Project Title:	***Pigeon Guillemot Restoration Research at the Alaska SeaLife Center***
Project Number:	01327
Restoration Category:	Research (continuing)
Proposed By:	Daniel D. Roby, Oregon State University (Objectives 2 and 3) George J. Divoky, Research Associate, UAF Institute of Arctic Biology (Objective 1)
Lead Trustee Agency:	USGS
Duration:	4th year, 4-year project
Cost FY 01:	$43,916 (estimated for Objective 1) $49,684 (estimated for Objectives 2 and 3)
Geographic Area:	Alaska SeaLife Center, and adjoining areas of Resurrection Bay
Injured Resource/Service:	Pigeon Guillemots, other injured seabird resources

ABSTRACT

This study tests the feasibility of direct restoration techniques for Pigeon Guillemots (e.g., installation of artificial nest sites, use of social attractants, captive propagation and release), a seabird species that was injured by the EVOS and has failed to recover. While raising young guillemots in captivity it will also be possible to conduct controlled experiments crucial to two other restoration objectives: (1) development of nondestructive biomarkers of petroleum hydrocarbon contamination in seabirds, and (2) understanding how dietary factors (prey species composition, prey size, lipid content, feeding frequency) constrain growth, development, and condition at fledging in guillemots and other fish-eating seabirds.

STUDY HISTORY

The first field season for this study was in 1998. During the 1998 field season a total of 44 guillemot eggs and 2 guillemot chicks were collected from nests in the wild and transported to the SeaLife Center for incubation and/or captive rearing. A total of 23 eggs were hatched (52% hatching success) and a total of 23 chicks were successfully fledged from the roof of the SeaLife Center. Blood samples were collected from chicks at predetermined ages for baseline levels of certain biomarkers. Chicks were raised on one of four types of forage fish: juvenile Pacific herring, Pacific sand lance, juvenile walleye pollock, or crescent gunnels. Growth rates were monitored on all chicks and they was found to be positively correlated with daily energy intake.

Success in hatching the 70 eggs collected in 1999 was 70% as compared with the 52% hatching success in the first year of the project. The increase in hatching success between the first and second years of this project are likely due to: 1) the differential success of hatching from different sites, 2) decreased vibration or other unintentional mishandling of the eggs in 1999, compared to 1998, after collection leading to damage to the developing embryo and/or 3) the horizontal transport of eggs in 1999 as compared to the vertical egg transportation in 1998. Nestling survival for chicks collected in the wild in 1999 was 89.3%, whereas it was only 71.4% for chicks hatched from eggs that were artificially incubated. All mortality for chicks collected in the wild (n = 3) occurred soon after collection, either in the field or during transport. All mortality for chicks hatched in captivity (n = 14) occurred in the first 11 days post-hatch and was apparently due to either brooder equipment malfunction (n = 9), lower GI tract blockage of unknown causes (n = 3), or microbial infections of the lower GI tract (n = 2). Thus, 61% of all eggs and chicks collected for captive-rearing in 1999 were successfully fledged into the wild. The fledging time of these chicks was found to correlate remarkably well with the period of civil twilight. In 1999, chicks were raised on two different forage fish: juvenile Pacific herring and juvenile walleye pollock. Once again, growth was found to be positively correlated to daily energy intake. Groups of chicks were dosed with different levels of weathered Prudhoe Bay crude oil (PBCO). Blood samples and excreta samples were taken before and following dosing for ongoing and future examination of biomarkers for oil exposure.

INTRODUCTION

The Pigeon Guillemot (*Cepphus columba*) population in Prince William Sound has failed to recover from declines that occurred both before and after the *Exxon Valdez* Oil Spill (EVOS). Post-spill studies of Pigeon Guillemot reproductive success have identified three primary factors preventing recovery:

1) In Prince William Sound (Naked and Jackpot islands) and Kachemak Bay, predation on eggs and chicks has been a major source of nesting failure (Hayes 1996, Prichard 1997, Golet 1999).

2) There has been a decline in the proportion of sand lance in the diet at some guillemot colonies in Prince William Sound (e.g., Naked Island) and Kachemak Bay, and the proportion of high-lipid schooling forage fish in the diet has been shown to be a key factor in guillemot reproductive success at both sites. The Alaska Predator Ecosystem Experiment (APEX) Project components F (Factors Limiting Pigeon Guillemot Recovery), G (Seabird Energetics), and M (Seabird/Forage Fish Studies in Lower Cook Inlet) are investigating the relationship between a lack of recovery in guillemot populations injured by the EVOS and the availability and quality of forage fish. A decline in availability of high-lipid forage fishes (sand lance, herring, capelin) in the last two decades may be responsible for lower growth rates, fledging weights, post-fledging survival, and adult recruitment in guillemot populations within the oil spill area.

3) The Nearshore Vertebrate Predator (NVP) Project (River Otter and Pigeon Guillemot component) tested the hypothesis that exposure to residual oil from the spill continues to limit recovery of Pigeon Guillemots. Pigeon Guillemots feed on a diversity of nearshore demersal fishes and schooling forage fish that use the substrate to avoid predators (e.g., sand lance), prey that were likely injured by EVOS. The approach of the NVP study is to measure certain biomarkers in blood and compare biomarker levels in nestlings from oiled and nonoiled areas. These blood biomarkers still need to be calibrated to known doses of weathered Prudhoe Bay Crude Oil (PBCO) in a controlled, laboratory setting.

