Survival of Adult Murres and Kittiwakes in Relation to Forage Fish Abundance

Project Number:	01338
Restoration Category:	Research
Proposed By:	U.S. Geological Survey (PI- John F. Piatt)
Lead Trustee Agency:	DOI-BRD
Cooperating Agencies:	DOI-FWS
Alaska SeaLife Center	no
Duration:	4th year, 4-year project
Cost FY 01:	$47,200
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 continue to decline or are not recovering. In order to understand the ultimate cause of seabird population fluctuations, we must measure productivity, recruitment, and adult survival. Recent APEX studies focused on measuring productivity only. Recruitment measurement demands an unrealistic study duration. We propose to augment current studies in lower Cook Inlet that relate breeding success and foraging effort to fluctuations in forage fish density by using banding and resighting to quantify the survival of adult common murres and black-legged kittiwakes.

INTRODUCTION

Some seabird populations in the Gulf of Alaska have undergone marked fluctuations during the past few decades (Hatch and Piatt 1995; Piatt and Anderson 1996), including periods of decline or non-recovery. Ultimately, the ability of injured or declining seabird populations to recover depends on: 1) breeding success, or productivity; 2) fledgling survival and subsequent recruitment; and 3) overwinter survival of adults (Harris and Wanless 1988). Without concurrent measurement of at least two of these three parameters, it is difficult to determine which factor is most limiting to a population's recovery.

Mechanisms that regulate seabird populations by influencing productivity, recruitment, and adult survival are poorly understood, but food supply is clearly important (Cairns 1992). Studies sponsored by the ***Exxon Valdez*** Oil Spill Trustee Council (EVOSTC) in 1995-99 (APEX, Restoration Project 00163) have shown linkages between food supply and population fluctuations. Exactly which parameters of reproductive strategy are driven by food supply, and so drive population fluctuations, remain unclear. To date, APEX has focused on forage fish availability and its relationship to energy expenditure and productivity.

We are determining the overwinter survival of adult common murres (***Uria aalge***) and black-legged kittiwakes (***Rissa tridactyla***) using established banding and resighting techniques at two of the colonies investigated under APEX. Results of past work show clear differences in prey availability between the two colonies, with forage fish being scarce around Chisik Island and abundant around Gull Island. Both seabird species must work significantly harder at Chisik to provide food to their chicks. This difference appears to be manifested in sharply reduced kittiwake production at Chisik Island. Observing that kittiwake populations have been steadily declining at Chisik while increasing at Gull, one might be tempted to conclude that weak productivity and recruitment are driving the Chisik kittiwake population declines. However, while murres (at least in recent years) have been similarly productive at Chisik and Gull, the Chisik Island murre population has historically declined at an even greater rate than the kittiwake population.

From these data we conclude that the murre population decline at Chisik Island and concurrent increase at Gull Island may be attributable to differences in adult survival rates. Measurement of survival rates, in coordination with APEX's focus on food supply, energy expenditure and colony productivity, should help to more completely resolve the mechanisms underlying seabird population fluctuations, particularly for those species such as murres that are able to buffer against periods of food shortage by increasing foraging effort (Burger and Piatt 1990; Irons 1992).

Our continued research will measure adult survival of both murres and kittiwakes at Chisik and Gull Islands. We will use conventional banding/resighting methods to establish both species' adult survival rates. Working in collaboration with the Cook Inlet Seabird and Forage Fish Studies (CISeaFFS) component of the APEX project, we will compare survival between colonies in relation to foraging stress, breeding success, and forage fish abundance as determined during APEX surveys in 1995-1999. Foraging stress from breeding effort is probably a major contributor to adult overwinter mortality (Golet et al. 1998). Our work will enhance understanding of the relationships among survival, reproduction, and foraging energy

expenditure in kittiwakes and murres in lower Cook Inlet. In a broader context, our research will clarify the mechanisms and limiting parameters underlying natural population declines or the failure of injured populations to recover.

NEED FOR THE PROJECT

A. Statement of the Problem

Research has provided few clear examples of how seabird population biology is affected by changes in prey availability (Hunt et al. 1991). Consequently, it has been difficult to understand the non-recovery of some EVOS-damaged seabird populations because natural changes in forage fish stocks may have also contributed to their decline. The picture is further complicated by our inability to pinpoint which aspect of population biology ultimately drives population fluctuations. To determine the cause of population declines or non-recovery, the population's productivity, recruitment, and adult survival should be measured concurrent with evaluation of available food supply (Cairns 1992).

