ranges for black-legged kittiwake colonies in Prince William Sound.

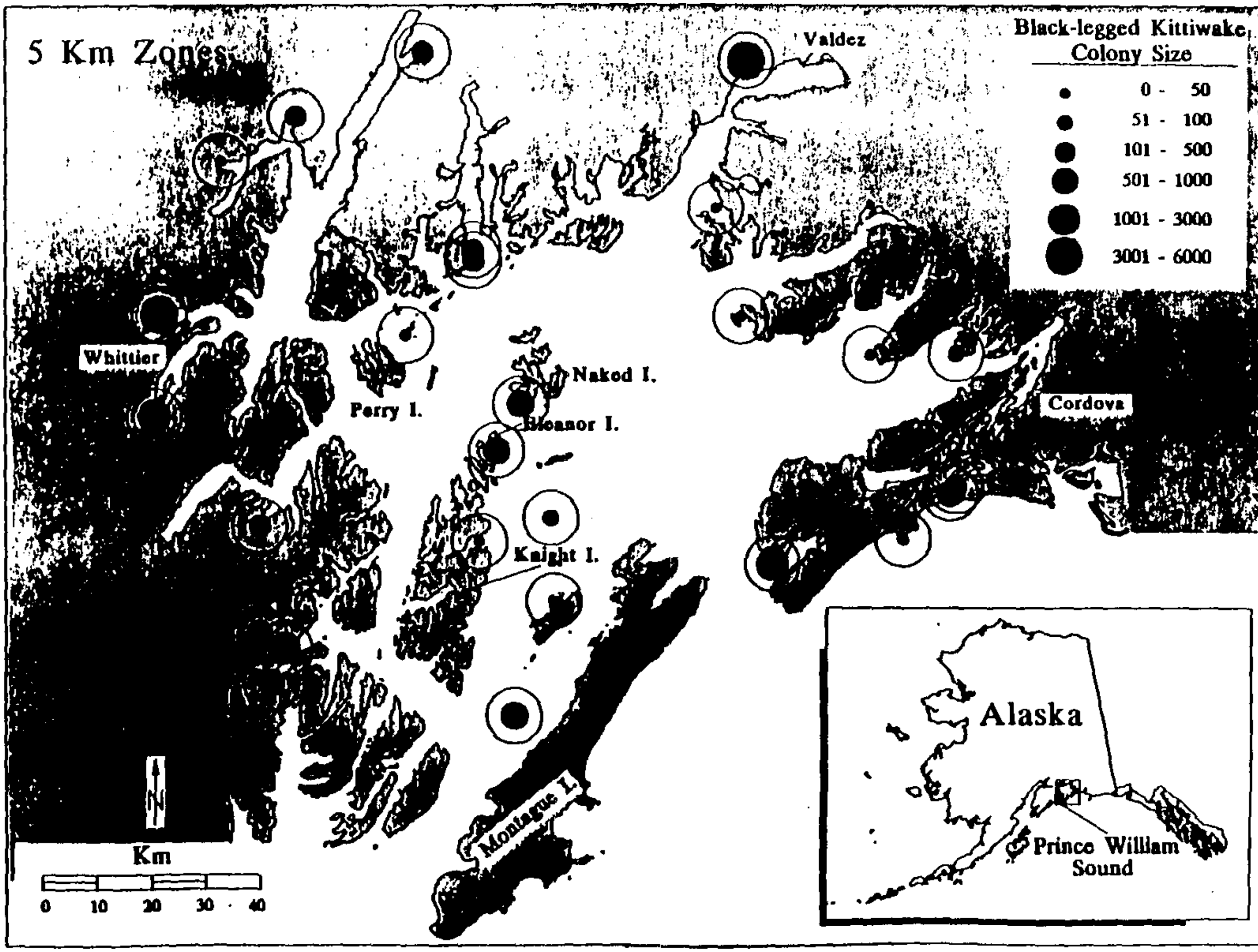
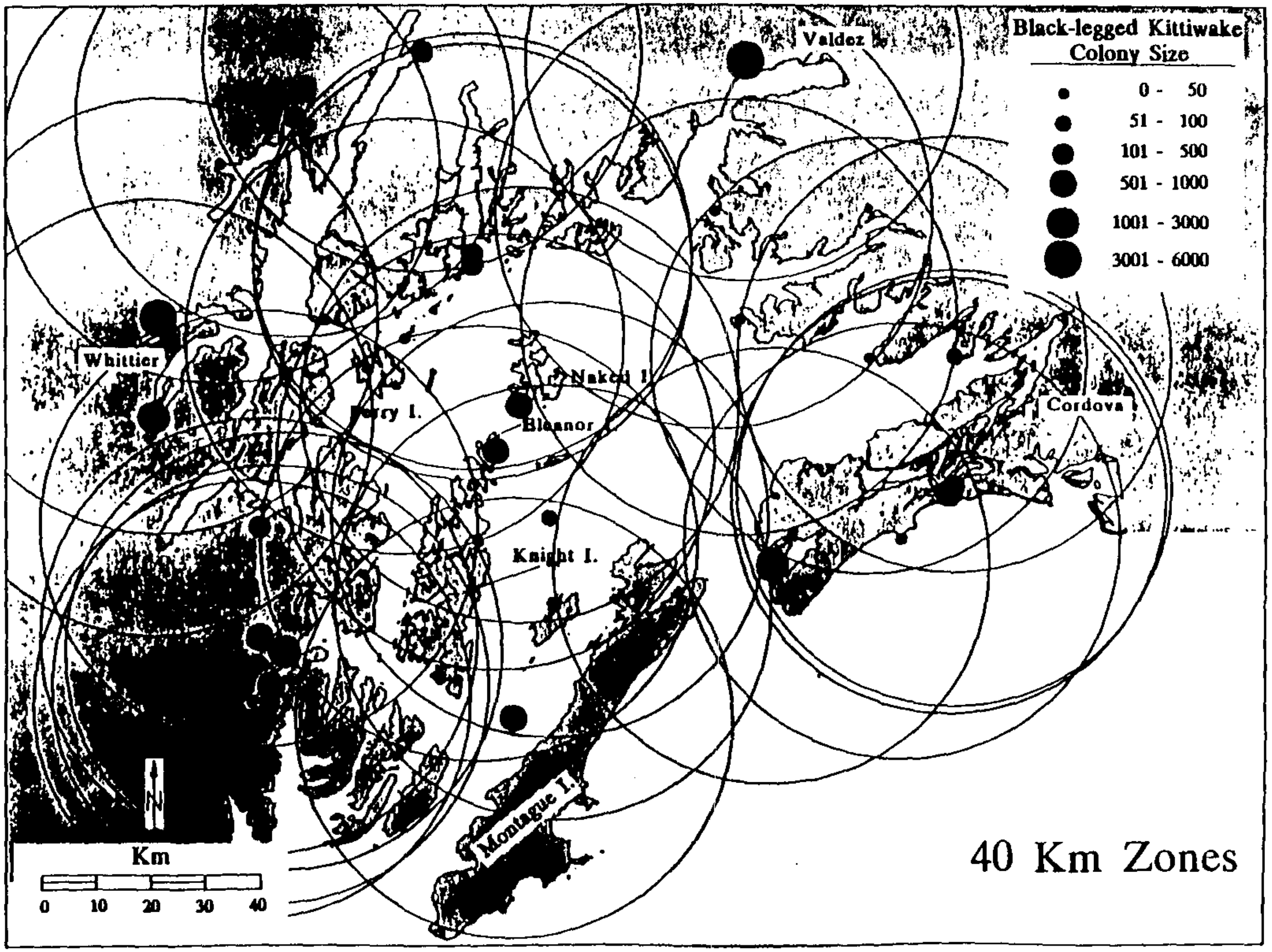

5 Km Zones
Black-legged Kittiwake
Colony Size
0 - 50
51 - 100
101 - 500
501 - 1000
1001 - 3000
3001 - 6000
Valdez
Whittier
Perry I.
Naked I.
Eleanor I.
Knight I.
Cordova
Montague I.
Km
0 10 20 30 40
Alaska
Prince William
Sound

FIGURE 7.

