The North Pacific Research Board (NPRB) was established by Congress in 1997 to develop a comprehensive science program of the highest caliber that provides a better understanding of the North Pacific, Bering Sea, and Arctic Ocean ecosystems and their fisheries.

The NPRB carries out science planning, prioritizes pressing fishery management and ecosystem information needs, coordinates with other ocean science programs, competitively selects research projects, and communicates research results to diverse audiences.

Since its founding, the North Pacific Research Board has developed a comprehensive program of marine research. The Science Plan, developed with guidance from the National Research Council of the U.S. National Academies of Sciences, serves as the foundation for annual requests for proposals organized by major research themes, including:

- Lower Trophic Level Productivity
- Fish Habitat
- Fish and Invertebrates
- Marine Mammals
- Seabirds
- Humans
- Other Prominent Issues
- Integrated Ecosystem Research
- Other Research and Partnerships

The annual requests for proposals result in the majority of the funded projects, which are numbered by the year they were funded (e.g., #201 funded in 2002). The Board also supports integrated ecosystem research programs that look in-depth at Alaska’s major ocean ecosystems, with a program ongoing in the Bering Sea and in development for the Gulf of Alaska.

This research summary describes research funded from 2002 through 2008.
MARINE MAMMALS

Marine mammals are among the more visible and engaging components of the marine ecosystem and are often considered to be sentinels of how an ecosystem is functioning. Top predators in the marine ecosystem, the 26 marine mammal species found in Alaska waters also provide important subsistence resources to many Alaska communities. This cultural and ecological role makes it important for us to understand how these species interact with other ecosystem components and how overlap with commercial fisheries and other human activities impact marine mammal populations. Based on recommendations from the National Research Council and NPRB’s enabling legislation to address both pressing fisheries management needs and marine ecosystem information needs, the Board has funded marine mammal research under the following six categories:

- foraging success
- marine habitat use
- population dynamics
- fisheries interactions
- other human-related impacts
- long-term climate change

The Board funds a mix of long and short-term marine mammal research, focusing on species that may be at greatest risk from interactions with major commercial fisheries of the Bering Sea, Aleutian Islands, and Gulf of Alaska. From 2002-2008, the Board supported 33 marine mammal studies for a total of just under $5.3 million. Studies focus on a variety of baleen and toothed whale species, northern fur seals, Steller sea lions, harbor seals, ice seals, Pacific walrus, and sea otters. Twenty studies have been completed with 13 currently ongoing. Of these, 26 are process studies, two are monitoring, three are modeling, and two are retrospective studies, most focused predominantly in the Bering Sea and Gulf of Alaska, with only a few in the Arctic.
NORTH PACIFIC RESEARCH BOARD :: SCIENCE PROGRAM :: MARINE MAMMALS

MARINE MAMMALS

307 Bering Sea right whales: ongoing research and public outreach. J. Hildebrand
312 Ice seal bio-monitoring in the Bering-Chukchi Sea region. J. Quakenbush, G. Sheffield
313 Effects of prey availability and predation risk on the foraging ecology and demography of harbor seals in Prince William Sound: Development and test of a dynamic state variable model. G. Blundell, L. Dill, A. Frid
411 Investigations into dietary specialization of killer whales in the Bering Sea and Aleutian Islands. A. Hirons, P. Krahn, P. Wade
412 Sperm whale and longline fisheries interactions in the Gulf of Alaska - passive acoustic component. W. Kuperman, J. Straley, A. Thode
414 Seasonal foraging strategies and consequences for northern fur seals at colonies with opposite population trends. R. Ream, A. Springer
501 Remote monitoring of survival and short-range year-round movements of harbor seals in Prince William Sound. G. Blundell
513 Winter movements of fur seal pups. R. Andrews, R. Davis
514 Consequences of fur seal foraging strategies. R. Ream, A. Springer
515 Ice seal movements. P. Boering, B. Kelly
518 Bering Sea whales and oceanography. D. Mellinger, J. Moore
519 Bering Sea whale acoustics. J. Weidmann
527 Evaluation of sperm whale deterrents. L. Behnken, W. Kuperman, S. Mesnick, V. P. Connell, J. Straley, A. Thode
535 Dietary specialization of killer whales. A. Hirons, P. Krahn, P. Wade
613 Population structure of ringed seals. B. Kelly, R. Johnson
626 Testing low-cost methods to reduce sperm whale depredation in the Gulf of Alaska. J. Straley, A. Thode
631 Distribution, abundance, and ecology of Pacific walruses in the Bering Sea. C. Jay, B. Konar, R. Herren
632 Remote monitoring of survival and short-range year-round movements of harbor seals in Prince William Sound. G. Blundell
633 Multi-scale predictions of right whale (Eubalaena japonica) habitat in the North Pacific and Bering Sea. J. Ford, E. Grigg, A. Hirons
634 Genetic population structure of bowhead whales, using historical bone and baleen samples. P. Mesnick
635 Comparison of stable carbon and nitrogen isotope ratios in muscle and epidermis of subsistence-harvested bowhead, beluga and gray whales. L. Dean, E. Follmann
636 Identifying critical foraging habitat of lactating northern fur seals and the spatial overlap with commercial fisheries in the eastern Bering Sea. P. Klimas, A. Tate
646 Steller sea lions in Alaska. Direct mortality by humans. M. Turek
717 Threatened southwest Alaska sea otter stock: Delineating the causes and constraints to recovery of a keystone predator in the North Pacific Ocean. J. Bodkin, A. Estes
718 Using predictive habitat modeling and passive acoustics to locate breeding habitats of North Pacific right whales in the Pacific Islands Region. C. Good, E. Grigg, D. Johnston, D. Mesnick
719 Analysis of acoustic and oceanographic data from the Bering Sea. D. Mellinger, E. Sprong
720 Migration, wintering destinations and habitat use of North Pacific right whales (Eubalaena japonica). P. Clapham, P. Heide-Jorgensen, A. Zerbini
730 A cooperative pollock acoustic biomass survey for management of fisheries interactions with Steller sea lions in the Aleutian Islands. S. Amaraun, L. Fritz, E. Gingerell
807 Testing the localized depletion hypothesis: Is Steller sea lion foraging success affected by local fish effort? D. Herrman
818 Walrus distributional and foraging response to changing ice and benthic conditions in the Chukchi Sea. J. Grebmeier, C. Jay
826 Monitoring, avoiding, and deterring humpback whale bycatch in coastal Alaskan fisheries. A cooperative approach. A. Rice, K. Wynne
827 Ambient noise monitoring in the Beaufort Sea using autonomous vertical arrays. A. Thode
Foraging Success

