PROTOCOLS FOR LONG-TERM MONITORING OF SEABIRD ECOLOGY IN THE GULF OF ALASKA

Project Number:	00501
Restoration Category:	Research, Monitoring
Proposed By:	U.S. Geological Survey
Lead Trustee Agency:	DOI-BRD
Cooperating Agencies:	DOI-FWS
Alaska SeaLife Center	No
Duration:	1st year, 2-year project
Cost FY 00:	$39,900
Cost FY 01	$14,000
Cost FY 02	$0
Geographic Area:	Cook Inlet, Gulf of Alaska
Injured Resource:	Multiple resources

ABSTRACT

Some seabird populations damaged by the *Exxon Valdez* oil spill have not recovered, and populations will need to be monitored for many years to assess both recovery and ecological conditions affecting recovery. Detailed studies of individual seabird colonies and marine ecosystems in the Gulf of Alaska (GOA) have been conducted by the USGS and USFWS under the auspices of damage assessment and restoration programs of the EVOSTC. Much has been learned about factors influencing seabird populations and their capacity to recover from the spill in the GOA. As we move towards long-term monitoring of populations, however, we need to develop protocols and long-term monitoring strategies that focus on key parameters of interest and that are inexpensive, practical and applicable over a large geographic area.

INTRODUCTION

Some seabird populations in the Gulf of Alaska have undergone marked fluctuations during the past few decades, some of which were due to effects of the *Exxon Valdez* oil spill (Byrd et al. 1998, Piatt and Anderson 1996). Results of investigations conducted with funding of the EVOSTC during the period 1989-1999 have included damage assessment studies of populations (e.g., Nyeswander et al. 1993) and restoration studies to evaluate the ecological conditions affecting seabird recovery. The latter studies have focused on how food availability, environmental conditions, and biological constraints on seabirds at colonies affect overall population dynamics (e.g., Piatt et al. 1998, 1999; Zador and Piatt 1999, Robards et al. 1999, Roseneau et al. 1999).

In Cook Inlet, these detailed studies included many research components that required considerable funding and logistic effort. At sea, we have measured forage fish distribution and abundance (with acoustic, trawl and seine surveys) in relation to oceanography (assessed with AVHRR imagery, CTD profiles, and moored thermographs). At colonies, we have measured a range of seabird parameters including adult and chick diets, chick feeding rates, chick growth rates, adult time-budgets (foraging time, nest attendance), breeding phenology, breeding success (laying, hatching, fledging), and population size (plot and whole-colony censuses). In FY1999, the total budget for these studies was 959 K, of which 68% was provided by the EVOSTC and the remainder was provided by the USGS and USFWS. These figures do not include costs of in-kind agency support (vessels, equipment, facilities, etc.).

As the EVOSTC moves from restoration research programs to monitoring programs, a stated goal is to support long-term monitoring of marine ecosystems and species impacted by the spill in Prince William Sound and the Gulf of Alaska. The objectives and scope of a long-term monitoring program are still being evaluated (R. Spies, 1998 EVOSTC Annual Restoration Meeting), but it appears that the level of effort currently under way in the Gulf of Alaska would have to be scaled back under the projected EVOSTC monitoring budget. With the knowledge obtained during the past five years in Cook Inlet, we can develop a monitoring strategy that includes measurement of key parameters that provide statistically rigorous data on seabird population trends, productivity, etc., and on ecological factors influencing seabirds. We would like to design a program that is cost-effective and logistically practical, allowing the EVOSTC to expand seabird monitoring from Cook Inlet to other areas in the Gulf of Alaska for an extended period of time.

NEED FOR THE PROJECT

A. Statement of the Problem

For long-term “monitoring” of seabird populations, the level of detailed observations made at any given colony necessarily depends on the objectives of the monitoring program, and the effort (person-days) that can be practically expended given logistic and funding constraints. Over the years, for example, a variety of methods have been devised to monitor seabird population trends and productivity (e.g., Nettleship 1976, Birkhead and Nettleship 1980, Piatt et al. 1988, 1990; Byrd 1989) and in almost all cases, a balance has been struck between the need for detailed information and time or logistic constraints. In some cases, options may be recommended for obtaining data at differing levels of resolution while retaining acceptable statistical power (e.g., Gaston et al. 1983, Hatch and Hatch 1989).