Recent EVOSTC-funded work (APEX, Restoration Project 00163M) measured productivity and foraging differences of seabirds in response to fluctuating prey availability. Results from research conducted in lower Cook Inlet show a correspondence between kittiwake productivity and forage fish availability to breeders. There is no correspondence, however, in species such as the murre which are able to increase foraging effort in response to decreasing forage fish abundance (Burger and Piatt 1990, Zador and Piatt 1999). Differences in recruitment and/or adult survival are thus implicated as important determinants of population fluctuations. Yet their relative importance has not been established by EVOSTC researchers, despite past work which has shown that variation in either recruitment or adult survival could obscure or even offset population fluctuations apparently driven by productivity differences (Hudson 1985).

Since murres and kittiwakes do not commence breeding until they are several years old (Hudson 1985; Aebischer and Coulson 1990), it is not feasible to measure recruitment in Cook Inlet seabird populations within the time frame required by EVOSTC funding. Measurement of adult overwinter survival has not yet been studied within a complete ecological framework, and has been identified by APEX reviewers as an important topic for expanded research in pursuit of understanding population fluctuations and recovery.

B. Rationale

Population changes are continually being driven by natural ecosystem changes, and are occasionally driven by anthropogenic perturbations such as the ***Exxon Valdez*** oil spill. In order to separate natural population fluctuations from anthropogenic population changes, we must have a complete understanding not only of the factors which drive population changes (e.g. change in prey availability) but also of the population biology parameter which is most altered by those driving forces. Annual productivity in relation to varying prey availability has been studied, but

cannot explain all observed population trends. It is not feasible to measure chick survival and recruitment. Therefore, to assess the potential for recovery of seabirds affected by the spill by pinpointing the cause of population trends, a study of adult survival and its relationship to prey availability is required.

In collaboration with the ecosystem-based study of seabird foraging conditions and breeding biology conducted by APEX in lower Cook Inlet (Restoration Project 00163M), we have a unique opportunity to assess not only the role of adult survival in seabird population fluctuations, but also the suspected linkage between foraging effort during the breeding season and adult overwinter survival. By choosing species with different long-term breeding strategies (kittiwakes maintain investment in reproduction at relatively constant [high] levels despite variation in food supply; murres adjust reproductive effort in relation to prey availability by altering buffer or "loafing" time) we will address questions raised by APEX work that shows linkage between prey availability and population fluctuation in some species (kittiwake) but only implies a linkage in others (murre). Refined understanding of foraging effort in relation to food supply will further our understanding of the costs of breeding in murres and kittiwakes. Stress induced by increased foraging effort in response to poor foraging conditions (Kitaysky et al. 1999a) may explain variation in adult survival.

C. Location

The proposed research will be undertaken in lower Cook Inlet, Alaska. The project's benefits will be realized throughout the EVOS area, in the form of enhanced understanding of seabird population trends and recovery mechanisms. Homer, Alaska is the only community that may be directly affected by the proposed research (as detailed below).

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 (Fred Elvsaas, pers. comm.). 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. We inform the local tour boat operators about our activities so that our presence at the island can be explained to visiting tourists. Chisik Island is managed by the Alaska Maritime National Wildlife Refuge, and we will employ charter vessels from Homer to support field work there. Chisik Island supports a small, seasonal fishing community and we will inform the summer residents about the nature and purpose of our activities. Whenever possible, equipment and other resources will be acquired locally.

PROJECT DESIGN

A. Objectives

1. To determine adult common murre and black-legged kittiwake overwinter survival rates, using conventional banding and resighting methods.

2. To relate differences in common murre and black-legged kittiwake overwinter survival to differences in prey availability, foraging effort and physiological stress during the breeding season.

3. To relate differences in common murre and black-legged kittiwake overwinter survival to differences in breeding success.

