PRINCE WILLIAM SOUND
SCIENCE CENTER
CORDOVA, ALASKA
P.O. Box 705 – Cordova, AK 99574
(907) 424-5800 – fax 424-5820

September 3, 2008

Michael Baffrey, Executive Director
EVOS Trustee Council
441 West Fifth Avenue, Suite 500
Anchorage, AK 99501

Re: Interim FY09 funding for Project 080814 Seabird Predation on Juvenile Herring in Prince William Sound

Dear Michael,

We are writing to you regarding project 080814, Seabird Predation on Juvenile Herring in Prince William Sound. As per your request of 11 August 2008, attached please find the revised proposal, budget, and a detailed progress report.

The scope of our project has not changed. Our revised proposal provides a more detailed methodology and includes the five bird surveys that will be conducted in conjunction with the Humpback Whale Herring Predation cruises (EVOS 080804). The budget described in the original proposal will be the same except for an increase in overhead costs for the PWS Science Center and an additional month of salary for USFWS Principal Investigator Kathy Kuletz.

Seabirds are important predators of juvenile herring, making them an important long-term indicator for managers. Our project will provide a strong foundation for understanding herring predation as well as the role of herring for three seabird species that have not yet recovered from the EVOS oil spill: pigeon guillemot, marbled murrelet, and Kittlitz's murrelet. At the same time, the synergistic effect of working together with the herring hydroacoustic surveys and Humpback Whale surveys makes our project more cost efficient, and a better scientific effort.

We hope that you will recommend to the EVOS Trustee Council approval of interim FY09 funding for our Project 080814, Seabird Predation on Juvenile Herring in Prince William Sound.

Best wishes,

/s/
Mary Anne Bishop, Ph.D.
Co-Principal Investigator
Prince William Sound Science Center

/s/
Kathy Kuletz, Ph.D.
Co-Principal Investigator
US Fish and Wildlife Service

Encs.: Update and Budget
Cc: Catherine Boerner, EVOS Interim Science Director, JoEllen Lottsfeldt, Environ. Program Spec.
Dede Bohn, USGS Project Manager & Nancy Bird, President PWSSC

EVOSTC ANNUAL PROJECT REPORT

Project Number: 080814

Project Title: Seabird predation on juvenile herring in Prince William Sound

PI Name: Dr. Mary Anne Bishop and Dr. Katherine Kuletz

Time period covered: FY08

Date of Report: September 2008

Report prepared by: Neil Dawson, Mary Anne Bishop, and Katherine Kuletz

Project website: www.pwssc.org/research/biological/seabirds/SeabirdOnHerring.htm

Work Performed and Preliminary Results:

During FY2008, surveys of seabird distribution and abundance in Prince William Sound (PWS) were performed on four cruises: 5-12 and 26-30 November 2007, 24-29 January 2008 and 16-24 March 2008. Combining surveys from all 2007/2008 winter cruises, we surveyed a total of 874 km (178 km^2). For the 2008/2009 winter, seven cruises are planned that will include seabird surveys. What follows is: a) a brief summary of work performed; and b) a preliminary analyses.

Surveys in early November 2007 and March 2008 were conducted simultaneously with hydroacoustic surveys for herring (EVOS 080830 R. Thorne, PI). These cruises focused on bays in PWS known historically to hold large overwintering aggregations of juvenile herring (Fig 1). A second vessel sampled fish in and around the acoustic transects to determine species composition and age of fish schools.

Seabird data from these cruises were converted into densities (birds/km^2) for each species or species group. Seabird densities were calculated by bay, per transect and per km of transect line to enable analysis at different spatial scales. Data has been uploaded into Arcmap and seabird distributions mapped. The hydroacoustic and fish school composition data have been obtained for March and November 2007 cruises, but not for March 2008. We expect to receive the March 2008 hydroacoustic herring data from PI Thorne by late September 2008. We have categorized hydroacoustic transects into density of fish for depth bands of 0-5m, 6-20m, 21-50m, and >50m. These data are being analyzed to determine the spatial associations of each bird species with fish species, age-class, and school characteristics.

To substantiate the survey data, we also conducted focal observations of foraging seabirds, to verify which fish they are eating. However, winter weather and long travel times between bays limited observation opportunities. We will make focal observations a higher priority during cruises in winter 2008/09. Observations of foraging seabirds will be supplemented during field work for a complementary North Pacific Research Board study on marbled murrelet body condition that we will be conducting during the 2008/2009 winter.

Although the focus of this project is to survey seabirds and match their distribution with hydroacoustic data, we are also collecting unique winter data on seabird distribution and behavior throughout PWS. We collected data while on transit between bays to evaluate seabird habitat use outside of the bays. We have also placed bird observers on cruises run by NOAA's Auke Bay Lab (Humpback Whale predation on herring, EVOS 070830, S. Rice, PI). The whale cruises provide valuable insights into how the seabird distribution changes throughout winter and the additional data will aid in identification and characterization of foraging hotspots. The data from the whale cruises will also allow comparison of relative seabird densities over large areas throughout the period which juvenile herring may be vulnerable to predation. These data will augment our focus on the early and late winter periods, which may not be representative of conditions for the entire season. The whale cruises will also provide an opportunity to evaluate whether or not Humpback Whales in PWS facilitate foraging of seabirds by driving fish to the surface, as has been suggested in other regions.

Study Area

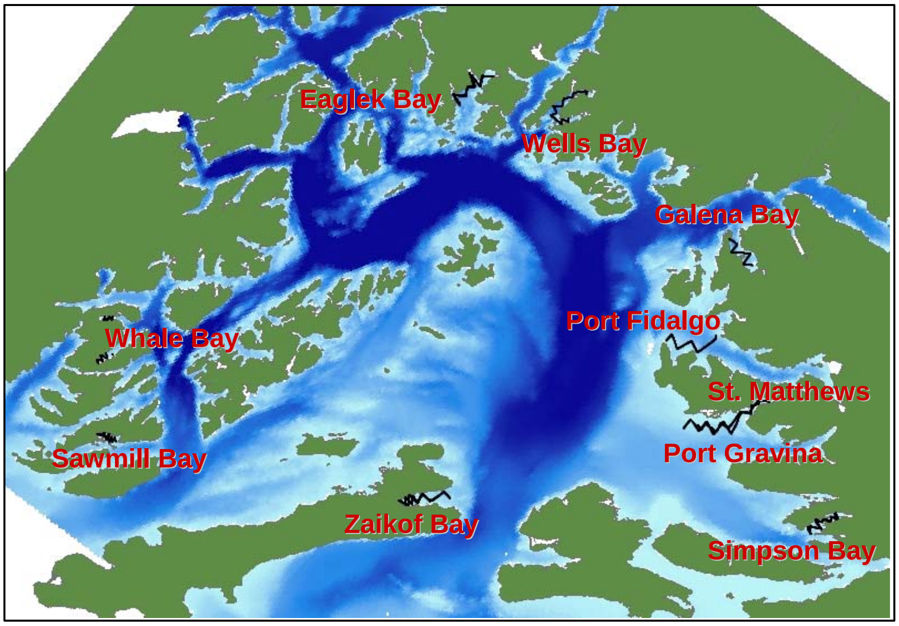

Figure 1. Prince William Sound study area, showing locations of herring hydroacoustic and seabird survey tracklines, in March and November 2007, and March 2008. Humpback Whale and seabird track lines varied by cruise.

Seabird Distribution in PWS

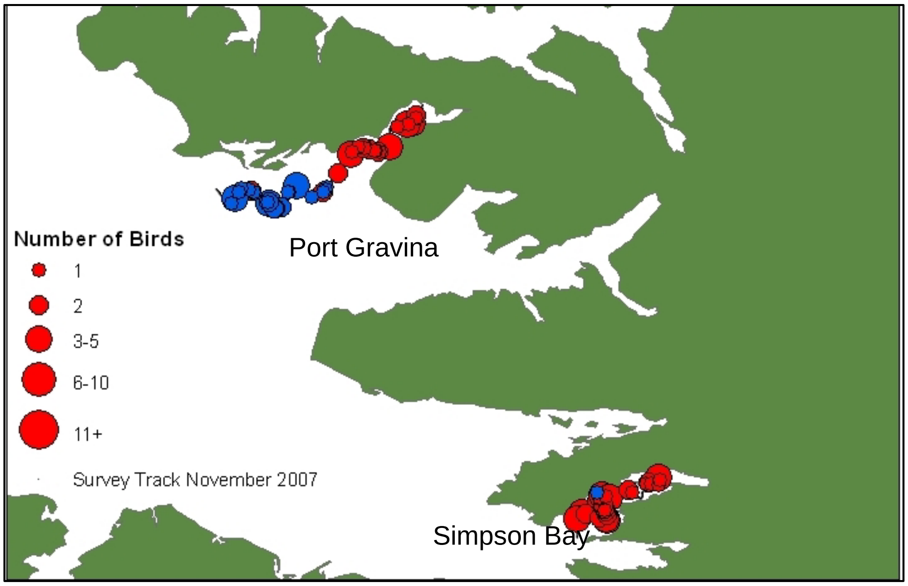

Figure 2a. Abundance of Marbled Murrelets (red) and Common Murres (blue) along hydroacoustic transects, in Port Gravina and Simpson Bay, November 2007.