This research has been and is being conducted at the Alaska SeaLife Center in Seward and addresses all three of the above limiting factors. Experimental studies using captive subjects are integrated with raising Pigeon Guillemot nestlings in captivity in order to establish free-ranging guillemot breeding colonies in the vicinity of the SeaLife Center. Predator-free nest sites have been built in the vicinity of the SeaLife Center and, in association with the use of decoys and audio playbacks of guillemot calls, are being used to help attract and recruit prospecting guillemots to breed. Guillemot populations are frequently nest-site limited (Storer 1952) and Pigeon Guillemots readily breed in anthropogenic structures, such as docks and breakwalls, at many locations throughout the species' range. Like most seabirds, guillemots are philopatric to their natal location, and cohorts raised in captivity at the SeaLife Center and released there can be expected to return and attempt to breed in the surrounding area. Although guillemots only rarely breed before three years of age, prospecting 2-year-olds that were raised in the first year of this three-year study can be expected to visit the SeaLife Center during the 2000 breeding season and furthermore, guillemots from the larger 1999 cohort may be expected to be seen during the 2001 breeding season.

Providing artificial nest sites has the potential to restore guillemot populations through enhancing both local recruitment of adults and nesting success. Our success in recruiting prospecting adult guillemots to use artificial nest sites and the proportions of captive-reared and immigrant guillemots that utilize artificial nest sites will allow us to test the feasibility of this direct restoration technique for enhancing recovery of guillemot populations in the EVOS area.

The proposed work is intended to result in the establishment of breeding colonies of free-ranging Pigeon Guillemots near the SeaLife Center. By banding immigrants to the colony and young that are raised and released at the SeaLife Center, we can establish a breeding colony comprised of known-age individuals whose breeding history is known. Accessibility of nest sites can be a major obstacle for studies of factors influencing nesting success and demographics of guillemots, and artificial nests sites can provide investigators with unique opportunities. A dockside Black-legged Kittiwake colony in Great Britain has been studied for the past 30 years and provided most of what is known about that species in the northeastern Atlantic (i.e., Coulson 1988). Establishment of Pigeon Guillemot colonies near the SeaLife Center has the potential of providing a similar resource, in addition to providing opportunities for integration with ASLC's public education program.

Besides providing recruits for the breeding colony of free-ranging guillemots to be established at ASLC, raising chicks in captivity will also provide the opportunity to conduct controlled experiments that are relevant to two major issues in Pigeon Guillemot restoration: (1) the effect of prey type, size, quality, and frequency of delivery on nestling growth rates and condition of young at fledging and (2) the utility of biomarkers in blood and excreta as indicators of exposure to crude oil and other environmental contaminants. Research on these two topics can best be conducted using captive subjects whose environment and diet can be carefully controlled to

avoid confounding variables so common in natural populations. In the first three years of this study (1998-2000), chicks were raised on different diet regimes to determine the effects of the prey type on growth rates. Chicks were fed either high-lipid schooling forage fishes (sand lance, herring), low lipid forage fish (juvenile walleye pollock), or nearshore demersal fishes (crescent gunnel, high cockscomb). These controlled feeding experiments end in FY 2000. The results from this study will complement continuing studies on the role of diet for productivity of nesting guillemots that are part of the APEX Project.

In FY 1999 and 2000, some chicks that are raised in captivity have been fed small, sublethal doses of weathered Prudhoe Bay crude oil (PBCO). Subsequent to dosing, samples of blood and excreta have been collected at prescribed intervals for measurement of biomarkers of health status. These results will allow us to define the dose-response relationship between ingested PBCO and each biomarker of exposure. Such results are essential for evaluating the efficacy of particular biomarkers and the utility of these biomarkers for assessing the exposure of free-ranging guillemots to oil.

Of particular value for interpretation of the results of captive feeding trials and crude oil dose-response experiments will be the subsequent release of these subjects and measurements of their return rates in subsequent years. Although it can not be assumed that all young guillemots that are fledged from the ASLC and survive to breeding age will return to breed near ASLC, the return rates of nestlings raised on various diets, plus return rates of oil-dosed and control nestlings, will provide valuable information on the long term effects of prey composition and oil exposure for guillemot fitness.

In FY 2001, the final year of the study, nest boxes will be checked for recruitment of pigeon guillemots and return rates of banded chicks from 1998-1999 captive released cohorts will be examined. As well, data relating to the social attraction portion of the project will be written for peer-reviewed scientific journals. Results of the growth and oil dosing experiments will be written up as a Master's thesis and be submitted to peer-reviewed scientific journals.

NEED FOR THE PROJECT

A. Statement of Problem

In the last two decades the Pigeon Guillemot population in Prince William Sound has declined from 15,000 to 5,000 individuals (Laing and Klosiewski 1993). While this decline apparently began prior to the EVOS, an estimated 10-15% of the population in the spill area died as a direct result of the spill. Post-spill censuses have not detected an increase in numbers, suggesting no appreciable recovery has occurred in the aftermath of the spill. Reasons for the lack of recovery are unclear, but may be related to changes in prey resource availability, continuing exposure of guillemots or their prey to oil, or nesting failure due to predation on guillemot eggs and/or nestlings.