Background

We will conduct the proposed research at Chisik and Gull Islands, in lower Cook Inlet. Chisik Island has relatively low prey availability within typical murre/kittiwake foraging ranges, while Gull Island has high prey availability. The Chisik Island populations of both murres and kittiwakes have shown steady declines over the past two decades, in contrast to the Gull Island populations which are expanding. Recent APEX work has shown a significant relationship between breeding success and foraging effort for kittiwakes, but not for murres. Both species show increased foraging effort with decreased prey availability, but it appears that murres have a greater range of foraging effort within which they can still successfully produce chicks, as indicated by past studies (Burger and Piatt 1990, Zador and Piatt 1999). This raises the question: Is there a delayed or hidden cost to successful breeders that have had to "work harder" to raise their chicks? One way such a cost may be expressed is in decreased annual adult survival.

Measurement of survival:

Adult overwinter survival in seabirds has typically been measured by intensive banding and resighting programs (Harris and Wanless 1988; Aebischer and Coulson 1990; Hatchwell and Birkhead 1991; Hatch et al. 1993; Sydeman 1993, Erikstad et al. 1995). A suite of potential confounding factors (loss of bands, emigration, intracolony movement, observer failure to see marked birds) complicate survival estimates based on banding and resighting (Harris and Wanless 1988; Hatch et al. 1993). Models have been developed which account for some of these problems (Pollock et al. 1990); overcoming the remaining uncertainties depends directly on the amount of personnel effort that can be dedicated to banding and resighting work. Intensive effort will be required to resight banded birds, especially during the pre- egg-laying stage. Adult common murres are particularly difficult to resight, due to the murre's compact body posture while at the nest site.

Measurement of foraging effort and physiological stress:

Increased foraging effort may be the most important contributor to reduction in adult seabird survival (Golet et al. 1998), illustrating the trade-off between yearly reproductive output and longevity. In 1997-2000 we are measuring murre and kittiwake foraging effort (in terms of bird-hours spent away from the colony) using a series of 6-8 all-day nest watches spread throughout the incubation and chick-rearing periods. All-day watches give information on nest-site attendance (a measure of 'loafing time'[Zador and Piatt 1999], foraging trip duration, and chick provisioning rate. For example, during four years (1995-1998) of study we have observed that average foraging trips are more than 50% longer at Chisik Island than Gull Island (murres: 190 vs. 122 min; kittiwakes 254 vs. 166 min; respectively).

All of the birds captured for banding are also sampled for levels of corticosteroid stress hormones in the blood. We have already found a strong relationship between stress hormone levels and food (energy) intake (Kitaysky et al. 1999b) in growing chicks, and differences in baseline levels of stress hormones between the 'food-rich' colony at Gull Island and the 'food-poor' colony at Chisik Island (Kitaysky et al. 1999a). We will continue to analyze baseline corticosteroid levels in all birds banded for the survival study, and will eventually be able to relate survival to stress in individual birds, as well as between colonies.

B. Methods

Sample Size and Survival Statistics: Assuming a binomial distribution (sample unit being an individual adult, with survival being a yes or no), a power analysis of sample size in a two by two table predicts that a sample size of 47 marked birds per island would resolve a 6% difference in survival between colonies with acceptable statistical power and confidence (Table 1). To double the resolution (3%) would require a sample size nearly five times greater. However, a sample size of 185 is predicted to resolve a 4% difference with strong power and significance at the 0.05 level. Previous studies have reported murre survival rates ranging from 87% to 98%, measured at stable colonies (Hudson 1985, Sydeman 1993). Given that our study colonies represent relative extremes of population expansion and decline, it is not unreasonable to expect their survival rates to also be at the extreme ends of the normal range. Therefore, detection of a 4% difference with statistical significance should adequately address our primary hypothesis. To allow for a small percentage of known band loss, our goal is to individually mark a minimum of 200 birds of each species at each colony.

We were unable to complete our banding objectives during FY98 fieldwork (as detailed in the FY99 Restoration Project Annual Report). One of the local effects of 1998's El Niño perturbation was markedly reduced attendance at our study colonies by both kittiwakes and murres. Furthermore, birds that did attend were unusually flighty and nervous, making them especially difficult to catch. Mainly due to these uncontrollable factors, we were not able to complete our target sample sizes of 200 marked birds of each species at each colony by 1998 (Table 2). By 1999, however, we had reached our target goals except for kittiwakes on Chisik Island. Kittiwakes remain difficult to capture owing to restricted access and the tendency for birds there to fail and desert nest-sites early in the season.