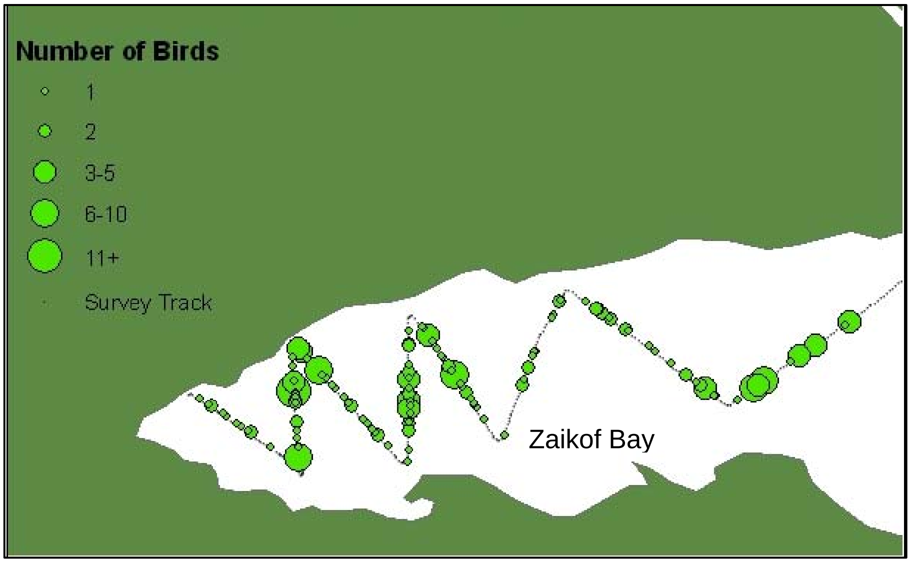

Figure 2b. Abundance of Glaucous-winged Gulls (green), Common Murres and Marbled Murrelets on hydroacoustic transects in Zaikof Bay, November 2007. Note the absence of murrelets and murres.

The distributions of different species or species groups vary dramatically (Figures 2a and 2b). Distinct distribution patterns were displayed by large Gulls, Marbled Murrelets and Common Murres (3 of the most numerous seabird species; table 1). Common Murres and Marbled Murrelets appeared at times to have very little overlap in distribution (Fig. 2a). Large gulls (primarily Glaucous-winged Gulls) were found in very large aggregations but often with few murres or murrelets present (Fig 2b). The distributions of these bird species appeared to reflect preferences for different herring age and size classes. Marbled Murrelets were strongly associated with juvenile herring (age 0-2). Common Murres were most often encountered in deeper waters with aggregations of adult herring (age-3 or older). Glaucous-winged Gulls were opportunistic and fed in areas with large fish concentrations, regardless of herring age/size class (see Fig. 6 below). The gulls may rely on diving ducks, loons and cormorants to drive fish to the surface, making them available for foraging. Similarly, we found that the Black-legged Kittiwake, a small gull and the 3rd most numerous PWS seabird in winter, did not show a clear association with fish of a certain age and may be more dependent on food being available at the surface.

Table 1. Population estimates for seabird groups in PWS in March 2005 (McKnight et al. 2006).

Species Group	Number $\pm$ SE
Murre	92,777 $\pm$ 23,423
Gull	66,961 $\pm$ 12,498
Cormorant	14,654 $\pm$ 3,090
Murrelet	12,640 $\pm$ 3,899
Merganser	4,300 $\pm$ 1,875
Grebe	3,425 $\pm$ 1,260
Loon	2,348 $\pm$ 1,024
Guillemot	1,486 $\pm$ 896

Seasonal patterns of seabird distribution

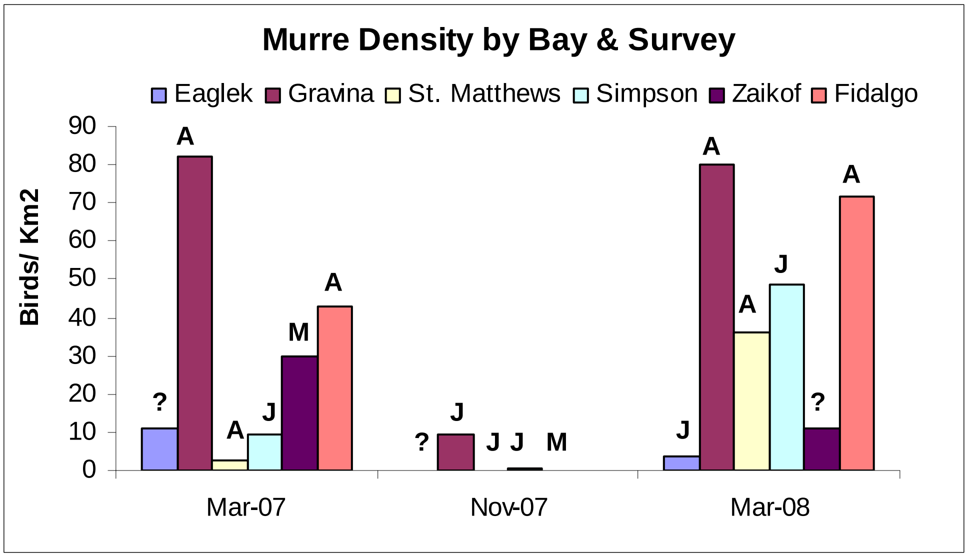

Figure 3. Density of Common Murres by bay and date. Dominant herring age classes of fish schools shown above where: A = adult, J = juvenile, M = mixed adult and juvenile, ? = unknown.

Juvenile herring concentrate in nearshore areas for up to two years before joining the adult population in deeper water (EVOS 2008). Adult herring spend the winter in central and eastern PWS before congregating to spawn in nearshore areas from March to early May (EVOS 2008). Perhaps in response to this shift in herring availability, seabirds also show clear seasonal movements in their distribution. We found a strong spatial association between Common Murres and adult herring (Fig. 3). In November, when schools of predominantly juvenile herring were found in greater densities in the bays, murres were relatively scarce. When murres were in the bays in early winter, they were usually near the bay mouth in deeper waters (Fig. 2a), where adult herring also occurred. However, in March when more adult herring were entering bays such as Port Gravina and Port Fidalgo, murres were present in large numbers compared to November (Fig. 3). Average density in bays with adult herring was 58.1 birds/km^2 compared to 6.6 birds/km^2 for bays with juvenile herring or with unknown fish composition.

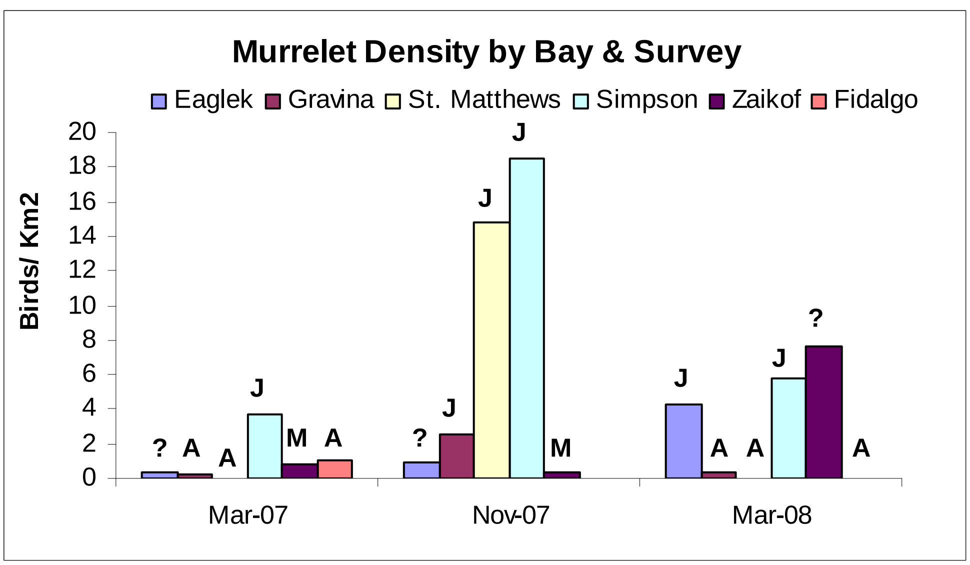

Figure 4. Density of Marbled Murrelet by bay and date. Dominant herring age classes of fish schools shown above where: A = adult, J = juvenile, M = mixed adult and juvenile, ? = unknown.

Marbled Murrelets appear to be a key predator of juvenile herring in PWS. Distribution of Marbled Murrelets was very different from that of murres, and murrelets closely followed the seasonal movements of juvenile herring (Fig. 4). Murrelet densities were higher in early winter in bays with juvenile herring schools. Murrelets became scarce as numbers of juvenile herring decreased in late winter (Figure 4). Murrelet density averaged 7.8 birds/km^2 in bays with juvenile herring compared to 0.8 birds/km^2 in bays without juvenile herring.

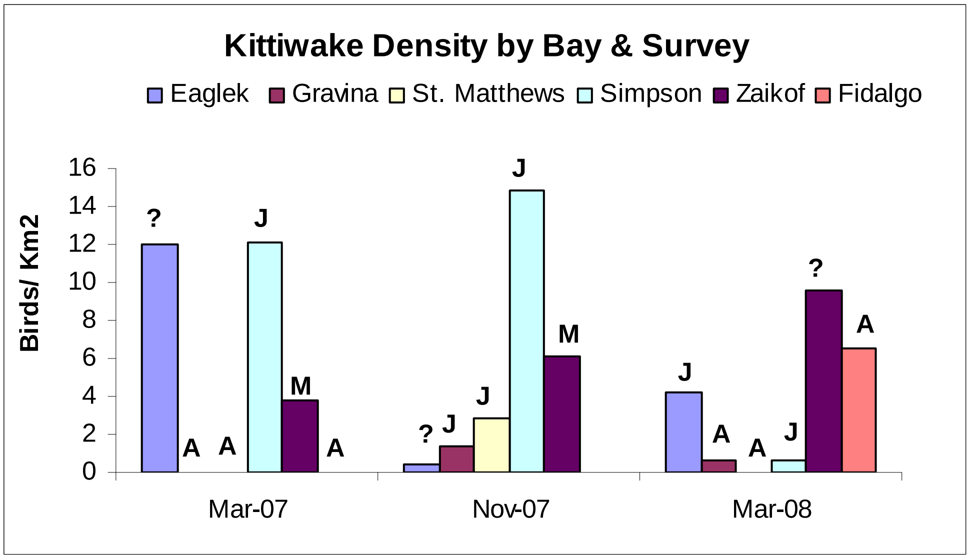

Figure 5. Density of Black-legged Kittiwake by bay and date. Dominant herring age classes of fish schools shown above where: A = adult, J = juvenile, M = mixed adult and juvenile, ? = unknown.

