

**STUDY TITLE:** Distribution and Abundance of Harbor Seals in Cook Inlet, Alaska.

**REPORT TITLE:** Distribution and Abundance of Harbor Seals in Cook Inlet, Alaska.

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FY2004 COST: 479,220

FY2005 COST: 849,700

FY2006 COST: 369,700

FY2007 COST: 61,200

FY2008 COST: 0

CUMMULATIVE PROJECT COST: \$2,192,700

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**BACKGROUND:** There are five subspecies of harbor seals (*Phoca vitulina*) found exclusively in the Northern Hemisphere. *Phoca vitulina richardii* inhabit the western coast of North America and are the most abundant subspecies, a large number of which reside in Alaskan waters where the population numbers more than 150,000. Harbor seals occupy a broad range in Alaska from approximately 130°W to 172°E (over 3,500 km east to west) and from 61°N to 51°S (over 1,000 km north to south). The Cook Inlet region of Alaska is located in the western Gulf of Alaska and supports a large abundance of harbor seals year round. The National Marine Fisheries Service and the Alaska Native Harbor Seal Commission recognize 12 stocks of harbor seals in Alaska. The seals in Cook Inlet are represented by a stock that ranges from Cook Inlet through the north side of Shelikof Strait and towards the Shumigan Islands. This study focuses on harbor seals within the Cook Inlet region.

In recent decades, the abundance of harbor seals has declined at several Alaska locations. For example, counts of harbor seals at Tugidak Island declined 85% between 1976 and 1988 and counts in Prince William Sound suggest population declines of approximately 63% between 1984 and 1997. The significance and causes of these declines are unknown, but there is concern about the present and future status of Alaska harbor seal populations. Because of the proximity of the declining populations to Cook Inlet, and the particularly high oil and gas activity within Cook Inlet, it is important to assess the potential impacts of oil and gas activities on harbor seals within Cook Inlet.

### **OBJECTIVES:**

The principal purposes of this study were divided into three separate tasks.

#### Task 1

1. assess the abundance and distribution of harbor seals throughout Cook Inlet,
2. identify and document the harbor seal haul-out sites that are most important for the key life history events of pupping (June) and molting (August), and
3. compare the pupping and molting situations to other seasons when these important life history events do not constrain the seals' behavior.

#### Task 2

1. How do changes in specific covariates (weather conditions, tidal height, time of day, date in seasonal life-history cycle) impact the haul-out behavior of harbor seals, and what is the combined impact of all the covariates taken together?
2. What is the relative importance of the various covariates on the haul-out behavior of harbor seals?
3. Does the relative importance or impact of specific covariates on harbor seal haul-out behavior change over the course of the seals' seasonal life-history cycle? For example, are seals more, or less, sensitive to changes in weather conditions during the molting season (August - September) than during other times of the year?

#### Task 3

1. To assess the seasonal patterns of abundance, distribution, and behavior of harbor seals in Cook Inlet, including an assessment of the seals' diving behavior.
2. To identify and determine the priority of importance specific marine habitats used by harbor seals in Cook Inlet associated with key life history events such breeding, pup rearing, and foraging.
3. To enhance estimates of harbor seal abundance in Cook Inlet by determining and applying a haul-out correction factor that adjusts aerial survey counts for the proportion of seals that are at-sea and not observed during aerial surveys.

4. To evaluate whether or not geographically distinct subpopulations of seals exist within Cook Inlet.

**DESCRIPTION:**

Task 1

The National Marine Mammal Laboratory (NMML) conducted 152 aerial surveys in Cook Inlet, Alaska from 2003-2005 to understand the seasonal abundance and distribution of harbor seals (*Phoca vitulina richardii*). Surveys were flown in August, October, April and June to coincide with breeding and pupping (June), molting (August) and non-breeding periods (October and April). The effects of seasonal and environmental variables (covariates) on the numbers of harbor seals hauled out during surveys were assessed using a generalized linear model. The final fitted model of harbor seal counts provided a measure the magnitude of seasonal changes in harbor seals hauled out in the study area. Analysis of data from satellite-linked geo-location and dive-recorder tags, obtained in Task III of this study, will complement these results by providing measures of habitat use at sea. Haul-out time lines, also obtained from satellite tags, will allow estimation of the total abundance of harbor seals in Cook Inlet, in contrast to the abundance ashore that we estimated from the aerial surveys alone.

Task 2

Fourteen remote time-lapse camera systems were deployed in 2003-2004 at the following five harbor seal haul-out sites: Aurora Rock, Anchor Point, and Augustine Island East, West-1 and West-2. After deployment, however, a few key factors prevented us from completing the majority of our objectives. The greatest obstacle to success of this project was the unreliability of the camera/controller combination that we selected. Even with frequent maintenance visits, one or more cameras at each site continued to fail for unknown reasons, and as a result we obtained only partial photographic coverage of the haul-out sites. Without accurate hourly seal counts, we were unable to address the original objectives of this project and relate the numbers of seals on a haul-out to specific covariates such as weather conditions, tidal height, time of day, and date in seasonal life-history cycle. The original objectives, however, were met even more effectively by addition of Task III to this project, which enabled satellite-tagging of a large sample of harbor seals; the satellite tags provided detailed haul-out time lines that will be analyzed to identify and describe the key factors in harbor seal haul-out behavior and to estimate total abundance from aerial survey counts of seals ashore.