UNDERSTANDING WHAT SPECIES MARINE MAMMAL POPULATIONS EAT IS CRITICAL FOR INTERPRETING HOW THEY FUNCTION IN THE MARINE ECOSYSTEM.

We also learn how they may be affected by commercial fisheries, either directly through competition for resources or indirectly through impacts on prey habitat and lower trophic level species. Through 2008, the Board has funded seven research projects addressing what specific marine mammal populations eat and the factors that affect their foraging success for $1.4 million.

Determining What Arctic Whales Eat
Project 635

STABLE ISOTOPE ANALYSIS ALLOWS RESEARCHERS TO determine where an individual fits into the food web and is an increasingly important tool in studying foraging ecology. This is especially true for marine mammals where scientists find it difficult to directly observe feeding or collect stomach samples. Project 635 investigated using this technique in bowhead, beluga, and gray whale foraging ecology studies in the Arctic. Stable isotope analysis usually looks at the nitrogen and carbon stable isotope ratios in muscle tissue, which has a turnover rate of about one month and gives a glimpse into the individual’s diet over that period of time. But researchers studying Arctic cetaceans have a more difficult time collecting muscle tissue that lies underneath a thick layer of blubber that can measure up to 30 centimeters in live animals. They can more easily collect skin samples with less-invasive techniques.

This study set out to determine how the isotope ratios of nitrogen and carbon in skin samples compared to those in muscle samples from the same individuals. Analyses based on skin samples would then become comparable to analyses of other species based on muscle samples. Investigators collected skin and muscle samples from subsistence-hunted bowhead and beluga whales from northern Alaska, and from subsistence-hunted gray whales in Russia. They also gathered samples from gray whales

Sample of ancient bowhead whale muktuk recovered from an ice cellar in Gambell, Alaska.
stranded along the California coast and from an approximately 1,000 year-old bowhead whale sample found in an ice-cellar in Gambell, Alaska.

Researchers found that both muscle and skin nitrogen stable isotope ratios were indicative of where the species fit in the Arctic marine food web. But skin had higher nitrogen ratios than muscle samples for both bowhead whales and gray whales, although not in beluga whales. The lower nitrogen isotope ratios in beluga skin may be because belugas eat a variety of fish species, or may be linked to their distinct molting process. Belugas molt annually, whereas baleen whales continuously slough skin throughout the year.

Carbon stable isotope ratios, on the other hand, showed an opposite trend—lower in skin than in muscle tissue in bowhead and beluga whale samples. Carbon is primarily found as fat, an integral part of whale skin. The different utilization of fat by muscle and skin likely explains these differences, which appears to be unique to each species. To counteract the effect of fat on reliable carbon stable isotope ratios, researchers concluded that fat should be extracted from skin samples before comparing carbon isotope ratios between skin and muscle tissue.

The ancient bowhead whale sample let researchers compare the diet of this individual to that of present day bowhead whales. Isotope ratios of carbon and nitrogen were similar, suggesting that the feeding ecology of bowhead whales has remained stable for a millennium. Stranded gray whales had higher muscle nitrogen and depleted skin carbon ratios compared to those from subsistence-hunted whales, suggesting that the stranded whales may have been suffering from nutritional stress before they died.

“Ancient bowhead whale samples compared to bowhead whales alive today suggest the feeding ecology of bowhead whales has remained stable for the last thousand years.”
IN THE BERING SEA AND ALEUTIANS, RESEARCHERS know little about the foraging behavior of killer whales and their role in the decline of several other marine mammal species. Researchers participating in projects 411 and 535 used stable isotope analysis, along with fatty acid and contaminant analysis, to investigate what these top predators are eating.

They examined blubber samples collected from over 200 killer whales and tissues samples from potential prey items to infer diet preferences of three different killer whale ecotypes found in the region.

As in other regions of the North Pacific, resident, transient, and off-shore killer whales fed on distinctly different animals—residents consume fish, transients consume marine mammals, and off-shores consume some fish but potentially other prey types as well.