The distribution pattern for Black-legged Kittiwakes was less pronounced than for murres and murrelets (Fig. 5). Kittiwakes had a slightly higher density of 4.8 birds/km^2 in bays with juvenile herring, compared to the 3.1 birds/km^2 in bays with adult herring or unknown. The surveys that we conducted in conjunction with the Humpback Whale cruises, which covered areas outside of the bays, revealed that Kittiwake density was very low outside of the bays. During these surveys, kittiwakes were virtually absent from PWS in midwinter, although their densities were occasionally high at the beginning and end of the winter period.

In January 2008, we surveyed over 100 km of transects throughout PWS, and recorded only 3 kittiwakes, whereas March surveys conducted by USFWS found winter population estimates of approximately 15,000 (McKnight et al. 2006). Although more January surveys are necessary before making final conclusions, these preliminary results suggest that kittiwakes do not become abundant in PWS until March, and thus their predation on juvenile herring in PWS varies considerably with seasonal changes in immigration. It may be that surface food including euphaasids and zooplankton, as well as fish, may be limited in PWS in winter, and thereby influencing the abundance and distribution of kittiwakes.

Spatial Overlap with Marine Mammals

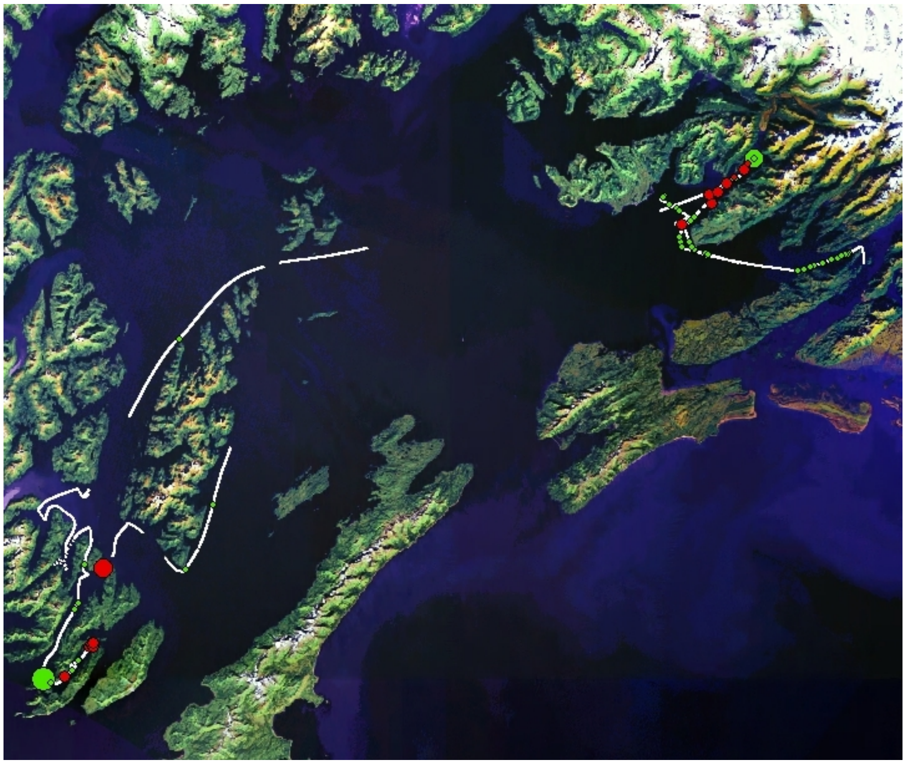

Figure 7. Distribution of loons (green) and Humpback whales (red) January 26-30, 2008.

The distribution of loons, a deep diving seabird group, was linked to the distribution of Humpback Whales (Fig. 7). While bays were indeed hotspots relative to deeper, open waters, high levels of activity were not entirely restricted to the bays. The mouths of bays, as well as narrow passages and channels between islands such as Elrington Passage and Orca Narrows, were used by high numbers of the deeper-diving seabirds (such as murres, loons and cormorants) and Humpback Whales. These kinds of physical features also provide potential wintering habitat for adult herring (EVOS 2008). Interestingly, surveys conducted in very deep waters (> 150m) were characterized by comparatively low levels of bird and whale activity.

Seabird Response to Fish Densities

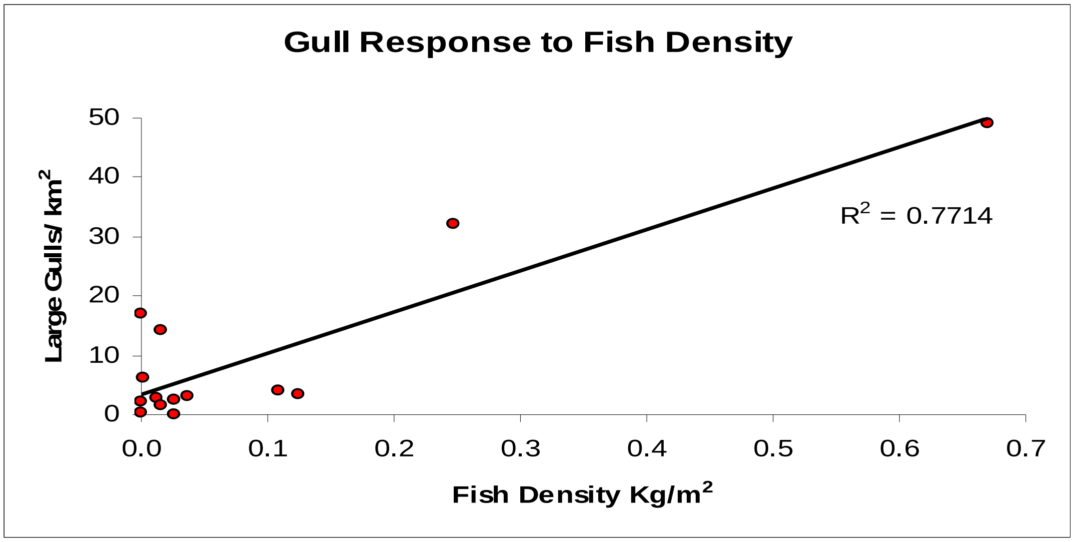

Figure 6. Relationship between densities of large gulls (Glaucous-winged and Herring) and fish observed during hydroacoustic surveys in March and November 2007. Gull densities were positively related to fish densities (R^2=0.77, P<0.001).

We found a strong association between Glaucous-winged and Herring Gulls and fish density, regardless of location and age class (juvenile or adult) of the fish present (Fig. 6). Both of these gull species are known to be opportunistic and adaptable foragers. Although they may be key predators of herring in PWS, they are not necessarily herring specialists. Their consumption of juvenile herring in winter may vary annually depending upon the relative abundance of other food. For example, in March 2008, there was a strong run of Eulachon, *Thaleichthys pacificus* in rivers around the Copper River Delta. While the run occurs annually, it varies considerably in strength and timing. The abundance of gulls in PWS at this time dropped dramatically compared with previous surveys. Density of gulls in the bays was 8.4 birds/km^2 in March 2007, 13.9 birds/km^2 in November 2007, and just 3.5 birds/km^2 in March 2008.