Task 3

Between 2004 and 2006 we conducted four harbor seal tagging trips in Cook Inlet during the months of October and May. In total, we captured and released 93 harbor seals, 77 of which were tagged with satellite transmitters. Each transmitter was glued to the hair on the back of the seal using durable epoxy. Fourteen of the seals were also equipped with specially developed transmitters that were attached to one

of the rear flippers. Transmissions from the 91 tags resulted in 178,536 location estimates and 310,593 dive and haul-out behavior records. These data formed the basis for the development of novel analysis techniques. Johnson et al. (2008) developed a continuous-time correlated random walk (CTCRW) method for predicting animal locations from satellite tags. Higgs and Ver Hoef (2011) described a new statistical method for analyzing dive behavior based on dive histogram recordings obtained from satellite tags. This report demonstrates the application of the CTCRW model to provide estimates of seasonal changes in behavior and use patterns for harbor seals in Cook Inlet and Gulf of Alaska. Three statistics (trip length, trip duration and net trip distance) were examined as response variables in a mixed linear model. Haul-out behavior was examined based on the behavior records transmitted by deployed tags and modeled haul-out proportions were used to correct counts reported in Task I to total abundance. These insights into seasonal harbor seal movements, behavior and abundance are critical for understanding foraging ecology, marine habitat use, and risk of impacts from industrial accidents such as oil spills.

### **SIGNIFICANT CONCLUSIONS:**

#### Task 1

Kachemak Bay and Kamishak Bay were two regions with consistently high numbers of seals ashore across all seasons. Additional areas with relatively high numbers in some seasons were the mouth of Iliamna Bay, Augustine Island, Redoubt Bay and the sandbars north and south of Kalgin Island. In general, areas with high numbers of seals in June also had large numbers of pups. The adjusted counts and standard errors of harbor seals in the study area for each season were 2,635 (257) for April; 7,111 (313) for June; 8,301 (292) for August; and 2,407 (454) for October. The results presented in this report provide a solid foundation for understanding the seasonal distribution and abundance of seals ashore and can aid planning agencies in reducing, avoiding, or responding to impacts from human activities.

#### Task 2

The most significant conclusion from the deployment of remote time-lapse cameras is that, at the time of the study, off-the-shelf components (especially the camera/controller combination components) were not of sufficient build quality to perform reliably under the extreme weather conditions of Cook Inlet. We believe that low cost methods for year-round monitoring of harbor seal numbers ashore and haul-out behavior related to specific covariates would still be valuable to develop. Although we could not locate suitable alternatives among the commercially available components in 2005, the rapid evolution of digital camera technology may yet result in a simple, highly-reliable camera and interval controller. To assist others who may pursue similar objectives in the future, we have compiled a summary of considerations for this type of study that we believe will need to be taken into account even if a suitable technical solution can be found for the system components. Two very important considerations for this type of study are complete photographic coverage of the haul-out and good photographic quality.

### Task 3

Harbor seals tagged in central and southern Cook Inlet ranged as far southwest as the Semidi Islands and some seals used habitats around the north and northeast side of Kodiak Island. There was a strong seasonal pattern of more coastal and restricted spatial use during the spring and summer (breeding, pupping, molting) and more wide-ranging movements within and outside of Cook Inlet during the winter months. Analysis comparing seasonal dive behavior of a single adult female (AF) harbor seal and a juvenile male (JM) harbor seal showed similar results with reduced dive activity for the adult female in the month of June. Haul-out behavior also varied seasonally with the proportion of seals hauled out peaking at 0.43 in June compared to 0.32 in October. Combining the previously reported survey counts with these haul-out proportions resulted in a peak seasonal abundance of 23,954 (SE: 1576) seals in August compared to 10,820 (SE: 1240) in April.

#### **STUDY RESULTS:**

Detail results from this study are presented in three separate reports corresponding to each task.

#### **STUDY PRODUCTS:**

At least 10 distinct oral presentations and 7 distinct poster presentations were made as part of scientific meetings, government meetings, international meetings and co-management meetings, and community information meetings.

The following peer reviewed publications resulted from this work

1. Montgomery, R. A. 2005. Modeling the terrestrial habitat use of harbor seals. Master of Science Thesis. University of Washington, Seattle, Washington.
2. Montgomery, R. A., J. M. Ver Hoef, and P. L. Boveng. 2007. Spatial modeling of haul-out site use by harbor seals in Cook Inlet, Alaska. *Marine Ecology Progress Series* 341:257-264
3. Johnson, D. S., J. M. London, M.-A. Lea, and J. Durban. 2008. Continuous-Time Correlated Random Walk Model for Animal Telemetry Data. *Ecology* **89**:1208-1215.
4. Higgs, M. D. and J. M. Ver Hoef. 2011. Discretized and aggregated: modeling dive depth of harbor seals from ordered categorical data with temporal autocorrelation. *Biometrics*.