Researchers found that the fatty acid and contaminant analyses provided unambiguous classification to a particular ecotype, but that the stable isotopes analyses did not allow for a clear distinction between the three groups. Chemical analyses of both killer whale tissue and potential prey species let researchers identify not only ecotype differences but also regional and seasonal dietary differences within those groups.

Transient killer whales in the eastern Aleutian Islands appear to consume Steller sea lions and a variety of species lower in the marine food web, while transients in the area around the Pribilof Islands and eastern Bering Sea appear to feed exclusively on whales, such as Dall’s porpoise, minke, and gray whales. Interestingly, visual observations of killer whales around the Pribilof Islands conducted during sample collection indicated that killer whales were also consuming northern fur seals, which either implies that these whales had recently switched their diet preferences and their tissue samples did not yet reflect that change, or that these methodologies need to be further refined.

Resident killer whales in the Bering Sea and Aleutian Islands consumed sockeye and chinook salmon, as well as pollock. Seasonal and regional differentiation of diet awaits further sampling of the available prey field.

For offshore killer whales, chemical analyses indicate that their diet is clearly distinct from the other two ecotypes and the contaminant profile of these individuals suggest that they likely feed off the coast of California for a portion of the year, potentially on large, long-lived fish species.
MARINE MAMMALS :: Foraging Success

Foraging Strategies of Northern Fur Seals
Projects 414, 514

NORTHERN FUR SEALS APPEAR TO BE THE MOST abundant marine mammal in Alaska’s seas and provide an important subsistence resource to the residents of the Pribilof Islands. Yet the Bering Sea fur seal population has declined by over 80% in the past 50 years and no one knows why.

In contrast, the population of northern fur seals on Bogoslof Island in the eastern Aleutian Islands has increased dramatically. Projects 414 and 514 investigate the foraging strategies of female northern fur seals to determine how the diets, foraging range, and location of females differ at these two locations and how that affects the fitness of the individuals and their offspring.

Researchers attached satellite transmitters to adult females on each island to determine where individuals were going to feed during both the summer breeding season and the winter migration period, when animals spend eight months continuously at sea. They also collected a series of biological samples (blubber, milk, and blood) from adult females and their pups during the summer breeding season to examine how body compositions and diets differed between the two islands.

So far, scientists have found that during the winter migration, females from both populations use similar areas in the North Pacific Ocean to feed. In contrast, during the summer breeding season, adult females forage in different locations. Females breeding on the Pribilof Islands feed on the continental shelf and at the shelf break, while females from Bogoslof Island focus their foraging effort in the deep oceanic basin. Pribilof females stay out longer and travel farther than Bogoslof females, suggesting that they have to stay away from their pups longer to get enough food.

Researchers are using fatty acid analyses of blubber and milk samples collected at the start and end of the breeding season to determine how diets compare seasonally and between the two locations. Samples taken early in the breeding season, reflecting diets prior to arrival at the breeding colonies, indicate females from both locations eat similar prey, which agrees with the tagging results above.

Samples taken three months later at the end of the breeding season, reflecting foraging throughout the breeding season, differed significantly between females from the two locations, indicating that they are eating different things, and also concur with the tagging study.

Research continues to determine exactly what the fur seals are eating and how these differing foraging strategies impact the fitness, and potentially the survival, of both adult females and their offspring.
PROJECT 513 FOCUSES ON WHERE NORTHERN FUR seal pups go to feed and how often they acquire food during their first winter, a challenging period for these newly weaned animals still learning how to dive and capture fish. Using a combination of satellite-tracking and stomach temperature tags, researchers are investigating where young fur seals from the Commander Islands in Russia go after leaving their natal island and where and when they eat.

While the population of fur seals on the Commander Islands is smaller and relatively stable compared to the Pribilof Islands population, fur seals range widely and individuals from the two populations likely overlap during the winter period. By understanding how young pups from the Commander Islands find food during their first winter, researchers hope to gain a better understanding of the challenges facing young fur seal pups from the declining population as well.

Results to date indicate that most of the fur seal pups stayed in the western Pacific Ocean and traveled south towards the equatorial transitional zone. Pups traveling the farthest did not reach the transitional zone but veered in a more easterly direction to the central Pacific Ocean.

Most feeding seems to occur in the dark, when animals dive more and likely forage on prey that rises towards the surface at night. The young fur seals fed more often and for longer periods as their foraging and diving skills improved and as they reached prey-rich areas later in their migration, where they spent most of their time. Several fur seal pups also appeared to increase their foraging behavior at the periphery of cold-core eddies, which may represent areas of high ocean productivity and are likely profitable foraging areas for young fur seals.

Sea surface temperatures in the north Pacific and Bering Sea, from the Commander Islands to the Aleutians, showing transition zone at 40 degrees N. Track colors represent different sexes of fur seals (n=35; red=female; blue=male).

Northern fur seals.
SUCCESSFUL MARINE MAMMAL FORAGING DEPENDS not only on where and what resources individuals are consuming, but also on the impact of other animals, either through direct predation or through competition for similar prey resources. Project 313 examined the effect of prey resources and predators on the foraging behavior of harbor seals in Prince William Sound, a population that has declined since the mid-1980s.

