CAFF
Conservation of Arctic Flora and Fauna

CIRCUMPOLAR BIODIVERSITY MONITORING PROGRAM

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A FRAMEWORK FOR MONITORING ARCTIC MARINE MAMMALS

FINDINGS OF A WORKSHOP SPONSORED BY THE U.S. MARINE MAMMAL COMMISSION AND U.S. FISH & WILDLIFE SERVICE VALENCIA MARCH 2007

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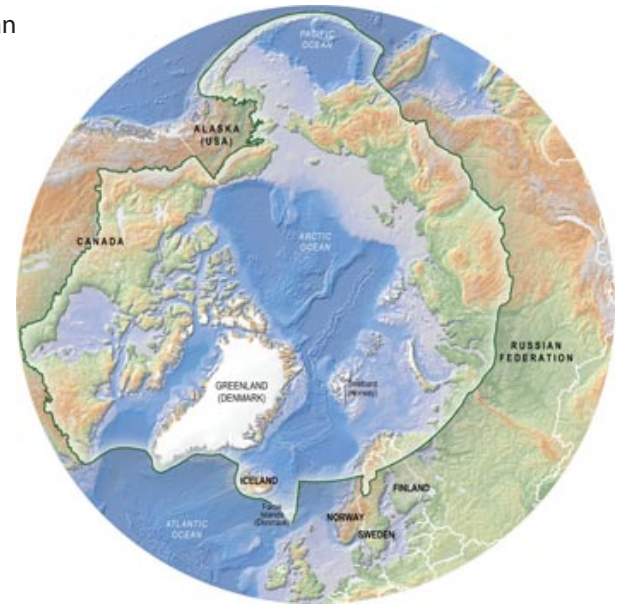

CAFF Designated Area

A Framework for Monitoring Arctic Marine Mammals

Findings from a Workshop Sponsored by the U.S. Marine Mammal Commission and U.S. Fish and Wildlife Service, Valencia, March 2007

A Supporting Publication to the
Circumpolar Biodiversity Monitoring Program
Framework Document

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Executive Summary

The U.S. Marine Mammal Commission and U.S. Fish and Wildlife Service convened an international workshop in Valencia, Spain, 4-6 March 2007 to develop long-term, pan-arctic monitoring strategies for arctic marine mammals. Workshop participants recognized the need to monitor not only the population dynamics of marine mammals but also the key factors that drive those dynamics, including behavior, health status, trophic dynamics, habitat quality and availability, and the effects of human activities (see Figure 1). Some factors may respond quickly to climate change and new human activities in the Arctic and thus may portend changes in the status of certain marine mammal species. Participants discussed previous and ongoing research and monitoring efforts for ringed seals and belugas and, using these species as case studies, developed a comprehensive monitoring framework for arctic marine mammals, including specific and general monitoring needs and tools that should be considered when developing integrated regional or species-based monitoring plans.

To develop and implement such plans, participants recommended that arctic nations convene international expert monitoring groups and charge the groups with --

1. Developing and periodically updating comprehensive monitoring plans;
2. Establishing research and monitoring priorities,
3. Developing data collection and sharing protocols,
4. Promoting research and monitoring partnerships, and;
5. Clarifying funding needs, identifying potential funding sources, and developing funding proposals.

Such a coordinated, multi-national, and multi-disciplinary approach is essential to ensure that adequate information is available to conserve arctic marine mammals in the face of climate change and associated changes in human activities.

1. Arctic Marine Mammals and Climate Change

Arctic marine mammals fall into two broad categories– those that occur in the Arctic throughout most of the year and depend on arctic ecosystems for all aspects of life and those that migrate to and from arctic waters and therefore are seasonally dependent on the Arctic (Table 1). The monitoring framework described here

