# NPRB PROPOSAL SUMMARY PAGE

**NPRB Use Only**

**Reference No: __632___________** **Date Received: _________________**

**(To be filled in by applicant)**

**Project Title: Distribution, Abundance, and Ecology of Pacific Walruses in the Bering Sea**

**Project Period**: From Date:_August 1, 2006___________ to___June 30, 2008________________


**Name, Address, Telephone Number and Email Address of Applicant:**
Suzann Speckman
US Fish and Wildlife Service
1011 E. Tudor Rd, MS 341
Anchorage AK 99503
Phone: (907) 786-3479; fax (907) 786-3816, email: suzann_speckman@fws.gov

**Principal Investigator(s): (Include name, affiliation and email address)**

Jay, Chadwick, USGS, chad_jay@usgs.gov

Douglas, Dave, USGS, david_douglas@usgs.gov

Konar, Brenda, UAF, bkonar@guru.uaf.edu

Speckman, Suzann, USFWS, suzann_speckman@fws.gov

Meehan, Rosa, USFWS, rosa_meehan@fws.gov


**Research Priority and Subcategory**:
2.e.iDistributionandabundanceoficesealsandwalrus________________________________________


**Summary of Proposed Work** (250 words or less):
The Pacific walrus (*Odobenus rosmarus divergens*) is a sea ice-dependent pinniped that faces an uncertain future. Little information exists to allow prediction or interpretation of the impacts of Arctic warming on Pacific walruses, their sea ice habitats, or their benthic prey. The U.S. Fish and Wildlife Service (USFWS), in collaboration with the U.S. Geological Survey (USGS) and Russian scientists from GiproRybFlot and ChukotTINRO, carried out a range-wide survey of the Pacific walrus in March and April of 2006, with the primary goal of estimating the size of the population. The survey was unique in that it utilized thermal scanners to enumerate walruses over large geographic areas, and remotely-deployed satellite tags to measure the haul-out behavior of free-ranging walruses. In addition, the survey supported collection of benthic samples for a University of Alaska Fairbanks (UAF) study in an important walrus foraging area. This proposal seeks financial support to examine aspects of Pacific walrus population biology and ecology using data resulting from this complex and highly collaborative field study. The first study component involves collaboration with Russian scientists to integrate survey data collected in U.S. and Russian territories, standardize data analysis, and derive a population estimate of the Pacific walrus. The second study component will examine relationships between walrus haul-out and movement behaviors and their sea ice environment. The third study component will determine whether benthic walrus prey composition, abundance, and biomass within an area of the St. Lawrence Polynya have significantly changed in the past 20+ years.

## NPRB PROPOSAL SUMMARY PAGE

| | |
|---|---|
| **Funding**: Total NPRB Funding Requested: $**299,768**<br>**By institution**: UAF: $64,115<br>USGS: $53,019<br>USFWS: $182,634<br><br>Total Matching Funds Used: $2,276,599______________________________ | |
| Legally Binding Authorizing Signature and Affiliation: | |

## RESEARCH PLAN

**A. Project Title.** Distribution, Abundance, and Ecology of Pacific Walruses in the Bering Sea

**Short Title**. Walruses in the Bering Sea. **Period**: August 1, 2006 – June 30, 2008

**B. Proposal Summary.**

The Pacific walrus (*Odobenus rosmarus divergens*) is a sea ice-dependent pinniped that faces an uncertain future. Little information exists to allow prediction or interpretation of the impacts of Arctic warming on Pacific walruses, their sea ice habitats, or their benthic prey. The U.S. Fish and Wildlife Service (USFWS), in collaboration with the U.S. Geological Survey (USGS) and Russian scientists from GiproRybFlot and ChukotTINRO, carried out a range-wide survey of the Pacific walrus in March and April of 2006, with the primary goal of estimating the size of the population. The survey was unique in that it utilized thermal scanners to enumerate walruses over large geographic areas, and remotely-deployed satellite tags to measure the haul-out behavior of free-ranging walruses. In addition, the survey supported collection of benthic samples for a University of Alaska Fairbanks (UAF) study in an important walrus foraging area. This proposal seeks financial support to examine aspects of Pacific walrus population biology and ecology using data resulting from this complex and highly collaborative field study. The first study component involves collaboration with Russian scientists to integrate survey data collected in U.S. and Russian territories, standardize data analysis, and derive a population estimate of the Pacific walrus. The second study component will examine relationships between walrus haul-out and movement behaviors and their sea ice environment. The third study component will determine whether benthic walrus prey composition, abundance, and biomass within an area of the St. Lawrence Polynya have significantly changed in the past 20+ years.

**C. Project Responsiveness to NPRB Research Priorities or Identified Project Needs.**

This proposal addresses elements in three research themes outlined in the NPRB Science Plan: “Population Dynamics,” “Marine Habitat Use,” and “Long-term Climate Change.”

<u>Primary Research Priority</u>: *Distribution and abundance of ice seals and walrus*

This project will summarize and report on the distribution, abundance, and movement patterns of Pacific walruses across their range in the Bering Sea. Data were collected through a collaborative research initiative by U.S. and Russian scientists in March and April 2006, and will be used to generate a population estimate with variance for the Pacific walrus. Results of this study are important for subsistence users in Alaska and Chukotka, federal regulators, managers, and stakeholders.

<u>Secondary Research Priority</u>: *Response of the Bering Sea Ecosystem to Environmental Change*

Walruses are an ice-dependent species, relying on pack ice as a substrate for birthing, nursing and resting. Projected changes in the duration, thickness, and extent of seasonal pack ice in the Bering Sea will likely affect walrus distributions and behavior (Tynan and DeMaster 1997) as well as prey distribution and abundance (Derocher et al. 2004). Data from radio-tagged walruses in the Bering Sea will be used to model walrus haul-out status relative to meteorological conditions in the sea ice environment and walrus movement patterns relative to sea ice drift. This work will provide insight into how walruses respond to the daily dynamics of their sea ice environment. Samples from a walrus foraging area and walrus stomach contents will be used to examine current composition, abundance, and biomass of benthic species and make comparisons with historical data. This study will indicate changes in prey availability that may impact walrus populations.

The overall project, Distribution, Abundance, and Ecology of Pacific Walruses in the Bering Sea, will further our understanding of how changes in sea ice conditions and benthic prey may affect walrus populations, and will provide valuable baseline data for evaluating future impacts of any ecosystem changes.

## D. Overall Project Design and Conceptual Approach

The Pacific walrus (*Odobenus rosmarus divergens*) is currently managed as a single stock of animals that inhabits the continental shelf waters of the Bering and Chukchi Seas. The population ranges across the international boundaries of the United States and Russia, and both nations share common interests in the conservation and management of this species. Although recent harvest levels are lower than historical highs, a lack of information on population size or trend prevents any assessment of the sustainability of current harvest levels. Projected ecosystem changes in the Bering Sea (e.g., Hunt and Stabeno 2000), including decreasing sea ice coverage and changes in benthic community composition (Overpeck et al. 2005, Grebmeier et al. 2006), further underscore the need for detailed population studies from which sound management decisions can be made.

From 2000 to 2005, the Marine Mammals Management office of the USFWS has led the effort to design a new approach and develop new technology for estimating the size of the Pacific walrus population. The USFWS, in collaboration with USGS and Russian scientists from GiproRybFlot and ChukotTINRO, carried out a range-wide survey of the Pacific walrus in March and April of 2006, with the primary goal of estimating the size of the population. The survey was unique in that it included thermal scanners to enumerate walruses over large geographic areas and remotely-deployed satellite tags to measure the haulout behavior of free-ranging walruses. These issues severely limited the precision of population estimates from past surveys (1975, 1980, 1985, and 1990; Garlich-Miller and Jay 2000).

The 2006 survey enables estimation of the size of the walrus population, but tagging data from the survey also provides an opportunity to further our understanding of walrus behaviors in the Bering Sea relative to meteorological conditions and sea ice drift. The survey also supported collection of benthic samples for a UAF study in an important walrus foraging area.

This proposal seeks NPRB funding to help support three study components on the distribution, abundance, and ecology of Pacific walruses in the Bering Sea. Together, these studies will provide valuable baseline data for evaluating future impacts of ecosystem changes.

The first study component, “Distribution and Abundance of Pacific Walruses in the Bering Sea”, involves collaboration with Russian scientists to integrate survey data collected in U.S. and Russian territories, standardize data analysis, and derive an abundance estimate of the Pacific walrus population. The current size and trend of the Pacific walrus population are unknown, and recent changes documented in the Bering Sea ecosystem (e.g., Hunt and Stabeno 2000) highlight the need for a precise population estimate for monitoring and managing this species.