Forty-kilometer foraging ranges for black-legged kittiwake colonies in Prince William Sound.


Black-legged Kittiwake Colony Size
0 - 50
51 - 100
101 - 500
501 - 1000
1001 - 3000
3001 - 6000
Valdez
Whittier
Naked I.
Perry I.
Eleanor
Knight I.
Cordova
Montague I.
N
Km
0
10
20
30
40
40 Km Zones

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1994 - September 30, 1995

Project Description: The primary objective in the 1994 study was to test techniques and collect data in PWS to aid in designing sampling methods for subsequent years. The researchers conducted seabird surveys simultaneously with hydroacoustic surveys to provide information on the presence of fish in the water. Groups of seabirds were found to be associated with schools of forage fish near the water's surface. The locations of forage fish appear to be influenced by ocean current, underwater geographical features, and the proximity of predators. In 1995 the Apex Predator Ecosystem Experiment (APEX) will include related monitoring and research of birds which prey on these small fish.

Budget Category:	1994 Project No. Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel	$0.0	$0.0	$432.0	$432.0	$750.7	
Travel	$0.0	$0.0	$53.9	$53.9	$85.5	
Contractual	$0.0	$0.0	$713.5	$713.5	$732.0	
Commodities	$0.0	$0.0	$123.5	$123.5	$99.0	
Equipment	$0.0	$0.0	$93.1	$93.1	$36.6	
Capital Outlay	$0.0	$0.0	$75.0	$75.0	$50.0	
Subtotal	$0.0	$0.0	$1,491.0	$1,491.0	$1,753.8	
General Administration	$0.0	$0.0	$95.8	$95.8	$144.9	
Project Total	$0.0	$0.0	$1,586.8	$1,586.8	$1,898.7	
Full-time Equivalents (F	0.0	0.0	11.6	11.6	13.0	

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
See Individual 3A Forms for Personnel Details				
Personnel Total	0.0	$0.0	0.0	$0.0

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

02/14/95

1995

Project Number: 95163A-L
Project Title: APEX
Agency:

FORM 2A
PROJECT
DETAIL

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1994 - September 30, 1995

Project Description: Recovery of apex predator populations in Prince William Sound depends upon restoration of available suitable forage. There exists very little information on forage species, and it has been recognized that efforts to restore populations of apex predators may fail if the role of forage species in the ecosystem is not determined. The project will be a multi-year study providing quantitative descriptions of the forage community in Prince William Sound and the functional role of forage fish species in the food web.

Budget Category:	1994 Project No. Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$5.0	$5.0	$40.0	
Travel		$0.0	$0.0	$0.0	$10.0	
Contractual		$0.0	$629.4	$629.4	$629.4	Contract's detailed budget attached.
Commodities		$0.0	$0.0	$0.0	$0.0	
Equipment		$0.0	$0.0	$0.0	$0.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$634.4	$634.4	$679.4	
General Administration		$0.0	$25.8	$25.8	$31.1	
Project Total	$0.0	$0.0	$660.2	$660.2	$710.5	
Full-time Equivalents (FTE)		0.0	0.2	0.2		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description		Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Intrm Program Manager	NOAA, GS-12			2.0	$5.0
	Personnel Total	0.0	$0.0	2.0	$5.0

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

1995

Project Number: 95163A
Project Title: APEX
Sub-Project: Forage Fish Assessment
Agency: NOAA

FORM 3A SUB-PROJECT DETAIL

P 2/28/96 1:42 PM

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:	Reprt/Intr	Remaining
Repl		$0.0
Intrm		
Travel Total	$0.0	$0.0

Contractual:	Reprt/Intr	Remaining
Repl Contract for forage fish surveys, fish biology work, data analysis and reporting.		$629.4
Contractual Total	$0.0	$629.4

06/01/94

1995

Project Number: 95163A
Project Title: APEX
Sub-Project: Forage Fish Assessment
Agency: NOAA

FORM 3B
SUB-PROJECT
DETAIL

Commodities:	Reprt/Intr	Remaining
Rept		$0.0
Commodities Total	$0.0	$0.0

Equipment:	Reprt/Intr	Remaining
Rept		$0.0
Equipment Total	$0.0	$0.0

06/01/94

1995

Project Number: 95163A
Project Title: APEX
Sub-Project: Forage Fish Assessment
Agency: NOAA

FORM 3B
SUB-
PROJECT
DETAIL

P 2/28/95 1 42 PM

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: By conduction long term data collection on seabird activity while simultaneously monitoring forage fish abundance and distribution we will determine seabirds' relationship to foraging resources, how seabirds' foraging behavior responds to change in the forage resource, and if forage availability is limiting population recovery.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$77.4	$77.4	$105.0	USFWS is considering reducing admin.
Travel		$0.0	$8.8	$8.8	$16.2	overhead charges in this component
Contractual		$0.0	$5.2	$5.2	$8.8	
Commodities		$0.0	$1.3	$1.3	$5.2	
Equipment		$0.0	$7.7	$7.7	$1.3	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$100.4	$100.4	$136.5	
General Administration		$0.0	$12.0	$12.0	$16.4	
Project Total	$0.0	$0.0	$112.4	$112.4	$152.9	
Full-time Equivalents (FTE)		0.0	1.8	1.8		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description		Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Project Leader	GS-11			6.0	$29.4
Research Assistant	graduate student			5.0	$15.0
Bio. Tech.	GS-5			5.0	$12.0
Expediter	Wage grade 4, step 2			3.0	$10.0
Project Manager	GS-12			2.0	$11.0
Personnel Total		0.0	$0.0	21.0	$77.4

NEPA Cost: $0.0
*Oct 1, 1994 - Dec 31, 1994
**Jan 1, 1995 - Sep 30, 1995

06/01/94

1995

Project Number: 95163B
Project Title: APEX
Sub-project: Seabird/Forage Fish Interactions
Agency: USFWS

FORM 3A
SUB-PROJECT
DETAIL

P 2/28/95 1 42 PM

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1994 - September 30, 1995

Travel:		Reprt/Intr	Remaining
Rept	Anchorage to Whittier: 3 people, 6 trips @ $100/round trip		$1.8
	field per diem: 3 people, 100 days @ $3/day		$1.0
	Anchorage to Cordova/Valdez: travel for additional field personnel (eg., substitutes, resupply, supervisor)		$3.4
	Emergency travel (injuries, equipment repair or replacement)		$0.6
	Travel to scientific meetings to present study results		$2.0
	Travel Total	$0.0	$8.8

Contractual:			
Rept	Safety training for 3 people @ $830/person		$2.5
	Telephone services in office and in field		$0.7
	Film processing		$0.2
	Postage and freight		$0.4
	Publication page charges		$0.5
	Maintenance and cleaning of binoculars		$0.3
	Maintenance and cleaning of cameras		$0.1
	Emergency repair equipment		$0.5
	Contractual Total	$0.0	$5.2

1995

Project Number: 95163B
Project Title: APEX
Sub-project: Seabird/Forage Fish Interactions
Agency: USFWS