Predation on Pigeon Guillemot eggs and chicks was apparently minimal before EVOS, but post-spill studies have frequently recorded high levels of predation from river otters and mink (Hayes 1995). High predation rates could be reducing production of local birds, increasing breeding dispersal (lack of fidelity to a previously used nest site or location) of established breeders, and decreasing the immigration of guillemots from other colonies. While Pigeon Guillemots typically have high fidelity to their breeding site, disturbance and lack of breeding success can increase the rate and distance of breeding dispersal. Populations suffering high levels of

disturbance, such as persistent nesting failure due to terrestrial predators, will decline due to a lack of production of new recruits, dispersal of breeding birds, and/or decreased immigration.

Two recent EVOS projects have identified potential reasons for a lack of recovery by Pigeon Guillemots in the EVOS area. The APEX Project has identified a major shift in the nearshore ecosystem that has apparently resulted in fewer high-lipid schooling fish, particularly sand lance (*Ammodytes hexapterus*) fed to chicks (Oakley and Kuletz 1994, Golet et al. unpubl. ms.). Pre-spill studies found sand lance, a nearshore schooling fish with relatively high average energy density, to be the dominant prey returned to chicks. Post-spill studies have found gadids and nearshore demersal fish to constitute the majority of the diet. The NVP project has attempted to determine if blood biomarkers can be used to monitor level of exposure to oil and if blood from individuals in wild populations currently indicates exposure to oil is occurring. Both of these projects have examined wild populations that are exposed to numerous sources of variability that confound the examination of factors affecting chick growth or blood biomarkers.

Dose-response experiments with guillemot nestlings fed small, sublethal amounts of weathered Prudhoe Bay crude oil may provide crucial validation and calibration results for interpretation of on-going and completed studies of biomarkers as indicators of crude oil exposure. Experimental studies with captive-reared guillemots will also provide a better understanding of how shifts in the diet of guillemots and other seabirds breeding in the EVOS area affects growth, development, fledging condition, and, ultimately, fitness. By monitoring the growth and development of nestlings raised on controlled rations, the relative nutritional quality of various prey can be assessed. Also, fitness tradeoffs between prey size/quality and provisioning rate can be assessed through monitoring of subsequent survival in the wild of captive-reared chicks. Understanding the constraints imposed on guillemots by diet composition, oil exposure, and nest site quality will be crucial for designing management initiatives to enhance productivity in this and other seabird species that are failing to recover from EVOS.

B. Rationale/Link to Restoration

Artificial nest sites have the potential to increase the size of both guillemot breeding colonies and populations. A Black Guillemot colony in arctic Alaska increased from 10 to 225 pairs in 17 years through provision of artificial nest sites (Divoky et al. 1974 and in prep.). In Washington State 27% of the 33 Pigeon Guillemot colonies are in piers or other anthropogenic structures (Speich and Wahl 1989). Establishment of a Pigeon Guillemot colony near the Alaska SeaLife Center will demonstrate the utility of direct restoration in assisting the recovery of Pigeon Guillemot populations in the northern Gulf of Alaska. If artificial nest sites are successful in attracting breeding adults and if successful reproduction ensues, artificial nest sites can be used in Prince William Sound to enhance productivity, recruitment, and immigration, all of which will facilitate recovery. Clusters of artificial nest sites similar to those at the ASLC can be installed near natural colonies that suffer from chronically high nest predation rates. Nests could be placed on pilings or "dolphins" constructed specifically for colony development.

Aside from providing prototypes for artificial colonies in other parts of the EVOS area, a breeding colony of free-ranging guillemots at the ASLC will allow investigators to conduct research on Pigeon Guillemots that would not be possible at natural colonies. Loss of eggs or chicks to predation has been a major source of nest failure in post-spill studies of Pigeon Guillemots in Prince William Sound (Hayes 1995, Golet 1999). In addition, marked adults and returning young will allow an examination of demographics that has not been possible in Prince William Sound studies. A lack of recovery could be due to demographic parameters (e.g., adult survival, subadult survival, immigration/emigration rates) not evident in studies of nesting

success or colony censuses. Guillemot demographics are much more easily studied at a colony of artificial nest sites where the banding of chicks and adults entails far fewer problems than at natural colonies. Should the proposed work result in the deployment and use of significant numbers of artificial nest sites in Prince William Sound, investigators will be able to obtain demographic information for that area that could explain the lack of recovery of local populations.

While the colonies of Pigeon Guillemots that we are attempting to established near the ASLC will have the benefit of captive-reared chicks returning to their natal location and assisting in establishment of the colony, immigration is obviously the source of adults founding new colonies. Immigrants can also be the primary source of recruits to established and expanding colonies (Petersen 1981). Unlike many seabirds, guillemots are semi-colonial and able to breed as single pairs as well as colonially. Prospecting guillemots can be expected to search for nesting opportunities more extensively than more colonial seabirds, which require minimum numbers of conspecifics for successful breeding. Nest sites at ASLC are likely to attract nonbreeding prospectors from the approximately 100 pairs of Pigeon Guillemots breeding between Aialik Cape and Cape Resurrection (Nishimoto and Rice 1987), as well as more distant colonies. An expanding colony of Black Guillemots in arctic Alaska drew most of its recruits from colonies more than 400 km distant (Divoky, in prep.).

A Pigeon Guillemot colony could also have the potential of attracting other seabird species to nest in the area of ASLC. Some of these other species may also be recruited by providing nest sites. A Black Guillemot breeding colony that utilized artificial nest sites in arctic Alaska also attracted Horned Puffins (*Fratercula corniculata*), some of which used the artificial nest sites (Divoky 1982 and unpubl.).