The second study component, “Walrus-Sea Ice Relationships in the Bering Sea: Understanding the Importance of Sea Ice as a Foraging Platform” will examine relationships between walrus haul-out and movement behaviors and their sea ice environment. Walruses generally prefer to haul out during sunny conditions and remain in water during windy or stormy conditions (Fay and Ray 1968). These and other factors have been used to quantify the relationship between walrus haul-out status and environmental conditions, but primarily with regards to adult males using land haul-outs and with somewhat limited and conflicting results (Hills 1992, Born and Knutsen 1997). Identifying factors associated with haul-out status can lead to more precise trend estimates from counts of hauled out animals, help determine the best times for conducting surveys, and provide insight into basic animal behavior (Adkison et al. 2003, Bengtson and Cameron 2004, Hayward et al. 2005). Furthermore, walruses will be impacted from reductions in the extent and thickness of sea ice in Arctic and sub-Arctic waters. Predictions on how walruses will respond to changes in sea ice will need to consider how walruses interact with their dynamic environment, such as maintaining their proximity to good foraging areas while encountering substantial sea ice drift. This study will use haul-out and animal movement data from tagged walruses to model walrus haul-out status relative to meteorological conditions in the sea ice environment and walrus movement patterns relative to sea ice drift. Meteorological data will come from NOAA's National Centers for Environmental Predictions (NCEP) and sea ice drift data will come from NASA's synthetic aperture radar (SAR) satellite imagery.

The third study component, "Evaluation of Walrus Foraging Grounds in the Bering Sea: a Spatial and Temporal Comparison" will determine whether benthic walrus prey composition, abundance, and biomass within an area of the St. Lawrence Polynya have significantly changed in the past 20+ years. It will also try to relate these changes to current walrus diet in a separate data collection effort. There is evidence that benthic communities in the Bering Sea have undergone significant changes in recent years, potentially due to climate change and declining annual and multiyear sea ice coverage and thickness. A change in benthic prey availability could significantly impact Pacific walrus populations, and it is therefore important to reassess the status of walrus foraging grounds in the Bering Sea. Benthic samples were collected in the St. Lawrence Polynya during the 2006 walrus survey. Species composition, abundance, and biomass estimates from these samples will be compared to historical benthic composition and biomass information found in the literature. In a separate field effort, stomachs will be collected from walruses harvested during subsistence hunting and contents will be sorted, analyzed and compared to historical stomach information found in the literature. Comparisons will also be made between the composition, abundance and biomass of benthic samples from the St. Lawrence Polynya to the actual prey (stomach contents).

Any potential level B harassment of walruses associated with aerial surveys was authorized under the Marine Mammal Protection Act of 1972, as amended, by U.S. Fish and Wildlife Service permit MA-039386-0. Any take during tagging operations was similarly authorized under the Marine Mammal Protection Act of 1972, as amended, by USGS-BRD permit MA-801652-3.

**D.1. Design and Approach: Distribution and Abundance of Pacific Walruses in the Bering Sea**

The range-wide survey of the Pacific walrus was carried out in March and April of 2006, prior to the onset of spring migration. The survey area covered the extent of the Bering Sea pack-ice over the continental shelf. U.S. and Russian scientific crews were responsible for coordinating survey effort on respective sides of the international border. The survey area was partitioned into survey blocks, and a systematic sample of transects within each block was sampled with airborne thermal scanners at high altitude using standard strip-transect survey methodology. The amount of heat produced, or thermal signature, was recorded for each walrus group that was detected by a thermal scanner. A sample of the detected groups was aerially photographed at a lower altitude with digital cameras. Counts of walruses in photographed groups will be used to model the relationship between thermal signatures and the number of walruses in a group.

Only walruses that are hauled out on the pack-ice are detectable in thermal imagery. Therefore, the population estimate derived from thermal scanning will be corrected for walruses that are in the water and unavailable to the thermal scanner. Immediately prior to the aerial survey, satellite transmitters programmed to record and transmit continuous haul-out data were deployed on walruses in Bering Sea pack ice. The proportion of tagged animals hauled out onto sea ice during a given time period will in turn be used to calculate correction factors for aerial surveys over a given region. The final population estimate will be developed cooperatively by U.S. and Russian scientists.

**Goal:**
Estimate the size of the Pacific walrus population with acceptable precision.

**Objectives**

1. Analyze digital photographs and thermal images of a sample of thermally detected walrus groups to determine the relationship between thermal signatures and the number of walruses in a group.
2. Estimate the number of walruses hauled out on ice.
3. Use haulout data from tagged walruses to estimate the proportion of time that walruses were in the water and unavailable to be detected by the thermal scanners.
4. Estimate total size of the Pacific walrus population with confidence intervals.

**Methods and Analysis**

Data collection for this project has been completed. This proposal seeks financial support for travel, meetings, analytical software, and salaries for Russian scientists. U.S. and Russian survey data will be combined, and data analysis and reporting will be done collaboratively by U.S. and Russian scientists, leading to a population estimate for the Pacific walrus.

Detailed data collection protocols are outlined in "A Study Plan for Estimating the Size of the Pacific Walrus Population" (USFWS 2005: http://alaska.usgs.gov/science/biology/walrus/publications.html). A synopsis of survey techniques and tagging methods is presented below.

*Aerial Survey Methods.* Aerial surveys were carried out using a combination of thermal scanners and digital photography (Burn et al. 2005, Burn et al. 2006). Equipment differences necessitated slightly different methods in the U.S. and Russia.

U.S. researchers used a Daedelus Airborne Multi-spectral Scanner (AMS), mounted in an Aero Commander 690B turbine engine aircraft. The system has a 0.625 milliradian instantaneous field of view (IFOV), and collects imagery across a sensor array 3,000 pixels wide. The AMS system records a thermal infrared channel (8.5 – 12.5 µm) with 12-bit radiometric resolution. Spatial resolution of the AMS system varies linearly with the altitude of the aircraft. Surveys were conducted at 6,400 m Above Ground Level (AGL), yielding a resolution of 4 m and a 12 km wide survey swath (strip width) along each transect. A thermal signature was recorded for each walrus group that was detected within the 12-km wide scanned strip. A sample of the thermally detected walrus groups was photographed from a second survey aircraft using a Nikon D2-X 12 mega-pixel camera. Digital photographs were taken using a 200 mm camera lens from an altitude of approximately 700 m AGL. Photographs and thermal images were matched by position and time.

Russian researchers used a "Malachite" Airborne Multi-spectral Scanner (AMS), mounted in an L-410 airplane. The Malachite scanner records a thermal infrared channel (f 8 – 13 µm) with 12-bit radiometric resolution. The system has a 1.5 milliradian IFOV, and collects imagery across a sensor array 2048 pixels wide. An infrared radiometer will be used for continuous temperature calibration of the thermal scanner. The angle of view of the scanner is 82 degrees. The survey was flown from an altitude is 1500 m AGL, resulting in a survey swath width of 2.4 km at a spatial resolution of 2 m. Digital photographs were collected at 3-5 second intervals during survey transects using a 6 mega-pixel Nikon D1-X camera equipped with a 210 mm lens.

*Tagging Methods.* Tagging effort was supported by the Russian icebreaker *Magadan* and the Alaska Department of Fish and Game vessel *Stimson.* Tags were puck-shaped transmitters and deployed by crossbow. They attached with a harpoon head in the blubber layer. Forty-six tags were deployed in the Bering Sea pack ice, all but one in an area to the south-west of St. Lawrence Island.

*Data Analysis*. Generation of abundance estimates for U.S. and Russian waters will involve the following sequence of steps.

*Estimating the relation between thermal signatures and walrus group size.* To determine the threshold temperature value between walruses and the background environment, a frequency histogram of temperature values in a survey transect will be examined. Within each image, the point at which the histogram rapidly decreases from thousands of pixels at each value to fewer than ten pixels is identified as the temperature threshold value (Figure 2). Pixels with temperatures warmer than the threshold value are classified as having some portion of their area covered by walruses. After determining the threshold temperature for each image, an index of the total amount of heat produced by each walrus group will be calculated.

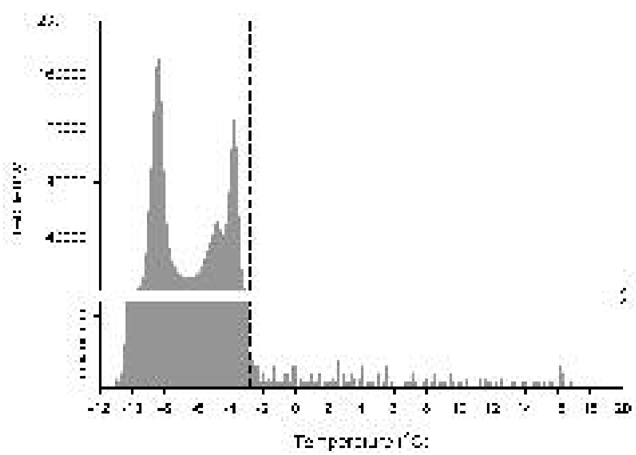

Figure 1. Example of frequency histogram of AMS thermal imagery showing temperature threshold between the background environment and walruses that occurs at -2.81° C. Pixels to the right of the threshold value have some portion of their area covered by walruses.