For a few of the parameters that were measured during the course of EVOSTC-funded seabird and forage fish studies (Table 1), standard protocols and analyses had already been developed for research and monitoring, and some of these methods were employed in Cook Inlet studies. For example, populations of Common Murres and Black-legged Kittiwakes can be monitored annually by counting index plots at least 5 times during the incubation and early chick-rearing period, and this provides enough statistical power to detect changes of 18-20% in populations between years (Hatch and Hatch 1988, 1989). Counting plots 10 times would allow detection of 12-14% changes in populations between years. At the three colonies in Cook Inlet (Barren, Chisik and Gull islands), 6-10 counts of plots were conducted in each year of EVOSTC-funded study (1995-1999), and future monitoring efforts would continue to use this protocol.

However, for most of the parameters measured in lower Cook Inlet under EVOSTC-funded studies (Table 1), standardized monitoring methods have not been established. Furthermore, we do not yet have a clear idea of how much statistical power we might retain under reduced sampling protocols. For example, if the EVOSTC would like to support a monitoring effort that continues to measure oceanographic parameters, plankton and fish abundance, then we need to identify which parameters are most useful to measure and what sample sizes are adequate to measure significant changes among years. We also need to consider options for sampling that can be supported by different levels of funding.

Similarly, if seabirds are to be monitored at colonies, which parameters would be most useful to measure, how would they be measured and how frequently do they need to be measured to detect trends? In general, the Alaska Maritime National Wildlife Refuge (AMNWR) and other seabird researchers in Alaska have fairly well-defined protocols for measuring seabird breeding and population parameters (Table 1), but these are based on 3-4 month-long field seasons (e.g., Byrd 1989). While these two parameters would almost certainly be measured in any long-term monitoring strategy we develop for the EVOSTC, methods could be further refined to reduce costs and effort per colony, or allow for larger geographic coverage of colonies in the Gulf of Alaska. For example, a comprehensive measurement of breeding phenology calls for detailed (every 2-4 days) assessments of nest status (egg, hatch, chick, fledge) throughout the breeding season. Alternatively, one might be able to measure a sample of chicks from a one-time session during chick-rearing, and extrapolate backwards from measurements of body size to estimate mean laying and hatching dates. Similarly, a one-time census during chick-rearing could provide a precise index of kittiwake breeding success that— although less accurate than measures obtained through repeated status-checks of nests— would nonetheless yield adequate data for monitoring long-term trends in productivity (although it would be less useful for assessing components of productivity). While we have collected data that would allow us to evaluate the reliability of “short-cut” methods for monitoring, we have yet to evaluate their practicality from the point of view of logistics or statistical power. Furthermore, we need to evaluate what is gained or lost by employing “short-cut” rather than comprehensive methods.

Therefore we propose a two-part study. First, we would conduct a ‘desk-top exercise’ to examine existing parameter datasets for statistical power and utility, and develop a series of protocols designed to meet differing funding and logistic scenarios. We would identify a ‘minimum protocol’ that includes measurement of the most valuable parameters for selected species in the shortest possible amount of time (e.g., 1-2 weeks), an ‘intermediate protocol’ which would identify which parameters could be successfully measured (and with what level of detail for which species) in some intermediate amount of time (e.g., 4-6 weeks), and a ‘maximum protocol’ which would identify work that could be accomplished over a full season (e.g., 12-20 weeks) but with reduced funding and personnel than currently supported under EVOSTC restoration studies. An important part of this process will be to identify what is gained or lost by choosing to use one method over another.

Second, we will compile final monitoring protocols for all aspects of the project and then develop and recommend a long-term monitoring strategy for the EVOSTC to consider for their future monitoring program. We envision applying different protocols to different colonies throughout the Gulf of Alaska depending on overall funding levels, partnerships, and logistic constraints inherent to individual colonies. Consideration will also be given to which colonies are most representative of different oceanographic domains, and to the frequency of sampling needed to detect trends.