The research component of this study will allow evaluation and validation of the use of nondestructive biomarkers (in blood and excreta) to assess the health status of individual guillemots and potential exposure to petroleum hydrocarbons. There is evidence that certain acute phase proteins (i.e., haptoglobin) in blood and porphyrins in excreta are induced by ingestion of sublethal doses of weathered crude oil (Prichard et al. 1997). The results of a dose-response experiment with wild guillemot nestlings in their natural nest sites, however, were ambiguous because of among-site variability in baseline values for biomarkers (Prichard et al. 1997). Also, guillemot nestlings were fed small doses (0.05-0.2 ml) of highly weathered PBCO in that study; and the dose levels were not sufficient to cause even a significant decline in growth rates of nestlings. Finally, blood samples for measuring biomarker levels were not collected until five days post-dosing, when any induction of an acute phase response had already likely peaked. Regardless of all these uncontrolled factors, the serum haptoglobin levels in guillemot chicks fed 0.2 ml of weathered PBCO were significantly different from that of controls. While the use of blood and fecal biomarkers for monitoring oil exposure and general population health of guillemots is promising, more research under controlled, captive conditions is required to validate the techniques and provide a sound basis for interpretation of results from wild guillemots.

There is a need for information on the relationship between diet and reproductive success for Pigeon Guillemots, a seabird species that is failing to recover from EVOS at an acceptable rate. 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 prey on a wide variety of fishes, including schooling forage fish (e.g., sand lance, herring, pollock) and subtidal/nearshore demersal fish (e.g., gunnels, blennies, sculpins; Drent

1965, Kuletz 1983). There is strong evidence of a major shift in diet composition of guillemot pairs breeding at Naked Island. Sand lance were the predominant prey fed to young in the late 1970s (Kuletz 1983), but currently sand lance is a minor component of the diet (G. Golet, unpubl. ms.). In contrast, guillemots breeding in Kachemak Bay continued to provision their young predominately with sand lance up through the 1996 breeding season, and sand lance was particularly prevalent in the diet at sites that support high densities of breeding pairs (Prichard 1997). Also, young of breeding pairs that provisioned their nestlings with mostly sand lance had higher growth rates (Prichard 1997, Golet et al. unpubl. ms.). Jackpot Island in southwestern Prince William Sound supports the highest nesting densities of guillemots anywhere in the Sound and growth rates of nestlings are correspondingly high. The high availability of juvenile herring to guillemots nesting at Jackpot Island may be responsible for both the high nesting density and high growth rates. Thus availability of high-quality schooling forage fishes (herring, sand lance) may be crucial for maintaining high nesting densities of guillemots.

C. Location

All captive rearing studies will be completed by FY 00. Guillemot eggs and hatchlings (<10 days post-hatch) were obtained from source colonies on the Kenai Peninsula, Kodiak Island, non-oiled parts of Prince William Sound, Southeast Alaska, or at other appropriate northern Gulf of Alaska colonies. The impact of these collections on the productivity of source colonies should have been negligible, as eggs lost during the first half of incubation are usually replaced during renesting and the majority of guillemot nesting attempts in the NGOA fail to produce fledglings because of high nest predation rates (see annual progress reports for EVOS Trustee Council projects 163F and 163M). All the captive-reared chicks that reach fledgling age in good health will be banded and released at ASLC to assist in efforts to establish local breeding colonies of free-ranging guillemots near ASLC. Artificial nest sites will be maintained near ASLC on an adjacent breakwater and other sites to enhance the prospects for colony establishment. Colonies in Resurrection Bay that may serve as sources of immigrants or may recruit captive-reared guillemots will be censused and checked for banded adults during the final year of the project, 2001 Other nesting platforms will be checked for recruitment of guillemots, as well. The information obtained from this project will benefit Pigeon Guillemot populations in the Gulf of Alaska, especially Prince William Sound. An understanding of the affect of prey type on chick growth will help explain the role of ecosystem shifts in continuing declines of Pigeon Guillemot populations. Assessing the utility of blood biomarkers for detecting and quantifying exposure to crude oil will benefit efforts to monitor the health status of Pigeon Guillemot populations throughout the spill zone without resort to lethal sampling procedures.

Laboratory analysis, including proximate composition analysis of fish will continue at Oregon State University. Scott Newman at UC-Davis, will aid in the analysis of blood biomarkers. Further assistance will be achieved using Alexander Kitayski at the University of Washington to examine the role of corticosterones in stress of dosed vs. undosed birds. Larry Duffy of the University of Alaska-Fairbanks may also aid in examination of haptoglobin induction in blood.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

All research will be conducted at the Alaska SeaLife Center, which will allow the community in and around Seward to observe progress in the establishment of guillemot colonies in both artificial and natural nest sites. Wild breeding colonies near ASLC have the potential for involving science classes from local schools. The location of colonies will potentially permit easy viewing by the public and allow science teachers to use the colony for instruction about

seabird breeding biology and restoration. Science classes could conduct observations on the occurrence and activities of prospecting and breeding guillemots. Some of these (timing of arrival in the spring and sightings of color banded adults) could provide important information for the period when the investigators are not in Seward. Local science teachers can receive annual summaries of information about local colonies (e.g., timing of clutch initiation, breeding success) that can provide the basis for lessons on regional climate change and annual variability in the marine environment. The Seaquest Program of the Chugach School System would be a logical avenue for presenting this material to students.