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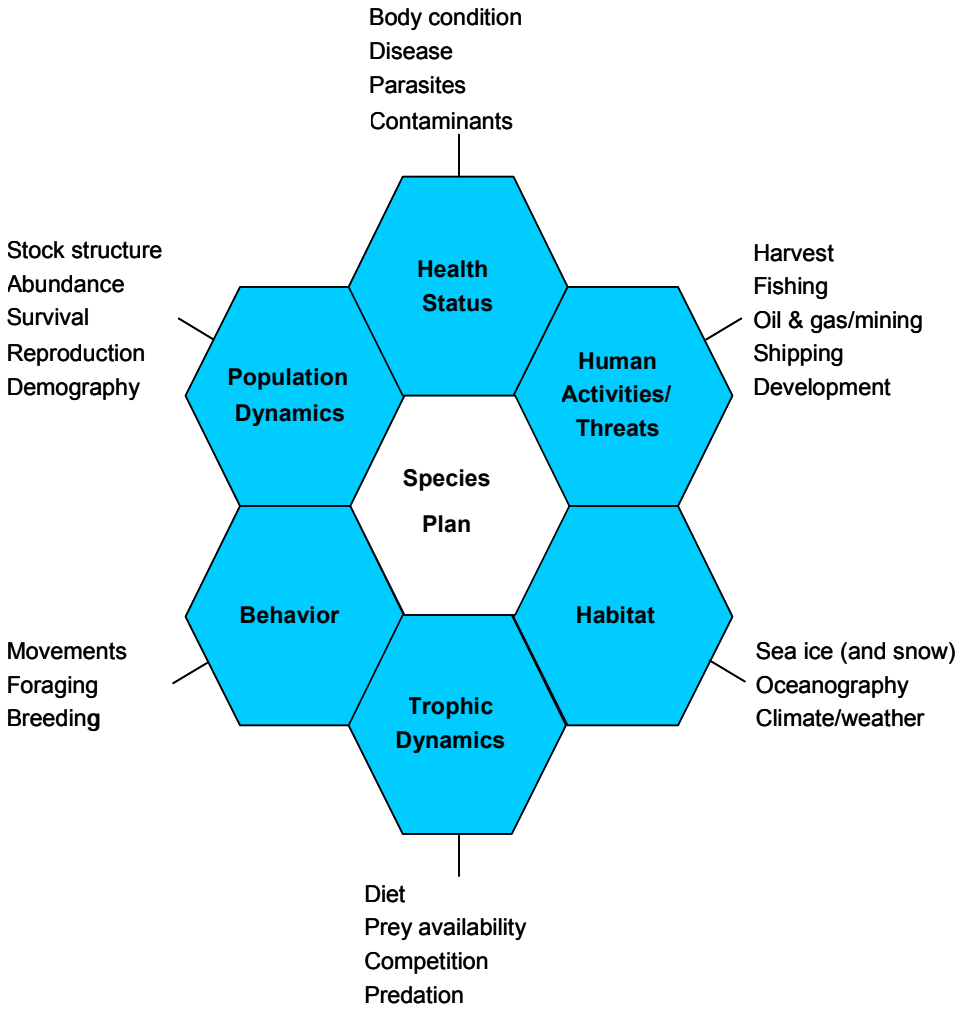

Figure 1. The components of a comprehensive plan for monitoring the status of a marine mammal species or stock, including population dynamics, the factors that influence those dynamics, and examples of parameters that might be monitored for each factor (see Table

Arctic species	Sub-arctic species
Bowhead whale (*Balaena mysticetus*)	Gray whale (*Eschrichtius robustus*)
Beluga (*Delphinapterus leucas*)	Humpback whale (*Megaptera novaeangliae*)
Narwhal (*Monodon monoceros*)	Fin whale (*Balaenoptera physalus*)
Bearded seal (*Erignathus barbatus*)	Minke whale (*Balaenoptera acutorostrata*)
Ringed seal (*Phoca hispida*)	Killer whale (*Orcinus orca*)
Walrus (*Odobenus rosmarus*)	Hooded seal (*Cystophora cristata*)
Polar bear (*Ursus maritimus*)	Harp seal (*Phoca groenlandica*)
	Ribbon seal (*Histriophoca fasciata*)
	Spotted seal (*Phoca largha*)

Table 1. Marine mammals that depend on arctic marine ecosystems for all (arctic species) or part of the year (sub-arctic species).

focuses on the seven marine mammal species that remain in the Arctic year-round, although it could be applied to studies of sub-arctic species, particularly those that are associated with sea ice.