Digital photographs of walrus groups will be processed and counted using ERDAS Imagine software (Leica Geosystems, Atlanta, Georgia), which has many image enhancement features. Supplemental funding from NPRB will make this software available to Russian scientists, provide training in its use, and provide financial support for the processing of digital images.

Data from photographed groups will be used to develop a regression model relating thermal signature intensity to group size. This model will be used to estimate the number of walruses in each thermally detected group that was not photographed. Pilot studies conducted near St. Lawrence Island in 2002 and 2003 indicated that variances of the photographic counts were proportional to the mean, or the square of the mean, counts. Therefore, we will use a generalized linear model (McCullagh and Nelder 1989) with an identity link and a Poisson or gamma distribution to estimate the relation between numbers of individuals and thermal signatures in the photographed groups. Estimation will be accomplished with SAS PROC GENMOD software (Statistical Analysis Systems, Cary, North Carolina, USA).

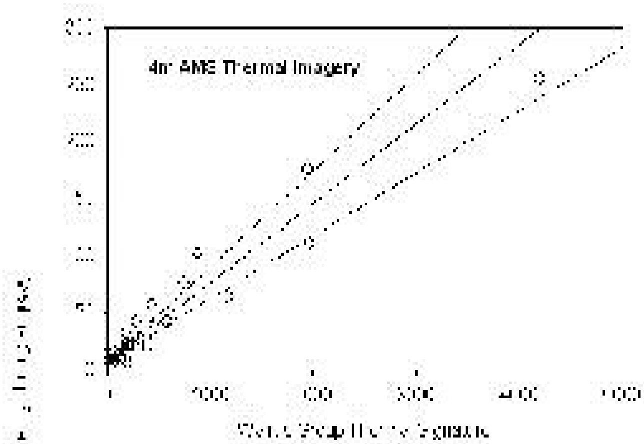


Figure 2. Example gamma regression of walrus group size as a function of thermal signature for AMS thermal imagery at 4 m spatial resolution (Burn et al. 2006). Dashed lines represent 95% confidence intervals. Data were collected in April 2002.

*Estimating the proportion of population hauled out.* The proportion of the population that was hauled out on the ice and therefore potentially available to be detected during the thermal scanner survey will be estimated with the satellite telemetry data from the tagged walruses as:

$$\hat{p} = \frac{1}{w}\sum_{i=1}^{w} p_i \,, \qquad (4)$$

where $p_i$ is the proportion of the relevant time period that walrus *i* was available to be detected. Its variance is estimated as:

$$V\hat{a}r(\hat{p}) = \frac{\sum_{i=1}^{w}(p_i - \hat{p})^2}{w(w-1)}. \qquad (5)$$

In practice, we expect to estimate separate availability proportions for different sets of blocks using only data from restricted areas or time periods. Here we consider only a single overall estimate that will be used for all blocks. Modifications required for using separate estimates are straightforward.

*Estimating totals for surveyed transects.* The number of walruses on a surveyed transect will be estimated by summing the counts of individuals in all the photographed groups and the estimated counts in all the detected groups that were not photographed and then dividing this total by the estimated proportion of the population that was available to be detected. For transect *t* in block *b*, we have:

$$\hat{N}_{tb} = \frac{\sum_{g=1}^{c_{tb}} y_{gtb} + \sum_{g=c_{tb}+1}^{G_{tb}} (\alpha + \hat{\beta} h_{gtb})}{\hat{p}}, \qquad (6)$$

where $y_{gtb}$ is the number of walruses in group $g$ on transect $t$ of block $b$, photographed groups are indexed 1, ... , $c_{tb}$, and groups that were not photographed are indexed $c_{tb}$+1, ..., $G_{tb}$. If there are no photographed groups on a transect, then $c_{tb} = 0$.

*Estimating totals for blocks and the population.* The total population size is estimated as a sum of separate ratio estimators (Cochran 1977) of the totals for each block:

$$\hat{N} = \sum_{b=1}^{B}\left(\hat{R}_b \sum_{t=1}^{T_b} A_{tb}\right) = \sum_{b=1}^{B} \hat{N}_b , \qquad (7)$$

where

$$\hat{R}_b = \frac{\sum_{t=1}^{t_b} \hat{N}_{tb}}{\sum_{t=1}^{t_b} A_{tb}}, \qquad (8)$$

$A_{tb}$ is the area of transect $t$ in block $b$, $T_b$ is the number of transects in block $b$, $t_b$ is the number of surveyed transects in block $b$, and $B$ is the number of blocks.

Requested NPRB funding will be used to apply this same type of analysis to the Russian thermal data, modified as necessary to accommodate any differences in scanner function. Estimated totals for Russian survey blocks will be included in sum (7) to obtain the total population estimate.

*Estimating variance.* We are currently considering two approaches for estimating the variance and obtaining confidence intervals for the population estimate. The first approach is based on the variance estimator presented by Bowden et al. (2003) for sums of correlated ratio estimates. The second approach for estimating the variance of the population estimate uses a re-sampling or bootstrap (Efron 1982) procedure based on the general approach of Booth et al. (1994) for finite populations. The procedure involves generating a series of simulated populations, estimating statistics of interest by resampling from each simulated population, and then averaging these statistics over the simulated populations. We may also consider a third type of approach for estimating variance based on modeling the spatial structure of the data (Cressie 1991). Properly accounting for this spatial structure may ultimately give more precise estimates of the population size.

**D.2. Design and Approach: Walrus-Sea Ice Relationships in the Bering Sea: Understanding the Importance of Sea Ice as a Foraging Platform**

Data on walrus movement and haul-out status, with good spatiotemporal resolution, were collected in the Bering Sea ice in spring 2004, 2005, and 2006 in association with the spring 2006 population survey (see "Distribution and Abundance of Pacific Walruses in the Bering Sea" above). In addition to using these data to develop a correction factor for the survey, we will use these data to model walrus haul-out status relative to meteorological conditions in the sea ice environment and walrus movement patterns relative to sea ice drift.

Synthetic aperture radar (SAR) is the only satellite imagery that can be acquired at any time of the day or night and during adverse weather conditions. SAR products are available at resolutions as high as 30 m. SAR's ability to pass relatively unaffected through clouds, illuminate the Earth's surface with its own signals, and precisely measure distances, makes it especially useful for applications such as sea ice monitoring and surface deformation detection. SAR imagery will be used to produce data on sea ice motion. The coupling of this high quality imaging product with marine mammal tracking data is unique to this study.

**Goal:**
Better understand walrus haul-out and movement behaviors in the Bering Sea relative to meteorological conditions and sea ice drift. We will use daily walrus satellite tracking data, globally-interpolated climate data, and daily synthetic aperture radar (SAR) satellite imagery of sea ice.

**Objectives**

1. Assess relations between walrus haul-out state and meteorological variables.
2. Assess relations between walrus movements and sea ice drift.

**Methods and Analysis**
Satellite radio-tags were remotely deployed on walruses in the spring of 2004, 2005, and 2006 in Bering Sea ice. The tags were specifically designed to provide a time series of the haul-out status of a tagged walrus. Tags were deployed remotely, either by crossbow or air gun (Jay et al. 2006); in 2006 they were all deployed by crossbow and were of only one type. Tags were affixed to the animal's dorsum with a subdermal anchor in the animal's blubber layer.

The tags provided Argos location estimates. The location estimates will be filtered to reduce the frequency of erroneous locations using an algorithm developed by USGS. The tags also had a conductivity sensor that measured every second whether the tag was submerged or not. The conductivity measures were summarized over larger segments of time (< 30 min), stored in memory, and transmitted with each Argos transmission. The segment was coded "dry" if > 90% of the conductivity measures were "dry" (open circuit), and "wet" otherwise. Sensor data from the tags will be decoded and compiled into a time series of 30-min segments of haul-out status (in or out of water).

Segments of haul-out status will be linked to animal location, then to the nearest grid cell of meteorological data. The meteorological data will consist of temperature, wind speed, and barometric pressure from NOAA's National Centers for Environmental Predictions (NCEP).

A generalized linear model will be used to assess relations between haul-out status and the meteorological variables during each of the tagging years. The modeling will also assess relations between haul-out status and the previous haul-out status of a walrus and of the concurrent haul-out status of other walruses.

To meet our second objective, daily synthetic aperture radar (SAR) satellite imagery of the Bering Sea, coincident with tagged walrus data in 2006, will be acquired from NASA through University of Fairbanks' Alaska Satellite Facility (ASF). The acquisition has been approved by NASA through an ASF Research Agreement with USGS Alaska Science Center. The SAR imagery will be processed with the RADARSAT Geophysical Processor System (RGPS) at the Jet Propulsion Laboratory in California to produce data on sea ice motion. This proposal seeks funding for the SAR processing.