FORM 3B SUB-PROJECT DETAIL

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:		Reprt/Intr	Remaining
Rept	Scientific supplies (film, waterproof notebooks, guidebooks, charts)		$0.1
	Rain gear, rubber boots, and gloves for 3 people @ $200/person		$0.6
	Duplication costs		$0.4
	Office supplies (computer diskettes, paper, pens)		$0.2
	Commodities Total	$0.0	$1.3

Equipment:		Reprt/Intr	Remaining
Rept	Binoculars		$0.7
	Data entry system		$7.0
	Equipment Total	$0.0	$7.7

06/01/94

1995

Project Number: 95163B
Project Title: APEX
Sub-project: Seabird/Forage Fish Interactions
Agency: USFWS

FORM 3B SUB-PROJECT DETAIL

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: The "Diet Overlap of Forage Fish Species" sub-project is designed to understand the Prince William Sound food web and its effects on the injured species. The 1995 sampling program will be a continuation of the 1994 pilot project (94163) to determine diet overlap and prey selection among forage fish species.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$10.0	$10.0	$25.0	NOAA will donate 3 mos. of PI (GS-11) & 1 month of project manager (GS-13)
Travel		$0.0	$5.0	$5.0	$5.0	
Contractual		$0.0	$0.0	$0.0	$0.0	
Commodities		$0.0	$4.5	$4.5	$4.5	
Equipment		$0.0	$0.0	$0.0	$0.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$19.5	$19.5	$34.5	
General Administration		$0.0	$1.5	$1.5	$3.8	
Project Total	$0.0	$0.0	$21.0	$21.0	$38.3	
Full-time Equivalents (FTE)		0.0	0.3	0.3		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Principal Investigator, GS-~~11~~ 9			3.0	$10.0
Personnel Total	0.0	$0.0	3.0	$10.0

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

1995

Project Number: 95163C
Project Title: APEX
Sub-Project: Diet Overlap of Forage Fish
Agency: NOAA

FORM 3A SUB-PROJECT DETAIL

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:		Reprt/Intr	Remaining
Rept	Juneau/Cordova round trip x 10		$3.5
	Juneau/Anchorage round trip x 2		$1.0
	Juneau/Fairbanks round trip x 1		$0.5
	Travel Total	$0.0	$5.0

Contractual:			
Rept			$0.0
	Contractual Total	$0.0	$0.0

06/01/94

1995

Project Number: 95163C
Project Title: APEX
Sub-Project: Diet Overlap of Forage Fish
Agency: NOAA

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1995 EXXON VALDEZ TRUS . COUNCIL PROJECT BUDGET

October 1, 1994 - September 30, 1995

Commodities:	Reprt/Intr	Remaining
Rept sample bottles, formalin, and microscope work supplies		$4.5
Commodities Total	$0.0	$4.5

Equipment:		
Rept		$0.0
Equipment Total	$0.0	$0.0

06/01/94

1995

Project Number: 95163C
Project Title: APEX
Sub-Project: Diet Overlap of Forage Fish
Agency: NOAA

FORM 3B SUB-PROJECT DETAIL

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: The "Diet Overlap of Forage Fish Species" sub-project is designed to understand the Prince William Sound food web and its effects on the injured species. The 1995 sampling program will be a continuation of the 1994 pilot project (94163) to determine diet overlap and prey selection among forage fish species.

Budget Category:	1994 Project No. .... Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$60.0	$60.0	$60.0	
Travel		$0.0	$0.0	$0.0	$0.0	
Contractual		$0.0	$0.0	$0.0	$0.0	
Commodities		$0.0	$0.0	$0.0	$0.0	
Equipment		$0.0	$0.0	$0.0	$0.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$60.0	$60.0	$60.0	
General Administration		$0.0	$9.0	$9.0	$9.0	
Project Total	$0.0	$0.0	$69.0	$69.0	$69.0	
Full-time Equivalents (FTE)		0.0	1.5	1.5		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept fisheries technician III			6.0	$20.0
fisheries technician III			6.0	$20.0
fisheries technician III			6.0	$20.0
Personnel Total	0.0	$0.0	18.0	$60.0

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

1995

Project Number: 95163C
Project Title: APEX
Sub-Project: Diet Overlap of Forage Fish
Agency: ADF&G

FORM 3A SUB-PROJECT DETAIL

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Travel:	Reprt/Intr	Remaining
Rept		$0.0
Travel Total	$0.0	$0.0

Contractual:		$0.0
Rept		
Contractual Total	$0.0	$0.0

06/01/94

1995

Project Number: 95163C
Project Title: APEX
Sub-Project: Diet Overlap of Forage Fish
Agency: ADF&G

FORM 3B
SUB-
PROJECT
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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:	Reprt/Intr	Remaining
Rept		$0.0
Commodities Total	$0.0	$0.0

Equipment:	Reprt/Intr	Remaining
Rept		$0.0
Equipment Total	$0.0	$0.0

06/01/94

1995

Project Number: 95163C
Project Title: APEX
Sub-Project: Diet Overlap of Forage Fish
Agency: ADF&G

FORM 3B
SUB-
PROJECT
DETAIL

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: Tufted puffins are cost effective samplers of forage fish. This component will strengthen the APEX project by offering comparisons between surface-feeding kittiwakes and diving puffins and near shore feeding guillemots. The same parameters will be measured for puffins as for guillemots and kittiwakes, and data will be shard with the energetics components of the APEX project.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$11.0	$11.0	$52.5	NBS will contribute $30K in personnel costs to this project
Travel		$0.0	$3.9	$3.9	$8.0	
Contractual		$0.0	$0.0	$0.0	$5.0	
Commodities		$0.0	$7.4	$7.4	$10.0	
Equipment		$0 0	$27.7	$27.7	$22.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$50.0	$50.0	$97.5	
General Administration		$0.0	$1.7	$1.7	$8.2	
Project Total	$0.0	$0.0	$51.7	$51.7	$105.7	
Full-time Equivalents (FTE)		0.0	0.2	0.2		
	Dollar amounts are shown in thousands of dollars.					

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Principal Investigator, GS-13			1.5	$7.5
Project Assistant, GS-9			1.0	$3.5
Personnel Total	0.0	$0.0	2.5	$11.0

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163D
Project Title: APEX
Sub-Project: Puffins as Samplers
Agency: NBS

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:		Reprt/Intr	Remaining
Rept	Anchorage/Whittier, 2 people, 2 trips @ $100/trip		$0.4
	Anchorage/Homer, 4 people, 1 trip @ $150/trip		$0.6
	Float plane trips to study site, PI, 2 trips @ $250/trip		$0.5
	Field per diem, 200 person days @ $3/day		$0.6
	Volunteer air fares, RT lower 48, 3 @ $600		$1.8
	Travel Total	$0.0	$3.9

Contractual:			
Rept			$0.0
Intrm			
	Contractual Total	$0.0	$0.0

06/01/94

1995

Project Number: 95163D
Project Title: APEX
Sub-Project: Puffins as Samplers
Agency: NBS

FORM 3B SUB-PROJECT DETAIL

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Commodities:		Reprt/Intr	Remaining
Rept	Food		$2.5
Intrm	Fuel for Zodiak and 25 foot Boston Whaler		$1.1
	Sleeping bags and pads, 4 @ $200		$0.8
	Waterproof boat bags		$0.2
	Rain gear and rubber boots, 4 @ $200		$0.8
	Misc. camp gear (stoves, lanterns, tools, cook kits)		$1.0
	Scientific supplies (screens, sampling bags, preservatives, scales)		$1.0
	Commodities Total	$0.0	$7.4

Equipment:			
Rept	SSB radio, antenna, battery		$2.2
Intrm	VHF radios, 2 @ $500		$1.0
	Generator		$0.5
	Bomb shelter tents, 4 @ $620		$2.5
	Inflatable boat (Zodiak Mark II or equivalent)		$3.0
	Outboard motors (25 h.p. and 15 h.p.)		$3.0
	Floatation/exposure suits , 5 @ $300		$1.5
	Binoculars (4 Pentax @ $160)		$0.6
	Burrow probe video system, 2 @ $6200		$12.4
	Climbing equipment		$1.0
	Equipment Total	$0.0	$27.7

06/01/94

1995

Project Number: 95163D
Project Title: APEX
Sub-Project: Puffins as Samplers
Agency: NBS

FORM 3B
SUB-
PROJECT
DETAIL

1995 EXXON VALDEZ TRUSTEE JNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: This component will collect information on kittiwake foraging and reproductive parameters that indicate food stress.