Model Results: Selection of Foraging Area by Seabirds

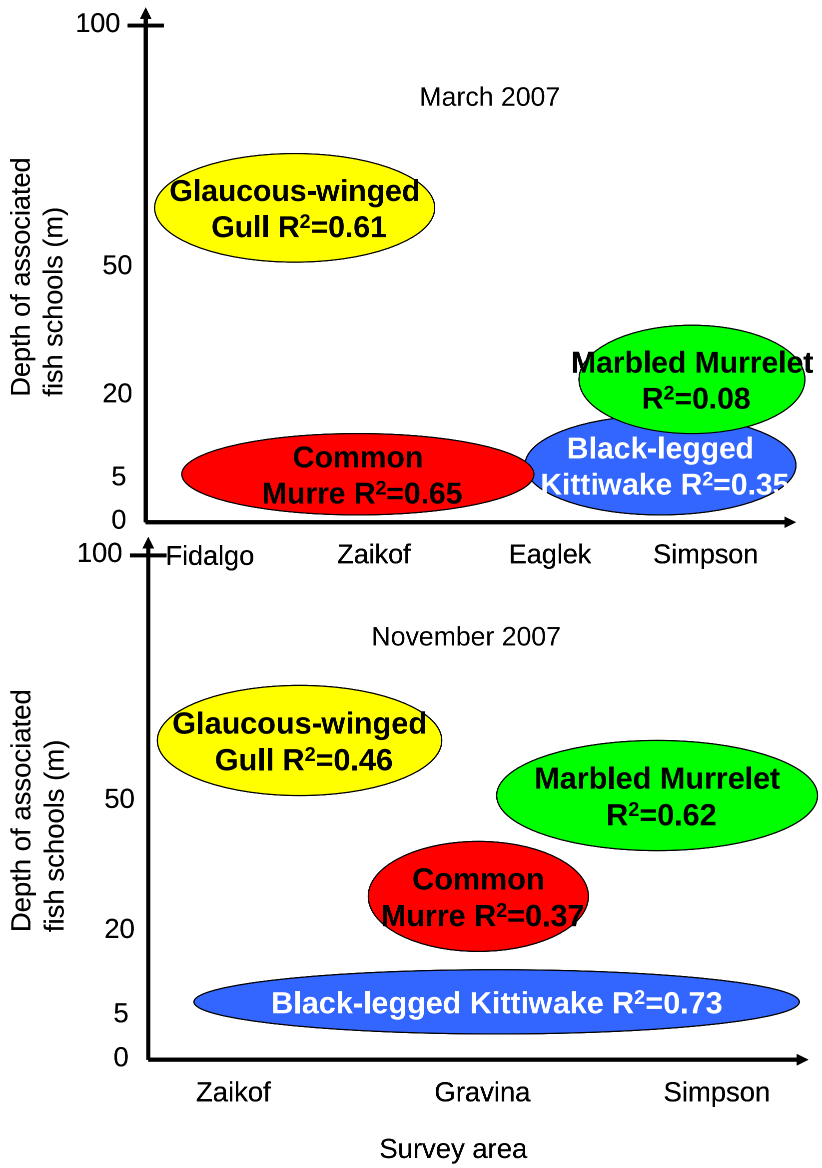

Figure 8. These two diagrams summarize model results (detailed in table 2) illustrating bird distribution by survey area and depth of associated fish prey (primarily adult or juvenile herring). Width of bubble reflects favored bays. March 2007 and November 2007.

We ran Generalized Additive Models with a Poisson distribution and a log link function using backwards selection to explain densities of 4 seabird species by survey transect. Explanatory variables included survey areas as nominal variables, density of fish through water column, density of fish 0-5m, density of fish 0-20m, density of fish 0-50m, average depth per transect, density of other seabird species groups and presence of other seabird species groups. The model yielding the lowest Akaike's Information Criterion (AIC) was selected (Burnham and Anderson 2002). Regression trees were used to corroborate the results and further explain relationships. The same analysis was performed for every 300m^2 grid along the survey track with additional explanatory variables including distance to shore, bathymetric slope, aspect and shelter from prevailing easterly winds (calculated using GIS).

Table 2. Model selection results explaining variation in seabird densities by survey transect.

Species	2007 Survey	R^2	Areas	Significant Variables Fish Depth	Other Variables
Glaucous-winged Gull	Mar	0.61	Fidalgo	0-5m	Murre & seaduck density
	Nov	0.46	Zaikof, Gravina	All depths	Seaducks, cormorants & murres present
Common Murre	Mar	0.65	Zaikof, Fidalgo,	0-5m	Water Depth
	Nov	0.37	Gravina	0-20m	Water Depth
Marbled Murrelet	Mar	0.08	Simpson	0-20m	
	Nov	0.62	Simpson	0-50m	Water Depth
Black-legged Kittiwake	Mar	0.35	Simpson, Eaglek	0-5m	
	Nov	0.73	Simpson	0-5m	

Seabird densities were best explained by a model containing survey area and fish density at a specific depth (Fig. 8, Table 2). Kittiwakes were particularly dependent on juvenile herring being present in the top 5m of the water column, whereas Marbled Murrelets were found where fish were within the top 20m in March and top 50m in November. Common Murres favored schools of fish located near the surface in March when adult herring were spawning but down to 20m depth in November. Although feeding on schools nearer the surface, Common Murres occurred in deeper, open water. When analyzed at a finer spatial scale of 300m^2 murre density was positively correlated with distance to shore and they were associated with depths greater than 40m. Glaucous-winged Gulls were linked to high fish densities regardless of the school depth. At the finer scale of < 300 m^2 the model suggested that Glaucous-winged Gulls were associated with congregations of seaducks, loons, cormorants and murres. Models at this finer scale of < 300 m^2 included more environmental and bathymetric variables (slope, aspect, distance to shore, windshelter). However, our preliminary results thus suggest that it will be difficult to define significant relationships at scales of < 300 m^2. Similar studies in other regions have found that fine-scale relationships between seabirds and prey are not well defined (Logerwell and Hargreaves 1996).

Literature Cited:

Burnham, K.P., and D.R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer-Verlag. New York, New York, USA.

Exxon Valdez Oil Spill Trustee Council. 2008. Prince William Sound Herring Restoration Plan, Draft, Issued January 10, 2008.

Logerwell, E.A. and N.B. Hargreaves. 1996. The distribution of seabirds relative to their fish prey off Vancouver Island: opposing results at large and small spatial scales. Fisheries Oceanography, 5, 163-175.

McKnight, A., K.M. Sullivan, D.B. Irons, S.W. Stephensen, and S. Howlin. 2006. Marine bird and sea otter population abundance of Prince William Sound, Alaska: trends following the T/V Exxon Valdez Oil Spill, 1989-2005. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project 050751), U. S. Fish and Wildlife Service, Anchorage, Alaska.

Future Work:

Further seabird surveys will be performed in conjunction with seven cruises during the 2008/2009 winter. These include five Humpback Whale cruises (Sept, Oct, Dec, Jan, Mar) and two Hydroacoustic cruises (Nov and Mar). Below is the schedule, where √ = completed survey.

Month	Seabird Surveys 2007/2008 Winter	Seabird Surveys 2008/2009 Winters
Sep		Humpback Whale
Oct		Humpback Whale
Nov	√ Herring Hydroacoustic	Herring Hydroacoustic
Dec	√ Humpback Whale	Humpback Whale
Jan	√ Humpback Whale	Humpback Whale
Mar	√ Herring Hydroacoustic	Humpback Whale Herring Hydroacoustic

Once data have been collected and all hydroacoustic and fish school composition data received from EVOS 080830 (R. Thorne, PI), final analysis will be performed, enabling us to suggest the likely impact of seabird predation on juvenile herring. This will include developing a seabird consumption model as described in the FY09 proposal. The final report will be submitted by March 31, 2010.

We foresee at least 3 peer-reviewed publications produced from this study:

- Interactions between herring and predators during winter in Prince William Sound, Alaska. Proceedings of the International Symposium on Herring. ICES Journal of Marine Science. Expected submission date January 2009.
- Food habits of seabirds in Prince William Sound during winter. *Journal Field Ornithology.* October 2009.
- Modeling biomass consumption of juvenile herring by avian predators in a sub-arctic estuary. *Fisheries Oceanography.* March 2010.

Coordination/Collaboration:

Our project relies on seabird surveys being performed onboard vessels associated with two EVOS projects: hydroacoustic surveys for herring (EVOS 080830, PI Thorne), and humpback whale predation on herring (EVOS 080804, PI Rice). EVOS 080830 provides our project with data from the hydroacoustic surveys and age composition of fish schools. Additional data on age composition of fish schools has been obtained from ADFG herring surveys (PI Steve Moffitt). The Humpback Whale predation on herring project provides our project with whale sightings and fish observations (jigging, dipnetting) associated with the sightings. EVOS 080811 (PWS herring forage contingency, PI Tom Kline) is providing our study with information on the condition and caloric content of year 1 juvenile herring before and after winter, data that will be used in modeling seabird consumption.

Our information on seabird predators will provide data for EVOS 080810 (PI D. Kiefer) “An Ecosystem Model of Prince William Sound Herring: A Management & Restoration Tool”. Our information is being gathered in conjunction with the only juvenile herring surveys planned for PWS, and should be completely compatible with models utilizing the juvenile herring survey data. Data from our surveys will also be submitted to the North Pacific Pelagic Seabird Database (USFWS and USGS, Anchorage, Alaska)

Community Involvement/TEK & Resource Management Applications:

Public presentation about the project for community education program onboard the US Coast Guard Cutter Sycamore, December 2007. (Dawson)

Project Poster with preliminary findings has been produced and prominently displayed for visitors to the Prince William Sound Science Center.

Contributed to community herring planning effort, 28th April to May 2nd. (Dawson)

Information Transfer:

Posters and Publications:

Dawson, N., M.A. Bishop, K. Kuletz, K. Brenneman, R. Thorne and R. Crawford. 2008. The importance of juvenile Pacific Herring *Clupea pallasi* to wintering seabirds in Prince William Sound, Alaska. Poster. Pacific Seabird Group Annual Conference, Blaine WA, 27th February-2nd March 2008.

Thorne, R.E., M.A. Bishop, N.M. Dawson, and R. Crawford. 2008. Herring and seabirds. The Breakwater, Newsletter of the Prince William Sound Science Center, Winter 2007-2008.

Publications in preparation:

Thorne, R.E., M.A. Bishop, N. Dawson, K. Kuletz, and R. Crawford. *In prep.* Interactions between herring and predators during winter in Prince William Sound, Alaska. Proceedings of the International Symposium on Herring. ICES Journal of Marine Science

Presentations:

Bishop, Mary Anne and Kathy Kuletz. Seabird predation on juvenile herring in Prince William Sound. EVOS Herring Working Group, October 2007, Anchorage.

Thorne, R.E., M.A. Bishop, N. Dawson, K. Kuletz, and R. Crawford. Interactions between herring and predators during winter in Prince William Sound, Alaska. International Symposium on Herring. National University of Ireland, Galway. August 26-29, 2008.

Website:
A webpage has been set up on the project, available since June 2008.
http://www.pwssc.org/research/biological/seabirds/SeabirdOnHerring.htm

Budget Changes:

For Prince William Sound Science Center (PWSSC), the estimated FY09 costs remain the same as in the FY07 original proposal except for PWSSC administrative overhead. Originally the overhead was estimated at 25.6%, however for FY09 the federally approved overhead is estimated at 28.82%.