Although climate change will affect marine mammal species directly, some of the most serious effects will be manifested indirectly through changes in habitat and increasing human presence and activity in the Arctic (Huntington and Moore 2008). The loss of sea ice is expected to have a significant, if not profound, effect on the ecology of most arctic marine mammals. Seals and walruses use sea ice as a platform for resting, molting, pupping, and nursing and caring for their young, and whether and how these animals will compensate for the loss of ice is not clear. For both arctic pinnipeds (seals and walruses) and cetaceans (whales), sea ice appears to function to varying degrees as a refuge from killer whale predation.

Polar bears use sea ice as a hunting platform and, in some cases, build their dens on multi-year ice. A

number of arctic marine mammals forage near the ice edge, in pack ice, or under the ice, where prey are often concentrated. Potential declines in ice-edge productivity or important ice-associated prey or keystone species, such as arctic and polar cod, could have a significant impact on the foraging success of arctic marine mammals.

Scientists expect that many sub-arctic marine mammal species will extend their range into the Arctic as temperatures and habitats change. These species may compete with arctic marine mammals for prey or habitat, alter predatory-prey relationships, and introduce diseases and parasites novel to arctic marine mammals.

Warmer temperatures and longer open-water seasons will facilitate increased human activities in the Arctic, including commercial shipping, commercial fishing, military activities, oil and gas operations, tourism, and coastal development. These activities will pose multiple risks to marine mammals, including disturbance through human presence or noise, ship strikes, direct and indirect fishery interactions, exposure to contaminants, and loss or degradation of important habitat for reproduction and feeding. Such risks are expected to increase in severity over time.

Trends in environmental conditions and human activities will vary regionally, as will their impacts on marine mammals. For example, climate change models predict that by 2050 summer sea ice will have declined significantly in the Barents, Beaufort, and Chukchi Seas, whereas it will remain relatively constant in Baffin Bay and the Labrador Sea (Figure 2; Overland and Wang 2007). Changes in the type and intensity of human activities likely will reflect both changes in the accessibility of various regions and the richness of their resources.

2. Status and Threats

The status of a marine mammal species or stock is a function of both its population dynamics and the key factors that drive those dynamics, including behavior, health status, trophic dynamics, habitat, and the effects of human activities (Figure 1). With a few exceptions, previous assessments of arctic marine mammals have focused primarily on their population dynamics and have achieved only limited success (Table 2). Further, much of the existing information is outdated and provides only a snapshot of status rather than a robust assessment of long-term trends.

3. Workshop to Develop Monitoring Plans for Arctic Marine Mammals

The U.S. Marine Mammal Commission and U.S. Fish and Wildlife Service convened an international workshop in Valencia, Spain during 4-6 March 2007 to develop a general monitoring strategy for arctic marine mammals. The workshop focused on ringed seals and belugas as case studies because they have circumpolar distributions, have been the subject of historic and recent studies, and are important subsistence resources for arctic communities.