Budget Category:	1994 Project No. .... Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$75.2	$75.2	$102.8	USFWS will contribute $89K to this
Travel		$0.0	$8.7	$8.7	$8.7	component in the form of data from
Contractual		$0.0	$21.6	$21.6	$21.6	the kittiwake productivity study
Commodities		$0.0	$23.7	$23.7	$23.7	
Equipment		$0.0	$10.2	$10.2	$8.2	USFWS is considering reducing admin.
Capital Outlay		$0.0	$0.0	$0.0	$0.0	overhead charges in this component
Subtotal	$0.0	$0.0	$139.4	$139.4	$165.0	
General Administration		$0.0	$12.8	$12.8	$16.9	
Project Total	$0.0	$0.0	$152.2	$152.2	$181.9	
Full-time Equivalents (FTE)		0.0	1.8	1.8		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Project leader, GS-11			6.0	$29.4
Bio. Tech., GS-5			5.0	$12.4
Bio. Tech., GS-5			5.0	$12.4
Expediter, wage grade 4, step 2			3.0	$10.0
Project Manager, GS-12			2.0	$11.0
Personnel Total	0.0	$0.0	21.0	$75.2

NEPA Cost: $0.0
*Oct 1, 1994 - Dec 31, 1994
**Jan 1, 1995 - Sep 30, 1995

Project Number: 95163E
Project Title: APEX
Sub-Project: Black-legged Kittiwake Component
Agency: USFWS

FORM 3A SUB-PROJECT DETAIL

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:		Reprt/Intr	Remaining
Rept	Anchorage/Whittier to transport boat, 2 trips @ $1,200/round trip		$2.4
	Anchorage/Whittier, 3 people, 4 trips @ $100/trip		$1.2
	Field per diem: 3 people, 120 days @ $3/day		$1.1
	Float plane trips to study site: 4 trips @ $250/trip		$1.0
	Emergency travel (injuries, equipment repair or replacement)		$1.0
	Travel to scientific meeting to present results of study		$2.0
	Travel Total	$0.0	$8.7

Contractual:			
Rept	Delivery of fuel and supplies (costs split w/PIGU study)		$4.0
Intrm	Safety training for 3 people		$2.5
	Truck rental		$5.0
	Maintenance, cleaning, repair, misc.		$10.1
	Contractual Total	$0.0	$21.6

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Project Number: 95163E
Project Title: APEX
Sub-Project: Black-legged Kittiwake Component
Agency: USFWS

FORM 3B SUB-PROJECT DETAIL

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Commodities:		Reprt/Intr	Remaining
Rept	Food: 3 people for 120 days		$3.6
Intrm	Boat fuel: 150 gal/day for 60 days		$13.5
	Scientific and camp supplies, software updates, and office supplies		$6.6
	Commodities Total	$0.0	$23.7

Equipment:			
Rept	Radio tags		$6.2
Intrm	Emergency replacement equipment		$2.0
	Camp equipment (stoves, lanterns, tents, tools, etc.)		$1.2
	Telemetry antennas		$0.8
	Equipment Total	$0.0	$10.2

06/01/94

1995

Project Number: 95163E
Project Title: APEX
Sub-Project: Black-legged Kittiwake Component
Agency: USFWS

FORM 3B SUB-PROJECT DETAIL

1995 EXXON VALDEZ TRUSTEE JNCIL PROJECT BUDGET
October 1, 1994 - Sep.ember 30, 1995

Project Description: This study will monitor the feeding and breeding ecology of pigeon guillemots on Naked and Jackpot islands in Prince William Sound and census their populations there and at other designated sites.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$92.8	$0.0	$120.4	USFWS is considering reducing admin.
Travel		$0.0	$9.4	$9.4	$9.4	overhead charges in this component
Contractual		$0.0	$23.1	$23.1	$23.1	
Commodities		$0.0	$24.3	$24.3	$23.3	
Equipment		$0.0	$7.0	$7.0	$2.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$156.6	$156.6	$178.2	
General Administration		$0.0	$15.5	$15.5	$19.7	
Project Total	$0.0	$0.0	$172.1	$172.1	$197.9	
Full-time Equivalents (FTE)		0.0	2.3	2.3		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Project Leader, GS-11			6.0	$29.4
Bio. Tech., GS-7			6.0	$17.6
Bio. Tech., GS-5 x 2 people			10.0	$24.8
Expediter, wage grade 4, step 2			3.0	$10.0
Project Manager, GS-12			2.0	$11.0
Personnel Total	0.0	$0.0	27.0	$92.8

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163F
Project Title: APEX
Sub-Project: Monitoring of Pigeon Guillemots
Agency: USFWS

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1995 EXXON VALDEZ TRUSTEE JNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:		Reprt/Intr	Remaining
Rept	Anchorage/Whittier to transport boat, 2 trips @ $1,200/round trip		$2.4
	Anchorage/Whittier, 3 people, 4 trips @ $100/trip		$1.6
	Field per diem: 3 people, 120 days @ $3/day		$1.4
	Float plane trips to study site: 4 trips @ $250/trip		$1.0
	Emergency travel (injuries, equipment repair or replacement)		$2.0
	Travel to scientific meeting to present results of study		$1.0
	Travel Total	$0.0	$9.4

Contractual:			
Rept	Delivery of fuel and supplies (costs split w/PIGU study)		$4.0
	Safety training for 3 people		$2.5
	Truck rental		$5.0
	Maintenance, cleaning, repair, misc.		$11.6
	Contractual Total	$0.0	$23.1

06/01/94

Project Number: 95163F
Project Title: APEX
Sub-Project: Monitoring of Pigeon Guillemots
Agency: USFWS

Commodities:		Reprt/Intr	Remaining
Rept	Food: 3 people for 120 days		$3.6
	Boat fuel: 150 gal/day for 60 days		$13.5
	Scientific and camp supplies, software updates, and office supplies		$7.2
	Commodities Total	$0.0	$24.3

Equipment:			
Rept	Emergency replacement equipment		$2.0
	VHF radios, repeater, antenna for base camp		$4.0
	Tools for boat and camp		$1.0
	Equipment Total	$0.0	$7.0

06/01/94

Project Number: 95163F
Project Title: APEX
Sub-Project: Monitoring of Pigeon Guillemots
Agency: USFWS

1995 EXXON VALDEZ TRUSTEE ,UNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: Assess the taxonomic and biochemical composition of seabird diets and determines the relationship of diet to nestling provisioning rates, chick growth energetics, and the reproductive of seabird breeding in the EVOS area.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$28.7	$28.7	$44.3	
Travel		$0.0	$7.1	$7.1	$10.4	
Contractual		$0.0	$27.2	$27.2	$32.0	
Commodities		$0.0	$53.0	$53.0	$21.7	
Equipment		$0.0	$37.0	$37.0	$0.0	Equipment costs may be reduced if PI can
Indirect Costs (42.2% in FY95, 10% in FY9		$0.0	$64.6	$64.6	$10.8	obtain use of Trustee Council boat,
Subtotal	$0.0	$0.0	$217.6	$217.6	$119.2	motor, tents, etc.
General Administration		$0.0	$6.2	$6.2	$8.9	
Project Total	$0.0	$0.0	$223.8	$223.8	$128.1	
Full-time Equivalents (FTE)		0.0	1.3	1.3		
	Dollar amounts are shown in thousands of dollars.					