Earlier research suggested that a lack of food or predation, acting independently, did not adequately explain the decline of harbor seals. In this study, researchers looked at how food and predators might combine synergistically to influence the behavior, survival, and reproduction of seals. Investigators attached radio transmitters and time-depth-recorders to individual harbor seals to observe their feeding behavior (how deep they dive, when diving occurs, etc.) and also looked at the depth distribution of Pacific herring and walleye pollock, two of the main prey species of harbor seals in the Sound. Researchers also compiled existing information on the behavior of Pacific sleeper sharks and killer whales, two species thought to eat harbor seals. They used the data to develop a model that linked foraging behavior to body condition and survival.

During the field component of the study, some seals made only shallow dives of less than 50 meters, where encounters with sharks are unlikely but food encounters are very unpredictable. Other seals frequently dove to depths of 100 to 300 meters, where walleye pollock is a predictable and profitable food source, but the risk of encountering sleeper sharks is also high.

Theoretically, this individual variation in risk-taking by seals reflects their current level of energy reserves in accumulated fat, with better reserves allowing safer foraging options. Predation from killer whales appeared to have little influence on seals, possibly because killer whales have also declined locally.

The model predicted that harbor seals are killed by predators more often when food resources are scarce, whether as a result of human harvest or competition. If seals are overly cautious of predators they may stay in areas that lack sufficient energy resources for reproduction, and therefore must work harder and longer to gather necessary prey. Modeling results indicated that this increased foraging effort can raise the risk of predation from sleeper sharks and killer whales beyond that experienced when seals forage more efficiently in riskier areas. Results also suggested that predation risk from Pacific sleeper sharks can compromise energy gain by seals, but that this effect will vary between individual seals.
Marine Habitat Use

Besides understanding what marine mammals eat, we also need to understand how their distribution and habitat use overlap with commercial fisheries, subsistence hunting, and other human activities.

From 2002-2008, the Board funded eight research projects for about $920,000 to address marine mammal habitat use in the North Pacific Ocean. Marine mammal scientists rely on a variety of techniques for studying marine mammal habitat, including analyzing historical data, using acoustic equipment to detect their presence, tagging with satellite tags to track marine mammals, and conducting marine mammal surveys from ships and airplanes.

**Winter Habitats of Beluga Whales**

**Project 324**

Subsistence hunters in Alaska, Northern Canada, and Russia harvest beluga whales. Effective management of these harvests requires understanding the winter migrations of beluga whale populations that summer in the Bering, Beaufort and Chukchi seas and in the Arctic Ocean, where much of the subsistence hunting occurs.

Project 324 aimed to identify and define the winter habitat of beluga whales in the Bering Sea and determine which stocks of whales were migrating along the coast of the Chukotka Peninsula in the fall. Researchers intended to attach satellite transmitters to beluga whales in Lavrentia Bay, Russia, in late fall where beluga whales had regularly been seen. Unfortunately, during the first two field years, belugas did not enter the study area or other parts of the bay. During the summer of the third field year, work refocused to the Anadyr River, where researchers captured a beluga whale and attached one tag. Bad weather prevented further capture attempts before the end of the field season.

Movements of the one tagged whale indicated that this animal remained in the Gulf of Anadyr and on the continental shelf during the fall and early winter, before moving north along the coast to Kresta Bay in midwinter, where it stayed until the tag failed in early February. Due to the difficulties of capturing belugas, researchers also focused on developing a satellite tag that they could attach to the whales via harpoon, which could be tested and utilized in future movement studies.

To learn which stocks of beluga whales visited the study area, researchers collected genetic samples from ten individual beluga whales in the Anadyr River area using crossbow biopsy darts. Preliminary results indicate that this group is most closely related to the Beaufort Sea stock of beluga whales.
Since large whales are difficult to detect by sight, and travel over vast areas of the world’s oceans, little is known about their distribution and seasonal occurrence. Ship surveys are costly and so scientists base most of what they know about the distribution and seasonality of large whales on the historical whaling data from the mid-20th century.

To learn more about which large whale species use specific areas of the North Pacific, researchers rely on acoustic technology to listen for the presence of large whales. Projects 307 and 519 used passive acoustic technology to study the seasonal presence of endangered North Pacific right whales and fin whales in the southeast Bering Sea and the western Gulf of Alaska. Commercial whaling in the 19th and 20th centuries severely depleted these two species throughout the North Pacific and Bering Sea, and decades after whaling ceased, we still do not know whether either species is recovering.

To understand how fisheries and resource extraction may impact these species, we need to know where the whales are and when they use these waters. Researchers attached underwater acoustic recording packages to moorings in two study areas, which provided continuous, long-term data recordings that could detect the presence, distribution, and behavior of calling whales that were within a range of approximately 100 kilometers.

In the southeast Bering Sea study area, right whales called from May to December but rates were highest in August, September, and December. No right whales were detected at the Gulf of Alaska study site. Researchers compared the annual occurrences of right whale calls to the oceanographic conditions. They hypothesized that the springtime presence of right whales on the southeast Bering Sea shelf in years with late spring blooms is related to the production and growth rates of copepods during a warmer-water, oceanic phytoplankton bloom following winters with moderate ice cover.

The occurrence of right whales on the shelf in the summer and fall may be related to their ability to forage on copepods concentrated in the bottom cold water layer. Researchers heard fin whale calls year-round on the southeastern Bering Sea shelf, with the highest call rates in the fall. They also detected fin whales at the Gulf of Alaska site in the late summer.