USFWS

Species	Stock	Abundance	Year	Trend
Bowhead whale	Bering-Chukchi-Beaufort Seas	10,500	2001	increasing
	E. Canada-W. Greenland	6,300	2002-2004	increasing
	Svalbard	unknown	—	unknown
	Okhotsk Sea	unknown	—	unknown
Beluga	Cook Inlet	380	2000	declining
	Eastern Bering Sea	18,100	1989-1991	unknown
	Bristol Bay	1,600	2000	increasing
	Eastern Chukchi Sea	3,700	1992	stable
	Eastern Beaufort Sea	39,300	1999	stable
	Foxe Basin	1,000	1983	unknown
	Western Hudson Bay	25,000	1978 & 1987	unknown
	Southern Hudson Bay	1,300	1987	unknown
	James Bay	7,900	2001	unknown
	St. Lawrence River	1,100	1997	stable
	Eastern Hudson Bay	1,200	2001	declining
	Ungava Bay	<50	2007	unknown
	Cumberland Sound	1,500	2001	increasing
	Eastern High Arctic-Baffin Bay	21,200	1996	stable
	West Greenland	7,900	1998-1999	unknown
	3 stocks in Okhotsk Sea	18-20,000	1987	unknown
	11 additional stocks	unknown	—	unknown
Narwhal	Canadian High Arctic	70,000	2002-2004	unknown
	Northern Hudson Bay	3,500	2000	unknown
	Eastern Baffin Island	15,000	1993	unknown
	West Greenland	2,000	1998-1999	unknown
	East Greenland	>1,000	1980-1984	unknown
Ringed seal[1]	Arctic subspecies	~2.5 million	1970s	unknown
	Baltic Sea subspecies	5,000-8,000	1990s	mixed
	Lake Saimaa subspecies	280	2005	increasing
	Lake Ladoga subspecies	3,000-5,000	2001	unknown
	Okhotsk Sea subspecies	>800,000	1971	unknown
Bearded seal[2]	Bering-Chukchi Seas	250-300,000	1970s	unknown
	Canadian waters	190,000	1958-1979	unknown
	Atlantic and Russian Arctic	unknown	—	unknown
	Okhotsk Sea	200-250,000	1968-1969	unknown
Walrus[3]	Atlantic subspecies	18-20,000	2006	mixed
	Bering-Chukchi Seas	~201,000	1990	unknown
	Laptev Sea	4,000-5,000	1982	unknown
	Other regions	unknown	—	unknown
Polar bear	Chukchi Sea	2,000	1993	unknown
	Southern Beaufort Sea	1,500	2006	declining
	Northern Beaufort Sea	1,200	1986	stable
	Viscount Melville Sound	220	1992	increasing
	McClintock Channel	280	2000	increasing
	Norwegian Bay	190	1998	declining
	Lancaster Sound	2,500	1998	stable
	Gulf of Boothia	1,500	2000	stable
	Foxe Basin	2,200	1994	stable
	Western Hudson Bay	940	2004	declining
	Southern Hudson Bay	1,000	1988	stable
	Baffin Bay	2,100	1998	declining
	Davis Strait	1,700	2004	unknown
	Kane Basin	160	1998	declining
	Barents Sea	3,000	2004	unknown
	Laptev Sea	4,000-5,000	1993	unknown
	3 other stocks	unknown	—	unknown

Table 2. Available data on population dynamics of arctic marine mammal species. Information on abundance, trends, and the year when the most recent data were collected are summarized by stock, except for ringed seals, bearded seals, and walruses, whose stock structure is unknown. Figure 3 shows the locations referenced in the table. Adapted from Richter-Menge et al. (2008).

1. Ringed seal stock structure unknown; information summarized for five recognized subspecies.
2. Bearded seal stock structure unknown; information summarized for geographic regions.
3. Walrus stock structure unknown; information summarized for Atlantic subspecies and geographic regions for Pacific subspecies.

Figure 2. Arctic climate regions with contrasting predicted trends in summer sea ice extent (modified from Overland and Wang 2007 based on suggestions from J. Overland). The majority of climate change models predict substantial reduction in summer sea ice for the Barents, Beaufort, and Chukchi Seas by the year 2050, while Baffin Bay and the Labrador Sea are predicted to maintain approximately the same summer ice extent as now. Model results for the Central Arctic, East Greenland, and the Kara and Laptev Seas are variable, reflecting uncertainty in the underlying dynamics in those regions.

Research and monitoring methods and challenges for ringed seals and beluga whales also are generally applicable to other arctic marine mammals. Scientists prepared background papers (Kovacs 2007 and Laidre 2007) describing the biology and ecology of ringed seals and beluga whales based on research conducted to date. Workshop participants included 53 scientists and members of arctic indigenous communities (Appendix 1) with expertise in the biology and ecology of marine mammals, arctic oceanography and climate, sea ice, marine mammal health, subsistence harvest and biosampling networks, and monitoring techniques. Participants identified key parameters for monitoring population status and research tools for assessing those parameters (Table 3). They also emphasized the importance of multi-disciplinary studies and partnerships that would include expertise outside that represented at the workshop. The resulting monitoring framework is intended to provide overarching guidance for the development of integrated regional or species-based monitoring plans, which may vary in terms of specific monitoring parameters or tools (Table 3) but should all assess both population dynamics and the factors that drive those dynamics (Figure 1).