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Ph.D. Grad Student & tuition			3.0	$6.7
Field Tech., 17 weeks @ $8.87/why x 3 + benefits			12.0	$19.8
Lab. Tech., 160hr. @ $13.92/hr + benefits			1.0	$2.2
Personnel Total	0.0	$0.0	16.0	$28.7

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163G
Project Title: APEX
Sub-Project: Seabird Energetics
Agency: University of Alaska Fairbanks

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1995 EXXON VALDEZ TRUSTEE ... JUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:		Reprt/Intr	Remaining
Rept	Fairbanks/Anchorage round trip x 16, PI meeting/EVOS conference		$3.0
	per diem for Fairbanks/Anchorage meetings @ $155/day for 13 days		$2.0
	per diem for field volunteers @ $300/mo. x 2ea. for 3 months		$1.8
	train from Portage/Whittier/Portage		$0.3
	Travel Total	$0.0	$7 1

Contractual:			
Rept	Project support Services from AKFWRU		$1.7
	Duplication fees, publication page charges, telephone		$1.5
	Maintenance; weatherport,, lab. & field equipment, Zodiak, motor & freezers		$2.3
	vessel charter to Naked Is., Jackpot Is., Shoup Bay, Eleanor Is., & Smith Is.		$18.0
	vehicle rental 2 $40/day x 2 vehicles		$3.7
	Contractual Total	$0.0	$27.2

06/01/94

Project Number: 95163G
Project Title: APEX
Sub-Project: Seabird Energetics
Agency: University of Alaska Fairbanks

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:		Reprt/Intr	Remaining
Rept	boat, lab., field, sample, camping and climbing supplies		$33.0
	boat fuel, 60 gals./day for 92 days		$11.0
	mustang suits, 6 ea. (will try to locate & use Trustee Council suits if available)		$9.0
	Commodities Total	$0.0	$53.0

Equipment:		Reprt/Intr	Remaining
Rept	Freezers x 6 for field samples		$8.7
	Boston Whaler, 17' (will attempt to obtain use of Trustee Council boat)		$15.0
	Outboard motor (40hp) will use Trustee Council motor if available		$4.5
	Weatherport, 12x16, 2 ea.		$2.8
	Field radio phone equipment x 3		$6.0
	Equipment Total	$0.0	$37.0

06/01/94

Project Number: 95163G
Project Title: APEX
Sub-Project: Seabird Energetics
Agency: University of Alaska Fairbanks

Project Description: Proximate composition and energetic content of selected forage fish species in Prince William Sound (was 95120-BAA)

Budget Category:	1994 Project No. .... Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$18.0	$18.0	$18.0	
Travel		$0.0	$3.0	$3.0	$3.0	
Contractual		$0.0	$0.0	$0.0	$0.0	
Commodities		$0.0	$3.5	$3.5	$3.5	
Equipment		$0.0	$1.0	$1.0	$0.0	
Indirect Costs (45%)		$0.0	$10.4	$10.4	$10.4	
Subtotal	$0.0	$0.0	$35.9	$35.9	$34.9	
General Administration		$0.0	$2.7	$2.7	$2.7	
Project Total	$0.0	$0.0	$38.6	$38.6	$37.6	
Full-time Equivalents (FTE)		0.0	0.1	0.1		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Program Manager			0.5	$2.5
Personnel				$15.5
Personnel Total	0.0	$0.0	0.5	$18.0

NEPA Cost: $0.0
*Oct 1, 1994 - Dec 31, 1994
**Jan 1, 1995 - Sep 30, 1995

Project Number: 95163H
Project Title: APEX
Sub-Project: Energetic Content of Forage Fish
Agency: Texas A&M University

Travel:		Reprt/Intr	Remaining
Rept	Texas/Anchorage x 2		$3.0
	Travel Total	$0.0	$3.0

Contractual:			
Rept			
	Contractual Total	$0.0	$0.0

06/01/94

Project Number: 95163H
Project Title: APEX
Sub-Project: Energetic Content of Forage Fish
Agency: Texas A&M University

Commodities:		Reprt/Intr	Remaining
Rept	Laboratory supplies		$3.5
	Commodities Total	$0.0	$3.5

Equipment:			
Rept	Equipment		$1.0
	Equipment Total	$0.0	$1.0

06/01/94

Project Number: 95163H
Project Title: APEX
Sub-Project: Energetic Content of Forage Fish
Agency: Texas A&M University

1995 EXXON VALDEZ TRUSTE. ,UNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: This component of the APEX project will provide scientific oversight, coordination, performance tracking, and integration of results. The program management employed will have elements that have been used effectively in other large, multidisciplinary programs for ecosystem assessment.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'95 Plannin Budget FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$58.2	$0.0	$0.0	$68.2	
Travel		$0.0	$0.0	$0.0	$5.0	
Contractual		$0 0	$0.0	$0.0	$5.0	
Commodities		$0 0	$0.0	$0.0	$1.0	
Equipment		$0 0	$0.0	$0.0	$0.0	
University Overhead (36.2%)		$0 0	$0.0	$0.0	$28.8	
Subtotal	$0.0	$58.2	$0.0	$0 0	$108.0	
General Administration		$8.7	$0.0	$0.0	$10.6	
Project Total	$0.0	$66.9	$0.0	$0.0	$118.6	
Full-time Equivalents (FTE)		0.8	0.0	0.0		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Project Leader, 50% salary	6.0	$48.2	0.0	$0.0
Assistant Project Leader	3.0	$10.0	0.0	$0.0
Personnel Total	9.0	$58.2	0.0	$0.0

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163I
Project Title: APEX
Sub-Project: Project Management
Agency: University of Alaska Anchorage

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:		Reprt/Intr	Remaining
Rept	Travel (funded in the planning budget, $5.0K)		$0.0
	Travel Total	$0.0	$0 0

Contractual:			$0.0
Rept	Database compatibility contract funded in the planning budget, $5.0K)		
	Contractual Total	$0.0	$0.0

06/01/94

Project Number: 95163I
Project Title: APEX
Sub-Project: Project Management
Agency: University of Alaska Anchorage

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Commodities:	Reprt/Intr	Remaining
Rept Commodities funded in the planning budget, $1.0K)		$0.0
Commodities Total	$0.0	$0.0

Equipment:		
Rept		$0.0
Equipment Total	$0.0	$0.0

06/01/94

Project Number: 95163I
Project Title: APEX
Sub-Project: Project Management
Agency: University of Alaska Anchorage