B. Rationale

Methodologies for measuring aspects of seabird ecology are constantly evolving as we gain insight into the meaning and utility of routinely collected data, and use new tools and technologies to simplify measures of routine parameters or to measure new parameters. For example, we can now measure sea surface temperatures and surface chlorophyll concentrations over the entire Gulf of Alaska on a daily basis through remote satellite sensors. We can measure temperature, salinity, chlorophyll concentration and turbidity of the entire water column in minutes with a CTD profiler. Seabird attendance, chick feeding rates and foraging trips can be monitored remotely with time lapse videography or real-time video relays. Food limitation and stress in seabirds can be evaluated by taking relatively simple measures of blood hormone levels.

Research conducted during the past five years under auspices of the EVOSTC in Cook Inlet has greatly expanded our knowledge of relationships between seabirds and their local environments. If the EVOSTC wants to continue to monitor seabird recovery in the Gulf of Alaska, then we need to distill what we have learned from our extensive studies and develop a streamlined monitoring program that is cost-effective while retaining the ability to compare results with those collected previously under APEX.

C. Location

The proposed work will be undertaken in offices of the USGS in Anchorage and the AMNWR in Homer. The project's benefits will be realized throughout the EVOS area, in the form of enhanced understanding of seabird ecology, population trends and recovery.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Gull Island in Kachemak Bay is owned by the Seldovia Native Association (SNA). Limited subsistence use occurs during summer, with occasional egging and harvesting of juvenile birds. It is also a major tourist attraction for visitors to Homer. Permission to work on and around the island has been obtained under the provision that annual reports of findings be made available to the SNA. In the past we have performed several outreach activities to inform local citizens of our research, including: 1) distribution of flyers and posters describing our work to the SNA, tour boat operators, the AMNWR Visitor's Center, and the Pratt Museum, 2) presentations at public meetings, and 3) cooperation with the Pratt Museum in their video monitoring of seabirds on Gull and the Barren islands. Chisik and the Barren islands are managed by the AMNWR and we employ charter vessels from Homer to support field work there. Chisik Island supports a small, seasonal fishing community and we keep summer residents informed about the nature and purpose of our activities. Whenever possible, equipment and other resources will be acquired locally in the Homer area. Traditional and local ecological knowledge will be sought from fishermen and other residents, particularly on the topic of seabird and forage fish population trends.

PROJECT DESIGN

A. Objectives

1. Using data collected in Cook Inlet during EVOSTC-funded restoration projects, assess the statistical power and utility of measuring biological parameters (Table 1) under different monitoring scenarios and at different frequencies.

2. Based on (1) and in consultation with other investigators, develop and compile written protocols for long-term monitoring of seabirds under different scenarios (minimum, medium, and maximum effort).

3. Based on (2) above, and other experience, develop a long-term monitoring strategy for seabirds in the Gulf of Alaska that also addresses issues of sampling for representative species and oceanographic domains, and frequency of sampling.

B. Methods

Objective 1: First we will have a meeting to discuss and identify parameters that would be most useful for long-term monitoring of seabirds and ecological factors influencing their populations. Questions to be resolved for each parameter include (but are not limited to): 1) would it provide useful, meaningful information for long-term monitoring? 2) how frequently *can* samples be taken each summer in a best case scenario, given appropriate logistic support? 3) how frequently *have* samples been taken in previous work? 4) how frequently should samples be taken *among* years to measure trends, and 5) what would be appropriate methods for evaluating the statistical power of different sampling scenarios?. In addition, we would need to define some working models for sampling scenarios. After considering logistic constraints, seabird breeding schedules, sampling locations (i.e., choosing sampling sites that are representative of specific oceanographic domains or geographic regions), and species of concern, we will need to develop a consensus on what kind of field effort might reasonably be undertaken in 'minimum', 'medium' and 'maximum' scenarios— i.e., how long would a colony be visited (e.g., 1-2, 4-6, 10-16 week windows), how many people would be deployed, what kind of logistic support might be required (boats, planes, camps, etc.).