PROJECT DESIGN

A. Objectives

Dr. George Divoky will undertake Objective 1:

1. Determine the feasibility of using direct techniques for restoration of Pigeon Guillemots, including:
    a) providing artificial nest sites
    b) use of social attraction, such as decoys and playbacks of vocalizations
    c) checking for recruitment of breeding adults to established artificial nest sites
    d) monitoring recruitment of chicks fledged from the SeaLife Center from 1998-1999 in colonies in Resurrection Bay and at the artificial nest sites at the SeaLife Center

Dr. Dan Roby will undertake Objectives 2 and 3:

This portion of the research project has the two primary objectives listed below. During the final year of the project (FY 01), the emphasis will be on interpreting data related to both objectives 2 and 3.

2. Determine the response of particular biomarkers of crude oil exposure (acute phase proteins, plasma sodium, corticosterone, fecal porphyrins) to variables of exposure in guillemot nestlings, and the survival of exposed nestlings post-fledging. Exposure variables that will be examined include:
    a) dose of ingested oil
    b) degree of weathering of ingested oil
    c) time since ingestion of dose
    d) number of previous exposures

2. Determine the effect of diet variables on growth performance, development, fledging condition, and post-fledging survival of Pigeon Guillemots, including:
    a) type of forage fish consumed, with emphasis on high-lipid forage fishes vs. low-lipid fishes
    b) lipid content of the diet
    c) size of prey items
    d) frequency of prey delivery

B. Methods

The partially completed (objective 1) and completed work (objective 2 and 3) will test the following three basic hypotheses, which relate to each of the three primary objectives listed above:

Hypothesis 1. Artificial nest sites, decoys, and playbacks of vocalizations can be used to establish new Pigeon Guillemot breeding colonies and enhance breeding success over that experienced at natural colonies using natural nest sites.

Hypothesis 2. Biomarkers from plasma and excreta of nestling Pigeon Guillemots can be used as indicators of exposure to weathered crude oil in the food supply, and the subsequent survival probabilities of young guillemots post-fledging.

Hypothesis 3. Growth performance, fledgling condition, and post-fledging survival of Pigeon Guillemot nestlings are sensitive to differences in prey type, prey size, feeding frequency, and lipid content of prey.

Methodology employed during the third year of the study (FY 00) will consist of the following:

Objective 1: Testing Feasibility of Direct Restoration Techniques
Dr. George Divoky

a. Installation of Artificial Nest Sites and Use of Social Attraction

Pigeon Guillemot nest sites have been constructed and installed at several locations in the vicinity of the Alaska SeaLife Center. Additional nest sites will be provided at each location if the number of breeding birds and prospecting adults exceeds the number of available nest sites. Design of the artificial nest sites was based on the sites developed by Dr. Divoky for Pigeon Guillemots in Puget Sound, with modifications based on studies of nest site characteristics that were associated with nesting success in Kachemak Bay (Prichard 1997). Sites have two entrances with a central nesting cavity. Baffles in the entryways to the nest cavity prevent avian predators from viewing nest contents. Based on the locations of Pigeon Guillemot nest sites associated with docks and piers, it appears that placing the sites beneath an overhang will increase their attractiveness to guillemots prospecting for nest sites. Sites under an overhang apparently have the advantage of decreased avian predation. Sites are large enough to accommodate monitoring devices (such as a closed circuit camera, platform scale, or activity monitor) that may be used in future research.

Guillemot decoys have been made from molds produced by Mad River Decoy in Vermont. A CD player with external speakers was used to play adult Pigeon Guillemot calls from May to mid August. Because prospectors may make recruitment decisions based on local breeding productivity (Boulinier et al. 1996), from late June to late August the calls of chicks in nest sites were also be played during the early morning and evening, when colony attendance can be expected to be highest. Similar combinations of decoys and audio playbacks have been used successfully for other seabird species, including alcids (Kress and Nettleship 1989, Kress 1983), but have never before been used to attract guillemots to nest at new locations.

We will begin systematic observations of artificial nest sites and decoy sets in May. Daily observations will be conducted at the times expected to have maximum colony attendance (0600-0900 and 1600-2000 Alaska Daylight Time, high tides). Initially observations will be recorded every 15 minutes on the number of Pigeon Guillemots visible from the roof of ASLC and their distance from artificial nest sites. Once guillemots begin associating with decoys and nest sites, we will conduct detailed observations on the behavior of prospecting birds. The location and

activities of prospectors will be recorded during 15-minute periods. Behavioral observations will be similar to those conducted by Preston (1968) on Black Guillemot social behavior.

b. Monitoring of Pigeon Guillemot Breeding Biology and Demographics

Should breeding occur in the artificial nest sites in 2001, we will obtain information on the breeding biology of birds using the nest sites. To reduce the chances of nest site abandonment, no adults will be captured during 1999, but if successful breeding takes place in 2000, we will attempt to noose breeding adults for banding in 2001. In 2001 the following breeding parameters will be monitored:

- date of clutch initiation
- egg weight and volume
- egg color and pattern
- date of hatching
- weight at hatching
- hatching success
- growth rate (measured every two-four days)
- fledging weight
- fledging age
- fledging success

The observations on breeding chronology and success can be compared with the recently completed monitoring of Pigeon Guillemot nesting in Prince William Sound and Kachemak Bay. Additionally the information on egg size and color can be used in future years to assess the potential of using egg characteristics to measure female survival and recruitment.