4. Existing International Research and Monitoring Efforts

Workshop participants emphasized the integration of new research and monitoring efforts with those already underway or in the planning stage. The Study of Environmental Arctic Change (SEARCH) science and implementation plans (SEARCH 2005) provide a common vision and direction for arctic research by U.S. federal agencies. This research is coordinated by the Interagency Arctic Research Policy Committee, which is developing an Arctic Observing Network that will gather data necessary to describe, understand, and guide response to climate change and its impacts

Key Parameters	Primary Monitoring Tools
Population Dynamics	
Population structure	Genetic analyses (biological samples from remote biopsies, live captures, subsistence harvest[L], strandings[L], ice entrapments) Distribution and movements (surveys, satellite tagging, local observations[L])
Abundance & trends	Visual surveys (aerial, boat-based, shore-based) Infrared or multispectral surveys (aerial, remote-sensing[P]) Mark-recapture methods (tagging, tattooing, branding, photo-ID)
Survival & reproductive rates	Biological samples (e.g., reproductive tracts; harvested[L], stranded[L], entrapped animals) Mark-recapture methods Demography from surveys (for species with visually-distinct sex and age classes)
Behavior	
Migration & distribution	Remote tracking (VHF & satellite-linked tags) Local observations (villages[L], research stations)
Foraging	Remote tracking
Breeding	Local observations Passive acoustic monitoring (for vocal species) Genetic analyses (biological samples from remote biopsies, live captures, subsistence harvest[L], strandings[L], ice entrapments)
Health Status	
Body condition	Morphometry (captured, harvested[L], stranded[L], entrapped animals) Photogrammetry (i.e., remote morphometry)
Diseases & parasites	Necropsies[V] (harvested[L], stranded[L], entrapped animals) Analyses of tissue samples[C] (biopsies, live captures, harvested[L], stranded[L], entrapped animals)
Contaminants	Analyses of tissue samples[C] (biopsies, live captures, harvested[L], stranded[L], entrapped animals)
Habitat	
Sea ice (extent, thickness, concentration, duration)	Remote sensing[P] (e.g., AVHRR, microwave) Local observations (villages[L], research stations)
Snow (depth, duration) [*primarily for ringed seals*]	Local observations (villages[L], research stations) Remote sensing[P] (microwave?)
Primary production (amount, location, bloom timing)	Oceanographic cruises[B] Local observations (villages[L], research stations) Remote sensing[B] (chlorophyll)
Trophic Dynamics	
Prey availability & quality	Diet (stomach and fecal samples[L], fatty acids, stable isotopes) Prey abundance & distribution (pelagic & benthic prey surveys[B])
Competition (arctic or formerly sub-arctic species)	Surveys of competitors[B] Studies of behavior of competitors[B]
Predation	Surveys of predators (e.g., killer whales, polar bears) Studies of behavior of predators[B]
Human Activities	
Subsistence harvest	Harvest monitoring programs (government or local[L])
Coastal development, Fishing, Shipping, Oil & gas/mining operations, Tourism, Military activities	Continual assessment of new activities and potential or observed impacts on arctic marine mammals[I]

Table 3. Key monitoring parameters and tools for assessing the status of arctic marine mammal populations. Based primarily on ringed seals and belugas, these parameters and tools are expected to pertain, at least generally, to all arctic marine mammal species.

Superscripts indicate the need for partnerships with experts outside of typical marine mammal research fields: B=biological oceanographers and fisheries biologists, C=contaminants monitoring groups (e.g., AMAP), I=industries and industry monitoring groups, L=local subsistence hunters or local monitoring networks, P=physical oceanographers and sea ice scientists, V=veterinarians and wildlife epidemiologists.

on arctic ecosystems and societies (IARPC 2007). Both SEARCH and the Arctic Observing Network will coordinate with international partners, particularly the International Arctic Science Committee and the Arctic Ocean Sciences Board, which developed the International Study of Arctic Change. These planning efforts have included participation by government and academic scientists at a variety of workshops and conferences, most notably the International Conferences on Arctic Research Planning (Bowden et al. 2007).

The Arctic Council also is actively engaged in planning and coordinating research and monitoring efforts. The Conservation of Arctic Flora and Fauna Working Group is currently focusing on monitoring trends in arctic biodiversity through its Circumpolar Biodiversity Monitoring Program (CBMP). The research and monitoring framework discussed here is intended to support that program's development of an integrated, pan-arctic marine biodiversity monitoring plan that will include marine mammals. The Arctic Monitoring and Assessment Program focuses on monitoring pollutants and their impacts on wildlife and humans, while the Arctic Contaminants Action Program strives to reduce emissions of pollutants into the arctic environment. The Protection of the Arctic Marine Environment Working Group focuses on assessing and controlling the impacts of human activities on arctic marine ecosystems, including the ongoing Arctic Marine Shipping Assessment (PAME 2006). A similar assessment of oil and gas industry activities in the Arctic was recently completed by AMAP (AMAP 2007).

