

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. Since 2003, 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.



Matthew Brown

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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



Craig George

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.”



Bowhead whales.

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Diets of Bering Sea Killer Whales

Projects 411, 535

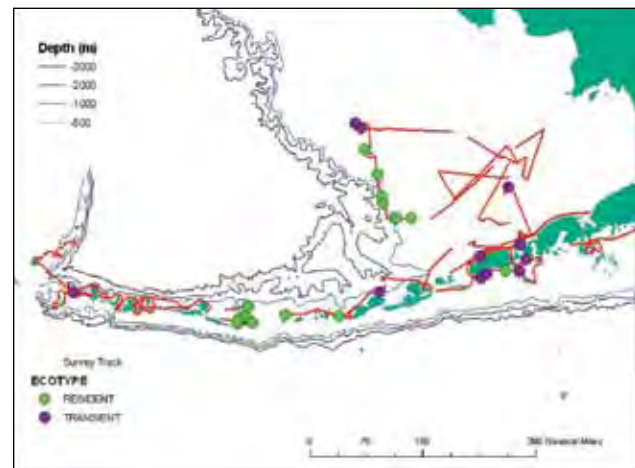
IN THE BERING SEA AND ALEUTIANS, RESEARCHERS know little about the foraging behavior of killer whales and their role in the decline of several other marine mammal species. Researchers participating in projects 411 and 535 used stable isotope analysis, along with fatty acid and contaminant analysis, to 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



Track of the 2005 survey, along with sighting locations for fish-eating resident and mammal-eating transient killer whales. Ecotype determination was made in the field by experienced observers, but is considered preliminary until genetic and acoustic analyses are complete.

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.



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Foraging Strategies of Northern Fur Seals

Projects 414, 514

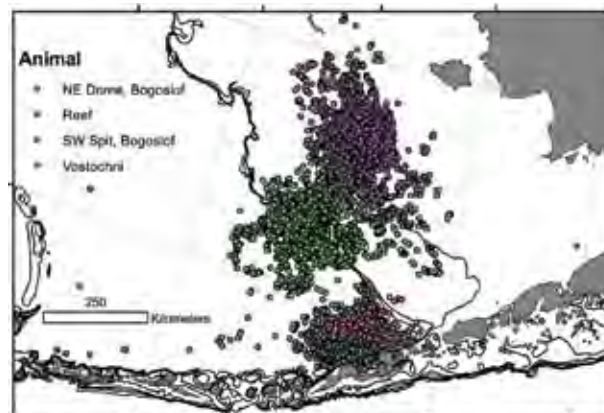
NORTHERN FUR SEALS APPEAR TO BE THE MOST abundant marine mammal in Alaska's seas and provide an important subsistence resource to the residents of the Pribilof Islands. Yet the Bering Sea fur seal population has declined by over 80% in the past 50 years and no one knows why.

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.

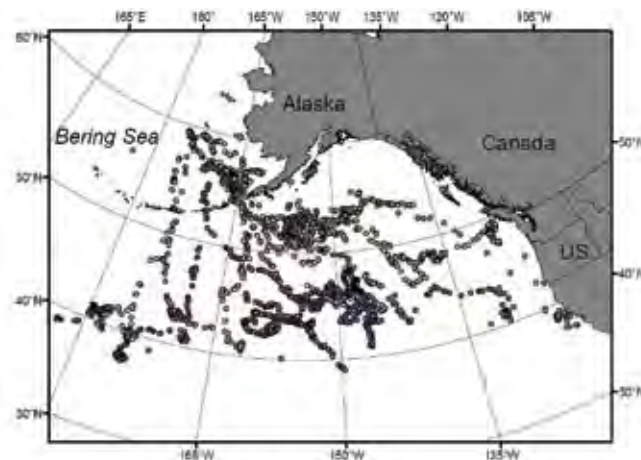
Researchers attached satellite transmitters to adult females on each island to determine where individuals were going to feed during both the summer breeding season and the winter migration period, when animals spend eight months continuously at sea. They also collected a series of biological samples (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.



Summer foraging locations of adult female fur seals from St. Paul I. and Bogoslof I. in July-October 2005.



Winter migration movements of adult female fur seals from St. Paul Island between November 2004 and March 2005.

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.

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First Winters of Northern Fur Seal Pups

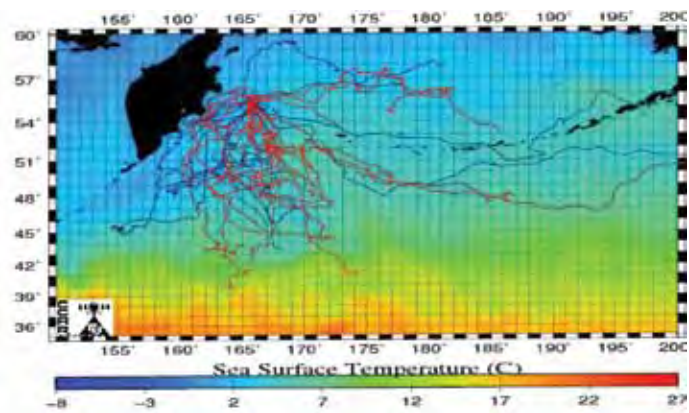
Project 513

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.

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Harbor Seals in Prince William Sound

Project 313

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.



Harbor seal on ice floe.