During the nestling period we will conduct observations on the prey types delivered to chicks. These observations will determine the taxonomic composition of nestling diets at each nest and collectively. These observations will be compared with diet data collected at natural colonies in Prince William Sound and Kachemak Bay (Golet unpubl. ms., Prichard 1997).

c. Recruitment of captively-reared pigeon guillemots.

We will attempt to locate guillemots that were raised at the Alaska SeaLife Center at regional colonies during our surveys. Resightings of banded guillemots from the ASLC will provide information on survival (by both year and experimental group) and dispersal distance for this species. Intercolony visits are common for pre-breeding alcids (Harris 1983, Kress and Nettleship 1989), and in 2001 we will search these colonies for banded individuals that were raised in captivity at ASLC in 1998 and 1999. Additionally, any recruits at the artificial nest sites at the ASLC will be monitored in the same way as above.

Objective 2. Validation and Calibration of Nondestructive Biomarkers for Monitoring the Health and Exposure to Oil of Guillemots
Dr. Dan Roby

We will be interpreting data relating to this objective in 2001.

a. Measurement of Certain Blood Biomarkers of Petroleum Hydrocarbon Exposure

In the third year of this study (FY 00), research on blood biomarkers of oil exposure will include controlled dose-response experiments with weathered PBCO. A range finding experiment will be conducted to determine the no-effect dose for guillemot chicks consuming weathered PBCO. We will also determine the time course of biomarker response to ingestion of PBCO, including the time post-ingestion when biomarker induction is no longer detectable. At days 15-25 post-hatch, we will feed guillemot chicks small, sublethal doses of weathered PBCO in number 2 gelcaps that are inserted into the abdominal cavity of a fish that is then fed to the nestling. Eight guillemot nestlings raised on herring (see below) will be assigned to each of the following oil ingestion treatments: control, 1.0 ml (total) of weathered PBCO, and 2.0 ml (total) of weathered PBCO. Control chicks will receive 1 ml (total) of corn oil in a number 2 gelcap inserted in a food fish. We know from previous experiments (Prichard et al. 1997) that a dose of 0.2 ml of weathered PBCO ingested three times during the latter part of the nestling development period does not have a significant effect on growth of Pigeon Guillemots. Consequently, these doses are designed to identify the "no-effect" dose for weathered PBCO.

Just before and following ingestion of the oil dose, we will collect 0.8 ml of blood in heparinized vials by puncturing the tarsal vein. Blood samples will be collected at 0 days, 2 days, 5 days, and 10 days after the initial day of ingestion of oil. Blood samples will be kept cool and centrifuged at 3,000 rpm for 20 minutes. Plasma will then be removed with a pipette and stored in snap-top plastic vials at -20^{o}C for laboratory analysis at the University of California Davis and the University of Washington. In the lab, we will measure haptoglobin and other acute phase protein levels in plasma samples in order to determine dose-response and time course of the response. Assays for blood biomarkers will be conducted in the laboratory of Dr. Scott Neuman at UC Davis. Blood biomarker levels will be compared among the control chicks raised on the three diets (see below) to assess the role of diet in determining baseline biomarker levels, relative to induction caused by ingestion of PBCO. Levels of corticosterones, measuring general stress levels, will be assayed in the lab of Alexander Kitayski at the University of Washington.

b. Measurement of Biomarkers in Excreta

In addition to collection of blood samples, samples of excreta will be collected over 24-h intervals each day after the intitial dosing of PBCO in order to measure fecal porphyrin levels and determine dose-response and time course of response. As with blood biomarkers, responses in fecal porphyrin levels will be compared among the three diet groups. Measurements of fecal porphyrins in excreta will be conducted in the laboratory of Dr. Larry Duffy at the University of Alaska Fairbanks.

Objective 3. Captive Feeding Trials to Assess the Relationship between Diet and Postnatal Development in Guillemots
Dr. Dan Roby

We will be interpreting data relating to this objectives in 2001.

a. Comparison of Guillemot Growth Performance on Diets of High-lipid or Low-lipid Schooling Forage Fish

In FY 00, 8-12 guillemot chicks will be raised on each of two diets: (1) 160 g of herring per day, or (2) 160 g of juvenile walleye pollock per day. These prey species are major components of guillemot chick diets at certain sites and the three species are representative of the two very different lipid levels in guillemot prey. These daily rations are designed so as to provide a variety

of caloric and lipid consumption rates that are within the normal range experienced by guillemot nestlings, but biomass consumption rates would be the same for each diet group. Herring and sand lance are representative of high-lipid forage fishes with relatively high energy densities. Juvenile walleye pollock are representative of low-lipid forage fishes with relatively low energy densities. Each chick will be kept in a separate cage so that food consumption can be monitored individually. The daily rations will be provided to most chicks in four daily feedings of 40 g each at approximately 8:00, 11:00, 15:00, and 19:00 ADT. Each day prior to the first feeding the body mass and wing length of each chick will be measured until each captive-reared chick fledges into the wild, at about 35-40 days post-hatch. Return rates of subadults in this final year of this study will allow us to assess the role of prefledging nutrition and fledging mass on subsequent post-fledging survival.

Approval of the field protocols for work with live birds described in this DPD have been obtained from the Institutional Animal Care and Use Committee at Oregon State University and from ASLC. Any take of eggs or incidental/unintentional take of nestling or adult guillemots will be covered by relevant Federal and State Scientific Collecting permits. All fledgling, captive-reared guillemots released to the wild were banded with USFWS stainless steel leg bands and polyvinyl colored leg bands under a Master Station banding permit held by the Oregon Cooperative Fish and Wildlife Research Unit.