Acoustic technology helps researchers detect the presence of elusive endangered North Pacific right whales.
**More Ears in the Water**
Projects 518, 719

TO CONTINUE PASSIVE ACOUSTIC RESEARCH ON THE distribution of large whales in the Bering Sea, the Board funded projects 518 and 719, which attached hydrophones to oceanographic moorings (M2, M4, and M5) along the Bering Sea shelf. These instruments continuously recorded acoustic events for one year, detecting vocalizations from right, fin, sperm, and humpback whales; bearded seals, and Pacific walrus. The marine mammals vocalized throughout the year and researchers are currently analyzing these acoustic events to determine differences between seasons and time of day for each species. By locating the recorders on oceanographic moorings, researchers can relate seasonal occurrences of each species with oceanographic conditions to better understand the physical processes affecting distribution, movement, and habitat.

A research vessel uses passive acoustic technology to detect right whales.

**North Pacific Right Whales**
Project 720

SCIENTISTS PARTICIPATING IN PROJECT 720 SEEK to better describe the seasonal movements, migration paths, and behaviors of North Pacific right whales by attaching satellite transmitters to whales in the southeast Bering Sea. By characterizing the right whale’s distribution and movements throughout their range, researchers will better understand right whale ecology and can better predict potential impacts from human activities.

During the first field year, researchers sighted 12 whales during ten different sighting events using aerial surveys, and 34 individuals during 22 different sighting events using ship-based survey methods. They tagged one right whale with a satellite transmitter, which monitored the movement of the animal for two months. Weather and unpredictable movements of individual whales hampered further satellite tagging attempts. In preparation for the 2009 field season, researchers are modifying how they attach satellite transmitters on whales to avoid the need for direct capture.

**Modeling Potential Habitat for Northern Right Whales**
Project 633

MODELING STUDIES ARE ALSO UNDERWAY TO HELP determine which areas of the North Pacific could serve as critical or potential habitat for endangered right whales. In Project 633, scientists are identifying potential habitat at varying spatial and temporal scales. Researchers are combining historical whaling data on right whale distribution with contemporary data on current right whale sightings to characterize how previous habitat relates to known current habitat areas. This project also draws on the distribution and life histories of the main food of right whales (calanoid copepods), knowledge of Atlantic right whale foraging strategies, and oceanographic information to inform their multi-scale predictive habitat-use model.

**Right Whale Calving Grounds**
Project 718

ALTHOUGH RIGHT WHALES MIGRATE SEASONALLY TO warmer waters in lower latitudes to calve and mate, little is known about exactly where they go. This impacts our ability to manage threats in critical calving areas and hinders the recovery of these endangered species. Researchers working on Project 718 are using information gained from studies on North Atlantic right whale calving habitat to build a predictive model of right whale breeding habitat in the Pacific, using existing hydrographic and satellite remote sensing physical data. This model intends to identify, in time and space, the most advantageous and dependable areas for right whale calving.
Population Dynamics

TO EFFECTIVELY MANAGE OCEAN WILDLIFE POPULATIONS, RESOURCE MANAGERS NEED TO UNDERSTAND WHY POPULATIONS INCREASE, DECREASE, OR REMAIN STABLE OVER TIME.

In the North Pacific, the populations of many marine mammal species have dramatically declined over the last several decades. For other species, researchers simply do not know whether they are thriving or not. To better understand the population dynamics of marine mammals in Alaska waters, especially those species important to subsistence communities, the Board has directed almost $1.4 million to seven research projects looking at declining populations of harbor seals and sea otters, as well as the status of ice seals, bowhead whales, and Pacific walrus populations.

MARINE MAMMALS :: Population Dynamics

Tracking Harbor Seals
Project 501

MONITORING THE SURVIVAL OF INDIVIDUAL ANIMALS within a wild, wide-ranging population can be extremely difficult, particularly for species lacking natural identification marks. To learn about the survival of young harbor seals in Prince William Sound, the Alaska Department of Fish and Game initiated a multi-year study using VHF radio transmitters implanted under the skin of individual animals. Researchers initially tracked the radio-tagged seals using vessels and airplanes, but these costly surveys are limited to periods of good weather in the late spring and summer. Project 501 established remote monitoring stations at six land-based haul-out locations in Prince William Sound that record the presence of the individual radio-tagged animals year-round.

Researchers hoped to more efficiently assess the presence and survival of radio-tagged harbor seals for up to five years. During the early phases of the project, investigators faced several technological difficulties and spent considerable effort ensuring that the signals from these remote monitoring stations reported true presence indicators. Once data-quality issues were resolved, scientists noted that the amount of remotely collected telemetry data far exceeded what would have been possible through traditional survey methods alone.
Health of Ice Seals

BEARDED, RINGED, SPOTTED, AND RIBBON SEALS ARE called “ice seals” because they depend upon sea ice for feeding, resting, and pupping. Although these species are important subsistence resources for Alaskans and play an important role in the arctic marine ecosystem, we know little about their biology or population dynamics. They range widely, and conducting marine mammal surveys in remote, ice-covered waters poses serious logistical issues, making it difficult to predict or interpret the impacts of Arctic warming on the population dynamics of these species.

The Board funded Project 312 as a monitoring study to examine the health and status of the four ice seal species in the Bering and Chukchi seas. Working with subsistence hunters in eight coastal Alaska villages (Barrow, Point Hope, Shishmaref, Diomede, Nome, Gambell, Savoonga, and Hooper Bay), researchers collected biological samples from more than 1,100 ice seals.