The budget for USFWS included $10.6k in FY10 for salary for K. Kuletz, which was time for the Co-PI to complete publications. We are adding that $10 to FY09, to better meet publication deadlines and to keep all costs for the project within FY09.

Trustee Council Use Only
Project No: ____
Date Received: ____

PROPOSAL SUMMARY PAGE
(To be filled in by proposer)

Project Title: **Seabird Predation on Juvenile Herring in Prince William Sound**

Project Period: FY09

Proposer(s):

Dr. Mary Anne Bishop, Prince William Sound Science Center, mbishop@pwssc.org

Dr. Katherine J. Kuletz, U.S. Fish and Wildlife Service, kathy_kuletz@fws.gov

Study Location: Prince William Sound

Abstract: Based on population trends, the Prince William Sound (PWS) Pacific herring population does not show signs of recovering. Predation pressure on juvenile herring may be an important factor in preventing recovery. This proposal is for the final year of a large-scale, three-year study to investigate seabird predation on juvenile herring during winter months (October-March), a season about which relatively little is known. Juvenile herring are heavily predated by multiple species of seabirds, including five species initially injured by the *Exxon Valdez* Oil spill, as well as Marbled Murrelet, Kittlitz's Murrelet and Pigeon Guillemot, three species that have not yet recovered. We will examine the spatial and temporal abundance of seabird predators in and around juvenile herring schools, as well as the physical and biological characteristics of the schools they feed on. Our project relies on seabird surveys being performed onboard vessels associated with EVOS projects 080830(hydroacoustic surveys for juvenile herring) and 080804 (humpback whale herring predation). Our bioenergetic models will provide estimates of juvenile herring consumption that will aid in planning future restoration efforts. Our data will also assess the role of seabird predation on herring recruitment by providing data to both herring and ecosystem modeling efforts.

EVOS Funding Requested FY09:	PWSSC	USFWS	TOTAL
	$ 128.7	$ 82.3	$ 211.0

Non-EVOS Funds to be Used: FY 09

Date: September 3, 2008

PROJECT PLAN

I. NEED FOR THE PROJECT

A. Statement of Problem

Pacific herring (*Clupea pallasi*) has been identified as a resource injured by the 1989 Exxon Valdez Oil Spill (EVOS). Based on population trends, the Prince William Sound (PWS) herring population does not show signs of recovering. The collapse of the PWS herring population including its commercial fishery has impacted not only the economy and well-being of PWS communities, but also a variety of seabirds and marine mammals that depend on herring. Pacific herring is a critical component of the diet of many marine mammals and seabirds in PWS (Agler et al. 1999; Matkin et al. 1999; Irons et al. 2000a). Holleman (2000) describes herring as a principal prey of at least 40 species in PWS. The PWS herring crash has been implicated in the decline of the endangered western stock of Steller sea lion (*Eumetopias jubatus*) (Thomas and Thorne 2003). Kuletz (2005) concluded that juvenile herring were critical to marbled murrelets (*Brachyramphus marmoratus*) and suggested that the decline in murrelets in PWS was linked to the concurrent decline in herring. Similarly, Irons and others (2000a) determined that the effects of EVOS on several marine seabirds lasted longer than expected and may be the result of reduced forage fish abundance. In addition, they found that the most persistent declines are associated with seabirds that over-winter in PWS, while birds that migrated to areas outside of PWS in winter recovered more quickly.

Herring populations tend to be dominated by the occasional strong year class. Most recently, the PWS 1999 herring year class showed a strong recruitment at age three (R. Thorne, PWSSC, pers. comm.), however, this recruitment event has been insufficient to restore herring populations to the levels of the 1980's. A critical bottleneck for herring recruitment is juvenile abundance and condition for young-of the-year (hereafter referred to as 0-age class) going into and coming out of the October to March winter period, a period when zero or negative growth rates occur (Paul and Paul 1999). The 0-age class juvenile herring are heavily predated by multiple species of seabirds (Irons 1992; Duffy 2000, Bishop and Kuletz unpubl. data). Brown (2003) suggested that herring 1-year age class abundance should be directly correlated with year class strength 2 or 3 years later, unless the local population is in a "predator pit". She suggested that predation pressure resulting from a stable or increasing predator population in PWS could maintain or reduce the herring recruitment when the juvenile herring population is composed of smaller school sizes and fewer aggregations over a reduced geographic range.

In Alaska, most studies on seabirds and prey fish have been conducted in the summer, and have focused on the effect of fish abundance and quality on seabird productivity or foraging behavior (Golet et al. 2000, Litzow et al 2002, Piatt et al. 1997, Suryan et al. 2000, 2002). Outside of summer, seabird predation on herring in PWS has focused on consumption of adult herring and herring spawn. As part of the SEA project, Co-Principal Investigator for this proposal, Dr. Mary Anne Bishop, studied avian predation on herring spawn during April and May at Montague Island (Bishop and Green 1999, 2001). She collected additional spring data on of adult herring consumption by birds at Montague Island during a study on avian mussel consumption (a component of the EVOS Nearshore Vertebrate Predator Project; Bishop et al. 1998). More recently, during 2005 and 2006 bird surveys were performed on vessels conducting adult herring hydroacoustic surveys in over-wintering areas. The hydroacoustic surveys were part of a PWS Science Center study (R. Thorne, PI) on the relationship between Steller sea lions and Pacific herring. Bird surveys indicated that common murre (*Uria aalge*), a deep-diving species, was the most common seabird observed, followed by glaucous-winged gull (*Larus glaucescens*) and loons (*Gavia* spp.) (M.A. Bishop, unpubl. data).

Juvenile herring (0, 1, 2 year olds) over-winter in several bays and inlets primarily in east-northeast and west-southwest areas of PWS that are distinct from adult over-wintering areas (Stokesbury et al. 2000; Norcross et al. 2001). Juvenile herring occur at more shallow depths than adult herring (<30m), making them potentially more available to shallow-diving seabirds. The importance of juvenile herring as a winter food resource for birds has not been investigated. There has been no information on numbers and distribution of avian predators on juvenile herring, how predictable or variable their consumption of juvenile herring is during winter, nor what hydrographic or oceanographic features the birds may be responding to. Based on previous U.S. Fish and Wildlife Service (FWS) seabird population surveys conducted during March, we have identified 20 seabird species wintering in PWS that are known (15 species) or suspected (5 species) to consume juvenile herring (Table 1).

Table 1. Piscivorous birds wintering in PWS known or suspected to consume Pacific herring. Population estimates from McKnight et al. 2006.

Species	Herring documented*	EVOS Status 2006 & Recovery Date	PWS winter Population 2005
Red-throated Loon	Yes		0 **
Pacific Loon	Yes		323 ± 266
Common Loon	Yes	Recovered 2006	1233 ± 662
Yellow-billed Loon	No info		27 ± 24
Horned Grebe	No info		2203 ± 782
Red-necked Grebe	Yes		1054 ± 813
Pelagic Cormorant	Yes	Recovered 2006	10649 ± 2575
Double-crested Cormorant	Yes	Recovered 2006	154 ± 138 ***
Red-faced Cormorant	No info	Recovered 2006	458 ± 449
Common Merganser	No info		3008 ± 1558
Red-breasted Merganser	Yes		962 ± 467
Black-legged Kittiwake	Yes		15903 ± 5416
Mew Gull	Yes		8925 ± 3497
Herring Gull	No info		2030 ± 813
Glaucous-winged Gull	Yes		35363 ± 8851
Common Murre	Yes	Recovered 2002	90902 ± 23191
Marbled Murrelet	Yes	**Unknown**	9431 ± 3291
Kittlitz's Murrelet	Yes	**Not Recovered**	****
Pigeon Guillemot	Yes	**Not Recovered**	1485 ± 896
Horned Puffin	Yes		88 ± 158
Bald Eagle	Yes	Recovered 1996	4378 ± 840

*Based on a review of *Birds of North America* species accounts; **loons difficult to identify in winter; total loons = 2347 ± 1023; *** total cormorants, including unidentified = 14654 ± 3089; ****Between 1990 and 2006, Kittlitz's Murrelets were observed wintering in PWS during 6 of 11 March USFWS surveys. .

Foraging behavior by seabirds can be influenced by many factors including prey abundance, prey location (depth), prey size, and the presence of other herring predators. For example, marbled murrelets are the most numerous alcid in PWS. During summer, Ostrand et al. (2004) found that marbled murrelets in PWS preferentially selected for schools of juvenile herring. Murrelet's selection of other fish species for consumption depended on herring availability, rather than fish school characteristics such as fish school depth or habitat.

Foraging in multi-species flocks is common among seabirds (Maniscalco and Ostrand 1997), and there appears to be mutual benefit gained by pursuit divers (e.g. loons, cormorants, alcids) and surface/plunge feeders (e.g. kittiwakes, gulls) by their joint participation (Porter and Sealy 1981). Co-Principal Investigator for this project, Dr. Kathy Kuletz (2005) found that murrelets in PWS foraged in larger groups when prey were less abundant, but foraged as pairs or individuals when prey was abundant, possibly because murrelets suffer kleptoparasitism by larger birds (Maniscalco and Ostrand 1997). The size of prey may also influence foraging behavior. In PWS, black-legged kittiwakes (*Rissa tridactyla*) foraged in larger flocks if prey were 0-age class herring, than they did when foraging on larger 1-age class herring (Irons et al. 2000b). In addition to fish abundance and size, hydrographic features may also play a role in attracting seabirds to a site. For example, marbled murrelets forage on small schools of fish in nearshore, shallow waters, or areas of upwelling (Kuletz et al. 1995, Kuletz 2005, Ostrand et al. 1998), presumably because prey are consistently available there. All these results suggest that group dynamics among birds is tied to fish type, abundance, and availability (as mediated by habitat).

