SENSING HABITAT USE BY ICE-ASSOCIATED SEALS; FROM DOG NOSES TO SATELLITE OBSERVATIONS

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Extant marine mammals represent multiple recolonizations of the marine environment by terrestrial mammals. Freed from the constraints of terrestrial locomotion, cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals, sea lions, and walruses) diversified and spread throughout the world's oceans. For those animals, land masses represented barriers, and their evolutionary history has been strongly influenced by tectonic events that opened and closed numerous seaways [1].

Sea ice also constrains movements and gene flow among marine mammal populations, and for some it has provided important refuge from predation [2, 3]. In recent times, walruses and 10 species of seals have relied on sea ice as a substrate for one or more important aspects of their life history including resting, giving birth, nursing young, and molting. At least 4 other pinniped species use the ice less regularly. All of the ice-associated seals are predators, but their diets and feeding habits vary by species with some specializing on pelagic fish, some on benthic invertebrate animals, and some on zooplankton, while others are generalists. Thus, the relationship between sea ice and preferred foods further influences the distribution of pinnipeds. Polar bears diverged from brown bears more recently to exploit ice-associated seals as prey.

Ice-associated seals were also important in human colonization of the Arctic, and indigenous hunters developed detailed knowledge of sea ice as marine mammal habitat [4]. The earliest remote sensing of Arctic marine mammals was practiced by Eskimo hunters, who depended on detecting seals, walruses, and whales under snow and ice for their livelihood. Hunters used acoustic sensors in the form of wooden paddles placed in the water and to which they pressed their ears to detect underwater calls by marine mammals. They also exploited the keen olfactory sensors of sled dogs to detect the odor of seals living under snow cover.

Scientific understanding of marine mammal ecology and many field practices have bases in indigenous knowledge. Nonetheless, the difficulty of observing animals living on—and largely under—sea ice had long limited our knowledge of habitat use by ice-associated seals. The past few decades, however, have seen substantial advances in our knowledge of seal ecology—including in polar sea ice—due primarily to technological advances in radio telemetry and in remote sensing of the cryosphere.

Over the past 50 years, radio tracking has been developed for locating marine mammals when they surface, and those records have been used to determine local movements. At the same time, analog and then digital recorders were developed for recording the duration and depth of dives by marine animals. Miniaturization of components and the development of satellite communications have allowed telemetric monitoring of environmental, physiological, and behavioral parameters for animals moving over vast distances [5]. The freedom from dependence on watercraft or aircraft has been especially important in tracking ice-associated seals. The National Marine Mammal Laboratory, in collaboration with Alaska Native hunters, and other researchers have begun to describe year-round habitat use for spotted seals, ribbon seals, ringed seals, and bearded seals based on satellite tracking. On-going satellite tracking of ice-associated seals is being used to determine:

1) whether ice-associated seals are faithful to specific geographic locations for breeding regardless of ice cover or whether breeding locations shift with variation in ice extent,
2) the importance of ice as a substrate to recently weaned seals,
3) whether seals leave the ice in spring in response to physiological needs or ice distribution,
4) how time spent on the ice varies throughout the year for each species.

At the same time that we have been developing tools for describing habitat use of ice-associated seals, the sea ice habitat has been undergoing rapid change as the climate warms. The consequences of declining ice cover—expected to be greatest in summer months—will vary among species. For example, spotted seals rest on land during the summer while many ribbon seals become pelagic. Many bearded and ringed seals, however, remain strongly associated with the ice throughout the summer. The relationship between sea ice and bathymetric features also is important to walruses and ice-associated seals. For example, during the spring breeding season, ribbon seals prefer ice that is proximal to feeding sites on continental shelf slopes [6], and resting and nursing walruses depend on ice that is over continental shelves as they are benthic feeders largely constrained to depths of less than 100 m [3].

For ringed seals, the snow cover on sea ice is a critical habitat feature. Ringed seals give birth in subnivean lairs they excavate above breathing holes maintained in the ice. The young are nursed in the lairs for the first 6 – 8 weeks of life, just before snow melt. Increasingly early snow melts in parts of the Arctic expose the young prematurely to predation and subsequent freeze events [3]. We used satellite-borne passive and active microwave data [7, 8] to correlate snow melts with seal emergence from their lairs. Near Prudhoe Bay Alaska, we documented a 25-day advance in snow melt on shorefast ice over the past three decades. Seal emergence documented by radio telemetry in five of those years corresponded to the remotely determined melt dates.

Advances in telemetry have vastly increased our knowledge of seal ecology. That knowledge provides insights in to the seasonally important features of snow and ice cover important to seal populations. It is timely for marine mammal researchers to work with remote sensing experts in forecasting the impacts on seals of changes in the cryosphere. Year-round, pan-Arctic monitoring of the extent and nature of snow and sea ice cover—with specific attention to marine mammal habitat needs—is urgently needed in the face of rapid climate change in the Arctic.

Ecological research at the National Marine Mammal Laboratory is increasingly facilitated by close collaborations with physical scientists at the Pacific Marine Environmental Laboratory, the Jet Propulsion Laboratory (NASA), the Institute of Ecology and Evolution (Russian Academy of Sciences), and the Geophysical Institute (University of Alaska Fairbanks). The intellectual excitement of these collaborations is tempered, however, by the realization that the habitats of ice-associated seals are changing very rapidly relative to the pace of scientific research.

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