An analysis of these samples indicates that individuals of the ice seal populations in northern Alaska are in relatively good health. Contaminant levels found in the tissues of sampled individuals were lower than levels found in samples from the Canadian Arctic, and reproductive rates for all species were relatively high. Between 86-91% of adult females appeared to be reproductively active, with ribbon seals maturing as early as two to three years of age.

By comparing current data to information collected in the 1970s, researchers also found that ringed seals are larger at younger ages in the present population, possibly indicating that current environmental conditions are favorable and promote growth. Genetic analysis shows high levels of genetic diversity in all four species, suggesting that all species belonged to historically large populations.

To address the question of population trend, researchers questioned Native subsistence hunters regarding changes in the number and distribution of ice seals over time, and responses seemed to indicate that populations of these species are stable.

Movements of Ringed Seals

TO UNDERSTAND POPULATION DYNAMICS, WE NEED to understand population structure and how, or if, individuals move between, and breed with, different subpopulations, thus increasing the genetic variability and decreasing their vulnerability to extinction. Project 515 studied ringed seal movements throughout the year to find out if individuals return to the same location to breed each year or breed at different sites, and with different individuals, during their reproductive lifetime.

Tracking records of ringed seals indicated that animals had small home ranges between ice freeze up and break up, most less than three square kilometers. In some parts of the species’ range, this can last up to nine months and encompass the breeding period when ringed seals give birth and mate. During ice-free periods, individuals ranged much farther, about 200 square kilometers, but returned to the same breeding sites the following year.

Fidelity to breeding sites raises the possibility that ringed seals may be subdivided into many demographically distinct subpopulations. Researchers developed a new molecular technique to collect, preserve, and extract DNA from molted skin left on the ice next to breathing holes during the breeding season.

In a follow-up study, Project 631, investigators are using this method to examine and estimate rates of gene flow and determine the structure of ringed seal populations. With the help of a trained dog and local hunters, scientists collected many samples in 2007 and 2008. Analyses of these samples, and the population structure they might reveal, are ongoing.
PACIFIC WALRUS DEPEND ON SEA ICE FOR THEIR survival and face an uncertain future as the Arctic warms and sea ice diminishes. Walruses range across the international boundaries of the United States and Russia, and both nations share common interests in the conservation and management of this species. Walruses are currently managed as a single stock of animals that inhabits the continental shelf waters of the Bering and Chukchi seas.

Although recent subsistence walrus harvests of approximately 5,000 animals a year in the U.S. and Russia combined are lower than historical highs of as many as 16,000 animals a year, our lack of information about population size or trends prevents any assessment of the sustainability of current harvest levels. NPRB funded Project 632 to examine Pacific walrus population biology and ecology using data from a range-wide survey carried out by the U.S. Fish and Wildlife Service, U.S. Geological Survey, and Russian scientists in 2006.

Specifically, scientists from both countries are working together to integrate and standardize survey data collected in U.S. and Russian territories to estimate the size of the Pacific walrus population. Researchers are using haul out and movement data from tagged walruses to model the behavior of individual animals relative to meteorological conditions and patterns of sea ice drift. They are also looking at whether benthic walrus prey composition, abundance, and biomass within an area of the St. Lawrence polynya have significantly changed in the past 20 years and how future changes may impact the Pacific walrus population.
Bowhead Whale DNA

Project 634

NEW MOLECULAR TECHNIQUES ARE ALSO BEING USED TO EXAMINE GENETIC STOCK STRUCTURE IN ARCTIC cetaceans to determine how vulnerable local populations of bowhead whales may be to changes in their environment and to subsistence harvesting. Project 634 is investigating the population structure of bowhead whales by studying historical samples of baleen and bone from subsistence hunted bowheads from St. Lawrence Island and Barrow, Alaska. Using a technique called single nucleotide polymorphisms (SNP), researchers are amplifying and genotyping DNA from low quality and quantity samples extracted from the ancient bones and baleen of bowhead whales.

Data from this project will complement ongoing studies by the International Whaling Commission on bowhead whale population structure based on modern day samples collected from subsistence hunters.

Declining Sea Otters

Project 717

ALTHOUGH SEA OTTER POPULATIONS IN ALASKA successfully recovered from intense harvesting for their pelts during the Russian and American fur trade of the 19th and 20th centuries, the numbers of otters in southwestern Alaska dramatically declined in the early 1990s. Alaska Natives still harvest sea otters as a subsistence resource, but that does not appear to account for the decline in southwest Alaska.

Project 717 is examining why otters are not thriving by studying local population density, food availability, and net energy gain of foraging sea otters at 13 sites along the geographical range of southwestern sea otters. Researchers are also surveying the beaches at each of these sites for sea otter carcasses to help determine causes of death. They hope to determine the eastern extent of the sea otter decline, currently thought to be somewhere between the Shumigan Islands and Kodiak Island, where sea otter densities remain stable.

As part of the study, investigators are evaluating the role of killer whale predation as a consistent cause of decline throughout southwestern Alaska and are looking at disease and other factors that may be constraining the recovery of the population.
Fisheries Interactions

ENTANGLEMENT AND COMPETITION FOR FOOD ARE AMONG THE INTERACTIONS BETWEEN THE COMMERCIAL FISHING INDUSTRY AND MARINE MAMMALS THAT REMAIN A PRESSING CONCERN FOR FISHERY AND WILDLIFE MANAGERS.