Since 2007 EVOS has funded winter juvenile herring surveys (November and March) as part of a three-year study (EVOS 080830, PI Thorne). Hydroacoustic surveys for juvenile herring have been conducted in selected bays throughout PWS, including the four bays sampled for juvenile herring during 1995 and 1996 as part of the EVOS Sound Ecosystem Assessment (SEA) project. Thorne's study uses 1) hydroacoustic surveys to determine juvenile herring biomass and abundance; and, 2) trawl surveys for species composition and size class. Concurrently, EVOS has funded NOAA (EVOS 080804, PI Rice) to investigate Humpback Whale predation on herring in Prince William Sound. Rice's study uses broad-scale surveys during winter to estimate the number of whales foraging on herring in PWS in winter. Together these two studies provide an unprecedented opportunity to study the relationship between seabirds and juvenile herring during winter.

Since March 2007 our project, EVOS 070814 & 080814, has been funded to investigate seabird predation on juvenile herring. We have conducted seabird surveys concurrent with juvenile herring hydroacoustic surveys and the Humpback Whale predation surveys. Our study has been investigating the effects of seabird predation on juvenile herring recruitment. Our study is designed to complement and expand on the studies that comprise the EVOS juvenile herring research program. From a fisheries management standpoint, this study will provide data on bird consumption that can be used by managers to more realistically model herring recruitment. Stock assessment models can then determine how much (what biomass) needs to be available to birds, so that both bird and commercial fishery requirements do not create a "predator pit". This proposal details our methods for year 3, FY 09.

B. Relevance to 1994 Restoration Plan Goals and Scientific Priorities

Pacific herring has been identified as a resource injured by the 1989 Exxon Valdez Oil Spill. Currently, the PWS herring population does not show signs of recovering. The Trustee Council recognized that conservation and improved management of injured resources and services will require substantial ongoing investment to improve understanding of the marine and coastal ecosystems that support the resources, as well as the people, of the spill region. In the case of herring, this knowledge can only be provided through a long-term monitoring and research program that will span decades.

The collapse of the PWS herring fishery has impacted not only the economy and well-being of PWS communities, but also several species of seabirds that depend on herring. Juvenile herring are an important winter-period food supply for marbled murrelet, an injured species with an unknown recovery status, as well as pigeon guillemot (*Cepphus columba*), a species that has not yet recovered. Kittlitz's murrelet, also a species that has not yet recovered, frequent PWS during some winters. This murrelet species is also a known juvenile herring predator. In addition, other species initially injured by the spill that feed on herring include common loon (*Gavia immer*), cormorants (pelagic, red-faced, and double-crested), and common murre. Thus actions that identify and protect important overwinter areas for herring will benefit multiple injured species.

The effort proposed here is relevant to most of the 8 categories for herring proposals outlined in the 2007 Invitation. Our information will be critical to understanding seabird predators and their impact on herring. Our study will also provide information important for planning, modeling, mapping and intervention. Until now, predation has not been included in herring population models. Brown (2003) noted in her modeling work that including information on predation in a herring recruitment model may become increasingly important if recruitment failure continues in PWS. Our data on seabird abundance and avian consumption of juvenile herring can be used in PWS herring population models to estimate a previously unquantified mortality term (mortality due to avian predation). Furthermore, the mortality term will be applicable to specific size/age classes of herring. Information from our study on areas with high seabird predation will also be important for planning any future intervention.

II. PROJECT DESIGN

A. Hypotheses & Objectives

The overall hypothesis of the seabird predation project is that Pacific herring adult recruitment depends partly on the density and distribution of juvenile herring predators, including seabird predators. We will test this hypothesis by comparing juvenile herring abundance (0, 1, and 2 year olds) spatially and temporally, relative to the distribution and abundance of wintering piscivorous birds in PWS. The specific objectives are:

1. Characterize the spatial and temporal abundance of seabird predators in and around juvenile herring schools in PWS.

2. Characterize key habitats and characteristics of fish schools where seabird predation on juvenile herring is significant.
3. Model juvenile herring consumption by the most important seabird predators.

In meeting these objectives, we will be able to assist in the assessment of the role of seabird predation on adult herring recruitment by providing data to both herring and ecosystem modeling efforts.

B. Procedural and Scientific Methods

The impact of seabird predation on juvenile herring will be documented by observing the distribution, relative abundance and behavior of birds foraging on juvenile herring. Based on their observations of marbled murrelets, Ostrand et al. (2004) suggested that multiple years of study were necessary to define prey selection. In order to best determine predation impact on herring from seabirds, we will conduct surveys over two consecutive winter seasons: 2007/2008 (n = 4 cruises) and 2008/2009 (n = 7 cruises; Table 2). Our seabird surveys will be performed throughout Prince William Sound in conjunction with: a) daytime and early-evening hydroacoustic transects for juvenile herring (EVOS 080804, PI Thorne); and, b) Humpback Whale herring predation surveys (EVOS 080830, PI Rice).

Table 2. Scheduled winter surveys for seabird predators on juvenile herring in PWS. Surveys are performed concurrently on boats conducting: a) hydroacoustic surveys for juvenile herring; and b) Humpback Whale herring predation surveys. √ = Completed Survey.

Month	Seabird Surveys 2007/2008 Winter	Seabird Surveys 2008/2009 Winter
Sep		Humpback Whale
Oct		Humpback Whale
Nov	√ Herring hydroacoustic	Herring hydroacoustic
Dec	√ Humpback Whale	Humpback Whale
Jan	√ Humpback Whale	Humpback Whale
Mar	√ Herring hydroacoustic	Humpback Whale Herring hydroacoustic

For the hydroacoustic transects a 58 ft charter vessel follows a zigzag track, approximately 200m or greater from shore, at a speed of approximately 6 knots (see R. Thorne's EVOS 080830 for hydroacoustic methods). Seabird observations will be conducted from the same vessel along these transects, using established U.S. Fish and Wildlife Service protocols (Klosiewski and Laing 1994) that have been adapted for GPS-integrated data entry programs (USFWS 2007). One observer will record number and behavior of birds and marine mammals occurring along a strip transect width of 300m (150m both sides and ahead of the boat). Additionally, any noteworthy observations will be recorded out to 1km either side. Observations will be recorded into a GPS-integrated laptop computer using the program Dlog (Ford

Consulting, Inc., Portland OR). This program provides location data for every record as well as sea conditions and weather entered and tracked on site by the observer. Bird surveys will be conducted concurrent with daytime hydroacoustic herring surveys. The same GPS-generated track lines are then repeated for a nocturnal hydroacoustic herring survey.

Hydroacoustic surveys will provide detailed information on the vertical and horizontal distribution of fish schools (including total depth of water, depth to each fish school, depth below each school) as well as density and biomass of juvenile herring populations in PWS during winter (October through March). Fish schools observed with the acoustic equipment will be sampled by a second boat immediately following the hydroacoustic boat during the nighttime surveys (see next paragraph). Additional information on fish schools will also be provided by Alaska Department of Fish and Game.

During our observations, we will determine the size and species of fish consumed by seabirds using two methods: fish sampling and direct visual observation. Fish sampling will also be used to identify size structure of herring schools and schools of other fish species consumed by birds. The hydroacoustic herring studies that we are collaborating with are collecting fish samples in the deeper waters using a modified mid-water trawl and/or a gill net. More shallow waters are being sampled using throw nets. When conditions allow, we will catch fish boiling at the surface (chased by the birds) using a dipnet (see Kuletz 2005). Fish captured below feeding birds will be considered potential prey items, and will provide prey species identification, size and weight.

Fish brought to the surface by birds will be identified using 10x42 binoculars and fish size will be estimated relative to the bill size of the bird. The known bill sizes for each species can then be used to approximate the size of the fish, which is a commonly employed method in seabird studies. Visual observations will be augmented by photos from a digital camera with a stabilizer that can be analyzed by multiple observers in the lab. Fish will be visually identified to the lowest possible taxon, using study guides developed by USGS and USFWS. The computer program will be altered to simultaneously record foraging observations during the surveys. Foraging data will include observations of foraging activity of birds, including numbers and species of predators, behavior, and associated fish observations (visual, acoustic, trawl-caught, or dipnetted). We will also be use a skiff to conduct bird observations while the mother ship is anchored. This will allow us to access shallow water habitats in the nearshore, an area not normally accessible with the seine boat, as well as to document the use of shallow water habitat by juvenile herring and avian predators.

C. Data Analysis and Statistical Methods

To describe the relationship between seabird densities and juvenile herring biomass in PWS we will run linear regressions, using juvenile herring survey data provided from the hydroacoustic surveys. For each bird species, a best model for explaining variability in bird densities will be determined using a general linear model. A natural log or square root transformation of the dependent variable will be used when appropriate to improve the fit of the model to the data. The relationship between date, densities of each seabird species observed, and herring biomass will be evaluated at three spatial scales: by bay, by transect and by kilometer of survey track.

The main hypothesis, that seabird predation on juvenile herring impacts adult herring recruitment, will be examined by modeling juvenile biomass among sites relative to local seabird abundance and consumption. This will be visualized using ArcMap GIS. GIS will also be used to calculate additional variables such as distance to shore. We will use multivariate logistic regressions to compare by year the characteristics of juvenile herring fish schools associated with seabirds to all other juvenile herring schools detected by hydroacoustics (Manly et al. 1993). Our analysis will focus on variables that appear to be important to seabird predation. These include school density, species composition and size structure, total water depth, depth to school, depth below each school, and distance from shore (Day and Nigro 2000; Ostrand et al. 1998, 2004, Kuletz 2005). School area (m^3) will also be included in the model if it becomes available. Models will be developed that are composed of all possible combinations of variables, excluding interactions. Logistic regressions will be fitted to all equations within the model set and ranked based on Akaike's information criterion (Akaike 1973, Burnham and Anderson 1998). For each year we will determine importance values for each independent variable using the model sets (Burnham and Anderson 1998).