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1995 EXXON VALDEZ TRUSTEL .OUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: This component is designed to collect data on common murres, black-legged kittiwakes and tufted puffins on the Barren Islands (which are within the EVOS area) that will be used in a multi-species analysis of seabird productivity and energetics. Products will include data on nesting chronology, productivity, feeding rates of chicks, time-budgets of adults, species of fish fed to chicks, and meal sizes of chicks.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$19.4	$19.4	$69.8	FY95 Personnel costs reduced by $15.0K.
Travel		$0.0	$6.4	$6.4	$7.3	These funds are being made available
Contractual		$0.0	$3.4	$3.4	$3.4	from a forage fish project sponsored by
Commodities		$0.0	$3.8	$3.8	$4.1	Minerals Management Service.
Equipment		$0.0	$0.0	$0.0	$0.6	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$33.0	$33.0	$85.2	
General Administration		$0.0	$3.1	$3.1	$10.7	
Project Total	$0.0	$0.0	$36.1	$36.1	$95.9	
Full-time Equivalents (FTE)		0.0	0.9	0.9		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Principal Investigator, GS-11/3			2.0	$8.2
Camp Leader/Bio. Tech., GS-7/1 (other funding source)			5.0	$0.0
Bio. Tech., GS-6/1			4.0	$11.2
Personnel Total	0.0	$0.0	11.0	$19.4

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163J
Project Title: APEX
Sub-Project: Barren Island Murres & Kittiwakes
Agency: USFWS

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:		Repr/Intr	Remaining
Rept	2 vessel days @ $2.0K/day		$4.0
	4 resupply fixed wing flights		$1.0
	1 helicopter in case if emergency		$1.4
	Travel Total	$0.0	$6.4

Contractual:			
Rept	1 SCA volunteer in Homer, 3 months	$0.0	$3.4
	Contractual Total	$0.0	$3.4

06/01/94

Project Number: 95163J
Project Title: APEX
Sub-Project: Barren Island Murres & Kittiwakes
Agency: USFWS

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:		Reprt/Intr	Remaining
Repl	Food		$2.8
	Gas, oil, blazo		$0.5
	Notebooks and film		$0.1
	Replacement climbing ropes and pitons		$0.4
	Commodities Total	$0 0	$3 8

Equipment:			
Repl			$0.0
	Equipment Total	$0.0	$0.0

06/01/94

Project Number: 95163J
Project Title: APEX
Sub-Project: Barren Island Murres & Kittiwakes
Agency: USFWS

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1994 - September 30, 1995

Project Description: Forage fish will be obtained from the stomachs of sport-caught large fish predator such as halibut and cod. This should prove to be an inexpensive way to obtain an index of forage fish abundance in the areas used by sport/charter vessels. This study component is designed to test the feasibility and effectiveness of obtaining low cost, spatial and relative abundance data on forage fish in the northern Gulf of Alaska.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$4.1	$4.1	$8.4	
Travel		$0.0	$0.4	$0.4	$0.5	
Contractual		$0.0	$3.6	$3.6	$3.7	
Commodities		$0 0	$2.0	$2.0	$2.0	
Equipment		$0.0	$0.0	$0.0	$0.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$10.1	$10.1	$14.6	
General Administration		$0.0	$0.9	$0.9	$1.5	
Project Total	$0.0	$0.0	$11.0	$11.0	$16.1	
Full-time Equivalents (FTE)		0.0	0.1	0.1		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Repl Principal Investigator, GS-11/3			1.0	$4.1
Personnel Total	0.0	$0.0	1.0	$4.1

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163K
Project Title: APEX
Sub-Project: Large Fish as Samplers
Agency: USFWS

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:	Reprt/Intr	Remaining
Rept 1 roundtrip Homer/Sewer + per diem		$0.4
Travel Total	$0.0	$0.4

Contractual:		$3.6
Rept 1 Student Conservation Association (SCA) volunteer in Homer for 3 months		
Contractual Total	$0.0	$3.6

06/01/94

Project Number: 95163K
Project Title: APEX
Sub-Project: Large Fish as Samplers
Agency: USFWS

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:	Reprt/Intr	Remaining
Rept tags, labels, notebooks, sample jars, ziplocks/whirlpacs, alcohol, glycerin, etc.		$2.0
Commodities Total	$0 0	$2.0

Equipment:		
Rept		$0.0
Equipment Total	$0.0	$0.0

06/01/94

Project Number: 95163K
Project Title: APEX
Sub-Project: Large Fish as Samplers
Agency: USFWS

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1995 EXXON VALDEZ TRUSTE ̲ ̲ COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: Forage fish will be obtained from the stomachs of sport-caught large fish predator such as halibut and cod. This should prove to be an inexpensive way to obtain an index of forage fish abundance in the areas used by sport/charter vessels. This study component is designed to test the feasibility and effectiveness of obtaining low cost, spatial and relative abundance data on forage fish in the northern Gulf of Alaska. This budget table reflects Student Conservation Association (SCA) volunteers managed by the National Park Service (NPS).

Budget Category:	1994 Project No. Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$3.6	$3.6	$3.7	
Travel		$0.0	$0.0	$0.0	$0.0	
Contractual		$0.0	$0.0	$0.0	$0.0	
Commodities		$0.0	$0.0	$0.0	$0.0	
Equipment		$0.0	$0.0	$0.0	$0.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$3.6	$3.6	$3.7	
General Administration		$0.0	$0.5	$0.5	$0.6	
Project Total	$0.0	$0.0	$4.1	$4.1	$4.3	
Full-time Equivalents (FTE)		0.0	0.3	0.3		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept 1 SCA volunteer in Seward			3.0	$3.6
Personnel Total	0.0	$0.0	3.0	$3.6

NEPA Cost: $0.0
*Oct 1, 1994 - Dec 31, 1994
**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163K
Project Title: APEX
Sub-Project: Large Fish as Samplers
Agency: NPS

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1995 EXXON VALDEZ TRUST[illegible] COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:	Reprt/Intr	Remaining
Rept		$0.0
Travel Total	$0.0	$0.0

Contractual:		
Rept		
Contractual Total	$0.0	$0.0

06/01/94

Project Number: 95163K
Project Title: APEX
Sub-Project: Large Fish as Samplers
Agency: NPS

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:	Reprt/Intr	Remaining
Rept		
Commodities Total	$0.0	$0.0

Equipment:	Reprt/Intr	Remaining
Rept		
Equipment Total	$0.0	$0.0

06/01/94

Project Number: 95163K
Project Title: APEX
Sub-Project: Large Fish as Samplers
Agency: NPS

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1994 - September 30, 1995

Project Description: This component will complete a historical review of the ecosystem structure in the Prince William Sound/Gulf of Alaska complex. Included in this review will obtaining and synthesizing several forage fish data bases.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$4.0	$4.0	$8.0	
Travel		$0.0	$1.2	$1.2	$2.0	
Contractual		$0.0	$0.0	$0.0	$0.0	
Commodities		$0.0	$0.0	$0.0	$0.0	
Equipment		$0.0	$2.5	$2.5	$2.5	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$7.7	$7.7	$12.5	
General Administration		$0.0	$0.6	$0.6	$1.2	
Project Total	$0.0	$0.0	$8.3	$8.3	$13.7	
Full-time Equivalents (FTE)		0.0	0.2	0.2		
	Dollar amounts are shown in thousands of dollars.					