Walrus movements and sea ice drift will be assessed by modeling the difference between vectors of walrus movement and sea ice drift relative to time, area, and animal. Walruses spend short periods on sea ice to rest (ave. 8 hrs), and long periods in water while swimming and foraging on the seafloor (ave. 27 hrs, unpubl. data). Segments of walrus movements over specified time intervals will be assigned to behavioral classes based on the walrus' magnitude and direction of movement relative to the sea ice's magnitude and direction of drift. We expect that these behavioral classes will include segments when the walrus 1) relocates instead of maintaining its proximity to relatively stationary ice, 2) maintains its geographic position instead of moving with drifting ice, or 3) moves in close proximity with its original ice during ice drift. These classes will be suggestive of the walrus' relative preference for foraging locations and ice platforms.

**D.3. Design and Approach: Evaluation of Walrus Foraging Grounds in the Bering Sea: a Spatial and Temporal Comparison**

This study will examine the composition, abundance, and biomass of benthic species in a portion of the St. Lawrence Polynya and determine what food is available for Pacific walruses in this area, and if these food sources have changed in the last twenty years. Data collected aboard the *Magadan* during the 2006 walrus survey will be compared to data collected from benthic studies conducted over the last twenty years in the Bering Sea (Stoker 1978, Oliver et al. 1985, Grebmeier and McRoy 1989, Grebmeier et al. 1988, Grebmeier et al. 1989, Grebmeier 1993, Grebmeier and Cooper 1995, Grebmeier and Dunton 2000, Lovvorn et al. 2005, Table 1). If significant changes are found, then a shift in trophic dynamics may have occurred in the St. Lawrence Polynya.

**Objectives and Approach**

The following hypotheses will be tested:

1) the composition, abundance, and biomass of benthic walrus prey in a portion of the St. Lawrence Polynya has significantly changed over the past 20+ years,
2) the species composition, abundance and biomass of prey items found in the stomachs of Pacific walruses has significantly changed over the last 30+ years,
3) the species composition, abundance and biomass of prey items found in current Pacific walrus stomachs is positively correlated with current available benthic prey composition, abundance, and biomass in the feeding grounds around the St Lawrence Polynya.

The specific objectives to address the hypotheses are:

1. Analyze benthic samples for species composition, abundance, and biomass.
2. Compare the data obtained in this study to historical benthic data (Table 1).
3. Analyze stomach contents of harvested Pacific walrus
4. Compare stomach data obtained in this study to historical stomach data (Table 2).
5. Compare benthic and stomach data obtained in this study.

| REFERENCE | LOCATION | COLLECTION DATE |
|---|---|---|
| Stoker 1978 | Bering Sea, Chukchi Sea | 1970-1974 |
| Oliver et al. 1985 | St. Matthew Island, St. Lawrence Island, Port Clarence, Sledge Island and Cape Nome | 1981-1983 |
| Grebmeier and McRoy 1989 | northern Bering Sea, Chukchi Sea | 1984-1986 |
| Grebmeier et al. 1988 | northern Bering Sea, Chukchi Sea | 1984-1986 |
| Grebmeier et al. 1989 | northern Bering Sea, Chukchi Sea | 1984-1986 |
| Grebmeier 1993 | Gulf of Anadyr, northern Bering Sea, Chukchi Sea | 1988 |
| Grebmeier and Cooper 1995 | St. Lawrence Island | 1990 |
| Grebmeier and Dunton 2000 | St. Lawrence Island, Gulf of Anadyr | 1984-1995 |
| Lovvorn et al. 2005 | St. Lawrence Island | 1999, 2001 |

Table 1. Known studies with benthic data from walrus foraging grounds in the Bering Sea.

| REFERENCE | LOCATION | COLLECTION DATE | NUMBER AND TYPE OF WALRUS STOMACH SAMPLE | | | |
|---|---|---|---|---|---|---|
| ------------ | ------------------ | ----------- | Adult females | Adult males | Other * | Total # of samples |
| Fay 1982 | Bering Sea and Savoonga | 1930's-1975 | n/a | | | |
| Fay and Stoker 1982a | Savoonga and Gambell | 1980 | 19 | 49 | 8 | 76 |
| Fay and Stoker 1982b | Savoonga, Gambell and Southeast Cape | 1982 | 8 | 28 | 2 | 38 |
| Fay et al. 1977 | Savoonga and Gambell | 1975 | 4 | 23 | | 27 |
| Fay et al. 1984 | West and North of St. Lawrence Island | 1970-1976 | 4 | 23 | | 27 |
| Fay et al. 1989a | *To be obtained - unable to acquire copy through UAF Interlibrary loan Department | | | | | |
| Sheffield 2001 | Bering Sea (Savoonga, Gambell, King Island, Nome, Wales and Nunivak Island) | 1952-1991 | 76 | 83 | 65 | 224 |

Table 2. Known studies with stomach content data from walrus foraging grounds in the Bering Sea. *other: (calves, juveniles, and/or gender unknown)

**Methods and Analysis**

*Foraging Grounds*

Benthic sampling took place from the Russian icebreaker *Magadan*, made available by the USFWS. Seven sites around the St. Lawrence polynya were sampled using a 0.1 $m^2$ van Veen grab. At each site, at least five benthic samples and one sediment sample were taken. The benthic samples were sieved through a 0.5 mm screen and all animals retained on the screen were preserved in 10% buffered formalin for later sorting and analysis. This proposal will fund the sorting, identifying, enumerating, and weighing of these samples. These data will be compared to benthic species composition and biomass information from the Bering Sea (Table 1).

*Stomach Content Analyses*

Stomach contents will be analyzed from approximately 50 adult walruses harvested through subsistence hunting in Savoonga and Gambell in May 2007. The USFWS will coordinate the collection of stomachs. Methods to be followed are as stated in Fisher and Stewart (1997) and

Sheffield et al. (2001). For each walrus, sex and age will be determined. The date and location of the kill will be recorded. Approximately a 5 lb sample of stomach contents will be removed from each stomach and drained in a fine-meshed paint strainer bag and the samples will be frozen within 24 hours of collection. Samples will be transferred to the University of Alaska at Fairbanks for analysis. Because not all prey items of walruses are digested at the same rate, samples will preferably be taken from stomachs containing indicators of recent feeding (i.e. stomachs that contain a greater quantity of sipunculid worms, polychaete worms, and/or clam mantle and viscera) to reduce potential bias. A more accurate representation of the diet of Pacific walruses will be given by sampling "fresh" stomachs since more prey items will be identifiable and present in the stomach contents (Sheffield et al. 2001). Native hunters will be compensated $20.00 dollars for every sample collected. Funding to compensate the Native hunters and to ship and analyze samples is another purpose of this proposal. For the lab analysis, the stomach contents will be washed through 4, 1 and 0.5 mm mesh sieves. Prey items will be identified, counted, blotted dry, and weighed to the nearest 0.1 g. Bivalve numbers will be based on identifiable siphons, feet, bodies, or shells. Gastropod, polychaete, and brachiopod numbers will be based on diagnostic hard parts such as opercula, jaws, and shell teeth. Additionally, the volume of food items will be determined by water displacement.

Comparisons using our data will include: 1) benthic community structure over time, 2) benthic community structure by sediment grain size, 3) current stomach contents by sex and age, 4) stomach content over time, and 5) current stomach contents and current benthic community structure. All data will be analyzed using the multivariate statistics available with the software package Primer (v6, Plymouth Marine Laboratories, Clarke and Warwick 2001). Within Primer, various analyses will be completed, including similarity indices, cluster analyses, multidimensional scaling (MDS), analysis of similarity (ANISOM), and BIOENV. These analyses will allow for both statistical testing and graphical representation of the data.

**E. Project Management**

The overall project, Distribution, Abundance, and Ecology of Pacific Walruses in the Bering Sea, will be carried out and administered by a team of three Principal Investigators, each of whom represents one of the three components: Dr. Rosa Meehan (U.S. Fish and Wildlife Service: Distribution and Abundance of Pacific Walruses in the Bering Sea), Dr. Chad Jay (U.S. Geological Survey: Walrus-Sea Ice Relationships in the Bering Sea: Understanding the Importance of Sea Ice as a Foraging Platform), and Dr. Brenda Konar (University of Alaska Fairbanks: Evaluation of Walrus Foraging Grounds in the Bering Sea: a Spatial and Temporal Comparison).

Dr. Rosa Meehan manages the Marine Mammal program for the U.S. Fish and Wildlife Service in Alaska. The program is responsible for management and study activities relative to tracking population status and trends for walrus, polar bears and sea otters as well as harvest related management associated with subsistence harvest.

Dr. Chad Jay has considerable experience in capturing and satellite-tagging walruses on land and sea ice. He has conducted research on walruses hauled out on land in the U.S. and Russia, and in ice habitats in summer and late winter in coastal Alaska and from ships in the Bering and Chukchi Sea. He has published several papers related to applications of satellite telemetry on walruses, including studies on the diving behavior of walruses and development of novel satellite radio-tag designs for walruses.