C. Contracts and Other Agency Assistance

Laboratory analyses of the biochemical composition and energy content of forage fishes fed to captive guillemots will be conducted in the laboratory of the PI at Oregon State University.

Analyses of biomarkers in blood plasma and fecal samples will be conducted in the labs of Dr. Scott Newman at the University of California Davis, Dr. Lawrence K. Duffy at the University of Alaska Fairbanks, and Dr. Alexander Kitayski at the University of Washington, where the expertise is available to perform these tasks.

SCHEDULE

A. Measurable Project Tasks for FY 01 (February 1, 2001 - January 31, 2002

Feb. 1-March 15:	Analysis and interpretation of field data from captive-reared chicks. Complete laboratory analyses of plasma samples and diet samples.
January 1 - 14:	Prepare for Annual Restoration Workshop.
January 15 - 24:	Attend Annual Restoration Workshop and present FY 00 results to peer reviewers.
Jan. 24 - April 14:	Prepare 2000 annual report of findings.
March 15-Jun 30. :	Preparation and completion of M. S. thesis.
May 1 - May 15:	Install artificial nest sites, decoys, and playback sound equipment at SeaLife Center.
May 15-Aug. 15	Periodic surveys and monitoring for pigeon guillemot recruitment.

March 15-Jan. 31: Completion and submission of manuscripts addressing objectives.

Dec. 15: Submit final annual report (FY 01 findings).

B. Project Milestones and Endpoints

FY 01

March 15, 2001:	Completion of laboratory analysis and data interpretation.
May 15, 2001	Final installation of audio playback equipment at ASLC.
Dec. 15, 2001:	Completion of fourth annual report of findings.
June 30, 2001:	Completion of M.S. thesis.
January 31, 2002:	Submission of manuscripts addressing objectives 1 and 2.

C. Completion Date

The anticipated completion of this project will be early in FY 02, at the end of calendar year 2001. This will allow adequate time to complete data analysis, thesis preparation by the Masters student, and manuscript preparation and submission following the last field seasons in 2000 (Objectives 2 and 3)and 2001 (Objective 1) and completion of laboratory analysis early in 2001.

PUBLICATIONS AND PROJECT REPORTS

The following publications are projected for this research project (this is a rough projection and by no means complete):

An annual report for the third year of this project will be submitted by 15 April 2001. The final report for this project will be submitted 15 December 2001. At least three manuscripts will be generated from this research, and all will be published in the peer-reviewed scientific literature. Each of these three manuscripts will address one of the three major objectives/hypotheses of this study: (1) guillemot colony establishment as a direct restoration technique, (2) biomarkers as a means of assessing exposure of guillemots to crude oil, and (3) diet as a factor in nestling growth and post-fledging survival. A portion of the final report will be excerpted from the thesis of the M.S. student on this project. This student, as first author, will be strongly encouraged and directly assisted by the PI to submit for publication in the peer-reviewed scientific literature the results from this research on objectives 2 and 3. Dr. Divoky will be first author on manuscripts relating to objective 1.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

The research described in this proposal takes advantage of the new research facilities and potential represented by the Alaska SeaLife Center and dove-tails nicely with continuing research as part of the APEX and NVP projects that assesses factors limiting recovery of Pigeon Guillemot populations damaged by EVOS. It is also relevant to efforts toward developing seabird models as upper trophic level sentinels of oil pollution in nearshore ecosystems. The

proposed research approach utilizes growth performance, fledgling body condition, and blood and fecal biomarkers to assess the health status of guillemot nestling exposed to oil and raised on different diet rations. These data are essential for developing techniques for long term monitoring of the health and status of guillemot populations in the EVOS area.

Studies of foraging, reproduction, and population recovery following the EVOS are on-going for pigeon guillemots. This proposal complements and enhances other studies on pigeon guillemots, without duplication of effort. The PI on the present proposal has been and will continue to work closely with David Irons and Greg Golet (PIs on APEX Component 00163 F "Factors Affecting Recovery of PWS Pigeon Guillemot Populations"), Dave McGuire (Co-PI on NVP studies of biomarkers of oil exposure in guillemot nestlings), and John Piatt (PI on APEX Components 00163 M "Lower Cook Inlet Forage Fish Studies" and 99163 N "Black-legged Kittiwake Feeding Experiment") in developing protocols for collecting data.

PRINCIPAL INVESTIGATORS

Objective 1

George J. Divoky
Research Associate, Institute of Arctic Biology, UAF
4505 University Way NE #71
Seattle, WA 98105
tel: 206-365-6009
fax: 206-368-8941
e-mail: fngjd@uaf.edu

George Divoky is a Postdoctoral Research Associate who has more than 20 years of research experience with guillemots and has been instrumental in designing techniques for direct restoration of guillemot populations.

Objectives 2 and 3

Daniel D. Roby
Oregon Cooperative Fish and Wildlife Research Unit
Department of Fisheries and Wildlife
104 Nash Hall
Oregon State University
Corvallis, Oregon 97331-3803
tel: 541-737-1955
fax: 541-737-3590
e-mail: robyd@ucs.orst.edu

Dan Roby has extensive experience with studies of the reproductive biology of high latitude seabirds and the relationship between diet composition and productivity. He is currently the PI of the Seabird Energetics component (Component G) of the APEX Project and Co-PI of the Diet Quality and Chick Growth component (Component N) of the APEX Project. He has been involved in research on the factors constraining recovery of Pigeon Guillemots in the EVOS area for the last four years.