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Biologist, GS 9			2.0	$4.0
Personnel Total	0.0	$0.0	2.0	$4.0

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: NBS

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Travel:	Reprt/Intr	Remaining
Rept Anchorage/Seattle roundtrip		$1.2
Travel Total	$0.0	$1.2

Contractual:		$0.0
Rept		
Contractual Total	$0.0	$0.0

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: NBS

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1995 EXXON VALDEZ TRUSTE OUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:		Reprt/Intr	Remaining
Rept			$0.0
	Commodities Total	$0.0	$0.0

Equipment:			
Rept	Misc. computer equipment, hardware and software		$2.5
	Equipment Total	$0.0	$2.5

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: NBS

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 1994 - September 30, 1995

Project Description: This component will complete a historical review of the ecosystem structure in the Prince William Sound/Gulf of Alaska complex. Included in this review will obtaining and synthesizing several forage fish data bases.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$6.2	$6.2	$8.0	
Travel		$0.0	$0.0	$0.0	$0.0	
Contractual		$0.0	$0.0	$0.0	$0.0	
Commodities		$0.0	$0.0	$0.0	$0.0	
Equipment		$0.0	$0.0	$0.0	$0.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$6.2	$6.2	$8.0	
General Administration		$0.0	$0.9	$0.9	$1.2	
Project Total	$0.0	$0.0	$7.1	$7.1	$9.2	
Full-time Equivalents (FTE)		0.0	0.3	0.3		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Biologist, GS 9			3.0	$6.2
Personnel Total	0.0	$0.0	3.0	$6.2

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: NOAA

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Travel:	Reprt/Intr	Remaining
Rept		
Travel Total	$0.0	$0.0

Contractual:		
Rept		
Contractual Total	$0.0	$0.0

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: NOAA

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1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:	Reprt/Intr	Remaining
Rept		
Commodities Total	$0.0	$0.0

Equipment:		
Rept		
Equipment Total	$0.0	$0.0

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: NOAA

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Project Description: This component will complete a historical review of the ecosystem structure in the Prince William Sound/Gulf of Alaska complex. Included in this review will obtaining and synthesizing several forage fish data bases.

Budget Category:	1994 Project No. . . . . Authorized FFY 9	'94 Report/ '95 Interim* FFY 95	Remaining Cost** FFY 95	Total FFY 95	FFY 96	Comment
Personnel		$0.0	$16.6	$16.6	$16.6	
Travel		$0.0	$0.0	$0.0	$0.0	
Contractual		$0.0	$0.0	$0.0	$0.0	
Commodities		$0.0	$0.0	$0.0	$0.0	
Equipment		$0 0	$0.0	$0.0	$0.0	
Capital Outlay		$0.0	$0.0	$0.0	$0.0	
Subtotal	$0.0	$0.0	$16.6	$16.6	$16.6	
General Administration		$0.0	$2.5	$2.5	$2.5	
Project Total	$0 0	$0.0	$19.1	$19.1	$19.1	
Full-time Equivalents (FTE)		0.0	0.6	0.6		

Dollar amounts are shown in thousands of dollars.

Budget Year Proposed Personnel: Position Description	Reprt/Intrm Months	Reprt/Intrm Cost	Remaining Months	Remaining Cost
Rept Biologist, Range 16 (Homer)			3.0	$7.0
Biologist, Range 16 (Kodiak)			4.0	$9.6
Personnel Total	0.0	$0.0	7.0	$16.6

NEPA Cost: $0.0

*Oct 1, 1994 - Dec 31, 1994

**Jan 1, 1995 - Sep 30, 1995

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: ADF&G

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Travel:	Reprt/Intr	Remaining
Rept		
Travel Total	$0.0	$0.0

Contractual:	Reprt/Intr	Remaining
Rept		
Contractual Total	$0.0	$0.0

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: ADF&G

1995 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 1994 - September 30, 1995

Commodities:	Reprt/Intr	Remaining
Rept		
Commodities Total	$0.0	$0.0

Equipment:		
Rept		
Equipment Total	$0.0	$0.0

06/01/94

Project Number: 95163L
Project Title: APEX
Sub-Project: Historic Review
Agency: ADF&G

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end

PHONE COMMENT LOG

Name	Affiliation	Phone	Address
Denny K. Weathers			
Box 1791, Deep Bay, Hawkins Island, via Cordova, AK 99574			

Add to mailing list? Yes X No ___ Newsletters only V Technical Docs + ___

Date of call: 3/1/95 Comment taker: CQ Evans

Subject of comments: Opposed to Eyak acquisitions

Comments:

I do not feel that purchase of lands or timber rights in areas which were not touched by the oil spill is an appropriate use of the funds. The Eyak lands under consideration are 25-40 miles from where the oil came ashore.

By making such deals I feel the Trustees will only benefit the Native shareholders, not the overall people, fisheries, marine mammals or other animals that were injured by the oil spill.

Dear Council:

Please save the trees. I am worried about them. I don't like cutting trees.

Jamie Holleman
(3½ years old)

(He's talking about Eyak Corp. lands -
- his Mama)

14300 Teton Place
Anchorage, AK 99516

February 13, 1995

Exxon Valdez Oil Spill Trustee Council
645 G Street
Anchorage, AK 99501

Dear Council members:

Please! Please find a way to purchase timber rights on Eyak Corporation lands!

I am grateful for all the trees you have saved so far--especially Chenega Corporation land. But it is way past time to resolve the issues with the Eyak Corporation and make a deal. The clearcutting that has gone on in the Sound since the spill is atrocious and serves the interests of no one. Now it is time to protect what is left: Port Gravina, Sheep Bay, Simpson Bay, Orca Narrows.

You have an incredible opportunity to do the right thing--for all Alaskans, Native and non-Native, for all Americans, for the trees. Please! Use the settlement money from the oil spill tragedy to protect the rainforest of Prince William Sound.

Sincerely,

MBHolleman

Marybeth S. Holleman

RAYMOND L. BELLAMY
60080 SKYLINE DR.
HOMER, AK. 99603

2-26-95

EXXON VALDEZ OIL SPILL COUNCIL
645 G ST. SUITE 402
ANCHORAGE, AK 99501

DEAR COUNCIL MEMBERS.

AGAIN I FIND MYSELF SENDING YOU A LETTER IN REGARDS TO BUYING OF MORE LAND FOR PARKS OR WHAT EVER WE WOULD LIKE TO CALL IT.

I'M VEERY MUCH CONCERNED IN WHERE THE MONEY WILL COME FROM TO MANAGE THE LAND YOU MAY BUY, AS YOU KNOW EVERY TIME YOU BUY PRIVATE LAND IT COMES OFF THE TAX ROLL, IN TURN THIS MEANS MORE TAXES FOR US THAT STILL MAY OWN SOME LAND. WITH VEERY TIGHT BUDGET'S ALREADY IN AFFECT FROM THE FEDS TO CITY'S, AND WITH A VERY LARGE PERCENTAGE OF THE PEOPLE WANTING LOWER TAXES, AND LESS INVOLVEMENT OF GOVERNMENT IN OUR LIFE, BUY BUYING MORE PRIVATE LAND FOR PARKS IN ALREADY A PARK RICH STATE, ALL WE WILL GET IS MORE GOVERNMENT INVOLVEMENT AND HIGHER TAXES,IN ORDER TO OPERATE THEM.

I FEEL THAT WE SHOULD FIND OUT BEFORE BUYING MORE , WHERE THE MONEY WILL COME FROM TO OPERATE THEM. W3E ALREADY HAVE ENOUGH PARKS WITH KEEP OUT SIGNS, BECAUSE OF LACK OF MONEY FOR TRAILS AND AREAS FOR THE PEOPLE TO USE. A BETTER PLACE FOR THIS MONEY WOULD BE FOR ITEMS NEEDED, AND UPKEEP IN PARKS WE ALREADY HAVE. THERE IS NOTHING THAT MAKES ME MORE UNHAPPY THEN A PARK OWNED BY THE PEOPLE THAT IS CLOSED TO THE PEOPLE.

3% OF ALASKA IS IN PRIVATE HANDS A LARGE PERCENTAGE OF THE REST IS OFF LIMITS.