Daily juvenile herring consumption by each species of bird will be determined using a bioenergetics model (Bishop and Green 2001) similar to that used by Madenjian and Gabrey (1995) and Hunt et al. (2000) for seabird energy requirements on Lake Erie and the Bering Sea, respectively. This model utilizes: 1) the daily energy needs of individuals of each species; 2) the abundance of each bird species at sites with juvenile herring (from our data); and, 3) the contribution of herring to the diet of each species (from on-site observations and the literature). We will use published species-specific metabolic rates (e.g. Feltham 1995) or allometric equations for each species and/or groups of species' daily energy needs (e.g. Birt-Friesen et al. 1989). Information on the condition and caloric content of juvenile herring before and after winter will be provided by the proposed EVOS study, "PWS herring forage contingency" (PI Kline EVOS 080811) or from the literature (Paul and Paul 1999). Caloric values of other fish species consumed will be taken from the literature (Anthony et al. 2000).

We will use the following equation to calculate *C*, the daily juvenile herring consumption (total kg) per individual bird predator: $C = (FMR/MEC) \times P \times H$. For this equation, *FMR* = field metabolic rate ($kJ \cdot d^{-1}$), *MEC* = metabolizable energy coefficient of juvenile herring, *P* = estimated proportion of total energy acquired from juvenile herring and, H = biomass of juvenile herring (kg) needed to produce 1 kJ.

Thus, knowing the energy requirements of each bird species, total bird numbers, the proportion of herring in their diet, and the energetic value of different age classes of herring and other prey consumed, it will be possible to calculate the number of herring consumed by birds

Based on USFWS winter surveys of PWS, we determined that 20 marine bird species are potential consumers of juvenile herring (see Table 1, page 4). Of these, 15 are documented herring predators. Based on our 2007/2008 preliminary results, six species of birds that occur in PWS in the winter will likely comprise the majority of our observations and data: pelagic cormorant, black-legged kittiwake, mew gull, glaucous-winged gull, common murre, and marbled murrelet. Although we will be recording visual observations of birds foraging and bringing fish to the surface, we will also assume that fish detected or caught (via trawls, seines, throw nets, and dipnets) below foraging birds are being consumed by the birds. This is a common assumption in seabird literature, and previous studies have used these methods in PWS (Kuletz 2005).

The total amount of herring consumed per bird species will be determined using the daily bioenergetics calculations (described above) for each species x total bird days in juvenile herring areas during winter. There will likely be a temporal component to herring consumption both in bird numbers and in proportion of herring in the diet. These data will be interpreted from the concurrent seabird/hydroacoustic juvenile herring surveys and seabird/Humpback Whale surveys and incorporated into the model of seabird consumption.

D. Description of Study Area

For Thorne's juvenile herring hydroacoustic and trawl surveys, coverage is comprehensive for PWS. Effort is allocated by several factors, including historical information, reports from fishermen, hunters and others transiting PWS, aerial surveys of marine mammals, and community observations. Thorne's study is a modified version of a sampling plan developed by Dr. Brenda Norcross (University of Alaska at Fairbanks) that included 10 bays and is based on historic observations of juvenile herring in spring and fall (Fig. 1). Thorne's surveys include four bays, Eaglek, Simpson, Whale and Zaikof Bays, that were sampled repeatedly during the SEA program (Norcross et al. 2001). Additional bays where Thorne has conducted hydroacoustic surveys at least once since 2007 include: Port Gravina, St. Matthews, Port Fidalgo, Two Moon Bay, Galena Bay, Wells Bay, Sawmill, and Whale Bay.

Humpback Whale surveys have been conducted primarily in southwest PWS. Cruises focus on areas where whales have been recently sighted, either during aerial surveys or by local researchers. During the two 2007/2008 winter cruises, areas surveyed included Port Gravina, Orca Bay, Windy Bay, Knight Island Passage, Sawmill Bay, Zaikof Bay, Elrington Passage, and Prince of Wales Passages.

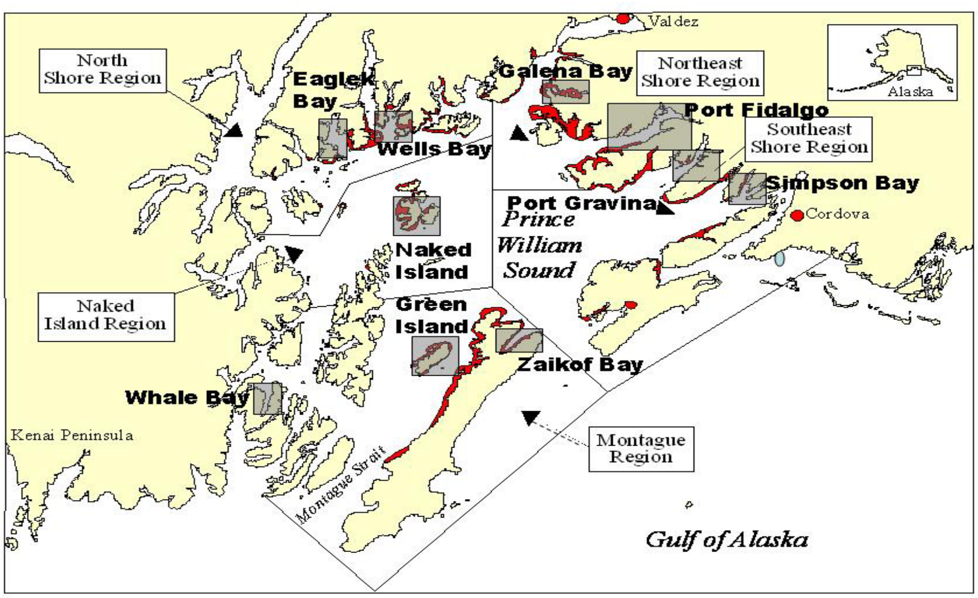

Figure 1. PWS study area, including bays historically important for juvenile herring.

E. Coordination and Collaboration with Other Efforts

This study is part of the PWS Science Center's Herring Research Program, and is designed to complement the Science Center's ongoing herring research, including the long-term study on Steller sea lion food limitation research. In addition, this study relies on conducting boat observations during two EVOS studies: Trends in adult and juvenile herring distribution and abundance in PWS" (EVOS 080830 PI Richard Thorne, PWS Science Center), and "Significance of Whale Predation On Natural Mortality Rate of Pacific Herring in Prince William Sound" (EVOS 080804 S. Rice, NOAA). Thorne's project will provide our project with data from the juvenile herring hydroacoustic and trawl surveys. The Humpback Whale project will provide our project with whale sightings and fish observations (jigging, dipnetting) associated with the sightings. Bird surveys conducted onboard the whale cruises provide valuable insights into how seabird distribution and densities change in relation to herring throughout winter, rather than focusing simply on the beginning and end of winter. The whale cruises will also provide an opportunity to evaluate if Humpback Whales facilitate foraging by seabirds by driving fish to the surface. The proposed study, "PWS herring forage contingency" (EVOS 080811, PI Tom Kline) will provide our study with information on the condition and caloric content of juvenile herring before and after winter, data that will be used in modeling seabird consumption.

Finally, in addition to these three studies, our information on seabird predators will provide data for the project "An Ecosystem Model of Prince William Sound Herring: A Management & Restoration Tool" (EVOS 080810 PI D. Kiefer). Our information will be gathered in conjunction with the only juvenile herring surveys planned for PWS, and should be compatible with models utilizing the juvenile herring survey data for all of PWS. Our data on seabird abundance and avian consumption of juvenile herring can be used in PWS herring population models to estimate a previously unquantified mortality term (mortality due to avian predation). Furthermore, the mortality term will be applicable to specific size/age classes of herring. In particular, our data will be applicable to 'trophic alternation' models of herring populations (Bakun 2006) that incorporate 'predator pit' dynamics. Our data will also provide seabird consumption rates that can be used to improve the PWS trophic mass balance model (Okey and Pauly 1999).

The proposed study will complement the North Pacific Seabird Observer Program funded by North Pacific Research Board in 2006 (NPRB Project No. 637), by contributing data on seabird abundance and distribution to the North Pacific Pelagic Seabird Database.

III. SCHEDULE

A. Project Milestones (these remain the same as in the original FY07 proposal)

1. Characterize the spatial and temporal abundance of seabird predators in and around juvenile herring schools in PWS. Completed September 2009.
2. Characterize key habitats and characteristics of sites where seabird predation on juvenile herring is significant. Completed September 2009.
3. Model the juvenile herring consumption by the most important seabird predators. Completed September 2009.

4. Assist in assessing the role of seabird predation on adult herring recruitment by providing data to herring recruitment model. Completed September 2009.