Dr. Brenda Konar's interests include foraging habitat of marine mammals. Dr. Konar spent much of her Ph.D. working with sea otters in the Aleutian Islands (published in Marine Ecology Progress Series). Dr. Konar also just completed an NSF funded project examining changes in the grey whale feeding areas in the Bering and Chukchi Seas (manuscript has been submitted to Progress in Oceanography) and another investigating fish and habitat (kelp and invertebrates) diversity and abundance surrounding Steller Sea Lion haul-outs around Kodiak Island (manuscript in prep).

Each Principal Investigator will manage the budget and time schedule and assure the completion of products for each component.

Collaborators and their area of expertise/responsibility include:

Don Atwood, Ph.D., Alaska Satellite Facility, Geophysical Institute, University of Alaska Fairbanks (datwood@asf.alaska.edu). Satellite remote sensing; downlinking, processing, archiving, and distribution of SAR data.

Douglas Burn, USFWS (Douglas_Burn@fws.gov). Thermal imagery, survey design and analysis.

Vladimir Chernook, Ph.D., GiproRybFlot (Chernook@mail.ru). Russian project management, thermal imagery, survey design and analysis.

David Douglas, USGS (David_Douglas@usgs.gov). Sea ice remote sensing methods, recent trends in diminishing sea ice area, declining ice age structure.

Joel Garlich-Miller, USFWS (Joel_Garlichmiller@fws.gov). Walrus biology and ecology, tag deployment.

Ron Kwok, Ph.D., Jet Propulsion Laboratory, California Institute of Technology (ron.kwok@jpl.nasa.gov). Sea ice dynamics, development of RADARSAT Geophysical Processor System (RGPS), an analysis tool for the production of sea ice motion information products.

Suzann Speckman, Ph.D., USFWS (Suzann_Speckman@fws.gov). Coordination of survey effort, data analysis, and report writing and dissemination of survey results.

Mark S. Udevitz, Ph.D., USGS (Mark_Udevitz@usgs.gov). Survey design and analysis, estimation of demographic parameters, modeling of wildlife populations.

**E.1. Project Management: Distribution and Abundance of Pacific Walruses in the Bering Sea**

This component will be carried out and administered by the U.S. Fish and Wildlife Service (USFWS) in close collaboration with researchers from the U.S. Geological Survey (USGS) and Russian colleagues from the Research and Engineering Institute for the Development and Operation of Fisheries (GiproRybFlot). The Principal Investigator for this study is Rosa Meehan, Ph.D. (Rosa_Meehan@fws.gov).

Success of this project will be measured through the publication of articles in peer-reviewed journals, reports to wildlife managers and subsistence users, and collaboration between U.S. and Russian researchers and managers concerning the status of the Pacific walrus population (including public outreach). Proposed manuscripts from our work include:

- An abundance estimate for the Pacific walrus population.
- Distribution and abundance of Pacific walruses in the pack-ice of the Bering Sea
- Walrus sea-ice relationships

**Work Schedule**

Calendar Year 1 (2006)

1. U.S./Russia research cruise in the Bering Sea to deploy telemetry tags on a representative sample of walruses (completed)
2. U.S./Russian researchers fly aerial surveys for Pacific walruses groups over pack ice in the Bering Sea (completed)
3. Processing of thermal imagery data and digital photographs collected in U.S. and Russian territories
4. Meeting in St. Petersburg, Russia, in September to present preliminary analysis and exchange U.S. and Russian data. Will also provide Russian colleagues with a copy of the software ERDAS Imagine and train them to use this software for digital photograph interpretation and analysis and processing of thermal data.
5. Data analysis. Begin development of an abundance estimate for the Pacific walrus population

Calendar Year 2 (2007)

1. Meeting to discuss and coordinate survey data analysis and work together on joint US-Russia manuscripts
2. Complete development of an abundance estimate for the Pacific walrus population
3. Final preparation of manuscripts for peer review and publication (USFWS funded)

**E.2. Project Management: Walrus-Sea Ice Relationships in the Bering Sea: Understanding the Importance of Sea Ice as a Foraging Platform**

This component will be carried out and administered by the Principal Investigator, Chad Jay, Ph.D. (Chad_Jay@usgs.gov), of the USGS.

Work will start on 1 June, 2006 and end on 1 June, 2008. Walrus telemetry data for this study have already been collected under efforts to conduct a walrus abundance survey. These data come from over 100 satellite tags deployed in spring of 2004-2006. This study seeks funding to process SAR imagery with the RADARSAT Geophysical Processor System (RGPS) at the Jet Propulsion Laboratory of the California Institute of Technology, and 2 months salary for nonpermanent staff (GS-11 equivalent) to support database management, GIS and computer language processing, and data analysis. Matching funds are being provided in the form of salaries from USGS.

Manuscripts resulting from this work will be finished by 01 June, 2008, and will include:
1. Analysis of walrus haul-out status relative to meteorological conditions.
2. Analysis of walrus movements relative to sea ice drift.

**Work Schedule**
<u>Calendar Year 1 (2006)</u>
1. Compile location and haul-out time series from 2004-2006 tagged walruses
2. Compile meteorological data sets coincident to the 2004-2006 walrus telemetry data
3. Begin derivation of sea ice motion data sets pertinent to 2006 tagged walruses

<u>Calendar Year 2 (2007)</u>
1. Complete derivation of sea ice motion data sets pertinent to 2006 tagged walruses
2. Model walrus haul-out status relative to meteorological conditions
3. Model walrus movements relative to sea ice drift vectors
4. Begin preparation of manuscripts

<u>Calendar Year 3 (2008)</u>
1. Complete preparation of manuscripts for submission to peer-reviewed journals

**E.3. Project Management: Evaluation of Walrus Foraging Grounds in the Bering Sea: a Spatial and Temporal Comparison**
This component will be carried out and administered by Principal Investigator, Brenda Konar, Ph.D. (<u>Bkonar@guru.usaf.edu</u>).

Dr. Konar is an Associate Professor at the School of Fisheries and Oceans, University of Alaska Fairbanks (UAF) and the major advisor of the graduate student working on the project. Tracie Merrill is the graduate student who will be completing the bulk of this work to fulfill her master's requirements. Merrill is currently a graduate student at UAF. Her interests include foraging dynamics and habitat of marine mammals. The suggested research is a 2-year proposal, starting in September 2006.

**Work Schedule**
<u>Calendar Year 1 (2006)</u>
1. Sample walrus foraging areas (completed)
2. Work up benthic samples (sort, identify, count and weigh; fall and winter)
3. Merrill to attend Primer Workshop (fall)
4. Begin data analysis

<u>Calendar Year 2 (2007)</u>
1. Stomach collections (spring)
2. Work up stomach samples (sort, identify, count and weigh; summer)
3. Complete data analysis (fall)

<u>Calendar Year 3 (2008)</u>
1. Thesis defense (spring)
2. Manuscript preparation (spring)
3. Complete final report (spring)

## Literature Cited


Adkison, M.D., T.J. Quinn II, and R.J. Small. 2003. Evaluation of the Alaska harbor seal (*Phoca vitulina*) population survey: a simulation study. Marine Mammal Science 19:764-790.

Bengtson, J.L., and M.F. Cameron. 2004. Seasonal haulout patterns of crabeater seals (*Lobodon carcinophaga*). Polar Biology 27:344-349.

Booth, J.G., Butler, R.W., and Hall, P. 1994. Bootstrap methods for finite populations. Journal of the American Statistical Association 89(428):1282-1289.

Born, E.W., and L.Ø. Knutsen. 1997. Haul-out and diving activity of male Atlantic walruses (*Odobenus rosmarus rosmarus*) in NE Greenland. Journal of Zoology (London) 243:381-396.

Bowden, D.C., White, G.C., Franklin, A.B., and Ganey, J.L. 2003. Estimating population size with correlated sampling unit estimates. Journal of Wildlife Management 67(1):1-10.

Burn, D.M., Webber, M.A., and Udevitz, M.S. 2006. Application of airborne thermal imagery to surveys of Pacific walrus. Wildlife Society Bulletin 34:51-58.

Burn, D.M., Udevitz, M.S., Webber, M.A., and Garlich-Miller, J.L. 2005. Development of Airborne Remote Sensing Methods for Surveys of Pacific Walrus. USFWS R7/MMM Technical Report. 28 pp.

Clarke, A. and Harris, C.M. 2003. Polar marine ecosystems: major threats and future change. Environmental Conservation 30:1-25.

Cressie, N. 1991. Statistics for spatial data. John Wiley & Sons, New York.

Derocher, A.E., Lunn, N.J. and Stirling, I. 2004. Polar bears in a warming climate. Integr. Comp. Biol. 44:163-176.

Efron, B. 1982. The jackknife, the bootstrap and other resampling plans. Society for Industrial and Applied Mathematics, Philadelphia, Pennsylvania.

Fay, F.H. 1982. Ecology and biology of the Pacific walrus, *Odobenus rosmarus divergens* Illiger. North American Fauna 74:1-279.