RECEIVED
FEB 28 1995
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL

THANK YOU

Raymond L Bellamy

RAYMOND L. BELLAMY

ALASKA CENTER *for the* ENVIRONMENT
519 West 8th Avenue, Suite 201 • Anchorage, Alaska 99501
(907) 274-3621 • fax: 274-8733

February 21, 1995

PRESS RELEASE:

As you know, recent events are putting a lot of pressure on attempts to save Eyak lands from large scale destruction. The moratorium which prevented clearcutting for the last year expires NEXT WEEK! Cordova residents, Eyaks, fishermen, environmentalists, scientists and tour operators are all scrambling to assist those trying to make a deal...
AND NOW JIMMY CARTER has weighed in on the side of protection and resolution.

For your information, we attach his letter.

Contact people:

Rick Steiner (Cordova) -- 424-5509 (eve); 424-3446 (day)
Caryl Boehnert (ACE) -- 274-3621
Eyak Corporation -- 424-7161
Phil Janik, USFS Negotiator -- 586-8863
Jim Ayers, State of Alaska -- 465-3500
EVOS Trustee Council -- 278-8012

JIMMY CARTER

February 21, 1995

To the Boards of Directors of the Eyak Corporation and Sherstone Corporation, and Exxon Valdez Oil Spill Trustee Council

I have been committed to the preservation of the Alaksan wilderness since before my administration. As Honorary Chair of the Alaska Wilderness League I am kept abreast of news concerning Alaska's great wilderness.

I understand that you are involved in negotiaions to purchase timber rights and conservation easements that would protect the coastal forests of the Prince William Sound, an area currently protected by a moratorium on logging which ends March 1, 1995. The Sound is now threatened by large scale logging, which would start March 2, due to the stalled negotiations.

I urge you to finalize your arrangements before the moratorium expires. The protection of this area is essential to maintaining the diverse and fragile ecosystem of the Prince William Sound and the home of the Eyak people.

Sincerely,

Jimmy Carter

P.O. Box 1185
Cordova, AK 99574
February 23, 1995

Exxon Valdez Oil Spill Trustee Council
645 G Street
Anchorage, AK 99501

Dear Council Members:

We appreciate your efforts in the negotiations with The Eyak Corporation and for keeping us informed at your public meeting held this afternoon in Cordova. As you could tell from the intensity of the testimony and the size of the turnout -rare for a meeting called on such short notice in Cordova- the outcome of your efforts will have profound consequences for our community.

While the information you conveyed to us was not the news we looked forward to, we continue to believe that a successful conclusion to the negotiations is still possible. We urge you to exercise as much flexibility as feasible.

Specifically, we strongly support, at minimum, the purchase under consideration for the core land parcels. However, we feel that this alone would fall far short of our highest hope which is the preservation of habitat and scenic values in eastern Prince William Sound. This will only be guaranteed by the comprehensive purchase of the core parcels and timber rights in the Orca Revised and Other Lands.

Although we are not privy to Eyak's latest counter-offer, we suspect that it includes retention by the corporation of certain development rights other than timber harvesting. We ask that you carefully and realistically balance the risks of these development possibilities against the longer term and greater consequences of large scale clearcut logging on the lands under consideration.

We understand that there are opportunities to employ the good offices of President Jimmy Carter and/or Robert Redford to facilitate in these negotiations. Their willingness to participate in this process is further confirmation of the unique and magnificent character of our home. Please consider their offers seriously.

Thank you for taking the time to come here and for your willingness to listen.

Very truly yours,

Karl Becker

Karl Becker

Nancy Bird

Nancy Bird

cc: Board of Directors, The Eyak Corporation

Feb. 23, 1995

TO: Eyak Board and Trustees Council

FR: Rick Steiner

RE: this afternoon's meeting in Cordova

Hi folks. I would imagine your all doing a little "downloading" at the moment concerning our meeting today.

It is very, very, very, very sad to me, and I know most of us, to see what the lack of resolution of this issue has done to our community here. As I stood at the back of the room, strategically located next to the nearest exit, I watched the crowd and saw alot of teary eyes as they left, one by one.

I just wanted to say that it is truly condidered a sign of dignity and social accomodation to be able to change our minds every once in awhile.

It is a basic, innate, instinctual human desire to be friends with one another. I think we all want that.

It seems were all finding out that someone leaving the autopilot on, on a fully loaded supertanker headed directly for a rock reef, is really, in the end, the least of our problems.

At any rate, I felt compelled to remind all of you of Robert Redford's very genuine and sincere and heartfelt offer to reconvene this at Sundance, if you all think that might help.

It has been my experience that the most difficult conflicts are the ones most worth resolving. This one is, as you all know, extremely difficult. I can't imagine any of you being faced with a more difficult challenge than this in your entire professional lives. It is also, as you all saw this afternoon, extremely worth resolving.

As you all heard loud and clear today, please hang in there. Get a deal here.

Please.

Steve Ranney
Box 2105
Cordova, AK 99574

To: Oil Spill Trustee Council

Feb. 21, 1995

Dear Council Members;

This fax is to urge your continued negotiation on the Eyak lands near Cordova.

While there may be an understandable amount of frustration on the part of your negotiators as this time consuming process drags on, please remember a large portion of Prince William Sound depends on your success.

You already have heard years of testimony and reports as to the high value of the habitat, of the valuable fish streams and abundant wildlife.

There is a strong feeling in Cordova that the Trustee Council may be tempted to take the easy way out of a difficult negotiating process by buying only the so called "core" lands. Please don't take this route!

I feel that this would only hasten the destruction of the Prince William Sound by providing the capital needed for large scale logging on the remaining Eyak lands.

While the process has been difficult for your negotiators, please remember that the goal is definitely worth the adversity encountered.

Thank you for your continued interest in the Eyak lands and we are all definitely waiting with bated breath in Cordova!

Sincerely,

Steve Ranney

Cordova Alaska
Fax 424-3764
Ph 424-3324

JUDY LIETZAU
P. O. Box 2195
Cordova, Alaska 99574-2195
907-424-7273

February 21, 1995

Molly McCammon, Director
EVOS Trustee Council
FAX: 907-278-8012

Dear Ms. McCammon,

As a resident of Cordova, I am concerned about the end of the logging moratorium March 1 and the resumption of clearcutting in our community and the immediate vicinity. Thank you for your deliberations up to now with Eyak Corporation. I know the meetings have been extensive and taxing; however, it is important to us here that the negotiations don't stop now.

I request that you institute another moratorium until such time as an equitable solution can be reached between the EVOS Council and the Eyak/Sherstone Boards of Directors. If necessary, contract with an independent mediator who can help you to accomplish this goal as was used in the Kodiak buyback.

It is essential to the health and well-being of our community that we keep our ecosystem intact and this buyback of Eyak lands would do much to ensure the stability of our fishing community. Thank you for your attention.

Sincerely,

Judy Lietzau

Judy Lietzau

PS Please copy to all members of the Council.

11.6.3 A

Oden Brutsie –
Henri Fonds – called to support.

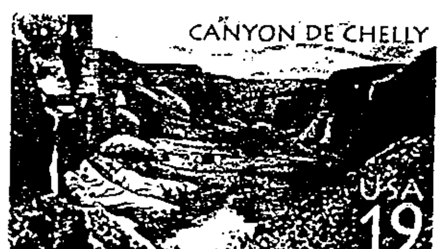
closed.

1/28/95

Please acquire the Native lands in the Kenai Fjords National Park using oil spill money. The coastline of the park supports many species directly affected by the oil spill. Even limited development of these Native lands, such as selling them for private cabin sites, would dramatically change the pristine character of the park.

Thank you,
Eve Abraham

Columbia, MD



Exxon Valdez Oil Spill
Trustee Council
645 G Street
Anchorage, AK
99501