B. Measurable Project Tasks

- FY 09, 1st quarter (October 1, 2008-December 31, 2008)
  Oct Trustee Council funding approval.
  Field work PWS seabird/whale predation surveys
  Nov Field work PWS seabird/hydroacoustic herring surveys
  Dec Field work PWS seabird/whale predation surveys
- FY 09, 2nd quarter (January 1, 2009-March 31, 2009)
  Jan Annual Alaska Marine Science Symposium
  Field work PWS seabird/whale predation surveys
  Submit first manuscript
  Mar Field work PWS seabird/whale predation surveys
  Field work PWS seabird/hydroacoustic herring surveys
- FY 09, 3rd quarter (April 1, 2000-June 30, 2009)
  Apr-Jun Analyze data
- FY 09, 4th quarter (July 1, 2009-September 30, 2009)
  Jul - Sep 30 Analyze data, Prepare manuscripts
- FY 10, 1st quarter (October 1, 2009-December 31, 2009)
  Oct Submit second manuscript
- FY 10, 2nd quarter (January 1, 2009-March 31, 2009)
  Jan – Mar Prepare third manuscript and final report
  March 31 Submit final report and third manuscript

IV. RESPONSIVENESS TO KEY TRUSTEE COUNCIL STRATEGIES

A. Community Involvement and Traditional Ecological Knowledge (TEK)

Because of the extensive knowledge of local fishers, local guides, and the historic knowledge of native Alaskans, an interactive exchange will be of great benefit to the project. Local fishermen are used in the vessel charters for both projects that we are conducting our onboard seabird surveys. We will also use the EVOS-sponsored PWS Fisheries Research Application and Planning group (PWSFRAP) as an additional means to reach local fishers and guides about the project. Results of the project will also be fully available to the local community through presentations at PWSFRAP workshops and public seminars given through the PWS Science Center. Articles will also be written for the local newspaper, *The Cordova Times* (publicly available), and for *The Breakwater*, the newsletter of the PWS Science Center informing the public of the study. The Prince William Science Center also maintains a regional science education and outreach program. Our project will also use the education/ outreach program to communicate the need and benefits of conservation of marine resources to the public and visiting student groups. As part of its outreach program, the PWS Science Center maintains an extensive web site. This project will be featured on the web, and will have links to the EVOS web site as well as links to any other collaborating projects.

Resource Management Applications

Our study will make it possible to model the bio-energetic requirements of EVOS-injured seabird species in winter. Currently very little is known about the biomass required to sustain seabird populations, particularly during winter months. Similarly, the importance of juvenile herring as a winter food resource for birds has not been investigated. Juvenile herring occur at more shallow depths than adult herring (<30m), making them potentially more available to shallow-diving seabirds. During winter months, there has been no information on number and distribution of avian predators on juvenile herring, predictability or variability in avian consumption of juvenile herring, nor what hydrographic features the birds may be responding to.

From a fisheries management standpoint, information on seabird predation is important because if the seabird predator population remains relatively constant or increases, then the currently lower herring stock levels in PWS could experience higher rates of predation. Until now, predation has not been included in herring population models. Brown (2003) noted in her modeling work of PWS herring that including information on predation in a herring recruitment model may become increasingly important if recruitment failure continues in PWS. Our study will provide information on the seabird component of herring predation. In addition, our study will provide data on habitat features that can be used to assist in identification of sites appropriate for restoration activities that will benefit herring and marine birds.

V. PUBLICATIONS AND REPORTS

In addition to annual reports, we foresee at least 3 peer-reviewed publications produced from this study. Their proposed titles, journals, and submission dates are:

- Interactions between herring and predators during winter in Prince William Sound, Alaska. Proceedings of the International Symposium on Herring. ICES Journal of Marine Science. Expected submission date January 2009.
- Food habits of seabirds in Prince William Sound during winter. *Journal Field Ornithology*. October 2009.
- Modeling biomass consumption of juvenile herring by avian predators in a sub-arctic estuary. *Fisheries Oceanography*. March 2010.

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2009 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2008 - September 30, 2009

Budget Category:	Authorized FY 2008	Proposed FY 2009						
Personnel	$28.6	$44.4						
Travel	$4.5	$4.5						
Contractual	$153.3	$143.7						
Commodities	$1.0	$1.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$187.4	$193.6						
General Administration	$16.9	$17.4						
Project Total	$204.3	$211.0						
Full-time Equivalents (FTE)	0.3	0.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:
Bird Surveys for FY09 will be conducted on vessel charters provided by 2 collaborative projects:
1) EVOS 090830, "Trends in adult and juvenile herring distribution and abundance in Prince William Sound" , Principal Investigator Richard Thorne, Prince William Sound Science Center)
.2) EVOS 090804 Significance of Whale Predation On Natural Mortality Rate of Pacific Herring in Prince William Sound, Principal Investigator S. Jeep Rice, NOAA Auke Bay Lab

In-kind contriibutions:
Equipment user fee (computers, surival suits, electronics, binoculars, rangefinders, etc.) = $10k

FY09

Prepared: Sept. 1, 2008

Project Number: 090814
Project Title: Seabird Predation on Juvenile Herring in PWS
Agency: DOI - US Fish and Wildlife Service, Dr. Kathy Kuletz

2009 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2008 - September 30, 2009

Personnel Costs:		GS/Range/	Months	Monthly		
Name	Position Description	Step	Budgeted	Costs	Overtime	
Kuletz	Co-project Leader	GS/12/5	3.0	10.6		
Unknown	Biological Technician	GS/7/1	3.0	4.2		
	Subtotal		6.0	14.8	0.0	
					Personnel Total	

Travel Costs:	Ticket	Round	Total	Daily	
Description	Price	Trips	Days	Per Diem	
Truck and boat tunnel fee (Portage - Whittier)	0.1	4			
Per diem (camp rate), 2 people, 60 days winter @ $3/d			60		
Per diem (Cordova), 1 person per trip ($72/d)		6	12	0.1	
Lodging, 6 nights, 2 rooms @ $85/night/room (Cordova)			6	0.2	
6 RT flights, Anchorage-Cordova	0.3	6			
				Travel Total	

FY09

Prepared: Sept. 1, 2008

Project Number: 090814
Project Title: Seabird Predation on Juvenile Herring in PWS
Agency: DOI - US Fish and Wildlife Service, Dr. Kathy Kuletz

2009 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2008 - September 30, 2009

Contractual Costs:	
Description	
4A Linkage	
Statistician (contract)	
Boat repairs and parts	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	

Commodities Costs:	
Description	
IT supplies (backup disks, batteries, electronic support, etc)	
Commodities Total	

FY09

Prepared: Sept. 1, 2008

Project Number: 090814
Project Title: Seabird Predation on Juvenile Herring in PWS
Agency: DOI - US Fish and Wildlife Service, Dr. Kathy Kuletz

2009 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2008 - September 30, 2009

New Equipment Purchases: Description		Number of Units	Unit Price	
Those purchases associated with replacement equipment should be indicated by placement of an R.			**New Equipment Total**	

Existing Equipment Usage: Description	Number of Units	
usfws skiff w motor	1	

FY09

Prepared: Sept. 1, 2008

Project Number: 090814
Project Title: Seabird Predation on Juvenile Herring in PWS
Agency: DOI - US Fish and Wildlife Service, Dr. Kathy Kuletz

2009 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2008 - September 30, 2009

Budget Category:	Authorized FY 2008	Proposed FY 2009						
Personnel	99.6	$89.5						
Travel	5.1	$5.1						
Contractual	$14.8	$3.8						
Commodities	1.5	$1.5						
Equipment	0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$121.0	$99.9						
Indirect	$27.3	$28.8						
Project Total	$148.3	$128.7						
Full-time Equivalents (FTE)	1.0	0.9						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

Bird Surveys for FY09 will be conducted on vessel charters provided by 2 collaborative projects:
1) EVOS 090830, "Trends in adult and juvenile herring distribution and abundance in Prince William Sound" , Principal Investigator Richard Thorne, Prince William Sound Science Center)
.2) EVOS 090804 Significance of Whale Predation On Natural Mortality Rate of Pacific Herring in Prince William Sound, Principal Investigator S. Jeep Rice, NOAA Auke Bay Lab

FY09

Prepared: Sept. 1, 2008

Project Number: 090814
Project Title: Seabird Predation on Juvenile Herring in PWS
Name: PWS Science Center, Dr. Mary Anne Bishop

2009 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2008 - September 30, 2009

Personnel Costs:			Months Budgeted	Monthly Costs	Overtime	
Name	Position Description					
Mary Anne Bishop, Ph.D.	Principal Investigator		6.0	10.0		
Neil Dawson	Research Technician		5.0	5.9		
	Subtotal		11.0	15.9	0.0	
					Personnel Total	

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	
Description					
Cordova to Anchorage	0.3	4	10	0.2	
National Meeting	0.9	1	5	0.2	
				Travel Total	

FY09

Prepared: Sept. 1, 2008

Project Number: 090814
Project Title: Seabird Predation on Juvenile Herring in PWS
Name: PWS Science Center, Dr. Mary Anne Bishop

2009 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2008 - September 30, 2009

Contractual Costs:	
Description	
Vessel Charter - provided by EVOS 090830 (PWSSC, R. Thorne, PI)l Vessel Charter - provided by EVOS 090804 (NOAA, S. Rice, PI) Aircraft Charter Cordova to PWS charter vessel 4@$500 ea network costs (based on $100/mo x staff mo) phone/fax/copying charges/mail/freight	
Contractual Total	

Commodities Costs:	
Description	
field, office & lab supplies	
Commodities Total	

FY09

Prepared: Sept. 1, 2008

Project Number: 090814
Project Title: Seabird Predation on Juvenile Herring in PWS
Name: PWS Science Center, Dr. Mary Anne Bishop

2009 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2008 - September 30, 2009

New Equipment Purchases: Description	Number of Units	Unit Price	
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	

Existing Equipment Usage: Description	Number of Units	
Laboratory - Prince William Sound Science Center	1	
Safety equipment - Prince William Sound Science Center	1	
Desktop Computers and software (PWSSC)	2	
CTD w flouremeter & turbidity	1	

FY09

Prepared: Sept. 1, 2008

Project Number: 090814
Project Title: Seabird Predation on Juvenile Herring in PWS
Name: PWS Science Center, Dr. Mary Anne Bishop