Observable interactions are generally restricted to direct mortality or entanglement in fishing gear and/or fishing gear damage, and catch loss for fishermen. Overlap in the species and size of prey items taken by marine mammals and targeted by commercial fisheries is more difficult to assess, but may limit the ability of marine mammals to obtain sufficient food for growth and reproduction. Through 2008, the Board directed $1.27 million to eight projects studying the interaction of various fisheries and marine mammal species.

Humpback Whale Entanglements
Project 826

AS HUMBACK WHALE POPULATIONS IN THE CENTRAL North Pacific increase at an annual rate of 6-10%, interactions with the fishing industry are also on the rise. As many as 71% of the humpbacks in Southeast Alaska bear evidence of prior entanglements. These large baleen whales get tangled in nearly every type of coastal fishing gear in Alaska, from gillnets, longlines, and seines to shrimp and crab pots used in commercial, sport, and personal use fisheries.

Through workshops, cooperative observations, and monitoring of fishing practices and humpback whale behavior, researchers participating in Project 826 will improve our understanding of the nature of humpback whale encounters. The study will also reveal the effectiveness of devices and techniques currently being used by the fishing fleets to deter or respond to entangled whales in nearshore fisheries in Southeast Alaska.

Northern Fur Seal Interactions with Fisheries
Project 636

PREVIOUS STUDIES HAVE SHOWN THAT NORTHERN FUR SEALS AND COMMERCIAL POLLOCK fisheries in the Bering Sea target similar prey. Given the overlap, the Bering Sea fishery could be linked to the decline of northern fur seals in the Pribilof Islands. Evaluating the role that commercial fisheries might be playing in the decline of northern fur seals requires fine-scale, high-resolution data on fur seal habitat use. Project 636 examined at-sea movement, habitat use and foraging behavior of adult female fur seals during the breeding season at a fine scale. Scientists tracked seven female fur seals using radio and satellite transmitters and dead-reckoning data loggers to assess where and how these females found food.

The fur seals ranged over a wide area of the Bering Sea with no perceived preference for feeding areas. The small sample of tracked fur seals suggests that the potential for competition with commercial pollock fisheries is low given the wide-spread distribution of fur seal foraging effort relative to the concentrated fishing activity along the outer shelf. Further sampling of the fine-scale movements and foraging of adult female fur seals throughout the summer and fall is being conducted as part of the Bering Sea Integrated Ecosystem Research Program and will aid in confirming the conclusions of this initial study.
Steller Sea Lion Interactions with Fisheries

Project 730

LIKE SEVERAL OTHER MARINE MAMMAL POPULATIONS in the North Pacific, the western population of Steller sea lions has dramatically declined since the 1970s, resulting in their endangered species listing in 1997. Although researchers still do not know the causes of the population decline and the factors constraining recovery, resource managers put a suite of protective measures in place to mitigate potential competition between fisheries and sea lions, including trawl exclusion zones around sea lion rookeries and haulouts to protect sea lion critical habitat. Implicit in the designation of the trawl exclusion zones is that competition between fisheries and sea lions occurs at local scales.

In light of this, resource managers need new strategies at local scales for assessing groundfish abundance, and the impact on sea lions of groundfish removals. Project 730 is investigating whether cooperative biomass assessments and surveys can be an effective way to manage fisheries at the local scales that are important to Steller sea lions or other predators.

Working collaboratively with the fishing industry, scientists are trying to determine if winter acoustic survey data obtained from commercial vessels are of sufficiently high quality to conduct a biomass assessment at local scales. They’re also collecting information about Steller sea lion distribution and diets in winter. By synchronizing the timing and spatial scale of the acoustic fishery survey and the sea lion work, researchers hope to determine how sea lions use the local area to forage relative to the biomass available, and the potential impact of reducing that biomass through fishery harvests.

Stellers in Resurrection Bay

Project 807

PROJECT 807, CURRENTLY ON HOLD DUE TO PERMITTING ISSUES, PLANS TO INVESTIGATE THE HYPOTHESIS THAT depletion of local fish aggregations by the fishery has negative impacts on Steller sea lions. Researchers will manipulate the fishing effort around Chiswell Island, a well-studied rookery for Steller sea lions in Resurrection Bay, Alaska. Manipulation of the fishing effort and monitoring of the foraging behavior of adult females during the breeding season should give us evidence for or against the localized depletion hypothesis, with obvious implications to sea lion and fisheries management.
FEATURE PROJECT
MARINE MAMMALS :: Fisheries Interactions
Sperm Whales Targeting Blackcod Fisheries
Projects 309, 412, 527, 626

IN SOUTHEAST ALASKA, ENDANGERED SPERM WHALES TAKE SABLEFISH off the longline gear of commercial fishing boats. In other parts of the world, this depredation behavior sometimes results in mortality and serious injury to the whales. The economic loss to fishermen presents fisheries managers with a difficult assessment problem as the amount of sablefish lost is unknown.

Sperm whales have learned to depredate deepwater sablefish longlines off Sitka, Alaska, and over the past decade their behavior has become more aggressive and widespread. During a typical encounter, when whales are present during the haul, about 3-6% of the catch is estimated to be removed, but sometimes over 50% of the catch has been lost by individual fishermen.