5. Local Monitoring Networks and Traditional Ecological Knowledge

Workshop participants emphasized the need for the development and maintenance of effective local monitoring networks and the collection and integration of traditional ecological knowledge as part of a comprehensive monitoring framework (Table 3, Figure 1). Many coastal arctic peoples have relied on subsistence harvests of marine mammals for centuries, and their cultures are rich with traditional ecological knowledge of marine mammals, including insights regarding their behavior, movements, natural history, and habitats. Such knowledge can guide or augment research, management, and conservation efforts targeting marine mammals. Traditional hunters of marine mammals continuously monitor

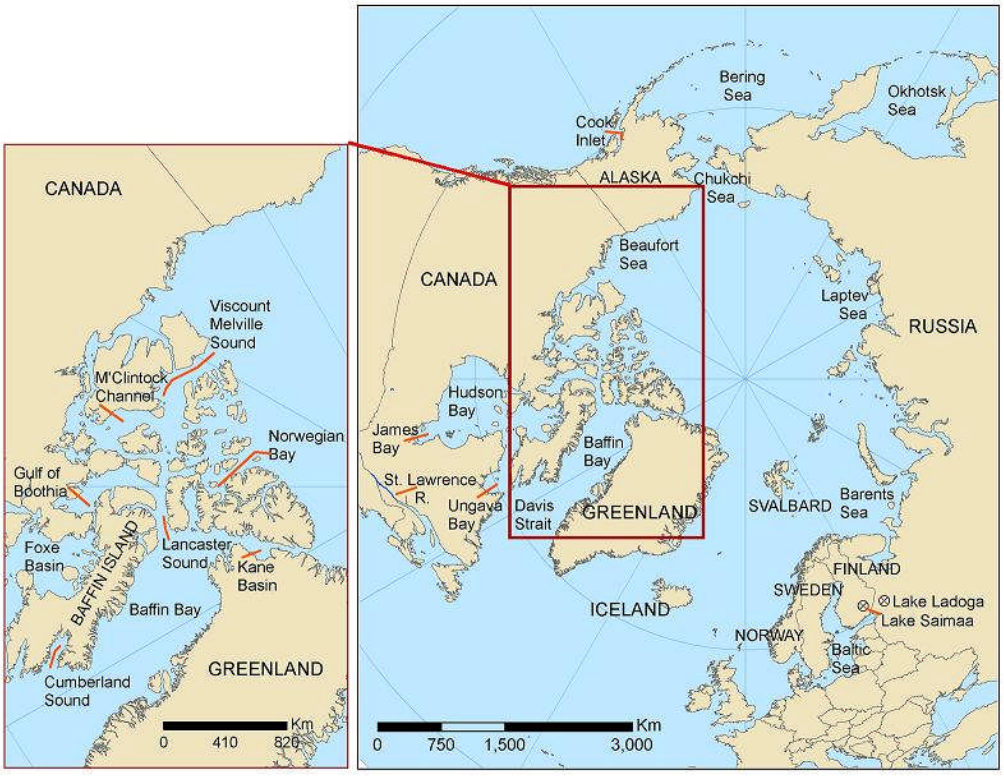

Figure 3. Map of the Arctic with places cited in the text or in Table 2.

local environmental conditions and the availability, behavior, and condition of animals that they rely on for subsistence, and they may be the first to detect important changes in the Arctic resulting from climate change. Marine mammals taken by subsistence hunters can be used for scientific research, providing information on reproductive rates, diet, and health status (body condition, diseases, parasites, and contaminants). In addition, facilities (e.g., airports) in arctic coastal villages and the equipment and skills of local people can provide essential support for a variety of other research and monitoring activities.