Fay, F.H., Bukhtiyarov, Y.A., Stoker, S.W. and Shults, L.M. 1984. Foods of the Pacific walrus in winter and spring in the Bering Sea. Pages 81-88 *in* Soviet-American cooperative research on marine mammals. Vol. 1-Pinnipeds. National Oceanic Atmospheric Administration, Technical Report NMFS 12.

Fay, F.H., Eberhardt, L.L., Kelly, B.P., Burns, J.J., and Quakenbush, L.T. 1997. Status of the Pacific walrus Population, 1950-1989. Marine Mammal Science 13(4):537-565.

Fay, F.H., Hills, S. and Quakenbush, L.T. 1989a. Determination of the age of walruses taken in the Alaskan subsistence catch, 1985-1987, together with the analysis of reproductive organs and stomach contents from the 1985 sample. Final Report, contract 70181-13097-87. U.S. Fish and Wildlife Service, Anchorage, AK. 81 pp.

Fay, F.H., and C. Ray. 1968. Influence of climate on the distribution of walruses, *Odobenus rosmarus* (Linnaeus). I. Evidence from thermoregulatory behavior. Zoologica 53:1-18.

Fay, F.H. and Stoker, S.W. 1982*a*. Analysis of reproductive organs and stomach contents from walruses taken in the Alaskan harvest, spring 1980. Final report, contract 14-16-007-81-5216. U.S. Fish and Wildlife Service, Anchorage, AK. 86 pp.

Fay, F.H. and Stoker, S.W. 1982*b*. Reproductive success and feeding habits of walruses taken in the 1982 spring harvest, with comparisons from previous years. Final report. Eskimo Walrus Commission, Nome, AK. 91 pp.

Fisher, K.I. and Stewart, R.E.A. 1997. Summer foods of Atlantic walrus, *Odobenus rosmarus rosmarus*, in northern Foxe Basin, Northwest Territories. Can. J. Zool. 75:1166-1175.

Garlich-Miller, J. and Jay, C.V. 2000. Proceedings of a workshop concerning walrus survey methods. USFWS R7/MMM Technical Report 00-2. 92 pp.

Grebmeier, J.M. 1993. Studies of pelagic-benthic coupling extended onto the Soviet continental shelf in the northern Bering and Chukchi Seas. Continental Shelf Research 13(5/6):653-668.

Grebmeier, J.M. and Cooper, L.W. 1995. Influence of the St. Lawrence Island Polynya upon the Bering Sea Benthos. Journal of Geophysical Research 100:4439-4460.

Grebmeier, J.M. and Dunton, K.H. 2000. Benthic processes in the northern Bering/Chukchi Seas: status and global change. *Impacts of Changes in Sea Ice and other Environmental parameters in the Arctic*. Report of the Marine Mammal Commission Workshop, 15-17 February 2000, Girdwood, Alaska. Available from the Marine Mammal Commission, Bethesda, MD, pp. 67-71.

Grebmeier, J.M., Feder, H.M. and McRoy, C.P. 1989. Pelagic-benthic coupling on the shelf of the northern Bering and Chukchi Seas. II. Benthic community structure. Mar. Ecol. Prog. Ser. 51:253-268.

Grebmeier, J.M. and McRoy, C.P. 1989. Pelagic-benthic coupling on the shelf of the northern Bering and Chukchi Seas. III. Benthic food supply and carbon cycling. Mar. Ecol. Prog. Ser. 53:79-91.

Grebmeier, J.M., McRoy, C.P. and Feder, H.M. 1988. Pelagic-benthic coupling on the shelf of the northern Bering and Chukchi Seas. I. Food supply source and benthic biomass. Mar. Ecol. Prog. Ser. 48:57-67.

Grebmeier, J.M., J.E. Overland, S.E. Moore, E.V. Farley, E.C. Carmack, L.W. Cooper, K.E. Frey, J.H. Helle, F.A. McLaughlin, and S.L. McNutt. 2006. A major ecosystem shift in the northern Bering Sea. Science 311:1461-1464.

Hayward, J.L., S.M. Henson, C.J. Logan, C.R. Parris, M.W. Meyer, and B. Dennis. 2005. Predicting numbers of hauled-out harbour seals: a mathematical model. Journal of Applied Ecology 42:108-117.

Hills, S. 1992. The effect of spatial and temporal variability on population assessment of Pacific walruses. Ph.D. Dissertation. University of Maine. 217 pp.

Hunt, G.L., Jr. and Stabeno, P.J. 2000. Ecosystem responses to weather patterns in the Southeastern Bering Sea. Arctic Research of the United States 14:17-24.

Jay, C.V., Heide-Jørgensen, M.P., Fischbach, A.S., Jensen, M.V., Tessler, D.F., and Jensen, A.V. 2006. Comparison of remotely deployed satellite radio transmitters on walruses. Marine Mammal Science 22:226-236.

Jay, C. V., and S. Hills. 2005. Movements of walruses radio-tagged in Bristol Bay, Alaska. Arctic 58(2):192-202.

Lovvorn, J.R., Cooper, L.W., Brooks, M.L., De Ruyck, C.C., Bump, J.K. and Grebmeier, J.M. 2005. Organic matter pathways to zooplankton and benthos under pack ice in late winter and open water in late summer in the north-central Bering Sea. Mar. Ecol. Prog. Ser. 291:135-150.

McCullagh, P. and Nelder, J.A. 1989. Generalized linear models, second edition. Chapman and Hall, Boca Raton, Florida.

Merrick, R.L. 1997. Current and historical roles of apex predators in the Bering Sea ecosystem. J. Northeast. Atl. Fish. Sci. 20:343-355.

Oliver, J.S., Kvitek, R.G. and Slattery, P.N. 1985. Walrus feeding disturbance: scavenging habits and recolonization of the Bering Sea benthos. J. Exp. Mar. Biol. Ecol. 91:233-246.

Oliver, J.S., Slattery, P.N., O' Connor, E.F. and Lowry, L.F. 1983. Walrus, *Odobenus rosmarus*, feeding in the Bering Sea: a benthic perspective. Fishery Bulletin 81:501-512.

Overpeck, J.T., M. Sturm, J.A. Francis, D.K. Perovich, M.C. Serreze, R. Benner, et al. 2005. Arctic system on trajectory to new, seasonally ice-free state. EOS. Transactions, American Geophysical Union 86(34):309-316.

Sheffield, G., Fay, F.H., Feder, H., and Kelly, B.P. 2001. Laboratory digestion of prey and interpretation of walrus stomach contents. Marine Mammal Science 17:310-330.

Stoker, S. 1978. Benthic invertebrate macrofauna of the eastern Continental Shelf of the Bering/Chukchi Seas. Ph.D. Dissertation, Institute of Marine Science, University of Alaska Fairbanks.

Tynan, C.T., and DeMaster, D.P. 1997. Observations and predictions of Arctic climate change: potential effects on marine mammals. Arctic 50:308–322.

USFWS and USGS. 2005. Study plan for estimating the size of the Pacific walrus population. . Unpublished internal document. 39 pp. Available at http://alaska.usgs.gov/science/biology/walrus/publications.html.

Udevitz, M.S. 2005. Statistical procedures for estimating Pacific walrus population size. Technical report, Alaska Science Center, U.S. Geological Survey, Anchorage, Alaska. 9 pp.

## NPRB BUDGET SUMMARY FORM

**PROJECT TITLE:** Distribution and abundance of Pacific walruses in the Bering Sea

**PRINCIPAL INVESTIGATOR:** Rosa Meehan and Suzann Speckman

| FUNDING SOURCE | YEAR 1 | YEAR 2 | YEAR 3 | TOTAL |
|---|---|---|---|---|
| **NPRB Funding** | 158,234 | 24,400 | 0 | 182,634 |
| **Match/In Kind** | | | | 2,276,599 |
| **TOTAL** | 158,234 | 24,400 | 0 | 2,459,233 |

Annual cost category breakdowns will be requested for matching funds only if project is funded

| Cost Categories | NPRB Year 1 | NPRB Year 2 | NPRB Year 3 | NPRB TOTAL | Match/In kind TOTAL (all years) |
|---|---|---|---|---|---|
| **1. Personnel Salaries** | 80,000 | | | 80,000 | 583,599 |
| **2. Personnel Fringe Benefits** | | | | 0 | |
| **3. Travel (include 1 trip to review mtg in Anchorage each year plus for the year following project conclusion)** | 20,000 | 20,000 | | 40,000 | 41,000 |
| **4. Equipment** | 10,000 | | | 10,000 | 352,000 |
| **5. Supplies** | 9,000 | | | 9,000 | |
| **6. Contractual/Consultants** | | | | 0 | 1,300,000 |
| **7. Other (Include $2000 for education and outreach)** | 10,700 | | | 10,700 | |
| **Total Direct Costs** | **129,700** | **20,000** | **0** | **149,700** | **2,276,599** |
| **Indirect Costs (22%)** | 28,534 | 4,400 | | 32,934 | |
| **TOTAL PROJECT COSTS** | **158,234** | **24,400** | **0** | **182,634** | **2,276,599** |