OTHER KEY PERSONNEL

The proposed research will be implemented by the Oregon Cooperative Fish and Wildlife Research Unit. It will be closely coordinated with and in cooperation with personnel of the Alaska SeaLife Center in Seward. Dr. Divoky will be assisted by a research assistant on objective 1. Dr. Roby will be assisted on objective 2 and 3 experiments with captive-reared chicks by Dr. Andrew Hovey, a graduate student in the Department of Fisheries and Wildlife at Oregon State University, a research assistant and two interns. Laboratory analyses of the proximate composition of diet samples will be conducted in the laboratory of Dr. Roby at Oregon State University. Assays of plasma and fecal biomarkers will be conducted in the laboratories of Drs. Scott Newman (UC Davis), Lawrence Duffy (University of Alaska Fairbanks), and Alexander Kitayski (University of Washington). 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.

LITERATURE CITED

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2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel		$0.0						
Travel		$0.0						
Contractual	$161.1	$81.2						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$161.1	$81.2			Estimated Fy 2002	Estimated FY 2003		
General Administration	$11.3	$5.7						
Project Total	$172.4	$86.9			$0.0	$0.0		
Full-time Equivalents (FTE)	1.3	1.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

prepared 7/7/00

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska SeaLife Center
Agency: DOI: 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					
	Subtotal		0.0	0.0	0.0	
					Personnel Total	

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	
Description					
				Travel Total	

FY01

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey

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

Contractual Costs:	
Description	
4A l Linkage: Roby contract 4A l Linkage: Divoky contract	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	
Commodities Costs:	
Description	
Commodities Total	

FY01

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: 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			
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

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2000
Personnel		$28.8
Travel		$2.3
Contractual		$14.5
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$45.6
Indirect		$13.5
Project Total	$0.0	$59.1
Full-time Equivalents (FTE)		1.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
		Estimated FY2002	Estimated FY2003		
		$0.0	$0.0		

Dollar amounts are shown in thousands of dollars.

Comments:

Indirect rate for OSU in FY00 is 43% of Modified Total Direct Cost (MTDC=Direct cost- assistanceship and equipment) on-campus research rate and 26% of MTDC off-campus research rate.

Indirect rate: $12,049 + $2,781 = $13,476
1. FY00 On-Campus direct costs=$34,329, which includes office salaries, benefits, meeting travel, office support. FY00 Modified direct costs (less tuition, equipment)= $28,021
43% of $28,021= $12,049
2. FY00 Off-campus direct costs= $10,695, which includes field salaries, benefits, field travel, and field housing. FY00 Modified direct costs (less tuition, equipment)= $10,695
26% of $10,695= $2,781

Not included in this budget are bench fees for the Alaska SeaLife Center

FY01

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey: Roby contract

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		
	Name	Position Description	Budgeted	Costs	Overtime	
	graduate research assistant		12.0	2.4		
		Subtotal	12.0	2.4	0.0	
					Personnel Total	

Travel Costs:			Ticket	Round	Total	Daily	
	Description		Price	Trips	Days	Per Diem	
						0.0	
	EVOS Annual Restoration Workshop	$120/day	0.6	1	3	0.1	
	PI meetings in Anchorage		0.6	1	6	0.1	
						Travel Total	

FY01

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey: Roby contract

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

Contractual Costs:	
Description	
duplication/computer fees lab analyses of blood & excreta samples for biomarkers (S. Newman, UC-Davis; A. Kitayski, UW; L. Duffy, UAF; acute phase porteins in blood, fecal poryphrins) publication- reports and visual aids shipping for samples phone services- long distance charges	
Contractual Total	
Commodities Costs:	
Description	
Commodities Total	

FY01

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey: Roby contract

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	
Description			
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

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey: Roby contract

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 1999	Proposed FY 2000						
Personnel		$14.3						
Travel		$5.4						
Contractual		$2.4						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$22.1			Estimated FY 2001	Estimated FY 2002		
Indirect		$0.0						
Project Total	$0.0	$22.1						
Full-time Equivalents (FTE)								
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY01

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey: Divoky contract

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		
	Name	Position Description	Budgeted	Costs	Overtime	
	Dr. George Divoky		2.5	4.5		
	Research Assistant		1.5	2.0		
		Subtotal	4.0	6.5	0.0	
					Personnel Total	

Travel Costs:		Ticket	Round	Total	Daily	
	Description	Price	Trips	Days	Per Diem	
	Seattle, WA to Seward SeaLife Center	0.7	2			
	Seward, AK to nest sites to check occupation					
					Travel Total	

FY01

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey: Divoky contract

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

Contractual Costs:	
Description	
Skiff rental for surveys in Resurrection Bay Duplication/computer fees Publication - reports, visual aids Vehicle rental Telephone services--long distance charges Housing in Seward	
Contractual Total	
Commodities Costs:	
Description	
Commodities Total	

FY01

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
Agency: DOI: U.S. Geological Survey: Divoky contract

2001 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number of Units	Unit Price	
Description			
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

Project Number: 01327
Project Title: Pigeon Guillemot Restoration Research at the Alaska Sealife Center
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