Furthermore, precise survival estimates based on banding are ideally generated by multi-year studies because long-lived seabirds often skip one or more years of attempts at breeding (Erikstad et al. 1995, Golet et al. 1998). Because of this, and also because returning birds are not always sighted in every year they come back to a colony (a function of observer effort and nest-site fidelity), it is desirable to have at least four years of re-sighting data for robust analyses of survival data (Pollock et al. 1990, Lebreton et al. 1992; W. Sydeman, pers. comm.).

We therefore proposed (and were funded for) an additional year of banding during summer 1999, necessitating an additional year of resighting fieldwork during summer 2000. The data analysis and writeup were projected into FY01. This extra year would boost our sample sizes into an optimal range, and allow for three years of resighting effort. However, it is clear that 4 years of resighting data are desirable for robust analyses of survival data (above), and we did not quite achieve our target sample size for kittiwakes on Chisik Island. We therefore propose to continue

banding kittiwakes at Chisik in FY00, and conduct one more year of re-sighting in FY 2001. This would also allow us to continue coordination of survival studies with the study of physiological stress (EVOSTC Project 99479), which has continued funding for field work in FY01.

We are not asking for more funds to conduct this additional resighting work beyond what we had originally proposed for analysis and write-up in FY2001. The fall and winter of 2000-2001 will still be spent compiling survival data, analyzing it with respect to stress and food availability data, and preparing draft reports (at least introduction, methods, some results and preliminary conclusions). In May of 2001, we will do one more intensive re-sighting effort (re-sighting only, no banding or other bird work) to get the final (4th year) of re-sighting with which to assess survival. We do not expect these data to change the main conclusions, rather to provide more robust statistical results. These results will be quickly incorporated into the final database, analyzed, and reported by September 2001. Any additional costs required for this effort will be covered by USGS.

Cooperating Agencies, Contracts, and Other Agency Assistance

Personal Services contracts may be used for statistical consultation and programming assistance.

SCHEDULE

A. Measurable Project Tasks for FY 01

Oct. 1-Jan. 31:	Evaluate results of FY00 work
Feb. 1-April 15:	Compile results from all years, analyze and initiate report
March:	Attend EVOS Symposium
April 15-May 30:	Last resighting effort on Gull and Chisik Is.
June 30-July 31:	Compile FY01 re-sighting results, analyze all 4 years data
Aug. 1- Sep. 15:	Complete report
Sep. 15:	Submit Draft Final Report to EVOSTC
Sep. 15- Dec. 31:	Completion and submission of papers for publication in peer-reviewed journals
Dec. 31:	Submit Revised Final Report to EVOSTC

B. Project Milestones and Endpoints

June 30, FY 01:	Resighting fieldwork will be completed
Dec. 31, FY02:	Final Report Complete and Submitted to EVOSTC
Dec. 31, FY02:	Submission of papers for publication in peer-reviewed journals

C. Completion Date

Our proposed research takes advantage of a natural comparative system (failing vs. thriving colonies) to reduce the time required to test the hypothesis that increased energy expenditure and stress during the breeding season will decrease adult survival. We propose three full field seasons of banding, re-sighting, and collection of productivity data (FY98, FY99, FY00) and one season of re-sighting only (FY01) to ensure an adequate sample size for robust analysis of survival. Efforts in FY01 and part of FY02 will focus on data compilation, analysis and publication of research results in peer-reviewed journals.

PUBLICATIONS AND REPORTS

The final planned product of the proposed research will be the final report detailing all findings, due on Sep. 15, 2001. Publication of project results in peer-reviewed journals will be pursued as soon as scientifically appropriate and logistically possible.

PROFESSIONAL CONFERENCES

Results of this project will be presented during FY02 at the Annual Meeting of the Pacific Seabird Group, or at other professional meetings where appropriate.

NORMAL AGENCY MANAGEMENT

This research would not be conducted as a normal part of USGS 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.

Logistic support from the USFWS and AMNWR will include vessel use, storage facilities, laboratory space, computer usage, and communications. Field sites and research platforms will be shared with the EVOSTC-funded APEX and sand lance projects.

EXPLANATION OF CHANGES IN CONTINUING PROJECT

The design of the proposed work has not changed. As explained above in 'Methods', however, banding efforts were extended by one year, and we propose one more re-sighting effort in FY01. This will give us 4 years of re-sighting data, greatly improving our ability to measure significant differences in survival of murres and kittiwakes at Gull and Chisik islands.

PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Dr. John F. Piatt, Research Biologist (GS-14) with the Alaska Science Center, Biological Resources Division, USGS in Anchorage. Obtained a Ph.D. in Marine Biology from Memorial University of Newfoundland in 1987 (dissertation on seabird-forage fish interactions). 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 and oversight of the proposed research.

PROJECT LEADER

Thomas I. Van Pelt, MSc. student at the University of Glasgow, Scotland, and current employee (GS-9) of the Alaska Biological Science Center. Over seven years of experience working in Gulf of Alaska and Aleutian marine ecosystems. Responsible for project design, logistics, data analysis, and preparation of manuscripts and reports.

OTHER KEY PERSONNEL

Ann Harding and Mike Shultz (USGS/BRD staff involved with APEX project) will share responsibility for fieldwork, data management and analysis, and manuscript preparation.

COLLABORATORS

Dr. Alexander S. Kitaysky, University of Washington, Dept. of Zoology. Will collaborate on project design and provide advice on methodology and analyses.

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Table 1. Power analysis of sample size (in a two by two table). One minus beta is power; a power of <0.50 is typical in survival estimations. One minus alpha is the confidence interval. Ps and Pe are estimated survival fractions at two hypothetical colonies. Thus, with a sample size of 47 (banded birds per colony), we would expect to resolve a 6% difference (Ps minus Pe) with a power of 0.51 and 90% confidence intervals. With a sample size of 185, we would expect to resolve a 4% difference with a power of 0.75 and 95% confidence intervals. In general, as sample size doubles, variance is halved (Heisey and Fuller, 1985). Resolution of differences <4% demands unacceptably large sample sizes.

alpha	Zalpha	beta	Zbeta	Ps	Pe	n =
0.10	1.18	0.25	0.68	0.92	0.89	352
0.10	1.18	0.49	0.01	0.92	0.89	226
0.05	1.65	0.25	0.68	0.95	0.91	185
0.05	1.65	0.25	0.68	0.95	0.90	125
0.10	1.18	0.25	0.68	0.95	0.90	100
0.10	1.18	0.49	0.01	0.94	0.89	72
0.10	1.18	0.49	0.01	0.95	0.89	47

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Table 2. Number of birds color-banded by year, location, and species.

Year	Gull Island		Chisik Island	
	Murre	Kittiwake	Murre	Kittiwake
1996	0	9	0	0
1997	30	40	132	69
1998	101	108	56	71
1999	68	114	74	29
Total	***199***	***271***	***262***	***169***

Grand Total: 901 (Gull 470; Chisik 431)
Note: Not included in total are 30 murres and 40 kittiwakes banded on Gull in 1997, but experimentally manipulated.

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$41.0						
Travel		$0.0						
Contractual		$0.0						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$41.0			Estimated FY2002	Estimated FY2003		
General Administration		$6.2						
Project Total	$0.0	$47.2			$0.0	$0.0		
Full-time Equivalents (FTE)		0.8						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
Requested funds in FY01 for personnel only-- and slightly higher than projected cost last year ($46.4) owing to employee wage increases.
Funds required for brief, intensive re-sighting effort in FY01 will be provided by USGS base funds.
Estimated at about 10K for temporary Biotech and volunteers, 8K for travel, charters and transportation, 3K for supplies and boat maintenance,

FY01

Prepared: 04/13/00

Project Number: 01338
Project Title: Survival of Adult Murres and Kittiwakes
Agency: U.S. Geological Survey

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	
Name	Position Description					
Thomas van Pelt	Wildlife Biologist	GS-9	10.0	4.1		
	Subtotal		10.0	4.1	0.0	
					Personnel Total	

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	
Description					
none					
				Travel Total	

FY01

Prepared: 04/13/00

Project Number: 01338
Project Title: Survival of Adult Murres and Kittiwakes
Agency: U.S. Geological Survey

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Contractual Costs:	
Description	
none	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	
Commodities Costs:	
Description	
none	
Commodities Total	

FY01

Prepared: 04/13/00

Project Number: 01338
Project Title: Survival of Adult Murres and Kittiwakes
Agency: U.S. Geological Survey

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	
Description			
none			
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	

Existing Equipment Usage:	Number of Units	
Description		

FY01

Prepared: 04/13/00

Project Number: 01338
Project Title: Survival of Adult Murres and Kittiwakes
Agency: U.S. Geological Survey