Following these discussions, data sets for the various parameters under consideration will be evaluated in several ways. First, we will consider whether each parameter *can* be measured under each scenario. For example, measurement of breeding parameters such as laying, hatching, *and* fledging success clearly cannot be accomplished in a 1-2 week visit. In contrast, one could measure fish abundance with beach seines at many temporal scales. Second, we will conduct a power analysis on appropriate parameters (using our historical data) to determine what level of sampling effort would be required to produce statistically useful results. For example, what level of beach seine sampling would be required to detect a 20% difference between years in forage fish CPUE? Similarly, how many days (and/or nests) must be monitored to detect inter-annual differences of 20% in chick-feeding frequency? Also, does sampling need to occur annually, or will multi-year intervals of sampling be adequate and still retain statistical power? This kind of analysis will provide a useful guide for determining which parameters *could* be usefully measured under different scenarios. Finally, some parameters might turn out to be of low value for statistical inference, but useful for ecological characterization. For example, low levels of trawl (or diet collection) effort might preclude detection of trends in fish abundance (or meal size), but may allow us to characterize prey (or diet) composition and/or detect significant changes in composition over time.

Objective 2. Following the completion of other objectives, we will solicit input from other investigators (e.g., from APEX projects in Prince William Sound) and compile the results of our work into a monitoring protocol manual. This document will outline which parameters can be measured under different operational scenarios and indicate what levels of statistical certainty may be expected under given sampling regimes. We will also identify what is gained or lost by choosing to conduct one scenario versus the others.

Objective 3. Based in part on results of objective (2), but also on other experience and knowledge about seabird colonies and logistics in the Gulf of Alaska, we will develop recommendations for a comprehensive monitoring strategy for seabirds in the Gulf of Alaska for use by the EVOSTC in planning a long-term monitoring program. This will include consideration of issues dealing with sampling frequency and locations.

Cooperating Agencies, Contracts, and Other Agency Assistance

USGS and FWS are cooperating on this project as an extension of their collaboration on EVOSTC (APEX) studies in lower Cook Inlet. Both agencies have collected data on different colonies, and we will both benefit from planning and coordinating future monitoring methods.
Personal Services contracts will be used for statistical consultation.

SCHEDULE

Measurable Project Tasks for FY 00

December 1:	Initial planning meeting and review of data needs
January 14-16:	Attend Annual Restoration Workshop
January-March:	Power analyses, data and protocol evaluation
March 1:	Coordination meeting
April 30:	Draft monitoring protocols completed, distributed for review
August:	Revisions to monitoring protocols based on reviews and field study
September 30:	Revised draft of monitoring protocol

Project Milestones and Endpoints

By September 30, 2000, we will have a draft manual of monitoring protocols. During the winter of FY01, we will work on development of a monitoring strategy for the Gulf of Alaska (a separate objective from protocols) and send that out for review. Following that, we would make final modifications to the monitoring protocol manual and the monitoring plan for the Gulf of Alaska. A final report will be completed by September 30, 2001.

Completion Date

All project objectives will be met by September 30, 2001.

PUBLICATIONS AND REPORTS

EVOSTC Annual Report FY00: “Protocols for long-term monitoring of seabird ecology in the Gulf of Alaska”

EVOSTC Final Report FY01: “Protocols and strategies for long-term monitoring of seabird ecology in the Gulf of Alaska”

PROFESSIONAL CONFERENCES

Results of this project will be presented at the EVOSTC Annual Restoration Meeting in January, 2001.

NORMAL AGENCY MANAGEMENT

This research would not be conducted as a normal part of USGS or FWS research on seabirds.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The proposed research issues are related to management and conservation of seabirds in Alaska as addressed by the U.S. Fish and Wildlife Service (USFWS) 'Seabird Management Plan' (USFWS Region 7, Migratory Bird Management). The proposed work will complement and be coordinated with: i) long-term studies conducted by the Alaska Maritime National Wildlife Refuge (AMNWR, USFWS Region 7), which includes annual monitoring of seabird productivity at 9 major seabird colonies throughout Alaska; ii) related studies (APEX) of seabird-forage fish interactions being supported by EVOSTC in Prince William Sound; and, iii) ongoing studies of seabird populations in areas of oil and gas development conducted by the Minerals Management Service (MMS) in Alaska and the Biological Resources Division of the USGS.