## NPRB BUDGET SUMMARY FORM

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT TITLE:** | Walrus-Sea Ice Relationships in the Bering Sea: Understanding the Importance of Sea Ice as a Foraging Platform | | | | Annual cost category breakdowns will be requested for matching funds only if project is funded |
| **PRINCIPAL INVESTIGATOR:** | Chad Jay, USGS | | | | |
| **FUNDING SOURCE** | **YEAR 1** | **YEAR 2** | **YEAR 3** | **TOTAL** | |
| **NPRB Funding** | 44,726 | 8,293 | 0 | 53,019 | |
| **Match/In Kind** | | | | 66,450 | |
| **TOTAL** | 44,726 | 8,293 | 0 | 119,469 | |

| **Cost Categories** | **NPRB Year 1** | **NPRB Year 2** | **NPRB Year 3** | **NPRB TOTAL** | **Match/In kind TOTAL (all years)** |
|---|---|---|---|---|---|
| **1. Personnel Salaries** | 5,188 | 5,188 | | 10,376 | |
| **2. Personnel Fringe Benefits** | | | | 0 | |
| **3. Travel (include 1 trip to review mtg in Anchorage each year plus for the year following project conclusion)** | | | | 0 | |
| **4. Equipment** | | | | 0 | |
| **5. Supplies** | | | | 0 | |
| **6. Contractual/Consultants** | 35,000 | | | 35,000 | |
| **7. Other (Include $2000 for education and outreach)** | | 667 | | 667 | |
| **Total Direct Costs** | **40,188** | **5,855** | **0** | **46,043** | **0** |
| **Indirect Costs** | 4,538 | 2,438 | | 6,977 | |
| **TOTAL PROJECT COSTS** | **44,726** | **8,293** | **0** | **53,019** | **0** |

## NPRB BUDGET SUMMARY FORM

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT TITLE:** | Evaluation of Walrus Foraging Grounds in the Bering Sea | | | | Annual cost category breakdowns will be requested for matching funds only if project is funded |
| **PRINCIPAL INVESTIGATOR:** | Brenda Konar, UAF | | | | |
| **FUNDING SOURCE** | **YEAR 1** | **YEAR 2** | **YEAR 3** | **TOTAL** | |
| **NPRB Funding** | 64,115 | 0 | 0 | 64,115 | |
| **Match/In Kind** | | | | 0 | |
| **TOTAL** | 64,115 | 0 | 0 | 64,115 | |

| **Cost Categories** | **NPRB Year 1** | **NPRB Year 2** | **NPRB Year 3** | **NPRB TOTAL** | **Match/In kind TOTAL (all years)** |
|---|---|---|---|---|---|
| **1. Personnel Salaries** | 24,964 | | | 24,964 | |
| **2. Personnel Fringe Benefits** | 3,269 | | | 3,269 | |
| **3. Travel (include 1 trip to review mtg in Anchorage each year plus for the year following project conclusion)** | 3,100 | | | 3,100 | |
| **4. Equipment** | | | | 0 | |
| **5. Supplies** | 4,750 | | | 4,750 | |
| **6. Contractual/Consultants** | 700 | | | 700 | |
| **7. Other (Include $2000 for education and outreach)** | 9,860 | | | 9,860 | |
| **Total Direct Costs** | **46,643** | **0** | **0** | **46,643** | **0** |
| **Indirect Costs** | 17,472 | | | 17,472 | |
| **TOTAL PROJECT COSTS** | **64,115** | **0** | **0** | **64,115** | **0** |

## NPRB BUDGET SUMMARY FORM - MULTIPLE ORGANIZATIONS

| | | | | | |
|---|---|---|---|---|---|
| **PROJECT TITLE:** | Distribution and abundance of Pacific walruses in the Bering Sea | | | | Annual cost category breakdowns will be requested for matching funds only if project is funded |
| **PRINCIPAL INVESTIGATOR(S):** | Rosa Meehan and Suzann Speckman; Chad Jay, USGS; Brenda Konar, UAF; | | | | |
| **FUNDING SOURCE** | **YEAR 1** | **YEAR 2** | **YEAR 3** | **TOTAL** | |
| **NPRB Funding** | 267,075 | 32,693 | 0 | 299,768 | |
| **Match/In Kind** | | | | 2,276,599 | |
| **TOTAL** | 267,075 | 32,693 | 0 | 2,576,367 | |

| **Cost Categories** | **NPRB Year 1** | **NPRB Year 2** | **NPRB Year 3** | **NPRB TOTAL** | **Match/In kind TOTAL (all years)** |
|---|---|---|---|---|---|
| **1. Personnel Salaries** | 110,152 | 5,188 | 0 | 115,340 | 583,599 |
| **2. Personnel Fringe Benefits** | 3,269 | 0 | 0 | 3,269 | 0 |
| **3. Travel (include 1 trip to review mtg in Anchorage each year plus for the year following project conclusion)** | 23,100 | 20,000 | 0 | 43,100 | 41,000 |
| **4. Equipment** | 10,000 | 0 | 0 | 10,000 | 352,000 |
| **5. Supplies** | 13,750 | 0 | 0 | 13,750 | 0 |
| **6. Contractual/Consultants** | 35,700 | 0 | 0 | 35,700 | 1,300,000 |
| **7. Other (Include $2000 for education and outreach)** | 20,560 | 667 | 0 | 21,227 | 0 |
| **Total Direct Costs** | **216,531** | **25,855** | **0** | **242,386** | **2,276,599** |
| **Indirect Costs** | 50,544 | 6,838 | 0 | 57,383 | 0 |
| **TOTAL PROJECT COSTS** | **267,075** | **32,693** | **0** | **299,768** | **2,276,599** |

Curricula Vitae

**Brenda Konar**

School of Fisheries and Ocean Sciences, University of Alaska Fairbanks
P.O. Box 757220, Fairbanks AK 99775-7220
907-474-5028 (work), 907-474-5804 (fax), bkonar@guru.uaf.edu

**Education:**

| | | |
|---|---|---|
| San Jose State University, San Jose, CA | Zoology | B.A. 1986 |
| Moss Landing Marine Laboratories, CA | Marine Sciences | M.S. 1991 |
| University of California, Santa Cruz | Biology | Ph.D. 1998 |

**Professional Appointments:**

| | |
|---|---|
| 2005-present | Interim UAF Director, Kasitsna Bay Laboratory (Seldovia, AK) |
| 2004-present | Associate Professor. School of Fisheries and Ocean Sciences, University of Alaska Fairbanks and Staff Scientist for the West Coast and Polar Regions Undersea Research Center. |
| 2000-2004 | Assistant Professor. School of Fisheries and Ocean Sciences, University of Alaska Fairbanks and Staff Scientist for the West Coast and Polar Regions Undersea Research Center. |
| 1999-2000 | Research Assistant Professor, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks and Staff Scientist for the West Coast and Polar Regions Undersea Research Center. |

**Research Interests:**

I am involved in various projects focused on nearshore ecology, including biodiversity, macroalgal/fish and invertebrate interactions, marine mammal foraging studies, monitoring programs, and scientific diving techniques.

**Scientific Expeditions:**

The majority of my research expeditions have involved scientific diving. I have participated in over twenty research cruises ranging from the Beaufort Sea to Prince William Sound, Alaska, many of which I was the lead scientist. Other expeditions include shore-based work in the Antarctic, Alaska, Florida, California, Baja California Mexico, and others.

**Publications:**

*5 most recent publications:*

Highsmith, R. C., K. O. Coyle, B. A. Bluhm, and B. Konar. *In press*. Gray whales in the Bering and Chukchi Seas. Chapter in J. Estes (ed.), Whales, Whaling and Ocean Ecosystems, UC Press

Konar, B. and Iken, K. *In press*. Competitive dominance among sessile marine organisms in a high Arctic boulder community. Polar Biology.

Brewer, R. and Konar B. 2005. Chemosensory responses and foraging behavior of the seastar *Pycnopodia helianthoides*. Marine Biology 147: 789-795.

Estes, JA, EM Danner, DF Doak, B Konar, AM Springer, PD Steinberg, MT Tinker and TM Williams. 2004. Complex trophic interactions in kelp forest ecosystems. Bulletin of Marine Science 74: 621-638.

Konar, B and Estes, JA. 2003. The stability of boundary regions between kelp beds and deforested areas. Ecology 84: 174-185.

*5 other publications:*

Iken, K and B Konar. 2003. Natural Geography in Nearshore Areas (NaGISA): The nearshore component of the census of Marine Life. Gayana 67: 153-160.

Konar, B. 2001. Seasonal changes in subarctic sea urchin populations from different habitats. Polar Biology 24:754-763.