Beginning in 2003, the Board funded a series of projects (309, 412, 527, and 626) to assist the Southeast Alaska Sperm Whale Avoidance Project (SEASWAP). A cooperative effort between scientists and fishermen, SEASWAP explores the occurrence of sperm whales in association with longline fishing activities along the continental slope and develop strategies to minimize these interactions.

A cooperative effort between scientists and fishermen, SEASWAP explores the occurrence of sperm whales in association with longline fishing activities.
Researchers learned that most depredation events are the result of male sperm whales removing fish directly from the longlines beginning in April or May, and continuing through the remainder of the fishing season. They also discovered that the distinctive noise made by fishing vessels as longlines are being hauled attracts animals within ten nautical miles of the fishing activity.

Deterrent measures, such as deploying decoy anchor lines, attaching acoustic reflectors to the fishing gear, conducting circle hauls to minimize the engine noise that attracts the whales, and changing the time of year when fishermen deploy their gear all show some promise and continue to be tested as a means of reducing sperm whale–fisheries interactions.
Other Human-Related Impacts

While commercial fishing is the most visible human activity with the potential to impact marine mammal populations, other activities, such as oil and gas exploration and subsistence hunting, may also play a role.

To investigate the impact of other human-related activities on marine mammals in the North Pacific, the Board funded two projects for just over $150,000 through 2008. One project looks at direct human impacts on the decline of Steller sea lions. Another project tackles the impacts of noise, an area of growing interest in the Arctic as the sea ice retreats and opens the Arctic to shipping and potential fisheries.

Impacts on Steller Sea Lions

Project 646

To examine the role of direct mortality by humans on the decline of the western population of Steller sea lions, Project 646 examined the hypothesis that historical indiscriminant shooting, indirect harvesting (i.e., entanglement) in commercial fisheries, and subsistence harvesting are not primary sources of sea lion population declines.

Researchers extensively reviewed historical data and conducted interviews with fishermen involved in the industry between 1975 and 1990, when the western sea lion population rapidly declined. Results corroborated previous research that the annual subsistence harvests of fewer than 600 Steller sea lions was not a primary cause of the population decline of Steller sea lions in western Alaska.

Interviews indicated that the intensity of the encounters between fishermen and Steller sea lions was particularly high in the Shelikof Strait area during the foreign and joint venture trawl fisheries for walleye pollock in the late 1970s and early 1980s. Respondents consistently indicated that the targeting of Steller sea lions in most commercial fisheries was random and opportunistic, and was in addition to incidental catches in fishing gear. Unfortunately, these interviews provided no quantitative measure of sea lion mortality, making it difficult to assess the actual impact of indiscriminant shooting on the Steller sea lion population during the period of decline.


General areas where Steller sea lions were incidentally taken, 1982–1984, in the Shelikof Strait joint venture walleye pollock fishery.
Ambient Noise in the Beaufort Sea
Project 827

OVER THE PAST FEW YEARS, THE USE OF SEISMIC AIR-guns to map subsurface hydrocarbon deposits has added new sources of acoustic noise to the marine environment, spurring concerns about the potential impact on the long-term viability of the regional marine mammal population, with a particular concern about potential impacts on bowhead whales during their fall migration across northern Alaska. In collaboration with the oil and gas industry, researchers participating in Project 827 are examining and monitoring ambient noise in the Beaufort Sea near Deadhorse, Alaska. Using autonomous vertical arrays, they measure ambient noise levels, directionality, and spatial structure to distinguish between local and distant noise sources. Investigators track airgun signals, bowhead whale calls, and other discrete sound sources to understand how they are influenced by the physical environment.

Long-Term Climate Change

CLIMATE CHANGE HAS BECOME A MORE PROMINENT ISSUE IN THE WORLD ARENA THAN WHEN THE 2005 NPRB SCIENCE PLAN CALLED FOR FUTURE RESEARCH ON THE IMPACTS OF REDUCED SEA ICE OR OTHER CLIMATE-RELATED CHANGES ON POPULATIONS DYNAMICS AND PREY RESOURCES.

Wildlife managers even then expressed concern about the implications of a warming environment on marine mammals, particularly for species that depend on sea ice. The Board has recently directed $176,000 to examine the effect of climate change on the Pacific walrus population in the Chukchi Sea.

Impacts of Climate Change on Walrus
Project 818

WITH THE DECLINE IN SEA ICE OVER GOOD, SHALLOW-WATER FEEDING GROUNDS IN THE CHUKCHI SEA, WALRUS are feeding more in the nearshore habitat they can reach from land-based haul-outs. Project 818 looks at the effect of climate change on these marine mammals and compares the foraging range and efforts between walruses using land haul-outs and those using ice haul-outs over the continental shelf in the Chukchi Sea. Scientists are also comparing the nearshore and offshore benthic prey communities available to walruses using the differing haul-out platforms and examining changes in these benthic communities over time, based on retrospective analyses of archived benthic data.
Mission
NPRB supports research to build a clear understanding of the North Pacific, Bering Sea, and Arctic Ocean ecosystems that enables effective management and sustainable use of marine resources.

Marine Mammals is one in a series of publications produced by the North Pacific Research Board in support the 2005 Science Plan developed with guidance from the National Research Council of the U.S. National Academies of Sciences.

Find out more by visiting our website at nprb.org