6. Key Challenges

Comprehensive monitoring of arctic marine mammals will require extensive coordination and cooperation among agencies and nations across the Arctic. Workshop participants recommended the formation of international working groups to design and coordinate monitoring efforts. Such groups might be sponsored or administered under the CBMP banner and would be required to address several key challenges which are outlined below (sections 7 -10)

7. Funding

Workshop participants were unaware of any sources of sustained funding for long-term monitoring of arctic marine mammals. Current funding for even short-term research is limited. Existing funds often are directed toward immediate, specific tasks (e.g., related to oil and gas operations or subsistence harvests) without suitable support to meet long-term data needs. As a result, managers often are faced with making management decisions based upon insufficient information regarding baseline patterns, and additionally they are unable to evaluate important long-term trends in the status of affected species. Research efforts have been limited spatially, and few marine mammal studies have been conducted in large regions of the Arctic, most notably in the Russian Arctic. To be successful, a monitoring strategy must describe funding needs and identify funding sources, including governmental, industrial, and environmental agencies and organizations.

8. Rapidly changing conditions

The rapid pace of change in arctic climate, ocean conditions, and sea ice extent poses both a challenge and an opportunity for research and monitoring efforts. Rapidly changing conditions may require frequent modification of research methods and confound interpretation of results. On the other hand, variation in environmental conditions may facilitate research into the functional relationships between environmental conditions and the status of arctic marine mammals, which is more difficult in a static environment. Research and monitoring designs must be sufficiently robust and flexible to adapt to, and take advantage of, changing environmental conditions and regional variation in environmental trends.

9. Collaboration, Consistency in Methods, and Comparability of Results

Current methods used to study marine mammals are not consistent across the Arctic, and comparisons of the data collected in different areas are therefore difficult to interpret meaningfully. To improve this situation, scientists must develop common protocols for data collection and sharing. The resulting strategy must integrate research and monitoring efforts and resources across international, national, regional, and local levels. A broad-based organization, such as the CBMP, is needed to maintain and administer partnerships, promote collaboration and coordination, and provide a conduit for reporting results.

10. Technical and Logistical Issues

The technical and logistical issues common to marine research throughout the world's oceans are

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exacerbated in the Arctic by the presence of sea ice and the remoteness of most arctic coastlines and seas. In particular, it is difficult to conduct oceanographic and ecological research in ice-filled waters. As a result, relatively little is known about the biology and ecology of ice-associated species, including fishes and invertebrates – some of which are key prey species of arctic marine mammals.

Logistical and technical challenges often demand expensive solutions and generally limit the research that can be conducted. Local monitoring efforts can help address the problem of accessibility, but only near coastal villages. Subsistence harvests can provide biological samples from harvested animals, although collection of such samples is limited to certain coastal villages primarily in Alaska, Canada, Greenland, and eastern Russia. Remote imagery from satellites provides useful information on certain topics (e.g., atmospheric and surface conditions), but it can be constrained by cloud cover or difficulties in distinguishing between terrestrial and shore-fast ice features in the coastal zone. These and other technical and logistical challenges can be overcome, but only with adequate funding and collaborative approaches.

11. Recommendations

Workshop discussions led to the following recommendations for collaborative research, monitoring, and planning efforts by arctic nations:

a ***Convene international expert monitoring groups***—Such groups are essential for identifying specific research and monitoring needs and coordinating efforts across the Arctic in accordance with the comprehensive monitoring framework described herein.

b. ***Develop comprehensive monitoring plans***—The expert monitoring groups should develop strategic, pan-arctic monitoring plans for marine mammals. The plans should incorporate the candidate parameters and tools set forth in the monitoring framework (Table 3) and should adapt as conditions, information, and resources change.

c. ***Establish research priorities***—Resources for research and monitoring undoubtedly will be limited, and the expert monitoring groups should establish priorities to maximize the value of the research conducted and information gained.

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d. ***Develop data collection and data sharing protocols***—The expert monitoring groups should establish protocols needed to compare information over space and time in order to identify important changes in the status of marine mammals and arctic marine ecosystems.

e. ***Promote research partnerships***—The expert monitoring groups should facilitate and coordinate partnerships representing international, national, regional, and local interests and should ensure that research and monitoring is sufficiently multi-disciplinary to address important conservation and management questions.

f. ***Clarify funding needs, identify potential funding sources, and develop funding proposal***s—The expert monitoring groups should work with funding agencies and organizations to maintain an ongoing appraisal of funding needs and potential funding sources and should develop and submit funding proposals as necessary and appropriate.

The comprehensive monitoring effort envisioned at the workshop will be a challenge to implement. However, such challenges can and must be overcome to ensure that adequate information is available to conserve arctic marine mammals in the face of climate change and associated changes in human activities.

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