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Dr. John F. Piatt, Research Biologist (GS-14) with the Alaska Biological Sciences Center, Biological Resources Division, USGS in Anchorage. Since 1987, studied seabirds at colonies and at sea in Gulf of Alaska, Aleutians, Bering and Chukchi seas. Author on 75 peer-reviewed scientific publications about seabirds, fish, marine mammals, and effects of oil pollution on marine birds. Responsible for coordination of the project, analysis of historical data from Gull and Chisik islands, developing monitoring protocol and long-term monitoring plan, and field work on Chisik Island.

G. Vernon Byrd, Supervisory Wildlife Biologist (GS-13) with the Alaska Maritime National Wildlife Refuge, USFWS, in Homer. Over 25 years experience studying seabirds throughout Alaska, with focus on developing methodologies for monitoring populations and productivity. Currently coordinates long-term monitoring activities on nine permanent annual study sites in Gulf of Alaska, Aleutians, Bering and Chukchi seas. Responsible for coordination and oversight of developing the monitoring protocols and long-term monitoring plan.

Dave Roseneau, Wildlife Biologist (GS-11) with the Alaska Maritime National Wildlife Refuge, USFWS, in Homer. Over 25 years experience studying seabirds throughout Alaska, with focus on studying ecology of seabirds, analyzing population trends and developing methods for research and monitoring. Responsible for analysis of historical data from Barren Islands, and preparation of monitoring protocols and long-term monitoring plan.

OTHER KEY PERSONNEL

Arthur Kettle, Wildlife Biologist (GS-7), Alaska Maritime National Wildlife Refuge, USFWS. Analysis of Barren Islands data, protocol development, preparation of monitoring plan.

Thomas Van Pelt (GS-9), Alaska Biological Science Center, USGS. Analysis of Chisik Island data, protocol development, preparation of monitoring plan, field work.

Michael Shultz (GS-7), Alaska Biological Science Center, USGS. Analysis of Gull Island data, protocol development, preparation of monitoring plan, field work.

Dr. Alexander S. Kitaysky, Post-doctoral Fellow, University of Washington, Dept. of Zoology. Will assist with data analyses, protocol development and preparation of monitoring plan.

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Table 1. Some important parameters that were measured during EVOSTC-funded studies
of seabirds and forage fish in Cook Inlet, 1995-1999.

Parameter	Method
Water properties	AVHRR imagery of sea-surface temperature
	CTD profiles of water column (temp, sal at depth)
	Moored thermographs (temp at depth)
1° and 2° production	SeaWifs imagery of surface chlorophyll (ng/ml)
	CTD Chlorophyll profiles with fluorometer (ng/ml)
	Vertical zooplankton tows (CPUE, mg/ml)
Fish abundance	Hydroacoustic surveys (mean backscatter/km2)
	Mid-water trawls (CPUE & % composition)
	Beach seines (CPUE & % composition)
	Bottom trawls (CPUE & % composition)
Seabird populations	Whole island census (total no./year)
	Index plot census (mean no./plot/year)
Seabird diet	Adult diet (% composition, mass)
	Chick meal (% composition, mass)
Seabird Breeding	Laying success (eggs/nest)
	Clutch size (eggs/pair)
	Hatching success (chicks/egg)
	Fledging success (fledglings/chick)
	Breeding success (fledglings/nest; from above
	Breeding success index (chicks/nest from 1 visit)
	Phenology (mean dates)
Seabird Behavior	Chick feeding rate (kJ/d)
	Foraging trip duration (min/day)
	Attendance (loafing) time (min/day)
Seabird Physiology	Adult body mass/condition, (g/body size)
	Corticosteroid (stress) hormone levels (ng/ml of
	Chick growth rate (g/day)
	Chick fledging mass/condition, (g/body size)
Seabird survival	Annual return of banded adult birds (% per