Konar, B. 2000. Seasonal inhibitory affects of marine plants on sea urchins: structuring communities the algal way. Oecologia 125:208-217
Konar, B. 2000. Limited effects of a keystone species: trends of sea otters and kelp forest at the Semichi Islands, Alaska. Marine Ecology Progress Series 199:271-280.
Konar, B and C Roberts. 1996. Large scale landslide effects on two exposed rocky subtidal areas in California. Botanica Marina. 39:517-524.

**Teaching History:**
University of Alaska Fairbanks:
Invertebrate Zoology (undergraduate level), Marine Biology (graduate level), various Graduate Seminars, Scientific Diving, Advanced Scientific Diving, Kelp Forest Ecology

**Graduate Advisors:**
At the University of California, Santa Cruz:
Drs. James Estes (major), Dan Doak, John Pearse, Peter Raimondi
At the Moss Landing Marine Labs:
Drs. Michael Foster (major), James Barry, James Harvey

**Thesis Sponsor:**
Present chair: Jennifer Bump, Casey Debenham, Nicholas Harman, Ben Daly, Joel Markis, Tracie Merrill
Past chair: Reid Brewer, Cathy Hegwer, Héloise Chenelot, Judy Hamilton, Heather Patterson
Present committee member: Arny Blanchard, Angela Dubois
Past committee member: Eloise Brown, Ann Knowlton, Christine Foshee

**Current Committees:**
Natural Geography in Shore Areas Scientific Steering Group
Kachemak Bay National Research Reserve Advisory Council
Kachemak Bay Science Conference Steering Committee
UA Diving Safety Control Board (chair)
UAF Faculty Senate
UAF Unit Criteria Senate Committee

**Collaborators:**
Bodil Bluhm, University of Alaska Fairbanks
Reid Brewer, University of Alaska Fairbanks
Ken Coyle, University of Alaska Fairbanks
Dan Doak, University of California Santa Cruz
Ken Dunton, University of Texas
James Estes, University of California Santa Cruz
Ray Highsmith, University of Southern Mississippi
Katrin Iken, University of Alaska Fairbanks
Brendan Kelly, University of Alaska Southeast
Greg Marshall, National Geographic
Brenda Norcross, University of Alaska Fairbanks
Jennifer Reynolds, University of Alaska Fairbanks
Alan Springer, University of Alaska Fairbanks
Tim Tinker, University of California Santa Cruz
Douglas Wartzok, Florida International University

USGS
science for a changing world

# CHADWICK V. JAY, Ph.D.

**Research Ecologist**
Phone: (907) 786-7414
Fax: (907) 786-7150
email: chad_jay@usgs.gov

U.S. Geological Survey
Alaska Science Center
4230 University Dr., Suite 201
Anchorage, AK 99508

## EDUCATION

| | | | |
|---|---|---|---|
| Ph.D. | 1996 | Fisheries Science – Marine | Oregon State University |
| M.A. | 1985 | Biology – Invertebrate Zoology | Humboldt State University |
| B.S. | 1981 | Fisheries Science – Limnology | Utah State University |

## AREAS OF EXPERTISE

- wildlife telemetry
- spatial and temporal patterns of animal distributions
- marine mammal and benthic ecology

## EXPERIENCE

| | |
|---|---|
| Research Ecologist, Project Leader, USGS Alaska Science Center, AK | 1994 - Present |
| Research Assistant, Oregon State University, OR | 1991 - 1994 |
| Fisheries Biologist, New Zealand Ministry of Agriculture and Fisheries | 1987 - 1990 |
| Principal Investigator, Humboldt State University, CA | 1982 - 1985 |
| Marine Mammal Observer, NMFS National Marine Mammal Lab, WA | 1985 |
| Field and Lab Technician (various) | 1979 – 1982 |

## SELECTED PUBLICATIONS

**Jay, C.V.**, M.P. Heide-Jørgensen, A.S. Fischbach, M.V. Jensen, D.F. Tessler, and A.V. Jensen. 2006 *(in press)*. Comparison of remotely deployed satellite radio transmitters on walruses. *Marine Mammal Science* 22(1):225-234.

Bornhold, B.D., **C.V. Jay**, R. McConnaughey, G. Rathwell, K. Rhyna, and W. Collins. 2005. Walrus foraging marks on the seafloor in Bristol Bay, Alaska – a reconnaissance survey. *Geo-Marine Letters* 25(5):293-299.

**Jay, C. V.**, and S. Hills. 2005. Movements of walruses radio-tagged in Bristol Bay, Alaska. *Arctic* 58(2):192-202.

Udevitz, M.S., **C.V. Jay**, and M.B. Cody. 2005. Observer variability in pinniped counts: ground-based enumeration of walruses at haul-out sites. *Marine Mammal Science* 21(1):108-120.

Mulcahy, D.M., P.A. Tuomi, G.W. Garner, and **C.V. Jay**. 2003. Immobilization of free–ranging male Pacific walruses using carfentanil citrate and naltrexone hydrochloride. *Marine Mammal Science* 19(4):846-850.

**Jay, C.V.**, and G.W. Garner. 2002. Performance of a satellite-linked GPS on Pacific walruses (*Odobenus rosmarus divergens*). *Polar Biology* 25:235-237.

**Jay, C.V.**, S.D. Farley, and G.W. Garner. 2001. Summer diving behavior of male walruses in Bristol Bay, Alaska. *Marine Mammal Science* 17(3):617-631.

**Jay, C.V.**, T.L. Olson, G.W. Garner, and B.E. Ballachey. 1998. Response of Pacific walruses to disturbances from capture and handling activities at a haul-out in Bristol Bay, Alaska. *Marine Mammal Science* 14(4):819-828.

# Rosa H. Meehan

U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

Phone: (907) 786-3349
fax: (907) 786-3816
email: rosa_meehan@fws.gov

## EDUCATION

**University of Colorado**, Boulder, CO ▪ 1986
**Ph.D.** in Environmental, Population, and Organismic Biology
Dissertation: "Impact of Oilfield development on Shorebirds, Prudhoe Bay, Alaska"

**University of Alaska**, Fairbanks, AK ▪ 1980
**M.S.** in Biology
Thesis: "Vocalizations of Boreal Owls (Aegolius funereus) during the Breeding Season"

**University of California**, Santa Cruz, CA ▪ 1976
**B.S. Honors** in Biology

## RECENT EMPLOYMENT

U.S. Fish and Wildlife Service**,** Region 7, Alaska:

**Division Chief, Marine Mammals Management** – Policy development and management of polar bear, sea otter and Pacific walrus and their subsistence by Alaska Natives under the Marine Mammal Protection Act and the Endangered Species Act in Alaska ▪ Current position

**Chief, Resources Division, Subsistence Management** – Regulation development, biological and anthropological assessment of subsistence uses relative to implementation of Subsistence Harvest management on Federal lands in Alaska. ▪ 1996-1999

**Chief, Division of Habitat Conservation** – Policy development and review of the implementation of a variety of resource management related statutes (Coastal Zone Management Act, Clean Water Act, Endangered Species Act) in Alaska ▪ 1993 - 1996

## RELATED EXPERIENCE

**Area V Program Lead,** Russia program coordinator, U.S. Fish and Wildlife, Anchorage, AK, 2002 – Present.

**Member,** Assessment Team, US National Assessment of the Potential Consequences of Climate Variability and Change Region: Alaska, 1997 - 2003

**Member,** Steering Committee, Bering Sea Impact Study, 1996 – 1999.

**President,** AAAS-Arctic Division, 1994.

## SELECTED PUBLICATIONS


Klein, David R., Leonid M. Baskin, Lyudmila S. Bogoslovskaya, Kjell Danell, Anne Gunn, David B. Irons, Gary P. Kofinas, Kit M. Kovacs, Margarita Magomedova, Rosa H. Meehan, Don E. Russell, Patrick Valkenburg. 2004. Management and Conservation of Wildlife in a Changing Arctic Environment, *in* Impacts of a Warming Arctic, Arctic Climate Impact Assessment. Cambridge University Press, 2004.

Meehan, R, V. Byrd, G. Divoky and J. Piatt. 1998. Implications of Climate Change for Alaska's Seabirds. *In*: Assessing the Consequences of Climate Change for Alaska and the Bering Sea Region.

Meehan, R., V. Sergienko, and G. Weller (*editors)*. 1994. Bridges of Science between North America and the Russian Far East. *Proceedings of the 45$^{th}$ Arctic Science Conference.*

Meehan, R. 1988. Oil development in Northern Alaska, A guide to the effects of oil development in the Prudhoe Bay Oilfield, Alaska. Environmental Protection Agency, Corvallis, Oregon. 200pp.

Meehan, R. 1988. characterization and value ranking of waterbird habitat on the Colville River Delta, Alaska. Report to the Environmental Protection Agency. 105 pp.

Walker, D.A., P.J. Webber, M.D. Walker, N.D. Lederer, R.H. Meehan, and E.A. Nordstrand. 1986. Use of geobotanical maps and automated mapping techniques to examine cumulative impacts in the Prudhoe Bay Oilfield, Alaska. Environmental Conservations 13(2):149-160